THE BIOLOGY AND MANAGEMENT OF WILD RUMINANTS

CHAPTER SEVEN

ENERGY METABOLISM OF WILD RUMINANTS

by

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CHAPTER 7. ENERGY METABOLISM

Metabolism, the biochemical processes characteristic of life, includes both assimilation (anabolism) and breakdown of protoplasm (catabolism). When the rate of assimilation equals the rate of breakdown, metabolism is at the maintenance level. If the rate of assimilation exceeds the rate of breakdown, growth or weight gains occur, and if breakdown exceeds assimilation, weight losses occur.

Anabolism occurs at different rates in different tissues, depending on the age, time of year, and activity of the animal. A young growing animal has a higher rate of metabolism per unit body weight than an older mature one. Young growing animals deposit more protein and skeletal tissue, and older, more mature animals deposit more fat tissue. Anabolism is greater in the summer and fall than in the winter and spring. In fact, weight losses usually occur in the winter as part of an adaptive survival strategy. Active animals have higher rates of metabolism than inactive ones, and activity levels are often reduced in the winter as another adaptive survival strategy.

Catabolism, the breakdown of tissue, is the reverse of anabolism. It is a part of maintenance. Some tissues are broken down and their energy, protein, and minerals become available to the animal. Body fat is an energy reserve that may be mobilized when ingested nutrients are not sufficient to meet the energy needs of the animal. Male Cervids partition resources into antlers in spring and summer, mobilizing minerals from some of their bones for deposition in the antlers. Pregnant females partition nutrients into their own maternal tissue and into fetal and reproductive tissue. Lactating females assimilate nutrients into milk, sometimes mobilizing their own tissues to do so. These are important capabilities when forage resources are depleted or unavailable.

Ruminants also have metabolic adaptations for the conservation of resources. Lower energy metabolism in the winter when range resources are more limited and higher metabolism in the summer when range resources are less limited is a seasonal conservation adaptation. This is an important metabolic adaptation for wild ruminants living on ranges with seasonally fluctuating resources, and may be critical for survival when range resources are especially limited, as in severe winters.

Measurements of energy metabolism have been made for many years. The French scientist, Lavoisier completed a very basic experiment in metabolism by placing mice in a container surrounded by ice and measuring the rate of ice-melt. He found that the energy required to melt the ice was related to the heat production of the mice, providing an early estimate of metabolism. Techniques have been refined considerably since that early experiment. While metabolic chambers are still used to directly measure the heat given off by an animal, indirect measurements and estimates are often made by gas analyses, and the amounts of oxygen consumed and carbon dioxide released used to estimate metabolic rates.

Several terms are used in the literature to describe metabolism measurements. Basal metabolism has been defined as the minimum energy cost when an animal is at rest in a thermoneutral environment and in a post-absorptive nutritive condition (Brody 1945). The definition of basal metabolism implies standard conditions for measurement rather than minimum metabolism for life. The resting animal is not active, nor is it sleeping. Thermoneutrality is the condition of being neither too hot nor too cold while in the metabolism chamber. Then, there are no thermogenic responses; the animal makes no attempt to keep from getting too hot (by panting, for example) or too cold (by shivering, for example). The post-absorptive condition eliminates the metabolic contributions of rumen microflora to the total heat production of the animal. These microflora produce their own metabolic heat as they break down the ingesta in the rumen. This heat is not a part of the host's metabolic heat production.

The energy required to maintain life during basal metabolism tests is used to meet the costs of circulation, excretion, secretion, respiration, and the maintenance of muscle tone. Basal metabolism is a laboratory measurement that is useful for comparative purposes, but it is not applicable to the field situation since free ranging animals seldom meet the conditions prescribed for a metabolism test.

The term fasting metabolism applies to metabolism tests conducted on animals in a post-absorptive condition and in a thermoneutral environment, but not corrected for activity. Results are given in this way when corrections for activity during the test cannot be made.

