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Emergence patterns and survival success of sea turtle hatchlings on the beach

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RESUMO

Conhecimentos sobre a sobrevivência de neonatos de tartarugas são essenciais para o desenvolvimento de medidas que aumentam a sobrevivência das mesmas nas praias. O presente estudo foi desenvolvido com o propósito de analisar a emergência e sobrevivência de neonatos de tartarugas marinhas, tendo a praia de João Barrosa da ilha de Boavista como modelo. Para o estudo foram efectuados censos matinais de rastros de neonatos de tartarugas, neonatos de tartarugas mortas e ninhos eclodidos usando dois transectos lineares na linha da maré alta. Os dados demostraram que mais de metade dos neonatos de tartarugas emergidos diariamente morreram. Foi observado que o local dos transectos exercem influência na sobrevivência de neonatos de tartarugas. A fase lunar também exerce influência na sobrevivência de neonatos de tartarugas na zona supralitoral, sendo maior nas noites de lua nova. Por último, os resultados demostraram que a sobrevivência de neonatos de tartarugas diminui com o aumento da distância do ninho à linha de maré alta. São propostas medidas de conservação e recomendações para aumentar a sobrevivência de neonatos de tartarugas nas praias.

Palavras-chave: Caranguejo fantasma, *Caretta caretta*, conservação, predação, tartarugas recém-nascidas

ABSTRACT

Knowledge about the survival of turtle neonates is essential for developing measures to increase turtle survival on breeding beaches. The present study was developed to analyse the emergence and survival of marine turtle neonates, using João Barrosa beach on Boavista Island as a model. For this study, morning censuses of neonate tracks, dead neonates and emerged nests were performed using two linear transects at the high tide line. The data showed that more than half of the daily emerged neonates died. It was determined that the location of the nests influences the neonate's survival. The lunar phase also influences the survival of the neonate turtles in the supralittoral zone, being greater on new moon nights. Finally, the results showed that neonate survival decreases with increasing distance from the nest to the high tide line. Conservation measures and recommendations to increase the survival of neonates on nesting beaches are proposed.

Keywords: ghost crabs, *Caretta caretta*, conservation, predation, turtle hatchlings

INTRODUCTION

Sea turtles are critical to the balance of marine ecosystems (Reis & Goldberg 2017), but they are threatened with extinction due to human and natural threats (Mrosovsky 1983), such as predation of eggs and hatchlings (Correia *et al*. 2016).

Ghost crabs are among the most important predators of turtle hatchlings (Erb & Wyneken 2019; Marco *et al*. 2015). Since the activity of ghost crabs coincides with the emergence period of turtles (Lucrezi & Schlacher 2014), they significantly affect their survival during the incubation and emergence process (Martins *et al*. 2021). Because potential prey will be more exposed to predators, lunar luminosity on the beach is related to the degree of hatchling predation (Silva *et al*. 2017). According to some studies, this factor influences the activity of ghost crabs, causing them to be more active on lighter nights/ full moon and less active on darker nights/ new moon (Fortaleza *et al*. 2020).

After 50–60 days of incubation (Demmer 1981), turtle neonates emerge from the nest at night (Glenn 1996) and crawl towards the sea. Their survival depends on several factors (Triessnig *et al*. 2012), such as the distance of nest emergence from the seashore, thus influencing hatchling survival (Erb & Wyneken 2019). The further away from the seashore emergence occurs, the more time a hatchling spends on the beach exposed to predators (Marschhauser 2010), while the risk of disorientation also increases. In addition, the presence of obstacles (marine debris, rocks, vegetation) on beaches, can make the crawl towards the sea more difficult and thus decrease the chance of survival (Aguilera *et al*. 2018a).

A better understanding of the factors influencing the survival of hatchlings would be useful for developing strategies that increase the survival success of neonates on beaches and support the conservation of sea turtles that are threatened with extinction.

This study was developed to analyse the emergence of hatchlings and the factors influencing their survival and to obtain useful information to assist in conservation programs of sea turtles.

MATERIAL AND METHODS

The study was carried out at João Barrosa beach (16°01'N, 22°45'W) within the Turtle Nature Reserve on the southeast coast of Boavista Island, Cabo Verde (Fig. 1). Cabo Verde is considered one of the most important nesting locations for the loggerhead turtle *Caretta caretta* (Marco *et al*. 2011). Boavista hosts more than 65% of the nesting sites in the archipelago (Ferreira-Veiga 2018), while João Barrosa beach hosts 20% of sea turtles nesting on the island (Marco *et al*. 2012). The field study took place between September 18 and October 11, 2021, which is an important period for the emergence of neonates in the archipelago (Marco *et al*. 2011).

