Mitigating the impacts of climate change in sea turtle reproduction: developing the evidence base for "clutch-splitting" as a low-cost management tool.

April 2024

Leo Clarke, Nelson Semedo, Diana Nadine Semedo, Samir Martins

Introduction

Environmental temperature influences numerous life-history stages of sea turtles including hatchling sex determination. As group sea turtles are already of conservation concern and there is thus concern over their continued conservation in a rapidly changing climate, which adds to widespread existing threats such as capture in fishing gear, plastic pollution, and poaching.

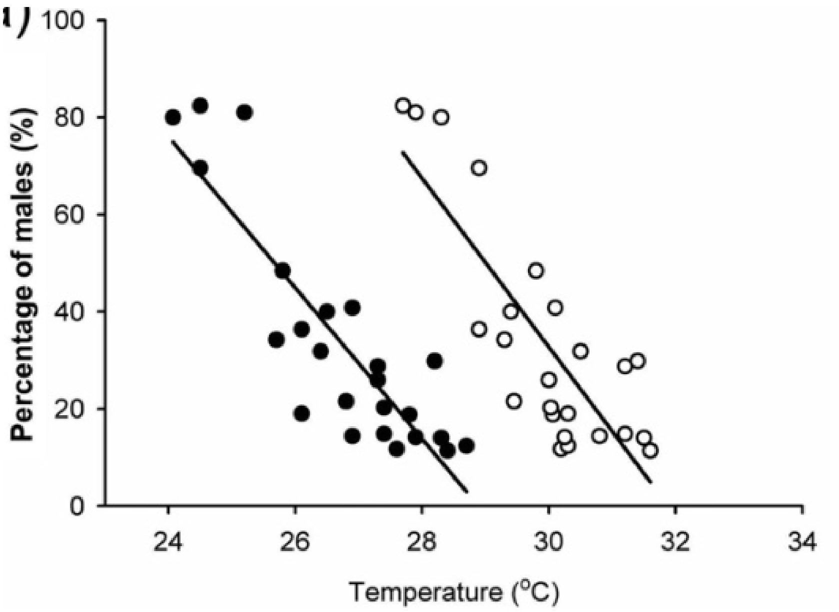
For species which exhibit temperature-dependent sex determination (TSD), the temperature during the gonad differentiation stage of incubation (the middle third, or second trimester of incubation), determines the sex of hatchlings. Lower temperatures (26-28 °C) result in a higher percentage of males produced, and higher temperatures (30-34 °C) yield predominantly female hatchlings. Intermediate temperatures between 28 to 30 °C generally lead to more balanced primary sex ratios (Figure 1).

Previous studies have determined that higher nest temperatures due to global climate change are already causing heavily female-biased hatchling sex and reduced hatching success. Thus, conservation managers are considering what mitigation techniques are available. Researchers have investigated various techniques to reduce sea turtle nest temperatures such as nest shading, watering, translocation to conservation hatcheries and laboratory incubation. These techniques are often resource and labour-intensive, however, and as sea turtles typically nest in remote locations in developing countries, practical solutions should be simple and cheap.

In addition, elevated nest temperatures my be further exacerbated by metabolic heat generated as the eggs develop. A novel, low-cost technique of halving an incubating sea turtle clutch size (“clutch-splitting”), thereby reducing the number of eggs and thus the amount of metabolic heat generated by the nest, effectively reduced overall nest temperatures relative to “whole” control clutches in an experimental conservation hatchery setting.

This work aimed to investigate the effectiveness of this technique in a natural nesting environment of the endangered loggerhead turtle *Caretta caretta*.

Figure 1. The relationship between air (open circles) and sand (black circles) temperatures during the middle trimester of incubation and the percentage of male hatchlings produced.



Aims

The project aimed to:

1. Collect temperature data to assess incubation temperatures and metabolic heating of split and whole clutches across the natural nesting environment.

