ACTA THERIOLOGICA
Vol. 21, 10: 157—163, 1976

Caloric Values of Small Mammals of Southeastern Quebec

Jean Marie BERGERON

Bergeron J. M., 1976: Caloric values of small mammals of southeastern Quebec. Acta theriol., 21, 10: 157—163. [With 1 Table & 1 Fig.].

A total of 164 small mammals were caught with a trapping effort of 11,002 trap-nights. The caloric value of a small mammal averaged 1.76 kcal/g; *Peromyscus maniculatus* (Wagner, 1845) yielded the highest value and *Clethrionomys gapperi* (Vigors, 1830) the lowest. The caloric value of dry weight varied from 5.27 kcal/g for *Sorex cinereus* (Kerr, 1792) to 5.86 kcal/g for *P. maniculatus*. I found monthly variations in ash contents of small mammals and correspondingly, monthly variations in the caloric values of ash-free weight. This value fluctuated from 6.54 kcal/g for *S. cinereus* to 7.50 kcal/g for *P. maniculatus*. Such high values are compared with those found in the literature.

[Dept. Biol., Univ. Sherbrooke, Qué. Canada J1K 2R1]

I. INTRODUCTION

Since Lindeman's introduction of the concept of energy transfer within food chains (Lindeman, 1942) the trend has been to covert biomass into energy. This holds true for many IBP programs throughout the world whose task is to standarize the ecosystems on a basis of energy flow and matter cycling. Golley (1959, 1960, 1961) is one of those who very early realized that the energy content of matter varied with species, season and habitat conditions. Since then, the caloric determinations of living matter have mushroomed although studies based on extensive material are still not very common.

The first step of a long term population quality study was initiated in 1972 on the grounds of Université de Sherbrooke. The study consisted in comparing energy values of small mammals trapped from 5 different habitats: a meadow, a mixed fir-white spruce forest, a mixed hemlock forest, a maple forest and a white spruce plantation.

The energy content and body composition of small mammals have been studied by Pitts (1960), Hayward (1965), Górecki (1965), and Fleharty, Krause & Stinnett (1973), and by many others. My goals were to add more data for American small mammals in the field of bioenergetics and to compare those with their European counterparts. Three parameters were studied: caloric value of fresh weight, caloric value of dry weight and caloric value of ash-free weight.

II. MATERIAL AND METHODS

The animals were caught from 5 sampling plots located within the Université de Sherbrooke ground limits of 200 acres (72°54′ N and 45°24′ W). The trapping method consisted of an Index Trap line of 50 Victor mouse traps set in 10 rows, 10 meters apart; the traps were left in the sampling plots for 4 consecutive nights. The 5 plots were trapped for an eleven month period ending in April 1973.

After being checked for fleas and external parasites, the animals were sexed, weighed, dehydrated and grounded manually. The dehydration procedure consisted in leaving the animals in a Boekel oven at 90° C until constant weight was attained, a procedure lasting 24 hr or less. This material was then ground and divided into 2 equal parts, the first one being kept in a dessicator for the calorimetry determination and the second one burned for 1/2 hr at 600°C in a Hotpack furnace to permit the correction for ashes (Johnson & Maxell, 1966). The first portion was then divided into 3 or 4 parts of approximately 0.7 g, pelletized and burned in a Gallenkamp Ballistic Bomb Calorimeter. Corrections were made for the thread and heat release of thermistors.

III. POPULATION COMPOSITION

A total of 164 animals were caught with a trapping effort of 11,002 trap-nights. I trapped 24.4% of the total catch in the meadow plot, 29.1% in the mixed fir-white spruce stand, 15.8% in the mixed hemlock forest, 20.1% in the maple forest and 10.4% in the white spruce plantation. I noted mainly the absence of *P. maniculatus* in the meadow, the absence of *S. cinereus* in the mixed fir-white spruce and maple forests and the absence of *C. gapperi* in the mixed hemlock stand. *B. brevicauda* totalled 40.9% of the total catch, followed by *P. maniculatus* with 28%, *C. gapperi* with 19.5%, *S. cinereus* with 7.3%, *Zapus hudsonius* (Zimmerman) with 1.8%, *Napaeozapus insignis* (Miller) and *Sorex fumeus* Miller with 1.2% respectively. The overall sex ratio of the catch was 1 : 1, although variations were observed in some species. The body weight of the 4 most numerous species averaged 18.0 g for *C. gapperi*, 17.9 g for *B. brevicauda*, 17.4 g for *P. maniculatus* and 3.0 g for *S. cinereus*. I noticed particularly high coefficients of variation of body weight for rodent species (22—25%) while those of shrews were much smaller (13—15%). According to Górecki (1965), this might be caused either by the presence of several age groups in the population or by the seasonal variation in the body composition of small mammals.

