TECHNICAL NOTES

Nomographic Estimation of Forage Intake by White-tailed Deer

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Abstract

Forage intake may be estimated by dividing the nutrients required by the animal by the nutrients supplied by forage. These two variables may be used with nomogram to estimate intake necessary to meet specific requirements. For example, a white-tailed deer with an ecological metabolism of 1,600 kcal and a forage digestibility of 0.4 has an estimated intake of 1.0 kg. One with an ecological metabolism of 5,500 and a forage digestibility of 0.8 has an estimated intake of 1.8 kg. A nomogram is especially useful when making quick estimates for management purposes.

Forage ingested by an herbivore provides the nutrients needed for maintenance and production. The basic relationship may be expressed with the word formula:

$$\frac{\text{nutrients required by the herbivore}}{\text{nutrients supplied by the forage}} = \text{intake}$$

The intake of free-ranging animals is not subject to direct control by a farmer, rancher, or wildlife manager, but is related to seasonal variations in nutrients requirements and hormone balances of the animals, and to seasonal variations in nutrients supplied by the plants. The basic relationships between nutrients required and nutrients supplied may be applied to a particular nutrient by using units of energy, time, and mass. Protein and energy have been evaluated for white-tailed deer *(Odocoileus virginianus)* by Moen (1973); the relationships apply to minerals and other nutrients too. Indeed, least cost analyses, balanced feeding, and other recently developed feeding programs for domestic animals are based on nutrients required and supplied by different feeds, with cost factors considered in formulating rations.

A simple method for estimating forage intake at different levels of ecological energy metabolism and forage digestibilities is presented here. The word formula for predicting intake by an animal in a neutral energy balance is:

$$\frac{\text{ecological metabolism (kcal day}^{-1}\text{)}}{\text{metabolically useful energy in the forage (kcal kg}^{-1}\text{)}} = \text{forage intake in kg day}^{-1}$$

Absolute levels of ecological metabolism vary in relation to ages, weights, and reproductive rates of deer. Seasonal variations in both ecological metabolism and metabolic energy in the forage occur. Seasonal patterns of ecological metabolism are sinusoidal as deer go from winter minimums to summer and fall maximums (Moen 1978). Variations in diet digestibilities and metabolic energy available in forage are dependent on current growing conditions and weather factors, with a general pattern of winter minimums in available forage energy as deer ingest dormant forage and summer maximums as succulent new growth is ingested. Diet digestibilities can change rapidly as foraging conditions change, however. An early winter snowfall may cover more-digestible late summer growth and force deer to consume less-digestible woody browse. Snow may also render acorns available, and make movements to cornfields or other concentrated food sources more difficult. A deer consuming dormant browse in late winter may shift to new spring growth rather quickly if snow conditions permit travel from a winter concentration area to a south-facing slope with emerging spring growth.

Since forage intake can be predicted from two biological functions that have finite limits, a nomogram is useful for estimating forage intake as ecological metabolism and forage energy vary throughout the year. These estimates are likely to be as accurate as estimates of the number of deer in a population, and they are easy to make as seasonal variations in metabolism and diet digestibilities occur.

Methods

Estimates of ecological metabolism per day (ELMD), calculated with equations in Moen (1978), are used as the numerator in the word equation for predicting intake given earlier. The denominator in the formula for predicting intake—metabolically useful energy in forage—is determined by first measuring the gross energy in forage, then the digestibility of the forage, and finally the metabolizable energy available from the digested forage. In the calculations presented here, the gross energy (GROE) is given as 4,500 kcal kg^{-1}. Digestible energy coefficients (DECO) may fall within the 0.20 to 0.90 range, so the digestible energy in the diet (DIGE) varies and may be expressed as a fraction of GROE: [(DIGE) = (GROE)(DECO)]. Metabolizable energy, METE, is a fraction of DIGE; METE = (DIGE) MECO), where MECO is the metabolizable energy coefficient. MECO is much less variable than DECO; 0.82 was used for cattle and sheep (National Academy of Sciences 1971). Robbins (1973) analyzed published data and gives values ranging from 0.72 to 0.94 for deer on different diets; 0.86 is used here.

Combining gross, digestible, and metabolizable energy, metabolically useful energy is equal to (GROE)(DECO)(MECO), with GROE = 4500, MECO = 0.86, and DECO a variable. Calculations of intake may be expressed as:

$$\frac{\text{ELMD}}{\text{(GROE)(DECO)(MECO)}} = \text{intake in kg day}^{-1} = \frac{(0\text{–}6000)_{\Delta=100}}{4{,}500(0.3\text{–}0.8)_{\Delta=0.1}(0.86)}$$

Forage intake per day necessary to meet ecological metabolism may be estimated with a nomogram (Fig. 1), where ELMD is on the *x*-axis, DECO is represented by a family of curves, and estimated intake is read off the *y*-axis.

