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OBSERVATIONS ON A LEATHERBACK TURTLE *Dermochelys coriacea* NESTING POPULATION NEAR PIGUWA, PAPUA NEW GUINEA

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Abstract

Some aspects of the reproductive biology and conservation of leatherback turtles Dermochelys coriacea *on an important nesting beach near Piguwa, Papua New Guinea, were studied in December 1989. Leatherbacks had an average overcurvature standard carapace length of 161·35 cm and laid a mean of 88·2 eggs. The eggs had a mean diameter and weight of, respectively, 52·20 mm and 81·05 g. Statistically significant positive relationships were found between the carapace lengths of nesters and the sizes and weights of their clutches. Nesters spent an average of 74 min at the nest site. The nests were about equally distributed on the front and rear halves of the beach and only a few nests were constructed below the beach scarp. Leatherback eggs, an important source of protein and currency for local inhabitants, are heavily harvested in December and January. A high-density nesting section of the beach was recommended for Wildlife Management Area (WMA) status. This means that the traditional beach owners, with the support of the federal government, would regulate the sustainable harvesting of leatherback eggs on the WMA. Ecotourism, centered on the nesting leatherbacks, is a distinct possibility.*

Key words: Papua New Guinea, leatherback turtle, turtle conservation.

INTRODUCTION

The leatherback turtle *Dermochelys coriacea* is unique among marine turtles. It is easily recognizable by the leathery shell with its longitudinal keels, and is the largest living turtle. It has an extensive circumglobal distribution and is chiefly oceanic, except when nesting. Nesting populations in many places around the world, however, are declining, due mainly to excessive egg exploitation and human encroachment on the nesting beaches. Leatherbacks are also eaten in some places, and they are subject to incidental drowning in fishing gear. For these and other reasons, the leatherback is classified as an endangered species by the International Union for Conservation of Nature and Natural Resources (Groombridge, 1982). It is also listed on Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), which means that international trade in the species or its products is prohibited between signatory nations, except under exceptional circumstances.

Little scientific information is available about leatherbacks in the Southwest Pacific Ocean. A few females nest in Australia and in the Fiji Islands; there is scattered nesting in the Solomon Islands; a few individuals have been sighted at sea in various areas of the Southwest Pacific Ocean; and the recently discovered nesting colony on Kepala Burung in Irian Jaya is now being monitored (summarized in Hirth, in press).

In Papua New Guinea (PNG) Pritchard (1979), Spring (1982*a*) and Lockhart (1989) distributed questionnaires, conducted interviews and made some village surveys. They also documented some sightings and nestings of the leatherback there. Quinn and Kojis (1985) estimated that ten leatherbacks nested nightly, during the nesting season, on the southern coast of Morobe Province, PNG, near Maus Buang (= Piguwa in this paper).

The purposes of this paper are to describe some of the salient aspects of the reproductive biology of the leatherback turtles nesting near the village of Piguwa, and to discuss the threats to and conservation of the nesting colony. This may be one of the largest leatherback cheloneries in the Southwest Pacific Ocean.

Two species of sea turtles are found in the area between Labu Tali and Busama (Fig. 1). The leatherback turtles, locally called hanna, nest mostly between November and March with a peak of nesting in

