



SIZE AND POWER IN MAMMALS

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Summary

The relationship between basal metabolism P and body mass M of 391 mammalian species has been analysed by least-squares regression, robust regression and covariance analyses. This relationship is a power function:

$$P = aM^b,$$

where the mass exponent b is 0.678 ± 0.007 (mean \pm s.d.) and the mass coefficient a takes different values. Theory of measurement revealed that the $2/3$ mass exponent is due to an underlying dimensional relationship between the primary quantity of mass and the secondary quantity of power.

This paper shows that the $2/3$ mass exponent is not the physiological problem of interest. It is not the slope of the metabolic regression line, but its location in the mass/power plane, that must be explained. This location is given by the value of the mass coefficient, the explanation of which is, and remains, the central question in comparative physiology.

Introduction

The relationship between body size and energy metabolism in animals has been studied for more than 150 years. In recent years there has been a renewed interest in this problem (Calder, 1984; Economos, 1983; Heusner, 1982*a,b*, 1984, 1985, 1987; Jürgens, 1989; McMahon and Bonner, 1983; Peters, 1983; Schmidt-Nielsen, 1984; Wieser, 1984).

Theoretical speculations (Sarrus and Rameaux, 1838–1839; von Hoesslin, 1888), followed by experimental and statistical studies (Rubner, 1883; Brody and Proctor, 1932; Brody, 1945; Kleiber, 1931–1932, 1947, 1961), have established that body mass M and basal metabolism P are related by a power function:

$$P = aM^b, \quad (1)$$

where a is the mass coefficient and b is the mass exponent.

Speculations about mechanisms of heat loss in mammals (Sarrus and Rameaux, 1838–1839; Rubner, 1883) or biological similitude (Economos, 1983; Gunther, 1975; Lambert and Teissier, 1927) predicted a mass exponent of $2/3$, while statistical analyses actually revealed significantly larger mass exponents of

Key words: body size, body mass, basal metabolism.

The aim of this paper is to show that, indeed, small and large mammals lie on parallel regression lines with slopes of $2/3$. The physical implications of this statistical model will be discussed.

The data sample

Metabolic data for 391 mammalian species from 17 orders (Artiodactyla, Carnivora, Chiroptera, Edentata, Hyracoidea, Insectivora, Lagomorpha, Macroscelidea, Marsupiala, Monotremata, Perissodactyla, Pholidota, Primates, Proboscidea, Rodentia, Scandentia and Sirenia) have been compiled from their original sources. I verified that body mass and energy metabolism were measured on the same animals and that the data were valid estimates of basal metabolism. The data have been standardized with respect to the units. Basal metabolism is expressed in Watts (W) and body mass in g (see Appendix). On the graphs, body mass is expressed in kg, to reduce the number of digits on the mass scale.

The coordinates of each data point were the averages of measurements from the same laboratory and made on individuals of the same mammalian species. When data for the same species, but from different sources, were available, the data for which the experimental conditions most closely approximated those of basal metabolism were selected. Each mammalian species was used only once in the statistical analysis, irrespective of the actual number of individuals from which the data point was derived.

Fig. 1 shows the bilogarithmic scatter diagram of the 391 data points. Each data point represents one species.

The dashed lines intersecting the x -axis represent the lower hinge, the median and the upper hinge of the box plot of the logarithm of body mass (Chambers *et al.* 1983). These lines divide the data sample into four equally sized groups or quartiles: 25% of the mammals in this sample are smaller than 41.4 g, 50% are smaller than 157.8 g, 75% are smaller than 1581 g. Within the mass range from 2.5 to 3 672 000 g there is an overwhelming predominance of small mammals: only 29 mammals or 7.4% are larger than 20 000 g.

Least-squares regression analysis

Least-squares regression between the logarithms of body mass and basal metabolism yielded the following statistics for the 391 mammals:

- (1) the sample mean vector \bar{Y}

$$\bar{Y} = [2.449074 \quad 0.063162];$$

- (2) the covariance matrix S

$$S = \begin{bmatrix} 1.182002 & 0.838756 \\ 0.838756 & 0.624837 \end{bmatrix};$$

- (3) the mass exponent b

$$b = 0.710 \pm 0.008.$$

0.73–0.75 (Brody, 1945; Kleiber, 1961). In, 1963, the Third Symposium on Energy Metabolism (Kleiber, 1965) adopted the 0.75 mass exponent for standardizing basal metabolism. A few theoretical interpretations of the 0.75 mass exponent have been proposed (McMahon, 1973; Blum, 1977). However, none has proved to be a satisfactory explanation (Calder, 1987; Heusner, 1987; Speakman, 1990).

In 1982, the validity of 0.75 mass exponent was challenged. Heusner (1982a,b) questioned the meaning of the interspecific regression line between the logarithms of body mass and basal metabolism by showing that the average values of basal metabolism in seven mammalian species do not lie on a single regression line. Bartels (1982) reported a 0.66 mass exponent for mammals whose body mass ranged from 2.5 to 380×10^6 g. A re-analysis of Bartels' data by Jürgens (1989) revealed a mass exponent b of 0.678 ± 0.017 ($N=81$). These studies also indicated that within different mass ranges b took significantly different values. For example, in small mammals b was significantly lower than in large mammals ($M < 20\,000$ g: $b = 0.602 \pm 0.031$, $N=67$; $M > 20\,000$ g: $b = 0.772 \pm 0.033$, $N=14$; $t=5.15$, $P < 0.001$). Bartels and Heusner's results suggested that the metabolic data for mammals may not lie on a single linear regression line.

Hayssen and Lacy (1985) concluded that a linear regression line did not accurately describe the relationship between the logarithms of body mass and basal metabolism in 293 mammalian species. Their overall exponent $b = 0.693 \pm 0.010$ was significantly different from 0.75 ($t=5.7$, d.f.=291, $P < 0.001$). A re-analysis of their data by Jürgens (1989) has corroborated his earlier findings in Bartels' data, i.e. in small mammals the mass exponent ($b = 0.648 \pm 0.012$, $N=275$) tended to be lower than in large mammals ($b = 0.862 \pm 0.167$, $N=18$).

Metabolic data published by Elgar and Harvey (1987) revealed the same trends: the overall mass exponent was significantly different from 0.75 ($b = 0.710 \pm 0.011$, $t=3.64$, d.f.=263, $P < 0.001$), and in small mammals the mass exponent was lower than in large mammals ($b = 0.648 \pm 0.014$, $N=234$ versus $b = 0.837 \pm 0.088$, $N=31$).

A study by McNab (1988) confirmed that in 320 mammalian species the overall mass exponent is significantly different from 0.75 ($b = 0.714 \pm 0.009$; $t=4.25$, d.f.=318, $P < 0.001$). But these data did not show a significant difference between the mass exponent in small and large mammals ($b = 0.683 \pm 0.009$, $N=297$ for small mammals; $b = 0.601 \pm 0.172$, $N=23$ for large mammals).

What general conclusions can be drawn from these four studies? In each sample, small mammals represented 83–94 % of the data points and in these animals b was not significantly different from $2/3$. Except in McNab's study, b tended to be greater in large mammals. The inclusion of a relatively small number of large mammals was sufficient to make the overall value of b significantly greater than $2/3$. These observations can be statistically explained if we assume that large and small mammals lie on different, but parallel, regression lines with slopes of $2/3$, the line for large mammals being above that for small ones. Adding a few large mammals to the small ones would then cause the sample estimate of b to be greater than $2/3$. Also, depending on the width and location of the mass range within which data points are sampled, different values of b would be observed.

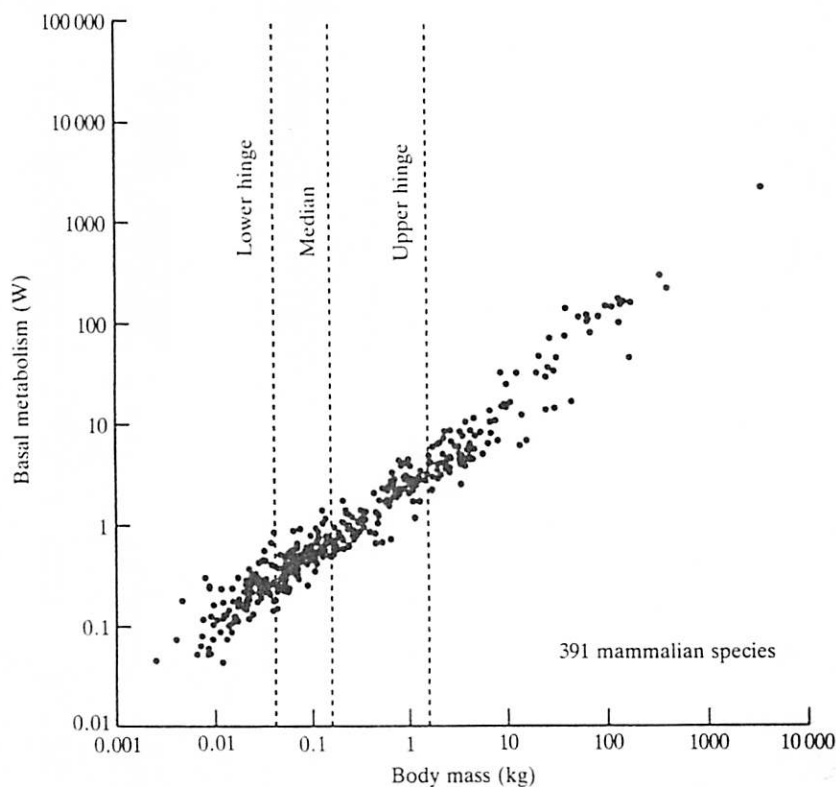


Fig. 1. Bilogarithmic scatter diagram of basal metabolism and body mass of 391 mammalian species. The vertical lines divide the data sample into four groups of equal size.

The regression was very significant: Snedecor's ratio of variances was $F=7808$, d.f.=1, 389, $P<0.001$; the coefficient of determination was $r^2=0.952$. The mass exponent b was significantly different from 0.75 ($t=5.05$, d.f.=389, $P<0.001$) and from $2/3$ ($t=5.37$, d.f.=389, $P<0.001$).

In 362 small mammals ($M<20\,000$ g) the mass exponent ($b=0.663\pm 0.009$) was significantly lower than in 29 large mammals ($M>20\,000$ g: $b=0.794\pm 0.094$; $t=2.05$, $P<0.05$). Clearly, a single rectilinear regression line does not accurately describe these data.

Robust regression analysis

Subdividing the range of body mass according to arbitrary mass limits is too subjective for analyzing the relationship between body mass and basal metabolism. An objective approach is to determine how many data points within the total mass range can be accurately described by one regression line. Statistically, this amounts to the identification and regrouping of data points (outliers) whose probability of falling about the same regression line is very low ($P\leq 0.006$). The

determination of outliers was performed by robust regression analysis (Rousseeuw and Leroy, 1987).

This technique, based on the least median of squares line (LMS line), partitioned the data sample into two groups. Group 1 consisted of 363 mammals (92.8%) within a mass range from 2.5 to 407 000 g. Their data points were randomly distributed about the LMS line with a slope of $b=0.665$ (unfortunately there was no method for estimating the error on the slope). The coefficient of determination was 0.959 and the scale estimate (or standard error of estimate) was 0.144. Group 2 consisted of 28 outliers (7.2% of the sample), 25 positive outliers (positive standardized residuals) and 3 negative outliers (negative standardized residuals). Since the leverage (Kleinbaum *et al.* 1988) of these negative outliers was small, they have been added to group 1. The positive outliers belonged to the following mammalian orders: Artiodactyla, 10 species (66%); Carnivora, 7 species (22%); Insectivora, 2 species (8%); Proboscidea, 1 species (100%) and Rodentia, 5 species (3%). The negative outliers belonged to the following orders: Chiroptera, 1 species (3%) and Insectivora, 2 species (8%).

