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## COMMUNICATION

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Subramanian Narayani, Sasidharan Venu & Andrea Joan D'Silva

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## COMPARISON OF BEACH PROFILES CONDUCIVE FOR TURTLE NESTING IN ANDAMAN

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**Abstract:** The present study was undertaken to compare beach characteristics associated with turtle nesting in the Andaman group of islands. Karmatang, Kalipur, Ramnagar, Chidiyatapu, Carbyn's Cove, and Wandoor were chosen as study sites. Beach slope, sand grain characteristics, and general vegetation patterns were analysed. The angle of inclination of the beach slope ranged from 2.06 to 8.3 degrees. Beaches with a higher angle had a comparatively higher number of nesting sites. The study shows that a single factor does not make a beach more conducive for nesting. Chidiyatapu has the widest beach but lacks other features and so it is not a preferred nesting site. The grain size of sand in Wandoor is highly favourable, but the intertidal region is not long and there are streams that can drown the nests. Karmatang has a long beach and a higher slope angle. Ramnagar has a moderate beach length and a high slope angle. The dominant grains at both the beaches were found to be granules. The absence of streams and artificial light, fewer number of anthropogenic activities, lack of obstacles, the presence of bordering vegetation, and a conducive beach slope with granular sand grains make Ramnagar, Karmatang, and Kalipur ideal for turtle nesting.

**Keywords:** Sand grain, beach slope, intertidal, ecology, beach angle, turtle nesting, Andaman.

### Tamil Abstract

அந்தமான் தீவுகளிலுள்ள கடற்கரைகளில் அதிகளவில் கடல் ஆமைகள் முட்டையிட வருவதற்கு ஏனையெல்லாம் ஏதுவான காரணிகள் என்பதைக் கண்டறிவதன் பொருட்டு இந்த ஆய்வு மேற்கொள்ளப்பட்டுள்ளது. அந்தக் காரணிகளைக் கண்டறிய கர்மாடங், காளிப்பூர், ராம்நகர், சிடியாடாபு, கார்பின்ஸ் கோவ் மற்றும் வண்டூர் ஆகிய கடற்கரைகள் ஆய்வுக் களங்களாக எடுத்துக்கொள்ளப்பட்டன. இங்கிருக்கும் கடற்கரையின் சாய்வுக் கோணம், மணல் துகள்களின் அளவு, கடற்கரைகளிலிருந்து தாவரங்கள் ஆய்வுக்குட்படுத்தப்பட்டன. அவ்வாறு உட்படுத்தும்போது இந்தக் கடற்கரைகளின் சாய்வுக் கோண அளவு 2.06 முதல் 8.3 வரை இருந்தது. சாய்வுக் கோணம் அதிகளவு இருந்த கடற்கரைகளில் அதிக அளவில் ஆமைகளின் வரத்து இருந்தது. ஆனால், இதை மட்டுமே ஆமைகள் கடற்கரைகளில் முட்டையிடுவதற்கான இன்றியமையாத காரணியாகச் சொல்ல முடியாது. ஏனெனில், சிடியாடாபுவில் கடற்கரையின் அகலம் (கோணம்) அதிகமாக இருந்தாலும் இது ஆமைகளால் பெரிதும் தேர்ந்தெடுக்கப்படவில்லை. வண்டூரில் மணல் துகள்களின் அளவு சரியான விகிதத்தில் இருந்தது. ஆனால் இந்நீளம் குறைவானது. இங்கே இருக்கும் கால்வாய்களும் முட்டைகளை மூழ்கடிக்கும் தன்மையில் அமைந்திருக்கும் என்பதால் இதுவும் ஆமைகள் முட்டையிட ஏற்றதாக இல்லை. ஆனால் ராம் நகர் மற்றும் கர்மாடங், காளிப்பூர் ஆகிய கடற்கரைகளில் அதிக அளவில் ஆமைகள் முட்டையிடுகின்றன. இந்தக் கடற்கரைகள் அதிகக் கோணத்தில் சாய்வு அளவு கொண்டவை மட்டுமல்ல நீளமானவை. பெரிய அளவீட்டில் மணல் துகள்களைக் கொண்டவை. கால்வாய்கள் இல்லாதவை. செயற்கை ஒளி, மனிதச் செயல்பாடுகள் போன்ற குறைவான தடைகளைக் கொண்டவை. மேலும் சுற்றித் தாவரங்களும் ஆமைகளின் வருகைக்கு ஏற்றவையாக இருக்கின்றன. எனவே இந்தப் பகுதிகள் ஆமைகள் அதிகமாக முட்டையிட ஏதுவாக இருக்கின்றன.

