“Nutritional management of ewes in late pregnancy to prevent metabolic disease”

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Overview:

- ***Meeting the nutrient requirements of prolific ewes***
- ***The precarious glucose economy of the late pregnant ewe and prevention of ketosis.***

Overview of the nutritional management of pregnancy in sheep:

- Pre breeding-ovulation rate

- Early pregnancy-embryo survival

- Mid pregnancy-period of placental growth

- Late Pregnancy-fetal growth and development, colostrum supply, mammary development

Flushing or Pre-breeding

- Short- and long-term nutrition both play a role in ovulation rate
- Increased nutrition for as little as one week can improve ovulation
  - Increase energy intake to 150-200% of maintenance 2-3 weeks before breeding
  - Bring diet back to maintenance or slight gain (1.1x maintenance) at ram introduction or up to ≈1 week later (depending on body condition of of ewes, BCS)
  - Forage diets may need some grain supplement to meet this need (0.5-1.5 lbs depending on forage quality)
  - Looking for an increase of 2.5-4 kg in bodyweight (0.5 BCS)
  - **25% increase in lamb drop commonly seen**
- Ewes respond best if not fat (>3.5 BCS)
  - Fat ewes (> 4 BCS) show little response


Ewes flushed by grazing on annual forage strips of BMR sudan grass and forage brassica hybrids (chinese cabbage x turnip)
Crop planted during early July into a killed pasture following pasture lambing and grazed in late August

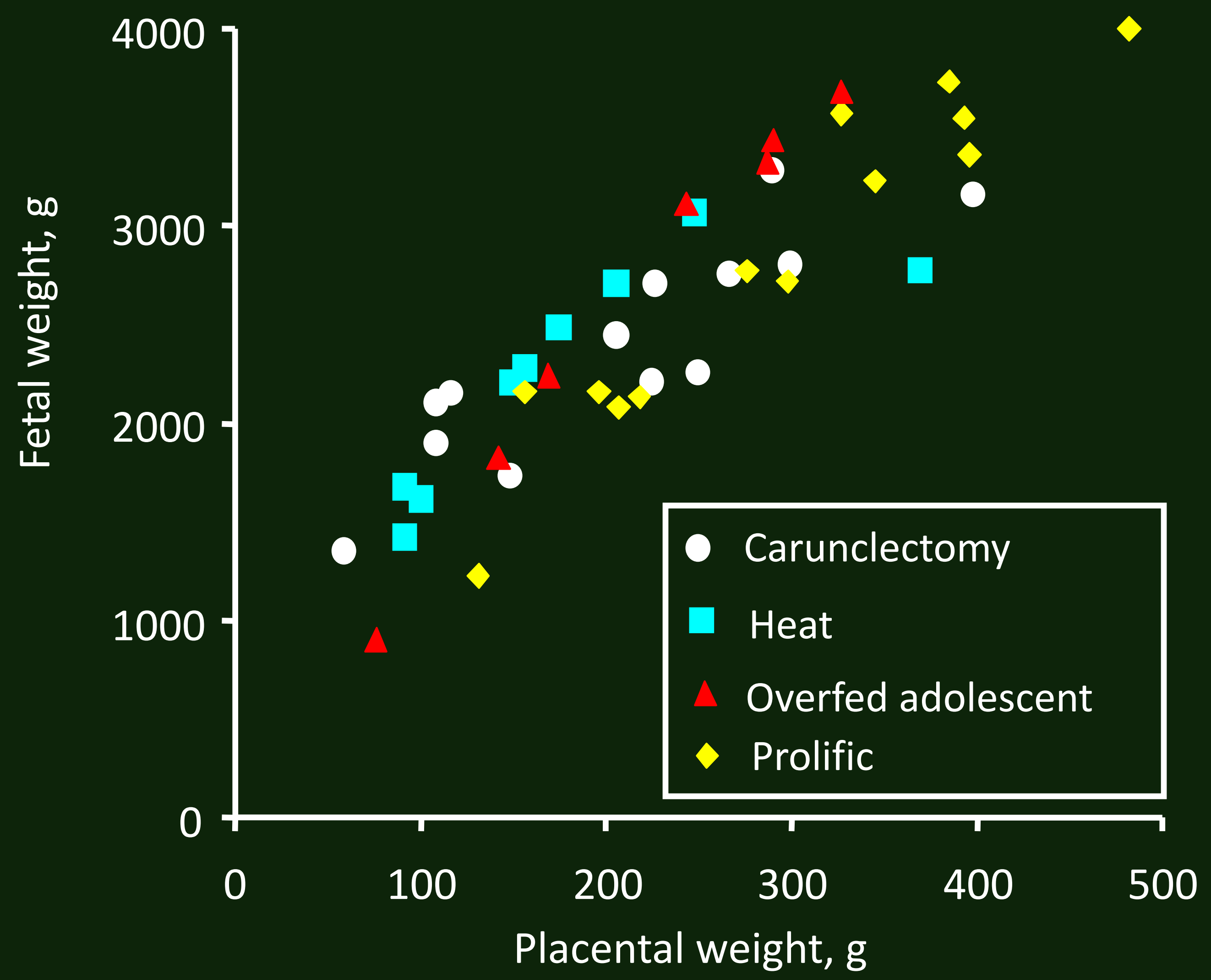
Early Pregnancy (first trimester)

- Period of implantation/placentation
  - ✓Successful implantation is insured when ewe/doe not losing weight
  - ✓Weight loss (negative energy balance) is associated with embryonic loss
  - ✓Excessive caloric intake may also be detrimental
- Ideal to scale down flushing upon ram introduction
  - ✓Over feeding during early pregnancy may suppress implantation/embryonic survival
  - ✓100-110% maintenance diet, grazing management to maintain weight or feeding of average quality hay/forage (~55-60% TDN)
  - ✓Overfeeding to the point of obesity (BCS 4) can lead to increased risk of metabolic problems in late pregnancy

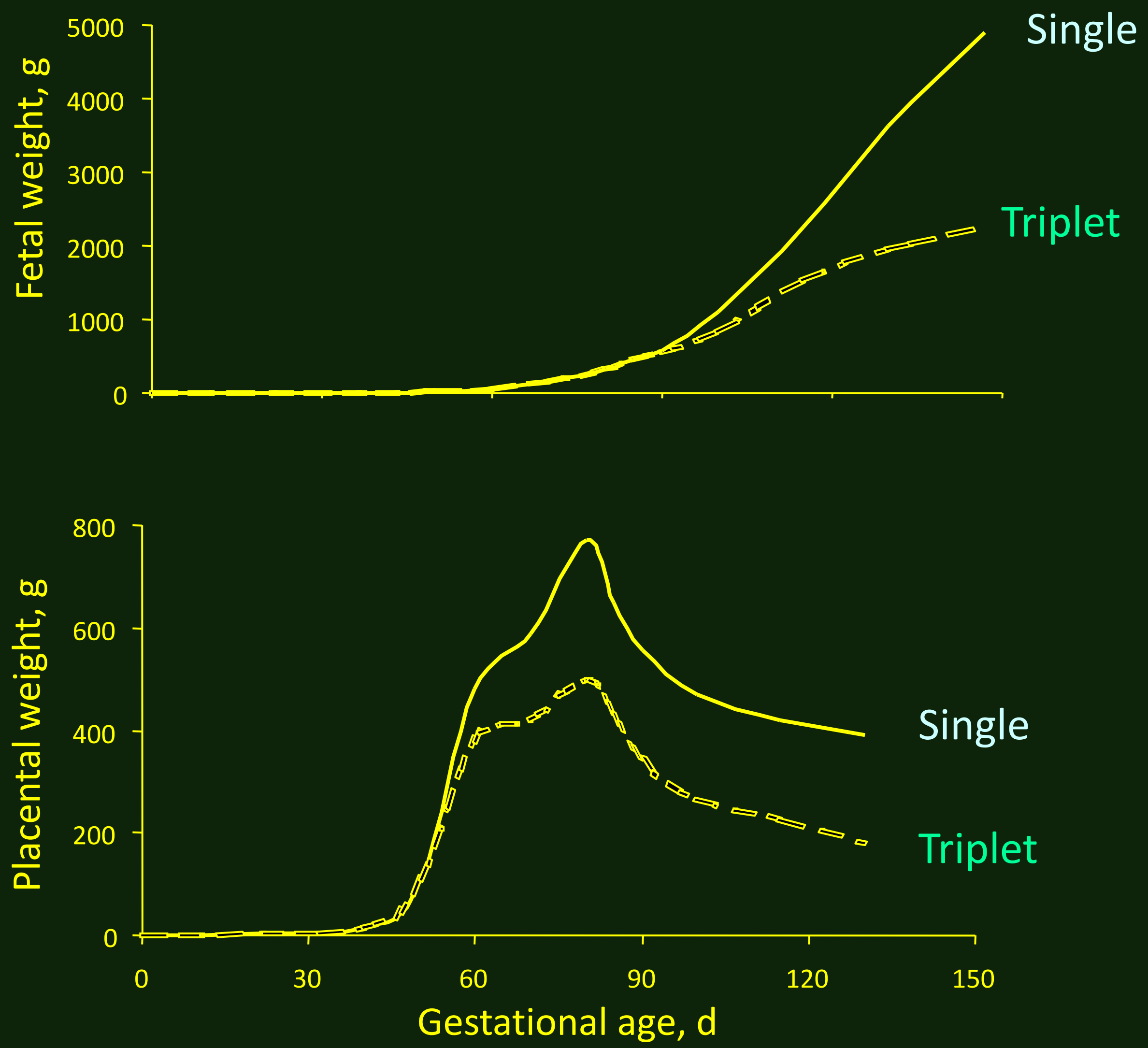
Mid-Pregnancy (second trimester)

