RESEARCH ON NESTING ECOLOGY OF GREEN SEA TURTLES ON WAN-AN ISLAND, PENGHU ARCHIPELAGO, TAIWAN: A TEN-YEAR REVIEW *

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Wan-an Island is a major green sea turtle nesting site in Taiwan. With support from the Council of Agriculture, a project on research and conservation of green sea turtle has been carried out since 1992. The nesting beaches was formally declared as a national wildlife protected area in early 1995. From 1992 until 2002, the nesting ecology of green sea turtles on Wan-an Island was studied. The nesting season lasted from mid-May to late October, with a peak in July and August. The nesting population ranged from 2 to 19 females. The size of nesting females ranged from 84.9 to 115 cm SCL. Each turtle emerged 1 to 20 times and deposited 2 to 5 nests per season. The nesting success ranged from 45 to 100%, and was influenced mainly by the beach compactness 30 cm below the surface. The incubation period ranged from 48 to 56 days, and hatching success ranged from 49 to 87%. Satellite telemetry studies revealed that the nesting population is a shared natural resource among nations in East Asia. Support from the Government, NGOs, press media and private industries has generated a public awareness campaign for wildlife conservation. A Sea Turtle Exhibition and Conservation Hall was opened on the island in late September 2002 which will act as a stepping stone for more collaborative activities between research and conservation entities.

NEST SITE FIDELITY OF GREEN TURTLES ON THE REKAWA TURTLE ROOKERY IN SOUTHERN SRI LANKA

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Introduction

All species of marine turtles migrate from their feeding grounds to nesting sites and return back with a high degree of accuracy (Miller, 1997). With the use of tagging and satellite telemetry, it has been found that marine turtles can migrate thousands of km between feeding and nesting grounds (Balazs, 1980). Green turtles migrate across international borders, while flatbacks rarely migrate beyond the Australian continental shelf (Limpus and Miller, 1993). Migration is an important and integral part of the turtles' life history strategy and the majority of migrating, adult female green turtles exhibit regional homing and strong nest site fixation in their re-nesting activities (Mrosovsky and Provancha, 1992). The short and long-range orientation and navigation mechanisms remain unknown (Hirth, 1997). Lohmann et. al. (1997) put forward a hypothesis for the turtle navigation mechanisms which include:

1. The chemical imprinting hypothesis including chemosensory cues in long-distance navigation and chemical cues in natal beach recognition
2. Magnetic map hypothesis.

But none of this has been confirmed. All species of turtles migrate to varying degrees. Using genetic studies it has been demonstrated that marine turtles return to their region of birth, but may not necessarily return to the beach of birth (Miller, 1997.). When a female turtle returns to the region of its birth and selects a nesting beach, the turtle will tend to re-nest within close proximately to its previously laid nest during the same nesting season. The inter-nesting intervals range from 12-15 days for loggerheads, greens, black turtles, hawksbills and olive ridleys. For the flatbacks it is 13-18 days and for leatherbacks, 9-10 day intervals.

Most of the turtle populations have individuals that display both regular and irregular re-nesting behaviour (Hughes, 1982). In Rekawa, eight green turtles nested within the same 2 km stretch of beach, in the same nesting season, and this was repeated in the next nesting season, which occurred after a gap of 2.5 to 3.5 years (Ekanayake et al., 2001).

Materials and Methods

A 2050 m stretch of beach on the project site (Rekawa beach) was marked by wooden posts at 50-meter intervals starting from 0 to 41 from right to left. Each post was marked with a number and the distance in meters that the post represented. Five nesting hawksbills were observed about one kilometre away from the survey area. All nesting turtles were tagged when they were covering their egg chamber. Two kinds of tags were used: Dalton Flexi Rototags (plastic, Dalton Supplies Ltd., England) and Titanium tags (metal, Stockbrands Co Pty. Ltd., Western Australia). A number and the TCP address were printed on both tags. When a turtle nested, the nesting site was recorded relative to a pair of beach posts. The distance to the nest from the vegetation line was also measured for some of the green turtle nests. The number of turtles attempting to re-nest within a single fifty-meter interval was observed.

Results

Six hundred and sixty four turtles from five species were observed nesting within the beach posts. Of these, 483 turtles (74.8%) re-nested at least once within the site and 163 turtles (25.2%) nested only once. Of the five species, only the green turtles came ever re-nested within the same 50 m interval, of which 230 nested at least twice in same location and one laid eight times in the same location.

Discussion

The remigration intervals for green turtles in Sarawak (Malaysia) was three years, Heron Island (Australia) 4.6 years, Melborne (Australia) two years and Tortuguero (Costa Rica) three years. We recorded a remigration interval for eight green turtles of 2.5 to 3.5 years in Rekawa beach.

