A Study on the Hawksbill Turtles (*Eretmochelys imbricata*) of Pulau Gulisaan, Turtle Islands Park, Sabah, Malaysia

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ABSTRACT. A tagging and nesting study on the hawksbill turtles of Pulau Gulisaan, Sabah Turtle Islands, was conducted from April 26 to July 1, 1996. Morphometric and meristic measurements were collected from 52 nesting turtles over 67 nights of beach patrols. A total of 64 egg clutches were deposited and nests were transplanted to a beach hatchery located on the island. Curved carapace length and width of female turtles averaged 76.26 and 65.74 cm, respectively. The turtles layed one to four clutches of eggs (mean of 1.36) during the study period , with clutch sizes ranging from 22 to 188 eggs (mean of 120.43). Eggs had an average diameter of 3.41 cm and weight of 19.87g while average straight carapace length and width and body weight of hatchlings were 3.99 cm and 3.13 cm, and 10.23 g, respectively. Internesting interval was 14 to 20 days (mean of 17.22 days) while incubation duration ranged from 49 to 57 days. The study has affirmed the importance of Pulau Gulisaan as a premier nesting site for hawksbill turtles. Recommendations are made for the intensification of monitoring activities on the turtles, and to consider the effects of population feminization attributed to the practice of incubating eggs in centralised hatcheries. Protection of turtles from deleterious fishing gear in marine habitats is also highlighted.

INTRODUCTION

The Turtle Islands Park (TIP) comprising Pulau Selingan, Pulau Bakkungan Kechil and Pulau Gulisaan (Fig. 1), provide nesting habitat to the largest

remaining hawksbill turtle population in the entire Southeast Asian region (Chan & Liew, 1996; Limpus, 1994). An analysis of nesting density of hawksbills in the TIP from 1979 to 1994 by Chan & Liew (1996) showed a general declining trend in the initial eight years (1979–1986), followed by a reversal in trend from 1986 to 1994. Current annual nestings of over 600 egg clutches per year almost double levels recorded in the mid-1980s. This recovery is attributed to bold conservation measures undertaken by the Sabah Government in the 1970s when the TIP were compulsorily acquired from private ownership and established as a Game and Bird Sanctuary. With that, commercial egg collection ceased, and all eggs deposited were collected and incubated in hatcheries located on the three islands. The Turtle Islands Park was gazetted as a State Park in 1984.

Hawksbill nesting is not uniformly distributed over the three islands of the TIP. Pulau Gulisaan, the smallest of the three islands and nearest to mainland Sabah, accounts for about 87% of the total hawksbill nestings, with Pulau Selingan and Pulau Bakkungan Kechil accounting for only 8 and 5% respectively (Chan & Liew, 1996). Therefore it is critical that Pulau Gulisaan be fully protected from human perturbations to maintain its suitability as a nesting habitat for hawksbill turtles.

The hawksbill turtles of the TIP have been subjected to a longterm tagging programme which was initiated in 1970 (de Silva, 1986). Monel cow ear tags (style 49 and 56) were used, with tags applied mid-way on the trailing edge of either flipper. The tagging position, type of tag used and tagging procedures have not changed since 1970. Workers from the TIP have reported heavy tag loss and were apprehensive about double tagging because they felt that this created stress and would cause turtles to abandon subsequent nestings. The TIP are under-staffed, and monitoring of nesting beaches is incomplete, resulting in many of the nesting turtles being missed.

In view of the problems outlined above, an intensive tagging and nesting study was conducted on the hawksbill turtles of Pulau Gulisaan from 26 April to 1 July 1996. This study sought to address the problem of tag loss by introducing double tagging, using the inconel (style 681) tag on one flipper, and the STI monel tags on the other. The study also determined nesting frequency, internesting interval, size of nesting turtles, clutch size, egg diameter and size of hatchlings. These parameters have not been described for the important hawksbill nesting population of the TIP before and would serve to contribute to the pool of information currently available on the endangered species.