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**Author Contributions:** SN assisted in field surveys and prepared the manuscript. SV conceived and designed the work and finalised the drafts. AJD'S carried out the field surveys and assisted in the manuscript writing.



## INTRODUCTION

Among the many species that appeared as part of the modern marine turtle families in the Cretaceous (Lutz & Musick 1996), only seven species remain today. Among these, one is endangered, three are vulnerable, two are critically endangered and one is listed as data deficient (Nicholas 2001; IUCN 2018). Five species are reported from India and four species are reported from Andaman & Nicobar Islands (Murugan 2010). Selection of a good nesting site is an important stage for oviparous animals, especially in those species that do not provide parental care (Morales-Mavil et al. 2016). Minimizing female mortality and maximizing offspring fitness are the driving forces for site selection by female turtles for nesting (Spencer 2002).

The Andaman & Nicobar archipelago is located in the Bay of Bengal between 6.750°–13.750° N & 92.000°–94.300° E, extends over 800km, and consists of islands, islets, and rocky outcrops with a coastline stretch of 1962km. Four species of marine turtles occur in the Andaman & Nicobar Islands: Leatherback *Dermochelys coriacea*, Hawksbill *Eretmochelys imbricata*, Green Turtle *Chelonia mydas*, and Olive Ridley *Lepidochelys olivacea*. These turtles are protected under Schedule I of the Indian Wildlife (Protection) Act, 1972. The ban on hunting and harvesting of turtles was enforced in 1977, but the indigenous groups of the Andaman & Nicobar Islands are exempt from the Act as marine turtles have been their source of food for centuries (Bhaskar 1984). The surveys and studies conducted in the Andaman & Nicobar Islands have recorded India's best nesting beaches for Leatherback, Hawksbill, and Green turtles (Andrews et al. 2006). The present study was undertaken to review the status of marine turtles in Andaman and to compare the beach characteristics associated with turtle nesting.

## MATERIALS AND METHODS

The study was conducted during February–March 2014.

### Study area

Six stations in the Andaman Islands were selected as study sites for this work. Karmatang Beach at 12.913°N & 92.896°E is a bay located in Mayabunder, North Andaman (Fig. 1). It is a sandy beach that is dark-coloured, giving the water a very turbid look. Good vegetation, with a mix of shrubs and trees, lines the beach. Ramnagar is

