SHORT COMMUNICATIONS

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BRAIN TEMPERATURE FLUCTUATIONS IN HELMETED GUINEAFOWL UNDER SEMI-NATURAL CONDITIONS

PHILIP C. WITHERS

AND

TIMOTHY M. CROWE

Birds are generally assumed to regulate their brain temperature (T_{br}) at a level somewhat lower than cloacal temperature (T_{cl}) (Richards 1970, Kilgore et al. 1973, 1976). Some birds when heat-stressed elevate T_{br} and T_{cl}, such that T_{cl}-T_{br} is relatively constant (Kilgore et al. 1973, 1976) whereas heat-stressed chickens do not have a T_{cl}-T_{br} gradient (Richards 1970). We previously demonstrated that Helmeted Guineafowl (*Numida meleagris*) have a labile T_{br} in the laboratory at ambient temperatures of 5–40°C, whereas T_{cl} is constant (Crowe 1978, Crowe and Withers 1979; Fig. 1). We suggested that the naked head and neck of guineafowl might facilitate heat exchange with the environment, based upon laboratory data and other morphological evidence (Crowe 1978).

However, we wished to document the normal pattern of T_{br}, and determine if there was any physiological significance of the naked head and neck, under natural conditions. Furthermore, we are unaware of any data pertaining to brain temperature of free-ranging birds under natural or semi-natural conditions. We report here our findings from a telemetric study of guineafowl brain temperature under semi-natural conditions.

We used a frequency-modulated temperature telemeter which transmitted in the 88–108 MHz band. A subcarrier oscillator provided a signal of varying frequency, determined by the temperature of a thermistor which was implanted in the brain. The signal of the telemeter was detected with a commercial FM radio and the output analyzed with a digital frequency counter (Venner Electronics type TSA6636/2M). The frequency of the subcarrier oscillator varied from about 1,000 Hz at 15°C to about 3,000 Hz at 45°C. Prior and subsequent calibration indicated that the frequency and temperature resolution was about ±1 Hz, or ±0.02°C. This technique allows the accurate, and almost instantaneous measurement of T_{br}. This is particularly important for monitoring rapid changes in T_{br} due to, for example, postural changes (Crowe and Withers 1979) or state of alertness (St. Paul and Aschoff 1968).

The telemeter, which weighed about 20 g, was fastened to the back of a guineafowl, and the thermistor was implanted in the skull so that it was touching the surface of the left hemisphere. The size of the thermistor precluded implantation deep within the cerebrum. The position of the thermistor was verified with X-ray photographs.

The experimental guineafowl was maintained in an outdoor aviary, with three other guineafowl, under natural photoperiod and temperature. Brain temperature was monitored intermittently for over one week. Ambient temperature, in the shade and in direct sunlight, was measured with Yellow Spring Instrument thermistors placed inside table-tennis balls that had been painted with flat black paint, so as to approximate black-bulb temperatures.

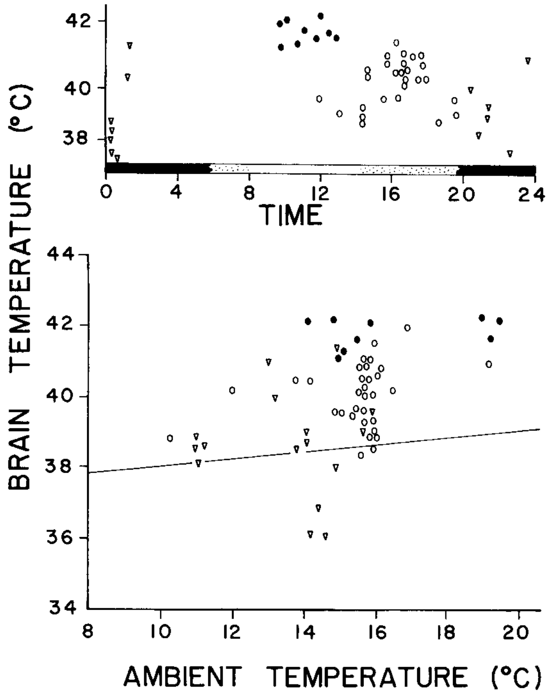

FIGURE 1. Brain temperature of guineafowl at different times of day and night (upper) and at different shade air temperatures (lower). Open circles indicate diffuse radiation but no direct solar radiation; closed circles are for direct solar radiation; open triangles are at night. Photoperiod is indicated on abscissa of upper graph. The line for T_{br} of guineafowl in the laboratory is from Crowe and Withers (1979); see text for regression equation.

The brain temperature (T_{br}) of the guineafowl under semi-natural conditions was markedly variable, ranging from 36 to over 42°C (Fig. 1). The T_{br}'s were usually higher than those of guineafowl under laboratory conditions (Crowe and Withers 1979). St. Paul and Aschoff (1968) and Richards (1970) reported intracerebral temperature gradients in chickens (*Gallus*), and similar gradients may occur in the guineafowl brain although the insulative properties of the keratin helmet might minimize such temperature differentials. Nevertheless, the surface T_{br} of the free-ranging guineafowl was usually higher than the deep brain temperature as measured in the laboratory.

