THERMOREGULATION IN FEMALE EMPEROR PENGUINS

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Breeding emperor penguins (Aptenodytes forsteri) must face the drastic antarctic winter while fasting. Efficient thermoregulation is therefore a key parameter for survival. Exhaustive investigation on thermoregulation and thermogenic mechanisms of adult emperor penguins has not yet been performed despite earlier studies (Pinshow et al., 1976; Le Maho et al., 1976). The aim of this work was therefore to study the thermoregulatory function of emperor penguins from the breeding colony of Pointe Géologie (Terre Adélie, Antarctica). During winter, nine females weighing around 30 kg were caught and used in one-day laboratory investigations at the Dumont d'Urville station. Non employed females (because of limited number of males) were used to limit the impact of the study on reproduction. Energy expenditure at various ambient temperatures ranging from 10 to -40°C was measured by indirect calorimetry in a thermostated chamber and body as well as skin temperatures was continuously monitored with thermocouples. Shivering activity was assessed by accelerometry. Parameters were recorded and analysed with a computerised acquisition system. Resting metabolic rate remained constant between 10 and -10°C (thermoneutral zone, TNZ) at 2.04 ± 0.05 W kg^{-1} and increased linearly from -20°C. At -40°C it was 49% above that measured in the TNZ. Lower critical temperature was -16.4 ± 2.8°C. Thermal conductance was 1.26 W $m^{-2}°C^{-1}$. Body temperature (37.2 ± 0.2°C) was constant over the range of ambient temperatures used. Skin temperatures (back, abdomen and flipper) gradually decreased as ambient temperature dropped indicating peripheral vasoconstriction to limit heat losses but were maintained above a few°C. Skin temperature of the feet remained at the highest level possibly because of postural adjustment. Respiratory quotient was close to 0.7 indicating a major use of lipids as fuel substrate. Shivering appeared between -20 and -30°C and estimated tremor activity was increased 2 fold at -40°C. Shivering threshold temperature was -24°C indicating the existence of small capacities for regulatory nonshivering thermogenesis corresponding to +15% of the resting metabolic rate in the TNZ. Present results therefore indicate that body size and shape as well as insulative and metabolic adaptations to cold contribute to the efficient thermoregulation of adult emperor penguins.

Le Maho, Y., Delclitte, P., Chatonnet J., 1976. Thermoregulation in fasting emperor penguins under natural conditions. Am. J. Physiol. 231, 913-922.

Pinshow, B., Fedak, M.A., Battles, D.R., Schmidt-Nielsen K., 1976. Energy expenditure for thermoregulation in emperor penguins. Am. J. Physiol. 231, 903-912.}

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