Fig. 2 shows the data and regression lines for both groups. Least-squares

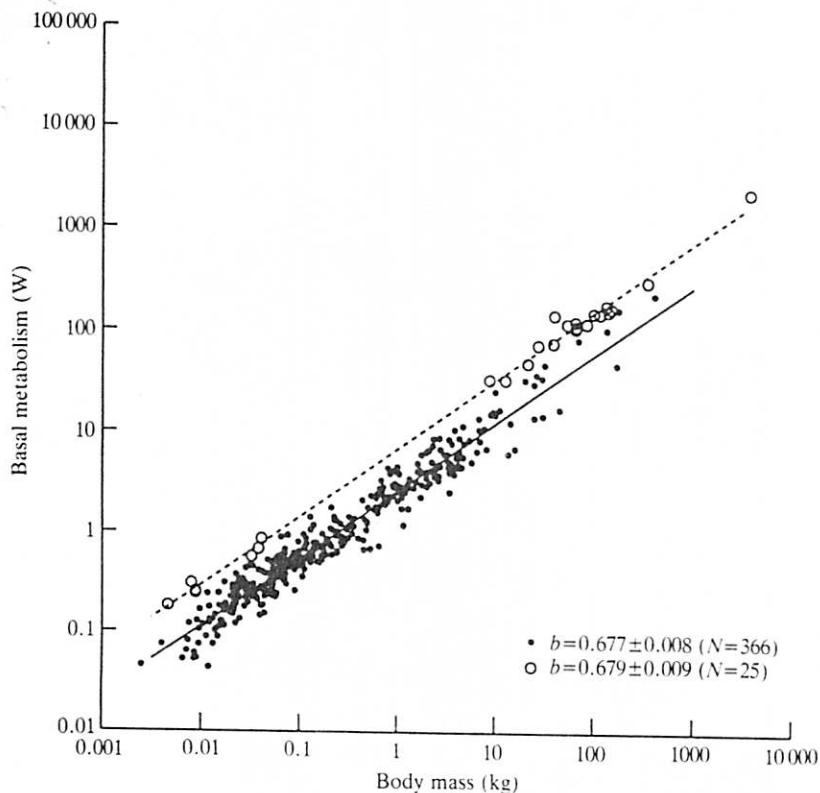


Fig. 2. Regression lines between the logarithms of basal metabolism and body mass in 391 mammalian species. The open symbols and dotted line show observations from the 25 positive 'outliers'. See text for further details.

regression analysis of group 1 yielded the following results: mass exponent $b=0.677\pm 0.008$, coefficient of determination $r^2=0.952$, standard error of estimate $s_{y|x}=0.146$, $F=7203$, d.f.=1, 364. Least-squares regression analysis of group 2 yielded the following results: $b=0.679\pm 0.009$, $r^2=0.996$, $s_{y|x}=0.077$, $F=5948$, d.f.=1, 23, $P<0.001$. In both groups, the regression was very significant; the mass exponents were not different and did not differ from $2/3$.

Covariance analysis of these two groups showed that the intragroup slope b was 0.678 ± 0.007 and the intragroup correlation coefficient r_i was 0.980. The difference in elevation of the two regression lines was very significant: $\log(a_1)=-1.623\pm 0.020$, $N=366$ and $\log(a_2)=-1.207\pm 0.037$, $N=25$, $F=182$, d.f.=1, 388, $P<0.001$.

In summary, the relationship between basal metabolism and body mass of 391 mammalian species can be accurately described by two regression lines with a common slope of $2/3$ and different intercepts.

Theoretical interpretation of the $2/3$ metabolic mass exponent

The foregoing statistical analysis has shown that a power function (equation 1) with a mass exponent of $2/3$ is a valid statistical model for describing the interspecific relationship between body mass and basal metabolism in mammals. This analysis has also shown that, contrary to common belief, the mass coefficient is not constant. Is this power function also a valid physical model - i.e. can a physical or physiological meaning be given to its parameters?

The power function or the so-called allometric equation has commonly been interpreted as revealing some kind of similitude among mammals (Gunther, 1975). In particular, the $2/3$ mass exponent has been considered to be a criterion of biological similitude (Lambert and Teissier, 1927) and the $3/4$ mass exponent a criterion of elastic similarity (McMahon, 1973). But comparative morphology clearly shows that small and large mammals are not geometrically similar. Furthermore, mammals and birds may fall on the same regression line with a slope of $2/3$. These observations call for a different explanation of the $2/3$ mass exponent.

The interspecific metabolic mass exponent of $2/3$, instead of revealing biological similitude among mammals, may very well reflect an underlying dimensional relationship between the physical quantities of mass and power. The following example from geometry illustrates this idea.

Geometry deals with three quantities: length L , surface area S , and volume V . These three quantities are dimensionally related:

$$[S] = L^2, \quad (2)$$

$$[V] = L^3, \quad (3)$$

therefore,

$$[S] = [V^{2/3}]. \quad (4)$$

The dimensional relationship (equation 4) is numerically implemented in any

given solid by relating the measures of surface area s and volume v by means of the volume coefficient c .

$$s = cv^{2/3}; \quad (5)$$

When s and v are expressed in units derived from the same unit of length ($\text{cm} \rightarrow \text{cm}^2, \text{cm} \rightarrow \text{cm}^3$), then c is determined by the form of the solid ($c=6$ in cubes and 4.84 in spheres). However, except for spheres, c is not form-specific, i.e. different forms may have the same value of c . Note that, depending on the values of c , the dimensional relationship (equation 4) can be numerically implemented in many different ways.

Equation 5 also expresses the relationship between volume and surface area in geometrically similar solids of different size, where changes in s and v are due only to changes in size. Equation 5 is not valid in solids that are not geometrically similar, where changes in s are also due to changes in form (c). The relationship between v and s is still a power function, but the underlying dimensional $2/3$ exponent is masked by the relationship between size and form. Now, the values of the volume exponent and volume coefficient are determined by the distribution of form within the volume range. In general, the volume exponent is different from $2/3$, with one exception – when form is randomly distributed within the volume range. In this case, the $2/3$ volume exponent does not reveal geometric similitude of the solids but the underlying dimensional relationship between the quantities of surface area and volume. The corollary of this is that the $2/3$ volume exponent is a necessary, but not sufficient, condition for geometric similitude.

This example shows that we must distinguish the dimensional relationship between quantities (equation 4) from the numerical relationship between the measures of these quantities (equation 5). We shall now apply these same principles to find the underlying dimensional relationship between the primary quantity of mass and the secondary quantity of power in the metabolic power function.

Primary quantities, such as mass M , length L and time T , are directly measurable. They have well-defined standards of measurement from which their units are derived. A secondary quantity, such as velocity ($L T^{-1}$), is a combination of the arbitrarily chosen primary quantities and has no standard.

With mass M , length L and time T as primary quantities, the dimensional equation of any secondary quantity Q is given by:

$$[Q] = M^{\alpha_1} L^{\beta_1} T^{\gamma_1}, \quad (6)$$

where the exponents α_1 , β_1 and γ_1 are the dimensions of mass, length and time, respectively (Bridgeman, 1931; Ellis, 1968). Since $\alpha_1=1$, $\beta_1=2$ and $\gamma_1=-3$ for energy metabolism, its dimensional equation is:

$$[P] = ML^2T^{-3}. \quad (7)$$

To establish the dimensional relationship between body mass M and basal metabolism P , we define a standard mammal that embodies the standards of volume, mass and time. In real, complex forms such as mammals, length and surface areas are fractals, i.e. their measure depends on the chosen units

(Mandelbrot, 1982). To avoid this complication we choose volume V , which is directly measurable, as one of the primary quantities. The period of a periodic process (cardiac or respiratory cycle) in this standard mammal is taken as the standard of time. With mass M , volume V and time T as primary quantities, the secondary quantities are then given by:

$$[Q] = M^{\alpha_2} V^{\beta_2} T^{\gamma_2}, \quad (8)$$

where α_2 , β_2 and γ_2 are the dimensions of mass, volume and time, respectively.

The dimensional equations of the secondary quantities of length, surface area and power (basal metabolism) are:

$$[L] = V^{1/3}, \quad (9)$$

$$[S] = V^{2/3}, \quad (10)$$

$$[P] = MV^{2/3}T^{-3}. \quad (11)$$

Since the standards of mass, volume and time are embodied in the same system, they, and the units that are derived from them, are linked by relationships of similitude. They cannot be independently changed. In two standard mammals which differ only in size, the following similitude relationships between their respective standards of mass (m_1, m_2), volume (v_1, v_2) and time (t_1, t_2) hold:

$$m_2 = \mu m_1, \quad (12)$$

$$v_2 = \nu v_1, \quad (13)$$

$$t_2 = \tau t_1, \quad (14)$$

where μ , ν and τ are similitude constants.

A change in a secondary quantity is then given by:

$$q_2 = q_1 \mu^{\alpha_2} \nu^{\beta_2} \tau^{\gamma_2}. \quad (15)$$

The similitude constants μ , ν and τ of the measures of M , V and T are themselves related by the following relationships. If the two standard mammals differ in size only, their density is the same. This is expressed by:

$$\nu = \mu. \quad (16)$$

Assuming that the measure of the time standard is proportional to length, then:

$$\tau = \mu^{1/3}. \quad (17)$$

Under these conditions, the relationship between the measures q_1 and q_2 of any secondary quantity is given by:

$$q_2 = q_1 \mu^{(\alpha_2 + \beta_2 + \frac{1}{3}\gamma_2)}. \quad (18)$$

Equation 18 defines a new system of units in which the dimensions of all the secondary quantities can be expressed in terms of only one primary quantity, mass. Dimensions have no intrinsic significance (Staicu, 1982). They are the result of arbitrarily chosen primary quantities, and, therefore, depend on the number and

nature of these primary quantities. Different quantities may have the same dimensional equation in the same system of units. For example, frequency and angular velocity have the same dimension T^{-1} in the M, L, T system. Flow, force and power are dimensionally equivalent ($[M^{2/3}]$) in the system based on mass alone.

The relationship between the measures of power (p_1, p_2) in two standard mammals is then:

$$p_2 = p_1 \mu^{2/3}, \quad (19)$$

which can be rewritten as:

$$p_2 = a m_2^{2/3}, \quad (20)$$

where a , the mass coefficient, is:

$$a = \frac{p_1}{m_1^{2/3}}. \quad (21)$$

Equation 20 is also the statistical model derived from regression analysis. The $2/3$ mass exponent is the dimension of the secondary quantity of power in terms of the primary quantity of mass. The $2/3$ mass exponent reveals the dimensional relationship between the units of mass and power, and not biological similitude in mammals. Indeed, with the large number of mammals, the values of the mass coefficient a tend to be randomized within the mass range. This randomization reveals the underlying, dimensional $2/3$ mass exponent.

Through the mass coefficient a , the dimensional relationship between mass and power is numerically implemented. With mass as the only primary quantity, a is dimensionless:

$$[a] = M^0; \quad (22)$$

i.e. a is mass-independent and a pure number.

Physiologically, a or the ratio $P/M^{2/3}$ is the energy spent per unit mass and per unit of the defined time scale: a is the mass-specific physiological power (Heusner, 1982b). The ratio $P/M^{2/3}$ is a mass-independent measure of basal metabolism (MIM, Heusner, 1985). Changes in this ratio measure the effect of metabolic factors other than mass. Animals with the same MIM lie on the same regression line. At the same body mass, these animals would have the same basal metabolism. Conversely, animals in which the MIM is different cannot have the same basal metabolism at the same body mass.

The system of units based solely on mass shows that the so-called allometric relationships are necessary consequences of the underlying dimensional relationships between mass and the various quantities that are measured in an organism and do not reveal special properties such as geometric, biological or elastic similarity in these organisms.

Conclusion

Theory of measurement reveals a necessary underlying dimensional relationship between mass and power, and statistical analysis confirms the existence of this

relationship in mammals. Statistics and the theory of measurement are both concerned with describing relationships accurately, not with providing physical explanations. An accurate description is a first and necessary step towards a physical explanation of a relationship. This paper shows that the mass exponent is not the physiological problem of interest. It is not the slope of the metabolic regression line, but its location in the mass/power plane that must be explained. This location is given by the value of the mass coefficient, the explanation of which is, and remains, the central question in comparative physiology.

Appendix

Species	M^* (g)	Bm^\dagger (W)	Source
ARTIODACTYLA			
<i>Bos taurus</i> ⁺	347 000.00	306.77	Blaxter (1966)
<i>Camelus dromedarius</i>	407 000.00	229.18	Schmidt-Nielson <i>et al.</i> (1967)
<i>Capreolus capreolus</i> ⁺	21 500.00	48.43	Weiner (1977)
<i>Cervus elaphu</i> ⁺	67 000.00	112.43	Brockway and Maloiy (1968)
<i>Connochaetes taurinus</i> ⁺	140 000.00	157.67	Taylor <i>et al.</i> (1969a)
<i>Kobus defassa ugandae</i> ⁺	100 000.00	152.04	Taylor <i>et al.</i> (1969b)
<i>Lama glama</i> ⁺	115 000.00	148.94	El-Nouty <i>et al.</i> (1978)
<i>Odocoileus virginianus</i> ⁺	65 320.00	106.67	Silver <i>et al.</i> (1969)
<i>Oreamnos americanus</i>	32 000.00	46.85	Krogh and Monson (1954)
<i>Ovis canadensis</i> ⁺	65 000.00	124.45	Chappel and Hudson (1978)
<i>Rangifer tarandus</i> ⁺	85 000.00	119.66	McEwan (1970)
<i>Sus scrofa</i>	135 000.00	104.15	Capstick and Wood (1922)
<i>Taurotragus oryx</i> ⁺	133 300.00	180.15	Taylor and Lymen (1967)
<i>Tayassu tajacu</i>	20 200.00	32.99	Zervanos (1975)
<i>Tragulus javanicus</i>	1 613.00	4.90	Whittow <i>et al.</i> (1977b)
CARNIVORA			
<i>Acinonyx jubatus</i> ⁺	39 000.00	76.86	Taylor and Rowntree (1973)
<i>Ailurus fulgens</i>	5 740.00	5.11	McNab (1988)
<i>Alopex lagopus</i>	3 600.00	7.74	Casey <i>et al.</i> (1979)
<i>Arctitis binturong</i>	14 280.00	12.54	McNab (1988)
<i>Canis latrans</i>	10 000.00	14.98	Golightly and Ohmart (1978a)
<i>Cerdocyon thous</i>	5 444.00	8.43	Hennemann <i>et al.</i> (1983)
<i>Enhydra lutris</i> ⁺	40 000.00	144.15	Iversen and Krog (1973)
<i>Fennecus zerda</i>	1 106.00	2.23	Noll-Banholzer (1979)

* M , body mass.

