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Citation	Proceedings of the 3rd Workshop on SEASTAR2000 (2002): 101-104
Issue Date	2002
URL	http://hdl.handle.net/2433/44167
Right	
Type	Conference Paper
Textversion	publisher

CLUTCH SIZE AND INCUBATION TEMPERATURES OF GREEN TURTLE EGGS

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ABSTRACT

Since clutch size of sea turtle eggs, through metabolic heating, can affect incubation temperatures, a study was conducted on Redang Island, Malaysia to look into the magnitude of this effect and its possible influence on sex determination of hatchlings. Miniature self-recording temperature loggers were used to monitor the incubation temperatures of relocated green turtle nests with 0, 5, 25, 50, 75, and 100 eggs at 60cm depth. Incubation temperatures were not constant but changed depending on weather, season, period of incubation and clutch size. The differential effects of metabolic heating on nest temperature due to clutch size only became evident after the first-third of incubation. These effects increase as the incubation progresses until hatching. Metabolic heating effects were greater in larger clutches compared to smaller clutch sizes. Incubation temperature reached its maximum after approximately 45 days of incubation. Clutch size can have a significant impact on incubation temperature through metabolic heating but may not necessarily influence significantly the sex ratio output of hatchlings.

INTRODUCTION

Incubation temperatures of sea turtle eggs have profound implications on the survival of the population since sexual differentiation of sea turtles are largely determined by incubation temperatures. According to Mrosovsky and Yntema (1980), a change of 1 - 2°C can make a considerable difference to the sex ratio of the hatchlings. There are numerous factors that can affect the temperature of the incubating turtle eggs ranging from climate, sand and beach characteristic, vegetation, water-table and metabolic heating from the eggs themselves. Some recent studies have been conducted to look into the effect of metabolic heating on incubating eggs though conclusions varied. Godley et al. (2001) reported that the level of metabolic heating varied markedly throughout the incubation period with levels being significantly higher in the final third of incubation. Broderick et al. (2001) found metabolic heating can cause a change in temperature between 0.07-2.86°C within nests and could cause a rise of up to 30% in the proportion of females. However, Booth and Astill (2001) did not believe metabolic heating to have much effect on hatchling sex ratio because they occur mainly after the sex-determining period. This study was conducted to look into the effect of clutch size and its effect on incubation temperatures for green turtle eggs incubated at the beaches of Redang Island, Terengganu, Malaysia.

MATERIALS AND METHODS

This study was conducted on two green turtle nesting beaches in Redang Island, Terengganu, Malaysia (5o 49'N, 103o 01'E) from May to October 2002. Though four species of sea turtles are known to nest on Malaysian shores, only the green and hawksbill turtle still nest on Chagar Hutang and Mak Kepit beach on Redang Island, the two beaches where this experiment was conducted. Freshly laid green turtle nests were excavated immediately after oviposition and placed in a clean pail with some sand before transporting them carefully to the experimental relocation site. The eggs were divided into different clutch sizes of 5, 25, 50, 75 and 100 per clutch and reburied forming a ring equal distance (1 - 1.5m) apart and at depths of 60cm to the center of each clutch. A temperature data logger (StowAway(r) Tidbit(r)) is placed at the center of each clutch to log the temperature of each nest at 2 hourly intervals throughout the duration of incubation. A temperature logger was also placed in the center of the ring of egg clutches without any eggs as a control. At the end of the incubation when the hatchlings have emerged, the eggs were excavated to determine the hatching success and to retrieve the temperature loggers. The temperature and time data were downloaded using the BoxCar Pro 4 software supplied with the loggers. The temperature data was trimmed to the dates of actual incubation before the analysis.

RESULTS AND DISCUSSION

Four replicate sets of experiment were conducted, three at Chagar Hutang beach and one at Mak Kepit beach. Due to technical errors some of the temperature loggers in Mak Kepit failed to give any data hence were not analysed. Hatching success from the clutches ranged widely from 12% - 100% (Table 1). Average hatching success was around 75% with greater variations in the 25 and 50 egg clutches, lowest in the 100 egg clutches (Fig. 1). We were unable to detect any correlation between hatching success and clutch size in this study because of the wide variation in hatching success caused by various factors.

