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GREEN TURTLE NESTING ACTIVITY IN PENANG ISLAND FROM 2010 TO 2016

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Abstract: Penang Island hosts a small nesting population of green turtles compared to other sites in Malaysia. Therefore, the objective of this study is to investigate the nesting activity of the turtles in Penang Island from 2010 to 2016 and compare them with a previous study that reported similar data from 2000 to 2009. The nesting data provided by various institutions and government departments, including the Kerachut Turtle Conservation Centre, were analyzed from January 2010 to December 2016. Results showed that 383 cumulative nestings were recorded throughout the 84 months of study, which averaged to around 54.71 nestings yearly. There was a reduction of nesting grounds from 13 to seven. These **findings** provide up-to-date status on the nesting statistics of green turtles in Penang Island.

Keywords: *Chelonia mydas*, nesting density, population, sea turtles.

Introduction

There are almost 320 species of turtles, but only seven live in the ocean (Ernst & Lovich, 2009). They are the green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), flatback (*Natator depressa*), Olive Ridley (*Lepidochelys olivacea*) and Kemp's Ridley (*Lepidochelys kempii*) (Ernst & Lovich, 2009).

The green turtle is the most common marine turtle that may be found in tropical, subtropical and temperate waters (Burnie & Wilson, 2001). As reported by Halim *et al.* (2001), the nesting frequency in Indonesia alone is 10,000 to 20,000 annually, making the turtles there a regionally important population in Southeast Asia. The green turtle is widely distributed in Malaysia, and it is a well-known species in Sri Lanka (Ekanayake *et al*., 2010), Australia (Limpus *et al*., 2003), Taiwan (Cheng *et al*., 2013), Turkey (Aymak *et al*., 2017), Japan (Kameda *et al*., 2017) and Thailand (Yasuda *et al*., 2006).

The green turtle, leatherback, Olive Ridley and hawksbill are known to make Malaysia their home (Chan & Liew, 1989). In Penang Island, female green turtles will return to lay their eggs in the shores of Kerachut and Teluk Kampi in Teluk Bahang, northwest of the island. These two beaches support the densest nesting activity in Penang (Sarahaizad *et al.*, 2012a). There are also fragments of Olive Ridley nesting sites in other beaches (Chan, 2006; Sarahaizad *et al.*, 2012a). The conservation and protection of sea turtles in Penang Island are carried out by the Kerachut Turtle Conservation Centre under the purview of the Fisheries Department.

The first nesting track of sea turtles in Penang Island was reported by Sarahaizad *et al.* (2012a), who studied the breeding patterns, eggs and nest statistics, besides the effectiveness of conservation programmes and threats to the sea turtle population between 1995 and 2009. The highest number of nests recorded was 73 in 2009, and the lowest was three in 1998.

There was also an improvement in terms of data collection between 2000 and 2009 as the Kerachut Turtle Conservation Centre had recruited sufficient manpower to monitor the two beaches. These resulted in the improvement

of data recording compared to the years from 1995 to 1999. Initially, in the 1990s, only two personnel were hired to monitor the beaches of Kerachut and Teluk Kampi. The number was increased to five (four shore personnel and one fisherman) to monitor the same beaches from 2000 to 2009 (Sarahaizad *et al*., 2012a). The same manpower was maintained from 2010 to 2016.

Therefore, the rationale of this study is to observe and discuss the current nesting statistics of green turtles between 2010 and 2016. Based on the publication by Chaloupka *et al.* (2008), five major populations of green turtles in Ogasawara (Japan), Hawaii (USA), Great Barrier Reef (Australia), Florida (USA) and Tortuguero (Costa Rica) had shown significant increase in nester or nest abundance for the past 25 years or more. The rise was due to protection and conservation efforts worldwide (Chaloupka *et al*., 2008). The status of nesting sites in Penang Island is important, as the International Union for Conservation of Nature (IUCN) has listed the green turtle in its Red List of threatened species (Seminoff, 2004; International Union for Conservation of Nature, 2018).

This study reports the current nesting activities (reproductive output and digging attempts) of green turtles between 2010 until 2016, their nesting density (spatial and temporal distribution) and survival of hatchlings that was cared for at the Kerachut Turtle Conservation Centre. This paper also compares the nesting status from 2010 to 2016 with data from 2000 to 2009 reported by Sarahaizad *et al*., (2012a).

The relationship between day visitors at the beach near the turtle conservation centre and turtle nesting density is also reported, as turtle landings can be influenced by shore recreational activities.

Materials and methods

Study Sites

Data was recorded at seven nesting grounds in Penang Island (Figure 1) that were identified by the Fisheries Department. The main nesting beaches were Kerachut and Teluk Kampi, which were within the Penang National Park. The park, spanning 2,563 ha (1,182 ha of forests and 1,381 ha of beaches), is one of the country's smallest parks, which was gazetted by the federal government on April 10, 2003, and managed by the Wildlife and National Parks Department (Perhilitan) (Taman Negara Pulau Pinang, 2016). Other minor turtle nesting grounds within the park were Teluk Aling, Teluk Duyung and Teluk Ketapang. Pasir Pandak and Batu Ferringhi were also minor nesting grounds, but they were not within the Penang National Park. Among all the nesting beaches, only Pasir Pandak is on the southern part of the island (Figure 1).

