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Leatherback Turtles, *Dermochelys coriacea*, Nesting in French Guiana, 1978–1995

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ABSTRACT. – Ya:lima:po beach in French Guiana exhibits the highest concentration of leatherback (*Dermochelys coriacea*) nesting in the world. Scientists and volunteers from more than 25 countries have worked within the Kawana marine turtle project for 16 years. Numbering and tagging of leatherbacks has been the main activity of this project. Number of nests per year has been estimated for 13 nesting seasons between 1978 and 1995. More than 50 thousand nestings were recorded annually in 1988 and 1992, but only 10 to 15 thousand annually in 1978–86, 1993, and 1995, with intermediate numbers of 20 to 30 thousand annually in 1987, 1989, 1991, and 1994. A general increase in the number of nests has been observed in the last few years as compared to the first years, but the actual trend is unclear. Analysis of the database of tagged leatherbacks (over 31,000 data points) elucidates behavior of this species within and between nesting seasons.

KEY WORDS. – Reptilia; Testudines; Dermochelyidae; *Dermochelys coriacea*; sea turtle; nesting; status; population; conservation; migration; French Guiana

Four species of marine turtles nest frequently in French Guiana: *Dermochelys coriacea*, *Chelonia mydas*, *Lepidochelys olivacea*, and *Eretmochelys imbricata*. For every 1000 nests of *D. coriacea*, approximately 100 nests of *C. mydas*, 10 of *L. olivacea*, and 1 of *E. imbricata* are seen (these values are only approximations and should not be used for further calculations). Exceptionally, females of *Caretta caretta* are also observed but at a rate of less than one per year. Turtles nest on beaches located along the entire 400 km coast line of French Guiana. However, many of these beaches appear and disappear at an approximate cycle of every 15 years due to the displacement of mud banks from the Amazon River in Brazil. The only stable beach in French Guiana is located on the estuary of the Mana and Maroni Rivers on the border to Surinam, between two Amerindian villages, Awa:la and Ya:lima:po. Approximately 90 to 95% of all the leatherbacks nesting in French Guiana are seen there.

The nesting seasons of the various marine turtles in French Guiana extend from early March to mid-August for *D. coriacea*, March to June for *C. mydas*, and April to August for *L. olivacea*. Nesting seasons for *E. imbricata* and *C. caretta* cannot be defined due to the small numbers of these species. For *D. coriacea* a second nesting season with small numbers of females per night has also been observed in December and January. The same observation has also been made in Surinam (H. Reichart, *pers. comm.*).

The time of arrival for nesting on the beach by leatherbacks is dependent on the localization of the beach and the tide level. Turtles nest during the entire night on beaches outside the Mana-Maroni estuary but mostly around high tide for beaches within the estuary. However, time of nesting is also sensitive to the exact localization within the estuary and the tide level (Fretey and Girondot, 1989a).

Near Ya:lima:po village, a center (Kawana project) established 16 years ago for the study of marine turtles has welcomed scientists and persons interested in the protection and the study of marine turtles (Fretey, 1996). There, from 1984 to 1993, a turtle hatchery has permitted the study of artificial incubation of leatherback eggs (Lescure et al., 1985; Girondot et al., 1990) and the influence of temperature on sex determination (Rimblot et al., 1985; Rimblot-Baly et al., 1986; Desvages et al., 1993). Since 1993, the artificial incubation of eggs has been discontinued for ethical reasons (Mrosovsky and Godfrey, 1995; Girondot and Pieau, 1996; Lovich, 1996). Data obtained on *D. coriacea* during the past 18 years (1978–95) will be reviewed in this paper.

MATERIALS AND METHODS

Numbering. — Turtles are numbered by nightly beach patrols from mid-April to late September. Outside this period, two local inhabitants count turtle tracks in the morning. In *D. coriacea*, a very large proportion of females landing also nest and the number of turtle tracks is therefore a good estimate of the number of nests. However, this method is not suitable from May to July because too many turtle tracks are present on the beach and only visual counts of turtles seen during the night are used.

Since 1988, a strategy has been developed to allow a good estimate of the total number of nests without counting turtles each night. Data from the 1987 season were used as a reference because the number of females was known exactly for all nights of that season. The percentage of error between the actual number of nests and its estimate using interpolation was calculated. The error was minimized if counts were performed every 7 days with 5 days without counts between them (Fig. 1) and therefore this strategy has been used since 1988.

