TOPIC 1. FACTORS AFFECTING PROTEIN METABOLISM

Protein metabolism of wild ruminants is affected by both biological and environmental factors. Like other mammals ruminants convert the ammonia released from the amino acids that are not used in protein synthesis into ammonia and then urea. Urea is a soluble compound that is excreted in the urine. Ruminants, however, have the ability to recycle urea, making it available to rumen microflora for synthesis into new protein tissue.

The amount of urea recycling is dependent on environmental conditions. More recycling occurs when the crude protein intake is less, and for wild ruminants, crude protein levels are a function of range condition.

Protein metabolism is also affected by the overall body condition of the animal, which is also affected by range conditions. Nutritional stress after fat reserves are depleted results in the breakdown of protein tissue, which means the animal is in a very critical situation. The interdependence of animal and range is illustrated again by these examples. Animal-range relationships of free-ranging ruminants are very dynamic, with feed-back mechanisms that eliminate direct proportions and simple equations when evaluating them mathematically.

UNIT 1.1: BIOLOGICAL FACTORS AFFECTING PROTEIN METABOLISM

Two factors affecting protein metabolism, the true biological value or metabolizable protein and urea recycling, will be discussed in this UNIT.

The true biological value of protein is a representation of the amount of protein that is actually used for metabolism, or true metabolizable protein. This is partly a function of the way the protein or nitrogenous compounds are packaged in the forage, and partly a function of the nitrogen balance of the animal.

The "packaging" of protein or nitrogenous compounds in the forage affects the digestibility of the forage. Those forages that contain nitrogen compounds that are easily broken down into amino acids are high digestible forages, and those that have cell structures which bind the nitrogen compounds or very complex proteins are low digestible forages.

The nitrogen balance of an animal affects the amount of true metabolizable protein by affecting the fate of nitrogen compounds in the forage. An animal on a high protein and low energy diet will use some of the nitrogen compounds as a source of energy. The caloric value per gram of proteins (5.7) is less than that of fats (9.5). There, is an additional inefficiency because animals do not completely oxidize proteins, but excrete portions of protein molecules in the form of ammonia and urea (Florey 1966:270). Thus the gross energy in a gram of protein oxidized in a bomb calorimeter is 5.7 kcal, and in a gram of protein metabolized in the animal, 4.8 kcal.

The nitrogen balance also affects the metabolic disposition of protein compounds. Urea recycling occurs when urea in the blood enters the gastrointestinal tract where it is broken down into ammonia and carbon dixoide. Some of the ammonia is then synthesized into protein by intestinal microflora, and the remainder is excreted in the feces.

Urea recycling represents a means of conserving nitrogen when ruminants are consuming poor quality forage (Robbins et al. 1974). When urea recycling is maximum due to very low crude protein in the forage, the only additional source of nitrogen is tissue nitrogen. Then, body condition may deteriorate rapidly. Short-term tissue nitrogen mobilization meets immediate and specific nitrogen requirements, but cannot continue for long periods of time, of course.

There are other factors affecting protein metabolism too, including requirements for maintenance and production; these are discussed in TOPICS 2 and 3. There are not many references available on protein or nitrogen metabolism of wild ruminants, so protein costs for various biological functions must be estimated from data on domestic ruminants.

LITERATURE CITED

Florey, E. 1966. An introduction to general and comparative physiology. W. B. Sanders Company, Philadelphia. 713 pp.

Robbins, C. T., R. L. Prior, A. N. Moen, and W. J. Visek. 1974. Nitrogen metabolism of white-tailed deer. J. Anim. Sci. 38(1):186-191.

REFERENCES, UNIT 1.1

BIOLOGICAL FACTORS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	48--6	437	1442	cerv	rumen nitrog level, variat	klein,dr; schonhe	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	38--1	186	191	odvi	nitrogn metabolism of wh-t	robbins,ct; prio/	1974
JWMAA	39--2	346	354	odvi	blood prot, gestatio, suck	harstook,ew; whe/	1975
JWMAA	39--4	692	698	odvi	ener, prot, blood urea nit	kirkpatrick,rl; /	1975
JWMAA	42--4	776	790	odvi	diet prot, energ fawn meta	verme,lj ozoga,j	1978
JWMAA	43--2	454	460	odvi	season, nutri, serum nitro	bahnak,br; holla/	1979