Two linear transects at high-tide lines were defined using a *Garmin Etrex 10 GPS* device: transect T1 (16º00´53´´N, 22º44´32´´W), with white sand without stones and 180 m in length, and transect T2 (16º00´58´´N, 22º44´24´´W), with white sand and abundant stones, 280 m in length (Fig. 1).

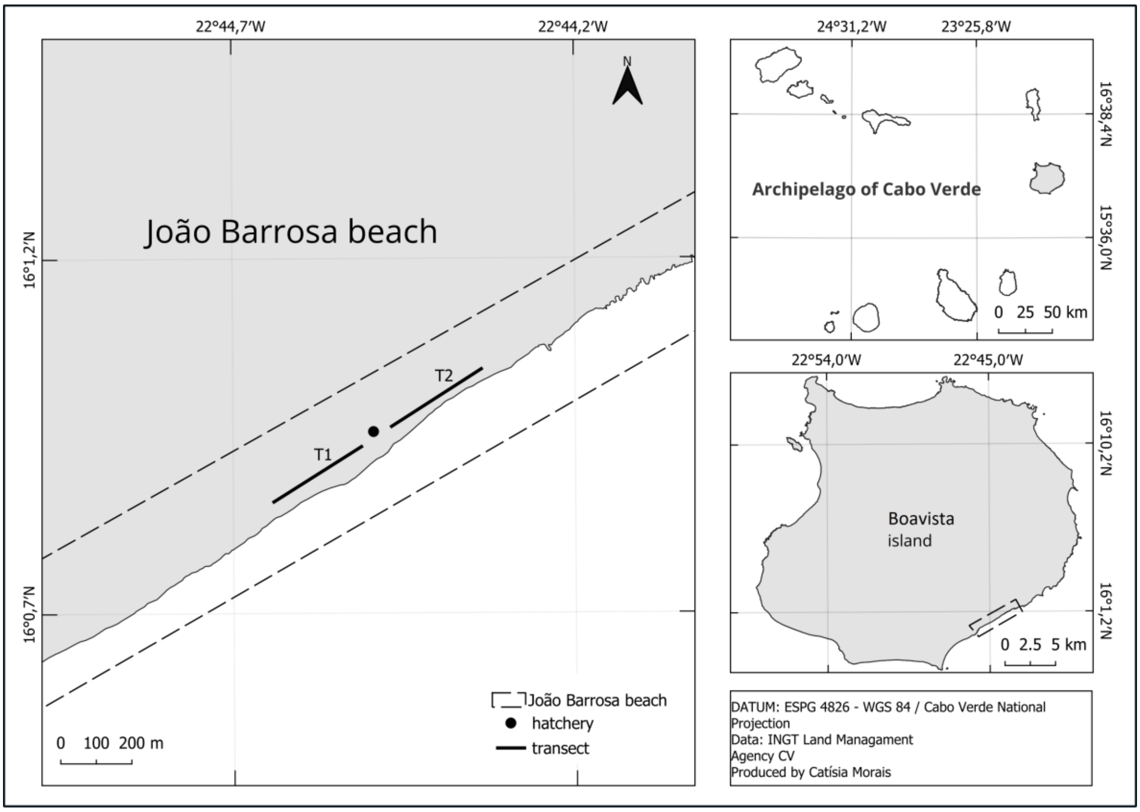

Fig. 1. Study area and study site. Map of Cabo Verde, highlighting Boavista Island and the selected beach of João Barrosa on the southeast coast of the island and the two transects (T1 and T2).

Morning censuses were conducted on each transect recording the following information: number of emerged nests, emergence tracks, tracks of neonates that entered the intertidal zone and dead neonates that were up to 2 m from the linear transect. Each track of neonates found in the transect was followed to find the nest location which was marked by a heap of stones and a number. For each detected emerged nest, the distance of the nest from the high tide line was measured and the emergence tracks were counted. All dead hatchlings found were counted, evaluated to see if it was preyed upon or not and then buried. Hatchling survival success only refers to the supralittoral zone. It was not possible to estimate survival in the intertidal zone. The density (D) of each variable was calculated, because the transect hasn't the same length, and the unit of measurement was "per meter of the beach":

D= Q/C (Q= daily quantity; C= length of the corresponding transect) and emergence success= daily emergence/ daily nest.

