Reproduction of Dairy Cows:

How Much Depends on Mineral and Vitamin Intake?

PennState Extension

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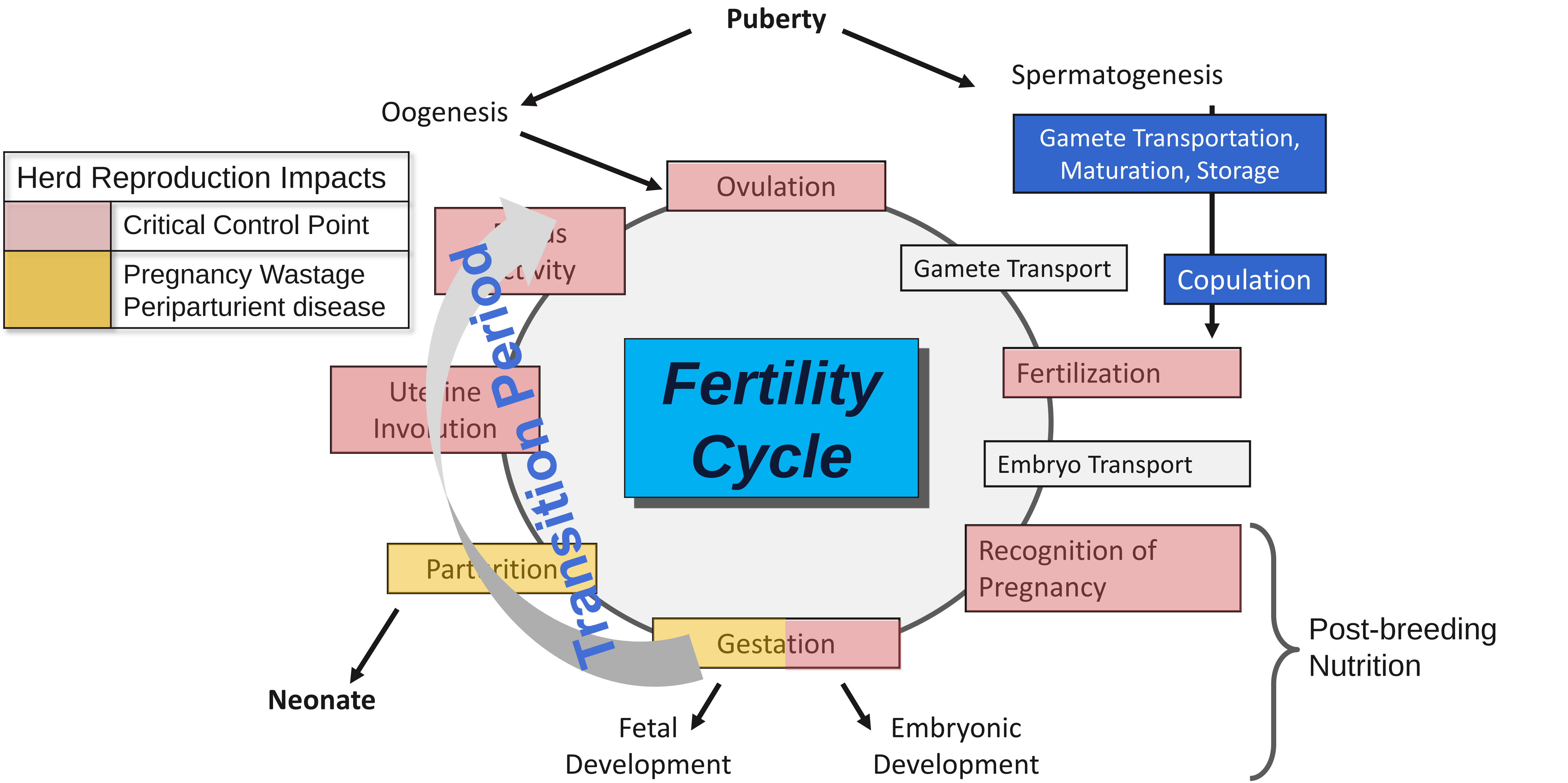
Sponsored by Josera Polska

