TOPIC 3. ESTIMATES OF PROTEIN COSTS FOR MAINTENANCE AND PRODUCTION

Estimates of protein costs for production are made whenever new tissue is produced which contains protein. New body tissue resulting from growth, fetal tissue, hair, and milk are all protein-containing tissue, and the protein in these tissues must come from either the diet or from the catabolism of body protein. Since body protein stores are not extensive, the diet is the main source of protein for production.

A general rule to follow when estimating the protein costs for production is that the cost is at least equal to the amount of protein in the new tissue. Then, there is an additional cost associated with the assimilation of that tissue, an "overhead" that results from the less than 100% efficiency of metabolic processes.

The UNITS in this TOPIC include descriptions of the protein-requiring productive processes characteristic of wild ruminants. The equations given may be used for first approximations when evaluating the total protein requirements of individuals at different times during their annual cycles.

UNIT 3.1 ENDOGENOUS URINARY NITROGEN

Some of the nitrogen excreted in the urine is derived from the catabolism of body tissues, and has traditionally been called endogenous urinary nitrogen. Such nitrogen is of metabolic origin; it has been assimilated into body tissue from dietary nitrogen, and then released again when the body tissue is catabolized. This quantity of endogenous urinary nitrogen has been considered a minimum daily requirement. A formula for estimating endogenous urinary nitrogen (EUNG) based on data in NRC (1976) and Moen (1973:335) is:

$$EUNG = (a)(MEWK)$$

where EUNG = endogenous urinary nitrogen in gms and
MEWK = metabolic weight in kg.

The protein required to replace the endogenous urinary nitrogen excreted, PRUN, in gms per day, is:

$$PRUN = (a)(MEWK)(6.25)$$

The value of (a) in the formulas above is slightly different in different sources. In Crampton and Harris (1969:174) it is 0.140. In the NRC (1976:6) publication, it is 0.120. In Robbins et al. (1974:189) it is 0.115. The equations for calculating endogenous urinary nitrogen are, then:

$$\text{General: } EUNG = 0.140\ LWKG^{0.75}$$
$$\text{Beef cattle: } EUNG = 0.120\ LWKG^{0.75}$$
$$\text{White-tailed deer: } EUNG = 0.115\ LWKG^{0.75}$$

The differences in these three equations are in the value of a; the general equation results in a larger estimate than the beef cattle and white-tailed deer equations. Comparisons of absolute values are made in a WORKSHEET.

LITERATURE CITED

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

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

National Research Council. 1976. Nutrient requirements of beef cattle. Number 4. National Academy of Sciences, Washington D. C. 56 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 3.1

ENDOGENOUS URINARY NITROGEN

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	38--1	186	191	odvi	nitrogen metabolism of w-t	robbins,ct; prio/	1974

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

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obmo

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

oram

CHAPTER 8, WORKSHEET 3.1a

Estimates of endogenous urinary nitrogen

Endogenous urinary nitrogen of white-tailed deer is dependent upon the weight of the deer and can be calculated from the ingesta-free weight with an equation from Robbins et al. (1974):

$$EUNG = 0.115 \ (LWKG^{0.75})$$

where EUNG = endogenous urinary nitrogen in grams and
LWKG = live weight in kg.

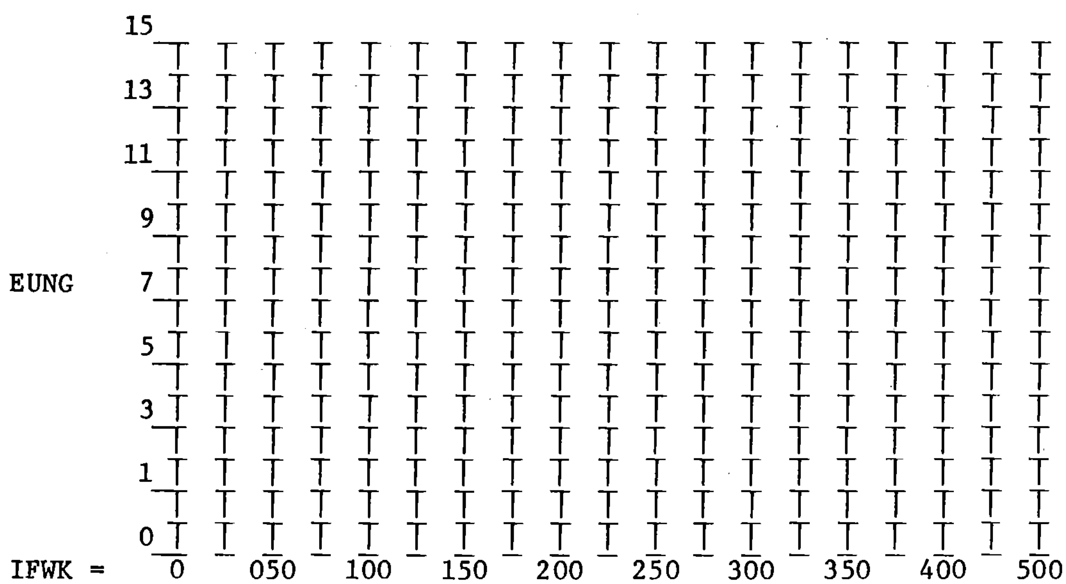
The NRC (1976:6) equation for beef cattle is:

$$EUNG = 0.120 \ (LWKG^{0.75})$$

The general equation based on Crampton and Harris (1969:174) is:

$$EUNG = 0.140 \ (LWKG^{0.75})$$

Plot the results using these equations below. Note that LWKG of deer is seldom over 100 kg. Beef cattle reach 500 kg or more at maturity.



