

Pregnant Ewe Nutrition

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There has been much interest over the past decade regarding pregnancy nutrition and its impact on animal health, reproductive, and lactational performance. As a result the pregnant, nonlactating animal has become the most scrutinized animal on the farm. In the not so distant past, and probably still in the present on many farms, management of the pregnant animal was by benign neglect. Everything was focused on the animal at the time of parturition and later as a result of the perceived importance of the lactating animal. The sheep producer as well as the supporting veterinarian can take a lesson from their dairy colleagues in placing a renewed emphasis on the nutritional management of the pregnant ewe. As profit margins continue to decrease, more effort should be placed on maximizing lamb viability. The objective of this presentation is to describe critical maternal and fetal metabolic processes and how nutritional management influences occurrence of metabolic disease and lamb viability problems. A new approach to nutritional assessment of the late pregnant ewe will be presented.

Maternal Nutrition Influences on Fetal Development

It has long been recognized that there is a substantial increase in nutrient requirements for the late pregnant and lactating ewe compared to maintenance (Table 1). Dietary recommendations for digestible energy (DE), crude protein (CP), calcium (Ca), and phosphorus (P) for the late gestation ewe are 1.5 to 2.0x greater compared to early gestation (1). The ewe to transition from late gestation into lactation requires a similar increase in dietary nutrient intake (1). These differences in nutrient requirements require appropriate modifications in the feeding program as well as metabolic alterations by the ewe to adequately support late gestation and lactation. If these metabolic changes are not effectively enacted metabolic disease and reduced lamb viability may result. Five critical control points during the transition period that need to be addressed to prevent periparturient problems are: 1. maximizing dry matter intake; 2. minimizing negative energy and protein balance; 3. stimulation of rumen papillae development; 4. maintaining calcium homeostasis and 5. minimizing immune system dysfunction.

Nutrition of the pregnant ewe at all stages of gestation has been shown to influence lamb viability. Of concern in reviewing the dietary nutrient intakes recommended (Table 1), one notices an expectation that dry matter intake will increase throughout these transitions. This is a point of concern in late pregnancy where physical fill limitation and other metabolic or endocrine factors may decrease intake capacity. Other issues such as forage quality and environmental factors will also influence intake capacity. If intake does decline, appropriate modifications to nutrient density will be necessary to ensure adequate nutrient intake. Otherwise the ewe will experience negative energy balance which could lead to rapid mobilization of fat reserves and subsequent hepatic lipidosis and pregnancy toxemia. Increasing the amount of grain in the diet can help compensate for low dietary energy availability, hence the need to acclimate the rumen microbes in an effort to prevent potential acidosis and off-feed problems.

Table 1. Recommended nutrient intakes and dietary nutrient content for a mature 70 kg ewe at various physiologic states.¹

Physiologic State	Dry Matter	Digestible energy	CP	Ca	P	Vit A	Vit E
	lb/day (% BW)	Mcal (Mcal/lb)	g (%)	g (%)	g (%)	IU (IU/lb)	IU (IU/lb)
Maintenance	2.6 (1.7%)	2.9 (1.09)	113 (9.4)	2.5 (0.20)	2.4 (0.20)	3,290 (1,246)	18 (6.8)
Gestation, Early	3.1 (2.0%)	3.4 (1.09)	130 (9.3)	3.5 (0.25)	2.9 (0.20)	3,290 (1,068)	21 (6.8)
Gestation, Late							
130-155%	4.0	4.7	193	6.2	5.6	5,950	27
Lambing Crop	(2.6%)	(1.18)	(10.7)	(0.35)	(0.23)	(1,503)	(6.8)
180-225%	4.2	5.4	214	7.6	4.5	5,950	28
Lambing Crop	(2.7%)	(1.32)	(11.3)	(0.40)	(0.24)	(1,424)	(6.8)
Lactation							
Singles	5.5 (3.6%)	7.2 (1.32)	334 (13.4)	9.3 (0.32)	7.0 (0.26)	5,950 (1,082)	38 (6.8)
Twins	6.2 (4.0%)	8.0 (1.32)	420 (15.0)	11.0 (0.39)	8.1 (0.29)	7,000 (1,136)	42 (6.8)

¹Adapted from NRC, Nutrient Requirements of Sheep, 1985 (1).

