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Hawksbill Turtles, *Eretmochelys imbricata*, Nesting on Redang Island, Terengganu, Malaysia, from 1993 to 1997

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Abstract. – A tagging and nesting study conducted from 1993 to 1997 on the hawksbill turtles of Chagar Hutang, Redang Island, revealed that a total of 9 individuals deposited 50 egg clutches over the 5-year period, with 86% of these incubated *in situ* or in relocated nests. Four to 21 egg clutches from 1 to 6 nesting individuals were deposited per year. Remigration occurred at intervals of 2 to 3 years, with rates of remigration recorded at 56%. Nesting occurred mostly from May to July, peaking a month ahead of green turtles which nest on the same beach and was more frequent between 2000 and 2300 hrs. Hawksbills took an average of 2 hours to complete the nesting process. The average size of nesting individuals was 82.3 ± 3.4 cm (range, 76.7–87.5) in curved carapace length, with each individual laying an average of 3.6 clutches per season at intervals of 12 to 18 (mean, 14.9) days. Egg diameter averaged 34.2 mm; hatchlings averaged 3.7 cm in straight carapace length and 10.9 g in weight. Incubation duration averaged 56 days (range, 50–62). Overall emergence success for *in situ* nests was 60.2%. Over 83% of *in situ* nests were attacked by one or more predators or affected by other negative influences on hatching success. Red ants infested over 53% of nests, crabs were found in 33%, monitor lizards attacked 40%, fly larvae were found in 13%, plant roots invaded 27%, and 10% were excavated by nesting turtles. The high rates of natural predation warrant intervention to enhance emergence success. Survival prospects of the hawksbill turtles of Redang Island is heavily dependant on the continuation and expansion of current conservation efforts.

Key Words. – Reptilia; Testudines; Cheloniidae; *Eretmochelys imbricata*; sea turtle; population size; tagging; reproductive biology; predation; survival prospects; Redang Island; Malaysia

Nesting of the hawksbill turtle (*Eretmochelys imbricata*) has been reported to be diffuse, with few known large nesting aggregations (Meylan, 1989). In Malaysia, important nesting populations of hawksbills are found in the Sabah Turtle Islands with over 600 nestings per year (Chan and Liew, 1996) and Melaka with over 300 nestings per year (Mortimer et al., 1993). Low density nesting occurs in Terengganu, with data from the Fisheries Department of Terengganu indicating that in the last ten years (1987-96) the total number of annual hawksbill nestings has ranged from 12 to 72, with Redang Island receiving from 0 to 49 of those nests annually.

In 1993, the Sea Turtle Research Unit (SEATRU) of Universiti Putra Malaysia Terengganu (UPMT) embarked on a long-term saturation tagging and nesting research program on the green turtles (*Chelonia mydas*) nesting at Chagar Hutang beach, Redang Island. This presented the opportunity to tag and monitor the nesting activity of every hawksbill also nesting on this beach from 1993 to 1997. The monitoring of nests incubated *in situ* yielded information on emergence success and nest survival.

MATERIALS AND METHODS

The study was conducted at Chagar Hutang (05°49'N, 103°00'E), a small and isolated beach 338 m long and 40 m wide, located in the northern part of Redang Island (Pulau Redang), Terengganu, Malaysia (Fig. 1). The beach is fronted by a small bay popularly known as "Turtle Bay" and is bordered by rocky promontories. It is backed by an undisturbed tropical rain forest which has been designated as a forest reserve.

With average monthly green turtle nestings of 100-150 during the peak months of June and July (Liew and Chan, unpublished data), Chagar Hutang is arguably the single most important nesting site for that species in Peninsular Malaysia. Like other nesting beaches on the island and the mainland of Terengganu, it is leased by the State Government to local villagers for egg collection. More than 50% of the eggs deposited are purchased each year for incubation in the various conservation projects conducted by the Fisheries Department of Terengganu and SEATRU. The social necessity of purchasing eggs for incubation renders sea turtle conservation projects an expensive exercise. While the commercial sale and consumption of leatherback eggs has been banned in Terengganu since 1987, sale of eggs of the other turtle species is still legal.