LITERATURE CITED

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

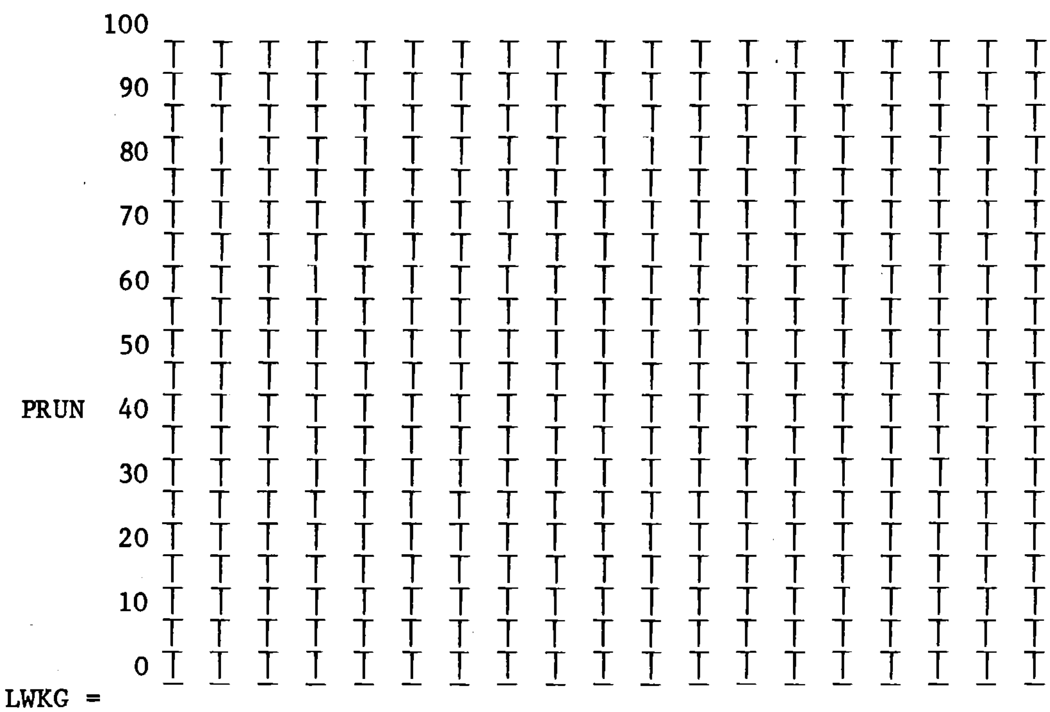
National Research Council. 1976. Nutritent requirements of beef cattle. Number 4. National Academy of Sciences, Washington, D. C. 56 pp.

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.

CHAPTER 8, WORKSHEET 3.1b

Protein required to meet EUNG losses

The protein equivalent of endogenous urinary nitrogen losses is determined by multiplying EUNG by 6.25, according to the formula on page 23. Select the weight range used, determine the amounts of protein required for endogenous urinary nitrogen losses using the 3 equations in the previous WORKSHEET, label the x axis (LWKG) and y axis (PRUN), and plot the protein required for endogenous urinary nitrogen in the grid below.



UNIT 3.2: METABOLIC FECAL NITROGEN

The nitrogen in the feces of dietary origin that has been assimilated into body tissue and then broken down again to appear in the feces is called metabolic fecal nitrogen. This category includes nitrogen from cells that have been absorbed from the linings of the gastrointestinal tract nitrogen from the protein compounds and nitrogen residues originating in secreted enzymes, and residual protein and nitrogen in intestinal microflora that ends up in the feces.

Metabolic fecal nitrogen in grams per day (MFNG) is related to food intake by the following formula modified from Moen (1973:366).

$$MFNG = k\ DWFK$$

where k = 5 and DWFK = dry weight forage in kg. DWFK necessary for maintenance is related to body weight, and has been calculated in previous UNITS in relation to energy metabolism. The calculated DWFK may be used as a starting point for calculating the protein requirements to meet quantities of metabolic fecal nitrogen excreted. If the calculated amount of food necessary to meet the energy requirements is low in protein, protein requirements may not be met by the predicted DWFK. This depends in part on the net protein coefficients of the forage ingested.

Metabolic fecal nitrogen for beef cattle given in the NRC publication (1976:6) is simply 4 g N/kg feed dry matter. Expressing this as an equation:

$$MFNG = (4)(DMIK)$$

where MFNG = metabolic fecal nitrogen in grams per day,
DMIK = dry matter intake in kg per day.

The value of "k" is variable in a formula in Moen (1973:336), based on the relative amounts of milk and forage in the diet. The values are:

on forage diets: k = 5

on milk diets: k = 2.5, and

forage and milk diets: k = 5 - (PNDM)(2.5)

where PNDM = percent nutrients derived from milk
= 1.136 - 0.045 LWKG (See CHAPTER 7, WORKSHEET 3.4a, Page 48a).

Note that the equations above relate metabolic fecal nitrogen to dry matter intake. As more forage is ingested, more nitrogen is released internally from the sources mentioned above to process the forage. MFNG is less when milk is ingested (c = 2.5) because fluid milk is more easily digested.

Actual calculations of MFNG are dependent on DMIK. Yet DMIK is dependent on energy and protein requirements, including MFNG. This feed-back mechanism suggests a need for an iteration procedure in final determinations of MFNG. Such a procedure is illustrated in a WORKSHEET.

LITERATURE CITED

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

National Research Council. 1976. Number 4. Nutrient requirements of beef cattle. 5th Rev. Ed. National Academy of Sciences, Washington, D. C. 56 p.

REFERENCES, UNIT 3.2

METABOLIC FECAL NITROGEN

SERIALS

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

JANSA 38--1 186  191  odvi nitrogen metabolism of whi robbins,ct; prior/1974
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CODEN VO-NU BEPA ENPA ANIM KEY WORDS----------------- AUTHORS---------- YEAR

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

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

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

oram

CHAPTER 8, WORKSHEET 3.2a

Estimates of metabolic fecal nitrogen

Estimate the metabolic fecal nitrogen in grams with the following equation:

$$MFNG = (5)(DMIK)$$

Suppose 9 gms of nitrogen were required for all body processes <u>except</u> MFNG. Suppse that the crude protein content of the forage was 12%. Then, one kg of forage would contain 120 gms of protein. This is equal to 19.2 gms of nitrogen (120/6.25 or 120 x 0.16 = 19.2). Suppose the net protein coefficient of this forage is 0.70. The amount of forage needed to supply 9 gms of nitrogen is (9.0)(1/0.70)/19.2 = 0.67 kg = DMIK. MFNG = (5)(0.67) = 3.35. Thus the total nitrogen required, including MFNG , is now 9.0 + 3.35 = 12.35. Substituting 12.35 for 9.0, DMIK is now calculated by (12.35)(1/0.70)/19.2 = 0.92. MFNG = (5)(0.92) = 4.60, which is added to 9.0, and the total nitrogen requirement, including MFNG , is now 9.0 + 4.60 = 13.60. Substituting 13.60 for 9.0, DMIK is now calculated by (13.60)(1/0.70)/19.2 = 1.01. MFNG = (5)(1.01) = 5.05, and 9.0 + 5.05 = 14.05. Substituting 14.05 for 9.0, DMIK = (14.05)(1/0.70)/19.2 = 1.05.

Note how DMIK began at 0.67, and successive calculations of the MFNG resulted in successive approximations of DMIK = 0.92, 1.01, and 1.05. Note that DMIK is getting larger due to the addition of MFNG requirements, but that increments are getting smaller with each cycle. The last calculation resulted in an increment of less than 4%;the next calculation [(5)(1.05)...] results in an increment of less than 1%.