Tagging and Identification. — From 1978 to 1984, plastic tags were used, but females lost them very rapidly.

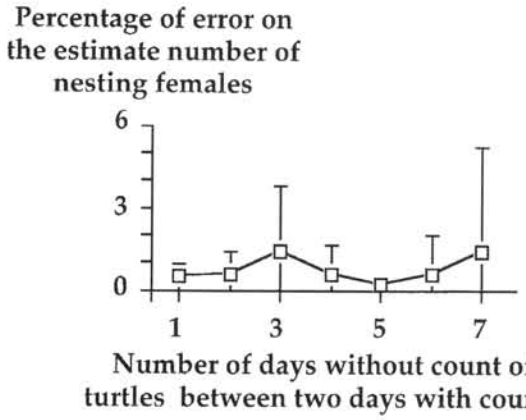

Figure 1. Percentage of error between the actual total number of nests seen in 1987 and its estimate using interpolation, based on different numbers of days between surveys.

From 1985, females were tagged using one titanium tag on the front left flipper (1985–86), one titanium tag on the rear left flipper (1987–88), or one monel tag on the rear left flipper (1990–93). In 1994, two monel tags were put on each rear flipper and in 1995, PIT (passive integrated transponder) tags were put in the right shoulder of 250 females.

RESULTS AND DISCUSSION

Morphometrics. — In 1987 and 1988, 1328 female leatherbacks were measured and 15 weighed. They had a mean weight of 339.3 kg, SD = 41.3 (range = 250–415 kg); a mean straight carapace length of 154.6 cm, SD = 8.98 (range = 127–252 cm); and a mean straight carapace width of 87.3 cm, SD = 6.21 (range = 67–109 cm).

Numbering. — The actual number of nests from 1978 to 1995 is shown in Fig. 2 (the estimates for 1978, 1982, and 1983 were performed with data of less than 2 months and only half the beach patrolled). More than 50 thousand nestings were recorded annually in 1988 and 1992, but only 10 to 15 thousand annually in 1978–86, 1993, and 1995, with intermediate numbers of 20 to 30 thousand annually in 1987, 1989, 1991, and 1994. A global increase in nesting has been observed since the earliest reports for French Guiana (Pritchard, 1969, 1973; Schulz, 1971). Moreover, old people of the villages say that leatherbacks did not nest on this beach during the 1950s. From year to year large variations in the number of nests are observed, and it is not possible to determine a trend for recent years.

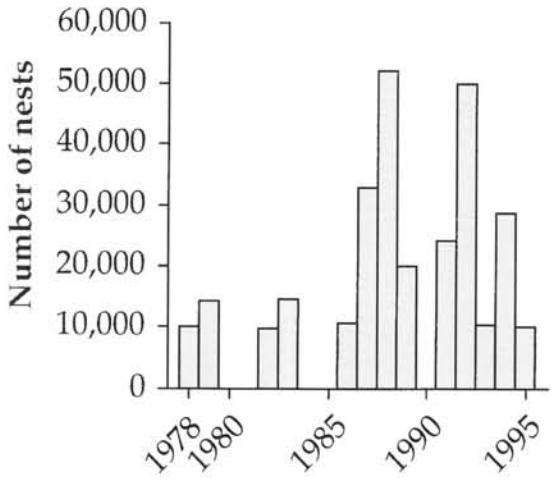

Figure 2. Number of leatherback nests per year on the Ya:lima:po–Awa:la beaches, French Guiana.

According to data from Surinam, concordance in the number of nests per year is observed for the two populations (data from Surinam are from Weijerman et al., in press). The correlation between the annual number of nests in French Guiana and Gandoca Beach, Costa Rica (Chacón et al., in press) is high but not significant (test for the data for 1991–92 and 1994–95, r = -0.787, $P = 0.28$). However, it is interesting to note that the year with the highest number of nests in French Guiana (1992) corresponds to the lowest number in Costa Rica and inversely, the year with the lowest number of nests in French Guiana (1995) corresponds to the year with the highest number of nests in Costa Rica. Data for more years are needed to confirm this pattern.

