Relationship between heart rate and metabolism in the hyrax (*Procavia capensis*) and guineapig (*Cavia porcellus*)

I.S. McNairn and N. Fairall
Mammal Research Institute, University of Pretoria, Pretoria

The relationship between heart rate and metabolism was investigated in the hyrax *Procavia capensis* and the guineapig *Cavia porcellus*. In both animals a positive linear relationship was found described by V_{O_2} (ml O_2 (g.h)$^{-1}$) = 0,003157 (HR) + 0,3678 for the hyrax and V_{O_2} (ml O_2 (g.h)$^{-1}$) = 0,00757 (HR) −0,4914 in the guineapig. The response to lowered ambient temperature differs between the species, the guineapig increases metabolic rate and maintains body temperature while the hyrax allows body temperature to drop while the increase in metabolic rate is relatively small. It is postulated that this response by the hyrax is an energy conserving strategy.
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Die verwantskap tussen hartsnelheid en metabolisme is by die dassie *Procavia capensis* en die marmot *Cavia porcellus* ondersoek. In beide diere is 'n positiewe liniêre verband gevind wat beskryf word deur V_{O_2} (ml O_2 (g.h)$^{-1}$) = 0,003157 (HR) + 0,3678 in die dassie en V_{O_2} (ml O_2 (g.h)$^{-1}$) = 0,00757 (HR) −0,4914 in die marmot. Die reaksie op verlaagde omgewingstemperatuur verskil tussen die twee spesies. Die marmot verhoog sy metabolisme en behou 'n redelik stabiele liggaamstemperatuur terwyl die dassie liggaamstemperatuur laat daal terwyl die verhoging in metaboliese tempo relatief klein is. Dit word voorgestel dat die reaksie 'n strategie is om energie te bespaar.
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I.S. McNairn and N. Fairall*
Mammal Research Institute, University of Pretoria, Pretoria 0002, South Africa
*To whom all correspondence should be addressed

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A relationship between mean resting metabolic rate (MRM) and heart rate is found in birds (Owen 1969; Wooley & Owen 1977), small mammals (Morhart & Morhart 1971) and domestic sheep (Webster 1969). This relationship was investigated in the hyrax and guineapig.

The known increase in metabolism at lowered ambient temperature (T_a) was used as a means of varying MRM. Three captive bred hyrax, 19 months old at the start of the experiment, with a mean mass of 2,5 kg, were compared with three guineapigs of mean mass 700 gm. The animals were acclimated at T_a 6, 18 and 27 °C with constant photoperiod of 12L:12D for three weeks prior to each set of measurements.

MRM was measured as oxygen consumption (V_{O_2}) in an open flow system as described by De Pocas and Hart (1957). Copper strips on a false bottom of the metabolic chamber were connected to an electrocardiographic recorder (ECG) and used to determine heart rate. Oxygen content of in-and-outflowing air was measured on a Beckman E2 oxygen analyzer and V_{O_2} calculated. Body temperature (T_b) was measured rectally before and after each experimental period with a clinical thermometer.

Figure 1 shows the relationship between V_{O_2} and T_a. At T_a 27 °C the MRM of the hyrax in terms of oxygen consumption was 0,649 ml O_2 (g.h)$^{-1}$ and for guineapigs 0,937 ml O_2 (g.h)$^{-1}$. Below 27 °C V_{O_2} increased linearly with decreasing temperature.

Heart rate of both hyrax and guineapigs was lowest at T_a = 27 °C. The hyrax had a mean of 94 beats per minute and the guineapig a mean of 181 beats per minute. Heart rate also increased linearly with decreasing ambient temperature (Fig. 2). T_b showed a linear decrease with T_a in both species with a mean decrease of 3 °C in the hyrax and 1 °C in the guineapig (Fig. 3).

The results indicate the expected difference in metabolic rate due to size although both species had higher actual values than predicted by the Brody-Kleiber equation V_{O_2} = 3,8 $M^{-0,75}$ at T_a = 27 °C.

