The development of thermoregulation in *Rhabdomys pumilio nambiensis*

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It has long been known that neonatal mammals do not possess the full thermoregulatory abilities of adults of their species (Pembrey 1895; Hull 1973). Among small rodents, individual young placed at ambient temperatures below 20–25 °C in the first days after birth characteristically allow their body temperature to fall close to ambient temperature, even when they have been taken from their mother recently and their stomachs are thus full of milk. In permitting their body temperature to fall, they experience greatly lowered metabolic rates and become quite lethargic. There is a progressive improvement in thermoregulatory ability at low ambient temperatures over the preweaning period, and by the time of weaning the young can typically maintain high body temperatures at relatively low ambient temperatures. This phenomenon, which permits them to remain fully active at such low ambient temperatures, also requires greatly elevated metabolic rates (Hill 1976).

It has been of interest to examine the development of thermoregulation in *Rhabdomys pumilio*, a small murine rodent which has a wide geographical distribution in southern Africa (Davis 1962). *R. pumilio* is a morphologically precocial animal. A fine white pelage is present at birth, and four dorsal stripes are fully evident at two days of age; eye opening occurs at the early age of five days (Enders 1974). At birth, the young weigh 3—4 g and reach an adult weight of between 40—60 g by about 10 weeks.

R. pumilio were reared in the laboratory from stock originally captured in 1973 at Gorab, 25°09′S, 16°31′E, in South West Africa. The ambient temperature maintained in the breeding colony was 23 °C, with a photoperiod of 14 h light, 10 h darkness. A total of 39 young mice from 16 litters were used for this study. The numbers of animals studied at each age and temperature are indicated by the numbers of points plotted in Fig. 1. Young aged 1–20 days were removed from their mother immediately before the study; they were placed singly in open 10,2-cm-diameter containers and put in a constant temperature chamber at ambient temperatures of 0–30 °C, in 5°C increments. Individuals were studied at only one ambient temperature on a given day. Oesophageal temperatures were recorded in animals less than five days old, using a fine copper-constantan thermocouple probe inserted 1,0–1,2 cm; the probe was connected to a Honeywell class 15 recording potentiometer. Rectal temperatures were taken in older animals, with an insertion depth of 1,3–1,6 cm.

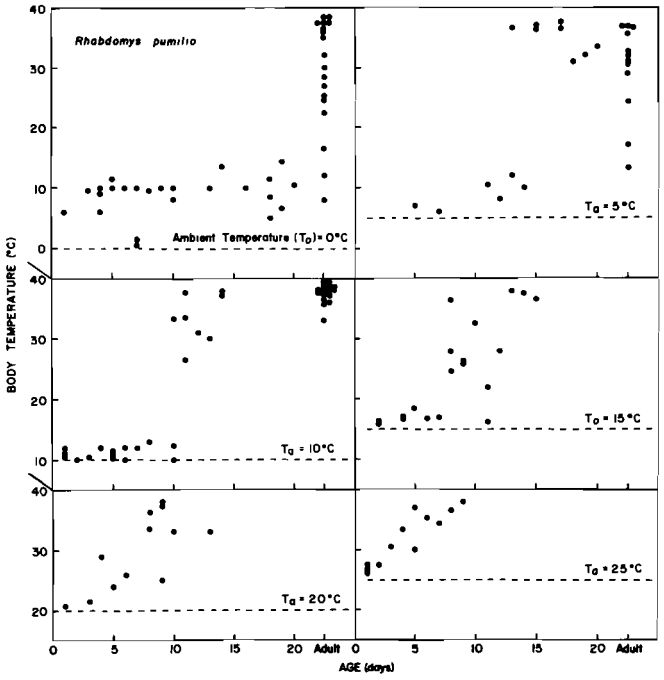

Fig. 1 Body temperatures after exposure to various ambient temperatures as a function of age in *Rhabdomys*. Each block gives the results for one ambient temperature; the ambient temperature is marked as a dashed line. Some of the plotted points for adults are displayed laterally for clarity.

Body temperatures were taken approximately every hour during an experiment. The duration of an experiment was based on several alternative criteria. If an adult animal was found in a clearly hypothermic state (less than 22,5 °C), the trial was immediately terminated because of the adults low tolerance of hypothermia. If animals younger than three weeks of age became hypothermic, they were removed if and when body temperature had fallen to about 8–13 °C. At such body temperatures all animals survived. In a few instances at ambient temperatures of 0 ° and 5 °C, body temperatures of young were allowed to fall to 0,5–6,0 °C. Most of these animals (83%) were unable to recover and died. Provided animals were not removed on the basis of one of the above criteria, tests were allowed to run 2,5–4,0 h. This time period was chosen because it was learned in preliminary trials that many adults could regulate well for the first 2 h but suffered gradual loss of regulatory ability between 2 and 2,5 h. Adults which were fully regulating at 3 h were found to continue to do so through the 4th h.

