METABOLISM AND THERMOREGULATION IN HATCHLING WESTERN GULLS

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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, hatchling 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 hatchling 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

theirs 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 livens*) 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 micrometeorological 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 R/V *Dolphin*, and then exposed to constant ambient temperatures (T_a) between 16° and 35.3°C for two-hour periods. These concluded with measurement of oxygen con-
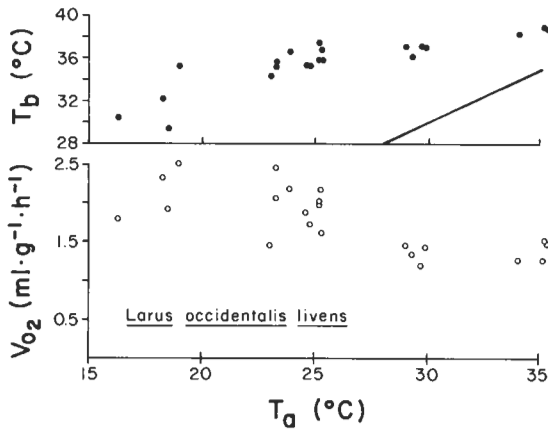
FIGURE 1. Relation of body temperature (T_b) and oxygen consumption ($\dot{V}_{O_2}$ corrected to STPD) to ambient temperature (T_a). The diagonal line marks equivalence between T_b and T_a. All measurements were made at the conclusion of two-hour exposures to single T_a's. The figure omits three values of BMR [1.08, 1.30, and 1.35 ml $(g\cdot h)^{-1}$] for which exact values of T_a are unavailable.

sumption ($\dot{V}_{O_2}$) and body temperature (T_b), using procedures and instrumentation described by Dawson et al. (1972, 1976). None of the 15 hatchlings studied was used in more than two tests and these were separated by at least two hours, during which the birds were kept at an T_a of 25°C and fed canned cat food. All of the gulls were returned to their respective nests at the conclusion of measurements.

Daytime $\dot{V}_{O_2}$'s of hatchling Western Gulls at 29°–35.3°C were taken as basal metabolic rates (BMR). These averaged 1.35 ± 0.041 (S.E.) ml $(g\cdot h)^{-1}$ 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 bird by the Lasiewski-Dawson (1967) equation, the Aschoff-Pohl equation for the active (α) portion of the daily cycle, and the A-P equation for the inactive (ρ) portion of the daily cycle (Aschoff and Pohl 1970). These percentages resemble those obtained in similar comparisons involving daytime measurements of BMR in hatchling Herring Gulls (*L. argentatus*; Drent 1967), and Ring-billed Gulls (see Table 2 in Dawson et al. 1976). The BMR of gull chicks thus approaches the metabolic rate characterizing adult non-passerine birds of similar size, even though the T_b of these chicks is below that of mature birds (cf. Fig. 1 and values for adult gulls given by Neumann et al. 1968).

The Western Gulls we studied possessed some ability to thermoregulate below thermal neutrality (Fig. 1), as do newly hatched gulls of other species. Thus only a minor dependence of T_b on T_a is apparent between 22.5° and 35°C. The equation relating these variables in this interval is:

$$T_b = 29.2 + 0.27\,T_a$$

with T_b and T_a in degrees C (S.E. of estimate, 0.695; r^2, 0.77; F ratio, 68.48). Performance was more variable below 22.5°C and some of the chicks had cooled several degrees by the end of the two-hour tests. An inverse relation exists between $\dot{V}_{O_2}$ for euthermic chicks ($T_b > 35.0$°C) and T_a between 19° and 30°C. This can be described by the following equation:

$$\dot{V}_{O_2} = 4.92 - 0.12\,T_a$$

where $\dot{V}_{O_2}$ and T_a are in ml $(g\cdot h)^{-1}$ and degrees C, respectively (S.E. of estimate, 0.200; r^2, 0.77; F ratio, 43.18). Metabolic data were converted to a thermal basis and heat transfer coefficients (thermal conductances), h, were calculated [$h = 4.8\,\dot{V}_{O_2}/(T_b - T_a)$] (where h, $\dot{V}_{O_2}$, and temperatures are in cal $[g\cdot h\cdot$°C$]^{-1}$, ml $[g\cdot h^{-1}]$, and degrees C, respectively). For hatchlings maintaining T_b at or above 30°C, h ranges from 1.44 to 2.12 cal $(g\cdot h\cdot$°C$)^{-1}$ [1.67 to 2.46 × 10⁻³ W(g·°C)⁻¹] at T_a near 35°C to 0.61 to 0.81 cal $(g\cdot h\cdot$°C$)^{-1}$ [7.09 to 9.41 × 10⁻⁴ W(g·°C)⁻¹], indicating a capacity for controlling heat loss. The mean of h for the 16–19°C interval is 0.72 cal $(g\cdot h\cdot$°C$)^{-1}$ [8.38 × 10⁻⁴ W(g·°C)⁻¹], which is 50% higher than the value of 0.48 cal $(g\cdot h\cdot$°C$)^{-1}$ [5.57 × 10⁻⁴ W(g·°C)⁻¹] predicted for a 65.4-g adult bird with 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 $(g^{0.49}\cdot h\cdot$°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_a of 16–19°C range from 4.78 to 7.11 cal $(g^{0.49}\cdot h\cdot$°C$)^{-1}$. This compares with 5.25 and 4.72-5.75 cal $(g^{0.49}\cdot h\cdot$°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.

Hatchling 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, Kespaik and Davydov 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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