Temperatures in the nests were generally very stable showing very little daily variations of less than 1°C compared to air temperatures taken in the shade which fluctuate between 5 - 8°C daily (Fig. 2). However, major temperature changes affecting all the clutches simultaneously do occur, which is presumably environmental in nature. Certain activities on the beach like the presence of crab burrows can exert some effect on the nest temperature too, causing them to fluctuate to a greater degree in tandem with air temperature. Results from the three replicates conducted in Chagar Hutang beach were combined and the mean temperature change caused by the different egg clutches were plotted against the control with no eggs. Figure 3 shows the mean temperature difference caused by metabolic heating as a result of varying clutch sizes. It can be seen that metabolic heating does not come into effect in the first 20 days of incubation. Following this, the temperature will climb steadily reaching a peak around 45 days and then declines steadily as the baby turtles hatch and climbs away from the remaining eggs to the surface. The degree of temperature rise is clearly related to clutch size where the larger the clutch, the greater the temperature rises. The 100 egg clutch can cause an increase in temperature of up to 2.5°C. However, highest temperatures are reached at a stage when the hatchlings are well-formed, well into the last third of incubation. During the middle third of incubation, the influence of metabolic heating on nest temperatures was just the beginning. By the time the embryonic development approaches the end of the middle third, the temperature increase was between 1-1.5 °C. If we presume that the sex of the hatchlings are well differentiated by that time, then metabolic heating would have little effect on hatchling sex ratio as proposed by Booth and Astill (2001). Nevertheless, Broderick et al. (2001) estimated that metabolic heating accounted for a rise of up to 30% in the proportion of females produced in the green turtles at the Ascension Island.

In this experiment, the relocated nests had clutch sizes ranging from 5 eggs to 100 eggs. The normal clutch sizes for the green turtles in Redang Island average around 100 eggs with about 50% of them having more than 100 eggs. Thus, the average metabolic heating effects in a normal green turtle nest would be much higher than reported here. There is hence a need to determine the metabolic heating effects in normal clutch-sized nests to give a better picture. It is still not clear exactly when during the middle third of incubation sexual differentiation occurs. The 15 - 20 days of the middle third of incubation is too rough. There is hence also a need to determine more precisely the sexual differentiation process and the exact time or stage of development it occurs before one can assess the impact of metabolic heating on sex ratio output. Direct measurements of heat generation from developing eggs would give greater insights to this phenomena and help develop theoretical models relating to factors influencing incubation temperatures and its impact on sex ratio output from nesting beaches.

Table 1. Summary of basic results obtained from the relocated egg clutches. (CH = Chagar Hutang beach, MK = Mak Kepit beach)

	Replicate	Replicate	Replicate	Replicate
	1	2	3	4
5 egg clutch	5 (1)	5 (2)	5 (3)	5 (4)
Location	CH	MK	CH	CH
Date incubated	8-May-02	14-Jun-02	6-Jul-02	23-Aug-02
Incubation period	57	52	?	?
Number of eggs hatched	4	4	5	2
Hatching success	80%	80%	100%	40%
25 egg clutch	25 (1)	25 (2)	25 (3)	25 (4)
Location	CH	MK	CH	CH
Date incubated	8-May-02	12-Jun-02	6-Jul-02	23-Aug-02
Incubation period	56	51	?	?
Number of eggs hatched	3	21	23	23
Hatching success	12%	84%	92%	92%
50 egg clutch	50 (1)	50 (2)	50 (3)	50 (4)
Location	CH	MK	CH	CH
Date incubated	8-May-02	11-Jun-02	6-Jul-02	23-Aug-02
Incubation period	56	46	?	?
Number of eggs hatched	10	46	23	50
Hatching success	20%	92%	46%	100%
75 egg clutch	75 (1)	75 (2)	75 (3)	75 (4)
Location	CH	MK	CH	CH
Date incubated	8-May-02	11-Jun-02	6-Jul-02	23-Aug-02
Incubation period	?	44	?	?
Number of eggs hatched	72	66	34	72
Hatching success	96%	88%	45%	96%
100 egg clutch	100 (1)	100 (2)	100 (3)	100 (4)
Location	CH	MK	CH	CH
Date incubated	8-May-02	9-Jun-02	6-Jul-02	23-Aug-02
Incubation period	?	44	?	?
Number of eggs hatched	83	65	90	92
Hatching success	83%	65%	90%	92%

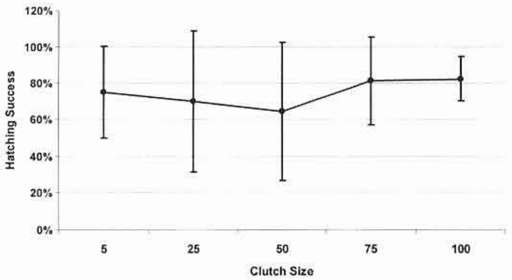

Fig. 1 Variations in hatching success between clutches of different sizes (mean + 1 standard deviation).

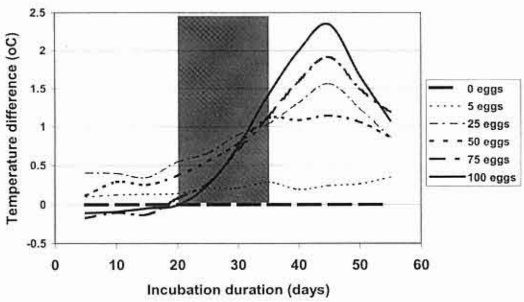

Fig. 3 Mean temperature differences (smoothen using 5-day averages) caused by metabolic heating due to clutch size differences. Shaded area indicates the middle third of incubation.

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