TOPIC 2. MEASUREMENTS OF PROTEIN METABOLISM

Protein metabolism proceeds at orderly rates in relation to the biological functions involved. The basis for the requirement of protein traces back to the losses of nitrogenous end-products from the body (Crampton and Harris 1969:166). If an animal is to be in protein balance, intake must equal output. When an animal is in a positive protein or nitrogen balance, more is being ingested in and deposited in body tissue than is lost. When an animal is in a negative protein or nitrogen balance, more is lost from the body than is ingested.

Protein is necessary for the maintenance of basic life processes, including the synthesis of enzymes, replacement of catabolized body tissue, replacement of tissue abraded from internal surfaces of the gastrointestinal tract, and from the skin. Measurements of endogenous urinary nitrogen have been made on few wild species. Domestic cattle and sheep have been studied rather extensively, and the results are useful for estimating the protein costs for wild ruminants.

Protein balances are rather delicate. Protein is not stored in large quantities like fat is, nor is the protein stored passively like fat. Body composition measurements, for example, show rather constant protein fractions, while fat and water fractions are inversely proportional as weight increases (see CHAPTER 2).

The basic biological functions of domestic ruminants and wild ruminants should be similar, so the results of measurements of protein metabolism on domestic ruminants may be approximations for wild ruminants by expressing relationships per unit body weight, metabolic body weight, or to some some other baseline.

Two kinds of measurements are discussed in the two units that follow. UNIT 2.1 includes discussions of direct measurements under controlled chamber or pen conditions, and UNIT 2.2 of indirect measurements, made by evaluating the apparent effects of different levels of protein intake or productivity.

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Crampton, E. W. and L. E. Harris. 1969. Applied animal nutrition. W. H. Freeman and Co., San Francisco. 753 pp.

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UNIT 2.1: DIRECT MEASUREMENTS AND CALCULATIONS

Protein requirements may be estimated directly by measuring the amount of and evaluating the protein fraction of selected metabolic products. Such measurements involve captive animals and feces and urine collections. The amounts of feces and urine and the metabolic nitrogen fraction of each of these waste products provides an indication of how much protein has been catabolized. Measurements of the amounts and protein fractions of accumulated body tissues provide a basis for estimating the protein required for growth. Considerations that must be made when evaluating these protein or nitrogen fractions are discussed next.

ENDOGENOUS URINARY NITROGEN

Nitrogenous compounds are one of the by-products of protein metabolism These compounds, such as ammonia and urea, must not be allowed to accumulate in the body as they can become very toxic. Urine is formed as a result of filtration, reabsorption, and secretion processes in the excretary system that result in the collection of nitrogen compounds that cannot be used (ammonia) or that are not recycled (urea).

The amount of urea recycled, a function of the crude protein in the diet, is variable and part of an adaptive strategy for nitrogen and protein conservation that has developed in free-ranging ruminants.

Endogenous urinary nitrogen, abbreviated EUNT, is derived from the catabolism of body tissue, and the quantity of EUNT is related to the metabolic body weight of the animal. An equation for calculating endogenous urinary nitrogen excreted by white-tailed deer, based on data in Robbins et al. (1974:189) is:

$EUNG = 0.115 \times (MEWK)$

where EUNG = endogenous urinary nitrogen in gms per kg per day, and MEWK = metabolic body weight in kg = $LWKG^{0.75}$.

The calculated protein requirement in gms per day to meet this loss of EUNG is:

PRUN = (0.115)(MEWK)(6.25)

where PRUN = protein required for endogenous urinary nitrogen.

The equation for EUNG given above, based on measurements on white-tailed deer fawns that were about 6 months old, may not be the best estimation for other species of wild ruminants, and ruminants of different ages. Other estimations may be made with the equation given on page 11 of this chapter, and with values published by the Agricultural Research Council (1965). Slight differences in the estimates from these two sources are discussed in Moen (1973:335). Estimates with the equation in Crampton and Harris (see page 11) are less than estimates based on the ARC values at the lower weights and greater at the higher weights for both cattle and sheep.