Beach Patrol, Nesting Activity, and Spatial and Temporal Distribution

Beaches were monitored for seven years (2010 to 2016) and nesting dates, frequency and digging attempts were recorded. The turtle eggs were collected and taken to the Kerachut Turtle Conservation Centre for hatching in a conducive environment (*ex-situ*) and to prevent poaching by humans and predators. However, the nests near the conservation centre were allowed to incubate naturally (*in-situ*) as they could be monitored. At the end of each year, the number of *in situ* and *ex situ* nests, and total eggs collected were tabulated by the Fisheries Department. Traces of poaching were also recorded.

Four Kerachut Turtle Conservation Centre personnel were deployed two at a time to patrol the beaches of Kerachut and Teluk Kampi from 2000 to 0500 every day.

Nest data in Teluk Aling, Teluk Duyung and Teluk Ketapang were obtained from Perhilitan and Universiti Sains Malaysia's Centre for Marine and Coastal Studies (CEMACS). .

The nesting data at Pasir Pandak and Batu Ferringhi were based on sightings by the local community and tourists. Digging activity was not recorded at these beaches as observation was done in an opportunistic manner. In addition, these beaches were located far from the Penang National Park.

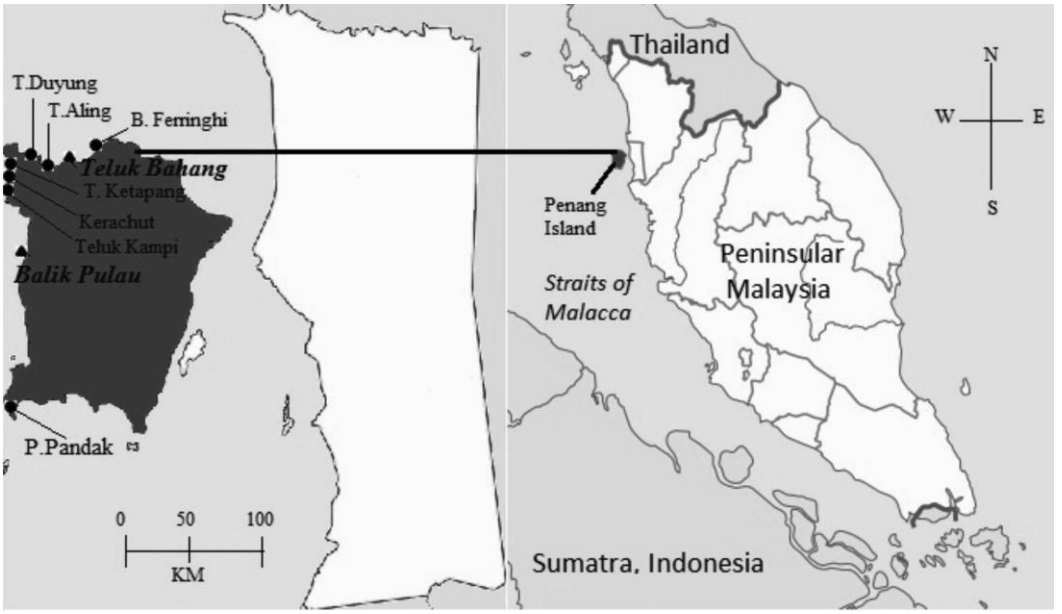

Figure 1: The seven sites in Penang Island where turtle nesting and digging activities were noted. They are the beaches of Kerachut, Teluk Kampi, Teluk Aling, Teluk Duyung and Teluk Ketapang in the Penang National Park (from Teluk Bahang to Balik Pulau). Pasir Pandak and Batu Ferringhi are located outside the park.

Digging activity is defined as the digging of several empty holes by the turtles before finding a comfortable location to lay their eggs. This would result in the formation of "fake nests". Digging attempts in every nesting occurrence were tabulated annually and its success (%) was calculated according to Equation 1. Digging success is the evaluation rate of successful digging against all digging actions [i.e. nest (true nest) and digging attempt (fake nest)].

$$\textit{Digging success}\ (\%) = \frac{N}{N + D} \times 100 \quad (1)$$

where N is the total nest and D is the total digging attempt.

The beach area at all seven nesting sites were measured using a 30 m tape (± 0.1 m) as part of calculations to determine nest density. The number of day visitors in Kerachut was obtained from the visitors' logbook at the turtle conservation centre.

Reproductive Output

Egg collection was performed according to the Standard Procedure for Turtle Management Guidelines, Peninsular Malaysia (Sukarno *et al*., 2007; Jabatan Perikanan Malaysia, 2016). The important thing was to handle the eggs with minimal rotation when transferring them from nest to bucket. Only two eggs were carried carefully per transfer. Sand was sprinkled on the egg mass to maintain temperature. Egg buckets were carried carefully with minimal vibration to the hatchery within three hours to reduce mortality (Parmenter, 1980; Harry & Limpus, 1989) and were immediately re-buried according to Sukarno *et al*. (2007) and Jabatan Perikanan Malaysia (2016). The eggs were transported by boat as the only way to access the Kerachut Turtle Conservation Centre was either by hiking or the sea.

As Pasir Pandak and Batu Ferringhi were far from the hatchery, the collection and transfer might take more than three hours to complete.