- Period of rapid placental growth
  - ✓Nutrition has little impact on placental growth process
  - ✓High temperature (>90° F) will impair placental development
- Placental size determines fetal size
- Aggregate placental mass determines extent of mammary development
  - ✓Larger placenta (larger litter and/or bigger lambs) = greater mammary development and milk supply. Mother nature's way of matching offspring needs to maternal milk supply.
- Moderate undernutrition during mid-pregnancy (-0.5 BCS) is tolerable during this period. This loss can be compensated by improved nutrition after day 100, but after day 120 this deficit cannot be recovered.

Placental size is a major determinant of fetal size near term



Fetal and placental growth in single and triplet births



Maternal requirements during Mid-pregnancy

- Maintenance forage diet
  - Grazing
  - Low-moderate quality forage
  - High quality forage should be limit fed and/or reserved for more demanding stages of production
- Free access to trace mineralized salt (TMS)
- Feed at higher levels or greater energy density if ewes are in low BCS (<2.5)

Considerations during Late pregnancy

- Ewe/doe will prioritize fetal tissues over her own if not consuming enough energy and/or protein
  - ✓Low body condition
  - ✓Less able to produce enough colostrum/milk later
  - ✓Can lead to ketosis/pregnancy toxemia
  - ✓Fetal growth will slow if maternal caloric restriction is severe
- Energy supplements are also needed for prolific animals plus high quality forage (2x maintenance for twins, 2.35x maintenance for triplets)
  - ✓Dams carrying singletons have much lower requirements (1.5x maintenance)

Maternal plane of energy nutrition during the last 30 days of pregnancy

Birth Type	% of Maintenance
Single	150
Twin	200
Triplet	235

- Challenge is to provide this level of nutrition when maternal feed intake can be constrained due to growing pregnant uterus.


Animals like this have limited intake capacity
yet high energy needs

Nutritional targets for late pregnancy:

- **Target ration NDF <40% unless forage NDFd >70%**
- **Maximize use of highly digestible fiber sources**
  - ✓ **Target intake= 3% of non pregnant BW**
- **Limit use of high starch energy sources (**i.e. corn and barley)
  - ✓ <50% of energy content(<30% dietary starch)
- **Energy and Protein density targets**

	(TDN, %)	Crude Protein (%)
✓Single	58	11
✓Twin	66	13
✓Triplet	73	15

- **Alter targets based on BCS and production system**

What is the best way to increase diet energy density during late pregnancy?

- Provide forages with higher digestibility
  - ✓ Quality pasture
  - ✓ Stored Forage
- Supplement diet with energy concentrate (corn and/or barley)
  - ✓ High starch content requires that dietary changes be made slowly
- Consider use of high energy, highly digestible fiber sources
  - ✓ Non forage: soy hull feed, wheat midlings
  - ✓ Forage: corn silage, BMR sudan silage

Forage Quality

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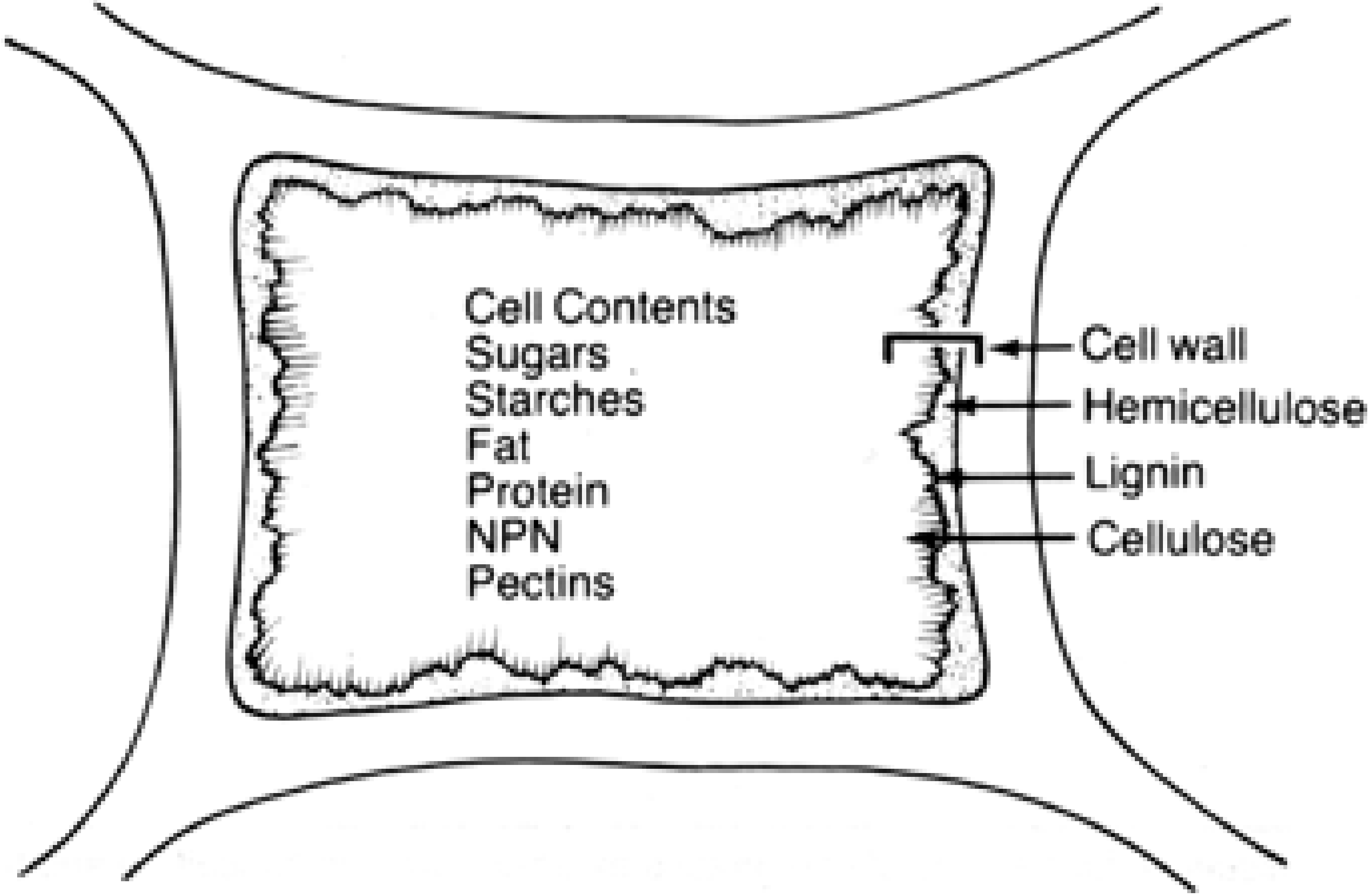