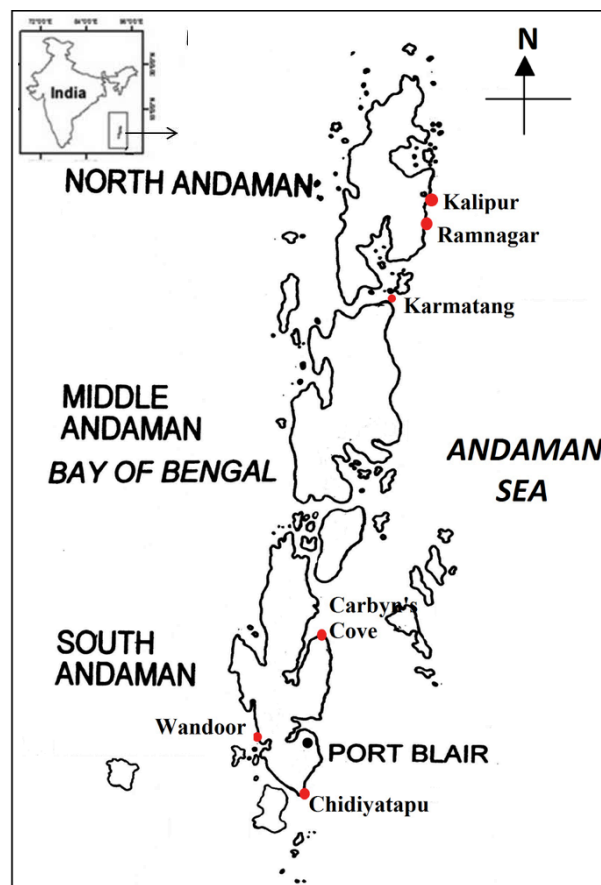


Figure 1. Study area

situated in Diglipur, North Andaman, and is located at 13.075°N & 93.028°E. This sandy beach is 15km away from Kalighat. It is surrounded by palm and coconut trees and coastal shrubs. Comparatively, it has stronger waves than the other study stations. Kalipur is located in Diglipur, North Andaman, and it is the only beach in the world where four species of turtles come to nest. Its coordinates are 13.235°N & 93.896°E and it is 18km from Diglipur. It has a combination of sand and rocks. Chidiyatapu houses the Munda Pahar Beach, which is 2.5km from Chidiyatapu Beach. Its geographical coordinates are 11.490°N & 92.708°E. The beach has a combination of sand and rocks and has small freshwater sources. Carbyn's Cove is a bay that is on the southeast of South Andaman. It is located at 11.490°N & 92.700°E. It is a sandy beach with rocks flanking its sides. There is an estuary adjoining it that supports a healthy mangrove vegetation. Wandoor is a marine national park located 29km from the city of Port Blair and is situated in the Bay of Bengal. It is located at 11.609°N & 92.675°E. It is a white sandy beach with two small freshwater inlets. It has a good surrounding vegetation of shrubs,

mangroves, and woody trees.

### The slope of the beach

The slope of the beach was estimated by employing the method described by Varela-Acevedo et al. (2009) using Auto Level, DSZ2 (manufactured by Suzhou FOIF Co. Ltd.). The distance between the scale and the telescope was calculated. The values of distance against height were plotted on a graph to obtain the beach profile.

### The angle of inclination

By finding the slope of the land, the height of the land was found at certain distances. Using the values of height and distance in the trigonometric formula  $\tan \theta$ , the value for the angle of inclination was obtained.

### Grain size analysis

The grain size of the sand on the beach was analysed following Varela-Acevedo et al. (2009). Using a corer of length 12.7cm and a width of 5.08cm, sand samples were obtained from the part of the beach that is higher than the tide mark. None of these parts were in the dune area as there are no dunes in Andaman. The collected samples were placed in sample bags for analysis. The grains were mixed well and sprinkled onto a slide with a layer of oil to adhere to the grains. The grains were then viewed under a polarising microscope that was fixed with a graduated ocular lens. The diameter of each grain was measured individually in divisions and converted to millimetres. In each sand sample, diameters of 170 grains were measured. Size class intervals and their corresponding frequencies were made and the results were depicted graphically. The class interval with the highest frequency was taken as the representative of the sand at that corresponding sampling site. The sand grains were classified based on Wentworth (1922).

### Extrinsic parameters

By comparing the vegetation at each of the six sites, the amount of vegetation at each site was classified as high, medium, or low. The presence of obstacles like trees was noted by visual examination. Anthropogenic activities/ influences like manmade structures, vehicles, shacks, and pollution were taken into account through comparison among the study stations. Techniques for identifying key parameters and estimating their values were followed from Varela-Acevedo et al. (2009). The transformed data of extrinsic parameters and the presence of turtle nests reported from literature (Andrews 2006; Murugan 2010) were used to perform principal component analysis and to generate a plot in PRIMER E-V6 package (Clark & Warwick 2001).

## RESULTS

### Extrinsic parameters

The extrinsic parameters are given in Table 1.