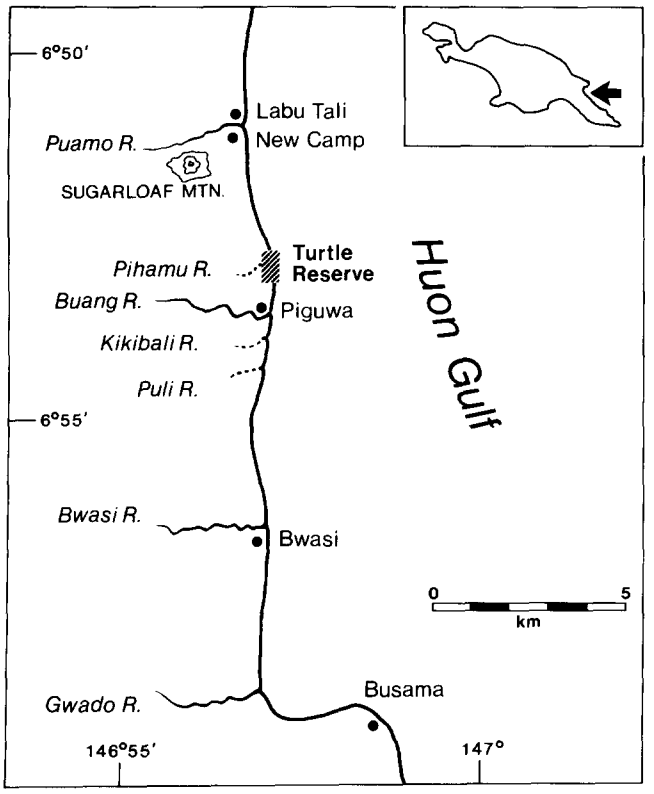

Fig. 1. Map of the study area showing localities mentioned in the text. Dashed lines are temporary rivers. The arrow indicates the study site in the insert map of New Guinea.

December and January. Their eggs are eaten or sold, but the meat is not eaten. Green turtles *Chelonia mydas* (locally, mungalu) are occasionally caught in fishing nets during regular fishing activities, and they are eaten.

METHODS OF STUDY

The leatherbacks nesting near Piguwa were studied between 1 and 15 December 1989. Turtles were tagged on the trailing edge of each front flipper with conventional metal tags. Three carapace measurements were taken (±0·1 cm): overcurvature total carapace length was measured with a flexible tape, lying in the groove between the anteriormost and posteriormost projections of the carapace; overcurvature standard carapace length was measured with the tape lying alongside the median dorsal keel and extending from the anterior notch to the posteriormost extension of the shell; and overcurvature carapace width was taken with the tape extended between the shell's widest points, perpendicular to the long axis of the body.

Most clutches, and individual eggs, were weighed (to the nearest 0·05 kg and 0·05 g respectively) immediately after laying, and all were processed within six hours of oviposition. Loose sand was carefully wiped from the eggs before processing. Maximum diameter of eggs (±0·5 mm) was taken with vernier calipers. In this paper, the words 'eggs' and 'clutch' refer to normal-sized, yolked eggs. Also laid with normal eggs are small, yolkless eggs which are identified as such in the text. Statistical data were analyzed on a computer using the package JMP, V1.0.5 (SAS Institute Inc., 1988–1990, SAS Campus Drive, Cary, North Carolina, USA). Some data were transformed to common logarithms to satisfy statistical assumptions.

DESCRIPTION OF THE NESTING BEACH

During our study period, the high-energy nesting beach had a linear shoreline and a moderate slope. The beach is intersected by several permanent and seasonal rivers. While we were there, three rivers (Puli, Kikibali and Pihamu) broke through the berm, as indicated in Fig. 1. The breaching can occur at different times of the year and at different sites, depending upon the weather. Leatherback eggs are exposed and destroyed when this occurs during the nesting season. Sugarloaf Mountain (elevation 387 m) is a conspicuous landmark.

The width of the nesting beach between New Camp and Bwasi varied from 0 to 30 m. The configuration and width of the nesting beach changes during the year, being affected by monsoons and by the rivers breaking through. Inland from the nesting beach are areas of rainforests, swamps, lagoons, and sites of slash-and-burn agriculture. A leatherback turtle 'reserve' has been unofficially established near Piguwa, and in December 1989 this was 725 m in length. No turtle eggs can be collected on this 'reserve'. A local committee oversees the 'reserve', and it is kept in as natural a condition as possible. Conspicuous shrubs at the rear of the 'reserve' are *Scaevola taccada* and *Hibiscus tiliaceus*. *Ipomoea* sp. and *Cyperus pedunculatus* are common plants in the middle of the 'reserve'. In some places, in the 'reserve' and along the nearby coast, the berm was littered with natural debris such as large logs, bamboo and coconut husks. Fortunately, we saw no anthropogenic debris like plastics or fishing line, nor did we see any tar balls.