But they were completed as soon as possible to maximise the hatching success.

Hatchlings were counted and tagged for each nest. Hatching success (%) in a nest was calculated using Equation 2.

$$\textit{Hatchlings success}\ (\%) = \frac{S}{E} \times 100 \qquad (2)$$

where S is the number of eggs that hatched, and E is the total number of eggs in a nest.

Statistical Analysis

Data were analyzed using the SPSS version 17 (SPSS Inc, Chicago, Illinois, USA) Normality of distribution was determined using the Kolmogorov-Smirnov (K-S) test, where $p > 0.05$ was considerd normally distributed (Pallant, 2002).

One-way ANOVA was used to determine significant differences among the normally distributed data groups. The Krukal-Wallis (K-W) test was used to test a non-normal distribution data between nesting throughout the months, nesting throughout the years, and nesting among the seven beaches.

Spearman's correlation analysis (ρ) was used to analyze significant relationship of continuous data between beach length and cumulative density, and number of day visitors and nesting density at Kerachut due to the small sample size.

The chi-square test (X^2) was used to find a significant difference between nesting groups and digging attempts per month. As the data were discrete and from the cumulative nesting and digging attempts of 84 months (2001-2016), this test was important to find similarities of distribution between the groups.

Results

Nesting Density, Spatial Temporal Distribution and Digging Attempts

The number of nestings and digging attempts at all seven beaches surveyed throughout the study are stated in Table 1. The total digging attempts was approximately three times more than nestings, and this behavior could probably be explained by the green turtles trying hard to find a comfortable position. This also probably reflected a deterioration of the beach environment, which made it uncomfortable for the reptiles to lay their eggs.

In order to understand the peak nesting season, the nesting density for seven years was divided per month. Therefore, the monthly cumulative nesting o was plotted in Figure 2. The highest cumulative density occurred in May and the lowest was in October and December (Figure 2, Table 1). It could be seen that the peak egg-laying season was between March and June. The nestings seemed to fluctuate up and down from 2010 to 2013, before a sudden drop in 2014, and rising steeply again to 2015 and 2016.

In Figure 3, the highest number of nestings occurred in May 2013. The the monthly (K-S=0.133, df=84, $p < 0.001$) and yearly (K-S=0.133, df=84, $p < 0.001$) nesting data were not normally distributed. Therefore, the Krukal-Wallis test was used to analyze the significant differences. Statistical analysis illustrates that nesting distribution was not uniformly distributed (uneven nesting distribution) throughout the months (Figure 2). However, almost equal nesting distribution throughout the years was suggested (Figure 3).

In Table 2, the cumulative nesting and digging attempts were grouped for seven years, according to the temporal distribution for every three months that allowed researchers to investigate the highest nesting occurrences according to discrete months. The reason for this grouping was to show which months were preferable for nesting. When the nestings were grouped by month, April to June seemed to contribute the highest cumulative density with 166 nestings and 405 digging attempts. This was followed by January to March, with 88 nestings and 227 digging attempts, and October to December with 52 nesting and 154 digging attempts. Furthermore, chi-square test was used to find a significant difference between groups

Table 1: Green turtle (*Chelonia mydas*) nesting record in Penang Island.

Type	Months	Years							Sum	Mean±SD	Median
		2010	2011	2012	2013	2014	2015	2016			
Nests	Jan	5	9	0	2	0	3	5	24	3.4±3.0	3.0
	Feb	7	4	1	2	1	1	4	20	2.9±2.1	2.0
	Mar	8	5	3	10	5	4	9	44	6.3±2.5	5.0
	Apr	5	6	6	14	12	3	11	57	8.1±3.8	6.0
	May	8	9	6	15	13	2	13	66	9.4±4.2	9.0
	Jun	6	9	10	4	7	2	5	43	6.1±2.6	6.0
	Jul	4	4	11	2	4	2	3	30	4.3±2.9	4.0
	Aug	2	4	8	0	0	9	5	28	4.0±3.3	4.0
	Sep	0	4	0	1	1	9	4	19	2.7±3.0	1.0
	Oct	0	2	1	5	0	9	0	17	2.4±3.2	1.0
	Nov	0	3	2	5	0	8	0	18	2.6±2.8	2.0
	Dec	5	2	2	1	0	7	0	17	2.4±2.4	2.0
	Total	50	61	50	61	43	59	59	383	54.7±6.5	
Digging attempts	Jan	17	16	0	4	0	7	8	52	7.4±6.4	7.0
	Feb	25	9	3	5	4	3	13	62	8.9±7.4	5.0
	Mar	27	10	7	20	18	11	20	113	16.1±6.5	18.0
	Apr	20	10	11	29	22	12	29	133	19.0±7.6	20.0
	May	31	12	11	33	28	4	45	164	23.4±13.6	28.0
	Jun	18	19	25	9	17	7	13	108	15.4±5.8	17.0
	Jul	13	12	38	3	11	8	6	91	13.0±10.7	11.0
	Aug	7	14	24	0	0	22	13	80	11.4±8.9	13.0
	Sep	0	10	0	4	6	18	12	50	7.1±6.1	6.0
	Oct	0	4	2	18	0	28	0	52	7.4±10.3	2.0
	Nov	0	12	4	8	0	25	0	49	7.0±8.5	4.0
	Dec	19	6	4	1	0	23	0	53	7.6±8.8	4.0
	Total	177	134	129	134	106	168	159	1007	143.9±23.2	