The protein required to meet this metabolic fecal nitrogen requirement may be calculated with the following equation, assuming that the protein contains 16% nitrogen:

$$PMFN = 6.25(MFNG)$$

where PMFN =protein required for metabolic fecal nitrogen.

Review this sequence so you understand it thoroughly. The iterations being completed result in the estimation of total nitrogen requirements, including the effects of metabolic fecal nitrogen on dry-matter intake, and the feed-back effects of dry matter intake on metablic fecal nitrogen.

Repeat these calculations with a forage that is low in crude protein say less than 5%. Depending on the value of NPRC, there is a level of crude protein at which ingestion rates must increase in order to keep up with the MFNG costs. Above that level, ingestion is counter-productive; metabolic processing costs more than is returned from the forage.

Urea recycling and changes in the biological value of the protein (hence NPRC) makes the biological process more complex than this mathematical process. The iterations described do help one understand a bit more about the balance between nutrient requirements and nutrient densities in the forage.

UNIT 3.3: PROTEIN REQUIRED FOR BODY GROWTH

The daily protein required for gain is a function of the amount of total gain per day and the composition, or fraction of the gain that is protein. Equations for body composition were given in CHAPTER 2, and the protein fraction equation is used here to calculate this requirement. The daily change in weight multiplied by the protein fraction of animals at this weight is the daily protein deposited, which is the minimum protein required for body growth. The efficiency of protein deposition affects the actual amount of protein required.

The protein composition of steers weighing 100 kg is 18 percent, and of those weighing 500 kg, 9%. Corresponding values for heifers are 18% and 7%, respectively. Note that the percent composition is higher for smaller and younger cattle that are still growing, and lower for the larger and older cattle that are more physically mature. The protein composition of white-tailed deer was much more constant for a wide range of ages and weights measured by Robbins et al. (1974). In fact, the protein content of males and females combined was 20% of the body weight at 6 and 60 kg body weight. Wild ruminants are expected to have a more constant protein fraction since they are neither bred nor raised for rapid gains which under confined conditions may result in a higher fat and lower protein content in the body.

LITERATURE CITED

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

REFERENCES, UNIT 3.3

PROTEIN REQUIREMENTS FOR BODY GROWTH

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	38--4	871	876	odvi	body composition of white-	robbins,ct; moen/	1974
JWMAA	31--4	679	681	odvi	protein requirements, fawn	ullrey,de; youat/	1967
JWMAA	39--3	582	589	odvi	protein requirements, fawn	smith,sh; holter/	1975
JWMAA	43--4	872	879	odvi	protein require, yearlings	holter,jg; hayes/	1979
NAWTA	31---	129	139	odvi	effects of dietary protein	murphy,da; coates	1966
PAABA	600--	1	50	odvi	nutr req growth, antlr dev	french,ce; mcewe/	1955
PAARA	209-1	1	11	odvi	eff feed restric, antl dev	long,ta; cowan,r/	1959

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

odhe

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

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obmo

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

oram

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

JONUA 86--3 281 289 rumi blood urea, protein intake preston,rl; schn/ 1965

Estimates of the protein requirements of white-tailed deer for body growth

The protein fraction of body growth is obviously the minimum protein required for body growth, with increases related to the efficiency of protein deposition during growth. The protein fractions of white-tailed deer of different weights from June through October were determined by Robbins et al. (1974). The equation for calculating the protein component of the body weight in kg (males and females combined), rearranged from the published paper, is:

$$PCBK = e^{1.0091 \ln IFWK - 1.6267}$$

where PCBK = protein component of the body in kg, and
IFWK = ingesta-free weight in kg.

The equation for the protein component of males and females combined, expressed as a fraction of ingesta-free weight, is:

$$PRFR = e^{1.0091 \ln IFWK - 1.6267}/IFWK$$

If IFWK = 6.0 and PCBK = 1.2, then PRFR = 1.2/6.0 = 0.20.
If IFWK = 34.0 and PCBK = 6.9, then PRFR = 6.9/34.0 = 0.20.
If IFWK = 68.0 and PCBK = 13.9, then PRFR = 13.9/68.0 = 0.20.

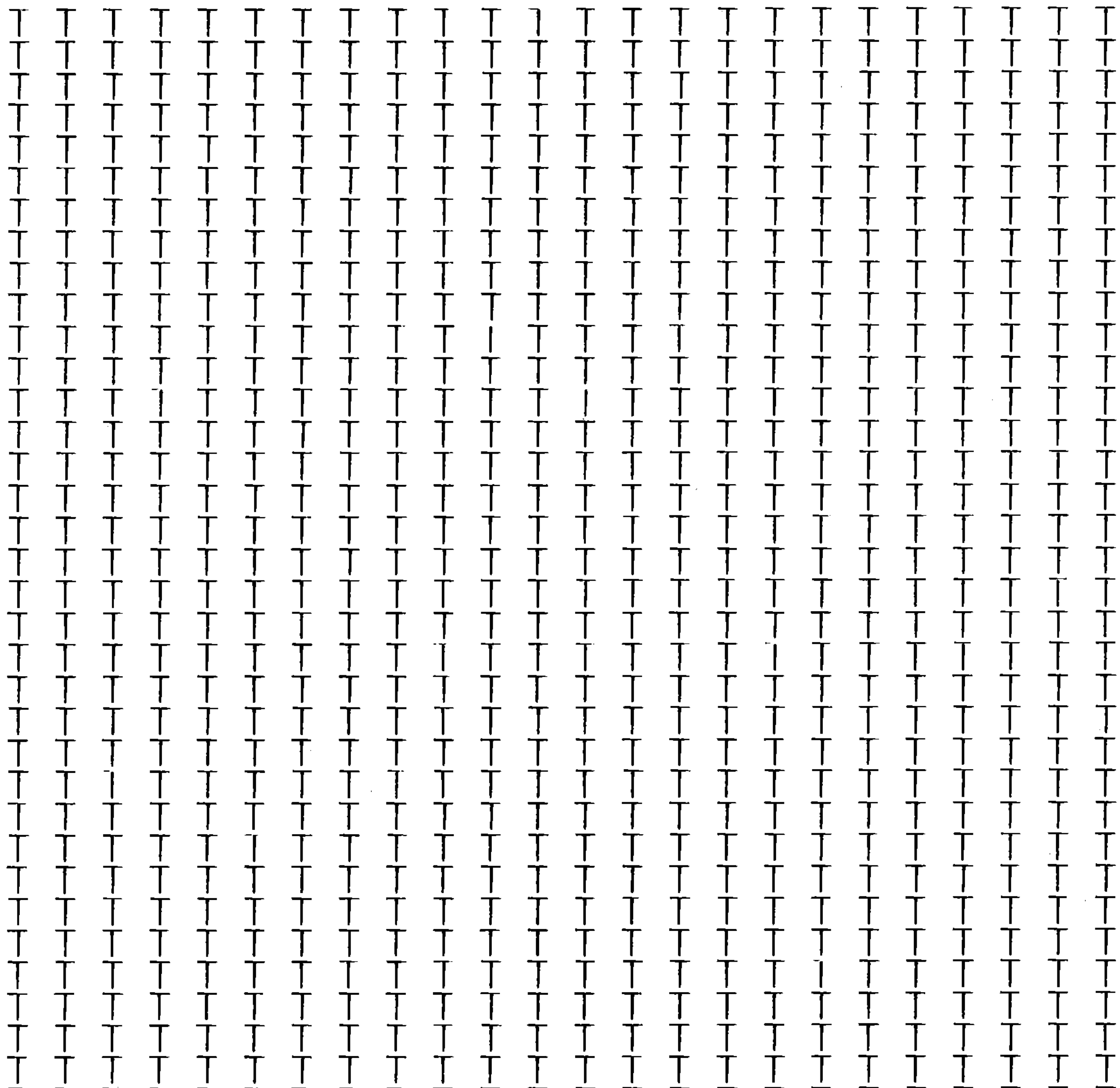
Thus the protein fraction is a constant 0.20 (or 20%) of the ingesta-free weight for a wide range of weights. The equation for the protein required for body growth is, then:

$$PRBG = (0.20)(DAGA)(1/PEFG)$$

where PRBG = protein required for body growth,
DAGA = daily gain, and
PEFG = protein efficiency of body growth.

The nitrogen component in kg (NTCK) is simply PRCK/6.25. Since the protein fraction is 0.20, the nitrogen fraction is 0.032, or 3.2% of the body. This is higher than the 2.5% estimate given in Moen (1973:336), based on data on domestic animals.

Protein and nitrogen components may be plotted on the grid on the next page for the range of ingesta-free weights selected. The axes are unlabeled since the 20% figure for white-tailed deer may be used as a first approximation for other wild ruminants of different weights. In other words, body composition of any wild ruminant may be estimated to include 20% protein, and this may be a better value than those based on domestic ruminants when none are available for particular wild species.



PRCK
or
NTCK

IFWK=

Literature Cited

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

UNIT 3.4: PROTEIN REQUIRED FOR HAIR GROWTH

Wild ruminants have two coats per year as a heavy winter coat is replaced by a light summer coat. Some species show color changes that are associated with the coat changes too. Physical and chemical characteristics of the hair coats and molting were discussed in CHAPTER 2, and the data given there on protein content of hair of different species should be used to estimate the cost of hair growth.

The overall nitrogen loss through hair and surface cells is calculated for cattle as: grams N = 0.02 $W^{0.75}$ (NRC 1976:6). This expresses the grams of nitrogen required for hair and surface cells each day as a directy proportion of metabolic body weight. Rewritten with four-letter symbols:

$$NRHG = 0.02\ IFWK^{0.75}$$

where NRHG = nitrogen required for hair growth and
IFWK = ingesta-free weight in kg.

The protein required for hair growth (PRHG) is 6.25 times NRHG; therefore:

$$PRHG = 0.125\ IFWK^{0.75}$$

Both NRHG and PRHG are in grams.

These equations result in average costs over the entire year. Estimates of the cost of hair growth per day for wild ruminants must consider changes in the growth rate of hair from season to season. The winter coats of North American wild ruminants begin growing in August or September, and growth is completed by November or December. The summer coat begins growing in April and May, and growth is completed by June. After growth is completed, the protein is irreversibly present in the hair, and represents a cost that is met twice each year.

The protein required for hair growth may be calculated with rates of hair growth and composition of the hair, just as the cost of body growth was calculated. Daily changes in the amounts of hair times the protein fraction of the hair are necessary inputs when calculating the daily protein cost of hair growth, just as in calculations of the costs of body growth. These options are presented in WORKSHEETS.

LITERATURE CITED

National Research Council. 1976. Number 4. Nutrient requirements of beef cattle. 5th Rev. Ed. National Academy of Sciences, Washington, D. C. 56 pp.

REFERENCES, UNIT 3.4

PROTEIN REQUIRED FOR HAIR GROWTH

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JANSA	38--4	871	876	odvi	body composition of white-	robbins,ct; moen/	1974

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
				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-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
JANSA	45--4	826	831	doca	hair indic calor-prot stat	haaland,gl; mats/	1977

Chapter 8, Worksheet 3.4a

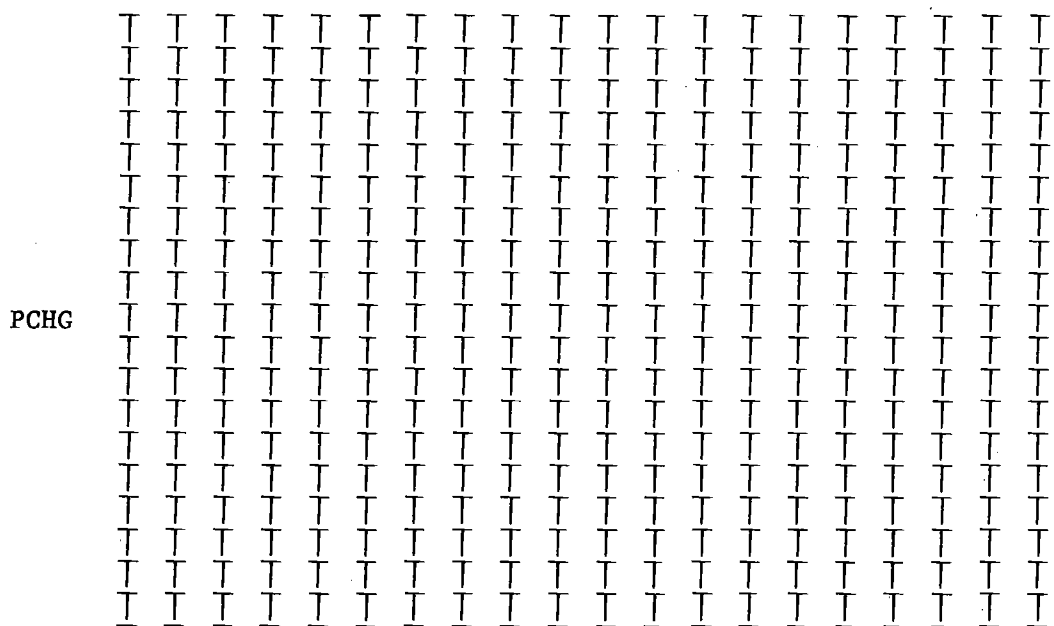
Estimates of the protein requirements for hair growth