### Beach slopes

Karmatang has a relatively flat reef slope (Fig. 2) with a minor dip at 2.4m and a major dip at 13.5m. The profile of Kalipur (Fig. 3) is very undulating with only one major visible rise at 31.4m. Ramnagar has a major rise at 7m and another at 12m (Fig. 4). The profile of Chidiyatapu (Fig. 5) shows that it has a number of indentations that can be difficult for turtles to navigate. From the profile of Carbyn's Cove (Fig. 6), it can be seen that there is only one major dip at 7m but otherwise, the land is relatively flat. In the case of Wandoor Beach (Fig. 7), there is a rise at 5.5m and a minor dip at 11.5m, but otherwise, the land is without many undulations. Chidiyatapu is the widest beach while Wandoor is the narrowest (Fig. 8).

**Table 1. Extrinsic parameters in the study sites**

Parameters	Karmatang	Kalipur	Ramnagar	Chidiyatapu	Carbyn's Cove	Wandoor
Intertidal (m)	53.6	32.9	21.3	73.5	15.6	14.9
Vegetation	High	High	High	High	Low	Moderate
Streams through the beach	Nil	Nil	Nil	2	Nil	2
Creek	Nil	1	Nil	Nil	1	Nil
Obstacles on the beach	Nil	Nil	Nil	Yes	Nil	Yes
Presence of nearby islands	Nil	Nil	Nil	Nil	2	Nil
Presence of reefs	Yes	Yes	Yes	Yes	Yes	Yes
Anthropogenic activities	Low	Low	Low	Moderate	High	Moderate
Angle of inclination	7.86°	2.062°	8.3°	2.75°	2.29°	5.71°