Throughout the study period (May to October of 1993-97) turtles landing on the beach to nest were allowed to deposit their eggs without disturbance, after which they were tagged with inconel and titanium tags on both front flippers through one of the three large scales on the trailing edge of the flippers. If the turtle already bore a tag, the tag was examined to determine if it needed adjustment or

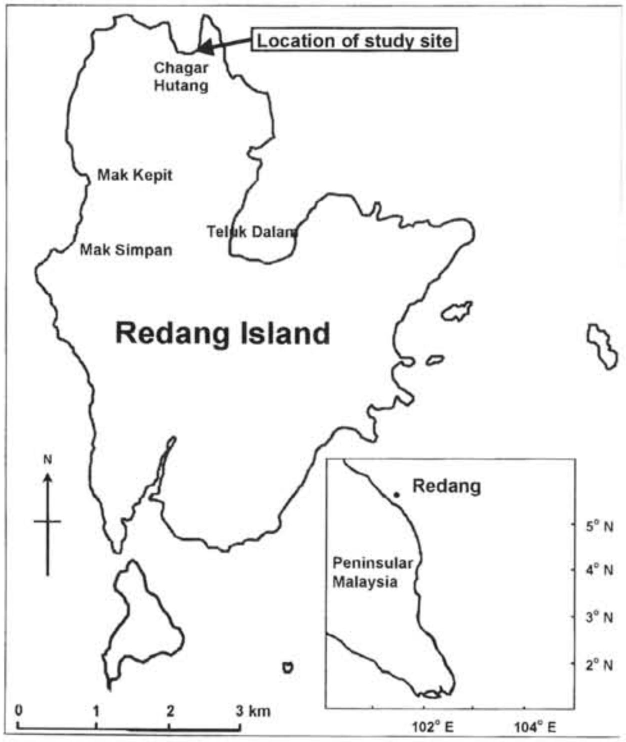

Figure 1. Map of Redang Island (Pulau Redang), showing the location of Chagar Hutang beach and other nesting sites on the island.

replacement. Curved carapace length (CCL) and width (CCW) were measured using flexible measuring tapes each time the turtles nested.

Nests were marked by labeled wooden stakes driven vertically into the sand just behind the egg chamber. A 2 m long nylon rope with a small weighted end was also placed in the egg chamber, with the trailing end bearing a back-up label tied loosely to the wooden stake. The exact location of each nest was determined by triangulation from the two nearest adjacent beach sector markers (spaced 10 m apart).

Eggs purchased for conservation were left to incubate *in situ* and were monitored throughout the incubation period for predator activity. Emerging hatchlings were allowed to make their seaward crawl unimpeded. Several days after emergence, the nests were excavated to determine the number of hatched eggs, dead, deformed, or live hatchlings in the nest, and unhatched eggs. All unhatched eggs were inspected for presence or absence of embryos. Emergence success was based on the number of live healthy hatchlings which had emerged as well as those found in the nest upon inspection, and did not include dead or deformed hatchlings remaining in the nest.

RESULTS AND DISCUSSION

Only 9 individual hawksbills nested on Chagar Hutang beach during the 5-year study period. Altogether, 50 clutches were laid, with 4 to 21 clutches attributed to between 1 to 6 individuals per year (Table 1). Since monitoring of Chagar Hutang beach has been completed for five seasons only, and the population is so low, we are unsure whether it is stable or in decline. Moreover, there is no record of historical nesting density on Redang Island. In any case, the extremely low population renders it very vulnerable to extirpation.

Of the 50 clutches deposited from 1993 to 1997, 43 (86%) were incubated *in situ* or reburied (Table 1). Reburied clutches were those taken by the Fisheries Department of Terengganu for incubation elsewhere. We tried to purchase all clutches deposited for incubation. However, 7 clutches were collected. We are appealing to the state government to stop leasing Chagar Hutang beach to villagers for egg collection, and to declare this important nesting beach as a totally protected area.

The average size of hawksbills nesting at Chagar Hutang was 82.3 ± 3.4 cm (range, 76.7-87.5) in curved carapace length (CCL) (Table 2). This is in close agreement with nesting populations found in Australia where average CCL ranged from 81.7 to 83.2 cm (Loop et al., 1995) and in Tortuguero, Costa Rica where average CCL was 82 cm (Bjorndal et al., 1985).