Tagging. — Our database of tagged turtles in French Guiana contains 31,557 data points extending over 9 years from 1987 to 1995. Analysis of this database permits us to elucidate some aspects of behavior within and between nesting seasons for *D. coriacea* in French Guiana, as outlined below.

Behavior Within Nesting Season. — For the 1988 season, the mean number of nests per female was estimated as 7.52 (Fretey and Girondot, 1989b). The estimate for 1987 was much lower (1.48; Fretey and Girondot, 1988), but the methodology was also different and the value is dependent on the relative tagging effort on the beach. Comparison of the two values for mean number of nests per female is impossible due to the lack of confidence intervals for the 1987 estimate. The 1988 estimate is more accurate but is probably subject to variation from year to year. The mean number of days between two nests varies from 6 to 15 with a mode of 9 to 10 (Fretey and Girondot, 1988). This observation is typical for *D. coriacea* (National Research Council, 1990). However, peaks of nesting are seen every 15 days during spring tides (full and new moon) on the Ya:lima:po beach (Fig. 3). These two observations appear to be contradictory.

We have analyzed whether females adjust their nesting day as a function of the tide (and by consequence, the moon phase). Using the 1988 tagging data, we analyzed all tagged females that nested between 14 to 11 (Group A) or 9 to 6 (Group B) days prior to a full or new moon. The distributions of the internesting intervals were then established for these two groups. Group A (-14 to -11 days) had a longer mean internesting interval of 10.01 days, Group B (-9 to -6 days) had a shorter interval of 9.76 days, with the difference significant ($G^2 = 42.6$, $P < .001$) (Fig. 4). Therefore, females adjust their internesting return date to be closer to a full or new moon and this behavior produces the observed peaks of nesting for spring tides.

We have very few data concerning shifting of nesting beach. Only two records of females tagged in French Guiana and recovered in Surinam are available (M. Godfrey, *pers.*

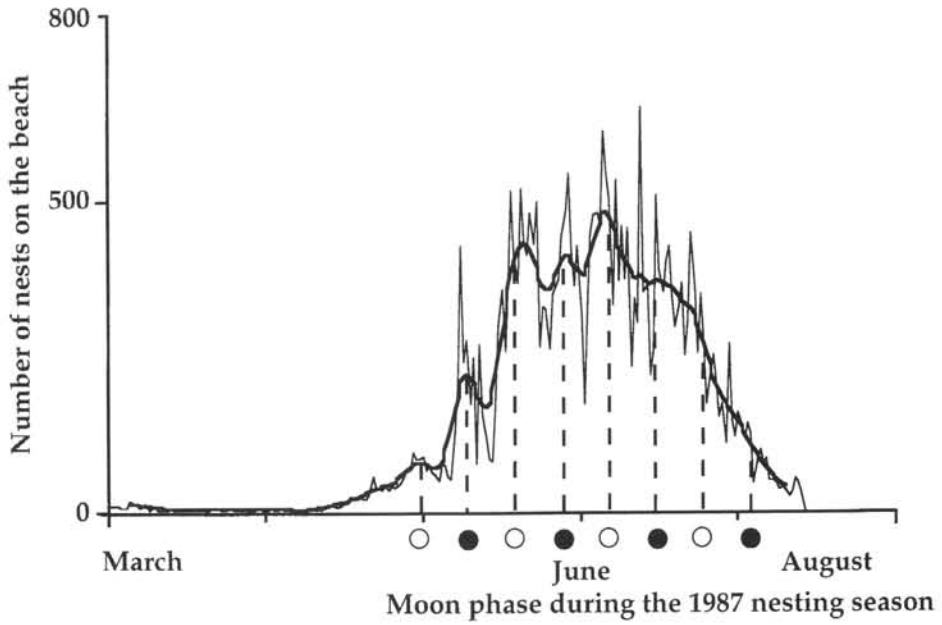

Figure 3. Number of leatherback nests during the 1987 nesting season (irregular fine line) and moving 15-day average for the same data (smooth bold line). Peaks of leatherback nesting are observed during spring tides (full and new moon; dashed lines).

comm.). One (G36490) nested and was tagged at Ya:lima:po in 1993 and was then seen to nest on Matapica Beach, Surinam, in 1995. Another (G36866) was tagged and nested twice at Ya:lima:po in 1991, was seen to nest on Matapica Beach, Surinam, on 5 May 1995, and then nested again two times at Ya:lima:po on 27 May and 24 June 1995. The Ya:lima:po and Matapica beaches are 150 km apart from each other. Apparently, a shift of nesting beach within the Guianas region is a possible but not frequent event.