The protein fraction of the hair is obviously the minimum protein required for hair growth, with increases related to the efficiency of protein deposition during hair growth. The protein fraction of hair of white-tailed deer was given by Robbins et al. (1974) and discussed in CHAPTER 2, UNIT 1.3, Pages 11-14. Knowing daily changes in hair weights, the protein composition of hair, and the physiological efficiency of hair growth, the protein cost of hair growth may be calculated with the formula:

$$\text{PCHG} = (\text{DLTA HAWG})(\text{PRFH})(1/\text{PEHG})$$

where PCHG = protein cost of hair growth in gms per day,
DLTA = delta, or daily change,
HAWG = hair weight in gms,
PRFH = protein fraction of the hair, and
PEHG = physiological efficiency of hair growth.

Refer back to CHAPTER 2 for data on hair growth, and then calculate PCHG. Compare the results over the annual cycle with the protein costs estimated with the formula for cattle (see page 31). An unlabeled grid is provided for plotting the results for the species of your choice.



LITERATURE CITED

Robbins, C. T., A. N. Moen, and J. T. Reid. 1974. Body composition of white-tailed deer. J. Anim. Sci. 38(4):871-876.

UNIT 3.5: PROTEIN REQUIRED FOR GESTATION

The minimum protein required for gestation is equal to the amounts deposited in fetal and associated reproductive tissues, with increases in proportion to the rate of physiological efficiency of protein deposition for this purpose. Protein requirements increase rapidly in the last two-thirds of the gestation period.

The total nitrogen content of the gravid uterus of white-tailed deer has been determined by Robbins and Moen (1975). The published equation (page 688) is modified to:

$$NCUG = e^{0.2096 + 0.0275\ DIGE}$$

where NCUG = nitrogen content of the uterus in gms, and
DIGE = days into gestation.

Nitrogen retention may be calculated by subtracting NCUG for successive days. An equation has already been determined for this by Robbins and Moen (1975) for white-tailed deer, and another equation given that may be adapted to any species. The equation for estimating nitrogen retention for gestation per day (NRGD) in white-tailed deer, modified from Robbins and Moen (1975:688), is:

$$NRGD = e^{0.0275\ DIGE - 3.3856}$$

where NRGD = nitrogen required for gestation (gms per day), and
DIGE = days into gestation.

The equation for any species, modified from Robbins and Moen (1975:688), is:

$$NRGD = [e^{0.0512\ (DIGE/LEGP)100\ -\ 1.7274}]\ [BIWK]$$

where NRGD = nitrogen required for gestation (gms per day),
DIGE = days into gestation,
LEGP = length of the gestation period, and
BIWK = birth weight in kg.

The above equation is particularly useful since it expresses a proportional nitrogen cost in relation to length of the gestation period and fetal weight at birth. Cattle, sheep, and deer were quite similar, and there is no reason to believe that the wild ruminants would be very different in this basic biological process.

WORKSHEETS provide opportunities to calculate the protein costs of gestation, expressed both as protein and nitrogen.

LITERATURE CITED

Robbins, C. T. and A. N. Moen. 1975. Uterine composition and growth in pregnant white-tailed deer. J. Wildl. Manage. 39(4):684-691.

REFERENCES, UNIT 3.5

PROTEIN REQUIRED FOR GESTATION

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	39--4	684	691	odvi	uterin comp, growth, pregn	robbins,ct; moen,	1975
NAWTA	31---	129	139	odvi	effects of dietary protein	murphy,da; coates	1966

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

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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 3.5a

Estimates of the protein required for gestation

Estimates of the daily protein required for gestation may be made with the equations in Robbins and Moen (1975). Since the protein required is 6.25 x nitrogen, the equations below include this conversion factor. The equations are:

odvi $\quad PRGE = (e^{0.0275\ DIGE - 3.3856})\ (6.25)$

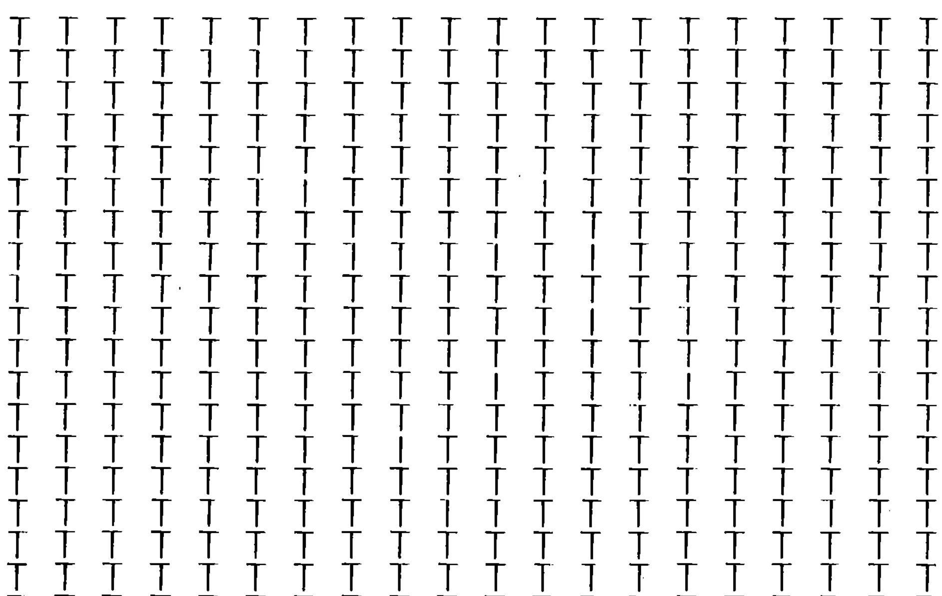
any species: $\quad PRGE = [e^{0.0512\ (DIGE/LEGP)100 - 1.7274}]\ [BIWK]\ (6.25)$

where PRGE = protein required in for gestation in grams per day,
DIGE = days into gestation,
LEGP = length of the gestation period, and
BIWK = birth weight in kg.

The two reproductive system variables needed (LEGP and BIWK) to calculate PRGD were given in CHAPTERS 1 and 2.

Calculate PRGD for intervals of DIGE and plot in the grid below. The results are minimum values; physiological efficiencies less than 1.0 will increase the actual cost per day of nitrogen retention.