† Bm , basal metabolism.

⁺ Positive outliers; ⁻ negative outliers.

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Species	M (g)	Bm (W)	Source
<i>Fossa fossa</i>	2 260.00	5.09	McNab (1988)
<i>Genetta tigrina</i>	1 700.00	4.21	Hennemann and Konecny (1980)
<i>Gulo gulo</i> ⁺	12 700.00	32.90	Iversen (1972)
<i>Herpestes auropunctatus</i>	611.00	2.27	Ebisu and Whittow (1976)
<i>Herpestes sanguineus</i>	540.00	2.31	Kamau <i>et al.</i> (1979)
<i>Lutra lutra</i>	10 000.00	25.34	Iversen (1972)
<i>Lycaon pictus</i> ⁺	8 750.00	33.01	Iversen (1972)
<i>Martes americana</i>	1 038.00	3.86	Worthen and Kilgore (1981)
<i>Martes martes</i>	920.00	4.14	Iversen (1972)
<i>Meles meles</i>	11 050.00	16.80	Iversen (1972)
<i>Mustela erminea</i>	210.00	1.75	Iversen (1972)
<i>Mustela frenata</i>	225.00	1.39	Brown and Lasiewski (1972)
<i>Mustela vison</i>	660.00	2.75	Farrel and Wood (1968)
<i>Nandinia binotata</i>	4 270.00	6.49	McNab (1988)
<i>Nasua nasua</i>	4 000.00	5.63	Chevillard-Hugot <i>et al.</i> (1980)
<i>Paradoxurus hermaphroditus</i>	3 410.00	4.03	McNab (1988)
<i>Phoca fasciata</i> ⁺	54 000.00	118.59	Iversen and Krog (1973)
<i>Phoca groenlandica</i> ⁺	150 000.00	168.93	Gallivan and Ronald (1981)
<i>Phoca vitulina</i> ⁺	27 400.00	73.29	Hart and Irving (1959)
<i>Potos flavus</i>	2 400.00	4.27	Muller and Kulzer (1977)
<i>Procyon cancrivorus</i>	1 160.00	2.56	Scholander <i>et al.</i> (1950)
<i>Proteles cristatus</i>	7 710.00	11.03	McNab (1984)
<i>Taxidea taxus</i>	9 000.00	15.20	Harlow (1981)
<i>Vulpes macrotis</i>	1 769.00	6.02	Golightly and Ohmart (1978a)

CHIROPTERA

<i>Anoura caudifer</i>	11.50	0.24	McNab (1969)
<i>Artibeus concolor</i>	19.70	0.22	McNab (1969)
<i>Artibeus jamaicensis</i>	47.00	0.30	Morrison and McNab (1967)
<i>Artibeus lituratus</i>	70.10	0.61	McNab (1969)
<i>Carollia perspicillata</i>	14.90	0.24	McNab (1969)
<i>Chrotopterus auritus</i>	96.10	0.80	McNab (1969)
<i>Cynopterus brachyotis</i>	37.00	0.26	McNab (1988)
<i>Desmodus rotundus</i>	29.40	0.20	McNab (1969)
<i>Diaemus youngi</i>	36.60	0.21	McNab (1969)
<i>Diphylla ecaudata</i>	27.80	0.22	McNab (1969)
<i>Dobsonia minor</i>	87.00	0.62	Bartholomew <i>et al.</i> (1970)
<i>Eonycteris spelaea</i>	52.00	0.27	McNab (1988)
<i>Eptesicus fuscus</i>	16.90	0.11	Herreid and Schmidt- Nielsen (1966)

Species	M (g)	Bm (W)	Source
<i>Eumops perotis</i>	56.00	0.22	Leitner (1966)
<i>Glossophaga soricina</i>	9.60	0.17	McNab (1969)
<i>Hipposideros galeritus</i>	8.50	0.05	McNab (1988)
<i>Histiotus velatus</i>	11.20	0.09	McNab (1969)
<i>Leptonycteris sanborni</i>	22.00	0.21	Carpenter and Graham (1967)
<i>Macroderma gigas</i>	148.00	0.78	Leitner and Nelson (1967)
<i>Molossus molossus</i>	15.60	0.13	McNab (1969)
<i>Myotis lucifugus</i>	6.50	0.05	Dodgen and Blood (1956)
<i>Myotis velifer</i>	11.89	0.04	Riedesel and Williams (1976)
<i>Noctilio albiventris</i>	27.00	0.18	McNab (1969)
<i>Noctilio leporinus</i>	61.00	0.40	McNab (1969)
<i>Nyctimene albiventer</i>	28.20	0.23	Bartholomew <i>et al.</i> (1970)
<i>Paranyctimene raptor</i>	21.30	0.17	Bartholomew <i>et al.</i> (1970)
<i>Phyllostomus discolor</i>	33.50	0.27	McNab (1969)
<i>Phyllostomus elongatus</i>	36.00	0.22	McNab (1969)
<i>Phyllostomus hastatus</i>	84.20	0.56	McNab (1969)
<i>Pteropus poliocephalus</i>	598.00	1.78	Bartholomew <i>et al.</i> (1964)
<i>Pteropus scapulatus</i>	362.00	1.37	Bartholomew <i>et al.</i> (1964)
<i>Rhinophylla pumilio</i>	9.50	0.10	McNab (1969)
<i>Sturnira lilium</i>	21.00	0.19	Morrison and McNab (1967)
<i>Syconycteris australis</i>	17.50	0.19	Bartholomew <i>et al.</i> (1970)
<i>Tadarida brasiliensis</i>	10.40	0.12	Herreid and Schmidt- Nielsen (1966)
<i>Tonatia bidens</i>	27.40	0.31	McNab (1969)
<i>Uroderma bilobatum</i>	16.20	0.18	McNab (1969)
<i>Vampyrops lineatus</i>	21.90	0.25	McNab (1969)
EDENTATA			
<i>Bradypus variagatus</i>	3 790.00	3.86	McNab (1978b)
<i>Cabassous centralis</i>	3 810.00	4.57	McNab (1980)
<i>Chaetophractus nationi</i>	2 150.00	3.15	McNab (1980)
<i>Chaetophractus vellerosus</i>	1 110.00	1.73	McNab (1980)
<i>Chaetophractus villosus</i>	4 540.00	4.55	McNab (1980)
<i>Choloepus hoffmanni</i>	4 250.00	4.50	McNab (1978b)
<i>Dasypus novemcinctus</i>	3 320.00	4.49	McNab (1980)
<i>Euphractus sexcinctus</i>	8 190.00	6.96	McNab (1980)
<i>Myrmecophaga tridactyla</i>	30 600.00	14.65	McNab (1982)
<i>Prionodontes maximus</i>	45 190.00	17.05	McNab (1980)
<i>Tamandua mexicana</i>	4 210.00	4.79	McNab (1984)
<i>Tamandua tetradactyla</i>	3 500.00	4.99	McNab (1984)
<i>Tolypeutes matacus</i>	1 160.00	1.18	McNab (1980)

Species	M (g)	Bm (W)	Source
<i>Zaedyus pichiy</i>	1 740.00	2.25	McNab (1980)
HYRACOIDEA			
<i>Dendrohyrax dorsalis</i>	2 210.00	4.18	Hildwein (1972)
<i>Heterohyrax brucei</i>	2 000.00	4.05	Taylor and Sale (1969)
<i>Procavia capensis</i>	2 400.00	3.65	Rubsamen <i>et al.</i> (1979)
<i>Procavia habessinica</i>	2 250.00	5.07	Taylor and Sale (1969)
<i>Procavia johnstoni</i>	2 750.00	6.81	Taylor and Sale (1969)
INSECTIVORA			
<i>Amblysomus hottentotus</i>	70.00	0.48	Kuyper (1979)
<i>Blarina brevicauda</i>	20.70	0.29	Platt (1974)
<i>Chrysochloris asiatica</i>	33.00	0.22	Withers (1978)
<i>Crocidura occidentalis</i>	33.16	0.25	Hildwein (1972)
<i>Crocidura russula</i>	13.70	0.15	Nagel (1977)
<i>Crocidura suaveolens</i>	7.50	0.12	Nagel (1980)
<i>Echinops telfairi</i>	116.40	0.75	Dryden <i>et al.</i> (1974)
<i>Echinosorex gymnurus</i>	721.20	2.84	Whittow <i>et al.</i> (1977a)
<i>Erinaceus albiventris</i>	450.00	0.84	McNab (1980)
<i>Erinaceus europaeus</i>	2 000.00	2.91	McNab (1980)
<i>Hemiechinus auritus</i>	397.00	0.87	Shkolnik and Schmidt-Nielsen (1976)
<i>Neomys fodiens</i>	17.10	0.31	Nagel (1980)
<i>Notiosorex crawfordi</i>	4.00	0.07	Lindstedt (1980)
<i>Paraechinus aethiopicus</i>	453.00	0.68	Shkolnik and Schmidt-Nielsen (1976)
<i>Scalopus aquaticus</i>	48.00	0.38	McNab (1979)
<i>Scapanus latimanus</i>	61.00	0.43	Contreras (1983)
<i>Scapanus orarius</i>	61.20	0.35	Kenagy and Vleck (1982)
<i>Scapanus townsendi</i>	130.10	0.60	Kenagy and Vleck (1982)
<i>Setifer setosus</i> ⁻	530.00	0.69	McNab (1980)
<i>Sorex cinereus</i> ⁺	7.90	0.31	Kenagy and Vleck (1982)
<i>Sorex minutus</i> ⁺	4.60	0.18	Gebczynski (1971)
<i>Suncus etruscus</i>	2.50	0.05	Nagel (1980)
<i>Suncus murinus</i>	52.30	0.49	Dryden <i>et al.</i> (1974)
<i>Tenrec ecaudatus</i> ⁻	650.00	0.74	Hildwein (1970)
LAGOMORPHA			
<i>Lepus alleni</i>	3 362.00	8.54	Hinds (1977)
<i>Lepus arcticus</i>	3 004.40	6.09	Wang <i>et al.</i> (1973)
<i>Lepus californicus</i>	2 300.00	7.38	Schmidt-Nielsen <i>et al.</i> (1965)
<i>Ochotona daurica</i>	127.70	1.40	Weiner and Gorecki (1981)
<i>Ochotona princeps</i>	109.00	0.94	MacArthur and Wang (1973)

Species	M (g)	Bm (W)	Source
<i>Sylvilagus audubonii</i>	701.70	2.57	Hinds (1973)
MACROSCELIDEA			
<i>Elaphantalus rufescens</i>	53.00	0.32	McNab (1984)
<i>Elaphantalus edwardi</i>	49.80	0.31	Leon <i>et al.</i> (1983)
<i>Petrodromus tetradactylus</i>	210.00	0.72	McNab (1984)
MARSUPIALIA			
<i>Antechinomys spenceri</i>	24.20	0.13	MacMillen and Nelson (1969)
<i>Antechinus maculatus</i>	8.50	0.06	MacMillen and Nelson (1969)
<i>Antechinus stuartii</i>	22.10	0.19	MacMillen and Nelson (1969)
<i>Caluromys derbianus</i>	357.00	1.15	McNab (1978a)
<i>Cercartetus nanus</i>	70.00	0.34	Bartholomew and Hudson (1962)
<i>Chinorectes minimus</i>	946.00	3.09	McNab (1978a)
<i>Cyclopes didactylus</i>	240.00	0.64	McNab (1984)
<i>Dasyercus cristicaudata</i>	88.80	0.26	MacMillen and Nelson (1969)
<i>Dasyuroides byrnei</i>	89.00	0.44	MacMillen and Nelson (1969)
<i>Dasyurops Dasyurus? maculatus</i>	1 782.00	3.01	MacMillen and Nelson (1969)
<i>Dasyurus geoffroii</i>	1 300.00	2.82	Arnold and Shield (1970)
<i>Dasyurus viverrinus</i>	909.90	2.31	MacMillen and Nelson (1969)
<i>Dendrolagus matschiei</i>	6 960.00	8.23	McNab (1988)
<i>Didelphis marsupialis</i>	1 329.00	3.44	McNab (1978a)
<i>Didelphis virginiana</i>	3 257.00	6.05	McNab (1978a)
<i>Echymipera kalabu</i>	695.00	1.92	Hulbert and Dawson (1974)
<i>Echymipera rufescens</i>	1 276.00	3.02	Hulbert and Dawson (1974)
<i>Gymnobelideus leadbeateri</i>	166.30	0.58	Smith <i>et al.</i> (1982)
<i>Isoodon macrourus</i>	1 551.00	3.23	Hulbert and Dawson (1974)
<i>Lagorchestes conspicillatu</i>	2 660.00	4.79	Dawson and Bennet (1978)
<i>Lasiiorhinus latifrons</i>	25 000.00	14.08	Wells (1978)
<i>Lutreolina crassicaudata</i>	812.00	2.29	McNab (1978a)
<i>Macropus eugenii</i>	4 796.00	7.78	Dawson and Hulbert (1970)
<i>Macropus robustus</i>	30 000.00	34.46	Dawson (1973)
<i>Macrotis lagotis</i>	1 477.00	2.79	Kinnear and Shield (1975)
<i>Marmosa microtarsus</i>	13.00	0.13	Morrison and McNab (1962)