Presentation Outline

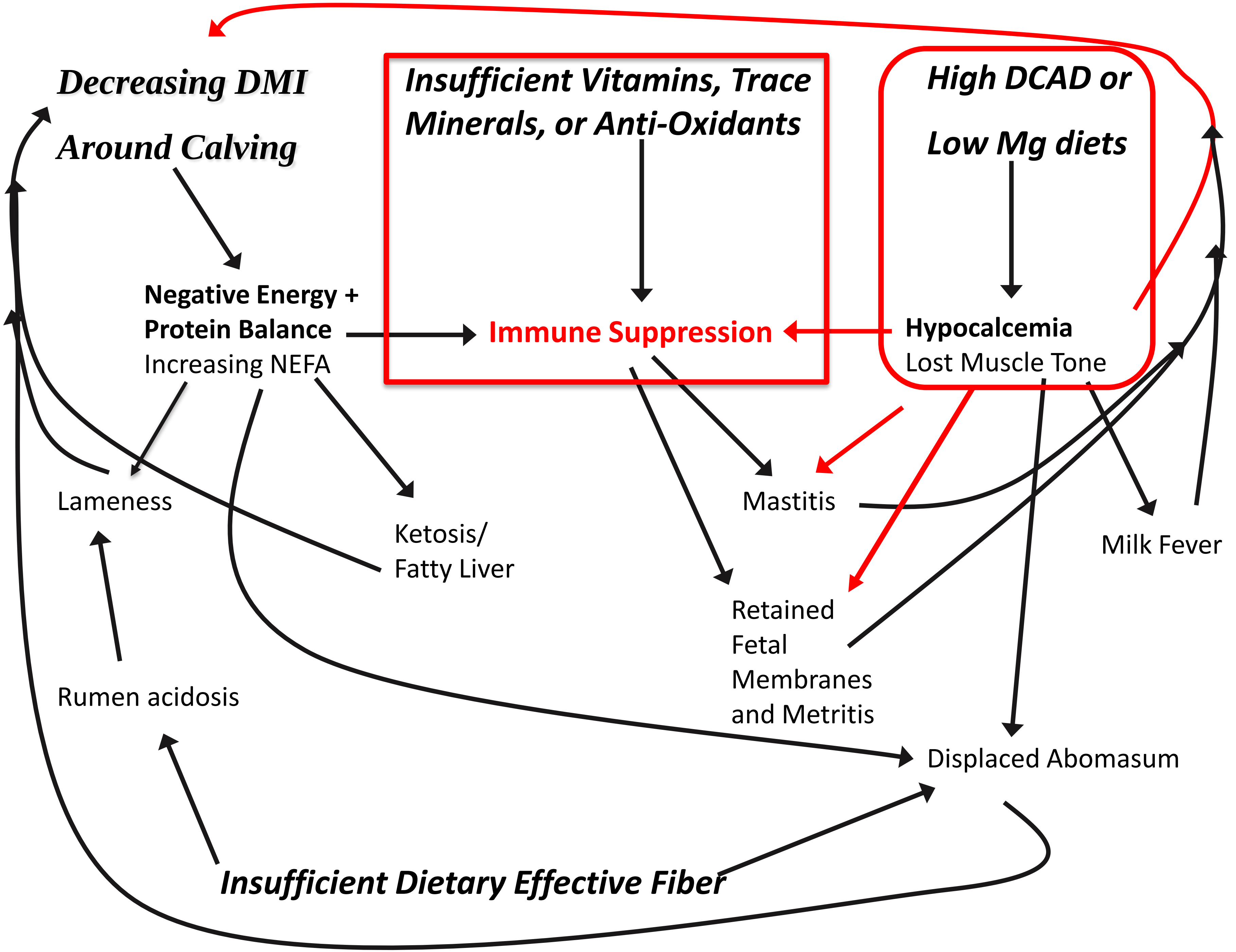
- Address the critical control points of transition success with emphasis on role of micronutrients
- Provide background information on micronutrient metabolism and physiology during transition
- Establish potential relationship between micronutrient status on maternal and fetal health
- Explore opportunities for micronutrient status enhancement

Transition Period Goals

- Support high (efficient) milk production
- Minimize loss (<0.5 units) or maintain BCS postpartum
- Low prevalence of postparturient diseases
- Maintain immunocompetency to pathogens and minimize inflammation
- Control/decrease days to first ovulation and maintain or enhance fertility
- Low stillborn rate and healthy calves