Although the population size of the hawksbills nesting on Chagar Hutang beach is small, remigration rates have been remarkable. All four turtles tagged in the first year of study (1993) returned to nest in subsequent years, one in 1995 and three in 1996. The remigrations occurred at intervals of two to three years, which is in close agreement with those reported for hawksbills elsewhere (Meylan, 1984).

Within only five years (1993-97) of an intensive tagging program, a total of 5 remigrations have been recorded. The number of turtles remigrating is calculated at 56% (5 of 9 individuals tagged) (Table 1). Meylan (1984) reported that few remigrations have been documented for hawksbills. In Tortuguero, only 9 out of 240 hawksbill turtles tagged since

Table 1. Hawksbill nesting activity and fate of clutches at Chagar Hutang beach from 1993 to 1997.

	Number of Turtles		Number of Clutches				
Year	New	Remigrant	Total	Reburied	*In Situ*	Collected	Incubated
1993	4	0	12	7	2	3	9 (75%)
1994	2	0	7	3	4	0	7 (100%)
1995	0	1	4	3	1	0	4 (100%)
1996	2	4	21	0	18	3	18 (86%)
1997	1	0	6	0	5	1	5 (83%)
Totals	9	5	50	13 (26%)	29 (58%)	7 (14%)	43 (86%)

Table 2. Reproductive data on hawksbills nesting at Chagar Hutang, Redang Island, from 1993 to 1997.

	n	Mean	SD	Range
Curved carapace length (cm)	14	82.3	3.4	76.7–87.5
Curved carapace width (cm)	14	71.7	3.1	65.0–75.8
No. of clutches/turtle/season	14	3.5	1.7	1–6
Internesting interval (days)	34	14.9	1.4	12–18
Clutch size (no. eggs/clutch)	34	155.9	22.8	115–202
Egg diameter (mm)	180 (18 clutches)	34.2	1.5	30.3–37.1
Hatchlings				
Straight carapace length (cm)	154	3.7	0.1	3.4–4.0
Straight carapace width (cm)	154	2.9	0.1	2.7–3.9
Body weight (g)	154	10.9	1.5	9.0–12.3
Incubation duration (days)	26	56.2	3.6	50–62

1956 were seen again in the next 26 years, while at Cousin Island, Seychelles, 25-30% of tagged hawksbills were seen in later seasons. The relatively high remigration rates at Chagar Hutang could be due to the shortness of the nesting beach (338 m) which made possible the monitoring of every individual turtle that landed to nest. It certainly indicates a high probability of inter-seasonal survival of the adults, a factor which would help in the recovery of the population if complete egg protection is sustained on a long-term basis.

Hawksbill nestings occurred mostly in the earlier part of the season, from May to July, with maximun density in June (Table 3). This is a month ahead of the green turtles which peak from June to August (Liew and Chan, unpublished data). Since beach monitoring commenced in May of each year, nesting in earlier months was not recorded.

Most nestings occurred between 2000 and 2300 hrs. (17 of 27 nestings recorded) with 9 of 27 occurring between 0100 and 0700 hrs. The nesting process was timed and separated into seven stages to facilitate time recording (Table 4). Total time taken for the whole nesting process ranged from 78 to 195 min, with a mean of about 120 min. These times are similar to those eleswhere (Witzell, 1983).

Table 3. Monthly nestings of hawksbills at Chagar Hutang beach throughout the project duration of each year. *Project started in June for 1993, and in May for other years.

Month	1993	1994	1995	1996	1997	Totals
May	*	2	–	9	–	11
June	7	3	2	8	–	20
July	4	2	2	4	2	14
August	1	–	–	–	2	3
September	–	–	–	–	2	2
October	–	–	–	–	–	–
Total Nestings	12	7	4	21	6	50

The duration of the various stages are shown in Table 4, and are similar to those for green turtles (Hirth, 1997), except for digging the body pit (17 min versus 23 min for green turtles) and filling of body pit and camouflaging (28 min versus 43 min for green turtles).

The 9 turtles (5 of which also remigrated during the study) deposited between one to six clutches per season. The average annual number of clutches per individual was 3.5 ± 1.7. However, this frequency is probably underestimated since monitoring commenced in May and any possible nestings in earlier months would have been missed. Notwithstanding, it is higher than the average of 2.3 clutches reported in the review of Márquez (1990), or the 2.6 clutches per female observed by Loop et al. (1995).