Parametric tests were performed, using the densities of variables that followed a normal distribution and that were homogeneous, while nonparametric tests were done for those that did not follow a normal distribution or were not homogeneous. Spearman correlation tests were performed to compare quantitative variables. These parametric tests served to compare the means between the locations of the transects and between the lunar phases (new moon, full moon and waning moon) (cf. https://www.vercalendario.info/pt/lua/caboverde).

RESULTS

The observed emergence success was 13.05 neonates per nest (Table 1). On two transects, the mean of neonates that survived in the supralittoral zone each night was 80.9±59.8, but more than half of the emerged neonates (82.0±58.8) died on the beach (56.3±29.3).

Transect T1 had the highest density of dead neonates per meter of beach (0.359±0.12), while transect T2 had the lowest density (0.158±0.11; Table 2). In transect T1 there were more emergences per meter of beach than in transect T2 (0.379 ± 0.26; 0.328 ± 0.22). The location of the transects significantly influenced the density of dead neonates (Student's t-test= 4.122, p< 0.05).

Table 1. Daily mean, standard deviation (SD) and the total number of neonates counted (N) of each variable in two transects (T1 and T2). Sample size (n= 21 days)

Study variables	Mean ± SD	N
Emergency tracks	82.00 ± 58.8	1720
Emerged nests	6.28 ± 4.0	132
Surviving neonates in the supralittoral zone	80.90 ± 59.8	1699
Dead neonates	56.38 ± 29.3	1184

Table 2. Daily density and standard deviation (SD) per meter of beach and SD of each variable in each transect (T1 and T2). Sample size (n= 21 days)

Study variables	Density ± SD (180m)	Density ± SD (280m)
Emergency tracks	0.379 ± 0.26	0.328 ± 0.22
Emerged nests	0.029 ± 0.02	0.025 ± 0.01
Surviving neonates in the supralittoral zone	0.351 ± 0.24	0.336 ± 0.22
Dead neonates	0.359 ± 0.12	0.158 ± 0.11

Regarding the influence of lunar phases, it was found that the differences in the mean density of dead hatchlings are statistically significant (ANOVA: F= 5.245, p= 0,016) for the different lunar phases, as well as for the variable's densities of surviving neonate tracks and density of hatched nests (Kruskal-Wallis: $p < 0.05$). The highest densities of dead neonates (mean± SD = 0.375± 0.11), tracks of surviving neonates in the supralittoral zone (mean± SD= 0.557± 0.28), emergence tracks (mean± SD= 0.558± 0.27) and emerged nests (mean± SD= 0.039± 0.01) were found during the new moon, while full moon had the lowest densities of dead neonates (mean± SD= 0.174± 0.14), surviving hatchling tracks (mean± SD=

0.232± 0.13), emergence tracks (mean± SD= 0.201± 0.12) and emerged nests (mean± SD= 0.017± 0.00) (Fig. 2). The differences in the variable density of tracks of non-surviving neonates were not statistically significant (Kruskal-Wallis: $p < 0.05$), meaning that the lunar phases only influence the variable densities of dead hatchlings, tracks of surviving neonates, emergency tracks and hatched nests.