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

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

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BIJOA	155-3	549	566	alal	ceel, chymotrypsin, pancre	lindsay,rm; steve	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AVSCA	16--4	513	519	rata	renal excret urea, nutriti	hove,k; jacobsen,	1975
AZOFA	11--3	200	203	rata	seas chang renal urea conc	eriksson,l; valto	1974
MAAIA	51---	381	419	rata	renal resp, high, low prot	valtonen,m	1979

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

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

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
                       obmo

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

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR
NUMEB 21--2 105  118  doan energet, prot depos, grwth thorbek,g         1977

CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR
BJNUA 24--- 983  988  anim bloo urea, asses prot qual eggum,bo          1970
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CHAPTER 8, WORKSHEET 1.1a

Urea recycling and the biological value of protein
metabolized by white-tailed deer (odvi)

The amount of urea recycled by white-tailed deer is a function of the crude protein in the diet. The equation given by Robbins et al. (1974) is:

$$\log_e Y = 5.3197 - 0.5007 \log_e X$$

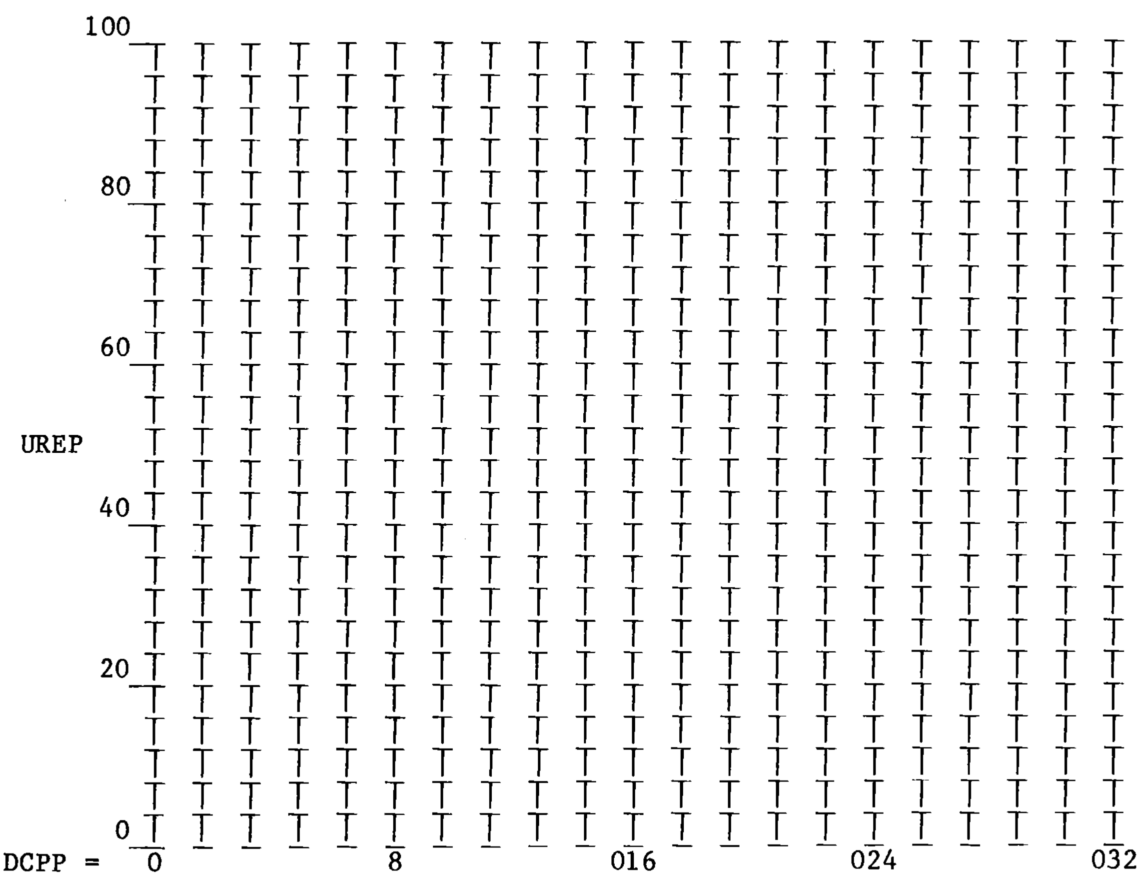
where X = dietary crude protein (%) and
Y = urea recycled (% entry rate).