MATERIALS AND METHODS

The study was conducted in Pulau Gulisaan (6°09'N, 118°03'E), approximately 40 km North of Sandakan, Sabah (Fig. 1). Occupying an area of only 1.6 ha, it is the smallest of the three Turtle Islands. Sandy beaches totaling approximately 1031 m and varying in platform width from several to almost 30 m surround the island. It is flat with a tapering elongated shape oriented in a north-east to south-west direction. The tapering south-western part consists of a shifting sandspit, while towards the east there is a reef flat which becomes exposed during low tide (Chan & Liew, 1996).

Pulau Gulisaan is located closest to the mainland and is accessible only by boat. The island is fully protected and is off-limits to tourists. Hence, no infrastructure is found on the island except for the staff quarters, a store, and two adjacent beach hatcheries located in the core of the island. It is managed by a total of four workers. During the period of study an additional three workers (including one of the authors, JJ) were deployed to help monitor the nesting turtles and collect relevant data.

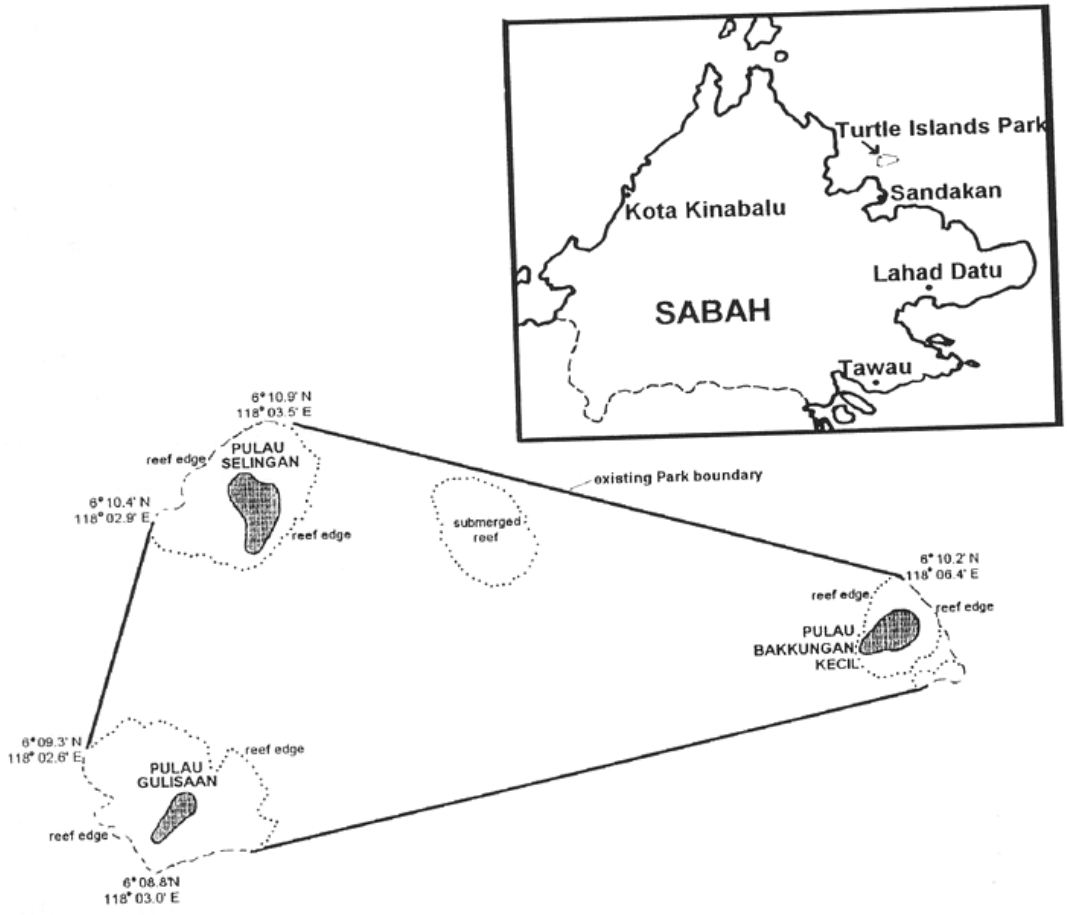

Fig. 1. Map showing the location of the Turtle Islands Park near Sandakan (inset), comprising the three islands of Pulau Selingan, Pulau Gulisaan and Pulau Bakkungan Kechil.