PRGE



DIGE =

LITERATURE CITED

Robbins, C. T. and A. N. Moen. 1975. Uterine composition and growth in pregnant white-tailed deer. J. Wildl. Manage. 39(4):684-691.

UNIT 3.6: PROTEIN REQUIRED FOR MILK PRODUCTION

The protein required for milk production is a function of the amount of milk produced, the protein content of the milk, and the physiological efficiency of lactogenesis. Milk is relatively high in protein, a biological necessity for the rapid growth of the neonate.

Milk production was discussed in CHAPTER 7, UNIT 3.4, with calculations of milk production in gms per day given in WORKSHEET 3.4a (Chapter 7 - Page 48a). The chemical composition of milk was discussed in CHAPTER 2, UNIT 2.2. After data on these characteristics have been determined, the protein cost of lactation per day may be estimated as at least the amount of protein in the milk, with increases in the protein required due to the physiological efficiency of lactogenesis.

The WORKSHEET at the end of this UNIT provides opportunities to synthesize concepts, data, and equations from previous CHAPTERS while estimating protein required for lactation.

REFERENCES, UNIT 3.6

PROTEIN REQUIRED FOR MILK PRODUCTION

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	25--1	66	70	odvi	deer milk, substitute milk	silver,h	1961
JWMAA	29--1	79	84	odvi	comp milk,bld nursng doe,f	youatt,wg; verme/	1965
NAWTA	31---	129	139	odvi	effects of dietary protein	murphy,da; coates	1966

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	37--2	217	218	odhe	composit, deer milk, calif	hagen,hl	1951
JOMAA	36--3	473	474	odhe	mule deer milk	browman,lg; sears	1955
JOMAA	58--3	420	423	odhe	changes nutri compos, milk	mueller,cc; sadle	1977
JWMAA	20--2	212	214	odhe	postnat grow, comp of milk	kitts,wd; cowan,/	1956
JWMAA	44--2	472	478	odhe	milk yield, black-tailed d	sadleir,rmfs	1980

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
BIJOA	153-3	647	655	ceel	whey proteins, red de milk	mcdougall,ei; ste	1976
JRPFA	37--1	67	84	ceel	comp, yield of milk, red d	arman,p; kay,rnb/	1974
ZTTFA	31--5	227	238	ceel	comp, milk, red deer, pt 1	brueggemann,j; d/	1973

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	48--2	213	215	alal	gros comp milk, fat, minrl	cook,hw; rausch,/	1970
JWIDA	12--2	202	207	alal	milk, hair, element relati	franzmann,aw; fl/	1976

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	45--6	1101	1106	rata	milk, gros comp, fat, prot	hatcher,vb; mcew/	1967
JDSCA	57-11	1325	1333	rata	milk comp chang, grazing r	luick,jr; white,/	1974

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CAFGA	37--2	217	218	anam	odhe, compos milk, compars	hagen,hl	1951

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JOMAA	36--2	305	308	bibi	the lipids in bison bison	wilbur,cg; gorski	1955

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	43--5	885	888	ovca	milk, gross comp, fat cons	chen,ech; blood,/	1965

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	48--4	629	633	ovda	milk, stage lact, composit	cook,hw; perarso/	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	34--6	569	571	obmo	gross composition of milk	tener,js	1956
CJZOA	48--6	1345	1347	obmo	gros comp,ftty acid, minrl	baker,be; cook,h/	1970

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CJZOA	47--1	5	8	oram	gross compos, fat acid con	lauer,bh; blood,/	1969
CJZOA	47--2	185	187	oram	miner const, milk, arctic	luer,bh; baker,b	1969

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
CBCPA	42b-2	323	328	many	electrophesis milk caseins	lauer,bh; baker,b	1972
CJZOA	49--4	551	554	many	carbohydra content, casein	baker,be; lauer,b	1971
CJZOA	55--1	231	236	many	amin acid comp casein milk	lauer,bh; baker,b	1977
IZYBA	4----	333	342	many	composit milk wild animals	ben shaul,dm	1962

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JRPFA	37--1	67	84	cerv	composi milk, cerv species	arman,p; kay,rnb/	1974

CHAPTER 8, WORKSHEET 3.6a

Estimating the protein required for milk production

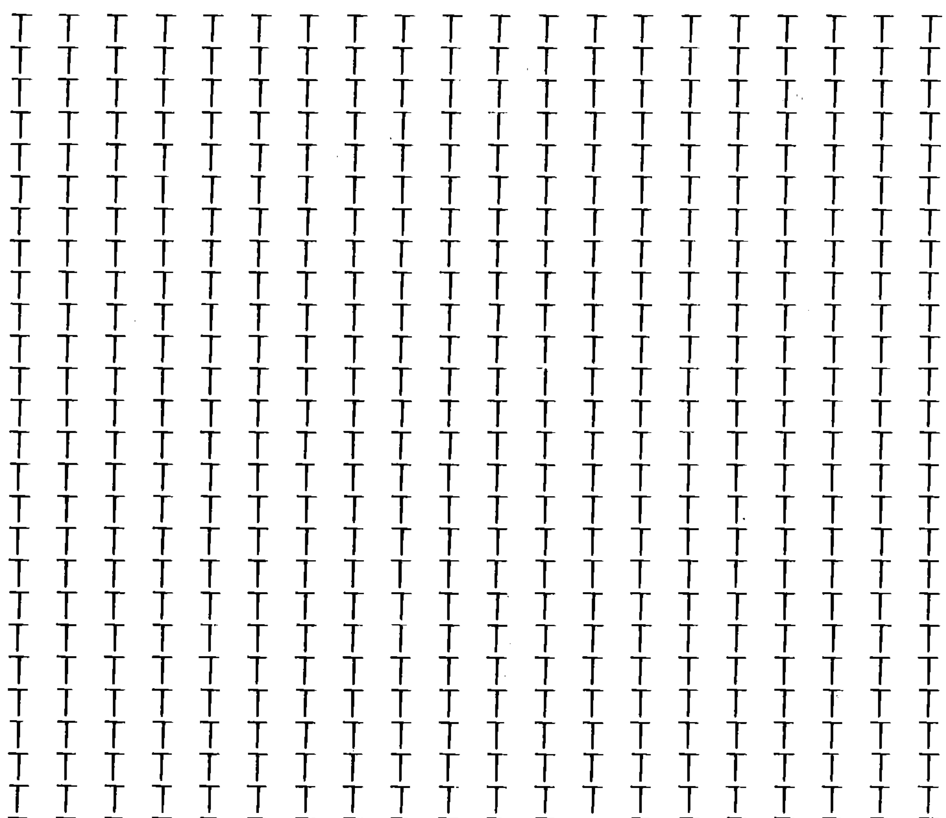
The protein required for milk production may be calculated by multiplying the amount of milk produced by the protein fraction of the milk by the reciprocal of the physiological efficiency of protein synthesis for milk production. In symbol form:

$$PRMP = (QMPK)(PRFM)(1/PEMP)(1000)$$

where PRMP = protein required for milk production in gms per day,
QMPK = quantity of milk produced in kg per day,
PRFM = protein fraction of milk,
PEMP = physiological efficiency of milk production, and
1000 = the conversion factor from kg to gms.