Rewriting this equation and changing X and Y to DCPP and UREP, respectively, the new equation is:

$$UREP = e^{5.3197 - 0.5007 \ln DCPP}$$

where UREP = urea recycled in percent and
DCPP = dietary crude protein.

Complete the calculations and plot the values below. At what % dietary crude protein is 100% recycling reached?



The biological value of the protein increased as the crude protein decreased. The equation in Robbins et al. (1974) is:

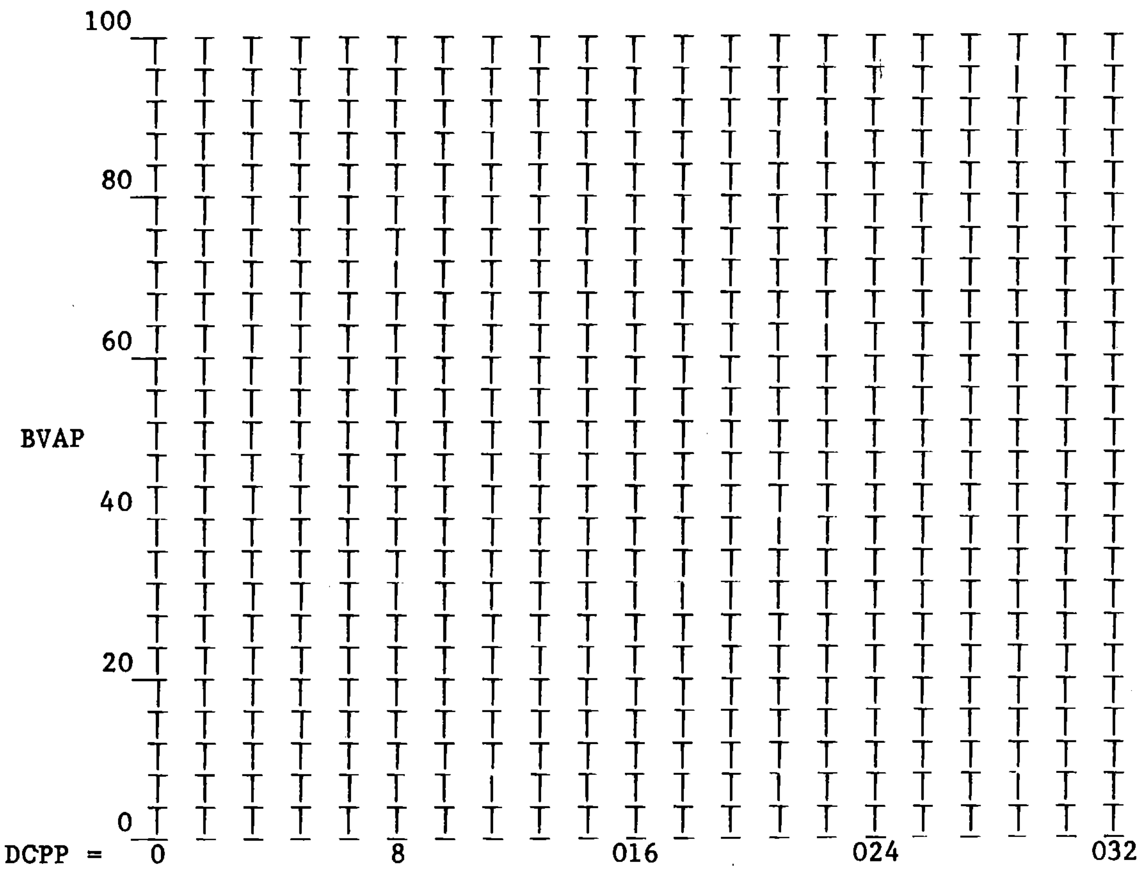
$$\text{Log}_e\ Y = 4.9825 - 0.3096\ \text{Log}_e\ X$$

where X = DCPP as defined before and
Y = biological value (%) = BVAP

Rewriting the equation:

$$BVAP = e^{4.9825 - 0.3096\ \ln DCPP}$$

The relationship may be plotted below.