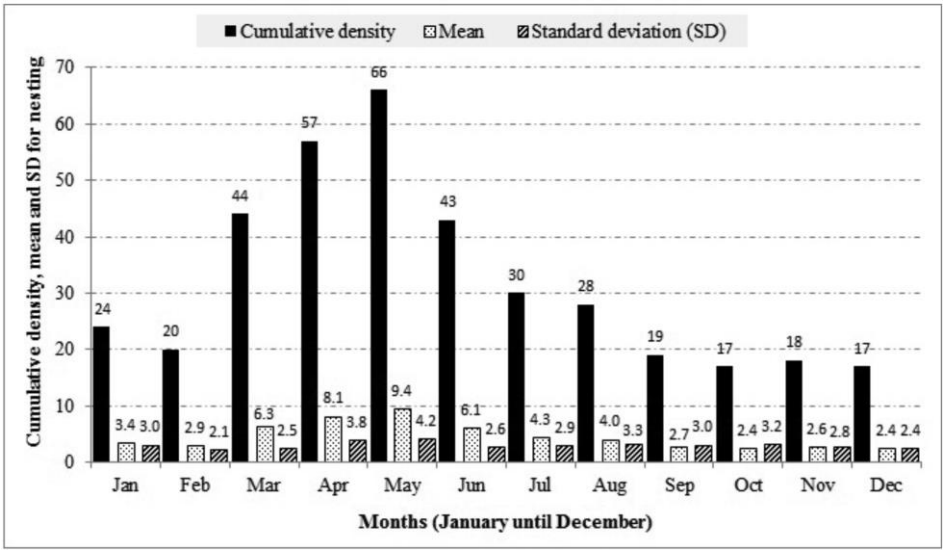

Figure 2: Cumulative nesting density per month for green turtles (*Chelonia mydas*) in Penang Island from 2010 to 2016 (84 months). Cumulative density is a sum number of nesting per month, and from this figure we are able to determine the peak, and the pattern of nesting season throughout the months. Peak season seem to occur from March to June. Statistical analysis illustrates that nesting distribution was not uniformly distributed throughout the months.

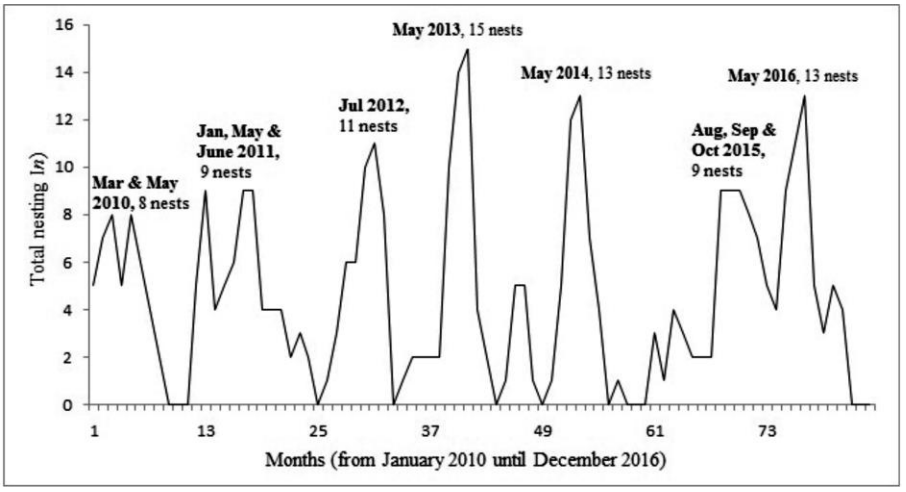

Figure 3: The continuous nesting pattern of green turtles from 2010 to 2016. Statistical analysis illustrates that nesting distribution had almost equal nesting distribution throughout the years.

of nesting and digging attempts divided by group of months. The pattern of nesting and digging attempts per group was almost equally distributed, which shows that nesting and digging attempts had almost the same numbers (almost similar distribution) across the group months (Table 2).

Higher digging success indicated better chance to build nests with fewer digging attempts. Table 2 shows that the lowest digging success occurred from October to December and the highest chances for turtles to successfully nest was from April to June. The reason was probably because nesting activity was high and

Table 2: Temporal nesting and digging attempts of green turtles in Penang Island. This table presents the nesting density, digging density and digging success per temporal month from 2010 to 2016. The pattern of nesting and digging attempts per group had almost similar distribution across the group (X^2=12.000, *df*=9, p>0.05)

Months	Cumulative density (*n*) of nests	%	Cumulative density (*n*) of digging attempts	%	Digging success (%)
January-March	88	23.0	227	22.5	27.9
April-June	166	43.3	405	40.2	29.1
July-September	77	20.1	221	22.0	25.8
October-December	52	13.6	154	15.3	25.2
Total	383	100%	1007	100%	

Table 3: Latitude, longitude, total nests located and beach length information for seven nesting beaches of Penang Island from 2010 to 2016.