These parameters have all been discussed in previous chapters. For QMPK, refer to CHAPTER 7; for PRFM, refer to CHAPTER 2; and for PEMP, use 0.5 to 1.0. PRFM may change during the lactation period. Then, PRFM = f(DILA), where DILA is days into lactation, and an equation replaces a single value for PRFM.

Calculate PRMP and plot the results on the grid provided. The x-axis is PRFM or DILA, the y-axis PRMP, and PEMP effects a family of curves.



UNIT 3.7: SUMMATIONS OF PROTEIN REQUIRED

Equations for several different protein costs have been presented in this CHAPTER. If the concepts underlying each of these are understood and the costs calculated, then the total cost can be determined by summation. Addition of the separate costs is simple, with one main precaution.

The main precaution is that the maintenance costs must be either treated separately or as part of particular production costs, but not both. Some of the endogenous urinary nitrogen, for example, may come from metabolic transactions involved with gestation. If EUNG includes nitrogen from fetal metabolism, then the protein costs of fetal growth should include only the net costs. This is an important concept, and one that must be applied in each calculation from each published source. Procedures for expressing costs are not standardized, of course, so careful reading of each paper is necessary to determine just what is included in the results.

Summations may be made for protein costs throughout the year by developing the biochronology of each species and making the appropriate calculations through time. When these are plotted over the annual cycle, a pattern emerges that may be represented by a single equation as for energy metabolism (See Moen 1978 and CHAPTER 7). I must admit that at the time of this writing I have not made such comprehensive calculations for protein costs.

One WORKSHEET with reminders of the cost items to include in the summation of protein costs is included at the end of this unit.

REFERENCES, UNIT 3.7

SUMMATIONS OF PROTEIN REQUIRED

SERIALS

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
JWMAA	31--4	679	685	odvi	protein requirement, fawns	ullrey,de; youat/	1967
JWMAA	43--4	872	879	odvi	protein require, yearlings	holter,jb; hayes/	1979
PAABA	600--	1	50	odvi	nutr req growth, antl dev	french,ce; mcewa/	1955

CODEN	VO-NU	BEPA	ENPA	ANIM	KEY WORDS-----------------	AUTHORS----------	YEAR
NAWTA	22---	119	132	od--	nutrient requirements deer	mcewan,lc; frenc/	1957
NAWTA	22---	179	188	od--	feed req for growth, maint	cowan,i mct; woo/	1957

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

CJZOA 48--5 905 913 rata seas chan, energ, nitr int mcewan,ch; wood,a 1970

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 3.7a

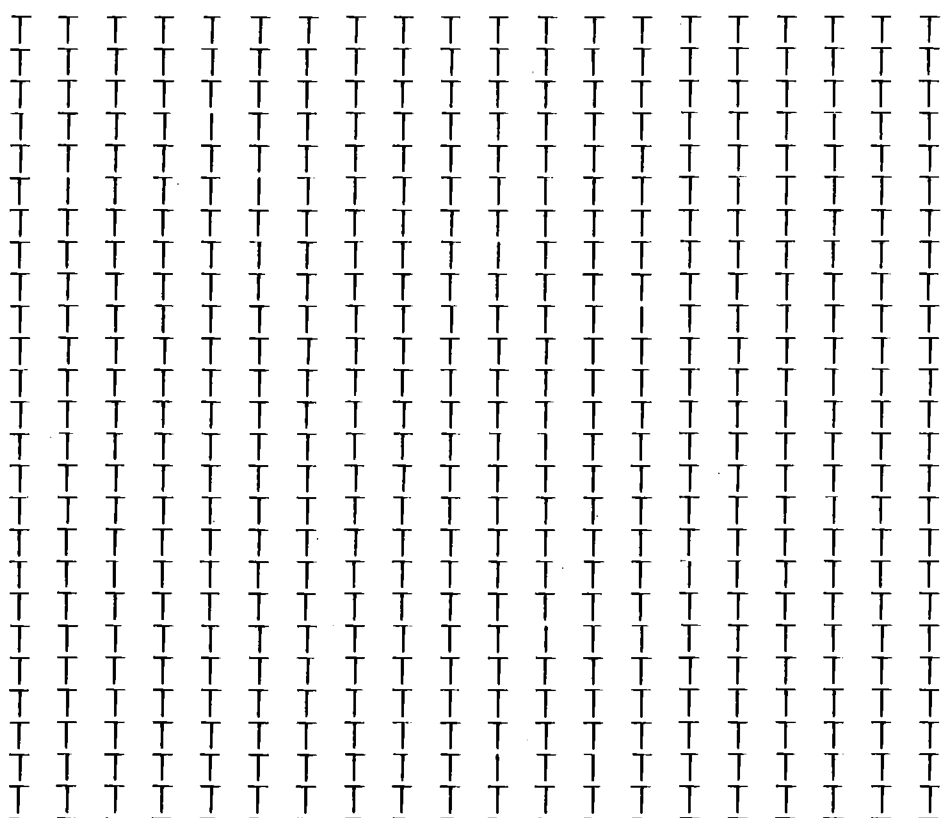
Estimates of total protein costs by summation

Total protein costs may be estimated by summing the costs for each of the maintenance and production processes. The costs to include are, in the order presented in this CHAPTER:

PRUN (WS 3.1b)
\+ PMFN (WS 3.2a)
\+ PRBG (WS 3.3a)
\+ PRHG (WS 3.4a)
\+ PRGE (WS 3.5a)
\+ PRMP (WS 3.6a)

TOTAL = ____ = PRGD

Calculations of the appropriate costs in relation to the biochronology at 7-day intervals will provide estimates of costs throughout the annual cycle. The patterns that emerge for different sex and age groups should be related to range characteristics and forage conposition discussed in PART IV. An unlabeled grid is provided for plotting results of the summations.



CLOSING COMMENTS

The basic format of CHAPTER 8 on protein metabolism is similar to that of CHAPTER 7 on energy metabolism. Estimates of protein costs have been described which provide first approximations at least. Some equations are based on well-designed experiments on wild ruminants. It is important to realize that biological costs to the animal go on whether we realize it or not. Therefore, first approximations are better than nothing, and students should not hesitate to include such estimates when necessary to maintain the integrity of the biological concepts. Concepts are fundamental; numbers and equations may be changed.