Species	M (g)	Bm (W)	Source
<i>Marmosa robinsoni</i>	122.00	0.55	McNab (1978a)
<i>Megaleia rufa</i>	25 000.00	30.13	Dawson (1973)
<i>Metachirus nudicaudatus</i>	336.00	1.15	McNab (1978a)
<i>Monodelphis brevicaudata</i>	111.00	0.43	McNab (1978a)
<i>Myrmecobius fasciatus</i>	480.00	1.05	McNab (1984)
<i>Perameles nasuta</i>	645.00	1.76	Hulbert and Dawson (1974)
<i>Petaurus breviceps</i>	128.10	0.50	Dawson and Hulbert (1970)
<i>Phalanger maculatus</i>	4 250.00	5.67	Dawson and Degabriele (1973)
<i>Phascogale tapotafa</i>	157.20	0.72	MacMillen and Nelson (1969)
<i>Phascolarctos cinereus</i>	4 700.00	5.72	Degabriele and Dawson (1979)
<i>Philander opossum</i>	751.00	1.90	McNab (1978a)
<i>Planigale gilesi</i>	9.40	0.07	Dawson and Wolfers (1978)
<i>Planigale ingrami</i>	7.10	0.06	Dawson and Wolfers (1978)
<i>Planigale maculata</i>	13.10	0.07	Morton and Lee (1978)
<i>Potorous tridactylus</i>	1 120.00	2.84	Nicol (1976)
<i>Pseudantechinus macdonnellensis</i>	43.10	0.15	MacMillen and Nelson (1969)
<i>Pseudocheirus occidentalis</i>	828.00	2.21	Kinnear and Shield (1975)
<i>Sarcophilus harrisi</i>	6 500.00	6.52	Nicol and Maskrey (1980)
<i>Satanellus hallucatus</i>	584.40	1.68	MacMillen and Nelson (1969)
<i>Setonix brachyurus</i>	2 510.00	4.52	Kinnear and Shield (1975)
<i>Sminthopsis crassicaudata</i>	14.10	0.11	Dawson and Hulbert (1970)
<i>Trichosurus vulpecula</i>	1 982.00	3.52	Dawson and Hulbert (1970)
MONOTREMATA			
<i>Ornithorhynchus anatinus</i>	1 200.00	2.50	Grant and Dawson (1978)
<i>Tachyglossus aculeatus</i>	3 430.00	2.55	Dawson <i>et al.</i> (1979)
<i>Zaglossus bruijnii</i>	13 630.00	6.22	Dawson <i>et al.</i> (1979)
PERISSODACTYLA			
<i>Equus asinus</i>	177 500.00	164.92	Yousef and Dill (1969)
PHOLIDOTA			
<i>Manis crassicaudata</i>	15 910.00	6.99	McNab (1984)
<i>Manis javanica</i>	4 220.00	6.23	McNab (1984)
<i>Manis tricupis</i>	2 730.00	4.63	Hildwein (1972)

mW

Species	M (g)	Bm (W)	Source
PRIMATES			
<i>Alouatta palliata</i>	4 670.00	11.57	Milton <i>et al.</i> (1979)
<i>Aotus trivirgatus</i>	1 020.00	2.56	Goffart (1977)
<i>Arctocebus calabarensis</i>	206.00	0.73	Hildwein (1972)
<i>Callithrix jachus</i>	190.00	0.86	Morrison and Simoes (1962)
<i>Cebuella pygmeaa</i>	105.00	0.55	Morrison and Middleton (1967)
<i>Cheirogaleus medius</i>	300.00	1.10	McCormick (1981)
<i>Euoticus elegantulus</i>	261.50	1.20	Hildwein (1972)
<i>Galago crassicaudatus</i>	1 039.00	2.93	Palacio (1977)
<i>Galago demidovii</i>	61.00	0.42	Hildwein (1972)
<i>Galago elegantulus</i>	261.50	1.20	Hildwein (1972)
<i>Homo sapiens</i>	70 000.00	82.78	Harris and Benedict (1919)
<i>Lemur fulvus</i>	2 330.00	4.20	Daniels (1984)
<i>Nycticebus coucang</i>	1 300.00	1.73	Muller (1979)
<i>Papio anubis</i>	9 500.00	16.05	Proppe and Gale (1970)
<i>Perodicticus potto</i>	1 011.00	2.07	Hildwein and Goffart (1975)
<i>Saguinus geoffroyi</i>	225.00	1.30	Scholander <i>et al.</i> (1950)
<i>Saimiri sciureus</i>	800.00	4.39	Stitt and Hardy (1971)
PROBOSCIDEA			
<i>Elephas maximus</i> ⁺	3 67 000.00	2 336.50	Benedict (1938)
RODENTIA			
<i>Acomys cahirinus</i>	42.00	0.26	Shkolnik and Borut (1969)
<i>Acomys russatus</i>	51.10	0.23	Shkolnik and Borut (1969)
<i>Aconaemys fuscus</i>	112.00	0.68	Contreras (1983)
<i>Agouti paca</i>	9 156.00	15.47	McNab (1988)
<i>Akodon azarae</i>	23.50	0.22	Dalby and Heath (1976)
<i>Alticola argentatus</i> ⁺	37.70	0.68	Weiner and Gorecki (1981)
<i>Ammospermophilus leucurus</i>	112.80	0.55	Kenagy and Vleck (1982)
<i>Aplodontia rufa</i>	630.00	1.56	McNab (1979)
<i>Apodemus flavicollis</i> ⁺	40.50	0.86	Fedick (1971)
<i>Arvicola richardsoni</i>	51.00	0.50	Bradley (1976)
<i>Arvicola terrestris</i>	97.50	0.64	Drozdz <i>et al.</i> (1971)
<i>Baiomys taylori</i>	7.30	0.08	Hudson (1965)
<i>Cannomys badius</i>	344.00	0.97	McNab (1979)
<i>Capromys pilorides</i>	2 630.00	3.36	McNab (1978b)
<i>Cavia porcellus</i>	728.00	2.25	Kibler <i>et al.</i> (1947)
<i>Chinchilla lanigera</i>	485.00	1.28	Kohl (1980)
<i>Citellus undulatus</i>	680.00	3.31	Casey <i>et al.</i> (1979)
<i>Clethrionomys gapperi</i>	23.00	0.26	Bradley (1976)
<i>Clethrionomys glareolus</i>	20.50	0.27	Pearson (1962)
<i>Clethrionomys rufocanus</i>	27.50	0.31	Pearson (1962)

Species	M (g)	Bm (W)	Source
<i>Clethrionomys rutilus</i>	28.00	0.43	Rosenmann <i>et al.</i> (1975)
<i>Coendou prehensilis</i>	3 280.00	5.17	McNab (1978b)
<i>Cricetus cricetus</i>	336.70	1.19	Gorecki and Wolek (1975)
<i>Cryptomys hottentotus</i>	71.00	0.38	Contreras (1983)
<i>Ctenomys fulvus</i>	300.00	1.06	Contreras (1983)
<i>Ctenomys maulinus</i>	215.00	1.05	Contreras (1983)
<i>Ctenomys peruanus</i>	490.00	1.24	McNab (1979)
<i>Cuniculus cuniculus</i>	2 000.00	6.42	Gelineo (1956)
<i>Cynomys ludovicianus</i>	1 112.30	2.40	Reinking <i>et al.</i> (1977)
<i>Dasyprocta azarae</i>	3 849.00	10.62	Arends (1985)
<i>Dasyprocta leporina</i>	2 687.00	8.78	Arends (1985)
<i>Dicrostonyx groenlandicus</i>	47.00	0.52	Casey <i>et al.</i> (1979)
<i>Dipodomys agilis</i>	61.00	0.36	Carpenter (1966)
<i>Dipodomys deserti</i>	107.50	0.49	Kenagy and Vleck (1982)
<i>Dipodomys merriami</i>	43.40	0.23	Kanagy and Vleck (1982)
<i>Dipodomys microps</i>	54.20	0.33	Yousef <i>et al.</i> (1974)
<i>Dipodomys ordii</i>	48.80	0.32	Kenagy and Vleck (1982)
<i>Dipodomys panamintinus</i>	56.90	0.38	Dawson (1955)
<i>Dipus aegyptius</i>	160.00	0.70	Kirmiz (1962)
<i>Dolichotis salincola</i>	1 613.00	4.09	Arends (1985)
<i>Epixerus wilsoni</i>	460.00	1.35	Hildwein (1972)
<i>Erithizon epixanthum</i>	6 790.00	13.76	Irving <i>et al.</i> (1955)
<i>Eutamias amoenus</i>	52.70	0.43	Kenagy and Vleck (1982)
<i>Eutamias merriami</i>	78.90	0.48	Wunder (1970)
<i>Eutamias minimus</i>	53.00	0.30	Willems and Armitage (1975)
<i>Eutamias palmeri</i>	69.40	0.64	Yousef <i>et al.</i> (1974)
<i>Funisciurus isabella</i>	60.00	0.57	Hildwein (1972)
<i>Funisciurus lemniscatus</i>	95.00	0.50	Hildwein (1972)
<i>Funisciurus mystax</i>	63.00	0.58	Hildwein (1972)
<i>Funisciurus pyrrhopus</i>	244.00	1.01	Hildwein (1972)
<i>Geomys bursarius</i>	197.00	0.78	Bradley and Yousef (1975)
<i>Geomys pinetis</i>	203.00	0.77	McNab (1966)
<i>Gis glis</i>	152.00	0.50	Gebczynski <i>et al.</i> (1972)
<i>Glaucomys volans</i>	62.80	0.37	Newman (1967)
<i>Heliophobius argenteocinereus</i>	88.00	0.42	McNab (1979)
<i>Heliophobius kapeti</i>	89.00	0.44	McNab (1966)
<i>Heliosciurus rufobrachium</i>	271.00	0.90	Hildwein (1972)
<i>Heterocephalus glaber</i>	39.00	0.14	McNab (1979)

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Species	M (g)	Bm (W)	Source
<i>Hydrochaeris hydrochaeris</i>	26 385.00	37.14	Arends (1985)
<i>Hydromys chrysogaster</i>	900.00	2.97	Dawson and Fanning (1981)
<i>Jaculus jaculus</i>	74.50	0.52	Hooper and Hilali (1972)
<i>Jaculus orientalis</i>	139.10	0.78	Hooper and Hilali (1972)
<i>Kerodon rupestris</i>	801.00	2.03	McNab (1988)
<i>Lagostomus maximus</i>	6 804.00	10.65	Kohl (1980)
<i>Leggadina hermannsburgensi</i>	12.20	0.13	MacMillen <i>et al.</i> (1972)
<i>Lemmus sibericus</i>	70.00	0.67	Coady (1975)
<i>Lemniscomys griselda</i>	51.00	0.35	Haim (1981)
<i>Lemmus trimucronatus</i>	64.00	0.89	Casey <i>et al.</i> (1979)
<i>Lepus americanus</i>	2 100.00	6.65	Hinds (1977)
<i>Liomys irroratus</i>	48.10	0.30	Hudson and Rummel (1966)
<i>Liomys salvini</i>	43.80	0.26	Hudson and Rummel (1966)
<i>Marmota flaviventris</i>	4 294.90	8.78	Reinking <i>et al.</i> (1977)
<i>Marmota monax</i>	2 650.00	3.73	Benedict (1938)
<i>Meriones hurrianae</i>	72.30	0.30	Goyal <i>et al.</i> (1981)
<i>Meriones unguiculatus</i>	67.00	0.43	Weiner and Gorecki (1981)
<i>Mesocricetus auratus</i>	119.50	0.58	Tegowska and Gebczynski (1975)
<i>Microdipodops pallidus</i>	15.20	0.11	Bartholomew and McMillen (1961)
<i>Micromys minutus</i> ⁺	8.71	0.26	Gorecki (1971)
<i>Microtus agrestis</i>	22.30	0.38	Hansson and Grodzinski (1970)
<i>Microtus arvalis</i>	23.90	0.34	Jansky (1959)
<i>Microtus californicus</i>	44.00	0.38	Bradley (1976)
<i>Microtus longicaudus</i>	41.40	0.40	Kenagy and Vleck (1982)
<i>Microtus mexicanus</i>	28.00	0.26	Bradley (1976)
<i>Microtus minutus</i> ⁺	8.70	0.24	Gorecki (1971)
<i>Microtus montanus</i>	30.79	0.46	Packard (1968)
<i>Microtus nivalis</i>	32.80	0.46	Bienkowski and Marszalek (1974)
<i>Microtus ochrogaster</i>	51.00	0.34	Bradley (1976)
<i>Microtus oeconomus</i> ⁺	32.00	0.57	Casey <i>et al.</i> (1979)
<i>Microtus pennsylvanicus</i>	38.00	0.41	Bradley (1976)
<i>Microtus pinetorum</i>	25.00	0.28	Bradley (1976)
<i>Microtus townsendii</i>	52.20	0.48	Kenagy and Vleck (1982)
<i>Mus musculus</i>	17.00	0.16	Pearson (1947)
<i>Mus musculus alb.</i>	26.00	0.34	Hart (1950)
<i>Mustela rixosa</i>	75.00	0.93	Casey <i>et al.</i> (1979)
<i>Myoprocta acouchy</i>	914.00	2.83	Arends (1985)
<i>Napaeozapus insignis</i>	21.60	0.22	Brower and Cade (1966)

