Nutrition and Reproduction in Transition Cows

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Overview- important concepts:

1) **The transition from late pregnancy to the onset of lactation is the most challenging period in the life of a dairy cow – <u>metabolically, health-wise, and nutritionally.</u>**
2) **The interaction of these factors sets the tone for each cows' milk production and reproductive success during lactation.**
3) **We will explore how the interaction of feed intake, energy metabolism and health status during the transition period can exert carry-over effects on reproductive performance of cows.**

Transition Period - Critical for future milk production and reproduction

Feed Intake, metabolism and health

High milk production during lactation

Fertility during breeding period

Periparturient transition period

Cascade of metabolic and physiological changes important for milk production, health and future reproductive performance

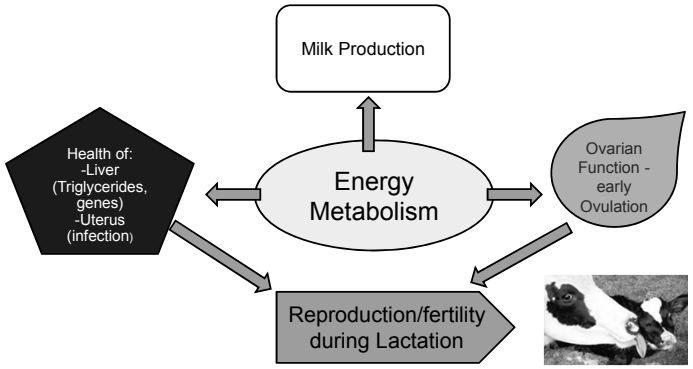
Rapid mobilization of lipid & protein stores for energy metabolism-lactation

Nutrient accrual – body reserves and fetus

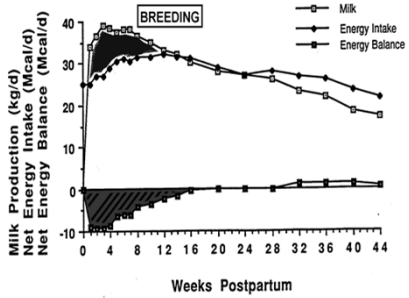
Calving

-3 weeks 0 + 3 weeks

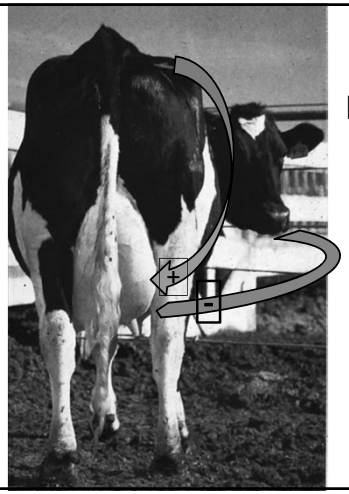
The importance of energy metabolism in the lactating dairy cow



Negative energy balance in early lactation- energy intake lags requirements



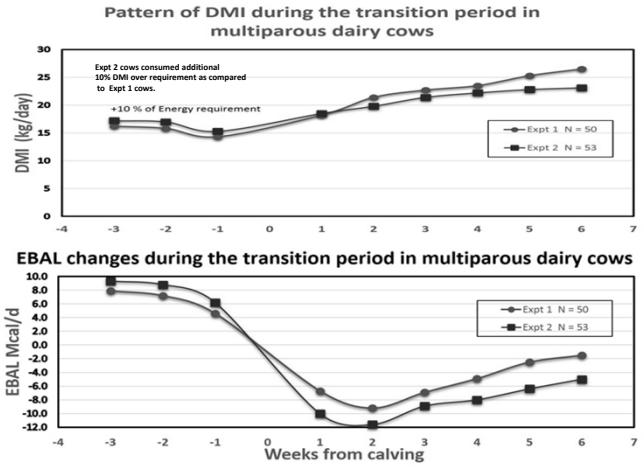
NEBAL during transition period results in marked shifts in metabolic hormones (insulin, IGF-I, GH) and metabolites (low glucose; ↑ NEFA & BHBA)



Negative Energy Balance - NEBAL

Feed energy intake is less than the energy required for milk production plus maintenance and the balance is mobilized from reserves of body fat.

