Distances covered and times taken for nesting of hawksbill turtles (*Eretmochelys imbricata*), Cousine Island, Seychelles

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Abstract - Nesting hawksbill turtles and their eggs and young were studied on Cousine Island, Seychelles from 1995–1999. The nesting sequence was examined for information on distances covered and times taken for the process, which was separated into 7 steps. The average time taken for completion of successful nesting was 103.6 minutes, and the average distance covered during the nesting process was 91.8 metres. Emergences by turtles making no attempt to nest covered significantly shorter distances (average 67.1 metres). When only those turtles for which full nesting sequences were recorded were compared, the differences in nesting vs. non-nesting emergences averaged a distance of 88m covered in 100.9 minutes vs. 53m covered in 22.7 minutes.

Key words - Reptilia, Testudines, Cheloniidae, marine turtles, Hawksbill turtles, *Eretmochelys imbricata*, nesting procedure, Seychelles.

INTRODUCTION

The Seychelles inner granitic islands are situated about 930km north of Madagascar and 600 km east of Africa, and lying between 4-5°S and 55-56°E. The hawksbill turtle is listed as critically endangered and the Seychelles host one of the five most important hawksbill turtle populations in the world (Meylan & Donnelly 1999). A considerable amount of work has been completed on aspects of breeding (Brooke & Garnett 1983; Diamond 1976; Frazier 1984; Garnett 1978; Hitchins *et al*. 2003a; Mortimer & Bresson 1994a, 1994b; Wood 1986), migrations and movements (Hitchins *et al*. 2003b; Mortimer & Broderick 1999) and conservation (Mortimer, 1984) - mainly for Cousin Island, or for the Seychelles generally. This paper gives results of some work done on nesting procedure by hawksbill turtles on Cousine Island, Seychelles, carried out between 1995 and 1999. Cousine Island is about 26 hectares and has a sandy turtle nesting beach about 900m long. Although Diamond (1976) indicated that the total nesting process took an average of 147 minutes for hawksbills (n=5) on the adjacent Cousin Island, and provided some indication of duration of some nesting stages, no detailed work on analyzing the time taken and distance covered for the nesting process by hawksbills has been previously undertaken in the Seychelles, and there appears to be very little detailed information on this process for hawksbills elsewhere.

METHODS

Patrols - Patrols were undertaken daily from August to April at 1-1.5 hour intervals whenever possible, normally between 0600 and 1830, sometimes earlier and later during nesting peaks.

Tagging - Untagged turtles were tagged, either while laying eggs, or while returning to the sea. Non-nesting turtles were tagged only while returning to the sea. Tags were positioned between the first and second large scales on the trailing proximal edge of each fore-flipper, or on the scales themselves. For this study double Inconel tags were used until 1995/96 and thereafter double titanium turtle tags were used. Extra tags were replaced on turtles when existing tags were damaged, difficult to read or looked as though they might be coming off the flippers. Tags were supplied by the Division of Environment, Seychelles Government, as part of their turtle monitoring program. Prior to 1995/96 single or double Monel tags were generally used in the Seychelles (Mortimer 1999). Emergences onto land were called successful when they resulted in eggs being laid. Unsuccessful emergences were of two kinds - one where at least one failed nesting attempt was made (the turtle attempting to dig a nest hole), and the other when no attempt at digging a nest hole was made, although "test" scrapes might be made with the fore flippers.

Sequence of nesting events - The sequence of nesting events followed was based on that outlined in Witzell (1983), but see also Hendrickson (1981), and modified as shown in Table 1. Distances covered by the turtles on land were paced, each pace being recorded as a meter, and a sketch was made of each emergence. The times taken for the turtles activities were obtained using a wrist watch. The measurements and times were not precise, and interpretation of some of the activities might have been done slightly differently by different observers. One of us (PMH) did most of the observations and recordings. We believe that errors in separating activities (e.g. between the end of egg-laying and the beginning of nest filling) were not more than 30 seconds, and in most cases would be less than 15 seconds. In cases where turtles rested between activities, the rest period was considered part of the immediately preceding activity. In some cases only parts of the sequence could be obtained - these results were pooled for the individual activities. Records for two turtles which had been obviously influenced by artificial light on their return trips to the sea have been omitted from the calculations dealing with times and distances spent on land (Tables 4 to 7).