Ecological metabolism is an expression of the total cost of maintenance, activity, and production processes of free-ranging animals (Moen 1973:123-124). The cost varies because the rates of these processes vary. Some of the variability is rhythmic due to seasonal patterns in weather and thermal exchange, the timing or reproductive functions, activity patterns, and other biological functions. Some of the variability is due to the effects of transients, such as quick changes in the level of energy expenditure for activity due to a flight response from a predator. The metabolic expenditures for each of these processes accumulate over a 24-hour period, resulting in the ecological metabolism per day (ELMD).

One very useful expression for evaluating rates of energy metabolism is base-line metabolism. This expression is a mathematical base-line, a common denominator used when dividing ecological metabolism per day (ELMD) to determine a multiple of base-line metabolism (MBLM) for comparative purposes, numerically equal to (70)(MEWK) KCAL per day and (294)(MEWK) KJOU per day (MEWK = $W_{kg}^{0.75}$). While the numerical value approximates the average basal metabolism of a large number of species, base-line metabolism should be considered as a mathematical base-line only and not as an average basal metabolism value. Average basal metabolism of white-tailed deer varies seasonally (Moen 1973), and averages are not appropriate representations of metabolic rhythms that vary in a patterned way through the year. Time-related ecological metabolism should be expressed as a function of time; the use of averages for long time periods results in the loss of too much information of ecological significance.

The ratio of ELMD to BLMD is called the multiple of base-line metabolism (MBLM). This ratio is weight-independent; the effects of weight appear in both the numerator and the denominator (MBLM = ELMD/BLMD). MBLM is especially useful when comparing ELMD for different species. When ELMD is expressed as a multiple of base-line metabolism, interspecies comparisons can be easily made since differences in size have been eliminated by the use of weight in both the numerator and denominator. MBLM may be used to establish a reasonable biological framework for expressing ELMD for a variety of species; calculations indicate that MBLM values approaching 5 are unrealistically high, and below 1.3 or so, low. Details for different species are discussed next.

LITERATURE CITED

Brody, S. 1945. Bioenergetics and growth. Reinhold Publ. Co., New York. 1023 pp.

Moen A. N. 1973. Wildlife ecology. W. H. Freeman and Co., San Francisco. 458 pp.

REFERENCES, CHAPTER 7

ENERGY METABOLISM

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TYPE	PUBL	CITY	PGES	ANIM	KEY WORDS-----------------	AUTHORS/EDITORS--	YEAR
aubo	repu	nyny	1023	doan	bioenergetics and growth	brody,s	1945
aubo	mopc	itny	1207	rumi	feeds and feeding, 21st ed	morrison,fb	1948
aubo	coms	itny	1020	doan	physiology, domestic anima	dukes,hh	1955
aubo	wile	nyny	184	rumi	metabolism in the rumen	annison,ef; lewis	1959
aubo	saco	phpa	546	many	fundamntls of ecol, 2nd ed	odum,ep	1959
aubo	acpr	nyny	236		rhyth activ, physiol, beha	cloudsley-thompso	1961
aubo	wile	nyny	454	many	the fire of life	kleiber,m	1961
aubo	ccth	spil	329	rumi	energy metaboli, ruminants	blaxter,kl	1962
aubo	agrc	loen	37	rumi	nutr req farm livest, rumi	agricultural rese	1965
edbo	acpr	loen	450	doan	energy metabolism	blaxter,kl,ed	1965
aubo	prha	ecnj	815	many	gener, comparative physiol	hoar,ws	1966
aubo	hutc	loen	332	rumi	energy metabolism, ruminan	blaxter,kl	1967
edbo	fase	bemd	737		metabolism	altman,pl; dittme	1968
edbo	acpr	nyny	427	many	comprtv nutritn wild anims	crawford,ma ed	1968
aubo	whfr	sfca	753	doru	applied anim nutri, 2nd ed	crampton,ew; harr	1969
edbo	jdve	zusw		doca	5th symp energy metabolism		1971
aubo	whfr	sfca	458	wiru	wildlif ecol: analyt appro	moen,an	1973
aubo	acpr	nyny	545	vert	scale effects in locomotio	pedley,tj,ed	1977