

## Aerial Observations of Courtship Behavior in Loggerhead Sea Turtles (*Caretta caretta*) from Southeastern Georgia and Northeastern Florida

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Courtship behavior has been reported for four species of sea turtles: *Chelonia mydas* (Harrison, 1954; Carr and Giovannoli, 1957; Hendrickson, 1958; Witham, 1970; Frazier, 1971; Booth and Peters, 1972; Bustard, 1972; Schulz, 1975; Simon et al., 1975; Marquez, 1990), *Eretmochelys imbricata* (Witzell, 1983), *Caretta caretta* (Caldwell, 1959; Caldwell et al., 1959; Witham, 1970; Dodd, 1988), and *Lepidochelys kempi* (Wood, 1953). However, the only detailed descriptions of courtship and subsequent mounting or mating involves *C. mydas* (Hendrickson, 1958; Booth and Peters, 1972; Bustard, 1972; Marquez, 1990). Dodd (1988) summarized the most detailed accounts of loggerhead courtship to date. Successful mounting or copulation after a courtship bout has not been observed in loggerheads (Dodd, 1988). Herein, we report observations of *Caretta* courtship and subsequent mounting, biotic and abiotic factors found in association with loggerhead courtship, and a discussion of loggerhead courtship relative to other turtle species.

During 1 December 1997 to 1 April 1998, aerial surveys were conducted along the coastal waters off southeastern Georgia and northeastern Florida. While locating Northern Right Whales (*Eubalaena glacialis*), information was recorded on turtles, large fish, and cetaceans. Data on turtles recorded during surveys include time, date, turtle species, latitude and longitude of sighting (GPS), sea surface temperature, water depth, and behavior associated with each sighting.

Surveys lasted approximately six hours (0900-1200 h, 1300-1600 h) and were flown on transects from Glynn County, Georgia to Duval County, Florida (Fig. 1). Twenty-two transect lines were flown three miles apart and to a maximum of 20 nautical miles offshore (Fig. 1). Surveys were flown at a standard altitude of 229 m at a ground speed of 100 knots using methodology developed by the Cetacean and Turtle As-

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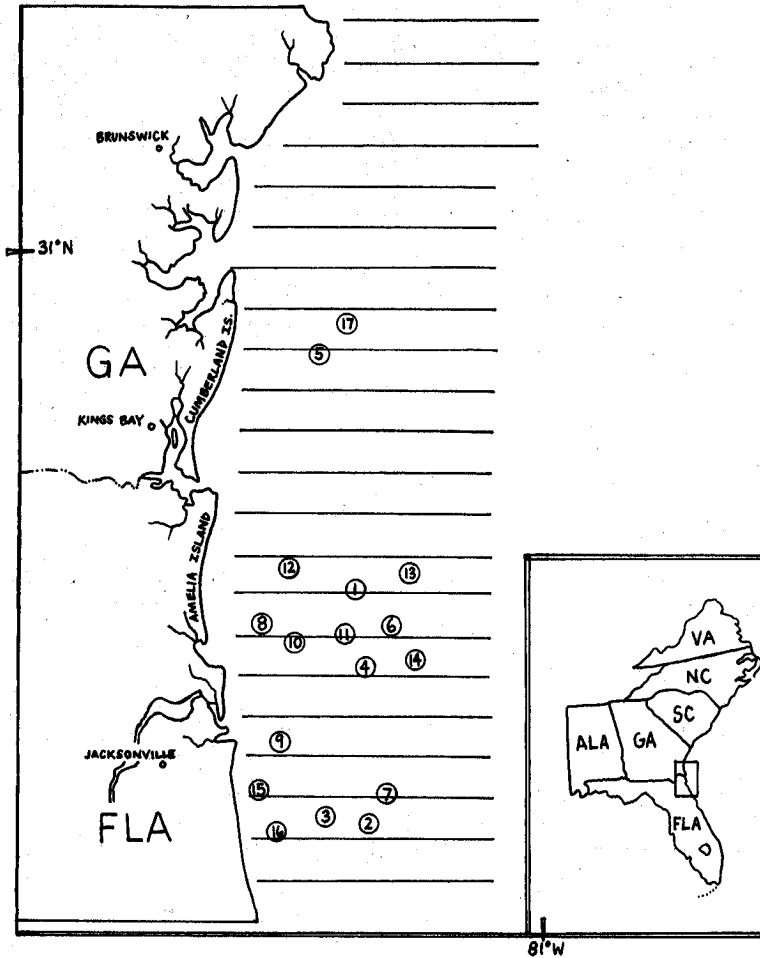