FECAL NITROGEN

Nitrogen in the feces comes from four sources. One, ingested but undigested protein in the diet ends up in the feces. Such protein compounds pass through the gastrointestinal tract intact. Two, nitrogen residues originating in digestive enzymes; three, protein compounds and nitrogen residues from the metabolic activities of the intestinal microflora, and four, protein compounds and nitrogen residues from the metabolic activities of the cells lining the gastrointestinal tract all end up in the feces. These different origins are not discerned when simply analyzing the feces for protein or nitrogen. Further, the third source includes protein or nitrogen from the metabolic functions of the intestinal microflora. The second and fourth sources are of metabolic origin, and represent protein metabolized by the body and used for maintenance and productive functions.

Metabolic fecal nitrogen results from the abrasion of epithelial cells from the gastrointestinal tract as food passes through and from proteins used in the digestion of food. The quantity of metabolic fecal nitrogen is a function of both food intake and the quality of the ingested food.

The usefulness of ingested protein to the animal is expressed as the biological value of the protein. The true biological value is defined by Crampton and Harris (1969:89) as the "percentage of true absorbed nitrogen that is used for maintenance and production, or for maintenance only." It is related to the content of essential amino acids (those amino acids which must be ingested because they cannot be synthesized in the body).

Suppose the protein contained a perfect assortment of amino acids. Then, all of the protein could be used by the body and none would be deaminized and its nitrogen component excreted in the urine. The urine would contain only nitrogen of metabolic origin. Suppose that the protein in a food did not contain a perfect assortment of amino acids. Then, only a fraction of the protein could be used, with the rest deaminized and the nitrogen excreted. This fraction times the protein digestibilility results in a net protein coefficient (NPRC), which is a measure of the amount of protein that can be used for metabolic purposes. Calculations of net protein coefficients are illustrated below.

Protein characteristics of the food	Amino acid <u>"index"</u>		Protein digestibility	<u>,</u>	NPRC
Perfect amino acid distribution,		·			0.05
high digestibility Good amino acid	1.00	x	0.95	=	0.95
distribution, medium digestibility	0.80	x	0.70	=	0.56
Poor amino acid distribution, low digestibility	0.50	x	0.50	=	0.25

These illustrations show how the amino acid distribution and digestibility interact (Oser 1951) to result in a net protein coefficient (NRPC). As NPRC decreases, food intake must increase if nitrogen requirements are to be met. The additional intake, however, raises MFNG requirements. Thus deteriorating protein quality of forage causes an increase in protein requirements, placing the animal in a negative feedback situation that results in low rates of ingestion and a negative protein balance.

GROWTH

Animals that are in a positive nitrogen balance are depositing more protein in body tissue than is being excreted. Protein is very important for body growth in young animals, it is deposited in hair as coat changes occur twice each year, and it is an important cost during reproduction as protein is an important component of fetal tissue and milk.

The protein costs associated with these productive processes may be estimated by determining the protein compositions and the quantities of the different tissues produced. Results of these "before and after" measurements may be expressed on a per day basis. Growth and chemical composition data were given in CHAPTERS 1 and 2. These data are needed when completing the WORKSHEETS in TOPIC 3.

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- Agricultural Research Council. 1965. The nutrient requirement of farm livestock. No. 2. Ruminants. Agricultural Research Council, London. 264 pp.
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- Moen, A. N. 1973. Wildlife ecology. W. H. Freeman and Co., San Francisco. 458 pp.
- Oser, B. L. 1951. Methods for integrating essential amino acid content in the nutritional evaluation of protein. J. Amer. Dietetic Assoc. 26:396.