RESULTS

The mean time taken for the complete nesting sequence was 103.6 minutes (range 61-164 min) (Table 2). There is great variation in the times spent out of the sea to nest by individuals (Table 3).

Table 1: Sequence of hawksbill turtle nesting events.

Activity	Beginnings of sequences
1. Out of sea to start of body pit	Leaving the sea
2. Dig body-pit	Start sweeping sand with fore-flippers to dig body pit
3. Dig nest-hole	Start digging the nest hole with hind flippers
4. Lay eggs	Laying of first egg
5. Cover eggs	Start moving sand into the nest hole with hind flippers.
6. Camouflage nest site	Start sweeping sand randomly with fore flippers and hind flippers after tamping down the sand in the nest hole.
7. Leaving site to enter sea	Moving towards the sea without sweeping sand.

Distances covered during nesting procedures

The mean total distance covered on land by turtles for successful nesting was 91.8m. Turtles which did not attempt nests covered less total distance (mean 67.1m) than did successfully nesting turtles (91.8m), or turtles that unsuccessfully attempted to nest (mean 109.1m) (Table 4). There was no significant difference between the mean total distance covered by turtles nesting successfully, and turtles which made unsuccessful nesting attempts. There was a significant difference between the distances traveled by turtles which made no nesting attempt, and the distance traveled by turtles nesting at their first attempt (Chi-square 34.6, p=0.001). The distance that turtles traveled to the nest was found to be usually equal or longer (78.2% of all cases) to the distance they traveled from the nest back to sea (Table 5).

Those turtles which traveled a longer distance to the nest than from it back to the sea, covered significantly longer mean distances to the nest than other nesting turtles, while turtles which traveled a shorter distance to the nest than from it, covered significantly longer mean distances from the nest to the sea than other nesting turtles. The remaining mean distances covered were not significantly different (Table 6).

In an extreme case, the distances covered by a long-traveling (but not light-disoriented), turtle (#36) were 202 m to her nest site, and 70 m to return to the sea.

Rate of activities

For turtles nesting successfully, the approach to a nesting site until the start of digging a body pit was done at a much slower speed (mean 2.1 m/min, range 0.5-8.0 m/min, n=66) than when the turtle was returning to the sea after completing nesting (mean 6.3 m/min. range 2.0-21.0 m/min, n = 66). The mean speed of completing nesting from time

Table 2: Times (minutes) taken for nesting by turtles. [a] = where full nesting sequence was recorded, (n =32). [b] = for all records

Activity	Mean time[a]	% of total time	Time range[a]	Time range[b]
1. Out of sea to start of body pit	21.2	20.4%	4-86	4-86 (n=35)
2. Dig body-pit	3.7	3.6%	1-18	1-18 (n=76)
3. Dig nest-hole	23.0	22.2%	9-53	6-53 (n=92)
4. Lay eggs	19.8	19.1%	5-45	5-45 (n=120)
5. Cover eggs	12.4	12.0%	6-22	2-42 (n=127)
6. Camouflage nest site	17.8	17.2%	6-34	3-38 (n=139)
7. Leaving site to enter sea	5.7	5.5%	2-18	1-29 (n=162)
Total time out of the sea	103.6		61-164	

Table 3: Variation in individual turtle times (minutes) taken for nesting.