FIG. 1. Survey transect lines and locations of courtship observations listed in Tables 1 and 2. Sighting numbers appear within each location dot.

assessment Program (Scott and Gilbert, unpubl. data). The survey team consisted of a pilot, data recorder, and two observers positioned on each side of the aircraft (Cessna 337) in rear seats. The observers scanned the water's surface at least 3.7 km away from each side of the plane. When pairs of turtles were located, the aircraft left the transect line at right angles to the sighting and circled it to obtain photographs. While photographs were taken, an available observer viewed the paired turtles through field glasses and recorded observations. Turtles were identified as to sex based on the presence or absence of visible tail length and/or by the presence of sexually dimorphic tapering of the posterior carapace (Dodd, 1988). An observation was considered to be complete when a male turtle was initially seen approaching a female and subsequently mounted her. However, additional incomplete courtship sequences were observed and reported. After documenting the observation, the aircraft returned to the transect line at the point of departure. All data were recorded at the end of each day into a data base program maintained by the New England Aquarium

in Boston, Massachusetts and the University of Rhode Island in Narragansett, Rhode Island.

Sequential analysis of loggerhead courtship behavior was conducted by pooling the 17 observations made during the surveys and grouping them by related communication sequences as defined by Carpenter (1980) and Bels and Crama (1994). Observations ceased soon after mounting and offer no information regarding the duration of time this particular behavior lasted.

Observations of courtship began on 16 March 1998 and lasted until surveys ended on 31 March 1998. Paired turtles were not seen prior to the previously mentioned dates. A list of all sightings and biotic and abiotic parameters associated with each sighting appears in Table 1. Behavior associated with each sighting appears in Table 2.

Courtship sightings occurred between 1129 h to 1507 h but were most prevalent between 1400 h and 1500 h. All sightings occurred when cloud cover was minimal and large numbers of *Caretta* of various size classes were basking at the water's surface. Surface

TABLE 1. Courtship observations for *Caretta caretta* set 1.

Sighting no.	Date	Time	Latitude/longitude	Water temp. (°C)	Water depth (m)
1	3-16-98	1416	30°32.0'N/81°09.1'W	16.7	17.1
2	3-19-98	1135	30°14.0'N/81°07.3'W	16.7	19.8
3	3-22-98	1430	30°14.0'N/81°13.7'W	15.6	14.7
4	3-24-98	1437	30°26.1'N/81°08.2'W	15.6	16.8
5	3-25-98	1150	30°47.0'N/81°09.9'W	15.6	15.0
6	3-25-98	1408	30°29.0'N/81°07.5'W	15.6	18.0
7	3-26-98	1445	30°17.0'N/81°06.7'W	17.2	23.1
8	3-27-98	1408	30°29.0'N/81°19.6'W	18.3	16.2
9	3-27-98	1451	30°20.0'N/81°18.1'W	18.3	13.5
10	3-29-98	1356	30°29.0'N/81°15.5'W	19.4	17.1
11	3-29-98	1406	30°26.0'N/81°08.1'W	19.4	16.8
12	3-30-98	1405	30°35.0'N/81°14.7'W	20.6	15.6
13	3-30-98	1408	30°35.0'N/81°07.1'W	20.6	21.9
14	3-30-98	1432	30°28.1'N/81°05.0'W	20.6	18.6
15	3-30-98	1507	30°17.0'N/81°19.7'W	20.6	13.8
16	3-31-98	1129	30°53.0'N/81°20.0'W	19.4	06.9
17	3-31-98	1145	30°50.0'N/81°08.1'W	19.4	14.1

water temperatures during this time ranged from 15.6 C to 20.6 C (avg. 18.3 C). Locations where each sighting occurred appear in Table 1 and Fig. 1.

We observed a sequence of six courtship stages which preceded mounting in *Caretta* (Fig. 2). Each sighting included one male and one female. In no observation was more than one male present. On four separate occasions we were able to record complete courtship sequences (Sighting nos. 4, 6, 8, and 9, Table 2; Fig. 2a-f). All four sequences included an approach by the male, courtship behavior, and mounting. Additionally, 13 incomplete sequences were observed and recorded (Sighting nos. 1-3, 5, 7, 10-17, Table 2). For the purposes of this discussion all 17 observations (Tables 1, 2) were pooled to formulate a general courtship behavioral sequence.