The difference in slope of the two lines illustrated in Fig. 1 indicates a difference in metabolic adaptation to lowered temperature. Whereas both increase metabolic rate, the response in the case of the guineapig is much greater than in

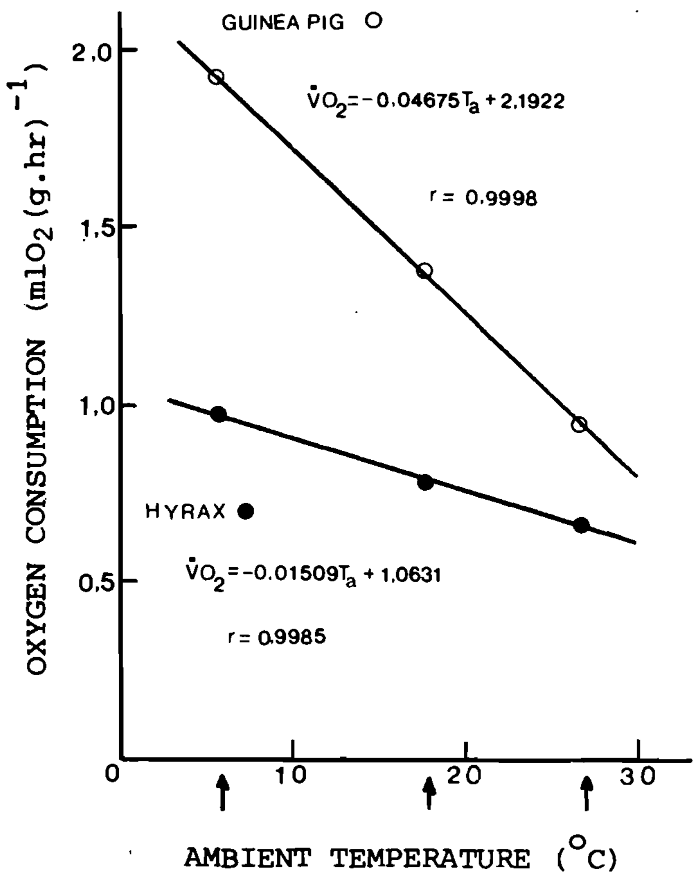

Fig. 1 The relationship between oxygen consumption ($\dot{V}O_2$) and ambient temperature (T_a) in hyraxes (●) and guineapigs (o).

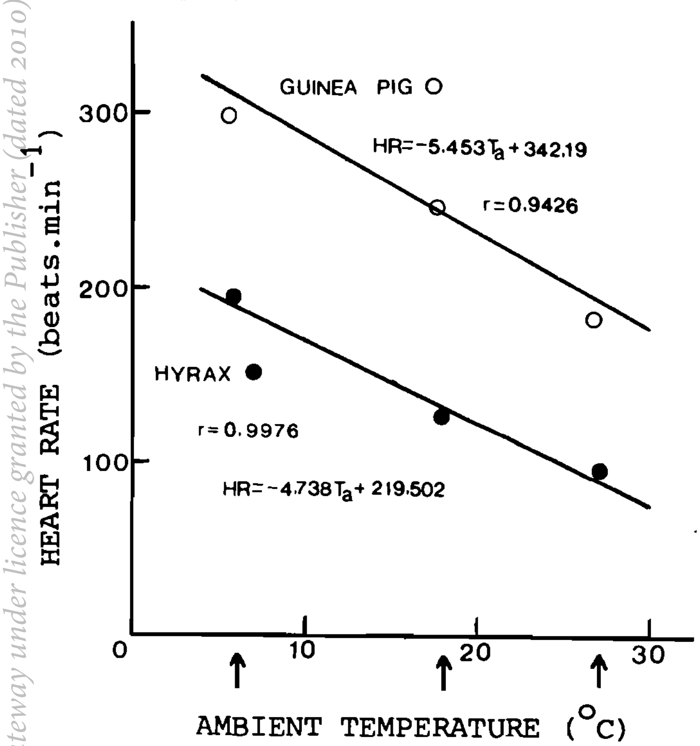

Fig. 2 The relationship beween heart rate (HR) and ambient temperature (T_a) in hyraxes (●) ang guineapigs (o).