	Turtle No. 7	35	99	Range (min)
1. Out of sea to start of body pit	14-30(2)	14-30(2)	7-20(2)	7-30
2. Dig body-pit	1-5(3)	2-3(2)	1-4(2)	1-5
3. Dig nest-hole	28-37(3)	16-53(2)	15-29(2)	15-53
4. Lay eggs	16-19(4)	14-21(2)	12-45(4)	12-45
5. Cover eggs	8-11(3)	15-17(2)	9-18(4)	8-18
6. Camouflage nest site	14-22(3)	21-22(2)	7-19(5)	7-22
7. Leaving site to enter sea	7-10(4)	7-11(2)	3-8(5)	3-11
Range (min) of total time out of sea	102-111(2)	86-145(2)	82-129(2)	82-145

of exit from the sea to the time of re-entry into the sea was 0.87 m per min, while non-nesting turtles covered the ground at mean speeds of 2.33 m per min (Table 7).

DISCUSSION

The only nesting stages previously recorded for hawksbills from the Seychelles was by DIAMOND (1976) for Cousin Island, but with very few samples (maximum 6) and with four nesting sequences, excluding the return to the sea (sequence 7). A comparison with the sequences obtained from Cousine shows one major difference (Table 8).

Although sequence times 2 - 6 are not significantly different (Chi square=0.96, df 2, p=1), the discrepancy in sequence 1 times between Cousin and Cousine cannot be explained except perhaps as being a result of the low number of samples from Cousine. However, if that were the case, then it would be expected that one or more of the other sequence times would show large differences as well. CHAN & LIEW (1999) recorded the same nesting sequences as we did for a population of Malaysian hawksbill turtles, obtaining a longer mean nesting process duration. However, we have taken the total duration as 114 min, not 117 min as given, because the average times given by the authors add up to 114, not 117. A comparison of the times recorded there and during this study is shown in Table 9.

The percentages are not significantly different for sequences 3 to 7 (Chi-square=3.9, df 4, p=1), but are significant for sequences 1 and 2 (Chi-sq.=8.7, p=0.01)

Table 4 Distances (m) traveled by turtles with different successes at nesting

	Nested successfully			**No nests**		
	At 1st attempt A	**At 2nd attempt B**	**At 3rd or 4th attempt C**	**No nesting attempt D**	**1-2 nesting attempts E**	**3 or more attempts F**
n	173(46.6%)	37(10.0%)	11(3.0%)	111(29.9%)	32(8.6%)	7(1.9%)
SD	39.9	33.5	45.0	43.2	39.8	32.1
Range	14-274	47-177	43-189	4-193	50-209	62-165
Mean distance	88.8	102.9	101.1	67.1	107.3	117.3
Mean A+B+C	91.8			Mean E+F	109.1	

Table 5 Distance relationships between nesting sequence 1 (S1) and sequence 7 (S7)

Distance relationships:	**S 1 longer than S7 by more than 5 m**	**S 1 and S7 within 5m**	**S1 shorter than S7 by more than 5 m**
n (%)	73 (33.0%)	100 (45.2%)	48 (21.7%)
Total A+B	173(78.2%)		

Table 6 Distances traveled to and from nests. [a] significantly longer (Chi-sq., p=.001) than other "To nest" distances. [b] significantly longer (Chi-sq., p=.001) than other "From nest" distances

Distance relationships:	**S 1 longer than S7 by more than 5 m**		**S 1 and S7 within 5m**		**S1 shorter than S7 by more than 5 m**	
n	**73**		**100**		**48**	
Mean distance (m)	58.1[a]	37.0	40.1	41.0	39.6	53.4[b]
Range	16-202	1-87	5-89	5-89	11-75	25-113
SD	28.3	17.0	18.7	18.7	16.5	20.2

The Malaysia hawksbills were quicker to get to, or find, a nest site; but took longer to prepare the body pit prior to digging the nest hole and to camouflaging the nest site. These differences may result from the levels of natural predation under which the sea turtles evolved. In the Seychelles there were no mammalian or reptilian predators before modern man arrived on the islands, and probably this was the case since the islands existed - therefore the turtles could be less wary and faster in leaving the sea and locating a nest site. A major predator of the Malayasian nests is a species of monitor lizard which affects up to 40% of the nests (Chan & Liew 1999). The presence of such predators could also account for the longer times taken to dig a (presumably) deeper body pit and to camouflage the nest more thoroughly. Whether or not these behavioral differences are consistent and perhaps fixed genetically, is of interest.

