In conclusion, it seems impossible that a nightjar could sing for eight minutes without replenishing its oxygen. It seems equally unlikely that sufficient oxygen could be acquired during the 25-40 ms gap between sound pulses. The temporal and amplitude pattern of their song suggests that nightjars may sustain long vocalizations by singing one part of their song, the short trill, during inhalation.

Why sing for so long? I have preliminary data that suggest there is individual variation in the maximum length of song; this implies that song length may have evolved under sexual selection or as an assessment cue of fighting ability.

John Brackenbury, Abbot Gaunt, John Krebs, Fernando Nottebohm, Ray Owen, Jr., and James Rooney kindly commented on the manuscript. The research was made possible by grants from the Association of American Rhodes Scholars and the Rhodes Trust. Maxine Horne typed the manuscript, and Vikki Kogut prepared the figure.

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METABOLISM AND THERMOREGULATION IN HATCHLING WESTERN GULLS

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AND

ALBERT F. BENNETT

Parental attentiveness provides hatchlings of many precocial and semiprecocial birds with a large measure of protection from the vagaries of the thermal environment. Nonetheless some of these species differ in thermoregulatory capacity of newly hatched chicks, in correlation with climatic conditions during the breeding season. For example, hatching ducks of species breeding exclusively in the arctic and subarctic tend to have better control of body temperature in cool environments than do those of species with wider and more southerly distributions (Koskimies and Lahti 1964). A similar pattern seems to exist for hatching gulls. Black-headed Gulls (Larus ridibundus) and Ring-billed Gulls (L. delawarensis) can approximately double their rates of heat production over basal levels when subjected to cold stress on the day of hatching (Kespaik and Davydov 1966, Dawson et al. 1976). In contrast, Laughing Gulls (L. atricilla), which appear to breed under somewhat warmer conditions, can increase their metabolic capacity by only 50% (Dawson et al. 1972). The range of metabolic capacity among hatchling gulls may be even greater than these values indicate, for the genus Larus includes more than 30 species whose respective breeding ranges embrace a latitudinal span from the arctic to the subantarctic. As opportunities arise, we are attempting to assess the extent of differences in thermoregulatory capacities among hatchlings of these species. We report here observations on chicks representing the subspecies of Western Gull (Larus occidentalis) breeding in the Gulf of California, Mexico.

Our experimental subjects were obtained from Isla Partida, Baja California Norte, Mexico (28°54'N, 113°3'W) on 29 April-1 May 1976. During this period, nights were cool, days were warm, and solar radiation was intense. Conditions were similar to those on nearby Isla Rasa (10 km SE), where we had made micro-meteorological measurements from 18-28 April 1976, in connection with studies of Heermann's Gulls (L. heermanni). Daily minimal and maximal temperatures at nest height on Isla Rasa averaged 12.9°C (range, 8.4-16.7°C) and 32.2°C (range, 28.7-34.7°C), respectively. Intensity of solar radiation reached 1036 W/m² at midday on 19 April 1976, and was near this level on several subsequent days.

Following collection, newly hatched Western Gulls were transferred for study to the nearby RV Dolphin, and then exposed to constant ambient temperatures (T₀) between 16° and 35.3°C for two-hour periods. These concluded with measurement of oxygen con-
FIGURE 1. Relation of body temperature ($T_b$) and oxygen consumption ($V_o$) corrected to STPD) to ambient temperature ($T_a$). The diagonal line marks equivalence ($T_b = T_a$). The figure omits three values of BMR [1.08, 1.30, and 1.35 ml (g.h)] for which exact values of $T_b$ are unavailable.

The three highest metabolic rates observed in the present study average 1.35 ± 0.041 (S.E.) ml (g.h)⁻¹ for the 11 birds tested (mean body mass 65.4 ± 1.27 g). This mean BMR represents 94, 82, and 103% of the respective values predicted for a 65.4-g adult non-passerine by Lasiewski et al.’s (1967) equation. Insulation is the reciprocal of $h$ and hatchling Western Gulls thus appear markedly inferior to adult birds of comparable size in ability to conserve heat. Among these chicks, the down thickness averages 10.3, 10.5, and 4.3 mm in the centers of the back, abdomen, and crown, respectively. When $h$ is expressed in cal (g⁻₀.₄₉.h⁻₀.₄₉.C)⁻¹ to minimize the complication of differences in body size on comparisons of hatchlings (see Dawson et al. 1976, for discussion), values for the three Western Gulls remaining warmer than 30°C at $T_b$ of 16–19°C range from 4.78 to 7.11 cal (g⁻₀.₄₉.h⁻₀.₄₉.C)⁻¹. This compares with 5.25 and 4.73-5.75 cal (g⁻₀.₄₉.h⁻₀.₄₉.C)⁻¹ for hatchling Laughing and Ring-billed gulls, respectively (Dawson et al. 1972, 1976). Thus, when differences in body size are minimized, newly hatched Western Gulls do not appear to differ substantially from the young of these other species in their inherent insulation capacity.

Hatching gulls studied thus far have only modest capacities for augmenting heat production in the cold. The three highest metabolic rates observed in the present study average 1.8 times BMR, placing newly hatched Western Gulls from the Gulf of California in an intermediate position between the Ring-billed and Black-headed gulls (Dawson et al. 1976, Kepaik and Davydo 1966) on the one hand, and the Laughing Gull (Dawson et al. 1972) on the other (see introductory paragraph). Superficially, at least, this rank appears to correlate with the general thermal conditions encountered by the four species during the breeding season.

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LITERATURE CITED


CONDUCTANCE, PORE GEOMETRY, AND WATER LOSS OF EGGS OF CASSIN’S AUKLET

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AND

H. RAHN

The ratios of egg mass to body mass in the Alcidae are relatively large (Sealy 1975) when compared with those of most other groups of birds (Rahn et al. 1975). Cassin’s Auklet (Ptychoramphus aleuticus) weighs about 165 g (Manuwal 1974a, b), and its single egg of about 29 g is twice that predicted from the egg mass-body mass relationship of birds in general (Rahn et al. 1975). The auklets nest in burrows and rock crevices, and during incubation the single egg is held between the lateral incubation patch and the wing (Manuwal 1974a, b). The incubation time of 38 days is considerably longer than the 25 days predicted for eggs of this size. It is of particular interest as it has been suggested that the functional egg characteristics such as conductance, water loss (Rahn and Ar 1974), and metabolism (Rahn et al. 1974) increase not only in proportion to their mass but are inversely related to incubation time. To see whether these generalizations apply also to Cassin’s Auklet eggs, we measured the conductance and incubation water loss of these eggs and described the physical dimensions of the egg and the shell as well as the pore geometry responsible for the egg conductance.

Eggs were collected in April 1977 and May 1978 on the Farallon Islands, west of San Francisco, California. The water vapor conductance was measured by the method of Ar et al. (1974). Egg volumes were measured by water displacement, and surface area and shell thickness by the method of Paganelli et al. (1974). Initial egg mass was obtained by weighing eggs after the air cell had been displaced with water, using a hypodermic syringe. In order to learn the number of pores the shells were boiled in 2.5% NaOH to remove protein fibers, then briefly etched in concentrated nitric acid. After drying, an aqueous solution of methylene blue was applied to the inner surface of the shell to render the pores more visible (Tyler 1953). Each egg was examined under a compound microscope and twenty fields (0.25 cm²) were counted and averaged.

### TABLE 1. Physical dimensions of Cassin’s Auklet eggs and shells.

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Schönwetter (1963) n = 80 28.0 4.67 3.37 1.88 0.22

Manuwal (1974a) n = 75 27.4 4.62 3.35