The decreasing biological value of the protein with increasing dietary protein may result from less efficient use of dietary protein due to more excretion and to less efficient urea recycling and use (Robbins et al. 1974).

LITERATURE CITED

Robbins, C. T., R. L. Prior, A. N. Moen, and W. J. Visek. 1974. Nitrogen metabolism of white-tailed deer. J. Anim. Sci. 38(1):186-191.

UNIT 1.2: ENVIRONMENTAL FACTORS

It is difficult to separate biological factors from environmental factors when evaluating protein metabolism. Crude protein in the diet is an environmental factor that causes changes in the efficiency of use by the biological organism. The stimulus is from the environment, the response is biological and internal.

Another enviromental stimulus that affects protein metabolism, catabolism in this case, is extreme cold that places the animal in a critical thermal environment (Moen 1968). An animal in good condition mobilizes fat if a thermogenic metabolic response is necessary. If the fat reserve is depleted, protein tissue is the only internal substrate for thermogenic responses.

Weight losses accelerate when protein tissue must be oxidized as a source of energy. The main reason for this is that the energy content of a gram of fat is about 9.5 kcal, and of a gram of protein, 5.7 kcal. Further, a gram of protein is not metabolized completely by animals; only 4.7 kcal of heat energy are released as part of the heat energy remains in waste products (ammonia and urea) that are excreted and lost to the animal (Florey 1966:270). Thus heat production per unit of protein tissue weight is only about half as much as heat production per unit of fat tissue. Accelerated weight losses and quick death must occur when depressed nutrition and cold stress are combined. The WORKSHEET that follows provides some insight into the relative effects of energy metabolism on fat and protein substrate.

LITERATURE CITED

Florey, E. 1966. An introduction to general and comparative physiology. W. B. Saunders Company, Philadelphia. 713 pp.

Moen, A. N. 1968. The critical thermal environment: A new look at an old concept. BioScience 18(11):1041-1043.

REFERENCES, UNIT 1.2

ENVIRONMENTAL FACTORS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS------------------	AUTHORS----------	YEAR
JANSA	38--1	186	191	odvi	nitrog metab of white-tail	robbins,ct; prio/	1974
JWMAA	43--2	454	460	odvi	season, nutri, serum nitro	bahnak,br holla/	1979

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

odhe

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

ceel

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

alal

CODEN	VO-NU	BEPA	ENPA	ANIM KEY WORDS-----------------	AUTHORS----------	YEAR
AZOFA	11--3	200	203	rata seas chang renal urea conc	eriksson, l;valto	1974
BJNUA	33--1	63	72	rata serum prot, urea, seas, nut	hyvarinen,h;hel/	1975