Carr (1981) remarked on the similar, stereotyped, conservative nesting behaviour of all the species of sea-turtles - with but minor differences between genera, and between populations of the same species. While generally displaying all the described (Witzell 1983) intrinsic nesting sequences, Cousine's hawksbills show individual differences in a). times taken for nesting, b). distances traveled to complete nesting, and c). in including or excluding such behavior as testing potential nesting sites by scraping with the fore flippers. Nest holes were dug and then left only if they collapsed during the digging process - so they were not exploratory digs, but either successful or unsuccessful nesting attempts. The individual's choice of a nesting site must surely include a function of "skill" derived from "exercising" the genetically fixed nesting behavior pattern. The more times she nests, the better the behaviour pattern guides her, and the more "skilful" she gets.

One of the factors influencing choice of nest site, and therefore in the time and distance taken for nesting, lies is the terrain into which the turtle emerges from the sea. We recorded numerous instances where a poor nest site (for example a site very likely

Table 7 Distances, time out of water and speed of activities for **(A)** successfully nesting and **(B)** unsuccessfully nesting turtles for which full sequences recorded.

	A (n = 40)			**B (n = 45)**		
	Time (min)	**Distance (m)**	**m per min**	**Time (min)**	**Distance (m)**	**m per min**
Mean	100.90	87.97	0.87	22.70	52.89	2.33
SD	27.44	33.50		15.46	34.01	
Range	61 – 164	26 – 174		2 – 81	4 – 137	

Table 8 Comparison of nesting sequences on Cousin (A) and Cousine (B) Islands.

Sequence[a]	**1**	**2 + 3**	**4**	**5 + 6**	**Total mean time (min)**
A Mean time (min)	62	32	20	25	147
B Mean time (min)	21.2	26.7	19.8	30.2	97.9

[a] See table 1.

Table 9 Comparison between nesting process times in Malaysia and Seychelles.

Sequence[a]	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total mean time (min)**
Seychelles	20.4%	3.6%	22.2%	19.1%	12.0%	17.2%	5.5%	103.6
Malaysia	12.3%	14.9%	20.2%	12.3%	8.8%	26.3%	5.3%	114.0

[a]See table 1.

to be eroded, or inundated, by the sea) was chosen. This happened, for example, when the beach eroded to a narrow strip at the base of a steep dune which was insurmountable, and where high tides swept to the base, or near the base, of the dune. Even though each individual had a choice of aborting that nesting attempt, some still chose to nest there. In other cases a female nested on or at the high-tide level - even though there was a wide beach and a variety of nesting sites within her easy reach (Hitchins *et al.* 2003b).

The reasons for this may relate to the skill of the individual - she may either be a first nester, or she may be nesting for the first time in the area - a stranger to the local conditions. Under such circumstance she might have been one of the 30% of turtles (table 4) which emerged but did not try to dig a nest. Or being a neophyte she may have lacked skill in choosing good nesting sites, in which case she could have been one of the 10% of turtles which tried, but failed, to complete a nest. We would consider a "skilful" turtle not only to be one of the 46.6% of turtles which nested at her first nesting attempt, but also one which chose a good nest site. We have not used the word "experienced" to describe such individuals, because a turtle cannot learn how to choose a good nest site from experience – she has no way of knowing what happens to her nest, of knowing if she made a good or a bad choice. The most important matter for the turtle is to locate a suitable nest site. This is defined as a site with a). a medium in which an adequate nest can be dug, and in which the eggs can incubate and hatch, and from which the hatchlings can emerge easily; and b). from which the sea is easily reached by the hatchlings.