Differences in NEBAL between cows at the same stage of lactation are **most related to differences in DMI.**



Why is DMI already lower for some cows 4 weeks before calving??

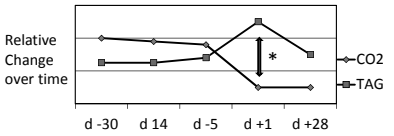
Far-off dry period energy supply carries over and affects metabolism in close-up period:

a. **↑ NEFA**
b. **↑ oxidative stress in liver → ↓ DMI**

Overfeeding energy during the far-off dry period has a greater carry-over effect on peripartum metabolism than differences in close-up period.

-During first 10 DIM, cows fed 80-100% NRC had ↑DMI, ↑EBAL, ↓NEFA & BHBA compared to 150%. #4563

Excessive energy intake (150%) during far-off period ↓ liver oxidation of NEFA to CO2 (by 20%) and ↑ esterification (1.8X) to triacylglycerol (TAG)*. #3764



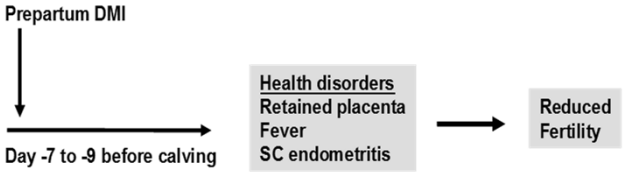
Dietary strategies during the dry period to reduce NEBAL

- Goal – meet, but do not exceed energy requirements by more than10-20% in far-off or close-up dry period.
- Control energy intake via high-bulk diets (straw):
  ~1.3 Mcal NEL/kg DM = ~15 Mcal/d/cow. Must meet requirements for protein, minerals & vitamins.

Or

- Limit feeding of higher energy diet.
  - Limit feeding difficult to manage successfully when heifers and cows are co-mingled in pens with social and behavioral interactions.

Prepartum DMI and Health



- **1-2 weeks pre-calving**
  - **Following fresh feed**
  - **⇓ Time eating**
  - **⇓ DMI**

1 kg ⇓ = 3X risk for metritis

➢**Social behavior and interactions affects transition cow health**

Prepartum decreases in DMI and energy balance are associated with postpartum health problems that impact fertility

- 1-2 weeks prepartum, cows that will develop uterine disease had ↓ DMI, ↑ NEFA, and ↓ neutrophil function.
- Prepartum NEFA provides monitoring tool for risks of RP, metritis and reduced pregnancy rate during lactation.
- ↑ NEFA during transition is associated with signs of **liver inflammation**, perhaps **via oxidative stress**, that may promote metabolic disorders.
- **Uterine inflammation** at calving is exacerbated by **NEBAL** and alters uterine involution ie. subclinical endometritis → delayed Ov and pregnancy.

Detrimental effects of NEFA and BHB during transition on future reproductive performance

Higher prepartum NEFA & BHBA → ↑ RP and other diseases. Qu, Y., A. N. Fadden, M. G. Traber, and G. Bobe. Potential risk indicators of retained placenta and other diseases in multiparous cows. J Dairy Sci 97 (7):4151-4165, 2014.

↑ NEFA & ↑ BHBA during transition period:

→ 13-20 % **decrease in risk of pregnancy during breeding**.

Large field study with 91 herds & 2250+ cows. Ospina, P. A., D. V. Nydam, T. Stokol, and T. R. Overton. Associations of elevated nonesterified fatty acids and beta-hydroxybutyrate concentrations with early lactation reproductive performance and milk production in transition dairy cattle in the northeastern United States. J.Dairy Sci. 93 (4):1596-1603, 2010.

