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NEST SITE SELECTION AND DIGGING ATTEMPTS OF GREEN TURTLES (*CHELONIA MYDAS*, FAM. CHELONIIDAE) AT PANTAI KERACHUT AND TELOK KAMPI, PENANG ISLAND, PENINSULAR MALAYSIA

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ABSTRACT

The Pantai Kerachut Turtle Conservation Centre represents the centre of research study of sea turtles in Penang Island. For the study of nest site selection, 37 nests were located between 10-40m from the high tide line at Pantai Kerachut than at the same distance (10-40 m) from high tide line at Telok Kampi. It is believed that 3 nests were located at a distance of 0-10m from the high tide line because the location is near to the water's edge and the sand which is exposed to high relative humidity (1.6-1.7%) is unsuitable for Green Turtles *Chelonia mydas* to lay eggs. At locations beyond 40 m from the high tide line, the sand is too dry (30-31ºC) and the low relative humidity (0.6-0.7%) makes it unsuitable for turtles to dig nests. For the study of nest site selection in relation to vegetation zone, more nests were distributed within the vegetation zone at both beaches. Green Turtles prefer to land and nest within the vegetation of Merambong (*Scaevola taccada*) due to the shelter, protection, and dark environment. At the open beach, Green Turtles are exposed to disturbance from feral dogs, while grass areas provide less shelter than Merambong trees.

Key words: nest site selection, high tide line, digging attempts, vegetation zone

ABSTRAK

Pusat Pemuliharaan Penyu Pantai Kerachut adalah satu-satunya pusat penyelidikan penyu yang terletak di Pulau Pinang. Untuk kajian tentang pemilihan tapak sarang dan kaitannya dengan jarak dari paras tinggi air laut, terdapat 37 taburan sarang yang terletak diantara jarak 10-40 m dari paras tinggi air laut di Pantai Kerachut berbanding pada jarak yang sama (10-40 m) dari paras tinggi air laut di Telok Kampi. Sekurangnya 3 sarang terletak di jarak 0-10 m dari paras tinggi air laut dipercayai berkaitan dengan lokasinya yang berdekatan dengan air laut dan pasirnya yang terdedah kepada kelembapan yang tinggi (1.6-1.7%) menjadi tidak sesuai untuk penyu agar (*Chelonia mydas*) untuk bertelur, manakala di lokasi melebihi 40 m dari paras tinggi air laut, keadaan pasirnya adalah terlalu kering (30-31ºC) dan kelembapan yang rendah (0.6-0.7%) adalah tidak sesuai untuk penyu membuat sarang. Untuk kajian pemilihan tapak sarang dan kaitannya dengan zon tumbuhan, banyak sarang terdapat di zon tumbuhan di kedua-dua pantai. Penyu agar lebih memilih untuk mendarat dan membuat sarang di zon tumbuhan dimana terdapatnya taburan pokok Merambong (*Scaevola taccada*) kerana tumbuhan ini memberi perlindungan dan suasana gelap. Di pantai terbuka, penyu agar terdedah kepada gangguan anjing liar, manakala kawasan berumput pula memberi kurang perlindungan berbanding pokok Merambong.

Kata kekunci: pemilihan tapak sarang, paras tinggi air laut, cubaan membuat sarang, zon tumbuhan

INTRODUCTION

According to Mortimer (1988), there are four species of sea turtles that nest in Peninsular Malaysia, namely Leatherback turtle (*Dermochelys coriacea*), Green turtle (*Chelonia mydas*), Olive Ridley turtle (*Lepidochelys olivacea*) and Hawksbill turtle (*Eretmochelys imbricate*). Sea turtles in Malaysia are economically important not just as a tourist attraction, but their eggs are a valuable source of protein (Mortimer, 1988). According to Chan *et al*.

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(1988), large number of sea turtles from all species are incidentally captured in fishing gear (trawl nets, drift nets). The Green turtle is classified as globally endangered species by IUCN (International Union for Conservation of Nature) with estimated 37-61% declined worldwide (Mortimer *et al*., 2011).

Nest site selection has an important role in the reproduction of all sea turtle species (Wood & Bjorndal, 2000), survival of hatchlings (Horrocks & Scott, 1991), hatchling size (Packard & Packard, 1994), and hatchling growth (Foley, 2000), since conditions inside the nest directly affect incubation period. For the maintenance of sea turtles populations, proper nest site selection is important (Wang & Cheng, 1999) to avoid eggs exposed to human poachers or carnivorous animals at unconditional nesting site. Characteristics of the sand and nest placement can influence reproductive fitness of the population (Mrosovsky, 1994; Ackerman, 1997). It has also been suggested that vegetation (Wang & Cheng, 1999), temperature (Roosenburg, 1996), and beach slope (Wood & Bjorndal, 2000) can have significant influence on natural nest site selection of Green Turtles. Additionally, according to Horrocks & Scott (1991), selection of nesting site and physical characteristics of the site strongly affect the success of nesting. On the other hand, structural properties of the sand such as compressibility and characteristics of the particles have been argued to be unrelated to nest site selection in green Turtles (Mortimer, 1995; Foote & Sprinkel, 1994).

