Body Fat Content and Metabolic Rate of Rodents: Desert and Mountain[1] (36879)

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Scholander *et al.* (1) concluded that resting metabolic rate of mammals is not adapted to climatic conditions. Recent studies (2, 3) have shown that metabolic rate of desert rodents is lower than that predicted from the known relationship between body weight and metabolic rate (4). This lower metabolic rate of desert rodents is considered to be an adaptive mechanism for life in the desert. However, Hayward (5) suggested that lower metabolic rate is related to higher body fat content of animals kept under laboratory conditions. This appears to be an oversimplification but deserves consideration. McNab (6) found that low metabolic rate was not due to high body fat content in two arid adapted rodents.

The objective of this study was to investigate the relationship between body fat content, metabolic rate, and environment.

Materials and Methods. Animals. Fifteen species of rodents representing three families and a wide variety of climatic conditions ranging from low desert to montane forest were used in this study. Ecological distribution of rodents used in the study are summarized in Table I. All animals used for fat analysis were snap trapped in the field, transported to the laboratory in plastic bags, and then frozen for future analysis.

Animals used for metabolic rate studies were live trapped. They were fed Purina mouse chow and oats with succulent vegetables (apples, carrots, and celery) as a source of water. Measurements of V_{O_2} were made on all animals within the first week of capture except in the case of *Eutamias dorsalis, E. umbrinus, E. minimus, Perognathus formosus,* and the cricetid rodents where V_{O_2} was measured within 1 mo of capture. The weight of animals in captivity differed little from their weight at time of capture.

Measurements. Rate of oxygen consumption (V_{O_2}) was measured at the thermoneutral zone of each animal in a closed circuit system as described previously (7). Total body fat content was determined by homogenizing the entire carcass for 20 min in a Waring blender with five times the animal's weight of water. Duplicate samples of the homogenate were dried in aluminum dishes containing sand for 16–18 hr at 105°. The difference in weight was determined and the percentage of total solids was calculated. Crude fat was extracted from the dried samples by the Soxhlet method (8). The fat was extracted for 16–18 hr using Baker analyzed reagent ether. After removal of the ether, flasks were dried, weighed, and the percentage of total fat of the carcass was calculated.

Results. Comparative data on V_{O_2} shown in Table II indicate that rodents fall into two groups on the basis of their V_{O_2} and ecological distribution. The first group includes those species living under desert conditions and their V_{O_2} is lower than predicted from Brody's equation (4). Within this group, species from low desert tend to have lower V_{O_2} than species from high desert. The second group is made up of species with a V_{O_2} near or above predicted, and are found at higher elevations ranging from arid woodland to montane forest.

Although body fat content ranged from 1.1 to 18.3%, a high body fat content did not

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TABLE I. Main Ecologic Distribution of Selected Rodents in Southern Nevada and Southwestern Utah.

Species	Biotic communities	Av elevational limits (m)	Elevation collected (m)
Sciuridae			
Ammospermophilus leucurus Antelope ground squirrel	Low–high desert	170–1500	800
Spermophilus tereticaudus Round-tailed ground squirrel	Low desert	170–1050	640
Spermophilus lateralis Golden-mantled ground squirrel	Montane forest	2100–3300	2700
Eutamias dorsalis Cliff chipmunk	Arid woodland	1400–2300	1800
Eutamias minimus Least chipmunk	Arid woodland	1500–2500	2000
Eutamias umbrinus Unita chipmunk	Woodland–montane forest	1800–2800	2100
Eutamias palmeri Palmer chipmunk	Montane forest	2100–2900	2400
Heteromyidae			
Dipodomys merriami Merriam kangaroo rat	Low desert	170–1400	800
Dipodomys deserti Desert kangaroo rat	Low desert	450–1100	700
Dipodomys microps Chisel-toothed kangaroo rat	High desert	1200–1600	1400
Perognathus formosus Long-tailed pocket mouse	Low–high desert	170–1500	1100
Perognathus longmembris Little pocket mouse	Low–high desert	170–1400	1200
Cricetidae			
Peromyscus cremicus Cactus mouse	Low desert–arid woodland	300–1800	1350
Peromyscus crinitus Canyon mouse	High desert–arid woodland	900–2000	1400
Neotoma lepida Desert wood rat	Low desert–arid woodland	300–1800	1250

coincide with low V_{O_2} (Table II). For example, the two species of ground squirrel with the highest fat content had V_{O_2} of 69 and 159% of predicted. The relationship between V_{O_2}, body weight, body water and fat free body weight (FFBW) was examined by correlation regression analysis. The correlation coefficients for V_{O_2} and these parameters were not significantly different from each other.