During the initial stages of courtship a male was observed approaching slowly towards a folded and

tucked female (Sighting nos. 1-6, 8, 9, and 11-17, Table 2; Fig. 2a). Approximately 0.9 meters from the female the male ceased approaching and began circling the female (Sighting nos. 1-6 and 11-17, Table 2; Fig. 2b). Circling lasted for approximately two to three minutes. During circling the folded and tucked female constantly readjusted her orientation towards the male, keeping her head facing the male at all times. Face to face orientation and circling ceased when the male dove under and towards the posterior side of the female. Immediately after diving the male began nuzzling the inguinal, and then the axillary, regions of the female (Sighting nos. 1-6, 8, 9, and 11-17, Table 2; Fig. 2c). Nuzzling or 'bridge sniffing', as defined by Harrel et al. (1996), consisted of 5-10 quick investigations by the male on either side of the female. Occasionally the female would turn her head to snap at the investigat-

TABLE 2. Courtship observations for *Caretta caretta* set 2. \* denotes complete courtship sequence.

Sighting no.	Female avoidance	Male approach	Circling	Nuzzling	Biting	Stroking	Mounting
1		X	X	X			
2		X	X	X			
3		X	X	X	X		
4*		X	X	X	X	X	X
5		X	X	X	X		
6*		X	X	X			X
7	X				X	X	X
8*	X	X	X	X	X	X	X
9*	X	X	X	X	X		X
10	X		X		X	X	
11		X	X	X			
12		X	X	X			
13		X	X	X			
14		X	X	X			
15		X	X	X			
16		X	X	X			
17		X		X			

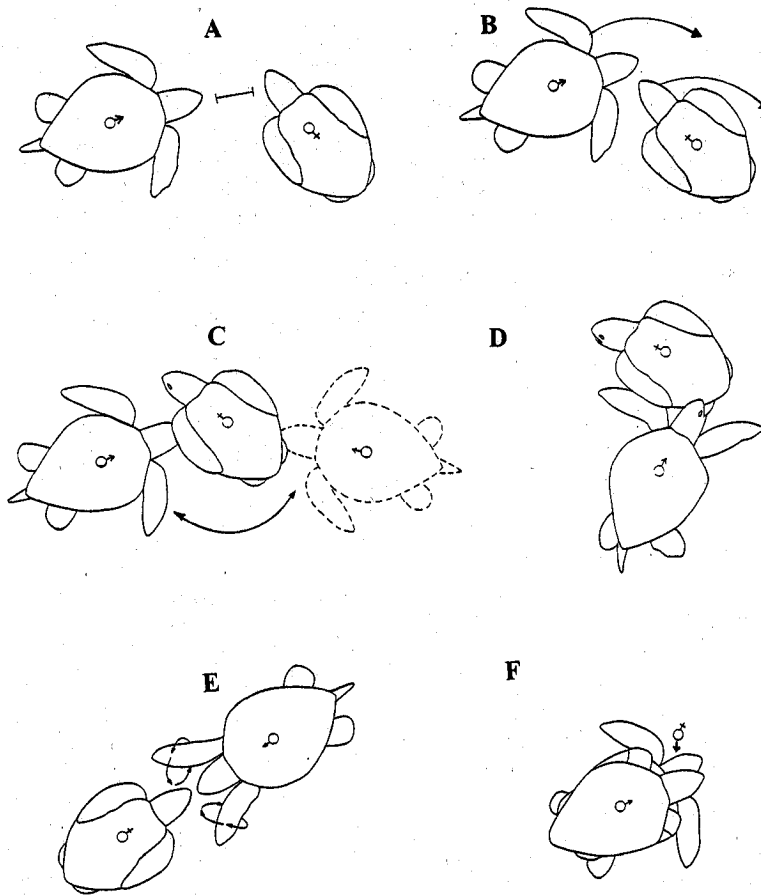


FIG. 2. Stages 1-6 of courtship behavior: a = male approaching folded and tucked female, distance between = approx. 0.9 m; b = circling; c = nuzzling; d = biting; e = stroking; f = mounting.

ing male (Sighting nos. 4, 6, 8, and 9, Table 2; Fig. 2c). Nuzzling lasted no longer than 1 to 2 min.

After the initial stages of courtship, nuzzling was followed by vigorous biting by the male (Sighting nos. 4-6 and 8-11, Table 2; Fig. 2d). Biting was directed towards the female's hind flippers which were tucked underneath the plastron, presumably in a "praying" position over the tail. Biting lasted for approximately one to five minutes. Two females (Sighting nos. 6 and 9, Table 2; Fig. 2f) allowed males to mount them after biting. Three females (Sighting nos. 4, 8, and 10, Table 2) remained unreceptive to males even after biting occurred.