This study which focused on nest site selection of Green Turtles, *Chelonia mydas* was conducted from December 2009 to December 2010 at Pantai Kerachut and Telok Kampi. The objectives of the study were: 1) to determine nest site selection in relation to the distance from the high tide line (10-20m, 20-40m, or >40m), 2) to determine nest site selection in relation to vegetation zone (within vegetation of Merambong trees, open beach, or grassy areas), and 3) to determine the locations of digging attempts in relation to vegetation zone (within vegetation of Merambong trees, open beach, or grassy areas).

MATERIALS AND METHODS

Study area and sites

Penang is one of the states in Malaysia which is located on the northwest coast of Peninsular Malaysia. Penang is the second smallest Malaysian state in area after Perlis. It is composed of two parts, namely Penang Island and Seberang Perai on the Peninsular. Highly urbanised and industrialised Penang is one of the most developed and economically important states in the country, as well as a thriving tourist destination. The two study sites, namely Pantai Kerachut (5º 27' 4" N, 100º 10' 58" E) and Telok Kampi (5º 26' 20" N, 100º 10' 46" E) were located at the west coast of Penang Island (Figure 1).

The total length of Pantai Kerachut is 558 m. The slope gradient is 15° and the sand colour ranges from white to dark brown. The average morning

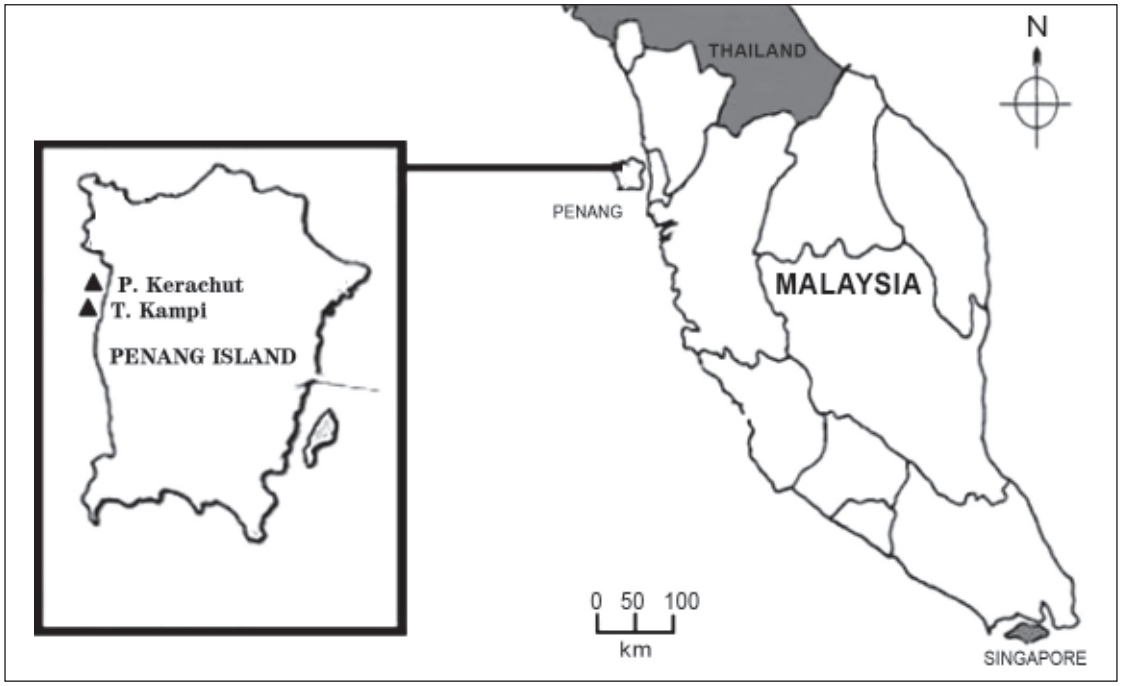

Fig. 1. Map of Penang Island situated in the northern region of Peninsular Malaysia. The surveyed beaches are marked with triangles for Pantai Kerachut and Telok Kampi.

temperature for one breeding season (December 2009-December 2010) was 27.5°C with an average wind speed of 3.23 m/s, whereas the average evening temperature was 28.9°C with an average wind speed of 2.44 m/s. The relative humidity in Pantai Kerachut is approximately 86%. Other adjacent beaches are Telok Kampi, Telok Ketapang, Telok Aling, Telok Duyung, and Telok Bahang. The distance of Pantai Kerachut from Penang National Park is approximately 1 km.

