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Nesting ecology of the green sea turtle *Chelonia mydas* along the Saurashtra coast

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Abstract

The nest and clutch characteristics of the green sea turtle *Chelonia mydas* were assessed during 2000-02 in the Mangrol – Porbandar beach of Saurashtra coast (Lat. 21° 6' - 21° 38' N; Long. 69° 37' - 70° 6' E) in India during December 2001 – January 2002. The nesting density was 5.1 nests/ km. Within the area of survey, the nesting site preference was evaluated for 11 transects. Maximum nest density was within 20 m from the high tide line where moisture content of the soil was 3.6%. Of the total nests observed (194), the depth of 63% nests varied between 71 - 90 cm. Except in one transect, the soil particle size was below 0.7 mm. There was no correlation between the nest density, and the soil *p*H and salinity. The number of eggs in each clutch ranged from 61 - 135 with a mean of 93. About 25% of the nests were predated by wild animals. The mean hatching and emergence success was 79% and 76%, respectively. It is estimated that 17,964 eggs were laid, but only 10,936 hatchlings emerged successfully and reached the sea.

Key words: Nesting ecology, green sea turtle, *Chelonia mydas*

Introduction

On a global scale, the green turtle *Chelonia mydas* is the most widely studied species among the sea turtles. This circumtropical migratory species nests in tropical and subtropical regions. Several researchers have cautioned severe depletion of the green turtle stocks around the world oceans (Marcovaldi *et al.*, 2003). In the Indian territorial waters, except for a few nesting records (Bhaskar, 1984; Sunderraj *et al.*, 2002; Tripathy and Choudhury, 2002), there are not many studies on the green turtle. Nesting of any significance is restricted to the Saurashtra coast of Gujarat. Lack of information on this migratory species about its visits to the Indian coast, is a lacuna in for understanding the life history of this species.

In India, intensive efforts have been made during the last three decades to conserve the olive ridley *Lepidochelys olivacea* that mass nests in the beach at Gahirmatha in Orissa. Comparatively, attempts to conserve the green turtle are lukewarm as sighting the adults, observing the nesting and protecting the hatchlings are difficult, compared to the other species. As a result, not much attention has been paid on the green turtle research in India. Therefore, the nest and clutch characteristics of the green sea turtle *Chelonia mydas* were assessed in the Mangrol – Porbandar beach of Saurashtra

coast (Lat. 21° 6' - 21° 38' N; Long. 69° 37' - 70° 6' E) in India during 2000 – 2002. The results of the study are discussed

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Material and methods

The study was restricted to a 38 km stretch in the 80 km beach between Mangrol and Porbandar in the Saurashtra coast. Nest surveys were conducted for 16 months, split into two periods, viz., May-November 2000 (4 days/month; a total of 28 days) and May 2001-January 2002 (16 days continuously in December 2001 and January 2002; a total of 48 days). Two survey teams consisting of three persons were employed in each transect at night (from 20:00 to 03:00 hrs) and the following day (07:00 to 10:00 hrs). The survey area was divided into 11 transects (Fig. 1) and each transect was surveyed by foot during night and day. Wherever the turtle crawl mark was clear its width was measured by using a standard measuring tape. The green turtle crawl marks and nests were identified and differentiated from the crawl marks of other turtles following the method suggested by Pritchard and Mortimer (1999). The presence of clutch was ascertained by (i) directly observing egg deposition; or (ii) excavating the nesting pits; or (iii) observing the predation on eggs; or (iv) probing. The nesting density(ND) was determined by using the following formula:

N D = Number of nesting pits / Distance covered (km).

For each nesting crawl mark and nest, the distance from the high tide line (HTL) to the nesting pit was measured.