IV. CALORIC VALUES OF BIOMASS

One of the most important caloric equivalent in bioenergetic studies is the conversion of the total biomass into calories. This value is known to be quite variable because it includes the variations in fat, water and ash contents, and body weight. The yearly average of 1.76 kcal/g of live weight (Table 1) found in this study represents a very high figure among wild-caught small mammals. Such high values were reported only by Davenport (1960) for *P. polionotus* (1.94 kcal/g), Sharp (1962) for *O. palustris* (1.90 kcal/g), and Myrcha (1968) for *L. europaeus* (1.87 kcal/g). Nevertheless, it is well known that laboratory reared animals can easely double the caloric conversion of their biomass (Caldwell & Connell, 1968; Brisbin, 1970).

The caloric value of biomass ranges from 1.6 to 2.0 kcal/g for rodents and from 1.4 to 1.8 kcal/g for shrews (Figure 1 a). A *t* test for the difference between two sample means shows a significantly higher average for *P. maniculatus* ($P<.01$), while *C. gapperi* and *S. cinereus* have equal means. Seasonal patterns of caloric values were observed in all rodent and shrew species except *S. cinereus*. *P. maniculatus* reaches maximum

Table 1

Mean bioenergetic conversions of 4 species of small mammals.

Means	*P. maniculatus*	*C. gapperi*	*B. brevicauda*	*S. cinereus*
Caloric value of biomass (cal/g)	1846±159	1690±172	1711±148	1749±133
Caloric value of dry weight (cal/g)	5863±313	5740±259	5456±387	5271±302
Water content (%)	68.4±1.8	70.6±2.3	68.6±1.8	66.8±1.5
Ash content of dry weight (%)	21.7±3.8	22.2±3.1	22.4±3.5	18.4±3.1
Caloric value of ash-free weight (cal/g)	7504±433	7373±376	7039±626	6536±581

of 1.99 kcal/g in October a value which is statistically different ($P<.05$) from the minima of April, June, July, August and September. *C. gapperi* reaches its lowest caloric value in September and its highest in October, November and December. *B. brevicauda* yields its highest value in October and its lowest in February. For this species, a gradual increase is observed in July, August and September.

In addition to these records, two *Z. hudsonius* caught in June 1972 yielded 2.23 and 2.17 kcal/g respectively. A male *N. insignis* trapped at the end of August 1973 gave a value of 1.99 kcal/g. Two *S. fumeus* caught in the winter time (December and January) showed respective values of 1.67 and 1.59 kcal/g.

V. CALORIC VALUES OF DRY WEIGHT

The overall caloric value of dry weight for all species averaged 5.62 kcal/g; the maximum was attained in October (6.02 kcal/g) and the minimum in February (4.71 kcal/g). This confirms the well known summer-winter decrease of body energy content expressed on a dry weight basis.

P. maniculatus and *C. gapperi* have equivalent yearly means and these proved to be statistically higher than those of the shrew species ($P<.01$). Figure 1b shows the monthly means of caloric values of dry weight for the most common species. These values are much higher than what is usually found in the literature, and can only be compared to Golley's

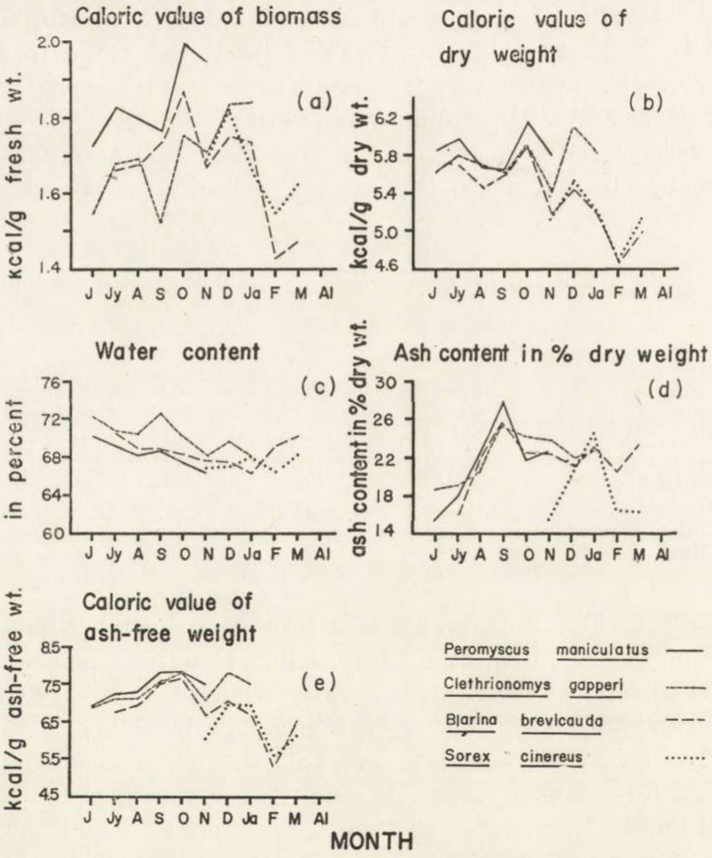

Fig. 1. Bioenergetic conversions of small mammals.