The location of Telok Kampi is adjacent and nearest to Pantai Kerachut, and approximately 300 m from Pantai Kerachut. The length of Telok Kampi is 810 m with a slope gradient of 10°. The average morning temperature for one breeding season was 27.0°C with a wind speed of 0.58 m/s, and the average evening temperature was 30.4°C with a wind speed of 0.94 m/s. The relative humidity in Telok Kampi is approximately 80%. Main transport to get to Pantai Kerachut and Telok Kampi is by boat.

Nest site selection

The study was carried out at Pantai Kerachut and Telok Kampi (Figure 1) from December 2009 to December 2010.The study on nest site selection (Wang & Cheng, 1999) in relation to the distance from the high tide line (López-Castro *et al*., 2004), and nest site selection in relation to the vegetation zone, open beach, and grassy areas (Wang & Cheng, 1999) was carried out at both beaches, and the data were analyzed separately.

Nest site selection in relation to the distance from the high tide line

The same procedures of intensive nocturnal survey and morning track count of verifying nest were carried out at Pantai Kerachut and Telok Kampi. Both beaches were surveyed at night between 1900 and 0600 hrs during the intensive nocturnal survey to find any emergence, tracks or nests. However, in order to determine the distance of the original nests located from the tide line (López-Castro *et al*., 2004) at both beaches, the distance of the nests was measured once the Green Turtles had finished nesting and returned to the sea (Hay & Speakman, 1993). The distance was measured using a 30 m measuring tape from the high tide line to the nesting site. Sand Temperature and relative humidity of each nest were recorded on the day of oviposition using a soil thermometer (±1°C) at nest depths of 5 cm, 0.5 m away from the nest, at the same distance of nest from high tide line. In this study, the location of the nests measured from the high tide line was divided into three distance intervals López-Castro *et al*. (2004):

1) below 10 m (<10m),
2) 10-40 m,
3) beyond 40 m (>40 m)

Nest site selection in relation to vegetation zone, open beach, and grassy areas

In this study, the nests were observed at both Pantai Kerachut and Telok Kampi, and intensive nocturnal surveys and morning track counts were carried out from December 2009 to December 2010. Once the Green Turtles had finished nesting and returned to the sea, nest site selection was determined and classified into three categories:

1) within the vegetation zone of Merambong tree, *Scaevola taccada*.
2) at open beach
3) at the bushes and grass areas

Location of digging attempts in relation to vegetation zone, open beach, and grass areas

Digging attempts were made by adults before they built nests and deposited eggs (Hay & Speakman, 1993; Broderick & Godley, 1999). The same procedures of intensive nocturnal survey and morning track count were carried out from December 2009 to December 2010 at Pantai Kerachut and Telok Kampi to determine the location of digging attempts. The total number of digging attempts found for the entire period of study was counted, and the locations of digging attempts at both beaches were determined and divided into three categories:

1) within the vegetation zone of *Merambong* tree
2) at open beach
3) at the bushes and grass areas

Statistical analysis

The data were analyzed using parametric methods when the data were normally distributed using the normality test, or had equal variance (Wang & Cheng, 1999). Otherwise, the data were analyzed using non-parametric methods when the data were abnormally distributed (Chen & Cheng, 1995). The Kruskal-Wallis Test was used to analyze the data of non-parametric for three or more groups (Pallant, 2002). The Null Hypotheses are: 1) vegetation zone has no significant influence on nest site selection of the Green Turtles of Pantai Kerachut and Telok Kampi; 2) distance from high tide line has no significant influence on nest site selection of the Green Turtles of Pantai Kerachut and Telok Kampi; 3) vegetation zone has no significant influence on the number digging attempts aborted at Pantai Kerachut and Telok Kampi.

RESULTS

Nest site selection in relation to distance from the high tide line

From a total of 43 nests recorded, 22 nests were analyzed at Pantai Kerachut, while 21 nests were analyzed at Telok Kampi. Table 1 shows nest site selection in relation to the distance from the high tide line. At Pantai Kerachut, no nest was found at the distance of 0-10 m from the high tide line, 19 nests (86.4%) were recorded at the distance of 10-40 m from the high tide line and three nests (13.6%) were identified at a distance beyond 40 m from the high tide line. These results could be related to sand humidity (Table 4). At the distance of 0-10 m, the sand was exposed to high humidity (>1%), being an open beach and near to the water's edge. Beyond 40 m from the high tide line, the sand was dry (30-31°C) due to low humidity (0.6-0.7%). Sand texture beyond 40 m was also hard and dry due to lack of sand moisture, deeming it unsuitable for turtles to lay eggs. Between 10-40 m from the high tide line, humidity and temperature of the sand were optimum (optimum relative humidity is ≤1% and optimal temperature is 27°C-32°C) for Green Turtles to lay eggs.