Species	M (g)	Bm (W)	Source
<i>Neotoma albigula</i>	172.40	0.72	Brown (1968)
<i>Neotoma cinerea</i>	320.90	1.41	Brown (1968)
<i>Neotoma fuscipes</i>	186.70	0.83	Lee (1963)
<i>Neotoma lepida</i>	106.00	0.36	Nelson and Yousef (1979)
<i>Notiomys macronyx</i>	62.00	0.47	Contreras (1983)
<i>Notomys alexis</i>	32.30	0.25	MacMillen and Lee (1970)
<i>Notomys cervinus</i>	34.20	0.23	MacMillen and Lee (1970)
<i>Ochrotomys nuttalli</i>	19.50	0.15	Layne and Dolan (1975)
<i>Ocodon degus</i>	206.00	1.08	Arends (1985)
<i>Octodontomys gliroides</i>	152.00	0.74	Arends (1985)
<i>Ondatra zibethicus</i>	842.00	3.89	Sherer and Wunder (1979)
<i>Onychomys torridus</i>	19.10	0.17	Whitford and Conley (1971)
<i>Oryzotolagus cuniculus</i>	2350.00	8.60	Terroine and Trautman (1927)
<i>Oxymycterus roberti</i>	83.50	0.51	McNab (1984)
<i>Perognathus californicus</i>	22.00	0.12	Tucker (1965)
<i>Perognathus hispidus</i>	40.00	0.28	Wang and Hudson (1970)
<i>Perognathus intermedius</i>	14.60	0.09	Bradley <i>et al.</i> (1975)
<i>Perognathus longimembris</i>	8.90	0.05	Chew <i>et al.</i> (1967)
<i>Perognathus parvus</i>	19.20	0.16	Kenagy and Vleck (1982)
<i>Perognathus penicillatus</i>	16.00	0.13	Brower and Cade (1966)
<i>Perom leucopus noveboracensis</i>	26.00	0.32	Hart (1953)
<i>Peromyscus boylii</i>	23.20	0.31	Mazen and Rudd (1980)
<i>Peromyscus californicus</i>	48.00	0.25	McNab and Morrison (1963)
<i>Peromyscus crinitus</i>	13.60	0.10	Kenagy and Vleck (1982)
<i>Peromyscus eremicus</i>	20.70	0.15	McNab and Morrison (1963)
<i>Peromyscus floridanus</i>	30.80	0.29	Glenn (1970)
<i>Peromyscus gossypinus</i>	21.50	0.21	Glenn (1970)
<i>Peromyscus leucopus</i>	22.30	0.19	Pearson (1947)
<i>Peromyscus maniculatus</i>	17.00	0.17	Kenagy and Vleck (1982)
<i>Peromyscus megalops</i>	66.20	0.51	Musser and Shoemaker (1965)
<i>Peromyscus pirrensis</i>	137.80	0.68	Hill (1975)
<i>Peromyscus polionotus</i>	12.00	0.12	Glenn (1970)
<i>Peromyscus sitkensis</i>	28.33	0.26	Hayward (1965)
<i>Peromyscus thomasi</i>	110.80	0.70	Musser and Shoemaker (1965)
<i>Peromyscus truei</i>	33.00	0.26	McNab (1973)
<i>Phodopus sungorus</i>	33.20	0.30	Weiner and Gorecki (1981)
<i>Pitymys pinetorum</i>	25.00	0.28	Bradley (1976)
<i>Praomys natalensis</i>	41.49	0.18	Haim and le Fourie (1980)
<i>Proechimys semispinosus</i>	498.00	1.77	McNab (1982)

Species	M (g)	Bm (W)	Source
<i>Pseudomys gracilicaudatus</i>	79.80	0.47	Dawson and Dawson (1982)
<i>Rattus meltada</i>	67.40	0.33	Goyal <i>et al.</i> (1981)
<i>Rattus norvegicus wild</i>	170.00	0.96	Morrison and Ryser (1951); Hart (1971)
<i>Rattus rattus</i>	117.00	0.77	Hildwein (1972)
<i>Reithrodontomys megalotis</i>	9.00	0.13	Pearson (1960)
<i>Rhabdomys pumilio</i>	39.62	0.18	Haim and le Fourie (1980)
<i>Sciurus aberti</i>	624.00	2.42	Golightly and Ohmart (1978b)
<i>Sciurus carolinensis</i>	440.00	2.08	Bolls and Perfect (1972)
<i>Scotinomys teguina</i>	12.00	0.18	Hill and Hooper (1971)
<i>Scotinomys xerampelinus</i>	15.20	0.18	Hill and Hooper (1971)
<i>Sigmodon fulviventer</i>	137.80	1.17	Bowers (1971)
<i>Sigmodon hispidus</i>	152.40	0.71	Scheck (1982)
<i>Sigmodon leucotis</i>	128.60	1.05	Bowers (1971)
<i>Sigmodon ochrognathus</i>	115.10	0.87	Bowers (1971)
<i>Spalacopus cyanus</i>	136.00	0.57	Contreras (1983)
<i>Spalax Ehrenbergi</i>	128.00	0.62	Nevo and Shkolnik (1974)
<i>Spalax leucodon</i>	177.90	0.63	Gorecki and Christov (1969)
<i>Spermophilus armatus</i>	312.80	0.88	Hudson <i>et al.</i> (1972)
<i>Spermophilus beecheyi</i>	599.60	1.79	Baudinette (1972)
<i>Spermophilus beldingi</i>	288.56	0.80	Hudson <i>et al.</i> (1972)
<i>Spermophilus citellus</i>	240.00	1.28	Kayser (1939)
<i>Spermophilus franklinii</i>	607.00	2.19	Haberman and Fleharty (1971)
<i>Spermophilus lateralis</i>	270.16	0.74	Hudson <i>et al.</i> (1972)
<i>Spermophilus leucurus</i>	96.00	0.54	Hudson (1962)
<i>Spermophilus mohavensis</i>	239.50	0.63	Hudson <i>et al.</i> (1972)
<i>Spermophilus richardsoni</i>	273.07	0.74	Hudson <i>et al.</i> (1972)
<i>Spermophilus saturatus</i>	261.15	0.80	Kenagy and Vleck (1982)
<i>Spermophilus spilosoma</i>	157.80	0.50	Hudson <i>et al.</i> (1972)
<i>Spermophilus tereticaudus</i>	167.20	0.53	Hudson <i>et al.</i> (1972)
<i>Spermophilus townsendi</i>	212.52	0.60	Hudson <i>et al.</i> (1972)
<i>Spermophilus tridecemlineatus</i>	182.30	0.59	Hudson <i>et al.</i> (1972)
<i>Spermophilus undulatus</i>	1000.00	4.50	Erikson (1956)
<i>Stochomys longicaudatus</i>	82.33	0.55	Hildwein (1972)
<i>Tachyoryctes splendens</i>	234.00	0.92	McNab (1966)
<i>Tamias amoenus</i>	57.00	0.54	Jones and Wang (1976)
<i>Tamias merriami</i>	75.00	0.44	Wunder (1970)

Species	M (g)	Bm (W)	Source
<i>Tamias striatus</i>	87.40	0.51	Wang and Hudson (1971)
<i>Tamiasciurus hudsonicus</i>	224.00	1.41	Pauls (1981)
<i>Tatera indica</i>	86.80	0.43	Goyal <i>et al.</i> (1981)
<i>Thomomys bottae</i>	143.00	0.68	Vleck (1979)
<i>Thomomys talpoides</i>	82.60	0.55	Kenagy and Vleck (1982)
<i>Thomomys umbrinus</i>	95.30	0.46	Bradley <i>et al.</i> (1974)
<i>Trichomys apereoides</i>	323.00	1.16	Arends (1985)
<i>Zapus hudsonicus</i>	30.00	0.25	Morrison and Ryser (1962)
SCANDENTIA			
<i>Ptilocercus lowii</i>	57.50	0.24	Whittow and Gould (1976)
SIRENIA			
<i>Trichechus inunguis</i>	170 000.00	46.91	Gallivan and Best (1980)

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References

- ARENDS, A. (1985). Comparative energetics of caviomorph rodents. PhD dissertation, University of Florida.
- ARNOLD, J. AND SHIELD, J. (1970). Oxygen consumption and body temperature of the Chuditch *Dasyurus geoffroyi*. *J. Zool., Lond.* **160**, 391-404.
- BARTELS, H. (1982). Metabolic rate of mammals equals the 0.75 power of their body weight. *Exp. Biol. Med.* **7**, 1-11.
- BARTHOLOMEW, G. A., DAWSON, W. R. AND LASIEWSKI, R. C. (1970). Thermoregulation and heterothermy in some smaller flying foxes (Megachiroptera) of New Guinea. *Z. vergl. Physiol.* **70**, 196-209.
- BARTHOLOMEW, G. A. AND HUDSON, J. W. (1962). Hibernation, estivation, temperature regulation, evaporative water loss and heart rate of the pigmy possum, *Cercartetus nanus*. *Physiol. Zool.* **35**, 94-107.
- BARTHOLOMEW, G. A., LEITNER, P. AND NELSON, J. E. (1964). Body temperature, oxygen consumption and heart rate in three species of Australian flying foxes. *Physiol. Zool.* **37**, 179-198.
- BARTHOLOMEW, G. A. AND McMILLEN, R. E. (1961). Oxygen consumption, estivation, and hibernation in the kangaroo mouse, *Microdipodops pallidus*. *Physiol. Zool.* **34**, 177-183.
- BAUDINETTE, R. V. (1972). Energy metabolism and evaporative water loss in the California ground squirrel. Effects of burrow temperature and water vapor pressure. *J. comp. Physiol.* **81**, 57-72.
- BENEDICT, F. G. (1938). *Vital Energetics. A Study in Comparative Basal Metabolism*. Washington: Carnegie Institution.
- BIENKOWSKI, P. AND MARSZALEK, U. (1974). Metabolism and energy budget in the snow vole. *Acta theriol.* **19**, 55-67.
- BLAXTER, K. L. (1966). The efficiency of feed conversion by livestock. *J. R. agric. Soc.* **125**, 87-99.
- BLUM, J. J. (1977). On the geometry of four dimensions and the relationship between metabolism and body mass. *J. theor. Biol.* **64**, 599-601.
- BOLLS, N. J. AND PERFECT, J. R. (1972). Summer resting metabolic rate of the gray squirrel. *Physiol. Zool.* **45**, 54-59.
- BOWERS, J. R. (1971). Resting metabolic rate in the cotton rat *Sigmodon*. *Physiol. Zool.* **44**, 137-147.
- BRADLEY, S. R. (1976). Temperature regulation and bioenergetics of some microtine rodents. PhD dissertation. Ithaca: Cornell University.