→ 1.9X ↑ risk of metritis, 1.7X risk of RP, ↓ risk of pregnancy 1st AI, 23% ↑ time to pregnancy. Meta-analysis. Abdelli, A., D. Raboisson, R. Kaidi, B. Ibrahim, A. Kalem, and M. Iguer-Ouada. Elevated non-esterified fatty acid and beta-hydroxybutyrate in transition dairy cows and their association with reproductive performance and disorders: A meta- analysis. Theriogenology 93:99-104, 2017.

Prepartum decreases in DMI and energy balance are associated with postpartum health problems that impact fertility

- 1-2 weeks prepartum, cows that will develop uterine disease had ↓ DMI, ↑ NEFA, and ↓ neutrophil function.
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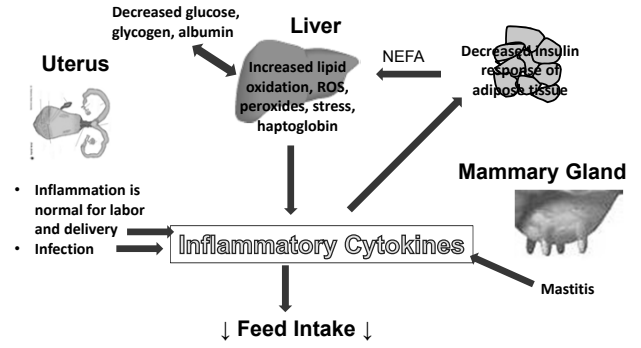
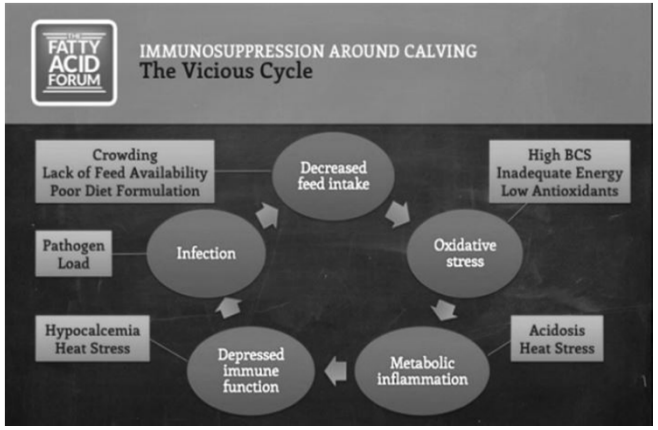
Liver metabolism during transition period

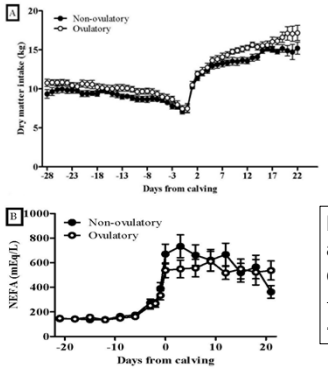
- Liver adaptation to increased availability of NEFA is increased lipid oxidation for energy.
- First step produces reactive oxygen species (ROS) that can form lipid peroxide.
- **Perhaps via oxidative stress, peroxides can trigger liver inflammation**, decreased DMI and shifts in liver metabolism of carbohydrates and lipids that may lead to metabolic disorders.
- Healthy liver – increased glucose (gluconeogenesis), glycogen and albumin (-APP).
  - with inflammation, decreases in these, increased +APP and accumulation of triglycerides.

Inflammation is common in transition cows





Peripartum changes in DMI associated with reproductive performance

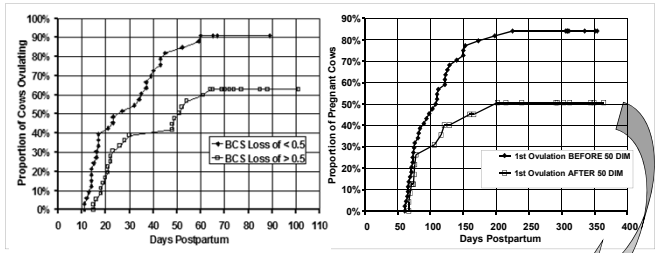


As early as 4 weeks prepartum, differences in DMI and NEBAL (↑NEFA) are apparent in cows that develop OV *vs.* NOV follicles during first 3 weeks postpartum.