To protect from natural predators, the clutches were translocated to the beach hatchery at Madhavpur by the Department of Forests, Gujarat. At the time of translocation, the clutch size was determined by counting all the eggs in randomly selected clutches. When the nests were excavated, the depth of the nests from the surface to the bottom was measured. To determine the size, ten eggs randomly collected at the time of translo-

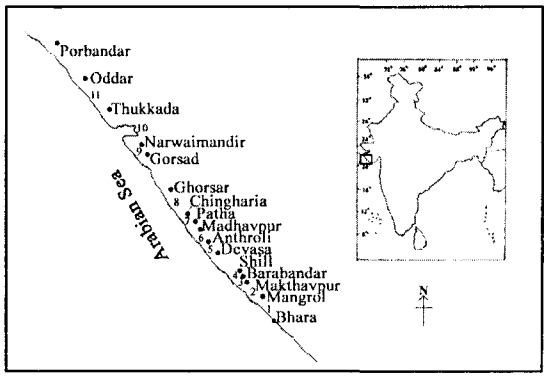

Fig.1. Area of survey (numbers denote Transects) between *Mangrol (Lat. 21° 6' N; Long. 70° 6' E) and Porbandar beach* (Lat. 21° 38' N; Long. 69° 37' E) along Saurashtra coast

cation were measured using a vernier caliper. The weight of each egg was determined to an accuracy of 0.01 g.

Beach soil from the nests was collected (250 g) at 30, 50 and 80 cm depth. The uppermost and deepest layer of eggs laid were within these depth ranges. The soil collected from a single pit was mixed and brought to the laboratory to estimate the moisture content, particle size, *p*H and salinity. To estimate the moisture content, a known quantity of the collected soil was dried at 105° C in a hot air oven for 40 hours (Stancyk and Ross, 1978). To determine the texture of soil, the mean particle diameter was calculated by fractionating the sand with sieves of different mesh size (No: 100, 44, 30, 18, 14 and 7). The cumulative frequency was plotted showing the percent of sediment (from coarsest to finest) on the ordinate and the sieve size in *p*hi units on the abscissa – where Ø (*p*hi) = log (mm). The intercepts of the 16, 50 and 84 percentiles with the cumulative curve were used to calculate the mean particle diameter following Mortimer (1990) as :

Mean diameter (Mn Ø) = Ø16+ Ø50+ Ø84/ 3.

The mean diameter was transformed into mm unit.

Dried sand (10 g) was immersed in plastic vials holding 10 ml of deionised water for determination of *p*H, using a *p*H meter (Hanna, German make). Soil salinity was determined following the method suggested by Strickland and Parsons (1969). To determine the hatching and emergence success in the natural habitat, randomly selected nests (that were not translocated to the hatchery) were located by backtracking the seaward path of hatchlings (Mortimer, 1990) or by digging the saucer shaped depressions in the sand indicative of hatchling activity below the surface. The hatching and emergence success were calculated following Miller (1999). Statistical analyses like mean, standard deviation, analysis of variance (ANOVA- one way), regression and Student's 't' test were made following Snedecor and Cochran (1967).

Results

Nesting density

During the 16 months' survey, nesting of *C. mydas* was observed only in December 2001 and January 2002. A total of 194 nests were recorded. The density of nests was high (14.3 nests/km) in Transects 5 and 9 (Table 1). The mean density in the 38 km stretch was 5.1 nests/km. In all the 11 transects, the beach was generally plain with sandy slope of 10 to 60 m from the HTL. However, in some transects the beach sand extended up to 150 - 200 m, beyond which, vegetation was seen. Transects 5 and 9, where the nesting density was high, were characterized by rocky patches in the foreshore waters.

Nest soil characteristics

The nest soil *p*H ranged from 8.41 to 8.73, and the salinity from 0.17 to 0.61 ppt (Table 1). The difference between the lowest and highest *p*H values (t=9.09) and

between the lowest and highest salinity values (t=5.66) were statistically significant ($p<0.05$). However, there was no correlation between the nest density and these parameters.

Except in Transect 8, the particle diameter in the nests of all other transects was below 0.7 mm, indicating preference for beaches with small soil particle size (Table 1). The mean particle diameter in the area of highest nesting density (Transects 5 and 9) was 0.506 and 0.622 mm, respectively.