- BRADLEY, W. G., MILLER, J. S. AND YOUSEF, M. K. (1974). Thermoregulatory patterns in pocket gophers. *Physiol. Zool.* **47**, 172-179.
- BRADLEY, W. G. AND YOUSEF, M. K. (1975). Thermoregulatory responses of the plains pocket gopher, *Geomys bursarius*. *Comp. Biochem. Physiol.* **52A**, 35-38.
- BRADLEY, W. G., YOUSEF, M. K. AND SCOTT, I. M. (1975). Physiological studies on the rock pocket mouse *Perognathus intermedius*. *Comp. Biochem. Physiol.* **50A**, 331-337.
- BRIDGEMAN, P. W. (1931). *Dimensional Analysis*. New Haven, London: Yale University Press. 113pp.
- BROCKWAY, J. M. AND MALOY, G. M. O. (1968). Energy metabolism of the red deer. *J. Physiol., Lond.* **194**, 22P-24P.
- BRODY, S. (1945). *Bioenergetics and Growth*. New York: Reinhold. 1023pp.
- BRODY, S. AND PROCTOR, R. C. (1932). Growth and development. XXIII. Relation between basal metabolism and mature body weight in different species of mammals and birds. *Mon. agric. exp. Stn Res. Bull.* **166**, 89-102.
- BROWER, J. E. AND CADE, T. J. (1966). Ecology and physiology of *Napaeozapus insignis* (Miller) and other woodland mice. *Ecology* **47**, 46-63.
- BROWN, J. H. (1968). Adaptation to environmental temperature in two species of woodrats, *Neotoma cinerea* and *N. albigula*. *Misc. Publ. Mus. Zool. Univ. Mich.* **135**, 1-48.
- BROWN, J. H. AND LASIEWSKI, R. C. (1972). Metabolism of weasels. The cost of being long and thin. *Ecology* **53**, 939-943.
- CALDER, W. A., III (1984). *Size, Function and Life History*. Cambridge, MA: Harvard University Press.
- CALDER, W. A., III (1987). Scaling energetics of homeothermic vertebrates: an operational allometry. *A. Rev. Physiol.* **49**, 107-120.
- CAPSTICK, J. W. AND WOOD, T. B. (1922). The effect of change of temperature on the basal metabolism of swine. *J. agric. Sci.* **12**, 257-268.
- CARPENTER, R. E. (1966). A comparison of thermoregulation and water metabolism in the kangaroo rats *Dipodomys agilis* and *Dipodomys merrimami*. *Univ. Calif. Publ. Zool.* **78**, 1-36.
- CARPENTER, R. E. AND GRAHAM, J. B. (1967). Physiological responses to temperature in the long-nosed bat, *Leptonycteris sanborni*. *Comp. Biochem. Physiol.* **22**, 709-722.
- CASEY, T. M. AND CASEY, K. K. (1979). Thermoregulation of arctic weasels. *Physiol. Zool.* **52**, 153-164.
- CASEY, T. M., WITHERS, P. C. AND CASEY, K. K. (1979). Metabolic and respiratory responses of arctic mammals to ambient temperature during the summer. *Comp. Biochem. Physiol.* **64A**, 331-342.
- CHAMBERS, J. M., CLEVELAND, W. S., KLEINER, B. AND TUKEY, P. A. (1983). *Graphical Methods for Data Analysis*. Pacific Grove, CA: Wadsworth and Brooks/Cole Publishing Company. 395pp.
- CHAPPEL, R. W. AND HUDSON, R. J. (1978). Winter bioenergetics of Rocky Mountain bighorn sheep. *Can. J. Zool.* **56**, 2388-2393.
- CHEVILLARD-HUGOT, M., MULLER, E. F. AND KULZER, E. (1980). Oxygen consumption, body temperature and heart rate in the coati (*Nasua nasua*). *Comp. Biochem. Physiol.* **65A**, 305-310.
- CHEW, R. M., LINDBERG, R. G. AND HAYDEN, P. (1967). Temperature regulation in the little pocket mouse, *Perognathus longimembris*. *Comp. Biochem. Physiol.* **21**, 487-505.
- COADY, J. W. (1975). Bioenergetics of the brown lemming (*Lemmus sibiricus*). PhD dissertation, University of Alaska at Fairbanks.
- CONTRERAS, L. C. (1983). Physiological ecology of fossorial mammals. A comparative study. PhD dissertation, University of Florida, Gainesville.
- DALBY, P. L. AND HEATH, A. G. (1976). Oxygen consumption and body temperature of the Argentine field mouse, *Akodon azarae*, in relation to ambient temperature. *J. therm. Biol.* **1**, 177-179.
- DANIELS, H. L. (1984). Oxygen consumption in *Lemur fulvus*. Deviation from the ideal mode. *J. Mammal.* **65**, 584-592.
- DAWSON, T. J. (1955). The relation of oxygen consumption to temperature in desert rodents. *J. Mammal.* **36**, 543-553.

- DAWSON, T. J. (1973). Thermoregulatory responses of the arid zone kangaroos, *Megaleia rufa*. *Comp. Biochem. Physiol.* 46A, 153-169.
- DAWSON, T. J. AND BENNET, A. F. (1978). Energy metabolism and thermoregulation of the spectacled hare wallaby (*Lagorchestes conspicillatus*). *Physiol. Zool.* 51, 114-130.
- DAWSON, T. J. AND DAWSON, W. R. (1982). Metabolic scope and conductance in response to cold of some dasyurid marsupials and Australian rodents. *Comp. Biochem. Physiol.* 71A, 59-64.
- DAWSON, T. J. AND DEGABRIELE, R. (1973). The cuscus (*Phalanger maculatus*) - a marsupial sloth? *J. comp. Physiol.* 83, 41-50.
- DAWSON, T. J. AND FANNING, F. D. (1981). Thermal and energetic problems of semiaquatic mammals. A study of the Australian water rat, including comparisons with the platypus. *Physiol. Zool.* 54, 284-296.
- DAWSON, T. J., GRANT, T. R. AND FANNING, D. (1979). Standard metabolism of monotremes and the evolution of homeothermy. *Aust. J. Zool.* 27, 511-515.
- DAWSON, T. J. AND HULBERT, A. J. (1970). Standard metabolism, body temperature and surface areas of Australian marsupials. *Am. J. Physiol.* 218, 1233-1238.
- DAWSON, T. J. AND WOLFERS, J. M. (1978). Metabolism, thermoregulation and torpor in shrew sized marsupials of the genus *Planigale*. *Comp. Biochem. Physiol.* 59A, 305-309.
- DEGABRIELE, R. AND DAWSON, T. J. (1979). Metabolism and heat balance in an arboreal marsupial, the koala (*Phascolarctos cinereus*). *J. comp. Physiol.* 134, 293-301.
- DODGEN, L. L. AND BLOOD, F. R. (1956). Energy sources in the bat. *Am. J. Physiol.* 187, 151-154.
- DROZDZ, A., GORECKI, A., GRODZINSKI, W. AND PELIKAN, J. (1971). Biogenetics of water voles (*Arvicola terrestris* L.) from southern Moravia. *Ann. Zool. Fennici* 8, 97-103.
- DRYDEN, G. L., GEBZYNSKI, M. AND DOUGLAS, E. L. (1974). Oxygen consumption by nursing and adult musk shrews. *Acta theriol.* 19, 453-461.
- EBISU, R. J. AND WHITTOW, G. C. (1976). Temperature regulation in the small Indian mongoose (*Herpestes auropunctatus*). *Comp. Biochem. Physiol.* 54A, 309-313.
- ECONOMOS, A. C. (1983). Elastic and/or geometric similarity in mammalian design. *J. theor. Biol.* 103, 167-172.
- ELGAR, M. A. AND HARVEY, P. H. (1987). Basal metabolic rates in mammals: allometry, phylogeny and ecology. *Funct. Ecol.* 1, 25-36.
- ELLIS, B. (1968). *Basic Concepts of Measurement*. Cambridge: Cambridge University Press. 220pp.
- EL-NOUTY, F. D., YOUSEF, M. K., MAGDUB, A. B. AND JOHNSON, H. D. (1978). Thyroid hormones and metabolic rate in burros, *Equus asinus*, and llamas, *Lama glama*, and effects of environmental temperature. *Comp. Biochem. Physiol.* 60A, 235-237.
- ERIKSON, H. (1956). Observations on the metabolism of arctic ground squirrels (*Citellus parryi*) at different environmental temperatures. *Acta physiol. scand.* 36, 66-74.
- FARREL, D. J. AND WOOD, A. J. (1968). The nutrition of the female mink (*Mustela vison*). I. The metabolic rate of the mink. *Can. J. Zool.* 46, 41-45.
- FEDICK, A. (1971). Social thermoregulation in *Apodemus flavicollis* (Melchior 1854). *Acta theriol.* 16, 221-229.
- GALLIVAN, G. J. AND BEST, R. C. (1980). Metabolism and respiration of the Amazonian manatee (*Trichechus inunguis*). *Physiol. Zool.* 53, 245-253.
- GALLIVAN, G. J. AND RONALD, K. (1981). Apparent specific dynamic action in the harp seal (*Phoca groenlandica*). *Comp. Biochem. Physiol.* 69A, 579-581.
- GEBZYNSKI, M. (1971). The rate of metabolism of the lesser shrew. *Acta theriol.* 16, 329-339.
- GEBZYNSKI, M., GORECKI, A. AND DROZDZ, A. (1972). Metabolism, food assimilation and bioenergetics of three species of dormice (Gliridae). *Acta theriol.* 17, 271-294.
- GELINEO, S. (1956). Contribution à la connaissance de la calorification du Lapin (*Cuniculus cuniculus*). *Bull. Acad. serbe Sci.* 16, 1-16.
- GLENN, M. E. (1970). Water relations in three species of deer mice (*Peromyscus*). *Comp. Biochem. Physiol.* 33, 231-248.
- GOFFART, M. (1977). Hypometabolisme chez *Aotus trivirgatus*. *C. R. Séanc. Soc. Biol.* 171, 1149-1152.

- GOLIGHTLY, R. T., JR AND OHMART, R. D. (1978a). Metabolism and body temperature of two desert canids: coyotes and kit foxes. *J. Mammal.* **64**, 624-635.
- GOLIGHTLY, R. T., JR AND OHMART, R. D. (1978b). Heterothermy in free-ranging Abert's squirrels (*Sciurus aberti*). *Ecology*. **59**, 897-909.
- GORECKI, A. (1971). Metabolism and energy budget in the harvest mouse. *Acta theriol.* **15**, 213-220.
- GORECKI, A. AND CHRISTOV, L. (1969). Metabolic rate of the lesser mole rat. *Acta theriol.* **14**, 441-448.
- GORECKI, A. AND WOLEK, J. (1975). Thermoregulation in common hamsters. *Acta theriol.* **20**, 297-300.
- GOYAL, S. P., GHOSH, P. K. AND PRAKASH, I. (1981). Significance of body fat in relation to basal metabolic rate in some Indian desert rodents. *J. Arid Environ.* **4**, 59-62.
- GRANT, T. R. AND DAWSON, T. J. (1978). Temperature regulation in the platypus, *Ornithorhynchus anatinus*. Production and loss of metabolic heat in air and water. *Physiol. Zool.* **51**, 315-332.
- GUNTHER, B. (1975). On theories of biological similarity. In *Fortschritte der Experimentellen und Theoretischen Biophysik* (ed. W. Beier), **19**, 1-111. Leipzig: Thieme.
- HABERMAN, C. G. AND FLEHARTY, E. D. (1971). Energy flow in *Spermophilus franklinii*. *J. Mammal.* **52**, 710-716.
- HAIM, A. (1981). Heat production and dissipation in a south African diurnal murid *Lemniscomys griselda*. *S. Afr. J. Zool.* **16**, 67-70.
- HAIM, A. AND LE FOURIE, R. (1980). Heat production in nocturnal (*Praomys natalensis*) and diurnal (*Rhabdomys punilio*) South African murids. *S. Afr. J. Zool.* **15**, 91-94.
- HANSSON, L. AND GRODZINSKI, W. (1970). Bioenergetic parameters of the field vole *Microtus agrestis*. *Oikos* **21**, 76-82.
- HARLOW, H. J. (1981). Torpor and other physiological adaptations of the badger (*Taxidea taxus*) to cold environments. *Physiol. Zool.* **54**, 267-275.
- HARRIS, J. A. AND BENEDICT, F. G. (1919). *A Biometric Study of Basal Metabolism in Man*. Carnegie Institution. 266pp.
- HART, J. S. (1950). Interrelations of daily metabolic cycle, activity, and environmental temperature of mice. *Can. J. Res. D* **28**, 293-307.
- HART, J. S. (1953). Energy metabolism of the white-footed mouse, *Peromyscus leucopus noveboracensis*, after acclimatation at various environmental temperatures. *Can. J. Zool.* **31**, 99-105.
- HART, J. S. (1971). Rodents. In *Comparative Physiology of Thermoregulation* (ed. G. G. Whittow), pp. 1-149. New York: Academic Press.
- HART, J. S. AND IRVING, L. (1959). The energetics of harbor seals in air and in water with special consideration of seasonal changes. *Can. J. Zool.* **37**, 447-457.
- HAYSSEN, V. AND LACY, R. C. (1985). Basal metabolic rates in mammals: taxonomic differences in the allometry of BMR and body mass. *Comp. Biochem. Physiol.* **81A**, 741-754.
- HAYWARD, J. S. (1965). Metabolic rate and its temperature-adaptive significance in six geographic races of *Peromyscus*. *Can. J. Zool.* **43**, 309-323.
- HENNEMANN, W. W., III AND KONECNY, M. J. (1980). Oxygen consumption in large spotted genets, *Genetta tigrina*. *J. Mammal.* **61**, 747-750.
- HENNEMANN, W. W., III, THOMPSON, S. D. AND KONECNY, M. J. (1983). Metabolism of crab-eating foxes, *Cerdocyon thous*. Ecological influences on the energetics of canids. *Physiol. Zool.* **56**, 319-324.
- HERREID, C. E. AND SCHMIDT-NIELSEN, K. (1966). Oxygen consumption, temperature, and water loss in bats from different environments. *Am. J. Physiol.* **211**, 1108-1112.
- HEUSNER, A. A. (1982a). Energy metabolism and body size. I. Is the 0.75 mass exponent of Kleiber's Equation a statistical artifact? *Respir. Physiol.* **48**, 1-12.
- HEUSNER, A. A. (1982b). Energy metabolism and body size. II. Dimensional analysis and energetic non-similarity. *Respir. Physiol.* **48**, 13-25.
- HEUSNER, A. A. (1984). Biological similitude: statistical and functional relationships in comparative physiology. *Am. J. Physiol.* **15**, R839-R845.
- HEUSNER, A. A. (1985). Body size and energy metabolism. *A. Rev. Nutr.* **5**, 267-293.