Why is this important??

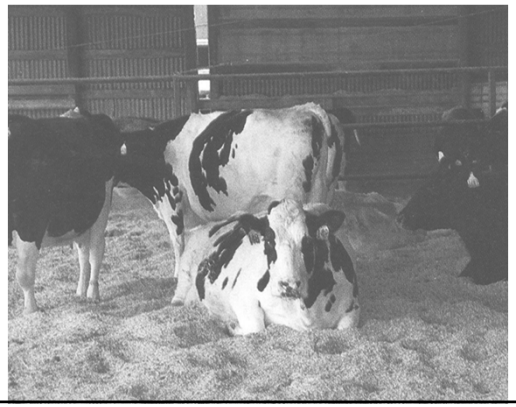
Early ovulation during lactation is associated with higher fertility later during the breeding period.
→ ↑ uterine environment (progesterone**)**
- associated ↑ metabolic signals (IGF-I**)**

Early NEBAL & BCS loss delays first ovulation and relates to poor fertility/increased risk of culling



Culling

Metabolic effects on ovarian follicular development begin during the dry period!

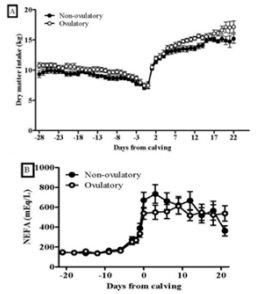


<u>Prepartum</u> differences in dry matter intake (DMI), energy balance and metabolic hormones are associated with <u>postpartum follicle outcome</u>

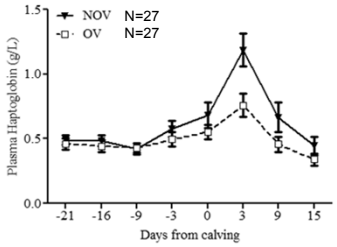
- Not surprising, if we consider that full follicular development requires many weeks (60-80 days) for completion *ie.* does not just begin after calving.

Peripartum changes in DMI associated with reproductive performance

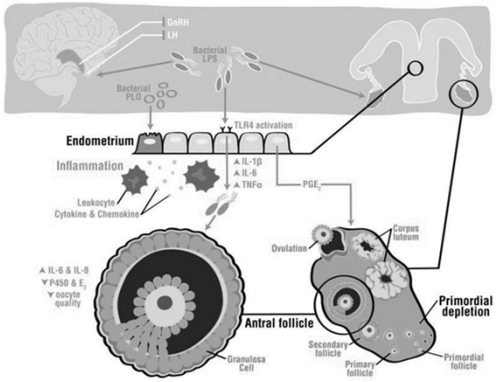
↓ DMI ↑NEBAL/NEFA



Hepatic acute phase response – Haptoglobin
- Ovulatory vs. Nonovulatory follicles



Uterine infection links with infertility in dairy cows



Bromfield et al., 2015 JAS 93:2021-2033

From calving to breeding, both uterine disease/inflammation or non-uterine diseases/inflammation reduce fertility after insemination

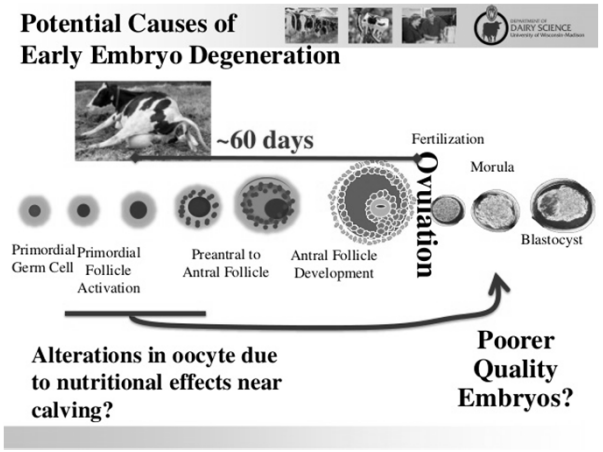
- Uterine disease/inflammation affects both developing oocytes in ovarian follicles and the uterine environment -- site of embryo development.
- Non-Ut disease at either preantral or antral follicle stage → ↓ pregnancy rate.