At Telok Kampi, three nests (14.3%) were recorded at the distance of 0-10 from the high tide line and 18 nests (85.7%) at the distance of 10-40 m from the high tide line. No nest was found beyond 40 m. The three nests recorded at the distance of 0-10 m, were located behind some rocks, which provided shelter, away from the human eyes, due to the huge natural rocks can fully covered Green Turtle figure during nesting. Thus, shelter and protection seemed to be the main criteria for nest site selection. No nest was found beyond 40 m at Telok Kampi and this could be related to the unsuitable environment for nesting, since the area was full of bushes and spiny trees. At the distance of 10-40 m from the high tide line, the nest site was suitable for turtle nesting with shelter and shade provided by Merambong (*Scaevola taccada*) and other shady trees. We have counted that there are 53 Merambong trees distributed at the distance of 10-40 m from high tide line at Pantai Kerachut. The average temperature at both beaches was 29°C at distance 10-40m from high tide line was also optimal for turtle nesting.

There was a statistically significant difference between nest site selection at Pantai Kerachut (Kruskal-Wallis: H (1) = 7.439, p <0.01) with a mean rank of 10.00 for 10-40 m and 21.00 for beyond 40 m. Nest site selection at Telok Kampi also differed significantly (Kruskal-Wallis: H (1) = 7.417, p <0.01) with a mean rank of 2.00 for 0-10 m and 12.50 for 10-40 m.

Nest site selection in relation to vegetation zone, open beach, and grassy areas

All 43 nests were grouped into three locations of nest site selection; within the vegetation zone, at the open beach, and within grassy areas. There was a statistically significant difference between nest site selection at Pantai Kerachut (Kruskal-Wallis: H (2) = 10.118, p <0.01) with a mean rank of 20.17 for vegetation zone, 10.33 for open beach, and 11.50 for grass areas. Nest site selection at Telok Kampi also differed significantly (Kruskal-Wallis: H (2) = 7.552, p <0.05) with a mean rank of 19.33 for vegetation zone, 10.33 for open beach, and 12.33 for grass areas. From the above results, it is clear that there was a difference in the number of nests across the three different categories at both locations.

At Pantai Kerachut, two nests (9.1%) were found at the open beach and 17 nests (77.3%) were found located within the vegetation zone of Merambong trees and three nests (13.6%) were located within the grassy areas (Table 2). At Telok Kampi, three nests (14.3%) were recorded at the open beach, 13 nests (61.9%) under the vegetation zone of Merambong trees, and five nests (23.8%) within the grassy areas. The results show that at both beaches, the vegetation zone with Merambong trees had the highest number of nest sites. Green Turtles preferred to land and nest within the vegetation zone of Merambong trees due to the shelter, protection, and dark environment to human vision. The open beach was exposed and shelter-free, thus, fewer nests were located here. Besides, nests were also highly exposed to monitor lizards (*Varanus salvator*) and

Table 1. Nest site selection in relation to the distance from high tide line. The location of nest was divided in three distances categories, 0-10 m, 10-40 m, and >40 m. The research was conducted at Pantai Kerachut and Telok Kampi, Penang Island from December 2009 to December 2010

Location	Distance of nest measured from high tide line						Total
	0-10 m	%	10-40 m	%	beyond 40 m	%	
P. Kerachut	0	0	19	86.4	3	13.6	22
T. Kampi	3	14.3	18	85.7	0	0	21
Total	3		37		3		43

Table 2. Nest site selection in relation to vegetation zone, open beach, and grassy areas

Location	Location of nests						Total
	Open beach	%	Vegetation zone (Merambong tree)	%	Grass areas	%	
P. Kerachut	2	9.1	17	77.3	3	13.6	22
T. Kampi	3	14.3	13	61.9	5	23.8	21
Total	5		30		8		43

Table 3. The locations of digging attempts, in relation to vegetation zone, open beach, and grassy areas

Location	Location of digging attempts						Total
	Open beach	%	Vegetation zone (Merambong tree)	%	Bushes and grasses area	%	
P. Kerachut	13	14.4	52	57.8	25	27.8	90
T. Kampi	25	34.2	34	46.6	14	19.2	73
Total	38		86		39		163

Table 4. Sand Temperature and relative humidity of 43 nests examined at three distances categories, 0-10 m, 10-40 m, and >40 m from high tide line at Pantai Kerachut and Telok Kampi

	Distance of nest measured from high tide line		
	0-10 m	10-40 m	> 40 m
Pantai Kerachut			
Avg. Temperature	27°C	29°C	31°C
Avg. relative humidity	1.6%	1.0%	0.6%
Telok Kampi			
Avg. Temperature	26°C	29°C	30°C
Avg. relative humidity	1.7%	0.9%	0.7%

smooth-coated otters (*Lutrogale perspicillata*). Overall, the results at both beaches showed that there were five nests located at the open beach, 30 nests within the vegetation zone, and eight nests located in the bushes and grass areas.