Behavior Between Nesting Seasons. — From year to year, the number of turtles tagged in French Guiana and then recovered elsewhere within the Atlantic Ocean is growing (Table 1). Females are caught both on west and east Atlantic coasts. For example, female G41420/G45918 was captured in Spain only 5 months after its last nesting in French Guiana. Females G36302 and G43041/G43042 were also captured only 5 months after their last nesting in French Guiana, but this time on west Atlantic coasts in USA. One year after nesting in French Guiana, females have been seen on east Atlantic coasts (France, Spain, and Morocco) or on west Atlantic coasts (Florida, Georgia, and South Carolina). Female G34567/QQM631/G41593 was remarkable. It was first tagged in French Guiana in 1990, then seen alive in a fishing net in Florida in 1991 and re-tagged, and then re-observed nesting twice in French Guiana in 1992 and 1994.

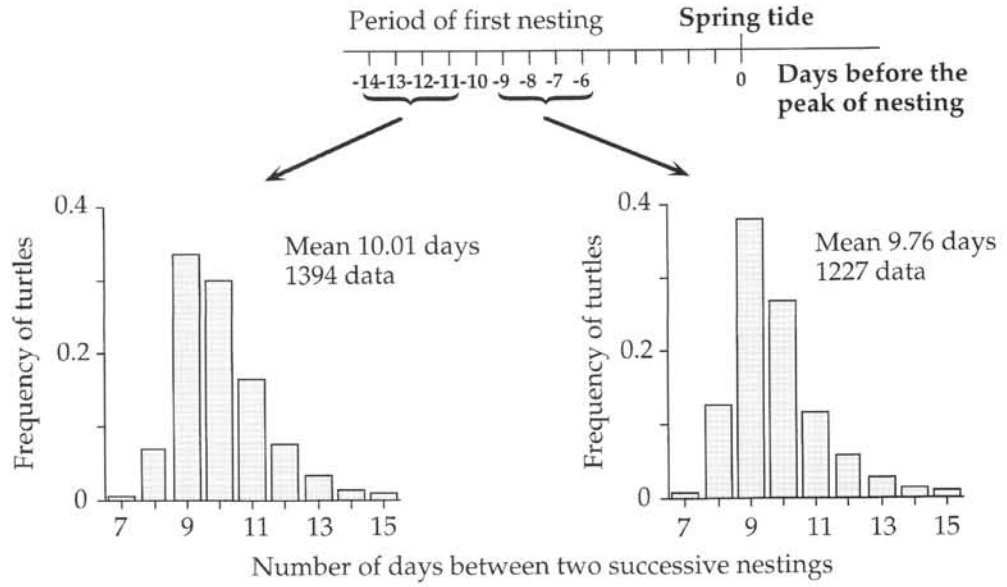

Figure 4. Distributions of the number of days between two successive nesting processes for turtles having nested (Group A) days -14 to -11 before spring tide (full and new moon) and (Group B) days -9 to -6 before spring tide, utilizing data from 1988.

Table 1. List of leatherbacks tagged in French Guiana and recovered elsewhere within the Atlantic.

Tag Number	Nesting Dates in French Guiana	Date and Location of Capture	Number of Months
	West Atlantic Captures		
G20024/ G31511	1985 14 May 1988	17 Feb 1989 Georgia, USA	9
G35151	29 Jun 1991	8 May 1992 South Carolina, USA	10
G36302	21 Jul 1993 1 Aug 1993	16 Jan 1994 Florida, USA	5
G38947	21 Jun 1990	12 Mar 1993 Florida, USA	32
G42743	27 May 1991	12 Apr 1992 Georgia, USA	10
G43041/ G43042	8 Jun 1994	7 Nov 1994 Georgia, USA	5
G23339	1987	Feb 1989 Georgia, USA	19
G25376	1988	Sep 1988 Newfoundland, Canada	4
G34567/ QQM631/ G41593	29 May 1990 7 Jun 1990 24 Jul 1992 4 Jun 1994 23 Jun 1994 3 Jul 1994	30 Jun 1991 Florida, USA	11
	East Atlantic Captures		
G41420/ G45918	26 Jun 1994	29 Oct 1994 Spain	5
G45041/ G46738	8 Jun 1994 26 Jun 1994	30 May 1995 Morocco	11
G46279	21 Jul 1992 5 Aug 1992 17 Jun 1994 27 Jun 1994	20 May 1995 France	10