Protein content of the gestation diet needs to be addressed when one increases grain to accommodate intake. Maternal protein deficiency in late gestation seemingly has a greater impact on birth weight than does energy deficiency (2). Severe or prolonged maternal protein undernutrition can not only result in intrauterine growth retardation of the fetus, but also negatively impact viability through decreased thermogenic capacity and reduced production of quality colostrum. However maternal and placental nutrient reserves can maintain fairly normal fetal growth patterns during short periods of undernutrition. As a consequence of prepartal maternal reserve depletion, there may be detrimental repercussions on subsequent colostrum development, lactational performance, and lamb viability. Issues of protein content and dry matter intake are borne out in a recent study.

Twin-pregnant ewes between day 110 to 140 of gestation were fed one of three diets containing equal energy but differing in protein content (8 - 12 - 15% CP). Ewes fed the 8% CP diet had an 18% reduction in fetal weight compared to the other diets, whereas, fetal weights were not different between the 12 and 15% CP diets (3). These data suggest there exists some capacity for the placenta to sustain amino acid delivery to the fetus, but it is not unlimited. Ewes receiving either 8 or 12% CP diets both lost maternal skeletal protein, whereas ewes on the 15% CP diet gained carcass protein mass. Although the NRC recommends 11.3% CP diet for late gestation ewes, only ewes receiving the 15% CP diet consumed sufficient CP amounts equal to daily NRC recommendations; the reason being intakes were much reduced. Mobilization of maternal skeletal protein ("labile protein") can explain why birth weight is not dramatically affected within reasonable variation in maternal nutritional status, at the expense of maternal protein mass. Parturition loss in maternal nutrient reserves or body protein may have severe

detrimental impact on health, lactation and reproductive performance following parturition since these nutrient pools are critical to support early lactational nutrient losses.

Pregnant ewes fed soybean meal and blood meal prepartum had greater body condition improvement at lambing and reduced body weight loss postpartum compared to ewes supplemented with either soybean meal or urea (4). Based on fetal growth curves, Robinson (5) determined that additional dietary protein sources over and above microbial protein were required to meet fetal needs beyond day 130 of gestation. The most effective method of meeting this requirement was through the feeding of a bypass protein source.

Fetal Development and Nutrition

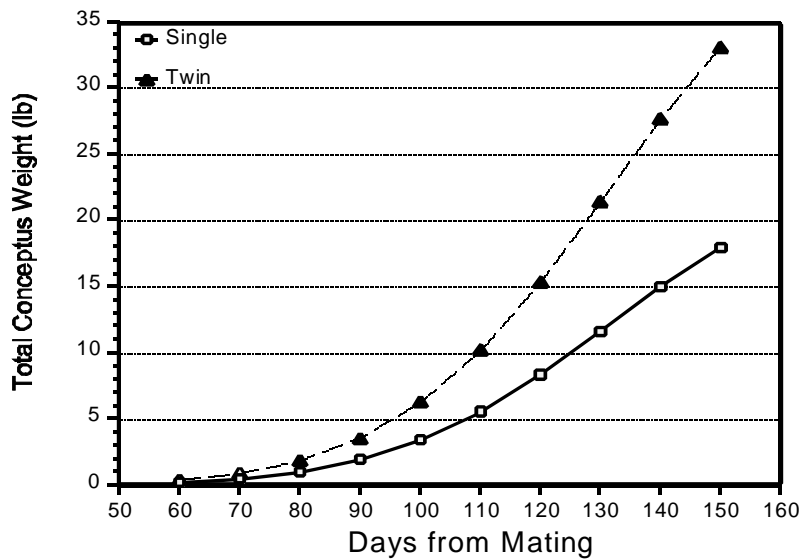
An exponential fetal growth pattern places the greatest nutritional burden of pregnancy on the pregnant ewe with greater than 60% of fetal growth occurring in the final month of gestation (Figure 1). Glucose is the primary nutrient required by both mammary gland and gravid uterus for metabolism. The mammary gland converts glucose to lactose while the gravid uterus oxidizes glucose as its primary metabolic fuel. Oxidation of glucose, lactate, and amino acids account for most of the energy utilization by the gravid uterus (6). Other potential energy substrates for the ewe include acetate, fatty acids and ketone bodies. These substrates, however, are not appreciably oxidized for energy by the gravid uterus as a result of their failure to be significantly transported across the placenta from maternal circulation (6,7). Glucose and lactate are transported across the placenta by facilitated diffusion, while amino acids are actively

transported (6).

This results in fetal glucose being totally dependent upon maternal concentrations in contrast to fetal amino acids concentrations being consistently greater than maternal levels (7,8). Complete oxidation of glucose and lactate can only account for 50 to 60% of the total fetal caloric requirement (6).