Males that were denied mounting after biting continued with further courtship behavior. Additional behavior began as the male placed himself face to face with the female. Once face to face the male proceeded to stroke the sides of the female's neck and head with the upper surfaces of his forelimbs (Fig. 2e). Stroking was conducted by moving the right front flipper in a counterclockwise motion and the left front flipper in a clockwise motion. This was done synchronously and with short, fast strokes. The longest bout of stroking (Sighting no. 4, Table 2) lasted approximately five minutes, but two other males (Sighting nos. 7 and 10,

Table 2) completed this stage in approximately three minutes. Two pairs associated with stroking behaviors (Sighting nos. 4 and 7, Table 2; Fig. 2e) mounted soon after stroking ended. One male (Sighting no. 10, Table 2) attempted to mount the female after stroking but was chased away by wild splashing and snapping from the female.

Instances of courtship behavior in *Caretta* have rarely been observed. Dodd (1988) summarized two instances of males circling females presumably prior to copulation. Within these courtship observations, one account noted that a male loggerhead would circle a female who occasionally readjusted her orientation to face the male. After several minutes of circling, the male approached the female rapidly from the rear and placed his head up onto her shoulder. Occasionally, the male bit the female's neck in an effort to hold her. Since the female was unreceptive, she pivoted and turned towards the male in an effort to dislodge or discourage him, and occasionally angled her carapace upwards.

The courtship bouts with unreceptive females, as described in Dodd (1988), are similar to those behaviors observed in sighting nos. 8 and 9 (Table 2) where males initially mounted unreceptive females and were

refused mating activities. However, after performing more elaborate displays of courtship, both males were permitted to mount.

Accounts of courtship observed in *Eretmochelys imbricata* (Witzell, 1983), *Lepidochelys kempi* (Wood, 1953), and *Chelonia mydas* (Harrison, 1954; Carr and Giovannoli, 1957; Hendrickson, 1958; Witham, 1970; Frazier, 1971; Booth and Peters, 1972; Bustard, 1972; Schulz, 1975; Simon et al., 1975; Marquez, 1990) are all similar to accounts reported for *Caretta* (Caldwell, 1959; Caldwell et al., 1959; Witham, 1970; Dodd, 1988; present study). In each account males were observed circling females and/or biting or nipping the flippers of the females. Aerial observations by Marquez (1990) reported that attendant males, presumably trying to unseat the mounted male, bit a male *C. mydas* involved in mating. No copulating pairs of *Caretta* were seen in company with additional males during the course of this survey.

Certain precopulatory behaviors demonstrated by *Caretta* also coincide with those reported from turtles of the genera *Pseudemys*, *Chrysemys*, *Trachemys*, *Terrapene*, *Kinosternon*, *Sternotherus*, and *Macrolemys* (Bels and Crama, 1994; Ernst et al., 1994; Harrel et al., 1996). Members of the genera *Pseudemys*, *Chrysemys*, and *Trachemys* are reported to employ axial stroking within their courtship sequences as well as biting and nuzzling (Ernst et al., 1994). More benthic turtles of the genera *Sternotherus*, *Kinosternon*, and *Macrolemys* do not perform axial stroking advances, although they have been reported to circle, bite, and nuzzle or 'sniff' the female during courtship (Bels and Crama, 1994; Harrel et al., 1996).

Carpenter (1980), Bels and Crama (1994), and Harrel et al. (1996) suggested that bridge sniffing or nuzzling is employed by male turtles to discriminate between the sexes. Nuzzling by male loggerheads was directed towards the axillary and inguinal areas of the females, in and around the areas containing the Rathke's glands. Such olfactory investigation also may help loggerheads to distinguish males from females. The extent to which the Rathke's gland functions in this type of olfactory evaluation is unknown and requires further attention (Rainey, 1981). Our methodology did not allow us to determine if observed turtles were undertaking an olfactory evaluation.