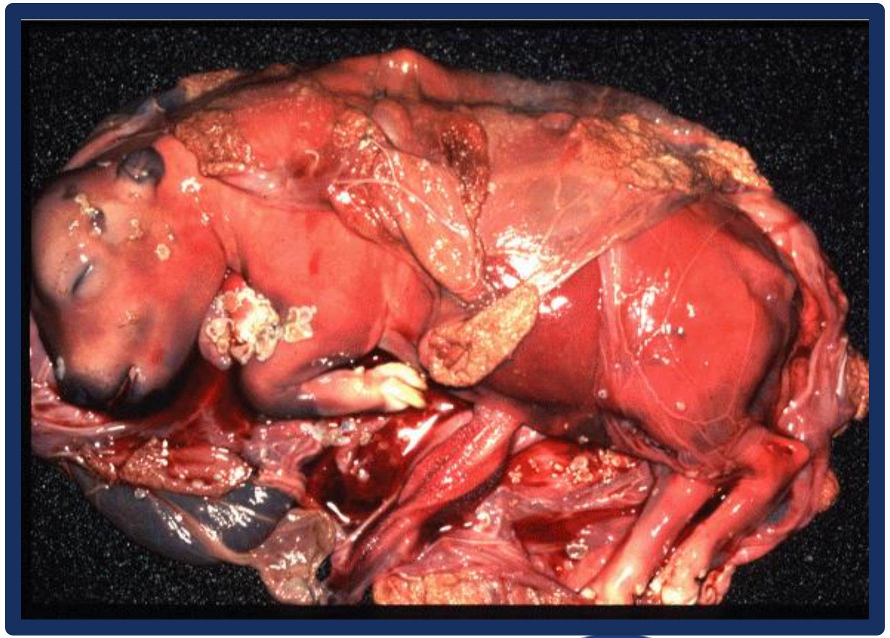
Van Saun, 1992



Goff, WBC 2016

Transition Mineral Status

- Fetal abortion and stillbirth are significant pregnancy wastage events
- Diagnostic efficiency for abortion or stillbirth cases is low (<45%)
- ***What role does nutrition play in these losses?***



Abortion diagnostics included necropsy, histopathology, bacteriology, virology, and other immunologic and serologic tests. A specific cause was identified in 29.5% (468 total cases) of the abortions.

J Vet Diagn Invest 2:283-287 (1990)

A survey of causes of bovine abortion occurring in the San Joaquin Valley, California

Mark L. Anderson, Pat C. Blanchard, Bradd C. Barr, Rick L. Hoffman

Wolf-Jäckel *et al. Acta Vet Scand* (2020) 62:1
https://doi.org/10.1186/s13028-019-0499-4
Acta Veterinaria Scandinavica

RESEARCH Open Access

Diagnostic studies of abortion in Danish cattle 2015–2017

Check for updates

Etiology of the abortion was diagnosed in 52 cases, resulting in a diagnostic rate of 33%.

At least one potential causal agent of abortion or perinatal mortality was detected in 39% of 4006 cases. Despite extensive diagnostic testing, an etiological diagnosis was not reached in 61 % of cases, highlighting the need for even more extensive (non-)infectious disease testing or more accurate tests.

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Contents lists available at ScienceDirect
Preventive Veterinary Medicine
journal homepage: www.elsevier.com/locate/prevetmed

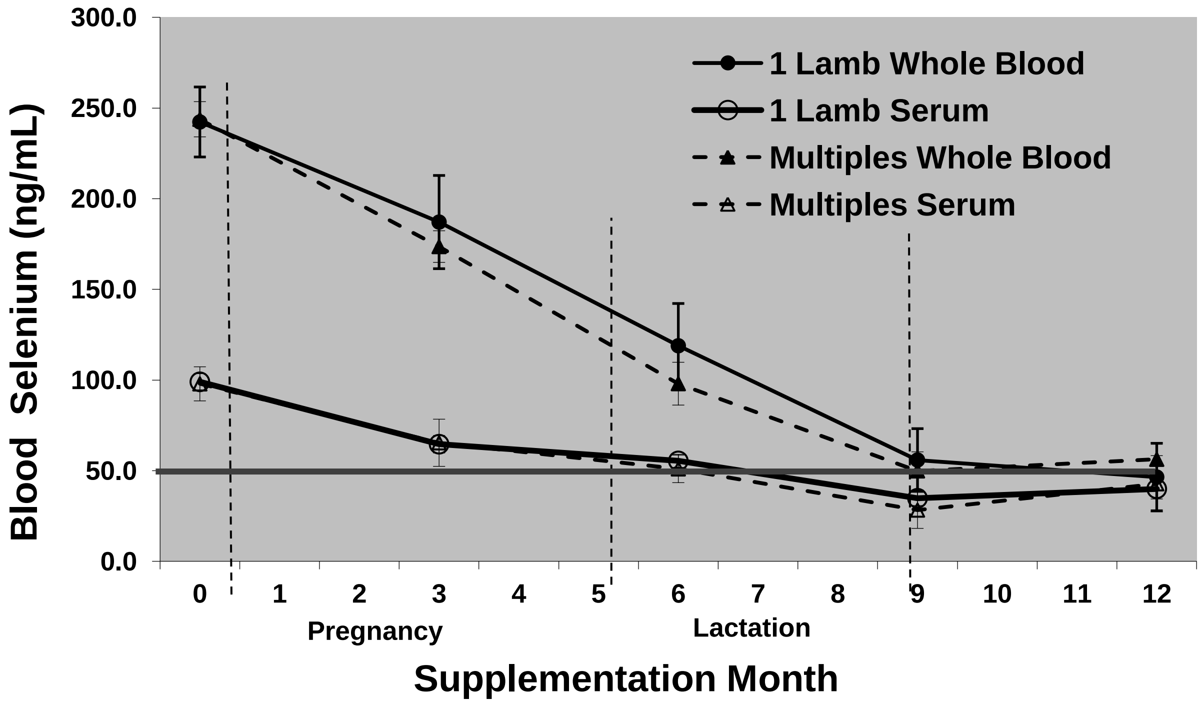
Retrospective study of factors associated with bovine infectious abortion and perinatal mortality