No.	Locations	Latitude	Longitude	Total nests located	Percentage (%)	Beach length (m)	Mean hatching success (%)
1	Kerachut (PNP)	5.451	100.181	282	73.6	558	≈73.2
2	Teluk Kampi (PNP)	5.442	100.179	81	21.2	810	≈65.6
3	Teluk Aling (PNP)	5.467	100.198	9	2.4	495	68.7
4	Teluk Duyung (PNP)	5.471	100.186	6	1.6	510	83.4
5	Pasir Pandak	5.279	100.182	3	0.8	756	82.5
6	Teluk Ketapang (PNP)	5.455	100.181	1	0.3	215	72.1
7	Batu Ferringhi	5.472	100.244	1	0.3	2800	0.00
Total				383	100.0		

*PNP= Penang National Park

competitive during that period, therefore, the turtles might be forced to build their nest faster with less digging. Turtles also probably felt uncomfortable on uneven sand surface caused by the digging of other turtles.

Seven nesting beaches were measured for beach length to investigate whether beach stretch could influence nesting density. Spearman's correlation analysis was used to analyze the correlation between length of beach and cumulative density of nesting as the sample size was small. Beach length was significantly correlated with cumulative nesting density, which explained that beach length was one of the factors that influence the nesting density of nesting grounds (Table 3).

This occurred because probably the beach provided more space for nesting and less interruption from other turtles. Thus, the need to prevent any disturbance during the first point of emergence from the sea until building a nesting. Longer beaches were believed to provide more space and freedom to nest, and this probably could relate to higher digging attempts found on the beaches as shown in Table 2.

Among the seven nesting beaches, the longest was Batu Ferringhi with a length of 2.8 km. The shortest was Teluk Ketapang at 215

m. In Table 3, Kerachut, being only 558m long, recorded the highest nesting density at 282. Compared with the second highest location, this figure was almost triple than the nests found in Teluk Kampi. The others, from most to least, were Teluk Aling, Teluk Duyung, Pasir Pandak, Teluk Ketapang and Batu Ferringhi.

The data was not normally distributed (K-S = 0.338, $df = 49$, $p < 0.001$), therefore, the Krukal-Wallis test was used to analyze the significant differences of nesting among the seven beaches. Nesting was not uniformly distributed among the seven beaches. This happened probably because the densest locations in Kerachut and Teluk Kampi were remote and surrounded by vegetation, which attracted more turtles to land in those beaches.

Relationship between Day Visitors and Nesting Density

This study looked at whether human recreational activities could affect the number of nestings on the beach. The presence of humans could alter a beach's characteristics (i.e; slope, sand texture) and turtles were observed to be easily discouraged from landing when the beach condition had become unfavourable.

According to Figure 4, the number of day visitors to Kerachut Turtle Conservation Centre for the study period was 40,617 (mean±SD = 5,802.4±1,373.9). 2014 had the least number of visitors, but the number had more than doubled the following year. Contrary to what was observed, the Spearman's correlation analysis (ρ) found that the number of visitors per year was not significantly correlated with nesting density at Kerachut. The correlation result showed that the human anthropogenic factor did not affect the nesting density at the beach, where turtles were not discouraged from nesting even though human activities had altered the beach characteristics.

Reproductive Output and Hatching Success

Since 1995 to 2009, the turtle egg relocation programme was carried out at the Kerachut Turtle Conservation Centre (Sarahaizad *et al*., 2012a). Table 4 shows that 86.4 % of the total nests were *ex situ* and 13.6 % were *in situ*. In addition, 19 nests had been poached within the Penang National Park [Kerachut (10), Teluk Kampi (seven) and Teluk Duyung (two)]. This was possibly committed by human visitors, who were allowed to camp and catch fish in the Penang National Park. Another two nests were poached in Pasir Pandak, with an overall of 21 poached nests (Table 4). One nest was found at Pasir Pandak in 2013 while another was found at Batu Ferringhi in 2015. The eggs from

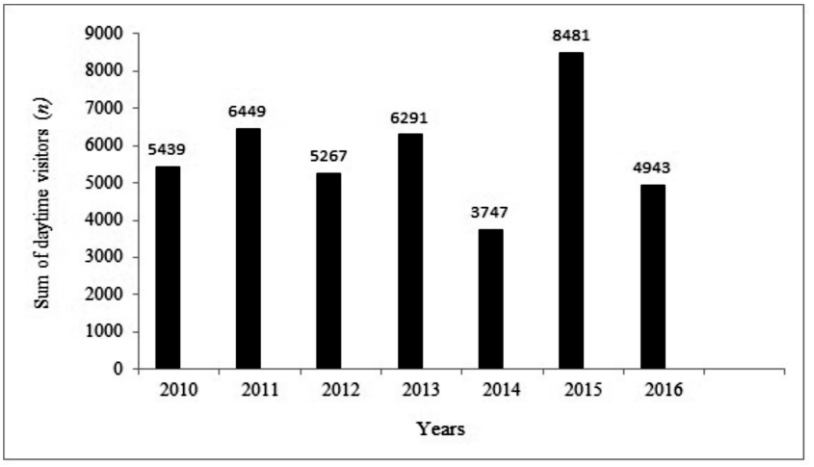

Figure 4: Yearly sum of day visitors at Kerachut Turtle Conservation Centre throughout the study period.

Table 4: Reproduction data from 2010 to 2016 at Penang Island. This table shows current data of total nests collected, total nests relocated, eggs collected, survival hatchlings and hatching rate per year.