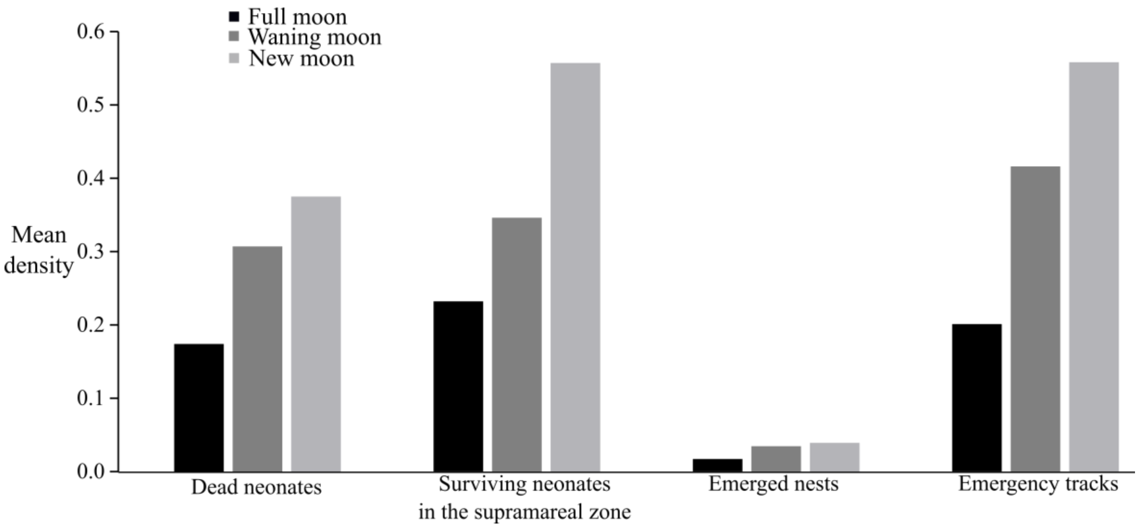

Fig. 2. Average densities of dead neonates, tracks of surviving neonates in the supralittoral zone, emergency tracks and emerged nests per meter from the beach in the three lunar phases.

The distance from the nest to the high-tide line was negatively correlated with the density of surviving neonate tracks (Spearman correlation: r= -0.238, p< 0.05), which means that when the distance from the nest to the high-tide line increases, the density of surviving hatchling tracks decreases.

DISCUSSION

In this study, it was not possible to discern the survival of neonates on the entire João Barrosa beach. This parameter was only evaluated for the supralittoral zone, as it was hard – indeed well-nigh impossible – to count tracks in the intertidal zone. Also, it was not possible to know the total number of dead neonates, because these were only counted along the transects. But as 68.6% of emerged neonates were found dead, 31.3 % may have survived or were washed away by the waves, displaced by ghost crabs or lost in another way. However, the results clearly show that the survival of turtles on the beach is low because most of the emerged hatchlings apparently perish before reaching the sea.

All dead neonates found showed signs of predation, e.g., a missing head or viscera could indicate ghost crabs being the predator as only ghost crab tracks were found in the study area. However, other predators recorded at João Barrosa beach include corvids and rats (Marco *et al*. 2011). The location of the nests influenced the density of dead neonates, this being higher in the T1 transect. This may be due to the characteristics of the nest location (Bourgeois *et al.* 2009), as T1 site had many stones. It also had a higher density of nests and consequently a higher number of emerged neonates and a higher rate of mortality. However, analyzing the different values, it appears that the daily density of emerged neonates in the two transects is the same, but the daily density of dead neonates is very different, showing that in transect T1 almost all the emerged neonates died (94.7 %) and in transect T2 only half died (48.1 %), so in this case the location of the nests clearly influenced the survival rate of neonates.

Hatchling survival in the supralittoral zone was lower during the full moon/ light night and higher during the new moon/ dark night. The fact that ghost crabs are restricted to the intertidal zone during the night (Fortaleza *et al*. 2020) and less active during low light nights (Silva *et al*. 2017), increased neonate survival in the supralittoral zone during the new moon/ low light. During the full moon, however, ghost crabs are more active and more neonates die because upon arrival in the intertidal zone, most were preyed upon due to the high density of ghost crabs in the area (Rodrigues *et al*. 2016). So, even if the density of dead neonates during the new moon is higher than during the full moon, 86% of emerged neonates died on full moon, while with new moon 67.2% died. In other words, during new moon, there are more surviving neonates in the supralittoral zone, but more dead neonates during full moon.

As the distance from the nest to the high-tide line increases, the survival of neonates decreases. However, a previous study conducted in Boavista concluded that the distance from the nest was not correlated with the predation rate of neonates (Martins *et al*. 2021) and predation was higher in the intertidal zone as this was where the highest density of ghost crabs is found (Strachan *et al*. 1999). However, the survival of neonates in the present study represents those that arrived in the intertidal zone, while Aguilera *et al*. (2018b) found that staying on the beach increased the chances of predation.

CONCLUDING REMARKS

The data obtained in this study will hopefully serve to improve the quality of information about sea turtles in Cabo Verde and help in the development of strategies to increase the survival of neonates on spawning beaches. One possibility would be to perform night patrols, looking for hatchling emergences and taking them closer to the water. These patrols could be concentrated on the darkest and lightest nights because this study demonstrated that these factors influence the survival of neonates during their stride towards the sea.

We recommend carrying out further studies during the hatching season in Cabo Verde, especially those focusing on the danger zones, i.e., the intertidal zone where predation is higher. Additionally, studies on ghost crab behavior are desirable, to better understand the relationship with neonate turtles. Continued implementation of the sea turtle conservation program, the registration and morning monitoring of emergence tracks on the important spawning beaches are recommended. Since Cabo Verde has a high density of nests, it would be an ideal study location to closely follow emergences of nests

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