Sand samples were taken from a depth of 0–5 cm at five sites, 5 m apart, in the middle of the 'reserve'. The composite was then analyzed using conventional techniques. The nesting beach here is composed of moderately sorted, medium-grain sand which has a pH 7·6. The color is gray (5Y 5/1, Munsell Soil Color Charts, 1975 edition) when dry and very dark gray (5Y 3/1) when moistened to field capacity.

The mean December, January and annual rainfall at the city of Lae (approximately 18 km straight-line distance from the turtle 'reserve') are 332, 267 and 4617 mm, respectively. The average December, January, and annual air temperatures at Lae are 27·1, 27·5 and 26·3°C, respectively (McAlpine *et al.*, 1975). In general, the climate around the leatherback nesting beach can be described as tropical rainy with no dry season (Köppen, 1936).

RESULTS AND DISCUSSION

When we arrived at the study site on 1 December, there were nine old body pits (i.e. up to about two months

old) on the turtle 'reserve'. Seven of these were on the front half of the nesting beach and two on the rear half. There were 22 old body pits between the 'reserve' and Labu Tali. Nine of the pits were situated below the beach scarp, nine were on the seaward half of the berm, and four were on the back half. During our study, only one turtle nested below the beach scarp. Eggs deposited below the scarp are probably destroyed by salt water infiltration. There were 117 old body pits between the 'reserve' and Bwasi, and these were nearly equally distributed across the berm. As described below, the presence of a body pit does not always signify that eggs were laid.

Thirty-four leatherbacks nesting between Labu Tali and Busama were tagged and measured, and we are certain that a minimum of 76 clutches were laid on this section of the coast between 1 and 15 December. The nesting was most dense between the Buang River and the Bwasi River. Of the 76 clutches, 40 and 36 were laid on the front and rear halves of the berm, respectively. The direct and indirect evidence indicates that, at least in the early weeks of the 1989–90 nesting season, the nests were located about equally across the berm, and very few nests were made below the beach scarp. This contrasts with some other leatherback colonies where, given a good sample size, up to about 50% of the nests may be laid below the high tide line (Mrosovsky, 1989). Quinn and Kojis (1985) estimated that ten turtles nested each night from November to January between Labu Tali and Busama and, considering an average of five renestings, they estimated that up to about 200 females may nest annually between these two villages. Bedding and Lockhart (1989) estimated that about 300 turtles nested annually in the area. Scientists are now conducting a long-range study of the nesting colony.

The overcurvature total carapace length of the 34 tagged turtles averaged 169·48 cm (SD 8·74, range 155–186·1 cm), the overcurvature standard carapace length averaged 161·35 cm (SD 8·77, range 145·1–180 cm), and the mean overcurvature carapace width was 114·78 cm (SD 5·48, range 104–128·4 cm). Quinn and Kojis (1985) found that the average carapace length of some nesters in the Piguwa area was 165 cm (range 110–190 cm, method of measuring not given). Unfortunately, researchers have measured leatherbacks in different ways, so accurate comparisons of nesters among different colonies are difficult. However, based on carapace length, the Piguwa area nesters appear to be among the larger leatherbacks in the world (cf. Hirth, 1980; Limpus *et al.*, 1984; Pritchard & Trebbau, 1984; Hirth & Ogren, 1987).

Of the 34 nesters tagged, 24 had one or more very visible recent or old injuries. The most common were wounds on the front and rear flippers. Cuts and scars on the head, neck and shoulders were less common. Two individuals had large pieces of the carapace missing (local fishermen identified the wounds as shark bites), and one female had a fresh crocodile bite on the side of the head. On the night of 5 December, one crocodile left the lagoon and crossed the berm near the 'reserve' and killed a leatherback in shallow water by biting off the head. Two nesting turtles had remoras attached to them. Of the 34 nesters, equal numbers oviposited before and after midnight. One-third of the nestings took place in rain. One turtle nested on 2 December near the Buang River and renested 10 days later 75 m south of its earlier nesting site. The average number of eggs in 37 clutches was 88·2 (SD 20·15, range 42–118). Quinn and Kojis (1985) found a mean clutch size of 92·3 (range 12–145).