The location of digging attempts in relation to vegetation zone, open beach, and grass areas

During the one-year study period, a total of 163 digging attempts were found. Digging attempts were recorded at the vegetation zone, open beach, or grass areas. There was a statistically significant difference between the number of digging attempts at the three different locations at Pantai Kerachut (Kruskal-Wallis: H (2) = 8.400, p <0.05) with a mean rank of 20.39 for vegetation zone, 9.33 for open beach, and 13.85 for grassy areas. The total number of digging attempts at Telok Kampi also differed significantly (Kruskal-Wallis: H (2) = 6.644, p <0.05) with a mean rank of 19.22 for vegetation zone, 15.11 for open beach, and 9.70 for grass areas.

Digging attempts at the vegetation zone, were frequently aborted. There was a total of 90 diggings at Pantai Kerachut and 73 diggings at Telok Kampi (Table 3). At Pantai Kerachut, 52 diggings (57.8%) were aborted within the vegetation zone, 13 diggings (14.4%) were aborted at the open beach, and 25 diggings (27.8%) were aborted at the grass areas. At Telok Kampi, 34 diggings (46.6%) were aborted within the vegetation zone, 25 diggings (34.2%) at the open beach, and 14 diggings (19.2%) at the grassy areas. At both beaches, most diggings were aborted at the vegetation zone, and this could be related to the obstacles caused by the roots of the Merambong trees. Overall, the results at both beaches showed that there were 38 digging attempts at the open beach, 86 digging attempts within the vegetation zone, and 39 digging attempts in the bushes and grass areas. From the study, an average of three digging attempts led to one successful nest.

DISCUSSION

Nest site selection plays an important role in the successful reproduction of all sea turtle species (Wood & Bjorndal, 2000). Sand characteristics, such as salinity and grain size may force females to change their nesting behaviour. Other general conditions include smooth slope, sandy beaches, and humidity levels (Ehrenfeld, 1979). The

difference in the number of nests located at the three intervals could be related to humidity, temperature and vegetation. According to López-Castro *et al*. (2004), humidity and temperature play an important role in the selection of suitable nesting sites for oviposition by adults. In addition, wave action, sand particles and slope also influence nesting of sea turtles (Madden *et al*., 2008).

The low percentage of nests located at the interval below 10 m could be attributed to the fact that this location was an open beach with not much shelter, rendering the eggs exposed to animal disturbances. Turtles are easily disturbed by humans (Maros *et al*., 2003; Madden *et al*., 2008), feral dogs (Donlan *et al*., 2004), and carnivorous animals (Maros *et al*., 2003) of smooth-coated otters (*Lutrogale perspicillata*) at the open beach. In addition, at the interval below 10 m from the high tide line, relative humidity was too high (>1%) and this would affect embryonic development. Nests would also be at risk from being exposed to high wave action (López-Castro *et al*., 2004) and tidal wash (Madden *et al*., 2008). These results are similar to the findings by Madden *et al*. (2008) at western Costa Rica, where nests excavated near the high tide line were exposed to tidal wash. In contrast, the distribution of bush trees, Merambong (*Scaevola taccada*) at the interval of 10-40 m above the tide line provided a dark surrounding and shelter from feral dog disturbance, Thus, turtles mostly preferred to nest here. Roots in the vegetation zone provide stability to the sand (Brown & Macdonald, 1995) so that nest excavation is not easily disrupted. In addition, flooding of nests may be reduced if the nesting site was further away from the high tide line (Brown & Macdonald, 1995). The results from this study is similar to López-castro *et al*. (2004) as optimum temperature and humidity were found between 20-30 m from high tide line, and high nest success was found at this interval. The short roots systems exist at vegetation zone may assist the construction of eggs chambers (Mortimer, 1995), however, large roots might disturb the process. Wang & Cheng (1999) had suggested that digging attempts could be impeded from the large trees with roots growing deeper, and penetrating into the sand.

At the interval beyond 40 m, the location was far from the sea, and the sand was dry and compact due to low relative humidity making it difficult for turtles to dig nests. These findings are similar to those of López-Castro *et al*. (2004) on the Olive Ridley turtles at Southern Baja California. Few nests were found at 30 m above the tide line due to dry sand. According to the study of López-Castro *et al*. (2004), optimum relative humidity is ≤1%.

Characteristics of the sand and nest site selection can influence the reproductive fitness and survival of the population (Whitemore & Dutton, 1985). As suggested by Hay & Speakman (1993) on the study of Loggerhead turtles, nests preference and the distribution was located away from the sea In this study, nest site selection was determined based on the location of nests found within vegetation zone, at the open beach, or within grassy areas. A greater number of nests were located within the vegetation zone at both beaches because Merambong trees provided a serene environment, sufficient shelter and protection against disturbance from humans or feral dogs. In comparison, grassy areas provided less shelter compared to Merambong trees, and the location was far from the tide line. The result is similar to Sarahaizad *et al*. (2012). In coarse, dry sand, turtle might have difficulty digging egg chambers, and might make multiple trials (digging attempts) to dug eggs chamber (Mortimer, 1990) perhaps due to desiccation at grassy areas as far from the sea. Wang & Cheng (1999) also observed similar results at Wan-An Island, Taiwan where more nests were distributed within the vegetation zone. They also suggested that there is a significant relationship between vegetation and nest site selection behaviour.