Years	**Total nests collected**	**Total nests relocated (*Ex-situ*)**	**%**	**Total unrelocated nests *(In-situ)***	**%**	**Total eggs collected per year**	**Total survival hatchings per year**	**Hatching success (%) per year**	**Record of poached nests per year**
2010	50	46	92.0	4	8.0	4,548 *Ex-situ*= 4,267 *In-situ*= 281	3,449	75.84	6
2011	61	47	77.1	14	23.0	6,329 *Ex-situ*= 5,028 *In-situ*= 1,301	3,890	61.46	3
2012	50	39	78.0	11	22.0	5,267 *Ex-situ*= 4,063 *In-situ*= 1,204	3,135	59.52	6
2013	61	60	98.4	1	1.6	6,357 *Ex-situ*= 6,248 *In-situ*= 109	3,450	54.27	3
2014	43	39	90.7	4	9.3	5,135 *Ex-situ*= 4,586 *In-situ*= 549	3,442	67.03	3
2015	59	52	88.1	7	11.9	7,360 *Ex-situ*= 6685 *In-situ*= 675	≈4,017	≈54.58	unrecorded
2016	59	48	81.4	11	18.6	6,107 *Ex-situ*=5,007 *In-situ*=1,100	unrecorded	unrecorded	unrecorded
Total	383	331		52		41,103	≈21383		21

these nests were successfully incubated in the hatchery as the personnel managed to collect the eggs before the poachers.

A total of 41,103 eggs were collected over seven years. The total survival of hatchlings was estimated at 21,383. There were missing data in 2015 and 2016, which might distort the survival rate of hatchlings. Lastly, the overall hatching success (%) for seven years's of incubating turtle eggs was estimated to be 52.0 %. More than 50 % hatching success was considered as good results as the conservation centre was trying its best to maintain the survival of the hatchlings.

Discussion

Nesting Activity from 2000 to 2009 and 2010 to 2016

The nesting density in this study was compared with similar results from 2000 to 2009 as reported by Sarahaizad *et al.,* (2012a). The annual mean nestings (54.7) and total nestings throughout the study (383) were lower than the previous study, which recorded 506 nestings and a mean of 56.2 per year (Sarahaizad *et al*., 2012a).

Therefore, the yearly nesting density for 16 years could be considered a minor decline. Similarly, there was a decline in nesting grounds as only seven nesting beaches were identified between 2010 until 2016, compared to 13 between 2000 until 2009 (Sarahaizad *et al.,* 2012a). Based on the researchers' observations, the stagnant nesting density was probably contributed by the similar management system applied by the Kerachut Turtle Conservation Centre at all the nesting beaches. The conservation centre personnel would quickly take action when a turtle landing was reported, which increased the chances to identify the nest and prevent poaching. However, this was only a tentative conclusion, as the seven years data were obtained (2010-2016) and compared with 10 years data (2000-2009).

In addition, the nesting density in Penang Island was compared with other nesting locations of various turtle species in Table 5. The table showed that green turtle nesting density in Penang Island was almost similar with the nesting densities of green turtles in Perak, but lower than Melaka (hawksbill turtle), Sabah (green turtle) and Terengganu (green turtle). A huge nesting density of hawksbills was observed in Melaka compared to Penang Island probably because Melaka had a wider beach length (Sarahaizad *et al*., 2018b) and many undisturbed areas. The turtle conservation centres in Sabah and Terengganu were located in remote and serene locations, away from human activities and urbanisation. Peak nesting season occurred between March, April, May and June, which was similar to nesting pattern in Terengganu (Aini Hasanah *et al.,* 2014).

As Peninsular Malaysia's northeast monsoon was stronger than the southwest monsoon (MOSTI, 2019), the turtles were observed to avoid landing from November to March (time of Northeast monsoon) due to choppy waters, strong winds and high tide (MOSTI, 2019). Therefore, more nesting was found from March to June, when the seas are calm, as turtles tended to avoid extreme environments for nesting. From the months of July to October (Figure 2), the nesting density starts to reduce as late May to early September, which is the time of Southwest monsoon with low precipitation, less cloud, and often featured by dry epochs (Chenoli *et al*., 2018). This makes sense as turtles were proven to avoid nesting at low humidity nesting ground and dry environment (López-Castro *et al*., 2004). From the observation on the behaviors between peaks nesting (March-June) and low nesting (July-October), the nesting behavior of the green turtles were related to environmental condition, avoiding uttermost ambiance as that would affect their preference for landing. In addition, it was high risk nesting during high precipitation and heavy rainfall condition as nest and eggs could easily be damaged.

In addition, the status of nesting density per beach was also observed. Green turtle landings in Kerachut and Teluk Kampi from 2010 to 2016 had increased by 227 compared to the previous data (2000-2009). From 2000 to 2009, the

Table 5: Nesting density in Malaysia's state.