When a turtle returns to its region of birth and selects a nesting beach, the turtle has a tendency to re-nest in relatively close proximity (0 to 5 km) to the original nest during the consequent nesting attempts within that nesting season. Green turtles especially show a high degree of nest site fidelity (Miller, 1997). According to our observations, 74.8% of turtles came to re-nest in the Rekawa beach at least once during the same nesting season and were mostly green turtles (the renesting occurrence for olive ridley was only 5.6%, for leatherbacks 39% and for loggerheads 16.6%). Based on these results it is clear that the green turtles have a high degree of nest site fidelity, but because 92.3% of the total number of turtles that nested in Rekawa (648) were green turtles, it is difficult to state conclusively that other turtles do not also have a high degree of nest site fidelity, given the low numbers that were observed.

The number of re-nesting events for the green turtles within a same location is shown in Table 1. We observed 313 green turtle re-nesting events in the same location of which 230 nested at least twice and nested eight times at about two weeks intervals. This suggests the turtle was able to identify and remember the nesting location for a long period. While some of these turtles laid in the other locations of this beach, what is noteworthy is the degree of nest site fidelity, whereby they returned to the place where they nested earlier. Miller (1997) states that the green turtles show a high degree of nest site fidelity among the marine turtles, and the observations made during this study confirm the findings of Miller (1997).

Table 1. The number of re-nesting times for the green turtles within a single fifty meter interval (same location)

Frequency of re-nesting within same location	Number of turtles re-nested within same location
1	*283
2	230
3	60
4	17
5	5
6	0
7	0
8	1

* No re-nesting

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HATCH RATES OF THE LEATHERBACK TURTLE (*DERMOCHELYS CORIACEA*) ON TWO MAJOR NESTING BEACHES IN SURINAME

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Introduction
Leatherback nest numbers in Suriname, South America, are amongst the highest world-wide, with estimated numbers of nests of 14,300 in 2000, 30,000 in 2001 and 12,750 in 2002 (Hilterman and Goverse 2002, 2003). Peak nesting occurs between April and August. Nest survival and hatch rates were determined in 2001 and 2002 for the two major leatherback nesting beaches, Babunsanti and Matapica. Babunsanti is in the Marowijne river estuary. Matapica is on the Atlantic coast. Beach morphology, sand type, salinity, sand turn-over, and vegetation cover differ between the beaches. The objective was to determine hatchling recruitment for Suriname and to see if differences in hatch success were typical for the beaches.

Methods and Materials
In 2002, a random selection of 162 nests on Matapica and 188 nests on Babunsanti were marked by triangulation. Nests were excavated three days after first hatchling emergence or 75 days after oviposition in the case of non- or unnoticed emergence. Hatch success (H%) = empty shells / total number of eggs (empty shells + pipped eggs + all non-hatched eggs, yolkless eggs not included). Successful nests are defined as nests from which one or more eggs had hatched. Emergence success (E%) was calculated by subtracting dead hatchlings and stragglers from the number of empty shells. Nests that had possibly been disturbed during marking were excluded for the determination of overall *in situ* hatch rates.

Results
For both years, hatch rates were remarkably higher on Matapica than on Babunsanti (Mann-Whitney U, $p<0.001$). In 2002, on Babunsanti, 25.9% of the marked nests failed to hatch. Of the successful nests, hatch success was 34.9% and emergence success was 33.2%. On Matapica, 12.0% of the nests failed to hatch, and hatch success of the successful nests was 63.7% and emergence success was 63.0% (Table 1, Fig.1). On Babunsanti, 93% of all nests showed signs of mole cricket predation. On Matapica, this was 83%. Egg predation per nest by the mole cricket, embryonic mortality of non-predated eggs, and the fraction of pipped hatchlings were significantly higher on Babunsanti ($p<0.05$) (Fig. 2). Mean clutch size was 85.0 ± 18.2 yolked eggs and 31.9 ± 18.0 yolkless eggs. The mean incubation period was 67.0 ± 2.3 days (n=123) on Matapica and 64.8 ± 3.2 days (n=86) on Babunsanti.

Discussion
Hatch rates as shown in the present study were significantly higher than previously reported for Surinam beaches (Hoekert 2000, Whitmore and Dutton 1986) and considered more reliable and representative because of a more random and less disturbing way of marking nests. The low hatch rates found on Babunsanti may be replicated on other beaches in the Marowijne river estuary like Yalimapo in French Guiana and may have a significant impact on population recruitment, as 15,000-30,000 nests are laid