Nightly beach patrols began from 26 April and lasted until 1 July 1996. During the 67 consecutive nights, beach patrols were divided into two teams, each consisting of 2–3 individuals. Each team surveyed the nesting beaches either during the early shift (1800–0100 h) or the late shift (0100–0600 h). During patrols, the use of flashlights was strictly controlled to minimize disturbance to the turtles.

Turtles that ascended the beach to nest were allowed to deposit their eggs undisturbed. Once oviposition was completed, they were tagged with inconel tags on the right front flipper and monel tags on the left, at one of the three large scales on the trailing edge of the flipper. If the turtle already bore a tag, the tag was checked if it needed adjustment or replacement. The tag numbers were read and recorded. Measurements of curved carapace length and width were taken using flexible measuring tape. Each turtle was also examined for diagnostic markings, deformities and macro-parasites. These characteristics were recorded and drawn on the data sheet and photographed when possible. Nesting was recorded to have occurred either at the northern to the eastern beaches, or the south-western beaches (i.e., the shifting sand-spit area) (Fig. 2). Time recorded for each nesting event was mostly during the time the nest was filled, or the camouflaging phase, in any case it was after egg deposition had taken place.

As soon as possible after oviposition, the nest was excavated. Both yolked and yolkless eggs were counted and random samples of ten yolked eggs per clutch were taken for weight and diameter measurements. Whole clutches were then replanted in their individual nests in the hatchery.

Hatchery nests were monitored for accurate emergence times, and the number of hatchlings produced. This number divided by the number of eggs buried in the nest provided data on emergence rates. Random samples of 20 hatchlings per nest were taken for weight and straight carapace length and width measurements. Nesting interval was calculated as the time from which a turtle laid a clutch of eggs to the time when she emerged again on the island because the turtle would have laid on this emergence if all conditions had been right.

RESULTS AND DISCUSSION

Although hawksbill nesting occurs all year round in Pulau Gulisaan, the first eight months of the year register about double the nestings occurring from September to December (Chan & Liew, 1996). The study period, chosen to coincide with the university holidays (to allow continuous monitoring over