This suggests amino acids account for 30

Figure1. Total conceptus weight during mid through late gestation in sheep with single or twin fetuses.



to 40% of the total conceptus caloric requirement in addition to providing the necessary substrate to support substantial protein synthesis activity (6,8).

Dynamic in vivo measures of fetal sheep crown-to-rump length measurements found fetal growth to be deterred or completely stopped during periods of induced maternal hypoglycemia during late pregnancy (9). In periods of maternal undernutrition, the fetus has little flexibility in terms of available alternative metabolic fuels. Fetal glucose and lactate concentrations and utilization decline, a direct result of declining maternal concentrations. In contrast, fetal amino acid uptake is essentially unaffected by maternal nutrient status, suggesting a greater role for amino acids in fetal energy production. A study using pregnant sheep showed amino acid oxidation, based on urea synthesis rates, to increase from 32% to 60% of total fetal oxygen consumption for diets either maintaining or restricting maternal nutrient intake throughout gestation, respectively (10). These data clearly demonstrate that amino acids are essential fetal energy substrates, especially during periods of maternal undernutrition and places an additional protein utilization burden on the dam.

Trace minerals are lost during gestation from the dam to the fetus where they are concentrated in the fetal liver to be used as a postnatal mineral reserve (11, 12). Fetal hepatic micromineral reserves are also augmented by consumption of colostrum, a highly concentrated source of most essential nutrients. Therefore, available neonatal nutrient reserves are the sum of placental transport and colostrum consumption, both of which are highly influenced by maternal nutrient status. In contrast to the microminerals, fat-soluble vitamins like vitamins A and E do not appreciably cross the placenta resulting in no gestational liver reserve (13). The neonate's primary source of vitamins A and E comes via colostrum ingestion supplied from an adequately supplemented dam (13). These trace nutrients not only are required for normal growth and development of the lamb, but also are essential to normal function of the immune system.

Nutritional Diagnostics

Clinical chemistry measures are commonly used in all veterinary hospitals as an aid in diagnosis of individual animal health problems. Application of this diagnostic procedure has been advocated as a useful flock-based diagnostic tool to monitor and diagnose metabolic status and disease (14, 15). The goal of any metabolite profiling is to obtain the "population" mean and determine dynamic changes over differing physiologic states. To obtain this we need to sample large numbers of animals. Initially, cost is the main deterrent to large animal numbers; however, why not pool samples since we are interested in mean value and not individuals? Samples can be pooled by appropriate physiologic states, age or disease categories to allow interpretation of dynamic changes in "population" means over a period of time. The only negative part to this variation is the loss of statistical evaluation, i.e., population variance. However, this is not a major limitation. Proper identification of appropriate animal groups or pools is absolutely critical if one is to obtain useful data.

Using a pooled approach to metabolic profiling in the sheep flock, one can assess energy balance, protein status, liver and kidney function, macrominerals and potentially microminerals and vitamins. Energy balance may be assessed through the use of body condition scoring or by the measurement of NEFA concentrations. Elevated NEFA concentrations are recognized around the time of lambing and represent increased lipid mobilization to counter negative energy balance. Prolonged or extreme lipid mobilization around lambing can lead to elevated liver fat infiltration and increased periparturient disease problems. Serum NEFA concentrations are very

sensitive to energy balance in contrast to serum glucose concentrations as a result of serum glucose being homeostatically regulated. Protein status is more difficult to evaluate given the lack of any metabolite that is specifically affected by dietary protein. Concentrations of total protein, albumin, BUN and muscle enzyme activities are often used as measures of protein status (14). In assessing mineral and vitamin status of an animal, one needs to consider the potential role of homeostatic regulatory processes and nutrient reserves (i.e., liver nutrient storage). Both of these physiologic processes will help to buffer nutritional insults and minimize changes in blood mineral or vitamin content that might confound interpretation of the measured nutrient's concentration. Taking serum samples at times when the homeostatic processes are physiologically challenged and ineffective (i.e., around lambing) may be the most appropriate time. Liver biopsy may be a useable method to assess liver storage of trace minerals and fat-soluble vitamins. Unfortunately in many flock situations, blood analyses are used preferentially in lieu of other more appropriate diagnostic procedures such as ration evaluation and physical exams and without regard for proper technique to ensure sound diagnostic information. Despite these problems, blood metabolite analysis can reveal some useful diagnostic information if properly interpreted in conjunction with animal, facility, and ration evaluations.

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