The moisture content of the nest soil decreased with increasing distance from the HTL. At mid-depth of the nest, the mean moisture content of the soil was 3.60 ± 0.50% within 20 m which further decreased to 1.12 ± 0.5% between 100 and 130 from the HTL. Thus the moisture content of the soil was negatively correlated with the distance from the HTL (r=0.973).

Nest characteristics

The nests were found between 12 m and 130 m from the HTL. Highest concentration was within 20 m from the HTL (Fig.2). Nearly 90.8% of the nests were between 12 m and 40 m from the HTL.

The depth of nests ranged from 62 to 122 cm (n = 35). In the 35 nests observed, 22 of them showed a depth varying between 71 and 80 cm and 81 and 90 cm (Fig. 3). The mean depth of 35 nests was 82.5 cm. The nest depth increased with increasing distance from the HTL (r = 0.772) (Fig. 4). However, beyond 100 m from the HTL, the nest depth decreased.

Table 1. *Nest soil pH, salinity, particle diameter and nest density (number of clutches/km) along the Mangrol - Porbandar coast.*

Transect	*p*H	Salinity(ppt)	Particle diameter (mm)	Nest density/km
1	8.55 ± 0.03	0.25 ± 0.05	0.630 ± 0.02	2.8
2	8.55 ± 0.59	0.61 ± 0.10	0.662 ± 0.04	3.3
3	8.53 ± 0.16	0.22 ± 0.05	0.602 ± 0.13	1.5
4	8.72 ± 0.14	0.28 ± 0.13	0.597 ± 0.13	2.5
5	8.73 ± 0.03	0.61 ± 0.11	0.506 ± 0.06	14.3
6	8.50 ± 0.05	0.30 ± 0.02	0.651 ± 0.04	2.3
7	8.61 ± 0.19	0.22 ± 0.05	0.573 ± 0.09	1.6
8	8.41 ± 0.04	0.17 ± 0.004	0.825 ± 0.22	9.7
9	8.49 ± 0.11	0.19 ± 0.001	0.622 ± 0.04	14.3
10	8.64 ± 0.11	0.28 ± 0.09	0.654 ± 0.02	3.3
11	8.57 ± 0.20	0.22 ± 0.05	0.648 ± 0.03	3.5
Mean	8.57 ± 0.09	0.30 ± 0.15	0.633 ± 0.08	5.1

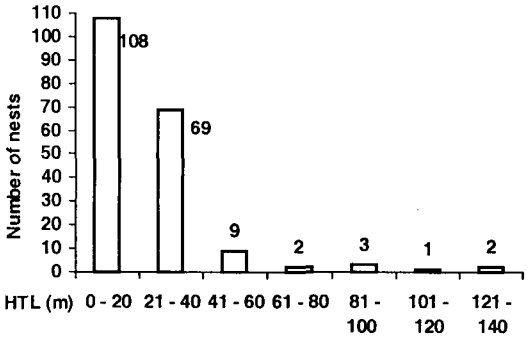

Fig. 2. *Nest placement from High Tide Line (n=194)*

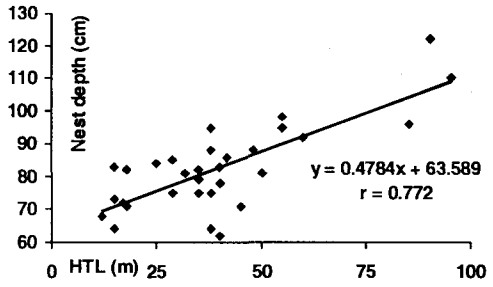

Fig. 4. *Relationship between distance from High Tide Line and nest depth n=35)*

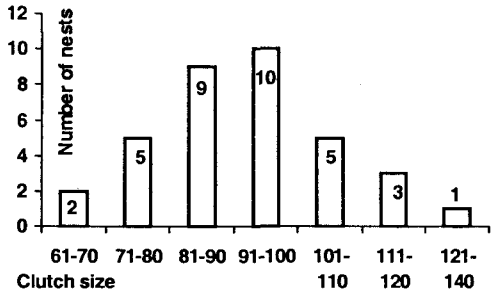

Fig. 5. *Frequency of clutch size (number of eggs); n=35*

Clutch characteristics

The number of eggs ranged from 61 to 135 (n=35) with a mean of 92.6 ± 15.20 and it showed variations (Fig. 5).