The wariness of all sea-turtles on leaving the sea to nest, and the speed with which they return to the sea after completing nesting, indicate evolutionary traits developed to reduce predation and dehydration, and to conserve as much energy as possible. The importance of successful completion of nesting is underlined by the cessation of some survival mechanisms during part of the nesting process. During the egg-laying and nest-hole filling phase, reaction to any disturbance is "switched off", a state which Johannes (1992) refers to as "reproductive stupor", so that the egg-laying process has a chance of completion even in the face of potential fatal disturbance. The nesting procedure is therefore carried out under the influence of both internal and external factors, and individuals are able to "balance" some of these influences to nest skillfully in the shortest possible time. It is probable that differences in nesting sequence times between Seychelles and Malaysian hawksbills, for example, illustrate this point.

Is there any evidence that sea turtles emerging as possible neophyte nesters, or strangers to the area, pick better nesting sites more quickly with repeated use of the area? One problem we have in the case of Cousine is that inter-island nesting does take place in the Seychelles (Hitchins *et al.* 2003b) and so it is not possible to positively identify a turtle as a neophyte nester, or, because of the relatively short duration of the turtle work done on the island, whether she was a stranger to the island. The situation would be much clearer if all information on tagging results was available to us from neighboring islands; however, this was sadly not the case.

For nesting turtles sequence 1 is generally either longer than sequence 7 (Tables 1 and 5), as the turtle is searching for a nest site during sequence 1, and not simply making her way back to the sea as during sequence 7; or the two distances are about equal, since it is in the interests of energy-saving that nesting emergences and returns are ideally made straight up and straight down the beach to and from a nest. For those turtles which attempted to nest, or did nest, the total mean distances traveled during were not significantly different. Those turtles which made no attempt to nest spent less time, and traveled shorter distances, than turtles which had nested or tried to nest. Some of the turtles which, on Cousine, returned to the sea without trying to nest had clearly been disturbed by the presence of people, but there were other cases where there was no such apparent disturbance. There are probably other factors which are disturbing to turtles, but which as yet have not been recognized as such. It is therefore not possible, at present, to say whether those turtles not attempting to nest had been disturbed in one way or another, or were engaging in some other activity (e.g. exploratory).

If the Seychelles turtles were not generally day nesters (Diamond 1976; Hitchins *et al* 2003b) disorientation resulting from artificial lights could have a far greater effect on the time spent, and distance traveled. In the two cases known where artificial lights interfered with orientation of adult turtles, sequence 7 distance was far greater (mean 223.5m, range 174-273m) than the sequence 1 distance (mean 96.5m, range 96-97m).

One female (#75) beached in the late afternoon, had three nesting attempts before finally digging her nest behind the dune crest. By the time she had finished camouflaging her nest it was dark, and on leaving the nest she paralleled the dune crest, seemingly attracted by lights on the island. She could not see the sea from behind the dune. When she reached a point 163m from the start of her nest, and beyond the influence of the island's lights, she could see the lights of a neighboring island, Praslin, and turned at right angles towards them. This led her to within sight of the sea, and she then moved directly across the beach to the surf. Before she finally reached the sea she had traveled another 116m; 369m in total. The time it took her was not recorded, but is estimated at being about 6 hours. In the only other nesting on record for #75 she also emerged in the late afternoon, and left her completed nest in the dark - however she was on the beach and with no interference from artificial lights made her way back to the sea without incident. A second female (#31) spent at least 5 hours out of the water in a sequence of events very similar to that followed by turtle #75. In this case the turtle was eventually physically turned towards the sea; she had traveled a total of 271m before entering the sea. Of the 10 nests recorded for this turtle over two seasons, all were completed in the late afternoon or early night, but only two were made behind the dune crest - the one recorded above, and the second one completed in daylight, so there was no artificial light to disorientate her.

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