- HEUSNER, A. A. (1987). What does the power function reveal about structure and function in animals of different size? *A. Rev. Physiol.* **49**, 121-133.
- HILDWEIN, G. (1970). Capacités thermoregulatrices d'un mammifère insectivore primitif, le tenrec; leurs variations saisonnières. *Arch. Sci. Physiol.* **24**, 55-71.
- HILDWEIN, G. (1972). Métabolisme énergétique de quelques mammifères et oiseaux de la forêt équatoriale. II. Résultats expérimentaux et discussion. *Arch. Sci. Physiol.* **26**, 387-400.
- HILDWEIN, G. AND GOFFART, M. (1975). Standard metabolism and thermoregulation in a prosimian *Perodicticus potto*. *Comp. Biochem. Physiol.* **50A**, 201-213.
- HILL, R. W. (1975). Metabolism, thermal conductance, and body temperature in one of the largest species of *Peromyscus*, *P. pirrensis*. *J. therm. Biol.* **1**, 109-112.
- HILL, R. W. AND HOOPER, E. T. (1971). Temperature regulation in mice of the genus *Scotinomys*. *J. Mammal.* **52**, 806-816.
- HINDS, D. S. (1973). Acclimation of thermoregulation in the desert cottontail, *Sylvilagus audubonii*. *J. Mammal.* **54**, 708-728.
- HINDS, D. S. (1977). Acclimation of thermoregulation in desert-inhabiting jackrabbits (*Lepus alleni* and *Lepus californicus*). *Ecology* **58**, 246-264.
- HOOPER, E. T. AND HILALI, M. E. (1972). Temperature regulation and habits in two species of jerboa, genus *Jaculus*. *J. Mammal.* **53**, 574-593.
- HUDSON, J. W. (1962). The role of water in the biology of the antelope ground squirrel, *Citellus leucurus*. *Univ. Cal. Publ. Zool.* **64**, 1-56.
- HUDSON, J. W. (1965). Temperature regulation and torpidity in the pigmy mouse, *Baiomys taylori*. *Physiol. Zool.* **38**, 243-254.
- HUDSON, J. W., DEEVERS, D. R. AND BRADLEY, S. R. (1972). A comparative study of temperature regulation in ground squirrels with special reference to the desert species. *Symp. zool. Soc. Lond.* **31**, 191-213.
- HUDSON, J. W. AND RUMMEL, J. A. (1966). Water metabolism and temperature regulation of the primitive heteromyids, *Liomys salvani* and *Liomys irroratus*. *Ecology* **47**, 345-354.
- HULBERT, A. J. AND DAWSON, T. J. (1974). Standard metabolism and body temperature of perameloid marsupials from different environments. *Comp. Biochem. Physiol.* **47A**, 583-590.
- IRVING, L., KROG, H. AND MONSON, M. (1955). The metabolism of some Alaskan mammals in winter and summer. *Physiol. Zool.* **28**, 173-185.
- IVERSEN, J. A. (1972). Basal metabolism of mustelids. *J. comp. Physiol.* **81**, 341-344.
- IVERSEN, J. A. AND KROG, J. (1973). Heat production and body surface area in seals and sea otters. *Norw. J. Zool.* **21**, 51-54.
- JANSKY, L. (1959). Working oxygen consumption in two species of wild rodents (*Microtus arvalis*, *Cethrionomys glareolus*). *Physiol. Boh.* **8**, 472-478.
- JONES, D. L. AND WANG, L. C. H. (1976). Metabolic and cardiovascular adaptations in the western chipmunk, genus *Eutamias*. *J. comp. Physiol.* **105**, 219-231.
- JÜRGENS, K. D. (1989). *Allometrie als Konzept des Interspeziesvergleiches von Physiologischen Grössen*. Berlin, Hamburg: Paul Parey. 136pp.
- KAMAU, J. M. Z., JOHANSEN, K. AND MALOY, G. M. O. (1979). Metabolism of the slender mongoose (*Herpestes sanguineus*). *Physiol. Zool.* **52**, 594-602.
- KAYSER, C. (1939). Contribution à l'étude de la régulation thermique. L'émission d'eau et le rapport H₂O:O₂ chez quelques espèces homéothermes adultes et en cours de croissance. *Ann. Physiol. physicochim. Biol.* **6**, 721-744.
- KAYSER, C. AND HEUSNER, A. (1964). Étude comparative du métabolisme énergétique dans la série animale. *J. Physiol., Paris* **56**, 489-524.
- KENAGY, G. J. AND VLECK, D. (1982). Daily temporal organization of metabolism in small mammals. Adaptation and diversity. In *Vertebrate Circadian Systems* (ed. J. Aschoff, S. Daan and G. Groos), pp. 322-338. Heidelberg: Springer.
- KIBLER, H. H., BRODY, S. AND WORSTELL, D. (1947). Surface area and metabolism of growing guinea pigs. *J. Nutr.* **33**, 331-338.
- KINNEAR, A. AND SHIELD, J. W. (1975). Metabolism and temperature regulation in marsupials. *Comp. Biochem. Physiol.* **52A**, 235-245.
- KIRMIZ, J. P. (1962). *Adaptation to Desert Environment, a Study on the Jerboa, Rat and Man*. London: Butterworth.

- KLEIBER, M. (1931-1932). Body size and metabolism. *Hilgardia* 6, 315-353.
- KLEIBER, M. (1947). Body size and metabolic rate. *Physiol. Rev.* 27, 511-541.
- KLEIBER, M. (1961). *The Fire of Life*. New York: Wiley. 454pp.
- KLEIBER, M. (1965). Metabolic body size. In *Energy Metabolism. Proceedings of the Third Symposium, Troon, Scotland, May 1964* (ed. K. L. Blaxter), pp. 427-435. London: Academic Press.
- KLEINBAUM, D. G., KUPPER, L. L. AND MULLER, K. E. (1988). *Applied Regression Analysis and Other Multivariable Methods* (second edition). Boston: PWS-KENT Publishing Company. 718pp.
- KOHL, H. (1980). Temperaturregulation, Stoffwechsel und Nierenfunktion beim Chinchilla (*Chinchilla laniger* Molina, 1782) und beim Viscacha (*Lagostomus maximus*). *Zool. Jb. (Physiol.)* 84, 472-501.
- KROGH, H. AND MONSON, M. (1954). Notes on the metabolism of a mountain goat. *Am. J. Physiol.* 178, 515-516.
- KUYPER, M. A. (1979). A biological study of the golden mole *Amblysomus hottentotus*. Master's thesis, University of Natal, South Africa.
- LAMBERT, R. AND TEISSIER, G. (1927). Théorie de la similitude biologique. *Anns. Physiol.* 3, 212-246.
- LAYNE, J. N. AND DOLAN, P. G. (1975). Thermoregulation, metabolism, and water economy in the golden mouse (*Ochrotomys nuttali*). *Comp. Biochem. Physiol.* 52A, 153-163.
- LEE, A. K. (1963). The adaptations to arid environments in wood rats of the genus *Neotoma*. *Univ. Calif. Publ. Zool.* 64, 57-96.
- LEITNER, P. (1966). Body temperature, oxygen consumption, heart rate and shivering in the California mastiff bat *Eumops perotis*. *Comp. Biochem. Physiol.* 19, 431-443.
- LEITNER, P. AND NELSON, J. (1967). Body temperature, oxygen consumption, and heart rate in the Australian false vampire bat, *Macroderma gigas*. *Comp. Biochem. Physiol.* 21, 65-74.
- LEON, B., SHKOLNIK, A. AND SHKOLNIK, T. (1983). Temperature regulation and water metabolism in the elephant shrew *Elephantulus edwardi*. *Comp. Biochem. Physiol.* 74A, 399-407.
- LINDSTEDT, S. L. (1980). Energetics and water economy of the smallest desert mammal. *Physiol. Zool.* 53, 82-97.
- MACARTHUR, R. A. AND WANG, L. C. H. (1973). Physiology of thermoregulation in the pika, *Ochotona princeps*. *Can. J. Zool.* 51, 11-16.
- MACMILLEN, R. E., BAUDINETTE, R. V. AND LEE, A. K. (1972). Water economy and energy metabolism of the sandy inland mouse, *Leggadina hermannsbergensis*. *J. Mammal.* 53, 529-539.
- MACMILLEN, R. E. AND LEE, A. K. (1970). Metabolism and pulmocutaneous water loss of Australian hopping mice. *Comp. Biochem. Physiol.* 35, 355-369.
- MACMILLEN, R. E. AND NELSON, J. E. (1969). Bioenergetics and body size in dasyurid marsupials. *Am. J. Physiol.* 217, 1246-1251.
- MANDELBROT, B. B. (1982). *A Fractal Geometry of Nature*. San Francisco: W. H. Freeman and Company. 461pp.
- MAZEN, W. S. AND RUDD, R. L. (1980). Comparative energetics in two sympatric species of *Peromyscus*. *J. Mammal.* 61, 573-574.
- MCCORMICK, S. A. (1981). Oxygen consumption and torpor in the fat tailed dwarf lemur (*Cheirogaleus medius*). Rethinking prosimian metabolism. *Comp. Biochem. Physiol.* 68A, 605-610.
- MCEWAN, E. H. (1970). Energy metabolism of barren-ground caribou (*Rangifer tarandus*). *Can. J. Zool.* 48, 391-392.
- MCMAHON, T. (1973). Size and shape in biology. *Science* 179, 1201-1204.
- MCMAHON, T. A. AND BONNER, J. T. (1983). *On Size and Life*. New York: Scientific American Library. 255pp.
- MENNAB, B. K. (1966). The metabolism of fossorial rodents. A study in convergences. *Ecology* 47, 712-733.
- MENNAB, B. K. (1969). The economics of temperature regulation in neotropical bats. *Comp. Biochem. Physiol.* 31, 227-268.
- MENNAB, B. K. (1973). The rate of metabolism of the spiny rat, *Proechimys semispinosus*, with

- comments on the ecological factors that influence the basal rate of metabolism in rodents and lagomorphs. *Bol. Zool. Biol. Mar. N.S.* 30, 93-103.
- McNAB, B. K. (1978a). The energetics of arboreal folivores. Physiological problems and ecological consequences of feeding on an ubiquitous food resource. In *The Ecology of Arboreal Folivores* (ed. G. G. Montgomery), pp. 153-162. Washington: Smithsonian Institute.
- McNAB, B. K. (1978b). The comparative energetics of neotropical marsupials. *J. comp. Physiol.* 125, 115-128.
- McNAB, B. K. (1979). The influence of body size on the energetics and distribution of fossorial and burrowing mammals. *Ecology* 60, 1010-1021.
- McNAB, B. K. (1980). Energetics and the limits to a temperate distribution in armadillos. *J. Mammal.* 61, 606-627.
- McNAB, B. K. (1982). The physiological ecology of South American mammals. In *Mammalian Biology in South America* (ed. M. A. Mares and H. H. Genoways), pp. 187-207. Special Publication no. 6. Pymatuning Laboratory of Ecology, University of Pittsburgh, Pittsburgh.
- McNAB, B. K. (1984). Physiological convergence amongst ant-eating and termite-eating mammals. *J. Zool., Lond.* 203, 485-510.
- McNAB, B. K. (1988). Complications inherent in scaling the basal rate of metabolism in mammals. *Q. Rev. Biol.* 63, 25-54.
- McNAB, B. K. AND MORRISON, P. (1963). Body temperature and metabolism in subspecies of *Peromyscus* from arid and mesic environments. *Ecol. Monogr.* 33, 63-82.
- MILTON, K., CASEY, T. M. AND CASEY, K. K. (1979). The basal metabolism of mantled howler monkeys (*Alouatta palliata*). *J. Mammal.* 60, 373-376.
- MORRISON, P. R. AND McNAB, B. K. (1962). Daily torpor in a Brazilian mouse opossum (*Marmosa*). *Comp. Biochem. Physiol.* 6, 57-68.
- MORRISON, P. R. AND McNAB, B. K. (1967). Temperature regulation in some Brazilian phyllostomid bats. *Comp. Biochem. Physiol.* 21, 207-221.
- MORRISON, P. R. AND MIDDLETON, E. H. (1967). Body temperature and metabolism in the pygmy marmoset. *Folia Primatol.* 6, 70-82.
- MORRISON, P. R. AND RYSER, F. A. (1951). Temperature and metabolism in some Wisconsin mammals. *Fedn Proc. Fedn Am. Socs exp. Biol.* 10, 93-94.
- MORRISON, P. R. AND RYSER, F. A. (1962). Metabolism and body temperature in a small hibernator, the meadow jumping mouse, *Zapus hudsonicus*. *J. cell. comp. Physiol.* 60, 169-180.
- MORRISON, P. R. AND SIMOES, J., JR (1962). Body temperatures in two Brazilian primates. *Bol. Fac. Filos, Cien. Let., Univ. Sao Paulo (Zool.)*, Brasil 24, 167-178.
- MORTON, S. R. AND LEE, A. K. (1978). Thermoregulation and metabolism in *Planigale maculata* (Marsupialia Dasyridae). *J. therm Biol.* 3, 117-120.
- MULLER, E. F. (1979). Energy metabolism, thermoregulation, and water budget in the slow loris (*Nycticebus coucang* Boddaert 1785). *Comp. Biochem. Physiol.* 64A, 109-119.
- MULLER, E. F. AND KULZER, E. (1977). Body temperature and oxygen uptake in the kinkajou (*Potos flavus*, Schreber), a nocturnal tropical carnivore. *Archs int. Physiol. Biochem.* 86, 153-163.
- MUSSER, G. C. AND SHOEMAKER, V. H. (1965). Oxygen consumption and body temperature in relation to ambient temperature in the Mexican deer mice, *Peromyscus thomasi* and *P. megalops*. *Occ. Papers Mus. Zool. Univ. Mich.* 643, 1-15.
- NAGEL, A. (1977). Torpor in the european white-toothed shrews. *Experientia* 33, 1455-1456.
- NAGEL, A. (1980). Sauerstoffverbrauch, Temperaturregulation und Herzfrequenz der Europäischen Spitzmause (Soricidae, Mammalia). Dissertation, Eberhard Karls Universität, Tübingen.
- NELSON, Z. C. AND YOUSEF, M. K. (1979). Thermoregulatory responses of desert wood rats, *Neotoma lepida*. *Comp. Biochem. Physiol.* 63A, 109-113.
- NEVO, E. AND SHKOLNIK, A. (1974). Adaptive metabolic variation of chromosome forms in mole rats, *Spalax*. *Experientia* 30, 724-726.
- NEWMAN, R. L. (1967). Metabolism in the eastern chipmunk (*Tamias striatus*) and the southern flying squirrel (*Glaucomys volans*) during winter and summer. In *Mammalian Hibernation III* (ed. K. C. Fisher, R. A. Dawe and C. P. Lyman).