The state of development of the young at any given age must be judged relative to the thermoregulatory abilities of adults. The body temperatures of adults taken from the nest in the animal colony were relatively variable, ranging from 31,5–39,5 °C. Young animals were considered to show normal, full regulation if they maintained a body temperature within this range. Interestingly, although adults consistently thermoregulated at test temperatures near 10 °C, not all adults could regulate at 5 °C, and many adults entered a hypothermic state at 0 °C (Fig. 1). At an ambient temperature of −10 °C, only one adult out of six tested was found to regulate fully. Thermoregulatory ability in adult *R. pumilio* at 0 °C proved to be relatively poor by comparison to many other rodent species of their size that have

been studied (Hart 1971). Possibly individuals from other parts of the geographical range of *R. pumilio* would show superior thermoregulatory ability in comparison to the animals from Gorab studied here (Borut, Haim, & Castel 1978).

Figure 1 presents the terminal body temperatures of all young studied at the various test temperatures. At ambient temperatures lower than 15 °C (Fig. 2), regulation in the young was either fully realized or not sustained at all (with body temperature falling close to ambient temperature). However, at ambient temperatures of 15 °C and above, young animals sometimes maintained body temperature above ambient temperature, though not at full adult body temperature, suggesting partial thermoregulation. The data indicate the following conclusions:

– No age group was found to regulate consistently at 0 °C.
– At 5 °C signs of regulation begin between approximately 13 and 15 days. However, not even all adults fully regulate at this temperature.
– At 10 °C regulation begins between 10 and 14 days.
– Some partial regulatory capacity is evident at 15 °C. Partial regulation occurs at eight through 12 days of age, and full regulation is suggested after 13 days.
– At 20 °C partial regulation is evident between four and eight days. After eight days, data are insufficient to show full regulation conclusively, but it appears probable.
– At 25 °C partial regulation occurred at two and three days. Full regulation occurred after four days.
— At 30 °C, although a one-day-old had a body temperature of 32,5 °C, two animals aged two and three days had body temperatures of 34,5 °C. Seven young aged seven to 13 days had body temperatures of 37,0–38,5 °C.

Although additional data would be desirable to clarify some points (but could not be obtained owing to difficulties in getting animals to breed), the present results provide adequate insight for a preliminary understanding of the ontogeny of homeothermy in *R. pumilio*. Thermoregulatory ability appears to develop according to a relatively smooth curve. Although *R. pumilio* is morphologically precocial, thermoregulatory development is not distinctly more rapid than in such morphologically altricial rodents as *Peromyscus leucopus* (Hill 1976). Accordingly, while pelage development is relatively advanced at an early age and the eyes open well within the first week after birth, the young are not prepared to remain homeothermic for substantial periods, when exposed alone, at temperatures of 10–15 °C until at least around 10–12 days of age. This factor would limit their ability to wander from the nest for protracted periods at early ages even though they would appear prepared to do so morphologically, unless microclimatic temperatures are relatively high. Unfortunately there is no information on microclimatic temperatures in the natural habitats of *Rhabdomys* during the breeding season. It is also evident that rate of morphological development is not necessarily well correlated with rate of physiological development in small rodents. The apparent inability of *R. pumilio* adults in the test population to thermoregulate consistently at temperatures near freezing is striking and coincides with the species' lack of nocturnal activity (Christian 1977).

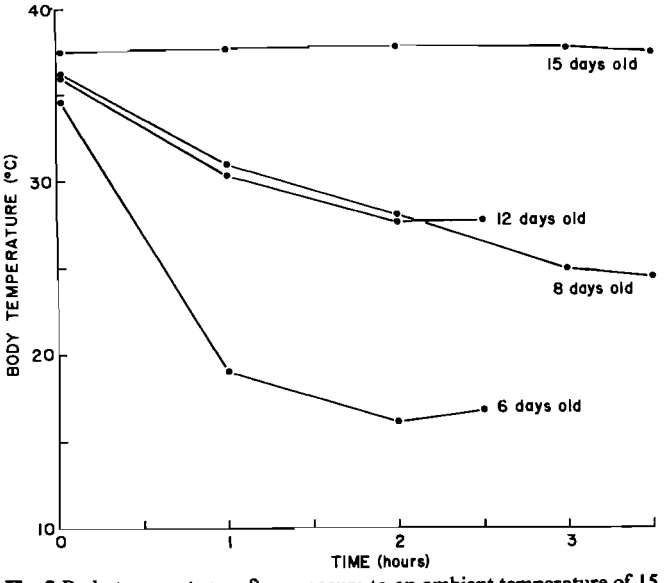

Fig. 2 Body temperatures after exposure to an ambient temperature of 15 °C as a function of time in *Rhabdomys* aged 6, 8, 12, and 15 days. Partial regulation is suggested in the intermediate aged animal.

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