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Funds for this research have been provided by the New York State Department of Environmental Conservation through Pittman-Robertson Project W-124-R and the N.Y. State College of Agriculture and Life Sciences, Cornell University. Authors wish to thank Elyse Egan for verifying the calculations and Tim Romocki for drawing the figure.

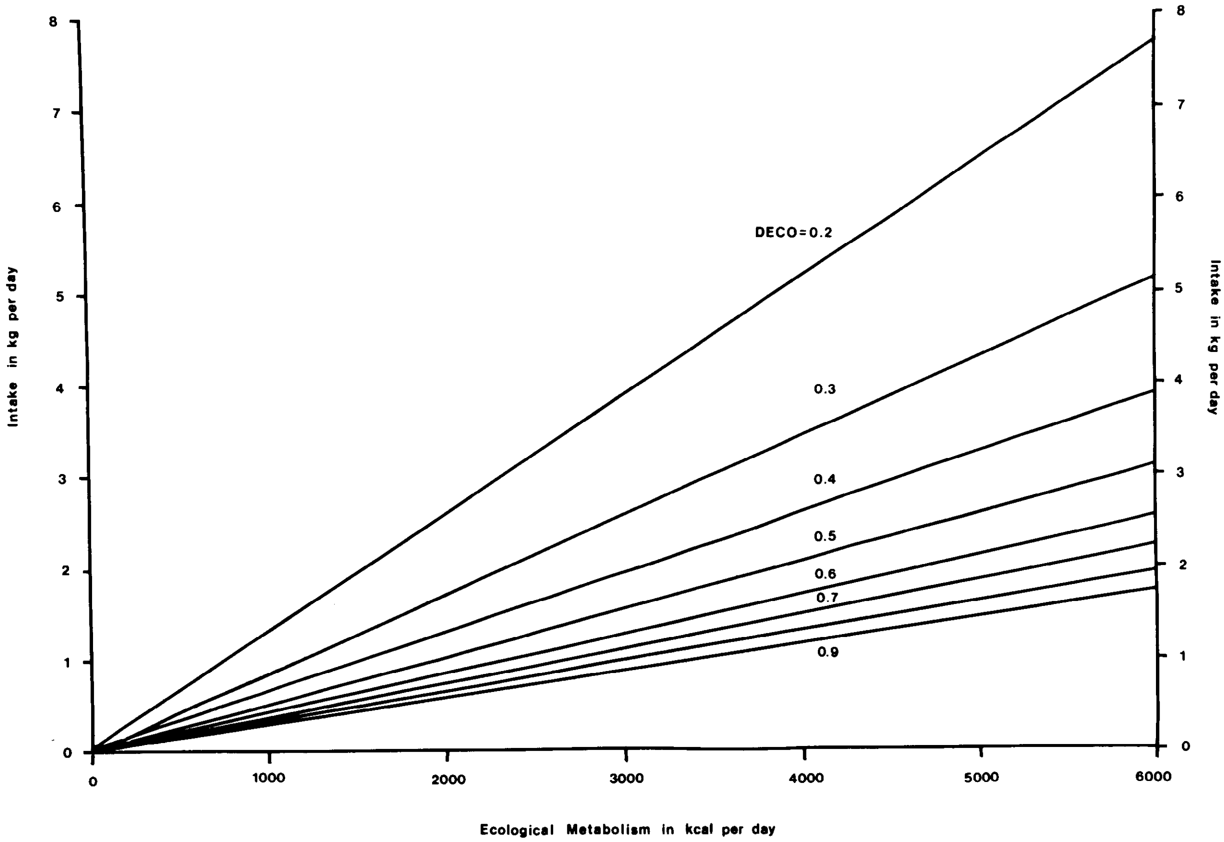

Fig. 1. *Nomogram for estimating intake per day (kg) from variations in ecological metabolism per day and digestible energy coefficients (DECO).*

Results

The use of nomograms is illustrated with several examples based on calculations in Moen (1978). A six-month-old, 40-kg female fawn has a predicted ELMD of 2,700 kcal/day in early December. Locate 2,700 on the *x*-axis. The DECO of forage at that time might be 0.5 and the required intake is estimated on the *y*-axis to be 1.4 kg. As winter proceeds, ELMD falls to about 1,600 kcal d^{-1}, and if DECO falls to 0.4, estimated intake is about 1.0 kg.