- NICOL, S. C. (1976). Oxygen consumption and nitrogen metabolism in the potoroo, *Potorous tridactylus*. *Comp. Biochem. Physiol.* **55A**, 215-218.
- NICOL, S. C. AND MASKREY, M. (1980). Thermoregulation, respiration and sleep in the Tasmanian devil, *Sarcophilus harrisii* (Marsupialia Dasyuridae). *J. comp. Physiol.* **140**, 241-248.
- NOLL-BANHOLZER, U. G. (1979). Body temperature, oxygen consumption, evaporative water loss and heart rate in the fennec. *Comp. Biochem. Physiol.* **62A**, 585-592.
- PACKARD, G. C. (1968). Oxygen consumption of *Microtus montanus* in relation to ambient temperature. *J. Mammal.* **49**, 215-220.
- PALACIO, C. (1977). Standard metabolism and thermoregulation in three species of lorosoid primates. Master's thesis, University of Florida, Gainesville.
- PAULS, R. W. (1981). Energetics of the red squirrel. A laboratory study of the effects of temperature, seasonal acclimatization, use of the nest and exercise. *J. therm. Biol.* **6**, 79-86.
- PEARSON, A. M. (1962). Activity patterns, energy metabolism, and growth rate of the voles *Clethrionomys rufocanus* and *C. glareolus* in Finland. *Ann. zool. Soc. Zool. Bot. Fennicae Vanamo* **24**, 1-58.
- PEARSON, O. P. (1947). The rate of metabolism of some small mammals. *Ecology* **28**, 127-145.
- PEARSON, O. P. (1960). Oxygen consumption and bioenergetics of harvest mice. *Physiol. Zool.* **33**, 152-160.
- PETERS, R. H. (1983). *The Ecological Implications of Body Size*. Cambridge: Cambridge University Press. 329pp.
- PLATT, W. (1974). Metabolic rates of short-tailed shrews. *Physiol. Zool.* **47**, 75-90.
- PROPPE, D. W. AND GALE, C. C. (1970). Endocrine thermoregulatory responses to local hypothalamic warmings in unanesthetized baboons. *Am. J. Physiol.* **219**, 202-207.
- REINKING, L. N., KILGORE, D. L., FAIRBANKS, E. S. AND HAMILTON, J. D. (1977). Temperature regulation in normothermic black-tailed prairie dogs, *Cynomys ludovicianus*. *Comp. Biochem. Physiol.* **57A**, 161-165.
- RIEDEL, M. L. AND WILLIAMS, B. A. (1976). Continuous 24-hr oxygen consumption studies of *Myotis velifer*. *Comp. Biochem. Physiol.* **54A**, 95-99.
- ROSENMAN, M., MORRISON, P. R. AND FEIST, P. (1975). Seasonal changes in the metabolic capacity of red-backed voles. *Physiol. Zool.* **48**, 303-313.
- ROUSSEUW, P. J. AND LEROY, A. M. (1987). *Robust Regression and Outlier Detection*. New York: John Wiley and Sons. 329pp.
- RUBNER, M. (1883). Ueber den Einfluss der Körpergrösse auf Stoff- und Kraftwechsel. *Z. Biol.* **19**, 535-562.
- RUBSAMEN, K., HELLER, R., LAWRENZ, H. AND ENGELHARDT, W. V. (1979). Water and energy metabolism in the rock hyrax (*Procapris habessinica*). *J. comp. Physiol.* **131**, 303-309.
- SARRUS, F. AND RAMEAUX, J. F. (1838-1839). Rapport sur un mémoire adressé à l'Académie royale de Médecine. Commissaire Robiquet et Thillaye, rapporteurs. *Bull. Acad. r. Med., Paris* **3**, 1094-1100.
- SHECK, S. H. (1982). A comparison of thermoregulation and evaporative water loss in the hispid cotton rat, *Signodon hispidus texianus*, from northern Kansas and south-central Texas. *Ecology* **63**, 361-369.
- SCHMIDT-NIELSEN, K. (1984). *Scaling. Why is Animal Size so Important?* Cambridge: Cambridge University Press. 241pp.
- SCHMIDT-NIELSEN, K., CRAWFORD, E. C., NEWSOME, A. E., RAWSON, K. S. AND HAMMEL, H. T. (1967). Metabolic rate of camels. Effect of body temperature and dehydration. *Am. J. Physiol., Lond.* **212**, 341-346.
- SCHMIDT-NIELSEN, K., DAWSON, T. J., HAMMEL, H. T., HINDS, D. AND JACKSON, D. C. (1965). The jack rabbit - a study in its desert survival. *Hvalradets Skr.* **48**, 125-142.
- SCHOLANDER, P. F., HOCK, R., WALTERS, V. AND IRVING, L. (1950). Adaptation to cold in arctic and tropical mammals and birds in relation to body temperature, insulation, and basal metabolism. *Biol. Bull. mar. biol. Lab., Woods Hole* **99**, 259-271.
- SHERER, J. AND WUNDER, B. A. (1979). Thermoregulation of a semi-aquatic mammal, the muskrat, in air and water. *Acta theriol.* **24**, 249-256.
- SHKOLNIK, A. AND BORUT, A. (1969). Temperature and water relations in two species of spiny mice (*Acomys*). *J. Mammal.* **50**, 245-255.

- SHKOLNIK, A. AND SCHMIDT-NIELSEN, K. (1976). Temperature regulation in hedgehogs from temperate and desert environments. *Physiol. Zool.* **49**, 56-64.
- SILVER, H., HOLTER, J. B., COLOVOS, N. F. AND HAYES, H. H. (1969). Fasting metabolism of white-tailed deer. *J. Wildl. Mgmt* **33**, 490-498.
- SMITH, A. P., NAGY, K. A., FLEMING, M. R. AND GREEN, B. (1982). Energy requirements and water turnover in free-living Leadbeater's possums, *Gymnobelideus leadbeateri* (Marsupialia, Petauridae). *Aust. J. Zool.* **30**, 737-749.
- SPEAKMAN, J. R. (1990). On Blum's four dimensional geometric explanation for the 0.75 exponent in metabolic allometry. *J. theor. Biol.* **144**, 139-141.
- STAIČU, C. I. (1982). *Restricted and General Dimensional Analysis. Treatment of Experimental Data*. Tunbridge Wells, Kent: Abacus Press. 303pp.
- STITT, J. T. AND HARDY, J. D. (1971). Thermoregulation in the squirrel monkey (*Saimiri sciureus*). *J. appl. Physiol.* **31**, 48-54.
- TAYLOR, C. R. AND LYMEN, C. P. (1967). A comparative study of the environmental physiology of an East African antelope, the eland, and the Hereford steer. *Physiol. Zool.* **40**, 280-295.
- TAYLOR, C. R., ROBERTSHAW, D. AND HOFMANN, R. (1969a). Thermal panting. A comparison of wildebeest and zebu cattle. *Am. J. Physiol.* **217**, 907-910.
- TAYLOR, C. R. AND ROWNTREE, V. J. (1973). Temperature regulation and heat balance in running cheetahs. A strategy for sprinters? *Am. J. Physiol.* **224**, 848-851.
- TAYLOR, C. R. AND SALE, J. B. (1969). Temperature regulation in the hyrax. *Comp. Biochem. Physiol.* **31**, 903-907.
- TAYLOR, C. R., SPINAGE, C. A. AND LYMAN, C. P. (1969b). Water relations of the waterbuck, and East African antelope. *Am. J. Physiol.* **217**, 630-634.
- TEGOWSKA, E. AND GEBCZYNSKI, M. (1975). Oxygen consumption and behavior of the golden hamster at different temperatures. *Acta theriol.* **20**, 227-235.
- TERROINE, E. F. AND TRAUTMAN, S. (1927). Influence de la température extérieure sur la production calorifique des homéothermes et la loi des surfaces. *Ann. physiol. physicochim. Biol.* **3**, 422-457.
- TUCKER, V. H. (1965). Oxygen consumption, thermal conductance, and torpor in the California pocket mouse, *Perognathus californicus*. *J. cell. comp. Physiol.* **65**, 393-404.
- VLECK, D. (1979). The energy cost of burrowing by the pocket gopher *Thomomys bottae*. *Physiol. Zool.* **52**, 122-136.
- VON HÖESSLIN, H. (1888). Ueber die Ursache der scheinbaren Abhängigkeit des Umsatzes von der Grösse der Körperoberfläche. *Du Bois-Reymond Arch. Anat. Physiol.* **11**, 323-379.
- WANG, L. C. H. AND HUDSON, J. W. (1970). Some physiological aspects of temperature regulation in the normothermic and torpid hispid pocket mouse, *Perognathus hispidus*. *Comp. Biochem. Physiol.* **32**, 275-293.
- WANG, L. C. H. AND HUDSON, J. W. (1971). Temperature regulation in normothermic and hibernating eastern chipmunk, *Tamias striatus*. *Comp. Biochem. Physiol.* **38A**, 59-90.
- WANG, L. C. H., JONES, D. L., MACARTHUR, R. A. AND FULLER, W. A. (1973). Adaptation to cold. Energy metabolism in an atypical lagomorph, the Arctic hare (*Lepus arcticus*). *Can. J. Zool.* **51**, 841-846.
- WEINER, J. (1977). Energy metabolism of the roe deer. *Acta theriol.* **22**, 3-24.
- WEINER, J. AND GORECKI, A. (1981). Standard metabolic rate and thermoregulation in five species of Mongolian small mammals. *J. comp. Physiol.* **145**, 127-132.
- WELLS, R. T. (1978). Thermoregulation and activity rhythms in the hairy-nosed wombat, *Lasiornhinus latifrons* (Owen). *Aust. J. Zool.* **26**, 639-651.
- WHITFORD, W. G. AND CONLEY, M. I. (1971). Oxygen consumption and water metabolism in a carnivorous mouse. *Comp. Biochem. Physiol.* **40A**, 797-803.
- WHITTOW, G. C. AND GOULD, E. (1976). Body temperature and oxygen consumption of the pentail shrew (*Ptilocercus lowii*). *J. Mammal.* **57**, 754-756.
- WHITTOW, G. C., GOULD, E. AND RAND, D. (1977a). Body temperature, oxygen consumption, and evaporative water loss in a primitive insectivore, the moon rat, *Echinosorex gymnurus*. *J. Mammal.* **58**, 233-235.
- WHITTOW, G. C., SCAMMELL, C. A., LEONG, M. AND RAND, D. (1977b). Temperature regulation in the smallest ungulate, the lesser mouse deer (*Tagulus javanicus*). *Comp. Biochem. Physiol.* **56A**, 23-26.

- WIESER, W. (1984). A distinction must be made between the ontogeny and phylogeny of metabolism in order to understand the mass exponent of energy metabolism. *Respir. Physiol.* **55**, 1-9.
- WILLEMS, N. J. AND ARMITAGE, K. B. (1975). Thermoregulation and water requirements in semi-arid and montane populations of the least chipmunk *Eutamias minimum*. I. Metabolic rate. *Comp. Biochem. Physiol.* **51A**, 717-722.
- WITHERS, P. C. (1978). Bioenergetics of a 'primitive' mammal, the cape golden mole. *S. Afr. J. Sci.* **74**, 347-348.
- WORTHEN, G. L. AND KILGORE, D. L. (1981). Metabolic rate of pine marten in relation to air temperature. *J. Mammal.* **62**, 624-628.
- WUNDER, B. A. (1970). Temperature regulation and the effect of water restriction on Merriam's chipmunk, *Eutamias merriami*. *Comp. Biochem. Physiol.* **33**, 385-403.
- YOUSEF, M. K. AND DILL, D. B. (1969). Resting energy metabolism and cardiovascular activity in the burro, *Equus asinus*. *J. appl. Physiol.* **27**, 229-232.
- YOUSEF, M. K., JOHNSON, H. D., BRADLEY, W. G. AND SEIF, S. M. (1974). Tritiated water-turnover rate in rodents: desert and mountain. *Physiol. Zool.* **47**, 153-162.
- ZERVANOS, S. M. (1975). Seasonal effects of temperature on the respiratory metabolism of the collared peccary (*Tayassu tajacu*). *Comp. Biochem. Physiol.* **50A**, 365-371.