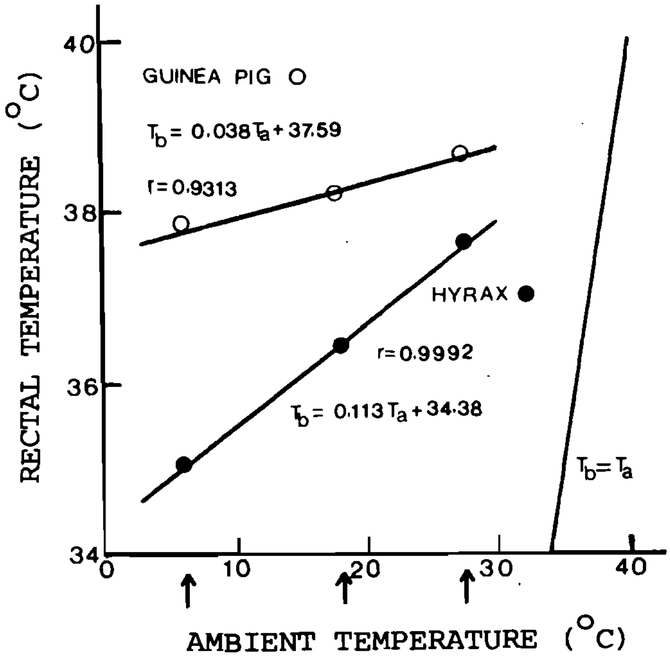

Fig. 3 The relationship between rectal temperature (T_b) and ambient temperature (T_a) in hyraxes (●) and guineapigs (o).

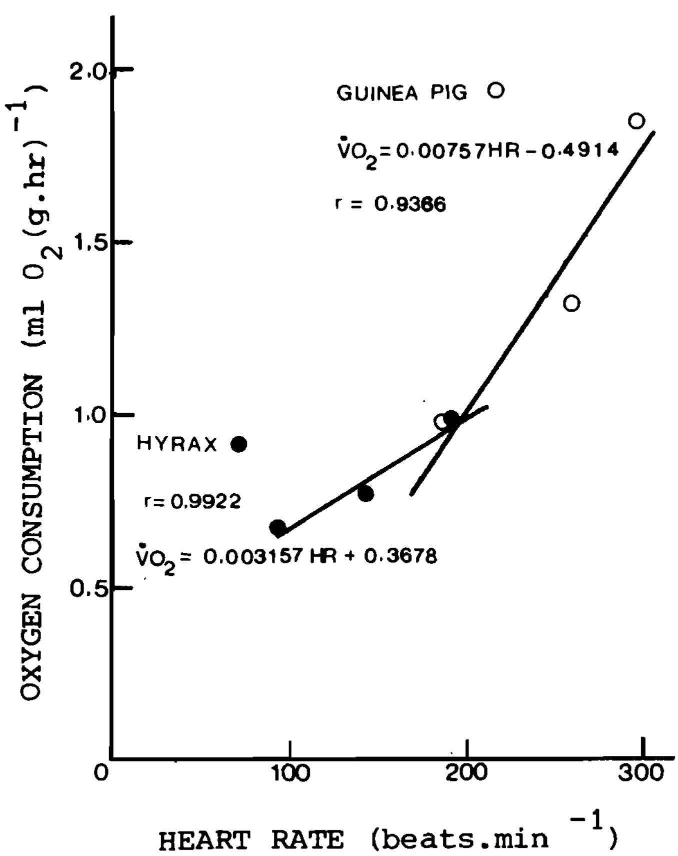

Fig. 4 The relationship between oxygen consumption ($\dot{V}O_2$) and heart rate (HR) in hyraxes (●) and guineapigs (o).

the hyrax. The relationship T_a and T_b (Fig. 3) points to the adaptive mechanisms being different in the two species. The relatively large drop in T_b shown by the hyrax can be explained by the relatively small increase in MRM at low T_a, and would result in a decreased temperature differential between the animal and its environment. The pronounced decrease in temperature shown by the hyrax has also been found by Barthlomew and Rainy (1971) and Louw, Louw and Retief (1972), with the former also finding a relatively small increase in metabolic rate at lowered T_a.

It is postulated that this finding reflects an energy conserving strategy in the hyrax, as the lowered metabolic rate would imply that less energy is needed to maintain the animal at lower T_a. The physiological hypothermia with its concomitant lowering of activity could be overcome by the known behavioural response to lowered T_a in this species, namely basking (Sale 1970; Fourie 1974; Booth 1975; Hoeck 1975). This would allow individuals to increase T_b using an exogenous energy source and it appears as if the pelage of the hyrax is highly suited to this function (Booth 1975).

As both heart rate and MRM are shown to be related to T_a there is a direct relationship between heart rate and MRM (Fig. 4). The relationship is linear and positive and conforms to what Morhardt and Morhardt (1971) found in ground squirrels of the genus *Spermophilius* and the bushy-tailed woodrat *Neotoma cineria*. It would therefore appear that in spite of its thermoregulatory adaptations it should be possible to measure resting metabolic rate from heart rate in the hyrax.

Because V_{O_2} = HR × SV × A–V O_2 diff. (Johnson & Gessamen 1973) where HR = heart rate, SV = Stroke Volume and A – V O_2 diff = the difference in O_2 concentration between arterial and venous blood, it is clear that exercise would influence the relationship and consequently the results of this study should be applied with care in the free living animal.

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