Discussion. Data summarized in Fig. 1 support the concept that ecological distribution is an important factor affecting V_{O_2} of rodents. Furthermore, body fat content has little effect on V_{O_2} (Table II). The adaptive significance of low V_{O_2} in small desert mammals has been recently discussed (3).

With the exception of the ground squirrels, *Spermophilus tereticaudus*, and *S. lateralis* which are seasonal hibernators, body fat content of wild rodents varied between 1 to 4%. This agrees with an earlier study (9) where it was found that small wild mammals contain from 2 to 6% body fat.

Correlation of V_{O_2} to body weight was suggested to be improved if V_{O_2} is related to

TABLE II. Minimal Rate of Metabolism and Body Composition.

	Species	Av wt (g)	V_{O_2} (ml/g hr) Measured	Expected (%)[a]	Fat (%)[b]	Fat free body wt (g)
1.	*Spermophilus tereticaudus*	107	0.61	59	7.8 ± 4.2	80.7
2.	*Perognathus formosus*	18	1.29	71	3.2 ± 0.6	18.1
3.	*Perognathus longimembris*	8	1.67	74	3.3 ± 0.8	8.2
4.	*Peromyscus eremicus*	20	1.39	79	2.8 ± 0.3	19.7
5.	*Dipodomys merriami*	38	1.21	81	3.3 ± 0.2	36.9
6.	*Ammospermophilus leucurus*	97	0.99	85	2.7 ± 0.4	92.6
7.	*Dipodomys microps*	57	1.17	87	3.3 ± 0.8	55.3
8.	*Peromyscus crinitus*	15	1.67	87	3.3 ± 0.6	14.3
9.	*Neotoma lepida*	97	1.02	88	2.5 ± 0.3	112.4
10.	*Dipodomys deserti*	95	1.09	93	2.3 ± 0.3	94.3
11.	*Eutamias umbrinus*	58	1.30	97	1.1 ± 0.8	53.2
12.	*Eutamias dorsalis*	51	1.35	98	2.1 ± 0.3	49.1
13.	*Eutamias minimus*	51	1.51	109	1.2 ± 0.3	31.1
14.	*Eutamias palmeri*	65	1.45	112	1.5 ± 0.7	55.7
15.	*Spermophilus lateralis*	164	1.55	153	18.3 ± 2.6	108.2

[a] Percentage expected = (measured V_{O_2}/predicted V_{O_2}) 100. Predicted V_{O_2} was obtained using Brody's equation (4).
[b] ± SE.

some component of body composition (10). The correlation coefficients of V_{O_2} to body water, FFBW and total body weight were similar. This finding is in contrast with Hayward (5) who suggested that FFBW is inferior to body water when related with V_{O_2} in *Peromyscus*.

The rodents used for the V_{O_2} studies were not the same animals used for fat analysis.

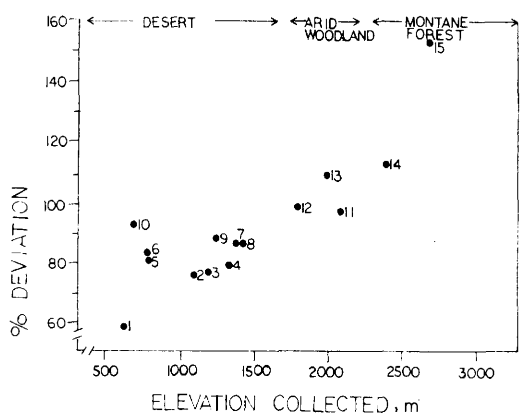

FIG. 1. Relationship between ecologic distribution and minimal metabolic rate. Numbers are those used in Table II.

However, since the body weight of captured animals did not change significantly in the laboratory, we believe that both groups of rodents are comparable and their comparison is valid.

In conclusion, there is no relationship between body fat content and V_{O_2} in the rodents studied. However, V_{O_2} appears to be related to environment. It is suggested that low V_{O_2} of desert rodents is an adaptive mechanism by which these animals tolerate heat and conserve energy and water.

Summary. Fifteen species of rodents representing three families and a wide range of ecologic distribution were used to investigate relationships between body fat and metabolic rates (V_{O_2}). There was no apparent relationship between fat content and V_{O_2}. The correlation between V_{O_2}, body weight, body water and fat free body weight was essentially the same. Ecologic distribution appears to be of more importance than fat content in modification of V_{O_2}.

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