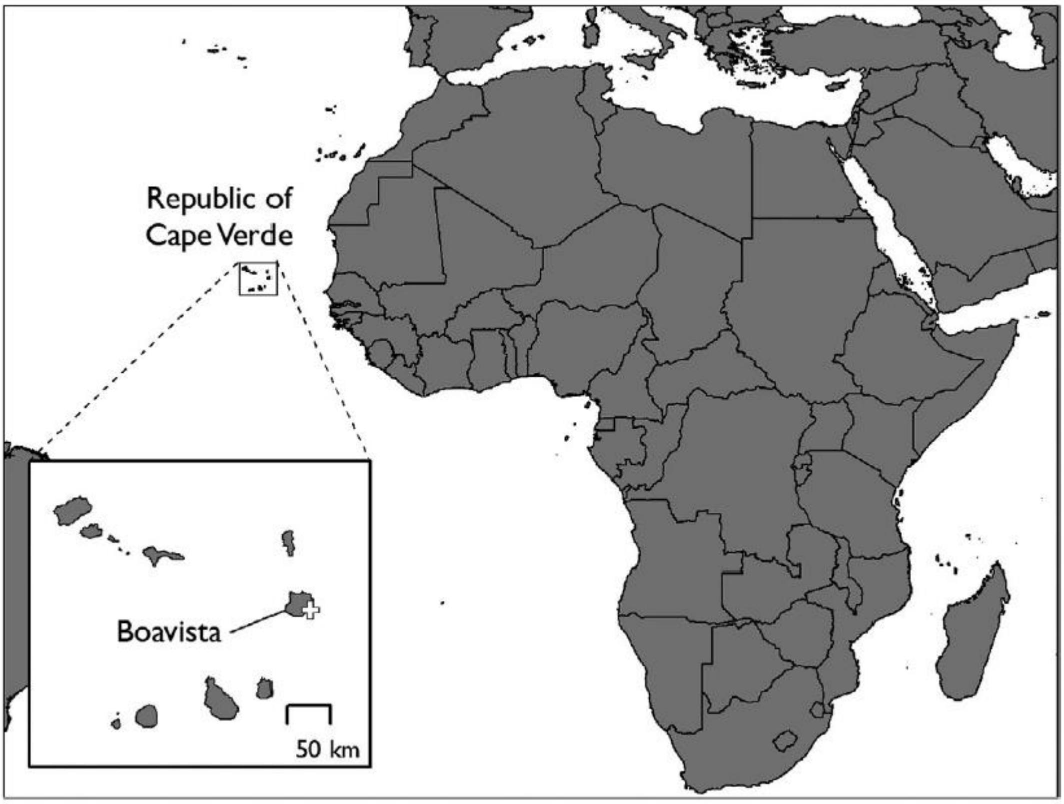
2. Assess how the thermal nest environment and metabolic heating vary in relation to beach elevation, nest depth, sand moisture content and clutch size.

3. Investigate hatchling fitness and predation rates in split and whole clutches.

Method

The work was carried out on Boa Vista Island, part of the Cabo Verde archipelago in the eastern Atlantic Ocean off West Africa (Figure 2). Cabo Verde supports more than 95% of the loggerhead's nesting activity in the entire eastern Atlantic. Field trips was carried out between 2nd and 6th of August and 20th and 30th September 2023 and in collaboration with BIOS.CV, a local NGO established in 2013 which runs a volunteer camp which that host volunteers, long-term monitoring staff and visiting researchers.

Figure 2. Map of the Republic of Cabo Verde off West Africa. The study was carried out on a beach marked by the white cross on the inset map.



During the first field visit temperature data loggers were placed in 19 loggerhead *Caretta caretta* nests after nesting females were encountered on the beach either during their ascent from the sea or during digging of the nest. Nests were allocated to two treatments: control clutches (n = 9), which were left to incubate naturally, and split clutches (n = 10). In split clutches, half of the eggs were removed from the egg chamber during oviposition (i.e. every other egg deposited was removed for relocation) and reburied at the same beach elevation a distance of 5 metres from the original nest. These eggs were not monitored further. An additional TDL was buried at 50 cm depth, the average nest depth of the Boa Vista population, 1 metre from the original nest at the same beach elevation to monitor sand temperatures and to allow the calculation of metabolic heating of the nest.

During the second visit nests were monitored for hatchlings every two hours overnight.

Results

The average clutch size in control clutches was 74 eggs and 35 eggs in split clutches. Of the 19 nests included in the study, eight nests hatched successfully. The failure of the remaining clutches to hatch was likely due to exceptionally high tides during August 2023 which left many nests inundated for prolonged periods, and unseasonably high rainfall.

Of nests that incubated successfully the data analysis revealed that nest temperatures increase gradually in the first trimester of incubation, and more rapidly in the second and third stages as embryonic development occurs. The temperature curve begins to plateau in the final stages as embryos complete development. The same trend is evident in metabolic heat profiles. The profiles of both responses across incubation diverge between control and split clutches as incubation progresses. Thermal profiles of nests in each treatment follow a similar pattern during the first and second trimesters of incubation but begin to diverge in the latter stages of the second trimester, before indicating further separation between treatments in the final third of incubation as embryonic development reaches its peak.

Discussion

Overall, the loss of several nests during this study limits the conclusions that can be drawn with any certainty from our results. However, broad trends in metabolic heat and temperature profiles provide some indication that clutch-splitting may be effective in reducing nest temperatures in the natural nesting environment, despite the lack of statistically detectable results and any elicited change in hatchling sex ratios.

The fact that fieldwork was carried out during the hottest part of the nesting season, which meant that all nests produced >95% female hatchlings, combined with our reduced sample size, likely limited the potential for any change in sex ratios to be detected. In fact, it suggests that during this time of year the method may be less effective in altering sex ratios. Nonetheless, the technique may prove effective in at other times in the nesting season and in reducing nest temperatures away from the upper thermal limit, towards which it appears they may be incubating.

Given the remaining uncertainty around the rate and magnitude to which sea turtles can adapt to mitigate the effects of global temperature increases, clutch-splitting may provide an alternative and low-cost management intervention for conservation managers.

Acknowledgements

This work was gratefully funded by donations from: The Alice McCosh Trust, British Herpetological Society and British Chelonia Group. The authors thank funders for their kind donations in contributing to this research. Fieldwork was supported by the staff of BIOS.CV.