Journal of Herpetology, Vol. 37, No. 1, pp. 183–185, 2003

Clutch Frequency of the Michoacán Green Seaturtle

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ABSTRACT.—Observed clutch frequency (OCF) and estimated clutch frequency (ECF) values were determined for the Green Seaturtle (*Chelonia mydas*) population that nests at Colola beach, Michoacán, México. Mean OCF and ECF values were 2.5 and 3.1, respectively. The use of the ECF value herein reported to estimate annual number of black turtle nesting females at this rookery decreased by approximately 20% previous population estimates based on OCF values.

Although clutch frequency (the number of egg clutches that an individual produces over the course of a given nesting season) has been estimated at various nesting colonies of the Green Seaturtle, *Chelonia mydas* (for review, see Van Buskirk and Crowder, 1994), information on populations recognized by same as the Black Turtle (*Chelonia agassizii*) or East Pacific Green Turtle (*Chelonia mydas agassizii*) that nests in Michoacán, México, is scarce. Based on sporadic observations, Alvarado et al. (1985) estimated a mean observed clutch frequency of 2.5 nests per season, whereas Márquez et al. (1982) estimated a mean observed clutch frequency of four nests per season. Clutch frequency values are important to estimate sea turtle adult female population size from annual nest counts and for construction of demographic models (Meylan, 1982; Johnson and Ehrhart, 1996). The objective of this study was to determine nesting frequency for the *C. mydas* Michoacán.

MATERIALS AND METHODS

The study was conducted at Colola beach (state of Michoacán), the main rookery for the green seaturtles in the eastern Pacific Ocean (Alvarado and Figueroa, 1992). Turtles nest along the 5 km of Colola beach from early September to late January. To register nesting turtles, nightly surveys were conducted from mid-September to mid-January every year from 1994 to 1998. Surveys were conducted from 2100 to 0500 h along the entire length of Colola beach. For study purposes, the beach was divided in three sections (east, west, and central) and each section was assigned to a team of three people. Each team transversed its section from three to five times each night. Survey coverage was similar among years.

Each turtle encountered was checked for tags. If previously tagged, tag identification numbers were recorded. If untagged, one monel and one plastic tag (National Band and Tag Co.), each bearing a unique identification number, were attached after the turtle had completed oviposition. Metal tags were placed on the left foreflipper and plastic tags on the left hind flipper. Curved carapace length (notch to tip) was taken with a flexible tape measure. Clutch size was determined from direct counts made as turtles deposited eggs.

Observed clutch frequency (OCF) and estimated clutch frequency (ECF) values were calculated for each turtle, of a random sample of 50 turtles per year, recorded nesting at least once. OCF is the number of occasions a turtle was encountered and confirmed to have nested during a nesting season. OCF may underestimate the true number of clutches a female deposited if the individual is missed by the tagging team during the nightly patrols or if nesting occurred on an unpatrolled beach. Following Frazer and Richardson (1985), we also calculated an estimated clutch frequency (ECF). ECF is the number of clutches that a turtle was presumed to have deposited during a nesting season. ECF values were based on recorded nesting events for each turtle and the number of days between events (internesting intervals). If an interval of 24 days or longer occurred between known nesting events of a turtle, it was assumed that the turtle nested undetected in the interim, and additional nests were added to her OCF to estimate an ECF. Although several factors (i.e., within season tag-loss, nestings occurring either before the first or after the last recorded emergence, and within-season nesting migrations between neighboring beaches) may result in lower ECF estimates than the actual nesting frequency, its use in sea turtle population size calculations, when recording of nesting events is not complete, gives more accurate numbers than if OCF values were used (Johnson, 1994; Addison, 1996).

RESULTS

The mean internesting interval for turtles at Colola was 12 days ($N = 86$; SD = 0.79), with a range of 11–13 days (Arias-Coyotl, 2001). The number of nests added to each turtle's record was calculated by dividing the total number of days (if longer than 25 days) by 12. For turtles with intervals between 22 and 24 days between observed nestings, one nest was added to its OCF. This method of estimating clutch frequency is similar to that described by Frazer and Richardson (1985) and Johnson and Ehrhart (1996) for the green turtle, Tucker and Frazer (1991) for the Leatherback Seaturtle (*Dermochelys coriacea*), and Addison (1996) for the Loggerhead Seaturtle (*Caretta caretta*).

The frequency distribution of the data did not approximate a normal distribution. Therefore, nonparametric statistical tests were used to analyze the data. The significance level considered was 0.05.

During the five years of the study, ECF and OCF values were determined for 250 turtles. Mean OCF for

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TABLE 1. Summary statistics for observed clutch frequency (OCF) and estimated clutch frequency (ECF) values for Green Seaturtles nesting at Colola beach, Michoacán from 1994 to 1998.

Year	*N*	Mean	SD	Minimum	Maximum
1994					
OCF	50	2.7	1.4	1	6
ECF	50	3.2	1.9	1	8
1995					
OCF	50	2.2	1.1	1	5
ECF	50	3.2	2.1	1	8
1996					
OCF	50	2.6	1.4	1	6
ECF	50	3.3	2.0	1	8
1997					
OCF	50	2.5	1.4	1	6
ECF	50	3.0	1.9	1	7
1998					
OCF	50	2.6	1.4	1	6
ECF	50	3.0	1.7	1	7
Combined					
OCF	250	2.5	1.4	1	6
ECF	250	3.1	1.9	1	8

these turtles was 2.5 (range = 1–6), and mean ECF was 3.1 (range = 1–8; Table 1). Using a Wilcoxon Matched-pairs Signed-rank Test (Netter et al., 1978) the difference between OCF and ECF was significant ($Z = -8.24$, $P < 0.001$). Using a Kruskal-Wallis test (Sokal and Rohlf, 1995), neither OCF nor ECF were not significantly different between years (P 0.05). To determine whether female body size or clutch size influenced ECF, we conducted Pearson correlation coefficient tests (Sokal and Rohlf, 1995). There was no correlation between carapace length and ECF ($r = -0.124$, P 0.05, $N = 250$). Clutch size also was not correlated with ECF ($r = 0.040$, P 0.05, $N = 250$).