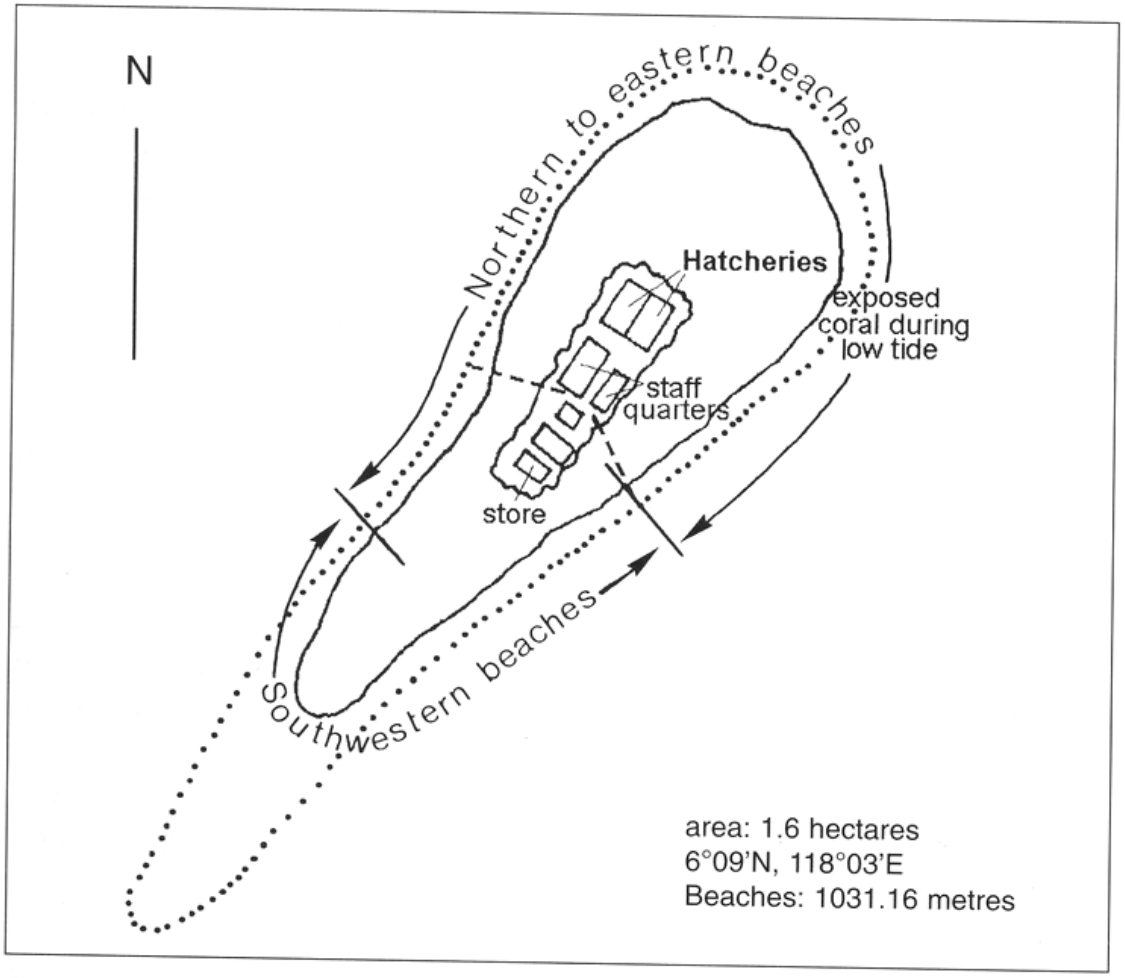

Fig. 2. Map of Pulau Gulisaan showing the general layout of the island, and the northern to eastern and southwestern beaches.

67 consecutive nights of beach patrols), also occurred during the major part of the nesting season. Two species of marine turtles were found to nest on Pulau Gulisaan. Green turtles were more abundant (87.9% of all turtle emergences) compared to hawksbill turtles (12.1% of all turtle emergences) (Table 1). This paper details findings on the hawksbill turtle, while information on the green turtle will be published in a separate paper. Data on hatching rates is also provided separately (Chan *et al.*, in prep.).

Pulau Gulisaan supported a total of 52 individual female hawksbill turtles manifested in 69 turtle nesting events during the study period. 64 (92.7%) of the nesting events resulted in egg deposition (Table 1), attesting to the suitability of Pulau Gulisaan as a nesting habitat for the hawksbill turtles. In comparison, Loop *et al.* (1995) monitored 365 individuals over 76 nights of beach patrols in Milman Island, Australia, while Chan & Liew (in press) reported nestings from nine individuals only over a five-year study period in Chagar Hutang beach, Pulau Redang. A total of 7725 eggs were deposited in Pulau Gulisaan during the study period and this represented about 13% of the

Table 1. Turtle nesting activity in Pulau Gulisaan from 26 April to 1 July 1996

Species	Total number of individuals tagged	Total number of nesting events	Total number of successful nesting events	Total number of unsuccessful nesting events
Hawksbill turtle	52	69 (12.1%)	64 (92.7%)	5 (7.3%)
Green turtle	279	501 (87.9%)	467 (93.2%)	34 (6.8%)
Total	331	570	531	39

total 61,467 hawksbill eggs deposited in the Turtle Islands Park for 1996 (P. Basintal, pers. comm.).