  -suggests reduced oocyte competence as the most likely effect.

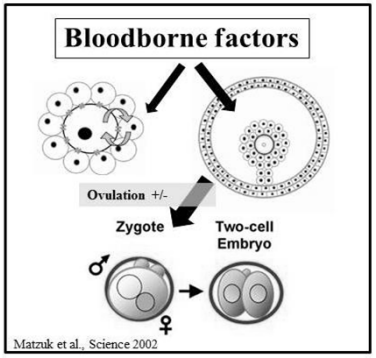
UT Disease = Ret. Placenta & metritis
NUT Disease = Mastitis, lameness, digestive & respiratory diseases

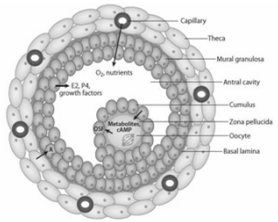
E. S. Ribeiro, A. P. A. Monteiro, R. S. Bisinotto, F. S. Lima, L. F. Greco, A. D. Ealy, W. W. Thatcher, and J. E. P. Santos. Conceptus development and transcriptome at preimplantation stages in lactating dairy cows of distinct genetic groups and estrous cyclic statuses. *J Dairy Sci 99 (6):4761-4777, 2016.*

Potential Causes of Early Embryo Degeneration



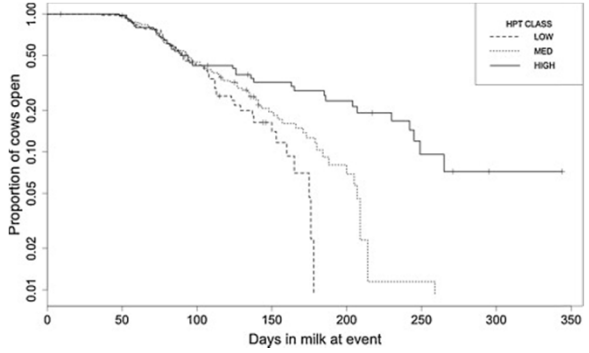
Blood born factors related to inflammation can transfer into follicular fluid to affect oocyte growth and viability, ovulation and embryo survival





Krisher, R.L. Ann. Rev. Anim. Biosci. 1:393, 2013

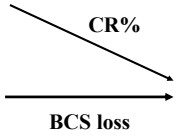
Survival curves for days to conception associated with plasma concentrations of haptoglobin (low, medium or high) following calving (d 2-8) in clinically healthy multiparous dairy cows (n=240)



Relationships between negative energy balance (NEBAL), body condition score (BCS) and conception rate (CR) to first insemination in high producing dairy cows

High milk production and NEBAL results in tissue mobilization and BCS loss.

Greater BCS loss during early lactation lowers fertility to insemination



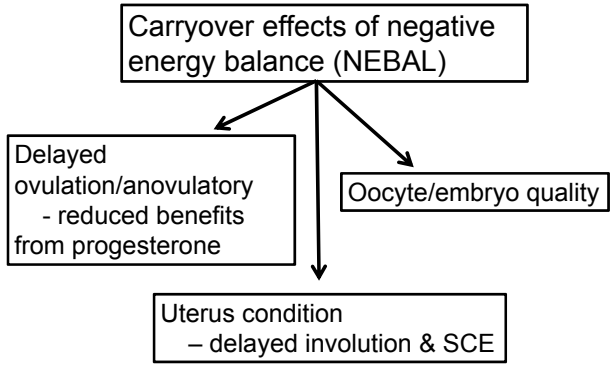
BCS change from calving to AI (70 DIM; 6400 cows)

	Pregnancy %	Odds Ratio	Pregnancy loss, %
≥ 1 unit	28	Referent	20.5
< 1 unit	37	1.4	14.5
No Change	42	1.7	10.7