There was a low percentage of nests located at the open beach, nearest to the high tide line at Pantai Kerachut and at Telok Kampi. According to Mortimer (1990, 1995) egg chambers located at the open beach are more prone to collapse and nests are more susceptible to destruction by the wave wash (Mrosovsky, 1983). This explains why only few nests were found at the open beach at Pantai Kerachut and Telok Kampi. Turtles preferred to lay eggs and build nests within the vegetation zone once they emerged from the sea (Wang & Cheng, 1999). Vegetation provides shelter and protection during the turtles' nesting activities. The study by Chen & Cheng (1995) showed that fewer nests were located at the open beach and this was due to the difficulty for the turtles to dig egg chambers on the open beach.

Compared to the percentage of nests located between the open beach and grassy areas, more nests were located within the latter. It is believed that grass can still provide shelter for turtles to nest. López-Castro *et al*. (2004) found nests located at the open beach near to the high tide line despite the risks involved. According to Ackerman (1997), when these nests are located near the tide line, they are indirectly exposed to high humidity, resulting in low nest success. These findings are similar to the findings by Bjorndal & Bolten (1992), where they found that the nesting success was low in the open beach, and higher in the grassy areas. It shows that Green Turtles prefer to nest at the grass areas rather than the open beach.

There was a statistically significant difference between the number of digging attempts located at

Pantai Kerachut in relation to vegetation zone, open beach, and grass areas. The total number of digging attempts located at Telok Kampi also differed significantly in relation to vegetation zone open beach, and grass areas. It shows that there is a difference in the number of digging attempts located across the three different categories at both locations.

Digging attempts were aborted significantly more often in the vegetation zone. There were 57.8% digging attempts at the vegetation zone of Pantai Kerachut and 46.6% at Telok Kampi. Digging attempts were aborted at the vegetation zone probably because of the rough sand, rocks, and roots (Parmenter, 1980). Madden *et al*. (2008) also reported that sand particles are important when selecting nesting site. We found that more digging attempts were aborted at the vegetation zone compared to open beach or grassy area, similar to the findings of Hays & Speakman (1993).

Less digging attempts were found at open beach compared to the vegetation zone at both beaches because it was an open place, exposed to more risks, such as disturbances from feral dogs (Fowler, 1979; Bjorndal, 1980; Brown & Macdonald, 1995) and smooth-coated otters. In this study, there were a few cases when the Green Turtles made a few digging attempts at the open beach, and laid their eggs in the vegetation zone, and this was similar to the results of Wang and Cheng's study (1999). Hays & Speakman (1993), however, found that Loggerhead turtles in Florida laid their eggs on the open beach, after making a few digging attempts in the vegetation zone. This could be related to the different vegetation types in Florida. According to Wang and Cheng (1999), tough root system of the brush growing on the beach of Florida may impede digging attempts. In contrast, the short and soft root system of Wan-An Island may help assist the construction of egg chambers and bind the sand (Mortimer, 1995).

CONCLUSION

Our results showed that Green Turtle prefer to nest in the vegetation zone, suggesting that Merambong vegetation along the shores of Pantai Kerachut should be preserved and increased. To reduce human and feral dog disturbance at Telok Kampi, we suggested that Pantai Kerachut Turtle Conservation Centre should hire full-time staffs and conduct volunteer works to monitor Telok Kampi beach and synchronized the time of intensive nocturnal survey from 1900-0600 hrs, similar to Pantai Kerachut. Volunteer work hasn't been performed at Pantai Kerachut, hence, it is suggested Pantai Kerachut Turtle Conservation Centre should organize a volunteer work in order to increase the monitoring work, and thus will indirectly increase the public awareness about turtle egg poaching.

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APPENDIX

Definitions

Intensive nocturnal survey: Defined as a night survey along the beach for the entire night from 1900 to 0600 hrs. During this time, the entire beach length was surveyed to search for any emerging turtle tracks, nesting or digging attempts (Chen & Cheng, 1995; Wang & Cheng, 1999). All sources of light had to be switched off during the survey period to avoid any disturbance, as turtles are very sensitive to light.

Morning track counts: Defined as a morning survey performed early in the morning between 0800 and 0930 hrs. This survey was under taken if the weather was bad the night before during the intensive nocturnal survey. During this time, the entire length of the beach was surveyed on foot to search for emerging tracks, nesting and digging attempts that were overlooked the previous night (Wang & Cheng, 1999).