Nightly nesting over the study period are shown in Fig. 3. Nestings occurred on 37 of the 67 nights of beach patrols, with lapses reaching seven consecutive nights on some occasions. The number of nestings per night averaged at 0.96 ± 1.22 (range of 0–5). Of the 64 successful nesting events monitored, 42 (66%) of them had completed oviposition by midnight (Table 2). No nestings were observed during the day. Data was insufficient to allow correlations with tidal conditions. However, observations of night-time nesting, with higher frequencies occurring before midnight is consistent with findings of Chan & Liew (in press), Loop *et al.* (1995) and data reviewed in Witzell (1983).

Although the turtles were found to nest on all the beaches, the northern and eastern beaches appeared favoured, both accounting for over 70% of all

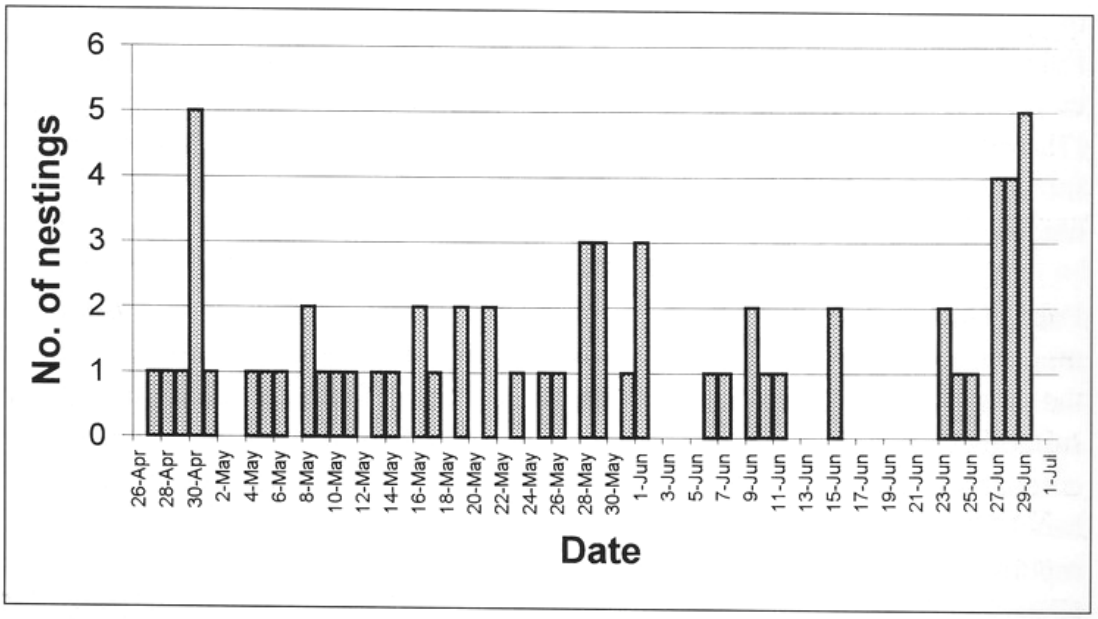

Fig. 3. Number of hawksbill nestings in Pulau Gulisaan from 26 April to 1 July 1996.

nesting events observed (Table 3). Factors such as stability of the beach platform, absence of artificial lighting (quite far from the staff quarters), and proximity to a reef flat off the eastern beach may have accounted for the hawksbills' preference for these beaches.