Forage Quality: determined by composition and digestibility of cell wall fraction

Cell wall component:	Digestibility:
Cellulose	50-90%
Hemicellulose	20-80%
Lignin	0-20%

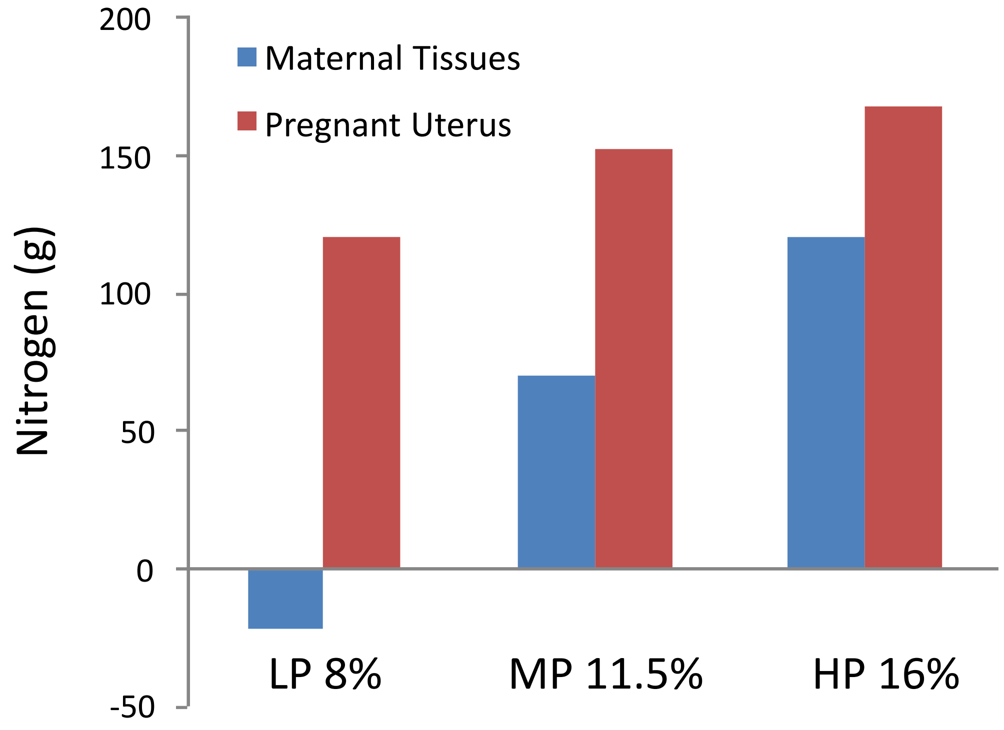
Fiber digestibility determines the amount of energy and protein available to the animal

Factors that determine fiber digestibility:

- **Plant maturity**
  - ✓ **Vegetative to mature**
- **Growing conditions**
  - ✓ **Temperature**
- **Plant species**
  - ✓ **Grasses (C3 vs. C4)**
  - ✓ **Legumes**


GEHL

Protein changes in maternal tissues during late pregnancy according to dietary protein (nitrogen) level



McNeill et al. 1997
Journal of Animal Science 75:809-816

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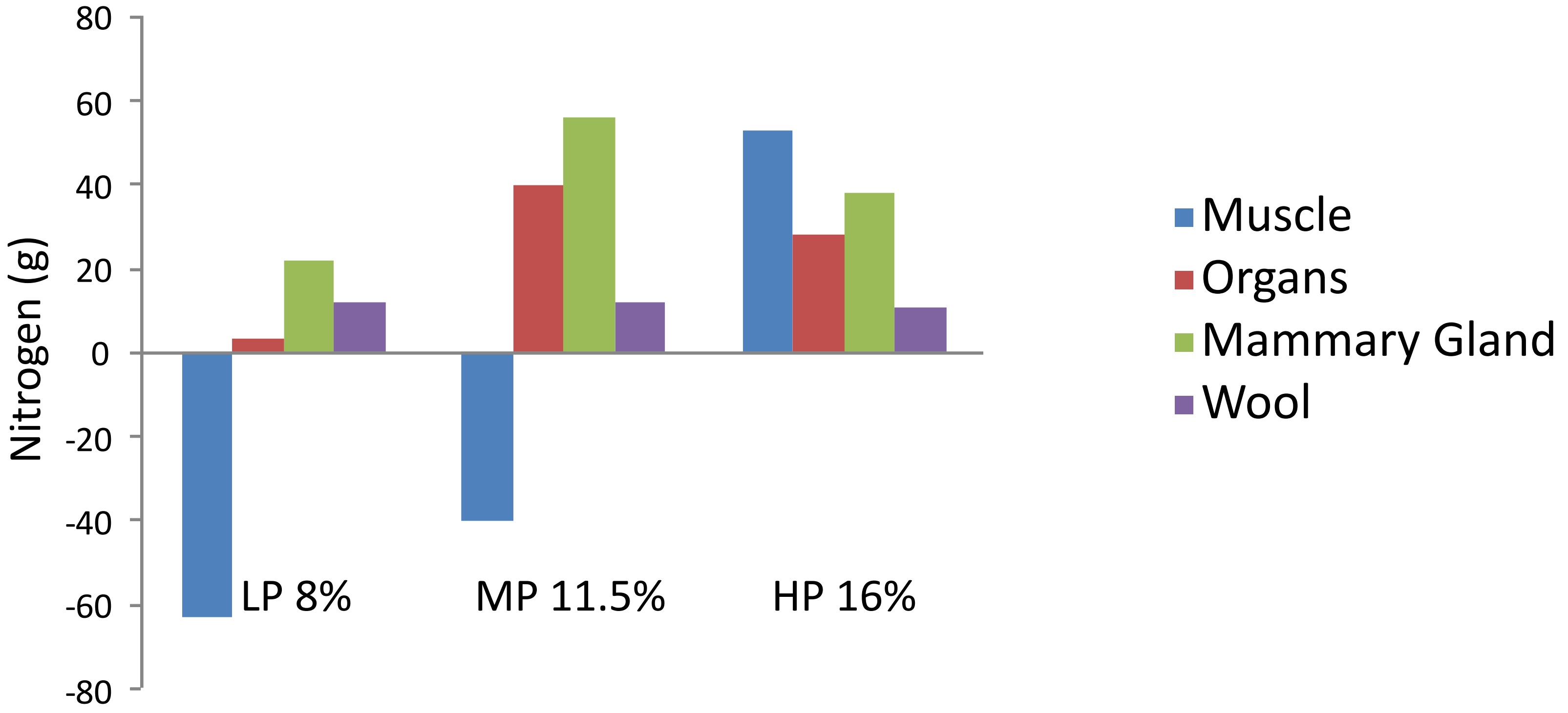

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Summary of protein nutrition during late pregnancy:

- Fetal growth is optimized at a protein plane (% crude protein) of 11% and 13%, for single- and twin-pregnant animals, respectively.

- Supplementation of protein above these thresholds will improve maternal muscle protein retention during late pregnancy

Will supplemental protein increase milk production?