No.	Malaysia's States	Turtle Conservation Centre	Estimate yearly nesting (species)	Year	Source of data	References
1	Penang Island	Kerachut Turtle Conservation Centre (Kerachut beach)	43-61 (green)	2010-2016	Department of Fisheries	This study
2	Penang Island	Kerachut Turtle Conservation Centre	506 (green) 0-9 (olive ridley)	2000-2009	Department of Fisheries	Sarahaizad *et al.* (2012a)
3	Perak	Segari Turtle Conservation and Information Center (Pasir Panjang beach)	10-220 (green)	1998-2013	Department of Fisheries	Sarahaizad *et al.* (2018a)
4	Melaka	Padang Kemunting Turtle Conservation Centre	463-481 (hawksbill)	2013-2014	Department of Fisheries	Sarahaizad *et al.* (2018b)
5	Terengganu	a) Redang Island	221–687 (green) 0-21 (hawksbill)	1993-2008	Chagar Hutang Turtle, Sanctuary (UMT)	Chan (2010)
		b) Setiu	28–201 (green)	2007-2012	Department of Fisheries	Aini Hasanah *et al*. (2014)
6	Sabah	Turtle Islands Park (Sabah Parks)	>501 (green) >69 (hawksbill)		Sabah State Park administrative	Chan *et al*. (1999)

cumulative nestings at Kerachut and Teluk Kampi were 81 and 55, respectively (Sarahaizad *et al*., 2012a). However, nestings from 2010 to 2016 were surprisingly high, with 282 recorded in Kerachut and 81 in Teluk Kampi.

This suggested that conservation efforts had paid off with a reduction of human activities at the beaches and efficient survey methods by centre personnel. However, the number of beaches where nestings occur had gone down, with Bayan Baru, Bayan Lepas, Pantai Belanda, Gertak Sanggul, Pantai Medan and Teluk Kumbar no longer visited by turtles from 2010 to 2016. This could be related to development projects in those areas (i.e; housing, commercial centres by the sea) that had expanded in the southern part of the island in the last 10 years, especially in Bayan Baru, Bayan Lepas and Teluk Kumbar.

In addition, no Olive Ridley nests were recorded between 2010 until 2016, compared to nine between 2000 until 2009 (Sarahaizad *et al*., 2012a). Nest poaching still occurred, with 21 identified cases throughout the study. This showed that the poaching rate in Penang Island was quite high, but the number was still manageable compared to Melaka and Terengganu. The green turtle population is large and it was difficult to control the illegal activity. There was demand for the eggs because locals do consume them as a traditional diet (Chan, 2006; Aini Hasanah *et al*., 2013). Therefore, the turtle conservation centres in Melaka (Sarahaizad *et al*., 2018b) and Setiu, Terengganu (Aini Hasanah *et al*., 2013), had decided to collect and incubate all eggs from reported nesting sites in a bid to achieve zero-poaching rate. Besides egg poaching, turtles also faced threats of being hunted for their meat and high frequency of getting caught in fishing nets, which leads to fatality (Joseph *et al*., 2017).

The nesting behavior of the green turtles in Penang Island was compared with hawkbills in Melaka. The nesting density of green turtles in Penang Island seemed to be influenced by beach length, but the hawksbills in Melaka were not (Sarahaizad *et al*., 2018b). It was probably because green turtles mostly nested at the same beaches randomly, and it was hypothesized that the number of nests would increase with increasing beach length.

Beach length was probably not the main factor influencing hawksbill turtles' landing preference, as their nesting time was shorter and harder to sight than the green turtle. In addition, sand characteristics also influenced the nesting preferences of different turtle specied (Zare *et al*., 2012; Madden *et al*., 2008). Therefore, it is proposed that beach length was not a major influence in determining nesting activities. Instead, from the latest research, hawksbills were more attracted to land at the beach with a short distance from the sea (Zare *et al*., 2012).

Green turtles were observed to nest at a longer distance from the tidal line (Sarahaizad *et al*., 2012b). However, one similarity observed was both species preferring to nest within areas with vegetation (Zare *et al*., 2012; Aini Hasanah *et al*., 2014; Sarahaizad *et al*., 2018b), where the eggs could be safely hidden from predators. The green turtle is widely distributed in Malaysia, with prominent nesting populations in Sabah, Sarawak, Terengganu, Penang, Perak and Melaka (Chan, 2006). It is hoped that the Department of Fisheries and Kerachut Turtle Conservation Centre could maintain its work with the local community as statistics had shown an increase in nesting density in Kerachut and Teluk Kampi. This indicated that turtle nesting sites [i.e.; location and vegetation (Yalcin-Ozdilek and Yerli, 2006; Liles *et al*., 2015)] in the area should be left undisturbed to provide shelter for turtle landings.

Overall, the nesting statistics in Penang Island had decrease slightly, probably caused by the land reclamation project in Gurvey Drive (15 km from Penang National Park) and developments in the southern region of the island. Additionally, it seemed that the nestings in Penang Island did not increase the population of the green turtle. The Gurney Drive reclaimation project probably had a net negative impact for future populations of sea turtles, which warranted protective measures.

Lastly, as turtles were migratory reptiles, it would be interesting to study the genetic profile of green turtles in the Straits of Malacca to determine the characteristics of the reptiles which nest in different parts of the peninsula. This study would provide important data on the similarities or differences in genetic make-up (Sarahaizad *et al*., 2018a) and this method referred to the initial study conducted by Joseph and Nishizawa (2016).

