Metabolism of Small Mammals, With Remarks on the Lower Limit of Mammalian Size

OLIVER P. PEARSON

Museum of Vertebrate Zoology, University of California, Berkeley

It has long been realized that small mammals have a faster rate of metabolism than large ones, and the nature of this relationship for mammals between 20 gm and 3,600 kg has been studied by Benedict (*1*) and others. Recent observations have extended the weight range to include one of the smallest mammals, a 3½-gm shrew (*4*, *5*). Data presented in this report fill the considerable gap between this tiny mammal and the much larger mice and permit delineation of the shape of the critical lighter end of the curve for weight vs. metabolism.

Rate of metabolism was determined by measuring oxygen consumption in a closed-chamber apparatus similar to that described by Morrison (*3*) but with larger surface of soda lime than in the original apparatus. As in the preceding work (*5*), no attempt was made to determine what conditions were "basal" for each species: all the animals were tested at about 24° C and were not post-absorptive. Each test lasted at least 2 hrs, until one or more periods of complete repose had been recorded. All the specimens were adults.

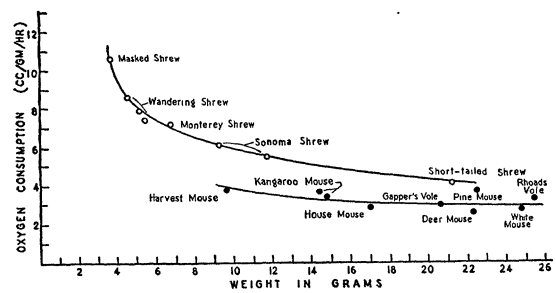

FIG. 1

In Fig. 1 the points for the short-tailed shrew (*Blarina brevicauda*), the masked shrew (*Sorex cinereus*), and the mice heavier than 15 gm are taken from Pearson (*5*) and in all instances are averages of several tests. Each measurement in Table 1 is the lowest metabolic rate recorded on a single test of each of the individuals listed.

It is apparent from Fig. 1 that in this weight range a resting shrew consumes oxygen more rapidly than a mouse of the same size. Presumably the cells of shrews metabolize at a faster rate than those of mice. However, it cannot be assumed that this is caused by a difference in body temperature, for the limited information available does not indicate that shrews have a higher temperature than mice (*2*, *6*).

Also revealed by Fig. 1 is the rather abrupt upswing of the curve at the lower end of the weight range. Instead of approaching infinity at 0 weight, the extrapolated curve for shrews becomes asymptotic at about 2.5 gm. This characteristic at once suggests why no adult mammal weighs less than 2.5 gm. A mammal smaller than this would be unable to gather enough food to support its infinitely rapid metabolism and would have to resort to a lowered body temperature or some other fundamental method of conserving energy. The young of many mammals and birds, of course, are much smaller than this critical size, but the low body temperature of these tiny offspring keeps their rate of metabolism slow enough so that the parents can satisfy their food requirements. Associated with this low body temperature is a sparseness of fur or feathers on the young of small species of birds and mammals. This nakedness may be a necessary condition for keeping body temperatures lower than that of brooding adults.

TABLE 1

RATE OF OXYGEN CONSUMPTION OF RESTING MICE AND SHREWS AT 24° C

	Common name	Weight (gm)	Oxygen consumption (cc/gm/hr)
Sorex vagrans vagrans	Wandering shrew	4.5	8.6
Sorex vagrans vagrans	" "	5.1	7.9
Sorex vagrans vagrans	" "	5.4	7.4
Sorex trowbridgii montereyensis ♂	Monterey shrew	6.7	7.2
Sorex pacificus sonomae ♂	Sonoma shrew	9.2	6.1
Sorex pacificus sonomae ♀	" "	11.7	5.5
Reithrodontomys megalotis longicaudus (average of 4 males)	California harvest mouse	9.6	3.8
Microdipodops megacephalus nasutus ♂	Kangaroo mouse	14.4	3.7
Microdipodops megacephalus nasutus ♂	" "	14.8	3.4

Since there are no mice in the weight range of the lightest shrews, the nature of the lighter end of the mammalian weight vs. metabolism curve must remain represented only by shrews. Some bats approach the small shrews in weight, but the lability of bat temperatures makes difficult a comparison between them and more homeothermic animals. Apparently because of small size and strenuous activities, many bats have resorted to a metabolic parsimony of periodically lowered body temperature that allows their expensively gathered fuel to nourish them longer.

References

1. BENEDICT, F. G. *Carnegie Instr. Wash. Publ. 503*, 1938, i–vii, 1–215.
2. KENDEIGH, S. C. *J. Mammal.*, 1945, **26**, 86–87.
3. MORRISON, P. R. *J. biol. Chem.*, 1947, **169**, 667–679.
4. MORRISON, P. R., and PEARSON, O. P. *Science*, 1946, **104**, 287–289.
5. PEARSON, O. P. *Ecology*, 1947, **28**, 127–145.
6. PEARSON, O. P. Unpublished data.