St. Paul and Aschoff (1968) reported a moderate circadian cycle in T_{br} for chickens, and the guineafowl

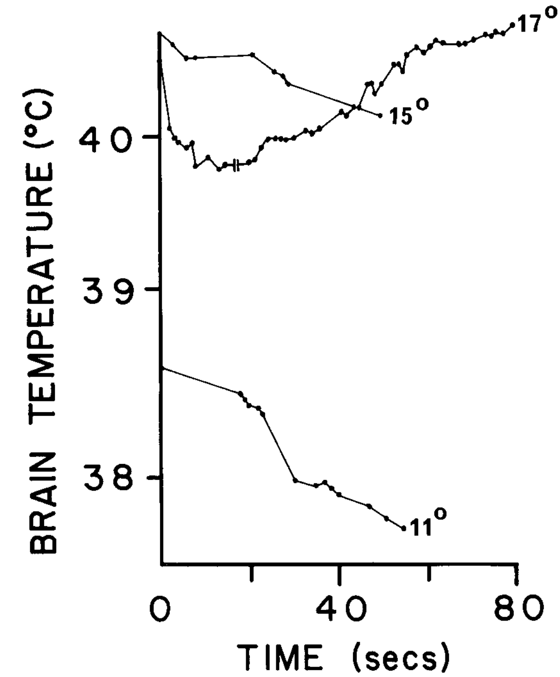

FIGURE 2. Brain temperature of guineafowl during postural changes when disturbed at night. Initial rapid decline in T_{br} is when the bird extends its head and neck; recovery in T_{br} occurs when the head and neck are retracted into the body feathers. Ambient temperature is indicated for each experiment.

T_{br} tended to show a diel cycle. However, the scatter in T_{br} for the guineafowl indicates that environmental variables, such as air temperature, radiation, convection and rain, probably influence T_{br} greatly. The highest T_{br}'s (41.8 ± S.E. 0.1°C, n = 9) were consistently recorded between 09:00 and 13:00 when the aviary was in direct sunlight. The lowest T_{br}'s were 38.6 ± 0.4°C (n = 16) during the night and particularly after rain. The T_{br}'s during the day, in diffuse but not direct sunlight, were intermediate at 39.9 ± 0.2°C (n = 32).

Brain temperature was significantly higher (ANOVA test, $P < 0.001$) during the day with direct solar radiation than at other times, but T_{br} was not significantly correlated with either shade or sunlight air temperature. Although T_{br} was significantly lower with diffuse radiation ($P < 0.001$) and during the night ($P < 0.001$), T_{br} was not correlated with shade air temperature. This lack of correlation between T_{br} and $T_{ambient}$ is in marked contrast to the laboratory data, where $T_{br} = 37.0 + 0.1\ T_{air}$ ($r^2 = 0.76$, n = 58). Free-ranging guineafowl are clearly able to maintain higher T_{br}, through physiological or behavioral means, than birds in the laboratory.

Guineafowl have marked postural adjustments at different ambient temperatures (Crowe 1978). In the cold, the naked head and neck are usually retracted into the neck and body feathers, or tucked under the wing. Active guineafowl at high ambient temperatures typically have the head and neck exposed. We observed rapid changes in T_{br} of 0.5°C or more, which were associated with postural changes, particularly if the guineafowl was disturbed at night when ambient temperatures were low (Fig. 2). The sleeping guineafowl, with head-retracted posture, had high T_{br}'s which rapidly decreased when the bird was disturbed and extended its head and neck. Similar, but less pronounced changes in T_{br} were noted during the day, when ambient temperatures were higher. St. Paul and Aschoff (1968) reported that the T_{br} of chickens increased upon optical stimulation or with increased alertness, presumably because of changes in blood flow. Any possible effects of this nature in guineafowl were either absent, or masked by the physical heat exchange effects upon postural changes.

These data for the T_{br} regulation of Helmeted Guineafowl under semi-natural conditions, although preliminary, clearly indicate that: (1) guineafowl under semi-natural conditions have a markedly labile T_{br}, from about 36 to 42°C; (2) T_{br} is generally greater for free-ranging guineafowl than for birds in the laboratory, reflecting the importance of incident solar radiation and diffuse radiation, and normal behavior patterns; (3) T_{br} of guineafowl under semi-natural conditions can be elevated in diffuse, and particularly in direct, solar radiation; we believe that the radiation effect is to directly warm the head and neck rather than influence blood flow patterns to the head (see Crowe and Withers 1979); (4) postural adjustments can result in rapid changes in T_{br} because of altered heat exchange with the environment.

Further experiments of a similar nature with other species should provide interesting comparative data concerning the normal patterns of brain temperature regulation. This is particularly so in view of the marked lability of T_{br} observed for guineafowl. It is not clear whether other species of birds might have similar patterns of T_{br} regulation.

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Percy Fitzpatrick Institute, University of Cape Town, Rondebosch 7700, South Africa. Present address of first author: Department of Biology, Portland State University, P.O. Box 751, Portland, Oregon 97207. Accepted for publication 14 February 1979.