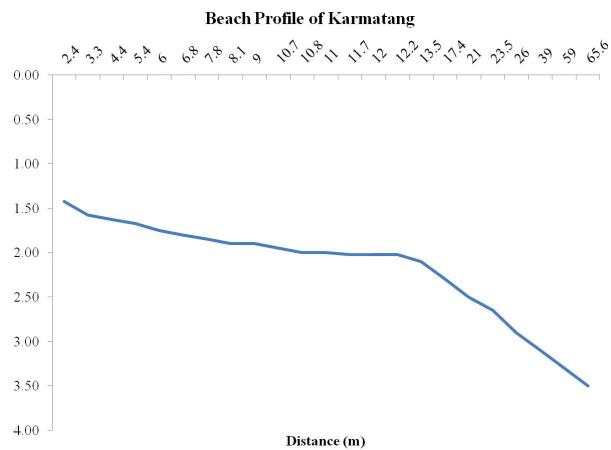


Figure 2. Beach profile of Karmatang

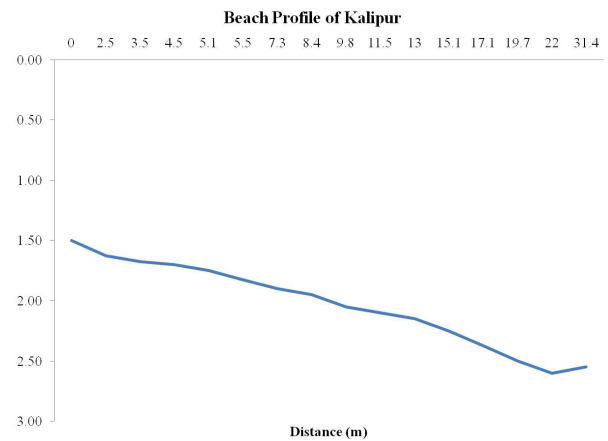


Figure 3. Beach profile of Kalipur

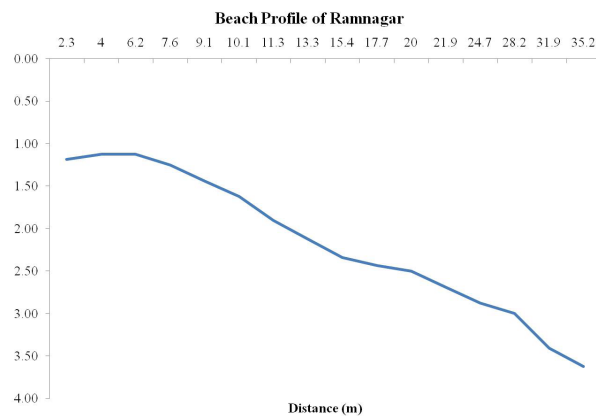


Figure 4. Beach profile of Ramnagar

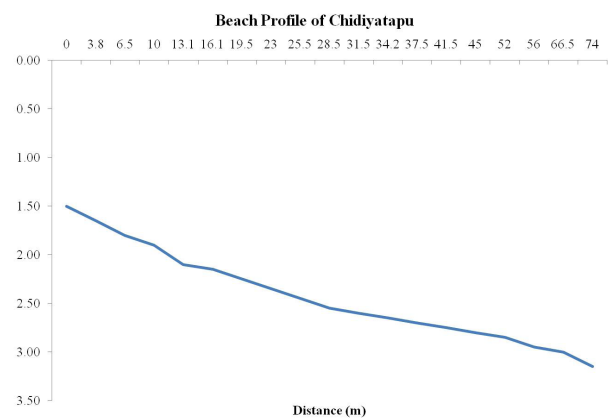


Figure 5. Beach profile of Chidiyatapu

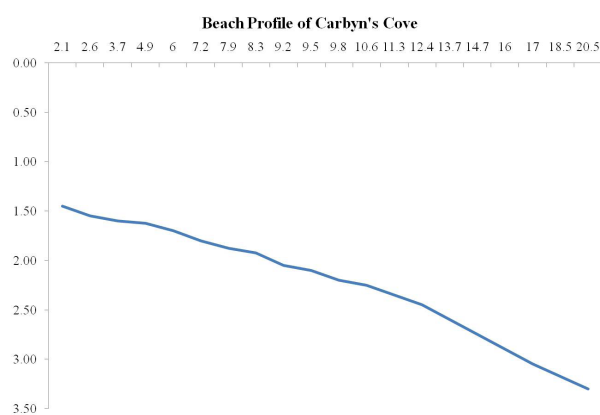


Figure 6. Beach profile of Carbyn's Cove

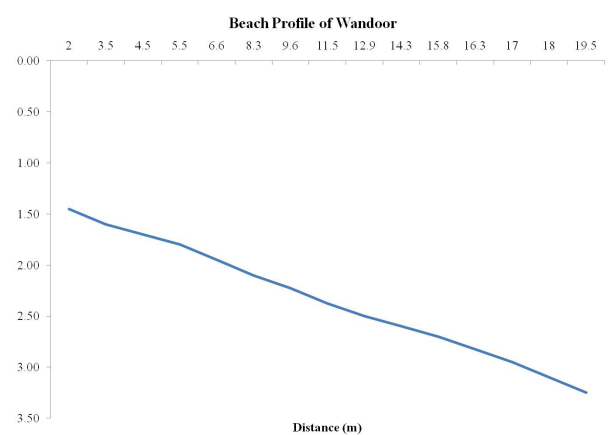


Figure 7. Beach profile of Wandoor

### The angle of the slope

The slope angles of the study stations are presented in Table 1.

### Sand grain analysis

In Karmatang, the majority of sand grains were small in size. This was the case in Kalipur and Ramnagar as well. In Chidiyatapu, the majority of sand grains were in

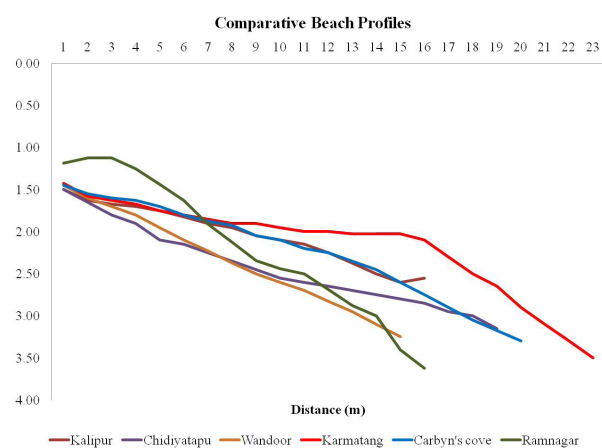


**Table 2. Grouping of grains based on size classification by Wentworth (1922)**

	Karmatang	Kalipur	Ramnagar	Chidiyatapu	Carbyn	Wandoor	Classification
0–1	0	1	0	0	0	0	Coarse sand
1.0–2.0	76	112	17	12	2	36	Very coarse sand
2.1–4	75	55	106	142	28	78	Granules
4.1–16	19	2	47	16	124	56	Pebbles
>16.1	0	0	0	0	16	0	Gravel

