POSTNATAL ONTOGENY OF THERMOGENESIS IN ADELIE PENGUIN CHICKS

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Marine birds critically depend on their reproduction colony on land for breeding. For most avian species in the Antarctic area, the breeding period is restricted to the short summer period. Unfledged hatched Adélie penguin chicks (*Pygoscelis adeliae*) are successively brooded by their parents until they are able to maintain their own body temperature. This strategy will immobilize one of the parents on the colony while the successful growth of the chicks depends on feeding by both parents. The rapid ontogeny of thermoregulatory mechanisms and metabolic pathways is therefore of critical importance for optimizing chick growth and survival and parental energy investment under harsh climatic conditions. Postnatal ontogeny of thermogenesis and metabolic pathways was therefore investigated in Adélie penguin chicks (Dumont d'Urville station, Terre Adélie, Antarctica). Chicks from identified nests were used in one-day experiments in the lab to assess thermoregulatory function and then put back on the colony. Newly hatched chicks showed small though significant regulatory thermogenesis (indirect calorimetry) but rapidly became hypothermic. The lower critical temperature (LCT) was around 32°C and thermal conductance was high (8.0 W $m^{-2}°C^{-1}$). By 2 weeks of age, peak metabolic rate was markedly increased (2-fold when expressed per unit weight and 8 fold per animal) while LCT was slightly shifted downward to 18°C. By one month of age, emancipated chicks showed marked capacity for cold resistance mainly through an improved thermal insulation illustrated by a very low LCT (-17°C) and low thermal conductance (2.2 W $m^{-2}°C^{-1}$). Peak metabolic rate could not be attained. Regulatory thermogenesis closely depended on shivering (assessed by accelerometry), which was visible soon after hatching. Thermogenic efficiency of shivering was rather low at birth but increased with age. Special authorisation was obtained to kill a few chicks of known age (decapitation after halothane anaesthesia) to investigate the ontogeny of tissue metabolic pathways. In newly hatched chicks, the activity of most enzymes was higher in leg (gastrocnemius) than in trunk skeletal muscles (pectoralis). Growth was associated with marked rises in the activity of most metabolic pathways. Improvement in thermogenic capacity paralleled marked increases in skeletal muscle oxidative capacity (cytochrome oxidase, citrate synthase), lipid metabolism (3-hydroxyacylCoA dehydrogenase, carnitine palmitoyl transferase) and carbohydrate metabolism (hexokinase, pyruvate kinase). These results therefore indicate that thermal emancipation of Adélie penguin chicks may be determined primarily by thermal insulation after thermogenic and metabolic processes have improved. The rapid maturation of insulative, thermogenic and metabolic processes may contribute to the breeding success of the species.

Financially supported by the French Institute for Polar Research, IFRTP.

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