DISCUSSION

Moll (1979) predicted that clutch frequency should increase with body size in most species of sea turtles. However, studies of several *Chelonia* populations have failed to find a significant correlation between body size and clutch frequency (Van Buskirk and Crowder, 1994; Johnson and Ehrhart, 1996), and no significant correlation between ECF and curved carapace length was found for the Michoacán turtles we studied.

It might be expected that within a season, turtles with high clutch frequencies would show smaller clutch sizes than turtles with low clutch frequencies. There was no influence of clutch size on ECF for the Michoacán turtles we studied. Based on data from several rookeries, Van Buskirk and Crowder (1994) did not find a significant correlation between clutch size and clutch frequency for *Chelonia mydas*.

There are few studies that report annual variation in *C. mydas* clutch frequency. Bustard (1974) reported that clutch frequency varied over three consecutive nesting seasons at Heron Island, Australia, but did not conduct statistical analysis. Johnson and Ehrhart (1996) reported that OCF values were not significantly different between two consecutive years for Florida green seaturtles, but ECF values were significantly different between the same years. These authors attributed this difference in ECF values to different sample sizes and to variation in the number of one-time nesters between years. When data for turtles estimated to have nested only once were removed from the comparison, there was no significant difference between the years. Both OCF and ECF values were not significantly different between years for the Michoacán turtles.

OCF values reported herein for the Michoacán turtles are similar to and ECF values are higher than the mean observed nesting frequency reported by Alvarado et al. (1985). Both OCF and ECF values reported herein are lower than the observed clutch frequency reported by Márquez et al. (1982) for this population. For the Florida population, Johnson and Ehrhart (1996) reported values of 2.4 for OCF and 3.0 for ECF. Mean OCF reported for other *Chelonia* rookeries ranged from 1.8–4.5 (Van Buskirk and Crowder, 1994). Although differences in clutch frequencies reported for various rookeries may represent actual variation among sites, they may also represent variation in tagging and survey effort, tag loss, and nest-site fixity of turtles among beaches.

A striking feature pointed out by Johnson and Ehrhart (1996) is that, in most studies of *Chelonia* nesting frequency, there was a high percentage (range = 25–50%) of turtles estimated to have nested only once in a given season. In Michoacán, 30.4% ($N = 250$) of black turtles studied deposited only one clutch. It appears than in most *Chelonia* rookeries a high number of the females (possibly comprised mostly of first-time nesters) that nest in a given season are expected to nest only once (Johnson and Ehrhart, 1996).

The green seaturtle of the East Pacific has exhibited an extreme decline in numbers over the last 30 years and is listed as endangered throughout its range (National Marine Fisheries Service and U.S. Fish and Wildlife Service, 1998). The difference between OCF and ECF values herein reported for the Michoacán turtles indicates that numbers of nesting females are lower than reported. Using an OCF of 2.5 to calculate black turtle female numbers at Colola beach, Alvarado-Díaz et al. (2001) reported that annual average number of black turtle nesting females from 1981 to 1999 was 489 (range = 2100 in 1981 to 100 in 1988). Using an ECF of 3.1, these estimates of annual numbers are reduced in approximately 20%, with an average number of females for the same period of 394 (range = 1693 in 1981 to 81 in 1988).

Acknowledgments.—We thank the U.S. Fish and Wildlife Service and Conservation International for financial support to the black turtle project in Michoacán. We thank J. Woody, R. Byles, E. Possardt, R. Mast, P. Burchfield and R. Márquez for their assistance. We also thank the community of Colola and the Universidad de Michoacán for their support.

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Accepted: 11 April 2002.

Journal of Herpetology, Vol. 37, No. 1, pp. 185–188, 2003

Skin Histocompatibility between Syntopic Pattern Classes C and D of Parthenogenetic *Cnemidophorus tesselatus* in New Mexico

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ABSTRACT.—At Conchas Lake State Park, San Miguel County, New Mexico, four allozymic variants of parthenogenetic *Cnemidophorus tesselatus* pattern class C and three allozymic variants of *C. tesselatus* D are syntopic with one gonochoristic and two parthenogenetic congeners. Our study of 14 individuals revealed that *C. tesselatus* C and D from this site are histoincompatible with both their maternal, *Cnemidophorus tigris marmoratus*, and paternal, *Cnemidophorus gularis septemvittatus*, progenitors. Evidence of skin histocompatibility between these combinations of *C. tesselatus* pattern class C and D lizards supports the hypothesis of a single hybrid origin for representatives of this species at the study site.

Zweifel's (1965) hypothesis that parthenogenetic *Cnemidophorus tesselatus* comprises a phylogenetic sequence of six color pattern classes, designated A, B, C, D, E, and F, has not received support from genetic studies (Parker and Selander, 1976; Dessauer and Cole, 1989; Densmore et al., 1989). Pattern classes assigned to *C. tesselatus* by Zweifel have been reallocated among three species by recent authors. Scudday (1973) described pattern class F as a new diploid species,

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