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

anam

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

bibi

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

obmo

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

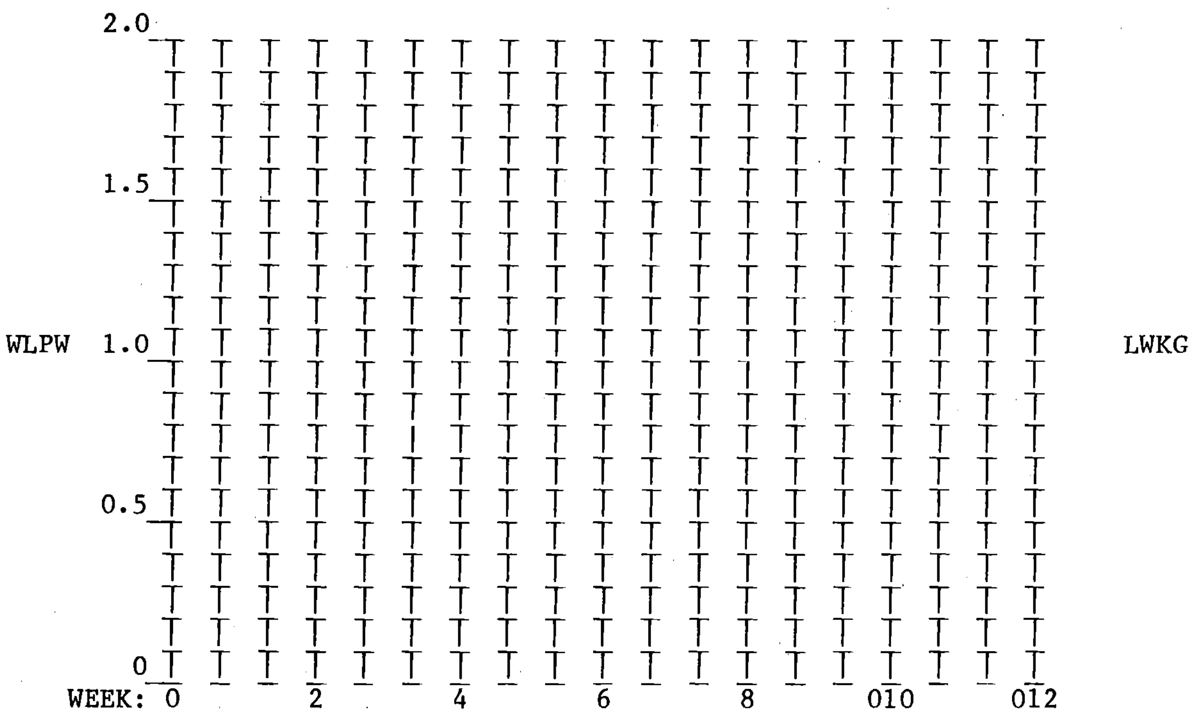
oram

CHAPTER 8, WORKSHEET 1.2a

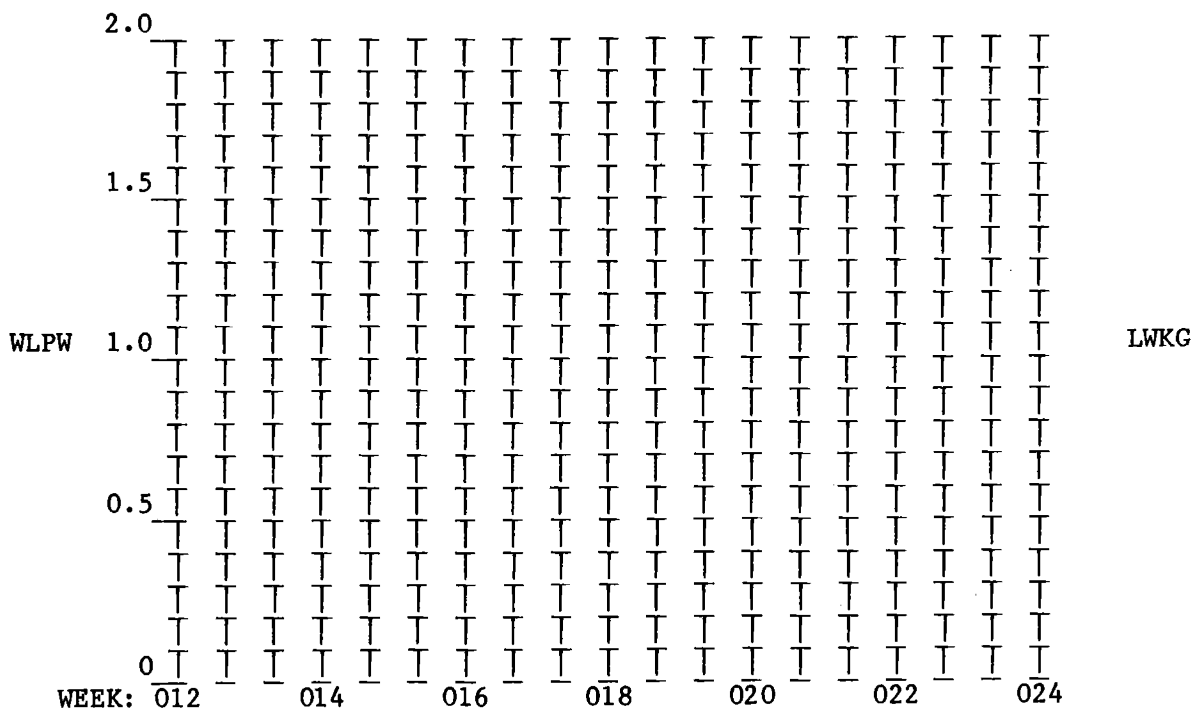
The effects of energy metabolism from fat and protein substrates on weight losses

About 9.5 kcal of heat energy are released when a gram of fat is metabolized. About 5.7 kcal are released when a gram of protein is oxidized in a bomb calorimeter, and 4.8 kcal when a gram of protein is metabolized. Demonstrate the effect of a change in substrate from fat to protein when one-half of the animals metabolic requirements are met by metabolized fat and protein tissue.