Relationship between Daytime Visitors and Nesting Density

Results also indicated that the nesting density was not influenced by day visitors on the beach. Turtle landing and nesting at Kerachut were not influenced by changes caused by human anthropogenic factors at nesting grounds [i.e., sand texture and sand compactness (Foley *et al*., 2006; Madden *et al*., 2008)]. This result might contradict with the behavior of green turtles that avoid nesting at beaches that were low in vegetation distribution, noisy and near human settlements (Sarahaizad *et al*., 2012b). But there are also some minor cases reported that sea turtles sometimes show contradictory behavior, where they avoided nesting at vegetation areas because of the roots (Hays and Speakman, 1993), and preferred to lay their eggs at the open beach.

No correlation was found between daytime visitors and nesting density. Compared to other nesting beaches, Kerachut and Teluk Kampi had recorded the highest nesting density since 1995, as these beaches were undisturbed.

Reproductive Output and Hatching Success

The egg relocation programme continued to be conducted between 2010 until 2016. This was because allowing them to incubate *in situ* was risky due to poaching, as Penang National Park was a tourist attraction. Therefore, it was recommended that conservation work in Penang should follow those of other states, where eggs are collected from all nesting sites and hatched *ex situ* at the conservsation centres. The incubation rate was estimated at 13.6 % of the nests (between 2010 and 2016) that were incubated as *in situ* nests at the hatchery of the Kerachut Turtle Conservation Centre.

Egg relocation was continously carried out with approximately more than 70 % eggs relocated every year (>50 % hatching success per year). In Melaka beaches, turtle eggs had been relocated since 1991, and there were positive results after 20 years in terms of increasing the number of nesting density of hawksbill turtles. From 1991 to 1992, there were more than 350 hawksbill nestings recorded in Melaka and the number increased to 481 between 2013 and 2014 (Sarahaizad *et al*., 2018b).

Therefore, by lessons from the successful of recovery trend of hawksbills in Melaka could be applied in Penang Island. In other nesting grounds, such as Redang Island, Terengganu, the eggs were left to incubate *in situ* as there was enough manpower at the conservation centres to monitor turtle nests (Joseph *et al*., 2017).

The mean hatching success in this study was estimated to be slightly lower compared to between 2000 until 2009. An accurate result on the number of survival hatchlings as in Table 4 was not ascertained, as data were not properly recorded in 2015 and 2016. Hatching success for three nests were not recorded in 2015, and 59 nests were not recorded in 2016.

Some changes had taken place in the management of Kerachut Turtle Conservation Centre, as the new personnel might have failed to record the data, which resulted the eggs survivorship section to be unrecorded in 2016. In Table 3, the hatching success per beach was more than 60 % Nesting beaches such as Teluk Aling, Teluk Duyung, and Teluk Ketapang were far away from the hatchery in Kerachut, but the hatching success was high because the conservation personnel had efficiently relocated the eggs for incubation (less than 3 hours) to reduce the mortality. In Perak, the highest survival hatchlings produced was estimated to be 5,018 in 2008 (Sarahaizad *et al*., 2018a). This number was higher than the highest survival hatchlings in Penang Island in 2015 (estimated 4,017 hatchlings).

Impact of Penang South Reclamation Project

Penang South Reclamation (PSR) project involved reclaiming three artificial islands from the sea near Teluk Kumbar (The Star, 2017). The project had received negative feedback from activists, fishermen and non-governmental organisations (NGO), which were concerned over their livelihood and the environmental impact, including on the turtle population.

For example, the Olive Ridley was a fragmentary species that required an isolated place to land and nest (Chan, 2006). They were only known to land in Teluk Kumbar and Gertak Sanggul (Sarahaizad *et al.*, 2012a). The first Environmental Impact Assessment for PSR was conducted in 2017, but it was rejected last year as conditions were not met with regards to the Fisheries Impact Assessment.

Six net-negative impact of PSR project had been highlighted in a local forum; reduction of fishermen's source of income due to the loss of important fishing grounds south of the island; destruction of coral reefs, which would degrade the survival of aquatics species; increased pollution of the ocean due to discharge from broken pipelines and mud dispersion; destruction of marine habitat due to undersea dredging; Risking the extinction of the Olive Ridley population in the island's south; and, increasing the cost of living as food and property values rise faster than the income of the local community.

Besides, it was also proposed that sand for the reclaimation works to be taken from the shores of Muka Head near the Penang National Park (Penang Forum, personal communication). This could indirectly affect the turtle population in the island's north. In this study, 363 nestings were recorded in Kerachut and Teluk Kampi, an increase of 62.5 % from 2000 to 2009. Therefore, sand collection at Muka Head might bring a negative impact on turtle population in the whole island as these two beaches appeared to be main nesting sites.

Conclusion

This paper provides the latest version of nesting statistics of green turtles in Penang Island. Kerachut and Teluk Kampi, the main nesting sites, showed an increase for nesting statistics per beach compared to between 2000 and 2009, However, this study found a fluctuating trend in nestings, with minor decline compared to previous years. The nesting grounds had also shown a decline in number. The publication of this paper is important as it discussed the status, spatio-temporal and reproduction success of green turtles in Penang Island. Unknown to many, the Pearl of the Orient was actually an important nesting location for green turtles and the Kerachut Turtle Conservation Centre had been effective in carrying out its work to protect turtle eggs, improvise nesting statistics and prevent poaching.

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