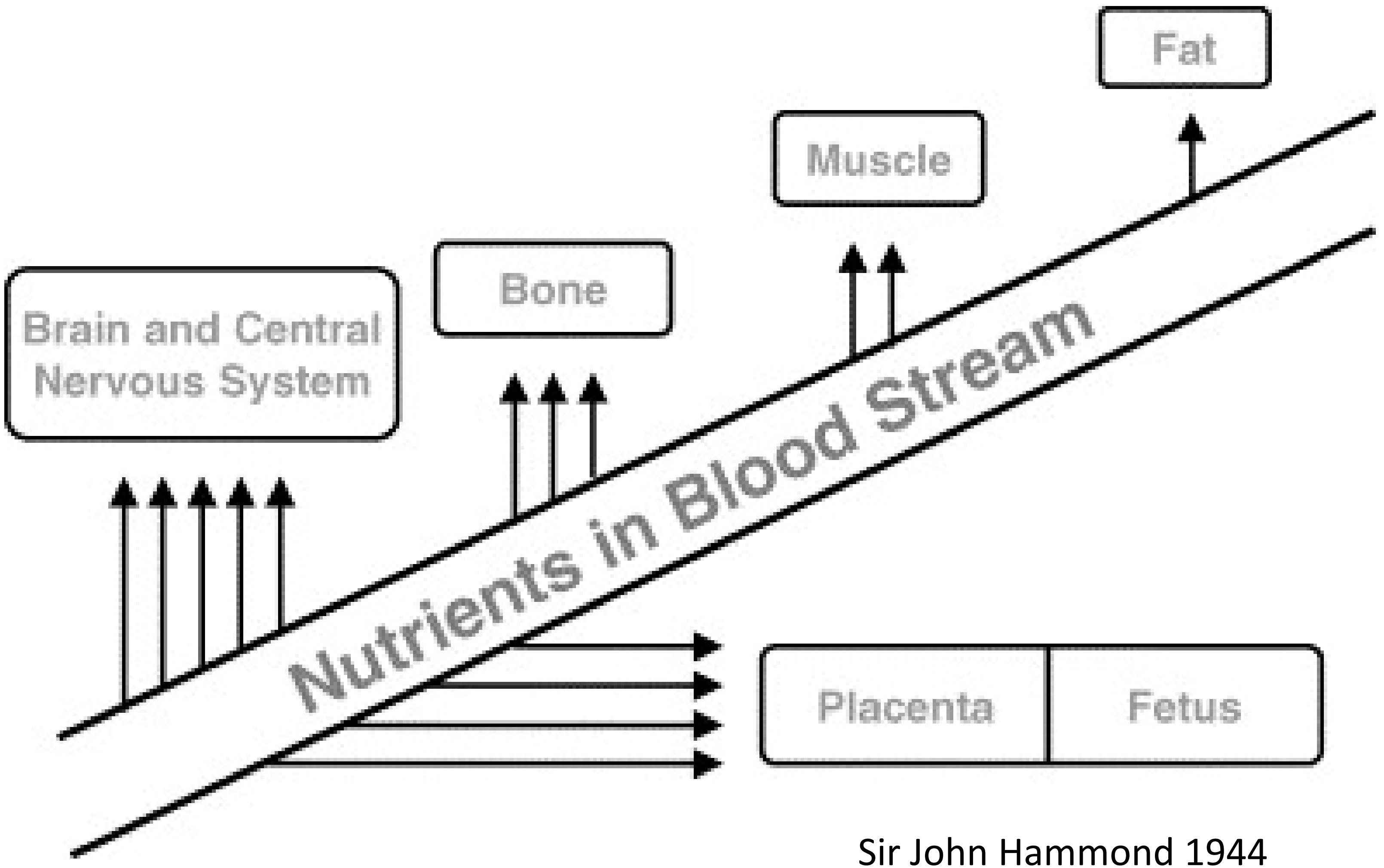
Is supplemental protein cost effective in terms of milk production and lamb growth?

Ketosis/pregnancy toxemia: when maternal adaptations in energy metabolism fail

- ✓Ewe does not consume adequate energy in late pregnancy
- ✓The massive need of glucose by the fetus and placenta require major adaptations/changes in maternal energy metabolism
- ✓When these adaptation fail, ketosis ensues

Glucose is a primary limiting fetal nutrient:

- Glucose and amino acids are the major macronutrients for fetal growth.
- The fetal compartment (placenta and fetus) does not use fatty acids for energy
- Mother uses fat for energy when glucose supply is limited thus maintaining fetal supply
- Fetal glucose supply has a major impact on:
  - ✓ Maternal energy use
  - ✓ Fetal use of amino acids for growth vs energy



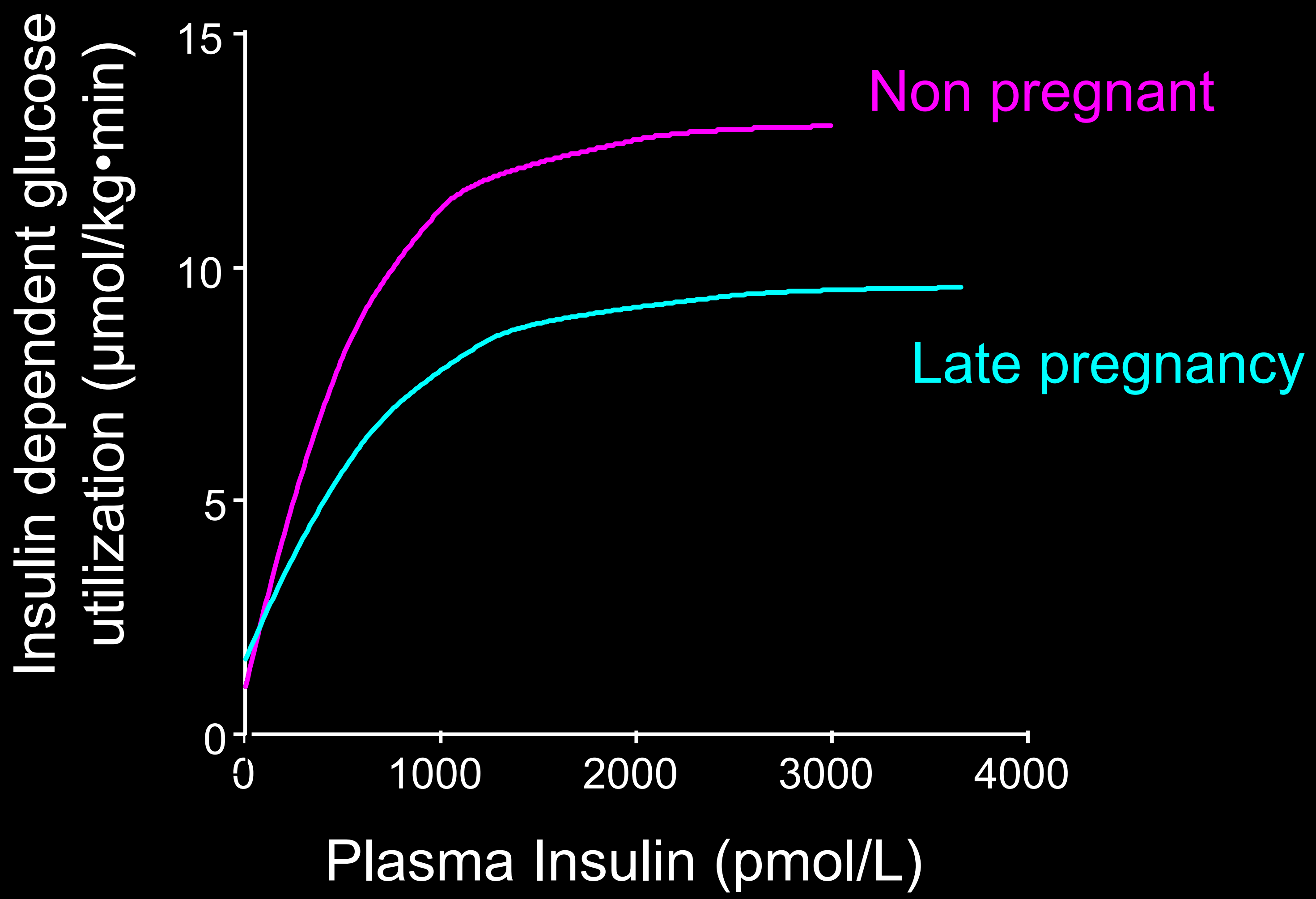
Sir John Hammond 1944

Maternal adaptations in energy metabolism

- Development of insulin resistance in major insulin responsive, non-uterine tissues