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DIRECT MEASUREMENTS AND CALCULATIONS

SERIALS

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CODEN VO-NU BEPA ENPA ANIM KEY WORDS----- AUTHORS----- YEAR JANSA 38--1 186 191 odvi nitrogen metabolism, deer robbins,ct; prio/ 1974 JWMAA 39--3 582 589 odvi protein requirement, fawns smith,sh: holter/ 1976 JWMAA 43--4 872 879 odvi protein require, yearlings holter,jb; hayes/ 1979

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----- AUTHORS----- YEAR JAVMA 155-7 1085 1085 odhe urine-collect device, male richmond, m; pill/ 1969

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----- AUTHORS----- YEAR BJNUA 24--3 843 855 ceel dosh, digest, nitrogen met maloiy,gmo; kay,/ 1970 CBPAB 60A-3 251 256 ceel nitrogen metabolism, red d simpson,am; webs/ 1978

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----- AUTHORS----- YEAR

alal

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----- AUTHORS----- YEAR rata

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----- AUTHORS----- YEAR anam

 CODEN VO-NU BEPA ENPA ANIM KEY WORDS------ AUTHORS------ YEAR

 b1b1

 CODEN VO-NU BEPA ENPA ANIM KEY WORDS------ AUTHORS------ YEAR

 ovca

 CODEN VO-NU BEPA ENPA ANIM KEY WORDS------ AUTHORS------ YEAR

 ovda

 CODEN VO-NU BEPA ENPA ANIM KEY WORDS------ AUTHORS------ YEAR

 ovda

 CODEN VO-NU BEPA ENPA ANIM KEY WORDS------ AUTHORS------ YEAR

 ovda

 CODEN VO-NU BEPA ENPA ANIM KEY WORDS------ AUTHORS------ YEAR

 obmo

 CODEN VO-NU BEPA ENPA ANIM KEY WORDS------- AUTHORS------- YEAR

 obmo

UNIT 2.2: FEEDING TRIALS

Feeding trials which give indications of the levels of dietary protein necessary for different growth and reproductive responses may be completed for captive animals in order to get some estimate of the protein fraction of the forage required for different levels of productivity. These are "black box" type experiments; inputs are compared to outputs without evaluating the mechanisms within the animal that result in the partitioning of the nutrients. Further, interactions between different nutrients are difficult if not impossible to consider and control.

Comparisons may be made between the results of feeding trials and the summation of different protein costs determined by measurements or calculations of the metabolic characteristics discussed in UNIT 2.1. The two independent approaches should have similar results, of course. Such comparisons are useful because they serve as checks on each other; "ecological accounting" is an important part of the many sequential calculations used to link animal to range in as many ways as possible.

REFERENCES, UNIT 2.2

FEEDING TRIALS

SERIALS

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CODEN VO-NU BEPA ENPA ANIM KEY WORDS----- AUTHORS----- YEAR

odhe

CODEN VO-NU BEPA ENPA ANIM KEY WORDS------ AUTHORS----- YEAR

cee1

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----- AUTHORS----- YEAR

alal

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CODEN	VO-NU	BEPA	ENPA	ANIM	KEY	WORDS	AUTHORS	YEAR
				rata				
CODEN	vo-nu	BEPA	ENPA	ANIM	KEY	WORDS	AUTHORS	YEAR
				anam				
CODEN	vo-nu	BEPA	ENPA	ANIM	KEY	WORDS	AUTHORS	YEAR
				bibi				
CODEN	VO-NII	REPA	ένρα	Δητμ	KEV	WORDS	AUTHORS	VEAR
CODEN	10 110	DDIA	DITLA	owaa	NO I	WOLDD	AUTHORD	
				ovca				
CODEN	VO-NU	BEPA	ENPA	ANIM	KEY	WORDS	AUTHORS	YEAR
				ovda				
CODEN	vo-nu	BEPA	ENPA	ANIM	KEY	WORDS	AUTHORS	YEAR
				obmo				
CODEN	vo-nu	BEPA	ENPA	ANIM	KEY	WORDS	AUTHORS	YEAR
				oram				