Nest site selection: Defined as nesting sites selected by sea turtles to lay eggs. In this study, nesting sites could be in the vegetation zone (Wang & Cheng, 1999), open beach (Hays & Speakman, 1993), or grassy areas (Wang & Cheng, 1999).

Vegetation zone: Vegetation zone is defined as an area with vegetation distribution that backs onto the beach (Wang & Cheng, 1999). The vegetation zones at Pantai Kerachut and Telok Kampi were mostly distributed with Merambong or sea lettuce

trees, and were located between the open beach and grassy areas. The scientific name for Merambong is *Scaevola taccada* (Family: Goodeniaceae), and is also referred to as ambong-ambong. This bush tree is distributed on natural shores, sandy beaches, and sand dunes, and it is considered among the most common seashore shrubs in many parts of the world (Chan, 2003). It is described as a shrub that can grow into a small tree of up to 3 m tall, with thick and succulent leaves and are arranged in a spiral (Chan, 2003).

Open beach: An area where there is no vegetation coverage (Wang & Cheng, 1999). At Pantai Kerachut and Telok Kampi, the open beach is measured from the water's edge before reaching the vegetation zone.

Grassy areas: The area beyond the vegetation zone, closer to the forest and located far from the water's edge.

Digging attempts: A few 'trials' made by adults, without depositing eggs, or also known as 'dummy nests' or 'fake nests'. When adults build nests and starts depositing eggs inside, these are known as the 'real' nests.

High tide line: Highest level of sea water at night.

Nest site selection in relation to distance from the high tide line: Defined as the distance of the original nest measured from the high tide line up to the nesting site. Once the turtles had finished nesting and returned to the sea, the distance was measured immediately from the high tidal line to the exact location of the nest.

REFERENCES

Ackerman, R.A. 1997. The nest environment and the embryonic development of sea turtles. In: Lutz, P.L., Musick, J.A. (Eds.). *The biology of sea turtles*. CRC Press, Boca Raton, Florida, United States of America. pp. 83-107.

Bjorndal, K.A. 1980. Demography of the breeding population of the Green Turtle, *Chelonia mydas*, at Tortuguero, Costa Rica.*Copeia*, **3:** 525-530.

Bjorndal, K.A. & Bolten, A.B. 1992. Spatial distribution of Green Turtle (*Chelonia mydas*) nests at Tortuguero, Costa Rica. *Copeia,* **1:** 45-53.

Broderick, A.C. & Godley, B.J. 1999. Effect of tagging on marine turtles on nesting behavior and reproductive success. *Animal Behaviour*, **58:** 587-591.

Brown, L. & Macdonald, D.W. 1995. Predation on Green Turtle, *Chelonia mydas* nests by wild canids at Akyatan beach, Turkey. *Biological Conservation*, **71:** 55-60.

Chan, E.H., Liew, H.C. & Mazlan, A.G. 1988. The incidental capture of sea turtle in fishing gear in Terengganu, Malaysia. *Biological Conservation*, **43**: 1-7.

Chan, L.K. 2003. Pantai Acheh Forest Reserve: the case for a state park. Penerbit Universiti Sains Malaysia, Pulau Pinang, Malaysia.

Chen, T.H. & Cheng, I.J. 1995. Breeding biology of the Green Turtle, *Chelonia mydas* (Reptilia: Cheloniidae) on Wan-An Island, Peng-Hu Archipelago, Taiwan. I. Nesting ecology. *Marine Biology,* **124:** 9-15.

Donlan, E.M., Towsend, J.H. & Golden, E.A. 2004. Predation of *Caretta caretta* (Testudinae: Cheloniidae) eggs by larvae of *Lanelater sallei* (Coleoptera: Elateridae) on Key Biscayne, Florida. *Caribbean Journal of Science*, **403**: 415-420.

Ehrenfeld, D.W. 1979. Behaviour association with nesting. In: Harless, M., Morlock, H. (Eds.). *Turtles: perspective and research*. Wiley, New York, United States of America. pp. 417-434.

Foley, A.M. 2000. The effect of incubation environment on loggerhead hatchlings and a potential advantage of temperature dependent sex determination. In: Kalb, H.J. & Wibbels, T. (Eds.), *Proceedings of the 19th International Sea Turtle Symposium. NOAA Technical memorandum NMFS-SEFSC-443, South Padre Island, Texas, Unites States of America*, *2-6 March 1999,* Volume 443. pp. 1-6.

Foote, J. & Sprinkel, J. 1994. Beach compactness as a factor affecting turtle nesting on the westcoast of Florida. In: Bjorndal, K.A., Bolten, A.B., Johnson, D.A. & Eliazar, P.J. (Eds.), *Proceedings of the 14th Annual Symposium on sea turtle biology and conservation, NOAA Technical Memorandum NMFS-SEFSC-351. NOAA, Miami, Florida, United States of America*. pp. 217-220.