The average number of clutches laid per turtle during the study period was 1.36 ± 0.66 (range of 1–4) (Tables 4 and 5), appreciably lower than those reported elsewhere. This value is underestimated as the study was conducted just a little over two months. Liew & Chan (unpublished data) found that estimates of clutch frequency within a season increased as the period of monitoring or beach patrols was lengthened. Loop *et al.* (1995) reported clutch frequencies of 2.6 over 76 nights of patrols, while Chan & Liew (in press) found that hawksbills in Pulau Redang deposited an average of 3.6 clutches per season. Over 70% of the turtles monitored during the study period deposited only one clutch of eggs (Table 4). This could be partly attributed to incomplete monitoring of nesting events, and possibility of the

Table 2. Timing of nesting (after completion of egg deposition) in 63 cases of successful nesting events in Pulau Gulisaan from 26 April to 1 July 1996.

Time egg deposition was completed	Before midnight	After midnight
No. of cases	42	22
% of total	66%	34%

Table 3. Spatial distribution of hawksbill nests along the northern, eastern, southern and western beaches of Pulau Gulisaan fron 26 April to 1 July 1996.

Location	Northern to Eastern Beaches	South-western Beaches	All beaches
No. of nests	49	20	69
% of nests	71%	29%	100%

Table 4. Nesting frequency of hawksbill turtles in Pulau Gulisaan from 26 April to 1 July 1996.

No. of nests deposited	1	2	3	4
No. of turtles	36 (72%)	11 (22%)	2 (4%)	1 (2%)

hawksbills depositing subsequent or previous clutches on any of the other eight islands which comprise the Turtle Islands of Sabah, and the Philippines (Chan & Liew, 1996). However, only one of the hawksbills which nested on Pulau Gulisaan was found to deposit a subsequent clutch in Pulau Selingan. Hawksbill nesting is quite rare on the other two islands of the STI, and no records of hawksbill nesting exist for the Philippines Turtle Islands (Palma, 1994). It is not likely that tag loss was a factor since all the turtles were double tagged. In order to ascertain the actual nesting frequency for the hawksbill turtles of Pulau Gulisaan, intense monitoring over at least a one-year cycle, concurrent with a double tagging programme, is recommended. The problem of insufficient staff to conduct the monitoring work can be solved by introducing a volunteer programme in which volunteers drawn from members of the public can be enlisted to help in beach patrols, as is practised in Chagar Hutang, Pulau Redang (see Chiew, 1998 for a popular account of the programme).

A summary of the data collected on morphometric and meristic measurements of the nesting turtles, eggs and hatchlings is given in Table 5. The various measurements obtained are consistent with those of hawksbill populations elsewhere (Witzell, 1983; Loop *et al.*, 1995; Chan & Liew, in press).

Curved carapace length (CCL) and width averaged 76.26 $\pm$ 5.08 and 65.74 $\pm$ 5.02 cm respectively. The turtles ranged in CCL of 63.7 to 86 cm, indicating presence of young individuals and older ones, and thus, active recruitment of neonates. This has been made possible through the active egg incubation programmes carried out by Sabah Parks since the early 1970s.

Average clutch size was 120.43 $\pm$ 27.41 eggs (range of 22 to 188). Egg diameter and weight were 3.41 $\pm$ 0.13 cm and 19.87 $\pm$ 2.43 g respectively. A few yolkless eggs (ranging from one to three) were usually found in the hawksbill nests. Eggs incubated in the hatchery had an average incubation duration of 53.60 ± 2.50 days (range of 49–57 days; n = 15 clutches). This is appreciably shorter than periods reported for hawksbill nests which had been transplanted or left undisturbed in other parts of the world (Witzell, 1983). There is therefore a strong possibility that hatchlings produced from the hatchery in Pulau Gulisaan are female-biased. Hatchlings sampled from 14 nests averaged 10.23 $\pm$ 0.12 g in body weight and 3.99 $\pm$ 0.04 and 3.13 $\pm$ 0.03 cm in straight carapace length and width respectively.

Regression analysis (Table 6) performed on the various measurements showed a highly significant relationship between the curved carapace width and curved carapace length of nesting turtles. A positive but weak correlation

Table 5. Summary of data collected on nesting turtles, eggs and hatchlings of hawksbills at Pulau Gulisaan from 26 April to 1 July 1996.