Santos et al., An.Reprod.Sci. 110:207, 2009

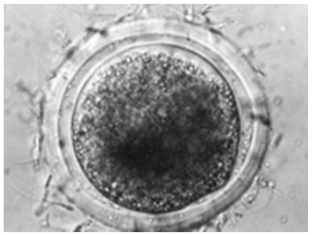
CR % among quartiles milk yield to 90 DIM – *NS*

Low fertility to AI in lactating dairy cows

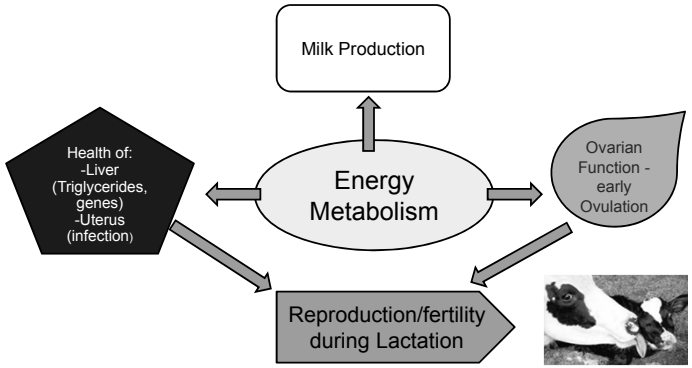


Effects of energy metabolism and/or inflammation on fertility to insemination

Oocyte health and embryo quality



The importance of energy metabolism in the lactating dairy cow



Take Home Message- 1

- Metabolic changes in periparturient cows associated with the onset of **negative energy balance** appear most responsible for the detrimental effects on both health and reproductive performance.
- Negative energy balance related to decreased **DMI** during early lactation is the **major nutritional link to low fertility** in lactating dairy cows.
- Negative energy balance delays recovery of postpartum reproductive function and exerts carryover effects (BCS, oocytes, uterus) that reduce fertility during the breeding period.

2 - What Nutritional Strategies Benefit Reproductive Performance in cows?

- Dry period feeding – Limit dietary energy intake throughout to maintain moderate BCS (~3.0) at calving; At requirement level.
- Advantages or Benefits:
  - **To minimize ↓ DMI prior to and at calving**
  - To minimize ↑ NEFA pre- and postpartum
  - To minimize negative effects on liver metabolism of NEFA – ↓ metabolic inflammation
  - To facilitate ↑ glucose production by liver for ↑ milk production
  - To minimize ↓ immune function that ↑ risk of infection/inflammation
- Dietary strategies prepartum to minimize hypocalcemia postpartum.
  - Feed low calcium diet
  - Feed anionic salts to optimize DCAD ratio
- What about feeding fat supplements??

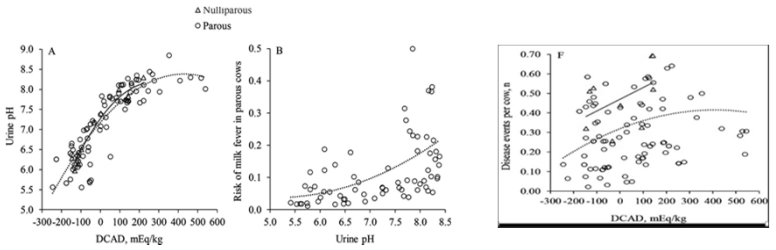
Effects of dietary fat or fatty acids on fertility in dairy cattle