- A major consequence is the diversion of glucose to the growing conceptus

Glucose is redirected to the fetal compartment via several mechanisms including changes in maternal tissue (muscle and fat) insulin responsiveness

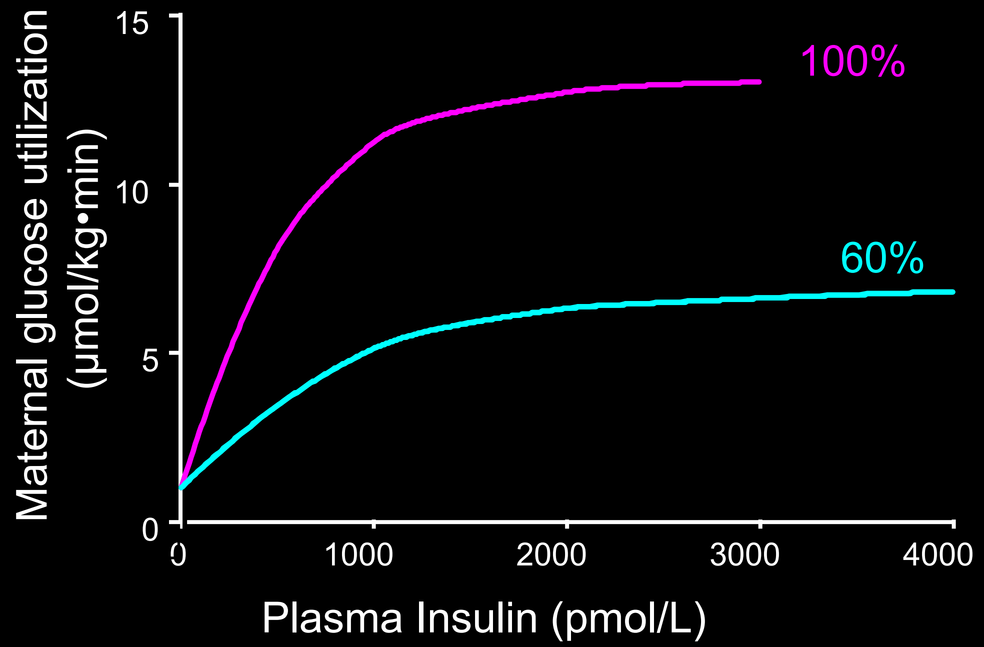


Petterson et al. 1993, J Nutr 123:1286

What happens when a ewe is underfed in late pregnancy?

- Ewe “runs” on her fat reserves
- Fetus receives proportionally more glucose to maintain growth
- If glucose supply is not adequate, the fetus also uses amino acids for energy and its growth slows

Maternal insulin resistance is exacerbated by undernutrition



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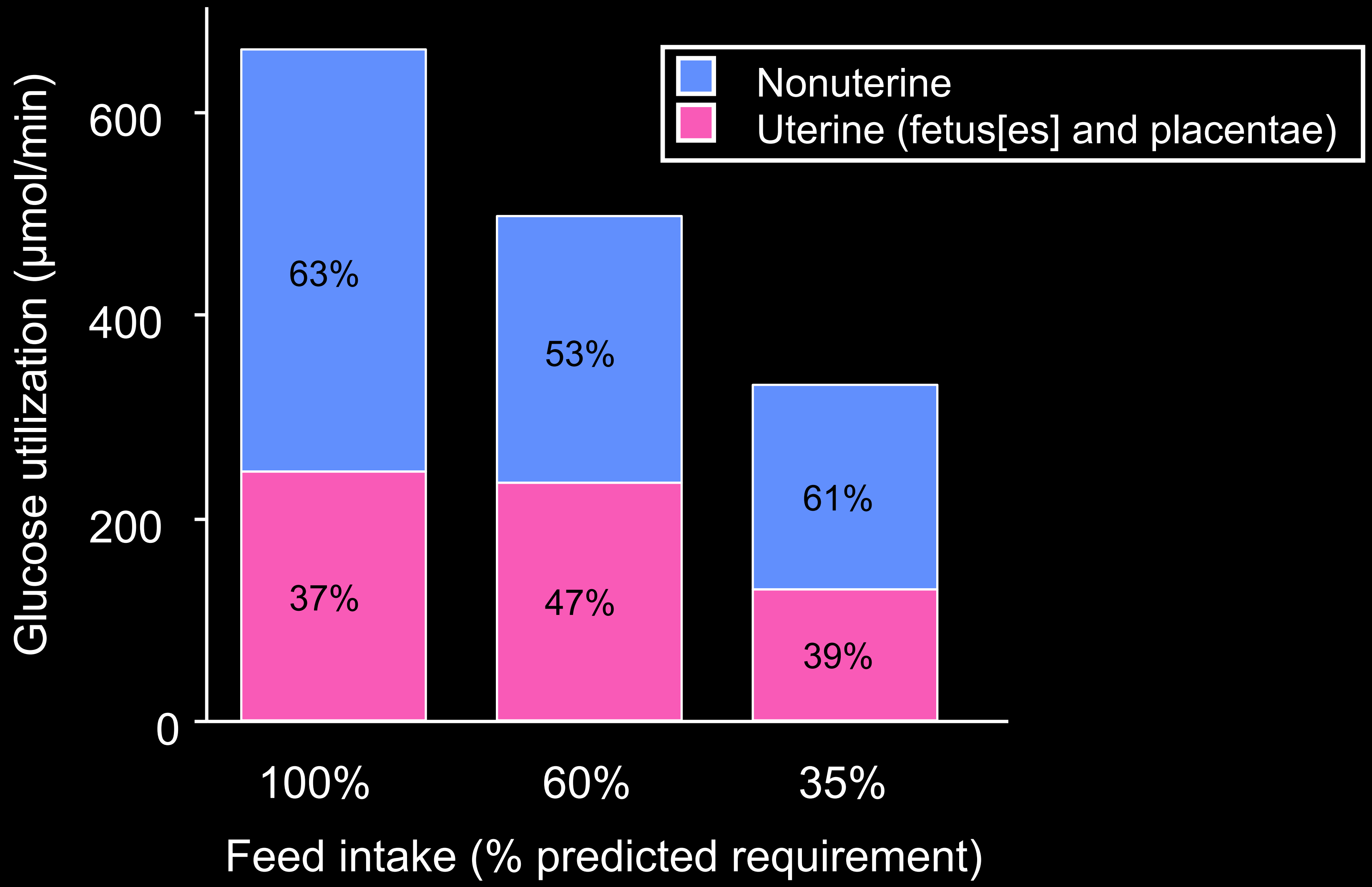
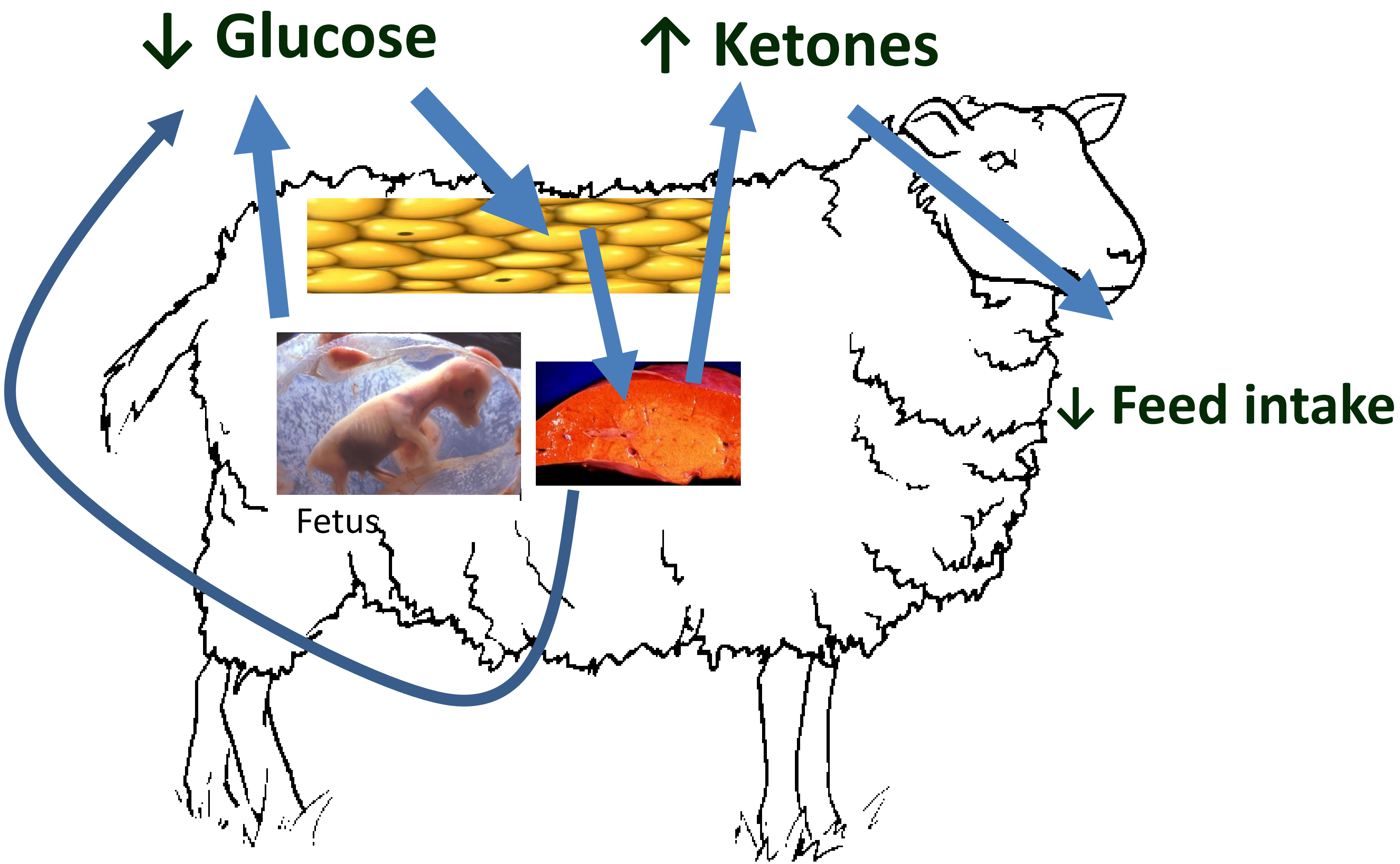