CCL = Curved carapace length
CCW= Curved carapace width
n = no. of clutches

SCL = Straight carapace length
SCW= Straight carapace width

	Mean	Std. Dev.	Range	No. of measurements
Adult Females				
CCL (cm)	76.26	± 5.08	63.70–86.00	64
CCW (cm)	65.74	± 5.02	56.10–79.00	64
Hatchlings				
SCL (cm)	3.99	± 0.04	3.40–4.50	257 (n=14)
SCW (cm)	3.13	± 0.03	2.70–3.50	257 (n=14)
Weight (g)	10.23	± 0.12	7.00–13.00	257 (n=14)
Eggs				
Diameter (cm)	3.41	± 0.13	3.00–3.70	264 (n=29)
Weight (g)	19.87	± 2.43	13.00–29.00	264 (n=29)
Clutch size (no. of eggs per clutch)	120.43	± 27.41	22–188	65
Days to emergence	53.60	± 2.50	49–57	15
Nesting interval (days)	17.22	± 1.98	14–20	9
No. of clutches per female	1.36	± 0.66	1–4	50

Table 6. Linear regressions between the various measurements shown in Table 5.

x	*y*	*a*	*b*	*r*	*N*	*P*-value
CCL	CCW	- 1.1799	0.8792	0.88	49	£ 0.05
CCL	Clutch size	- 64.3600	2.4572	0.49	46	< 0.05
CCL	Egg diameter	2.6481	0.0101	0.26	31	> 0.05
CCL	CCL (Hatchlings)	2.9564	0.0135	0.45	14	>0.05

between size of nesting female and mean clutch size was obtained. This agrees with data gathered elsewhere, that there is a significant positive correlation between size of nesting female and mean clutch size within a nesting population (Bustard, 1972; Moll, 1979; Balazs, 1980 and Chen & Cheng, 1995). However there were no correlations between the size of eggs and hatchlings with size of nesters observed from the regression analysis. According to Bustard (1972), the average size of the egg remains similar despite changes in the mother. This is further substantiated by Hirth (1980), who indicated no evidence of relationship between the mean size of eggs and the mean size of nesting females nor between the mean carapace length of hatchlings and mean carapace length of nesting females at different localities.

During the brief study, 52 individual turtles were examined for diagnostic markings and deformities. Commensals were present on all the 52 hawksbill turtles encountered. Two species of barnacles were found on the turtles, the *Chelonibia,* which attached superficially on the carapace, plastron, head or flippers of the turtles and an unidentified burrowing species. Usually, the Sabah Park workers removed *Chelonibia* by knocking them off with the handle of the tagging pliers. The common belief among the workers was that barnacles might bring death to the turtles (Sabah Park workers, pers. comm.). Some of the nesting turtles were also partially covered with green or red algae. According to Chan & Liew (1996), barnacles should not be removed unless they occurred in positions which pose direct debilitating effects on the turtles. Removal of barnacles might cause harm and infection to the turtles.

In conclusion, the study affirms the importance of Pulau Gulisaan as a premier nesting site for hawksbill turtles and this status must be maintained through continued protection of the island from any human perturbation whatsoever. Monitoring activities on the TIP should be intensified so that the data collected reflects more accurately the status of the turtle population. Volunteer programmes such as those practised in other turtle conservation programmes can be implemented to help in beach patrols. The practice of transplanting eggs to the hatchery for incubation presents the problem of female-biased hatchlings. The effects of population feminisation may not be evident now, but may, in the long term result in insufficient numbers of male turtles in the population to provide adequate mating chances for the female turtles. The turtles need protection in their marine habitats as well and due consideration must be given to mortalities arising from fishing activities. So far, there has been no assessment of the rate of incidental captures of turtles in fishing gear operating in the waters near the TIP. Continued survival of the hawksbills of the TIP will hinge heavily on offshore protection.

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