- Overall, including fats in transition diets improves fertility: pregnancy to insemination ↑ 27% & calving to pregnancy interval ↓16%. Limited number of studies precludes pinpointing specific fatty acids. Rodney, R. M., P. Celi, W. Scott, K. Breinhild, and I. J. Lean. Effects of dietary fat on fertility of dairy cattle: A meta-analysis and meta-regression. J Dairy Sci. 98 (8):5601-5620, 2015.
  - Many studies have shown mixed effects and raise a general concern – high lipid load from late pregnancy until calving, no matter if stored, mobilized or fed, affects the endocrine system, metabolism and ↓ DMI → ↑ risk for metabolic disorders PP. B. Kuhla, C. C. Metges, and H. M. Hammon. Endogenous and dietary lipids influencing feed intake and energy metabolism of periparturient dairy cows. Domest.Anim Endocrinol. 56 Suppl:S2-S10, 2016.
- Feeding n-3 Fatty Acids PP: fish oil (Ca salts > 30 DIM) or rumen-protected n-3 FA (0-60 DIM) → ↓ pregnancy losses after AI to → ↑ % pregnant. Silvestre, F.T., T. S. Carvalho, N. Francisco, J. E. Santos, C. R. Staples, T. C. Jenkins, and W. W. Thatcher. Effects of differential supplementation of fatty acids during the peripartum and breeding periods of Holstein cows: I. Uterine and metabolic responses, reproduction, and lactation. J Dairy Sci. 94 (1):189-204, 2011;
- S. Elis, S. Freret, A. Desmarchais, V. Maillard, J. Cognie, E. Briant, J. L. Touze, M. Dupont, P. Faverdin, V. Chajes, S. Uzbekova, P. Monget, and J. Dupont. Effect of a long chain n-3 PUFA-enriched diet on production and reproduction variables in Holstein dairy cows. Anim Reprod.Sci. 164:121-132, 2016.
- CLA

Meta-analysis of the effects of prepartum dietary cation-anion difference on performance and health of dairy cows - DCAD

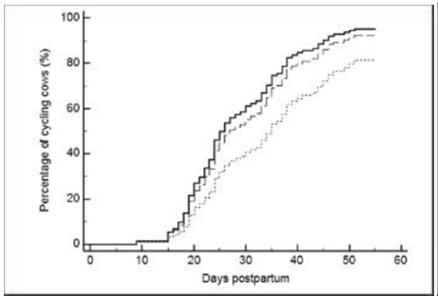
J.E.P. Santos, I.J. Lean, H. Golder, E. Block J Dairy Sci DOI: 10.3168/jds.2018-14628 Results from 42 Experiments

Feeding negative DCAD diet prepartum benefits Milk Production and DMI Postpartum and reduces disease events (RP, Metritis, DA and Milk Fever)



Lower Disease Events and Inflammation → Improved Fertility during Breeding Period

L. S. Caixeta, P. A. Ospina, M. B. Capel, and D. V. Nydam. Association between subclinical hypocalcemia in the first 3 days of lactation and reproductive performance of dairy cows. *Theriogenology 94:1-7, 2017.* *Used 97 cows in 2 NY herds*



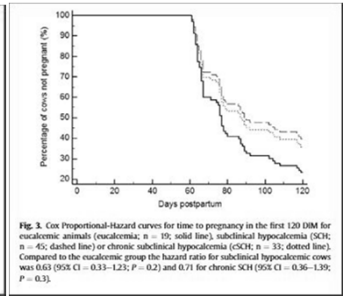


Fig. 3. Cox Proportional-Hazard curves for time to pregnancy in the first 120 DIM for eucalcemic animals (eucalcemia; n = 19; solid line), subclinical hypocalcemia (SCH; n = 45; dashed line) or chronic subclinical hypocalcemia (cSCH; n = 33; dotted line). Compared to the eucalcemic group the hazard ratio for subclinical hypocalcemic cows was 0.63 (95% CI = 0.33–1.23; $P = 0.2$) and 0.71 for chronic SCH (95% CI = 0.36–1.39; $P = 0.3$).

Milk production record-2016 FOCUS on DMI at calving

Can you imagine Gigi's feed intake/DMI capability and pattern after calving?? ~Minimum 90 lb DMI/d avg. What is the likelihood Gigi had PP health problems??

- Bur-Wall Buckeye Gigi, produced 74,650 pounds of milk with 2,126 pounds of fat and 2,142 pounds of protein- 365d.
  - 204 lbs milk/d average.
- Gigi achieved this as a nine-year-old, after a 61,000 pound record as an eight-year-old.

Questions???