The timing of the arrival of spring affects the intake necessary to satisfy an increasing energy requirement. As ELMD rises to 2,000 kcal day^{-1}, intake increases to 1.3 kg day^{-1} if the deer must remain on dormant forage with a DECO of 0.4. If spring arrives earlier and a diet with DECO = 0.6 is available, an adequate energy intake will be derived from about 0.9 kg of forage. As metabolism increases to a peak of 3,200 kcal day^{-1} as a bred yearling in the fall and early winter, when she weighs 55–60 kg, predicted intake is 1.4 kg day^{-1} if DECO = 0.6, 1.2 kg day^{-1} if DECO = 0.7, and 1.0 kg day^{-1} if DECO = 0.8. By midwinter, the deer again encounters less digestible forage to satisfy ecological metabolism, and slightly less than 1.4 kg of 0.4-digestibility forage is necessary to fulfill the 2,100 kcal day^{-1} energy needs. ELMD then rises steadily during spring, summer, and early fall, reaching a peak of 4,300 kcal as a two-year-old weighing 65–70 kg and nursing one fawn. Predicted intake is 1.6 kg if DECO = 0.7.

The next midwinter depression results in a drop in ELMD to 2,400 kcal as a 2½-year-old (Intake = 1.6 kg @ DECO = 0.4), followed by a steady rise during spring and summer to a peak of 5,500 kcal day^{-1} while nursing two fawns and approaching the fall weight-gaining period. Then, intake is predicted to be 2.0 kg @ DECO = 0.7. Adult deer occasionally bear three fawns, and the maximum ecological metabolism may exceed 6,600 kcal per day and estimated intake dry-weight forage day^{-1} (DECO = 0.7) is 2.4 kg in mid- to late-summer.

Estimates of the intake of male deer may be made in the same way. Male deer in good condition may reach a predicted high of 3,000 kcal per day during mid-winter depression, rise to 4,500 kcal day^{-1} in the fall as yearlings, drop to 2,100 kcal day^{-1} in their second winter, rise to 5,400 kcal day^{-1} in the fall as two-year-olds, drop to 2,500 kcal day^{-1} in their third winter, rise to 5,800 to 6,100 kcal day^{-1} as a mature adult bucks, and drop to 2,700 to 2,900 kcal day^{-1} in the winters (Moen 1978). These estimates are based on maximum weights of 44, 73, 91, and 100 + kg for a fawn, yearling, two-year-old, and mature adult, respectively. Minimum winter weights used in the estimations are about 70% of fall maximums.

Note that seasonal variations in ecological metabolism result in lateral movements on the *x*-axis of the nomogram, variations in the digestibilities are represented by the DECO lines, and intake oscillates vertically on the *y*-axis in relation to these two variables.

How does estimated intake compare with results from feeding experiments? In feeding trials carried out by Ullrey et al. (1970), deer ingested 0.6 to 1.6 kg of forage; nomogram estimates lie between 0.8 and 1.2 kg. Silver and Colovos (1957) completed feeding trials with two fawns—one male and one female—fed hemlock with a digestibility of about 0.6. The male's observed intake averaged 0.63 kg day^{-1}, just 0.08 kg less than the predicted intake of 0.71 kg. The female's observed intake was 0.48 kg day^{-1}, 0.20 kg less than the estimated intake of 0.68. Lower observed intake may be explained by the fact that both deer lost weight during the trial; energy requirements were being partially met by metabolized body tissue.

In another trial by Silver and Colovos (1957) two deer were fed witchhobble. A female who lost only 0.6 kg of weight during the trial had an observed intake of 0.6 kg day^{-1}, the same as estimated. A male ate more (0.92 kg day^{-1}) than predicted (0.66 kg day^{-1}), yet lost 1.76 kg weight. This animal was described as the most nervous and active and the least tame deer in their herd. Its actual metabolism was likely much higher than calculated ELMD, resulting in an underestimation of intake. Reactions of individual deer to experimental conditions cause variabilities not accounted for with the general equation in Moen (1978) and the nomogram in Figure 1.

The nomogram provides reasonable *estimates* of intake. It is not meant to replace calculations using programmed computing with equations in Moen (1978), but such facilities are often unavailable when making management decisions. When good estimates of ecological metabolism and digestibilities are used, the nomographic estimates of intake are likely to be as good as estimates of numbers in deer populations.

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