Aerial observation allowed us to provide initial reports on the sequential courtship behavior of *Caretta*. However, on one instance (Sighting no. 13, Table 2) a courting pair was observed to cease courtship when the female dove. Whether or not the female turtle was unreceptive to the male's advances or if the plane frightened her away is unknown. Additionally, due to the limitations associated with the platform used to conduct our study (e.g., glare, sea state conditions, sighting distance, etc.) it is possible that some of the encounters we are reporting may be homosexual. Photographing courting turtles from the air proved to be an inadequate means of visual documentation. While some photos were clear enough to construct illustrations of the depicted activities, most appeared dark and/or blurred. Film or video may help in future studies documenting sea turtle courtship and mating. Despite any drawbacks which may occur as a result of using aircraft to study turtles offshore, underwater

studies may prove to be much more costly as well as intrusive.

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#### LITERATURE CITED

- BELS, V. L., AND CRAMA, Y. J. M. 1994. Quantitative analysis of the courtship and mating behavior in the loggerhead musk turtle *Sternotherus minor* (Reptilia: Kinosternidae) with comments on courtship behaviors in turtles. *Copeia* 1994:676-684.
- BOOTH, J., AND J. PETERS. 1972. Behavioral studies of the green turtle (*Chelonia mydas*) in the sea. *Anim. Behav.* 20:808-815.
- BUSTARD, H. R. 1972. *Sea Turtles: Natural History and Conservation*. Collins Press, Sydney, Australia.
- CALDWELL, D. K. 1959. The loggerhead turtles of Cape Romaine, South Carolina (abridged and annotated manuscript of W. P. Baldwin, Jr. and J. P. Loftin Jr.). *Bull. Florida State Mus. Biol. Sci.* 4:319-348.
- , A. F. CARR, AND L. OGREN. 1959. Nesting and migration of the Atlantic loggerhead turtle. *Bull. Florida State Mus. Biol. Sci.* 4:295-308.
- CARPENTER, C. C. 1980. An ethological approach to reproductive success in reptiles. In J. B. Murphy and J. T. Collins (eds.), *Reproductive Biology and Diseases of Captive Reptiles*, pp. 33-48. SSAR Contributions to Herpetology No. 1. Lawrence, Kansas.
- CARR, A. F., AND L. GIOVANNOLI. 1957. The ecology and migrations of sea turtles. 2. Results of field work in Costa Rica, 1955. *Am. Mus. Novit.* (1835): 1-32.
- DODD, C. K. JR. 1988. Synopsis of the biological data on the loggerhead sea turtle. U.S. Fish Wildl. Serv. *Biol. Rep.* 88(14):1-110.
- ERNST, C. H., J. E. LOVICH, AND R. W. BARBOUR. 1994. *Turtles of the United States and Canada*. Smithsonian Inst. Press, Washington, DC.
- FRAZIER, J. 1971. Observations on sea turtles at Aldabra. *Phil. Trans. R. Soc. London* 260:373-410.
- HARREL, J. B., N. H. DOUGLAS, M. HARAWAY, AND R. D. THOMAS. 1996. Mating behaviors in captive al-

- ligator snapping turtles (*Macrolemys temminckii*).  
*Chelon. Conserv. Biol.* 2:101-105.
- HARRISON, T. 1954. The edible turtle (*Chelonia mydas*)  
in Borneo. 2. Copulation. *Sarawak Mus. J.* 6:126-  
132.
- HENDRICKSON, J. R. 1958. The green sea turtle, *Chelonia*  
*mydas* (Linn.) in Malaya and Sarawak. *Proc. Zool.*  
*Soc. London* 130:455-535.
- MARQUEZ, R. M. 1990. FAO species catalogue, Vol. 11.  
Sea turtles of the world. FAO fisheries Synopsis.  
No. 125:1-81.
- RAINEY, W. E. 1981. Guide to sea turtle visceral anat-  
omy. NOAA Tech. Mem. NMFS-SEFC-82.
- SCHULZ, J. P. 1975. Sea turtles nesting in Surinam.  
*Zool. Verh. Rijkmus. Nat. Hist. Leiden.* 143:1-143.
- SIMON, M. H., G. F. ULRICH, AND A. S. PARKES. 1975.  
The green sea turtle (*Chelonia mydas*): mating, nest-  
ing, and hatching on a farm. *J. Zool. (London)* 177:  
411-423.
- WITHAM, R. 1970. Breeding of a pair of pen-reared  
green turtles. *Q. J. Florida Acad. Sci.* 33:288-290.
- WITZELL, W. N. 1983. Synopsis of biological data on  
the hawksbill turtle, *Eretmochelys imbricata*, (Lin-  
naeus, 1766). FAO Fish. Synop. No. 137:1-78.
- WOOD, F. G. 1953. Mating behavior of captive logger-  
head turtles. *Copeia* 1953:184-186.

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