Fowler, L.E. 1979. Hatching success and nests predation in the Green Sea Turtle, *Chelonia mydas*, at Tortuguero, Coasta Rica. *Ecological Society of America*, **60(5):** 946-955.

Hays, C.G. & Speakman, J.R. 1993. Nest placement by Loggerhead Turtles, *Caretta caretta. Animal Behaviour,* **45:** 47-53.

Horrocks, J.A. & Scott, N.M. 1991. Nest site location and nest success in the Hawksbill Turtle (*Eretmochelys imbricata*) in Barbados, West Indies*. Marine Ecology Progress Series,* **69:** 1-8.

López-Castro, M.C., Carmona, R. & Nichols, W.J. 2004. Nesting characteristics of the Olive Ridley Turtle (*Lepidochelys olivacea*) in Cabo Pulmo, Southern Baja California. *Marine Biology,* **145:** 811-820.

Madden, D., Ballestero, J., Calvo, C., Carlson, R., Christians, E. & Madden, E. 2008. Sea turtle nesting as a process influencing a sandy beach ecosystem. *Biotropica*, **40(6):** 758-765.

Maros, A., Louveaux, A., Godfrey, A.H. & Girondot, M. 2003. *Scapteriscus didactylus* (Orthoptera: Gryllotalpidae) predator of Leatherback Turtle eggs in French Guinea. *Marine Ecology Progress Series*, **24:** 298-296.

Mortimer, J.A. 1990. The influence of beach sand characteristics on the nesting behaviour and clutch survival of Green Turtles (*Chelonia mydas*). *Copeia,* **1990**: 802-817.

Mortimer, J.A. 1988. Recommendations for a national strategy on sea turtle conservation in Malaysia – with suggestions for management of the nesting beach at Rantau Abang, Terengganu and of the turtle hatchery at Pulau Besar, Melaka. A Report to WWF/Malaysia and WWF/ USA (pp. 1).

Mortimer, J.A., Brandis, R.G.V., Liljevik, A., Chapman, R. & Collie. J. 2011. Fall and rise of nesting green turtles (*Chelonia mydas*) at Aldabra Atoll, Seychelles: Positive response to four decades of protection (1968–2008). *Chelonian Conservation and Biology*, **10(2):** 165-176.

Mortimer, J.A. 1995. Factors influencing beach selection by nesting sea turtle. In: Bjorndal, K.A. (Ed.), *The biology and conservation of sea turtle*. Smithsonian Institution Press, Washington, D.C., United States of America. pp. 45-51.

Mrosovsky, N. 1983. Ecology and nest-site selection of Leatherback Turtles *Dermochelys coriacea. Biological Conservation,* **26:** 47-56.

Mrosovsky, N. 1994. Sex ratio of sea turtle. *Journal of Experimental Zoology,* **270:** 16-27.

Packard G.C. & Packard, M.J. 1994. The physiological ecology of reptilian eggs and embryos. In: Gan, C. & Huey, R.B. (Eds.), *Biology of the reptilia, volume 16. Ecology B: defense and life history*. Branta Books, Michigan, United States of America. pp. 523-605.

Pallant, J. 2002. *SPSS survival manual-A step by step guide to data analysis using SPSS for windows (Version 12)*. Allen & Unwin, Sydney, Australia.

Parmenter, C.J. 1980. Incubation of the eggs of the green sea turtle, *Chelonia mydas*, in Torres Strait, Australia: The effect of movement on hatchability. *Australian Wildlife Research,* **7**(3): 487-491.

Roosenburg, W.M. 1996. Maternal condition and nest site choice: an alternative for the maintenance of environmental sex determination. *Ibis,* **36**: 157-168.

Sarahaizad, M.S., Mansor, Y. & Shahrul Anuar, M.S. 2012. The Distribution and Conservation Status of Green Turtles (*Chelonia mydas*) and Olive Ridley Turtles (*Lepidochelys olivacea*) on Pulau Pinang beaches (Malaysia), 1995–2009. *Tropical Life Sciences Research*, **23**(1): 63-76.

Wang, H. & Cheng, I. 1999. Breeding biology of the Green Turtle, *Chelonia mydas* (Reptilia: Cheloniidae), on Wan-An Island, PengHu archipelago. II. Nest site selection. *Marine Biology,* **133:** 603-609.

Whitemore, C.P. & Dutton P.H. 1985. Infertility, embryonic mortality and nest-site selection in Leatherback and Green Sea Turtles in Suriname. *Biological Conservation,* **34:** 251-272.

Wood, D.W. & Bjorndal, K.A. 2000. Relation of temperature, moisture, salinity, and slope to nest site selection in Loggerhead Sea Turtles. *Copeia,* **1:** 119-128.