Twenty eggs selected at random from 17 clutches were weighed and measured. As expected, there was a strong relationship between weight and diameter of eggs (Table 1, A). The mean diameter and weight of the 340 eggs were, respectively, 52·20 mm (SD 2·34, range 46–58 mm) and 81·05 g (SD 6·26 g, range 62–96·05 g). Mean egg diameters at some of the well-known leatherback colonies range between 50 and 55 mm (Hirth, 1980; Hirth & Ogren, 1987).

Table 1. Regressions (Y on X) of carapace lengths and egg traits of leatherback turtles at Piguwa, PNG
(Equation is the form $Y = a + bX$, where a is the intercept and b the slope. $^{*}p < 0{\cdot}01$, $^{**}p < 0{\cdot}001$. Carapace length is the overcurvature, standard measurement)

	Regression	Intercept	Slope	N	t	r^2	Range of X values
A	Log weight eggs, g (Y) Diameter eggs, mm (X)	1·439 5	0·008 9	340	13·63**	0·354**	46–58
B	Number yolkless eggs (Y) Number normal eggs (X)	56·033 3	−0·312 0	37	−2·93*	0·200*	42–118
C	Clutch (Y) Carapace length, cm (X)	−111·412 8	1·225 3	28	3·65*	0·338*	146–180
D	Log weight clutch, kg (Y) Carapace length, cm (X)	−0·806 4	0·010 4	20	4·46**	0·525**	146–175
E	Mean diameter eggs, mm (Y) Carapace length, cm (X)	35·760 3	0·101 6	17	1·76	0·172	146–175
F	Mean log weight eggs, g (Y) Carapace length, cm (X)	1·661 0	0·001 5	17	1·90	0·194	146–175

The number of yolkless eggs in a clutch was negatively related to the number of normal eggs (Table 1, B). Chua and Furtado (1988) found a similar relationship among leatherback clutches in Malaysia. The reason leatherback turtles lay a significant number of small, yolkless eggs along with the normal eggs remains a mystery and needs to be investigated. Most yolkless eggs are laid toward the end of oviposition.

Body size is closely related to traits describing a sea turtle's fitness. Statistically significant positive relationships were found between size and weight of clutch and the carapace length of nesters (Table 1, C and D). Approximately 53% of the variation in the weight of the clutch can be accounted for by carapace length. The mean diameter and mean weight of 20 eggs selected at random from 17 clutches were not significantly related to shell length (Table 1, E and F, $p < 0{\cdot}10$ and $p < 0{\cdot}08$, respectively). Hall (1988) did, but Tucker and Frazer (1991) did not, find a significant positive relationship between carapace length of females and clutch sizes among leatherbacks on Culebra Island, Puerto Rico. Hall (1988) also found that carapace length of nesters was positively correlated with egg and hatchling sizes. Hirth and Ogren (1987) found significant positive relationships between carapace lengths of nesters and their clutch sizes, average diameter and mean weight of eggs in Costa Rica. Future researchers at Piguwa, and elsewhere, should examine the numbers and sizes of eggs and hatchlings of different size nesters, over the entire nesting season, in order to get a better idea of fitness.

The nesting behavior of 13 leatherbacks at Piguwa (Table 2) was similar to that of leatherbacks elsewhere (Hirth & Ogren, 1987). More time was spent in filling the body pit and camouflaging the nest site than in any other stage of nesting. All 13 nesters dug shallow body pits (i.e. < 24 cm below the sand surface at the head end). The average straight line distance between 25 nests and the sea was 22·8 m (SD 6·70, range 11–35). Distances were measured at the time of oviposition.

The vast majority of turtles that we observed successfully nested at the site where they stopped crawling and constructed the body pit, but there were exceptions. One nester sporadically illuminated by flashlights of two egg poachers when she was ovipositing abandoned the nest and crawled back to the sea, voiding eggs along the way. Of three turtles that dug egg chambers near the Puli River, two abandoned the nest site after water seeped into the chamber (one returned to the sea, and the other crawled a few meters to higher ground and constructed another nest and oviposited), and the third oviposited in the chamber, which was about one-fourth filled with water. Another turtle in this area dug three shallow body pits and returned to the sea without nesting. One individual wandered extensively on a narrow berm between the sea and a lagoon, made an orientation circle on each of four very rudimentary body pits, and returned to the sea without nesting. It was a clear night, with a full moon, and reflections of light off the sea and lagoon may have disoriented her. On a similar night, a large female crawled into the lagoon after successfully nesting. We 'drew her out' of the lagoon by shining a flashlight on her head.