(1959) and Sharp's (1962) laboratory animals. The coefficients of variation compare very well with those of Górecki (1965) but never reach his values for the summer animals. In short, they varied from 1 to 7% for *P. maniculatus*, from 2 to 5% for *C. gapperi*, from 1 to 6% for. *B. brevicauda* and from 3 to 4% for *S. cinereus*. The sample variations do not show a summer-winter pattern and are usually quite variable througt-out the year.

Overall seasonal patterns do not show well in mice and voles. However, the analysis of variance indicates monthly differences within the groups. The lowest caloric value of *P. maniculatus* is found in September (5.66 kcal/g dry weight) and the highest in October (6.17 kcal/g). The remaining months show mean values not statistically different from those for September. The same holds true for *C. gapperi*, where the October values prove to be different from all other values. *B. brevicauda* shows a summer-winter decrease in energy content with a peak of 5.91 kcal/g in October and a low of 4.68 kcal/g in February. They lose around 1.23 kcal/g from fall to mid-winter which is much higher than what is known for the European common shrew (Górecki, 1965). *S. cinereus* yields a very constant value throughout the year (Figure 1 b). These values are much higher than those for the European common shrews which are longer in body size. There are no seasonal or monthly variations in the caloric values of dry weight for that species.

These differences cannot be caused by abnormal body water values since our values compare very well with those published on the subject. In short, the water content of the body is significantly higher for *C. gapperi*, intermediate for *P. maniculatus* and *B. brevicauda* and lowest for *S. cinereus* (Figure 1 c). There is no seasonal pattern for all species except *P. maniculatus* which shows a gradual decrease in water content from June to November. I noted also a generall lower water content during the winter months for *C. gapperi* and *B. brevicauda*. The low coefficients of variation (2—3% for all species) indicate the stability of this element in all species throughout the year.

VI. CALORIC VALUE OF ASH-FREE WEIGHT

The ash content of small mammals in thought to be quite constant and comparable between species. For this reason, many bioenergetic studies use the caloric conversion to standardize and compare the body values of animals. Figure 1 d shows the percentage of ash in rodent and shrew species. We readily see the very high value obtained for all species and seasons (average 21.8%). These yearly averages (Table 1) range from 18.4% for *S. cinereus* to 22.4% for *B. brevicauda*. Every species shows an overall high coefficient of variation from 14 to 17% which indicates the variability of the sample. The interspecific comparison of the means shows that *S. cinereus* is 4% lower than the other species, which is about twice the value found by Górecki (1965). Fleharty *et al.* (1973) found high values of ash contents (14.2—16.2%) and suggested that this might have been due to the age structure of the population. I mentioned in an earlier section that my small mammal sample was not at an uniform adult stage, and contained thus several juvenile and subadult animals.

I was unable to find definite seasonal patterns of ash contents of the body for the three most abundant species of small mammals. However, I can see some trends. June, July and August are usually the lowest months of ash yields while September and October are the highest. The ash contents remain quite high for the following 5 months of the year.

It can thus be assumed that the caloric value of ash-free weight for small mammals will be corrrespondingly higher than what was shown previously (Figure 1 e). The yearly average ranges from 6.54 kcal/g for *S. cinereus* to 7.50 kcal/g for *P. maniculatus* (Table 1). Mice and voles show June, July and August values statistically lower ($P < .02$) than those of September and October. This pattern is not so obvious for *B. brevicauda* although they still show higher values in fall and winter. The species tend to reflect the previously mentioned pattern of ash contents althougth minor deviations from this pattern suggest the action of other factors. These caloric values are much higher than those found for all European small mammals (Górecki, 1965; Hansson & Grodziński, 1970) and are even higher than those of European hares (Myrcha, 1968).

Acknowledgments: This study was supported by a grant from the National Research Council of Canada (A9540). I wish to express my thanks to Mr. Louis-Marie Thériault who provided the necessary technical help. Dr. Jacques Juillet made many useful comments about the statistical approach and Drs. Wilfred Blaine and Pierrre Béchard improved the English text.

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Accepted, February 25, 1975.

Jean Marie BERGERON

WARTOŚĆ KALORYCZNA CIAŁA DROBNYCH SSAKÓW Z POŁUDNIOWO-WSCHODNIEGO QUEBECU

Streszczenie

W ciągu 11 002 pułapko-dni złowiono 164 drobne ssaki. Wartość kaloryczna ich ciała wynosi średnio 1.76 kcal/g (Tabela 1, Ryc. 1). Wskaźnik ten jest najwyższy u *Peromyscus maniculatus* (Wagner, 1845) a najniższy u *Clethrionomys gapperi* (Vigors, 1830). Wartość kaloryczna suchej masy waha się od 5.27 kcal/g u *Sorex cinereus* (Kerr, 1792) do 5.86 kcal/g u *P. maniculatus*. Stwierdzono istnienie miesięcznych wahań w zawartości popiołu a co za tym idzie zmiany wartości kalorycznej w masie ciała bez popiołu. Ten ostatni wskaźnik zmienia się od 6.54 kcal/g u *S. cinereus* do 7.50 kcal/g u *P. maniculatus*. Te tak wysokie wartości porównane zostały z danymi z literatury.