Petterson et al. 1993, J Nutr 123: 1286 and Leury et al. 1990, Br J Nutr 64:449

How does ketosis/pregnancy toxemia happen?

- ✓low circulating glucose triggers massive fat mobilization
- ✓**capacity of liver to convert fat to energy is saturated**
- ✓ ketone production ensues to utilize fat metabolites
- ✓high circulating ketone levels depress appetite

Ketosis in sheep



Ketosis/Pregnancy Toxemia:

- Sporadic in most flocks, < 2% morbidity
- Flock outbreaks: 5% to 15% involvement
- Mortality > 80%
- Occurs during the final 21 days of pregnancy

Pregnancy Toxemia
(Field Observations)

- **Over feeding during early pregnancy**
- **Fat ewes that are also sedentary**
- **Prolific ewes regardless of energy reserves receiving inadequate plane of nutrition after day 115 PC.**
  - **Low digestibility/energy forages**
  - **Fasting due to**
    - **Shearing**
    - **Winter storms**

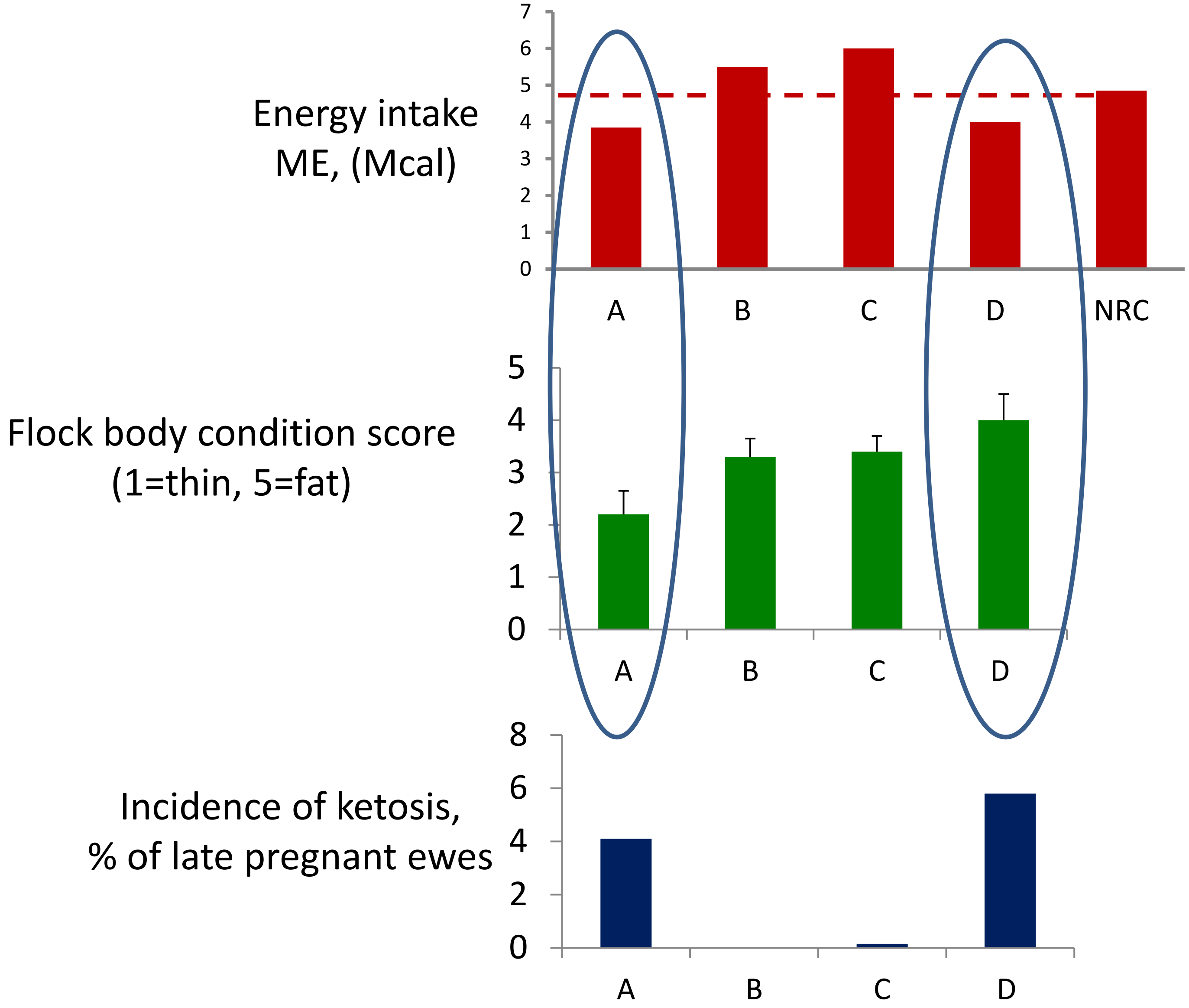
Prevention of ketosis:

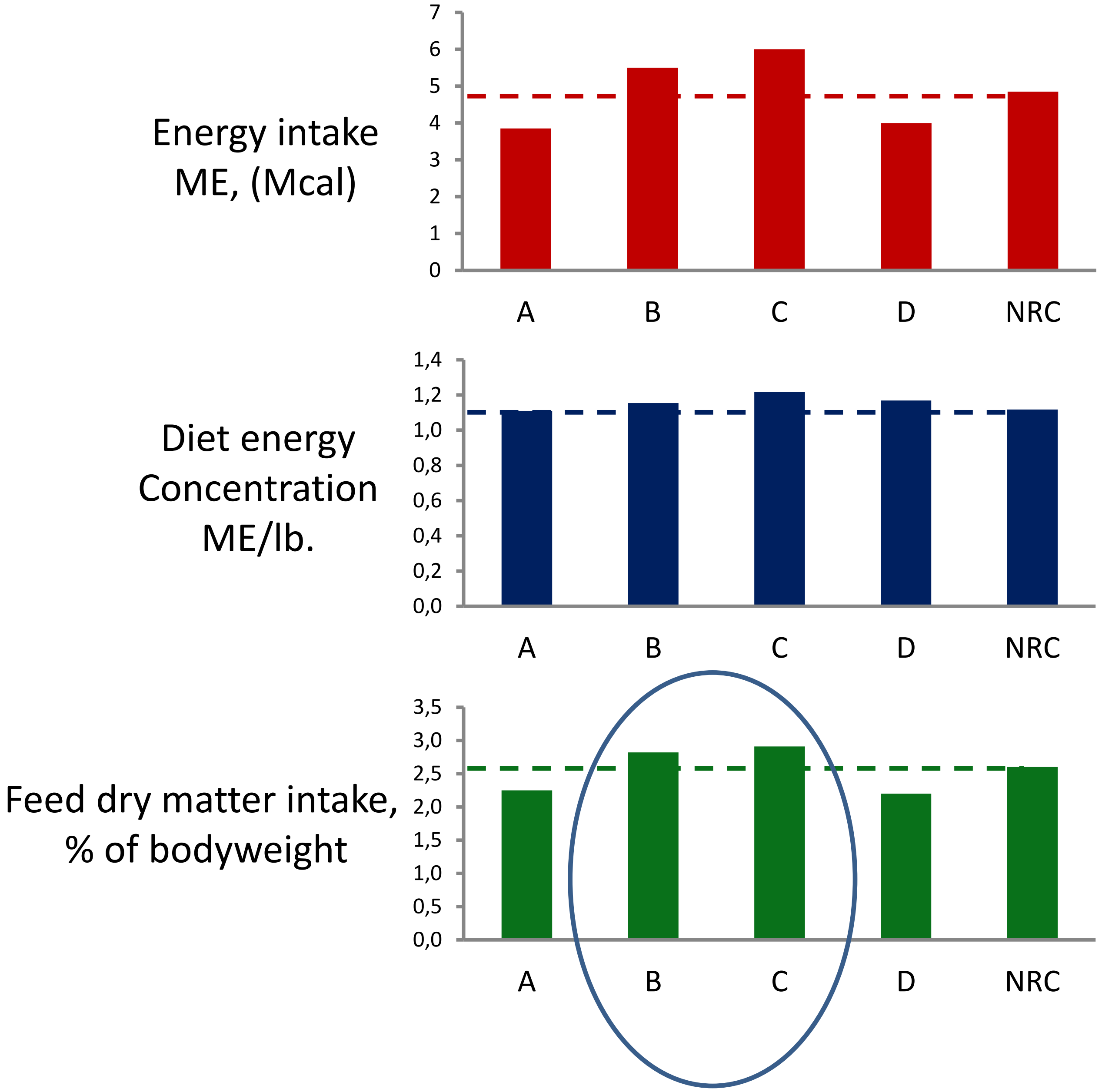
- Key concept is to increase energy density of diet in last 30 days
- Risk factors:
  - ✓ Plane of nutrition and body condition
    - ➢ Thin ewes in general-underfeeding exacerbates the problem
    - ➢ Fat ewes-that cannot consume enough energy in late pregnancy, excessive fat stores cause mass fat mobilization to the liver effectively limiting the capacity of hepatic tissue to synthesize more glucose
  - ✓ Stress-winter storms, shearing, etc.

Evaluation of transition diets and their relationship to health status and performance in large sheep flocks in 2014

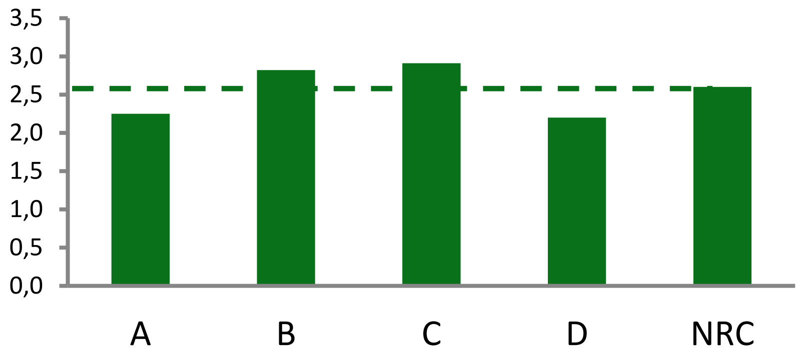
- Health status recorded by flock owners and CVM "Small ruminant production medicine" clerkship students
- Feed intake recorded by flock managers during late pregnancy and early-mid lactation
- Diet components and complete total mixed rations were sampled
- Diet samples were analyzed by NIR methodologies to estimate dietary energy and protein concentration and to characterize fiber fractions
- 8 farms evaluated, results from 4 farms during the late pregnancy period will be presented
- All flocks were "prolific" with lamb drop >200%
- Average ewe mass (parity 2+ in average body condition- BCS 3) ranged from 75-80 kgs between flocks
- All flocks fed some form of silage as the main source of dietary dry matter

Body condition score, incidence of ketosis and energy intake in large flocks during 2014

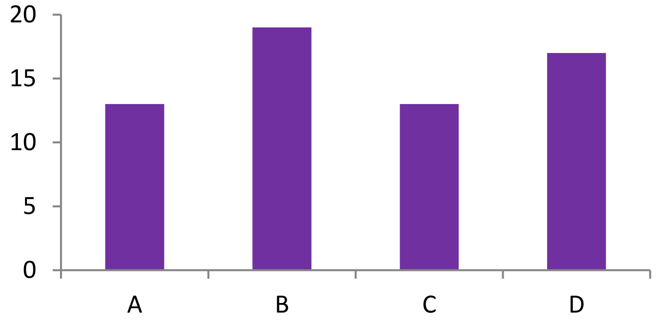



Energy intake
ME, (Mcal)
0
1
2
3
4
5
6
7
A
B
C
D
NRC
Diet energy
Concentration
ME/lb.
0,0
0,2
0,4
0,6
0,8
1,0
1,2
1,4
A
B
C
D
NRC
Feed dry matter intake,
% of bodyweight
0,0
0,5
1,0
1,5
2,0
2,5
3,0
3,5
A
B
C
D
NRC