Egg characteristics

The egg of the green turtle is spherical in shape and milky white in colour. The shell is flexible and leathery. The weight ranged between 40.8 - 55.5 g (mean 44.6-49.6g). There was no significant interclutch difference in the mean weight of individual eggs (F= 0.433; p>0.05) and in the mean egg weight between the 29 clutches (F=1.438; p>0.05). There was no correlation between the clutch size and egg diameter.

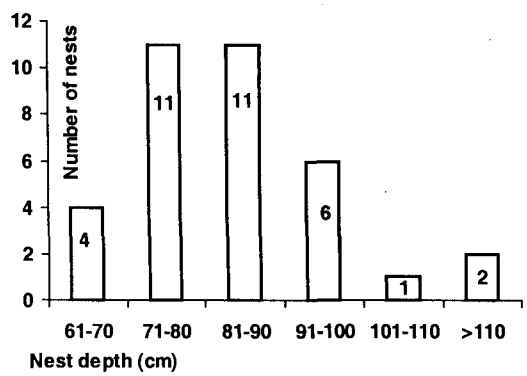

Fig. 3. *Frequency of nest depth (n=35)*

Hatching and emergence success

With increasing distance from the HTL, the hatching and emergence success decreased (Fig. 6). The emergence of hatchlings from nests was observed in the last week of January. The hatching success for 7 nests (which escaped predation) ranged between 71% and 86% and the emergence success varied from 68 - 82%. It appeared that the eggs need about 3.6% moisture content in the nest soil for higher success in hatching.

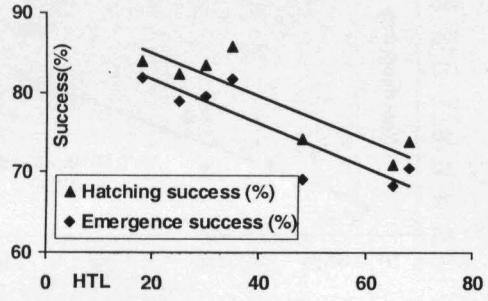

Fig. 6. *Relationship between High Tide Line and hatching and emergence success*

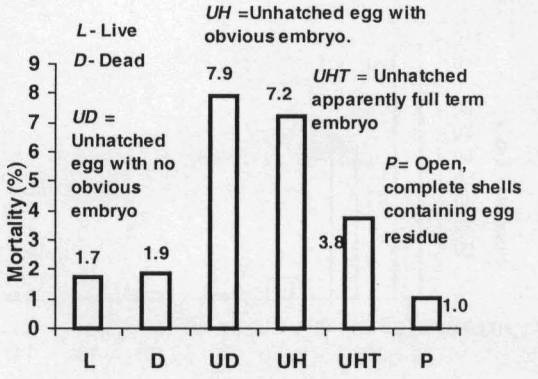

Fig. 7. *Causes for failure in egg development in natural nests (n=7)*

Failure in egg development

Causes for the failure in egg development, i.e., unhatched eggs with no obvious embryos, unhatched eggs with obvious embryos, unhatched apparently full term embryos in egg shell, and open, nearly complete shells containing egg residue were assessed for 7 natural nests. The major causes for the failure was unhatched egg with no obvious embryo (7.9% of total number of eggs) and unhatched egg with obvious embryo (7.2%) (Fig. 7). There were also instances in which the hatchlings died (2%) in the pipping stage and some hatchlings (2%) were alive but could not emerge out of the nest.