Aaron N. Moen
March 11, 1981

GLOSSARY OF SYMBOLS USED - CHAPTER EIGHT

BIWK = Birth weight in kilograms
BVAP = Biological value in percentage

DAGA = Daily gain
DCCP = Dietary crude protein
DIGE = Days into gestation
DILA = Days into lactation
DMIK = Dry matter intake in kilograms per day
DLTA = Delta
DWFK = Dry weight of forage in kilograms

ELMD = Ecological metabolism per day
EUNG = Endogenous urinary nitrogen in grams per day
EUNT = Endogenous urinary nitrogen

HAWG = Hair weight in grams
IFWK = Ingesta-free weight in kilograms

LEGP = Length of gestation period
LWKG = Live weight in kilograms

MBLM = Multiple of base-line metabolism
MEWK = Metabolic weight in kilograms
MFNG = Metabolic fecal nitrogen

NCUG = Nitrogen content of the uterus in grams
NRGD = Nitrogen required for gestation per day
NRHG = Nitrogen required for hair growth per day
NRPC = Net protein coefficient
NTCK = Nitrogen component in kilograms

PCBK = Protein component of the body in kilograms
PCHG = Protein cost of hair growth in grams per day
PEFG = Protein efficiency for body growth
PEHG = Physiological efficiency of hair growth
PEMP = Physiological efficiency of milk production
PNDM = Percent nutrients derived from milk
PRBG = Protein for body growth
PRCK = Protein component in kilograms
PRFH = Protein fraction of hair
PRFR = Protein fraction
PRFM = Protein fraction of milk
PRGD = Protein required in grams per day
PRGE = Protein required for gestation in grams per day
PRHG = Protein required for hair growth in grams per day
PRMP = Protein fraction for milk production in grams per day
PRUN = Protein required for endogenous urinary nitrogen

QMPK = Quantity of milk produced in kilograms per day
UREP = Urea recycled in percent

WLPW = Weight loss per week

GLOSSARY OF CODE NAMES - CHAPTER EIGHT

CODEN

AJBSA Australian Journal of Biological Sciences
AJPHA American Journal of Physiology
AZOFA Annales Zoologici Fennici

BIJOA Biochemical Journal
BJNUA British Journal of Nutrition

CAFGA California Fish and Game
CBCPA Comparative Biochemistry and Physiology
CJZOA Canadian Journal of Zoology

IZYBA International Zoo Year Book

JANSA Journal of Animal Science
JASIA Journal of Agricultural Science
JAVMA Journal of the American Veterinary Medical Association
JDSCA Journal of Dairy Science
JOMAA Journal of Mammalogy
JONUA Journal of Nutrition
JRPFA Journal of Reproduction and Fertility
JWIDA Journal of Wildlife Diseases
JWMAA Journal of Wildlife Management

MAAIA Journal of the Scientific Agricultural Society of Finland

NAWTA North American Wildlife and Natural Resources Conference, Transactions of the,
NUMEB Nutrition and Metabolism

PAABA Pennsylvania Agricultural Experiment Station Bulletin
PAANA Proceedings of the Australian Society of Animal Production
PAARA Pennsylvania State University College of Agriculture Agricultural Experiment Station Progress Report

ZTTFA Zeitschrift fuer Zellforschung und Mikroskopisch Anatomie

LIST OF PUBLISHERS - CHAPTER EIGHT

acpr	Academic Press	New York	nyny
base	Basel	New York	nyny
blsp	Blackwell Scientific Publications	Oxford, England	oxen
butt	Butterworth	London, England	loen
ccth	Charles C. Thomas	Springfield, IL	spil
cfmo	Carl Fr. Mortensen	Copenhagen Denmark	code
clpr	Clarendon Press	Oxford, England	oxen
dcch	D. C. Church, Oregon State	Corvallis, OR	coor
else	Elsevier	Springfield, VA	spva
hein	Heinemann	London, England	loen
meth	Methuen & Co., Ltd.	London, England	loen
nhpc	North-Holland Publishing	New York	nyny
rupr	Rutgers University Press	New Brunswick, NJ	nbnj

LIST OF WORKSHEETS - CHAPTER EIGHT

JULIAN DAY: MONTH AND DAY EQUIVALENTS

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Day
1	001	032	060	091	121	152	182	213	244	274	305	335	1
2	002	033	061	092	122	153	183	214	245	275	306	336	2
3	003	034	062	093	123	154	184	215	246	276	307	337	3
4	004	035	063	094	124	155	185	216	247	277	308	338	4
5	005	036	064	095	125	156	186	217	248	278	309	339	5
6	006	037	065	096	126	157	187	218	249	279	310	340	6
7	007	038	066	097	127	158	188	219	250	280	311	341	7
8	008	039	067	098	128	159	189	220	251	281	312	342	8
9	009	040	068	099	129	160	190	221	252	282	313	343	9
10	010	041	069	100	130	161	191	222	253	283	314	344	10
11	011	042	070	101	131	162	192	223	254	284	315	345	11
12	012	043	071	102	132	163	193	224	255	285	316	346	12
13	013	044	072	103	133	164	194	225	256	286	317	347	13
14	014	045	073	104	134	165	195	226	257	287	318	348	14
15	015	046	074	105	135	166	196	227	258	288	319	349	15
16	016	047	075	106	136	167	197	228	259	289	320	350	16
17	017	048	076	107	137	168	198	229	260	290	321	351	17
18	018	049	077	108	138	169	199	230	261	291	322	352	18
19	019	050	078	109	139	170	200	231	262	292	323	353	19
20	020	051	079	110	140	171	201	232	263	293	324	354	20
21	021	052	080	111	141	172	202	233	264	294	325	355	21
22	022	053	081	112	142	173	203	234	265	295	326	356	22
23	023	054	082	113	143	174	204	235	266	296	327	357	23
24	024	055	083	114	144	175	205	236	267	297	328	358	24
25	025	056	084	115	145	176	206	237	268	298	329	359	25
26	026	057	085	116	146	177	207	238	269	299	330	360	26
27	027	058	086	117	147	178	208	239	270	300	331	361	27
28	028	059	087	118	148	179	209	240	271	301	332	362	28
29	029	[060]	088	119	149	180	210	241	272	302	333	363	29
30	030		089	120	150	181	211	242	273	303	334	364	30
31	031		090		151		212	243		304		365	31

* For leap year, February 29 = JDAY 60. Add 1 to all subsequent JDAYs.