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MICROCLIMATE OF GULL-BILLED TERN AND BLACK SKIMMER NESTS

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The flux of water vapor in avian nests in various environments has recently received much attention in investigations of incubation physiology and behavior. Egg temperature, water-vapor conductance, and nest microclimate have been studied in species with incubation periods of differing length, mostly terns and gulls. In order to extend our knowledge of incubation in larids, we gathered comparative data on the nests and eggs of Gull-billed Terns (*Sterna nilotica*) and Black Skimmers (*Rynchops niger*). The nest vapor pressure of these ground-nesting species was of additional interest because this value is markedly higher in the ground-nesting Royal Tern (*Sterna maxima*; 27 torr; Vleck et al. 1983) than in most other ground-nesting birds that have been studied (18–20 torr; Rahn et al. 1976, Rahn and Dawson 1979, Grant 1982, Grant et al. 1982a). For this reason, we also measured the vapor pressure in tern and skimmer nests. Recent studies have shown that nest vapor pressure tracks ambient vapor pressure (Grant et al. 1982a) and that parent birds do not actively regulate nest vapor pressure (Walsberg 1983).

MATERIALS AND METHODS

Eggs were collected during May of 1980, 1982, and 1983 on Brant Island near Morehead City, Carteret County, North Carolina. Water-vapor conductance of the egg shell was measured by the method of Ar et al. (1974) and surface area was determined by the method of Paganelli et al. (1974). Initial egg mass was obtained by weighing eggs after replacing the air cell with water (Ar and Rahn 1980, Grant et al. 1982b). Egg volumes were measured by water displacement and pore numbers were counted by the method of Roudybush et al. (1980). The total effective pore area was calculated from shell conductance and thickness measurements as described by Rahn et al. (1976). Eggs were weighed with a Torbal torsion balance to 1 mg in the field in order to establish the rate of water loss. Central egg temperatures were obtained by two methods: grab-and-jab technique and by the thermocouple implant-continuous recording method. The former method consists of watching (from a blind) a bird who is incubating undisturbed for 45–60 min, and inserting a thermocouple into the center of the egg within 20–60 s of exposure. These egg temperatures were corrected for heat loss during exposure (see Results). With the latter method, thermocouple-implanted eggs were returned to the nest and monitored over 5–24 h with a Linear chart recorder buried near the nest site. Nest vapor pressures were measured with silica gel-filled eggshell hygrometers made from egg shells of the same species (Rahn et al. 1977) placed in tern and skimmer nests. Ambient vapor pressure was measured simultaneously in the colony with the use of eggshell hygrometers placed on the ground under shade platforms.

RESULTS

Gull-billed Tern eggs differed little from those of Black Skimmers in physical dimensions and water-vapor conductance (Tables 1, 2). Water loss of 13 Gull-billed Tern eggs averaged 117 $mg \cdot day^{-1} \pm 6$ (SE) and that of 24 Black Skimmers averaged 143 $mg \cdot day^{-1} \pm 4$ (SE). In the field situation, cooling curve determinations for the tern egg dropped 0.3°C/min over the range of egg temperatures encountered, while those of the skimmer were greater: 1.0°C for the first minute. Temperatures obtained by the two methods were not different and were averaged. Central-incubated egg temperatures averaged 35.1°C ± 0.6 (SE) for six Black Skimmer eggs and 35.6°C ± 0.9 (SE) for three Gull-billed Tern eggs. These egg temperatures are equivalent to internal saturation vapor pressures of 42.4 and 43.6 torr, respectively. Measured nest vapor pressure was 20.5 torr ± 1.4 (SD) in four tern nests and 25.3 torr ± 1.2 (SD) in four skimmer nests. These values are similar to those reported elsewhere for terns (Rahn et al. 1976, Grant 1982, Vleck et al. 1983). Ambient vapor pressure measured concurrently with nest vapor pressure averaged 20.2 torr ± 0.7 (SD) ($n = 6$). The vapor pressure of the Gull-billed Tern nest was virtually identical to ambient values obtained at ground level under shade only a few meters away, and that of the skimmer nest was only slightly higher.

DISCUSSION

Fractional water or mass loss over the entire incubation period of Gull-billed Tern eggs averaged 9.2%, based on an incubation period of 22–23 days (Harrison 1978), while that of the Black Skimmer averaged 11.2%, based on an incubation period of 20–22 days (Wolk 1959). These values are similar to that of the Forster's Tern (*Sterna forsteri*; Grant 1982), but are lower than those of other terns (Ar and Rahn 1980, Vleck et al. 1983). The relatively high ambient vapor pressure (20.2 torr) measured in the tern and skimmer colony may have contributed to the reduced fractional mass losses reported here. Grant et al. (1982a) and Walsberg (1983) have shown reductions in daily water loss from eggs exposed to high ambient vapor pressures.

The temperature of these eggs was similar to that of the White Tern (*Gygis alba*; Pettit et al. 1981), but substantially lower than that of the Sooty Tern (*Sterna fuscata*; Howell and Bartholomew 1962) and the Royal Tern (Vleck et al. 1983). Clutch size is one in White, Sooty, and Royal terns, two or three in Gull-billed Terns, and three or four in the Black Skimmer. Thus, egg temperature is not strong-

TABLE 1. Physical dimensions of Gull-billed Tern and Black Skimmer eggs and shells ($n = 12$ for both species). Data presented as mean ± one standard error.

	Gull-billed Tern	Black Skimmer
Egg		
Mass (g)	28.51 ± 0.49	26.90 ± 0.50
Volume (cm^3)	26.88 ± 0.46	25.31 ± 0.49
Density ($g \cdot cm^{-3}$)	1.060 ± 0.001	1.063 ± 0.001
Area (cm^2)	44.401 ± 0.508	42.724 ± 0.522
Length (cm)	4.67 ± 0.04	4.54 ± 0.05
Width (cm)	3.34 ± 0.03	3.31 ± 0.03
Shell		
Mass (g)	1.639 ± 0.030	1.648 ± 0.025
Thickness (mm)	0.212 ± 0.002	0.215 ± 0.004
Volume (cm^3)	0.944 ± 0.019	0.916 ± 0.016
Density ($g \cdot cm^{-3}$)	1.737 ± 0.008	1.801 ± 0.015

TABLE 2. Conductance and pore geometry. G_{H_2O} = water-vapor conductance, L = pore length or shell thickness, A_P = functional pore area, and N = number of pores.

	Gull-billed Tern		Black Skimmer	
	$\bar{x} \pm 1$ SE	n	$\bar{x} \pm 1$ SE	n
G_{H_2O} ($mg \cdot day^{-1} \cdot torr^{-1}$)	6.2 ± 0.2	12	6.4 ± 0.6	12
L (mm)	0.212 ± 0.002	12	0.215 ± 0.004	12
A_P (mm^2)	0.588 ± 0.017	12	0.607 ± 0.049	12
N	4,884 ± 218	6	5,503 ± 174	6

ly correlated with clutch size in these species. Gull-billed Terns incubate their eggs in a nest of loose sticks or in a scrape on the ground, White Terns build no nest, and skimmers, Sooty Terns and Royal Terns incubate their eggs in an unlined scrape. Thus, the differences in egg temperatures cannot be attributed solely to nest structure or lack thereof. They may be instead related to body/brood patch temperature, tightness of sitting, substrate temperature, and/or age of embryo at the time of temperature measurement.

In summary, eggs of the Black Skimmer and Gull-billed Tern differ little in physical properties and water-vapor conductance. We attribute their low fractional water losses to relatively high ambient and nest vapor pressures.

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