Total number of hatchlings

Of the 194 nests, it was observed that 48 were dug open by the wild animals, which predated all the eggs except the shells. Some nests were partially destroyed and few eggs were left undestroyed. However, these eggs did not hatch since they were subject to direct sunlight and heat. It is estimated that out of 17,964 eggs laid, 4,445 were predated and only 10,936 hatchlings emerged and reached the sea (Table 2).

Table 2. *Hatching (HS) and emergence (ES) success of Chelonia mydas eggs in relation to distance from the high tide line*

Distance (m)	No. of nests	Predated nests	Intact eggs	Total	HS (%)	No. of hatchlings	ES (%)	No. of emergence
< 20	108	27	81	7574	83.8	6347	81.9	6203
21 to 40	69	17	52	4862	83.9	4079	80	3890
41 to 60	9	2	7	655	74.1	485	69.1	453
61 to 130	8	2	6	561	72.5	406	69.5	390
Total	194	48	146	13652		11317		10936

Discussion

In the present study, a total of 194 nests (5.1/km) of the green turtle were recorded. Sunderraj *et al.* (2002) recorded 76 nests between Bhara and Navabandar along the Saurashtra coast in September 2000 (1.3 nests/km). The nesting density of green turtle was 4.6 nests/km and 4.2 nests/km in December 1980 and October 1981 respectively along the 110 km stretch from Veraval to Porbandar (Bhaskar, 1984). These studies indicated that the nesting season for the green turtle extends from September to January with peak in December and January along the Saurashtra coast.

The mean clutch size of *C. mydas* varied greatly (61 - 135 eggs) from one nest to another. Hirth (1980) compiled the available information from different beaches and reported that the clutch size of *C. mydas* ranged from 81 to 147 eggs. The variation in the clutch size of the green turtle is greater than that of the egg size. The egg diameter and weight were found to be 44.9 mm and 44.5 g respectively. Studies on this aspect by Hirth and Carr, 1970; Hughes,1974; Limpus *et al.*, 1984; Ackerman, 1981; Booth and Astill, 2001; have indicated no variation in the egg size of the green turtle populations in different parts of the world.

The clutch weight increased in proportion to the number of eggs in the clutch. Perhaps larger clutches were laid by larger specimens. It is known that the same female may nest 2 or 3 times in one season and it is possible that the clutch size in the later nestings of the same season would be smaller. Nevertheless, the eggs are of specific size irrespective of the size of the adults and the sequence of nesting. There was no correlation between the nest density, *p*H and salinity in the soil.

The soil particle diameter also did not influence the nest site selection. However, texture and mineral composition of the soil are considered to be the properties most obviously correlated with clutch survival (Mortimer, 1990). He pointed out that mean particle diameter less than 0.75 mm was having maximum percentage of emergence success. Of the 11 transects surveyed during the present study, 10 of them were ideal for the green turtle as the mean particle size was below 0.7 mm (mean 0.63mm).

The nesting density increased with increase in water content in the soil upto 3.6%. Mortimer (1990) also observed that the hatching and emergence success of the green turtle depended on the percentage of soil moisture content at Ascension Island. The highest hatching and emergence success was observed in the nests located within 20 m from the HTL with the highest moisture content (3.6%). The eggs of sea turtles are non-cleidoic and they continuously import water through the flexible shell from the surrounding soil (Venkatesan, 2003). Hence, optimum moisture content in the nest soil is a prerequisite for successful development of the embryo. Deeper nests probably ensure stable temperature and moisture conditions. In the present observation, the mean hatching and emergence success were

80.1% and 75.7%, respectively. Broderick and Godley (1996) estimated the hatching success of C. *mydas* as 80 - 85 % at northern Cyprus beach, which was higher than the success for C. *caretta* that nested in shallower pits in the same study area.

It could be concluded from the present study that the placement of nests in relation to distance from the HTL, nest depth, soil particle size and soil moisture content influence the nest site selection, hatching and emergence success. It is also possible that the green turtle may use several other multiple cues for nest site selection (Wood and Bjorndal, 2000), some of which have not been investigated in the present study.

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