Only those clutches which had not been depredated by monitor lizards or dug up by nesting turtles were used for estimating clutch size. Clutch size averaged 156 ± 23 eggs (range, 115-202, $n = 34$), among the largest clutch sizes ever reported (Bjorndal et al., 1985).

Internesting interval was observed to range from 12 to 18 days, with a mean of 14.9 ± 1.4 days. This is close to the mean of 14.3 days for hawksbills on Millman Island (Loop et al., 1995), but shorter than the 16.8 days for hawksbills at Tortuguero (Bjorndal et al., 1985).

Mean egg diameter determined from 180 eggs sampled from 18 clutches was 34.2 ± 1.5 mm (range, 30.3-37.1). This was in the lower range of means reviewed by Witzell (1983).

Measurements of 154 hatchlings taken from one nest gave means of 3.7 ± 0.1 cm for straight carapace length (range, 3.4-4.0), 2.9 ± 0.1 cm for straight carapace width (range, 2.7-3.9), and 10.9 ± 0.6 g for total body weight (range, 9.0-12.3). These sizes appear to be lower than those reported elsewhere (Witzell, 1983; Loop et al., 1995).

Incubation time was recorded for 26 nests and found to have a mean of 56 ± 4 days (range, 50-62). Emergence

Table 4. Time taken (in min) over each stage of the nesting process.

Activity	Ascent to Beach	Digging Body Pit	Excavation of Egg-chamber	Oviposition	Filling Nest	Filling Body Pit and Camouflaging	Return to the Sea	Total Duration
Average	14	17	23	14	10	30	6	117
± S.D.	8	10	10	4	4	12	6	30
Minimum	7	5	11	7	2	16	2	78
Maximum	35	45	42	25	19	64	26	195
n	16	24	25	33	23	20	23	15

success for all 30 nests incubated *in situ* was 60.15% (range, 1.5-97). The overall emergence success obtained is low compared to *in situ* or undisturbed nests in Fiji, Solomon Islands, Australia, and India (80.2-96.9%; Witzell, 1983), but is comparable to rates of 58.3% in Tortuguero (Bjorndal et al., 1985).

Predation of hawksbill eggs and hatchlings appeared to be serious. Over 83% of the 30 *in situ* nests were attacked by one or more predators or affected by other negative influences on hatching success. Red ants were the most common predator and attacked over 53% of the nests. The ants were successful in depredating nests at all stages of development. Eggs which had been attacked were marked by characteristic small holes on the shell and were sometimes filled with sand. Emerging hatchlings which had been attacked often died in the nest. In one nest, 61 hatchlings were found dead in the nest and were infested with red ants.

Crabs were found in 33% of the nests. Most of them were ghost crabs (*Ocypode* sp.), although hermit crabs were found in two instances. Crab predation was recorded as actual cases of crabs found in the nest upon excavation, or presence of crab burrows in the vicinity of the nest still undergoing incubation. Ghost crab predation on hatchlings during emergence and seaward crawl doubtless occurred as well but was not seen. Monitor lizards were observed to have attacked 12 nests (40%). In seven of these, the lizards had successfully dug up the nests and eaten some eggs before they were detected. When these nests were excavated after hatchling emergence, the number of eggs still present ranged from 46 to 100, appreciably fewer than the average number of eggs in nests that had not been depredated.

Plant roots invaded 8 nests (27%). In some of these nests, roots had completely enveloped the individual eggs, and were obvious causes of hatch failure. In other instances, roots, although present, did not appear to have lowered emergence success. Fly larvae were found in a few nests (13%) but it was not clear if depressed hatch rates were due to larvae, red ants, or plant roots. Furthermore, the larvae could have infested dead eggs that were already decayed. Nesting turtles dug up three nests (10%), with varying numbers of eggs destroyed in the process. However, egg loss caused by nesting turtles occured only in 1996, and was markedly absent in the other years. The high rates of natural predation at Chagar Hutang warrant intervention to control the predators more effectively.

On Redang Island, the few hawksbills present nest primarily at Chagar Hutang beach. Therefore, it is of critical importance that all eggs deposited be conserved with immediate release of the hatchlings. The longterm conservation project conducted by SEATRU will help ensure that most of the clutches will be purchased for incubation. However, as long as Chagar Hutang beach continues to be leased to local villagers for commercial egg collection, there will be no guarantee that 100% of the eggs will be protected.

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