Table 2. Distribution of the number of years between initial tagging and remigration to nest in French Guiana according to the year of tagging. The method of tagging and the tag models are described in the text.

Tagging year	Number of newly tagged females	Number of tagged females captured per year							
		1988	1989	1990	1991	1992	1993	1994	1995
1987	1,322	30	3	2	0	1	0	0	0
1988	5,417		1	31	4	5	12	4	2
1989	5			0	0	0	0	0	0
1990	1,312				9	119	51	48	15
1991	1,536					15	118	109	30
1992	2,662						39	119	41
1993	1,279							41	184
1994	2,303								20
1995	342								

According to these few data (0.03% of the turtles tagged in French Guiana have been observed outside the region), it appears that females migrate to the north from French Guiana after the nesting season and do not follow any particular route within the north Atlantic. But the data are still relatively scarce and many more are needed to truly understand the pelagic habits of females (Fretey and Girondot, 1996).

Remigration Interval Between Nesting Seasons. — The remigration intervals for tagged females returning to nest have been studied for several years (Table 2). It appears that the distribution of the number of years recorded between two nesting seasons is highly sensitive to the position of tagging and the kind of tags used (compare years 1987–88 and years after 1990 for different types of tagging). From 1985–86, only 4 females out of more than 1000 were seen 3 years after nesting in French Guiana (Fretey and Girondot, 1990) reflecting a high incidence of tag loss.

The remigration distributions are very different for the years 1990, 1991, and 1992 ($\chi^2 = 130.6$, d.f. = 6, $P < 0.0001$; for this test, turtles seen after 4 and 5 years for 1990 and 1991 are grouped with turtles not seen in order to be consistent with the 1992 data). Thus, nesting intervals are not cyclical because they vary for turtles seen in a given year, nor are they typical of one population because the distributions vary from year to year (see discussion in Frazer, 1989, who proposed that nesting intervals are typical of one population).

Several females have been seen during more than 2 nesting seasons with 88 seen during 3 seasons and 2 during 4 seasons. For these turtles, the number of years between the two first nesting seasons and between the last two is significantly correlated (Fig. 5; $r = -0.216$, $P = 0.042$). The number of years between the two last nesting seasons is inversely related to the number of years between the previous ones. This could be a compensatory strategy, suggesting that

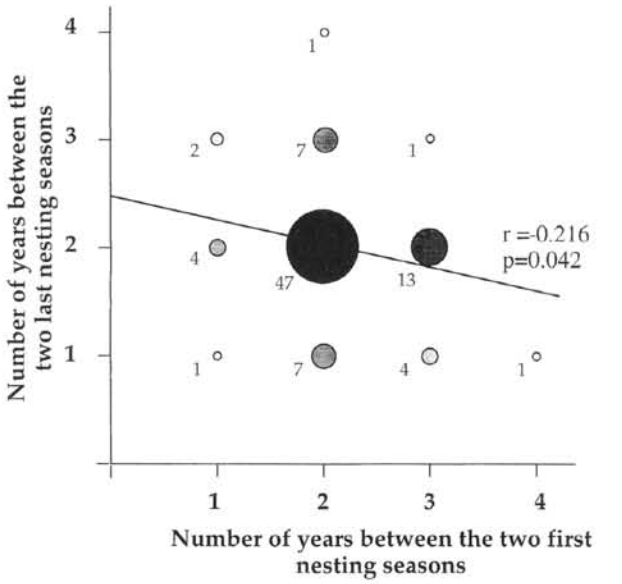

Figure 5. Relationship between two successive nesting intervals for turtles seen nesting in at least three separate seasons.

reproductive output should be studied at the level of several nesting seasons. However, the correlation is very slight and needs to be confirmed with further data.

Acknowledgments

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