Table 2. Amount of time (min) used by 13 leatherback turtles in five nesting stages at Piguwa, PNG

Stage	Mean	SD	Range
Dig body pit	11·1	2·25	9–15
Dig egg chamber	18·6	4·63	9–30
Oviposition	11·1	3·00	8–18
Fill egg chamber	9·9	1·88	7–15
Fill body pit and camouflage	23·4	5·91	15–31

One local tradition of egg collectors is to place the small, yolkless eggs back into the egg chamber and cover them with sand, in the belief that the turtle will return to nest here. Another, less common, custom is to throw one yolkless egg in the direction one wishes the turtle to renest. This direction is toward the village so next time one has to walk less distance to find the nester.

EXPLOITATION AND CONSERVATION

At the time of our study, the total human population of Labu Tali, New Camp, and Piguwa was about 500, with Labu Tali being the largest village. Fish is the main source of animal protein year around, and taro and sweet potatoes are the staple food crops. However, leatherback eggs are important sources of protein for local inhabitants during the nesting season, and the eggs also represent an important source of currency. The leatherbacks are not eaten in the Piguwa area, but the meat is eaten in other parts of PNG (Pritchard, 1979; Spring, 1982*a*, *b*;, Lockhart, 1989). Many eggs are collected during the peak nesting period in December and January. Those eggs not eaten locally (usually boiled, sometimes smoked) are taken to Lae and sold in the main market there. The price of an egg in Lae in early December 1989 was 10 toea (= US$0·12). However, on 13 December 1989, all turtle egg vendors agreed to henceforth charge 20 toea per egg, which brought the cost up to that charged for one chicken egg. Personnel from the University of Papua New Guinea and from the Papua New Guinea University of Technology are currently monitoring the size of the nesting population and the magnitude of the egg exploitation at Piguwa and at other nesting sites along the coast. Elders in the villages along the coast believe that there were more nesting turtles in the olden days. We informed the villagers that excessive egg harvesting in Terengganu, Malaysia is one of the main reasons for the alarming decline in the well-known nesting population there (Chua, 1988).

We recommended that the strand between the Buang and Bwasi rivers be gazetted a Wildlife Management Area (WMA). Landowners and government officials are now considering this. The WMA would be extended if

the ongoing research indicates dense nesting elsewhere. A WMA is an area where traditional owners of the land and water control the conservation of the habitat and its natural resources (Kwapena, 1982; Spring, 1982*c*; Eaton, 1988). This means that the beach owners, with the help of a local committee and the backing of the federal government, could regulate the sustainable harvesting of leatherback eggs. PNG is a leader in the WMA-type of conservation strategy (Carew-Reid, 1990). This WMA would also include provisions for ecotourism—a popular idea among some of the village leaders. A few tourists now spend a couple of hours on the beach observing and taking pictures of nesting leatherbacks. They usually come from Lae, by boat, and are guided on the beach by local people. Some popular international tourist books now give the location of this leatherback nesting colony.

Local school children are very eager to learn about and conserve the leatherbacks, and they are an important potential cadre for conservation. The headmaster of the school in Piguwa, with the help of the school children is keeping a logbook of the year-around nesting activity on the 'reserve'. A brief history of the establishment of the turtle 'reserve', the involvement of the school children, and the tourist potential is described by the Turtle Committee (1988). Local leaders are cognizant of the restrictions that must be placed on beachfront development, artificial lighting, and human activities in order to maintain the nesting beach and adjacent neritic zone in as natural (and, hence, biologically productive) a condition as possible. With proper guidance of the villagers, the leatherback turtle nesting colony at Piguwa will endure.

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