Begin with an animal weighing 100 kg with a 10 kg fat reserve and metabolism of MBLM = 1.5 so that ELMD = $(1.5)(70)(100^{0.75})$. The resulting ELMD is 3320 kcal. If one-half is met by daily intake and the other half by fat reserves, the first day weight loss is 0.17 kg. Making the calculations for one week at a time, weight loss after one week is 1.22 kg. The new weight is 100 -1.22 = 98.78. ELMD is then, $(1.5)(70)(98.78^{0.75}) = 2193$, and one-half of that is 1097 kcal of energy to be met by fat. At 9500 kcal per kg, the weight loss is 0.12 kg per day or 0.81 per week. The next week's weight is 97.94 and the calculations are cycled through again. Continue until the fat is gone, plotting the weight loss per week and the live weight in kg (LWKG) at weekly intervals below.



Continue the calculations after the fat is gone and protein must be the substrate metaboized. Continue plotting the results on the grid on the next page.


2.0
1.5
WLPW 1.0
0.5
0
WEEK: 012
014
016
018
020
022
024
LWKG

UNIT 1.3: INTERSPECIES COMPARISONS

General reviews of the literature indicate that protein metabolism processers are similar in both wild and domestic ruminants. Confined domestic animals are often given specific treatments to enhance growth, but such treatments do not alter basic metabolic processes. Urea and other non-protein nitrogen sources, for example, may be used as feed additives, even though domestic animals recycle urea naturally. Wild ruminants often do not not have access to foods high in protein or nitrogen, especially in the winter; urea recycling becomes a very important protein conservation adaptation then.

Endogenous urinary nitrogen has been measured in both domestic and wild ruminants. An equation for estimating endogenous urinary nitrogen in grams per day (EUNG) excreted, based on data in Crampton and Harris (1969:174) is:

$$EUNG = 0.002 \times 70 \ (MEWK)$$

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

The constant 0.002 represents the average ratio of nitrogen in gms to kcal basal metabolism.

EUNG calculated with this equation is larger than that determined for white-tailed deer by Robbins et al. (1974). The equation for deer is given in UNIT 2.1.

The use of first approximations of metabolic costs for wild ruminants based on data for domestic ruminants is preferable to saying "I don't know" when faced with the need to determine total daily costs of living. This is necessary when estimating protein costs, and also when estimating mineral, water, and vitamin requirements in CHAPTER 9.

LITERATURE CITED

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

Robbins, C. T., R. L. Prior, A. N. Moen, and W. J. Visek. 1974. Nitrogen metabolism of white-tailed deer. J. Anim. Science 38(1):186-191.

REFERENCES, UNIT 1.3

INTERSPECIES COMPARISONS

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JASIA	60--3	393	398	doca	exper, nutri, dairy heifer	broster,wh; tuck/	1963
JONUA	101--	1331	1342	doca	non-prot nitr, urea kineti	mugerwa,js; conra	1971

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AJBSA	20--5	967	973	dosh	transf nit, blood to rumen	weston,rh; hogan,	1967
BJNUA	21--2	353	371	dosh	metabolism of urea in shee	cocimano,mr; leng	1967
BJNUA	27--1	177	194	dosh	ammonia and urea metabolis	nolan,jv; leng,ra	1972
JANSA	35--6	1271	1274	dosh	eff wat rstric nutrnt dig	asplund,jm; pfand	1972
JONUA	86--3	281	288	dosh	blood urea, protein intake	preston, rl;schn/	1965
PAANA	6----	378	383	dosh	urea metabolism in sheep	cocimano,mr; leng	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
AJPHA	197-1	115	120	rumi	utiliz of blood urea, rumi	houpt,tr	1959
JDSCA	51--2	265	275	rumi	nitrogen metabolism of rum	waldo,dr	1968