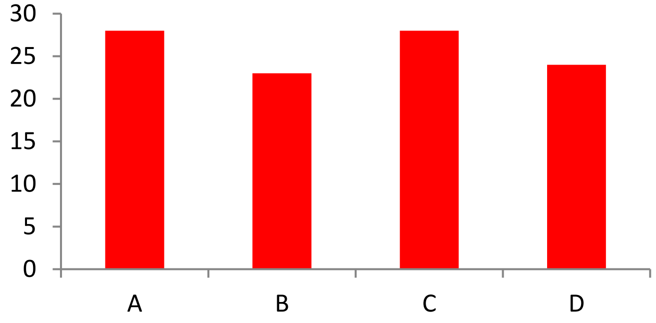
Feed intake,
% of bodyweight

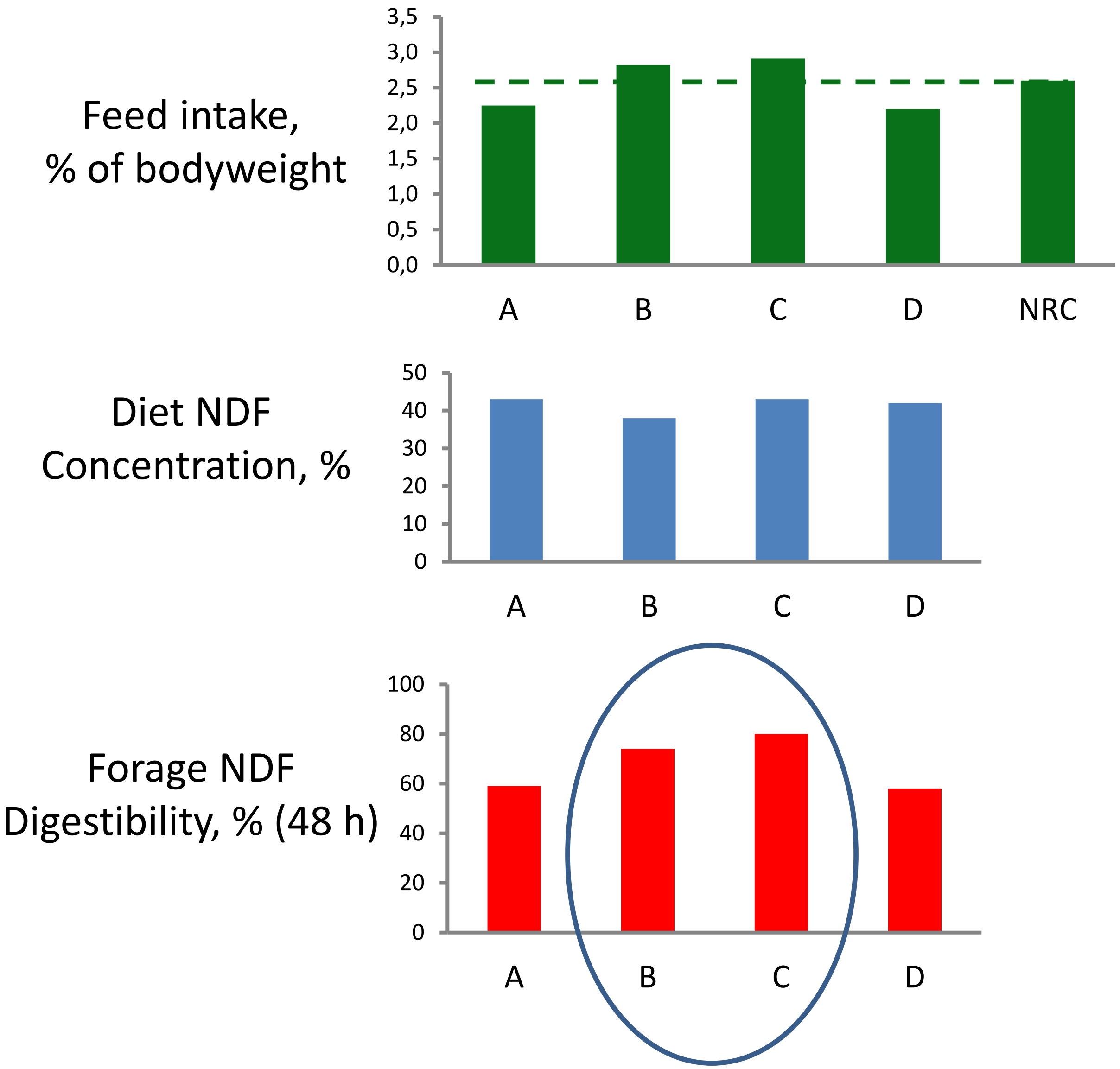


Diet Starch, %

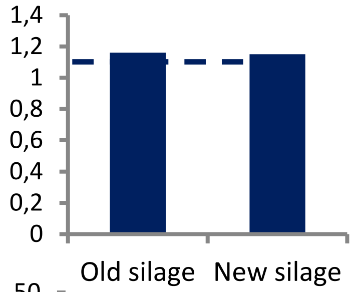


Diet ADF, %



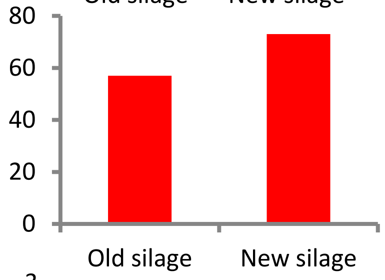

Feed intake,
% of bodyweight
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
A
B
C
D
NRC
Diet NDF
Concentration, %
50
40
30
20
10
0
A
B
C
D
Forage NDF
Digestibility, % (48 h)
100
80
60
40
20
0
A
B
C
D

Diet energy Concentration ME/lb.



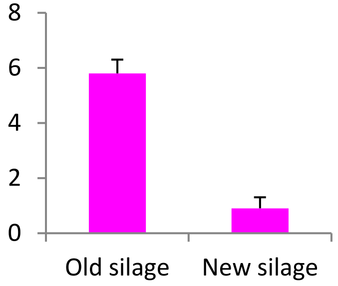
Diet NDF Concentration, %

Forage NDF Digestibility, % (48 h)



Feed intake, % of bodyweight

Incidence of ketosis, % of late pregnant ewes



Improvement of dietary NDF digestibility in flock D and its impact on feed intake and incidence of ketosis in late pregnancy

- Flock D had a high incidence of ketosis , 5.8%, during the April lambing period
- Ewes in flock D were also obese, BCS 4.0.
- Recommendations were made to improve dietary fiber quality and to reduce energy concentration of diet prior to late pregnancy
  - ✓ 67% of poor quality “husklage” was replaced with a 50/50 mix of high quality corn silage and alfalfa haylage
  - ✓ Ration cost increased by 33%

Improvement of dietary NDF digestibility in flock D and its impact on feed intake and incidence of ketosis in late pregnancy

- Projected flock income due to reduction in ketosis
  - 400 ewes @ 5.8%=22.4
  - 400 ewes @ 1.0%=4.0
  - 18.4 ewes and 32 lambs saved

    18.4x$275 plus 32x$50=**$6660**
- Cost of preventative treatment:
  - Feed cost differential = **$3564**
- Benefit of changing feed to reduce ketosis= **$3096**
- Additional benefits not assigned a $ value:
  - ✓ lambs grew faster
  - ✓ lamb mortality was reduced (birth to pre weaning)
  - ✓ Improved conception in next breeding cycle
  - ✓ Improved sheep welfare!

Prevention of pregnancy toxemia:

- Energy intake day 115 to term:
  - ✓Diet energy density (66%TDN for 200% crop)
  - ✓Feed intake (target 3.0% of body weight)
  - ✓Form of energy can affect intake
    - ➢High starch diet can depress intake, keep corn/barley <40% of energy
  - ✓Digestibility of diet determines intake
    - ➢NDF of total diet <40% for 200% crop
  - ✓Do not place fat ewes on a diet
  - ✓Avoid feed/fast periods: shearing, winter storms

Summary:

- Prolific ewes require a high level of energy nutrition to support fetal growth and prepare for a successful lactation
- Providing this energy content creates challenges in increasing dietary energy density while also maintain a high level of voluntary feed intake (target of 3% of BW).
- A combination of high quality forage and energy supplement are needed to maintain this high level of energy intake. High energy, non-forage fiber sources can also be used to substitute for forage when forage quality is lacking.
- Ketosis can be minimized by formulating diets that allow for a high level of energy intake and by managing ewes so that they are not obese in early pregnancy.

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Treatment of pregnancy toxemia:

- Early detection is key otherwise high mortality
- Provide glucose or glucose precursors
  - ✓ IV dextrose, 500-800 mL 10% dextrose/day
  - ✓ Propylene glycol, oral; 100-200 mL/day
  - ✓ Propylene glycol, malt, electrolyte mixtures
- Glucocorticoid therapy: 20 mg
  - ✓ Terminates pregnancy 2-3 days after administration if given after day 140 pc, will eliminate glucose “drain”
  - ✓ Hastens maturation of fetal lung by stimulating surfactant production
  - ✓ Increases conversion of maternal amino acid pool to glucose