**Table 3. Effect of extrinsic parameters (++ very favourable, +favourable, - not favourable)**

Site	Karmatang	Kalipur	Ramnagar	Chidiyatapu	Carbyn's Cove	Wandoor
Sand grains	+	++	++	-	-	++
Beach width	+	+	+	++	-	-
Stream/ creek	+	+	+	-	+	-
Presence of obstacles	+	+	+	-	-	-
Artificial light	+	+	+	+	-	+
Vegetation	++	++	++	++	-	+
Anthropogenic activity	++	++	++	+	-	+

**Figure 8. Comparison of beach profiles**

the middle-size category. In Carbyn's Cove and Wandoor, the sand grains were small in general. According to the classification of sand grains by Wentworth (1922), Karmatang and Kalipur have very coarse grains, Chidiyatapu and Wandoor have granules, and Carbyn's Cove has pebbles (Table 2). Overall, the majority of grains were in the size range 2–4 mm. Wandoor and Karmatang had a more or less equitable distribution of sand grain sizes. There were proportionally more larger grains in Carbyn's cove and more smaller grains in Kalipur.

### Effect of extrinsic parameters

With all the parameters mentioned above, Table 3 (++ very favourable, +favourable, - not favourable) provides a comparison of the study areas to show the effect of the analysed parameters on turtle nesting. The principal component analysis (Fig. 9) revealed that the absence of anthropogenic activities and nearby islands and the absence of creeks were closely associated with turtle nesting in the stations. The first two principal components accounted for 82% of the total variation. It is acknowledged here that if the specific number of nests in each area is included in the analysis, these results may vary. This is especially true of regions like Chidiyatapu and Wandoor for which results are only available from pre-Tsunami surveys.

### DISCUSSION

Sea turtle populations have decreased due to habitat destruction, anthropogenic activities on nesting beaches, predation of young hatchlings, and theft of unhatched eggs (Wyneken et al. 1988). The major potential terrestrial factors for choosing a beach for nesting are beach slope and width, the presence of interspecific competition, artificial lighting, and human activities. Studies have shown that there is a positive feedback between turtles and the beach dunes in which they nest (Bouchard & Bjørndal 2000). Beaches with good access to the sea, fine sands of small grain size, and adequate humidity and temperature were previously

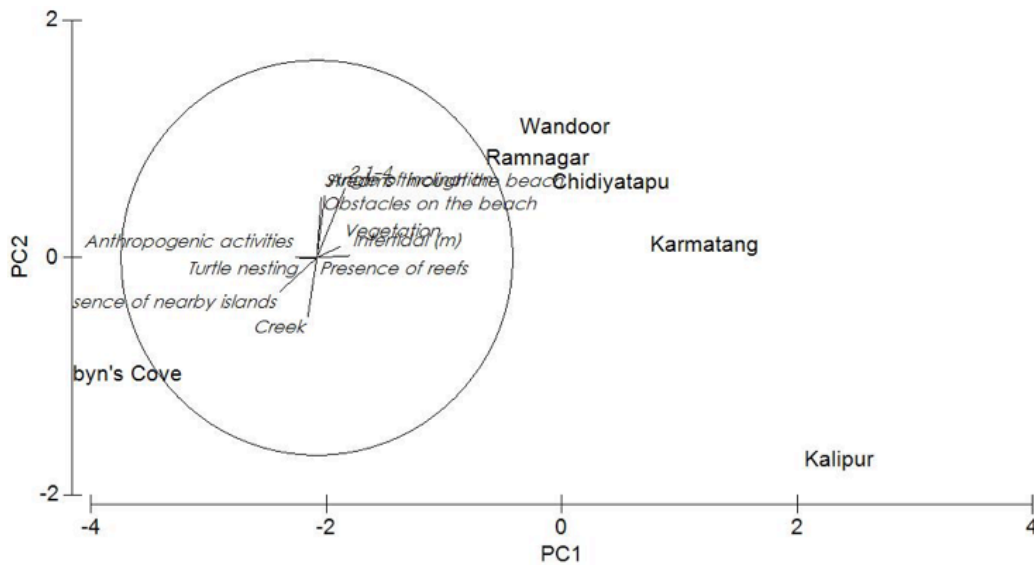


Figure 9. PCA plot of extrinsic parameters

noted as the desired features for site selection for turtle nesting (Wood & Bjørndal 2000; Morales-Mavil 2016).

The location of the nest in the tidal zone is crucial as the eggs must neither be flooded and eroded nor be exposed to land predators (Whitmore & Dutton 1985; Blamires & Guinea 1998). Hatchlings must be able to find the sea and the nest must not have visual obstructions that prevent the same (Godfrey & Barreto 1995). This shows that Wandoor, with the smallest beach width among all study stations, is not favourable for turtle nesting.

Debris on the beach prevents successful nesting and causes a phenomenon called as 'false crawl' where the females emerge from the water but do not deposit an egg clutch (Fujisaki & Lamont 2016). Artificial lighting too has been reported to disrupt patterns of nesting females (Weishampel et al. 2016).

Large angled beaches are preferred by turtles as water cannot move up the slope as easily and hence the nests are relatively safer from flooding (Godley et al. 1993). Ramnagar and Karmatang beaches have the steepest profile and larger angles, and so they are very favourable for turtle nesting. Ramnagar has the highest dominance of granules, which seem to be the ideal grain size as supported by the results from Hughes et al. (2009) that show that real nest contains medium sand or larger grains. Though Chidiyatapu has the widest beach, other factors are not very favourable and this leads to only sporadic nesting. Wandoor has the required grain size but the lack of intertidal width and the presence of streams in the beach are deterring factors. Considering all the features studied, the absence of streams,

absence of artificial light, a significantly lesser number of anthropogenic activities, lack of obstacles, and the presence of bordering vegetation make Karmatang, Kalipur, and Ramnagar very conducive for turtle nesting. It has been reported that a total of 99 nesting sites belonging to four species of turtles were seen in Ramnagar, Karmatang, and Carbyn's Cove (Andrews 2006). While it could be deduced from the present study that Kalighat is a beach conducive for turtle nesting, the evidence for turtle nesting in this beach is mainly anecdotal. Unfortunately, data from the literature for these stations is sporadic. It is acknowledged here that a comprehensive list of sea turtle nests in these stations could be useful in comparing predicted conduciveness and actual preference. It is hereby recommended that the number of nests along each beach in these stations is to be quantified to empirically ascertain nesting preferences of turtles in this region.

The spatial and temporal consistency of turtle nesting behaviour are of basic importance to conservation efforts as they can be used to interpret scales of behavioural patterns in relation to environmental parameters. This can be used to regulate human activities in the beaches where turtles nest regularly (Weishampel et al. 2016).

There are numerous studies all around the world regarding turtle nesting site selection, environmental criteria for embryonic development, and other aspects of sea turtle biology. The focal point of all these studies is that a better understanding of the biology and life history of turtles can help in planning more effective conservation strategies. When compared to other regions, the studies regarding turtles from Andaman



& Nicobar are meagre. Further research can point out the salient features of turtle nesting behaviour in these regions and they can be used for the conservation of these marine reptiles.

## CONCLUSION

Turtles have been part of Andaman's history since the 1800s. Their constant association with these waters and their homing in annually provides the best evidence that the beaches in Andaman do meet the turtles' requirements. This study shows that a single factor does not make a beach a better nesting site. It is shown from this study that there is a significant lack of literature pertaining to the reproductive biology of turtles in these islands. The results from further studies can be a backbone for planning developmental activities and developing infrastructure for these beaches in the future.

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