Check for updates

H. Van Loo [a,*], O. Bogado Pascottini [a,b], S. Ribbens [c], J. Hooyberghs [d], B. Pardon [e,1], G. Opsomer [a,1]

Vitamin and Mineral Nutrition

- Macro- and Microminerals
  - Efficiently cross placenta
  - Fetal liver – storage
  - Colostrum – concentrated
- Fat soluble vitamins
  - Do not cross placenta
  - Colostrum – concentrated
  - Physiologic decline around calving
- Drain on maternal status?
- Adverse effect on immune function?



Peripartum Vitamin Status

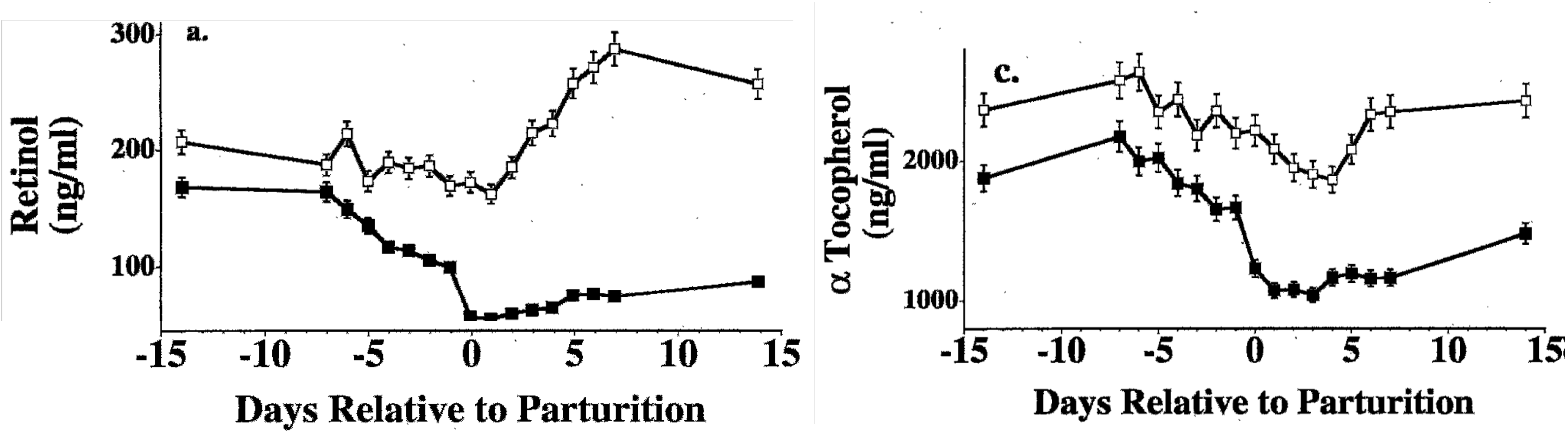


Figure 4. Plasma retinol (a), *β*-carotene, and *α*-tocopherol concentrations in intact ■(n = 8;) and mastectomized (n = 10; □) cows during the periparturient period.

Goff et al., JDS 2002

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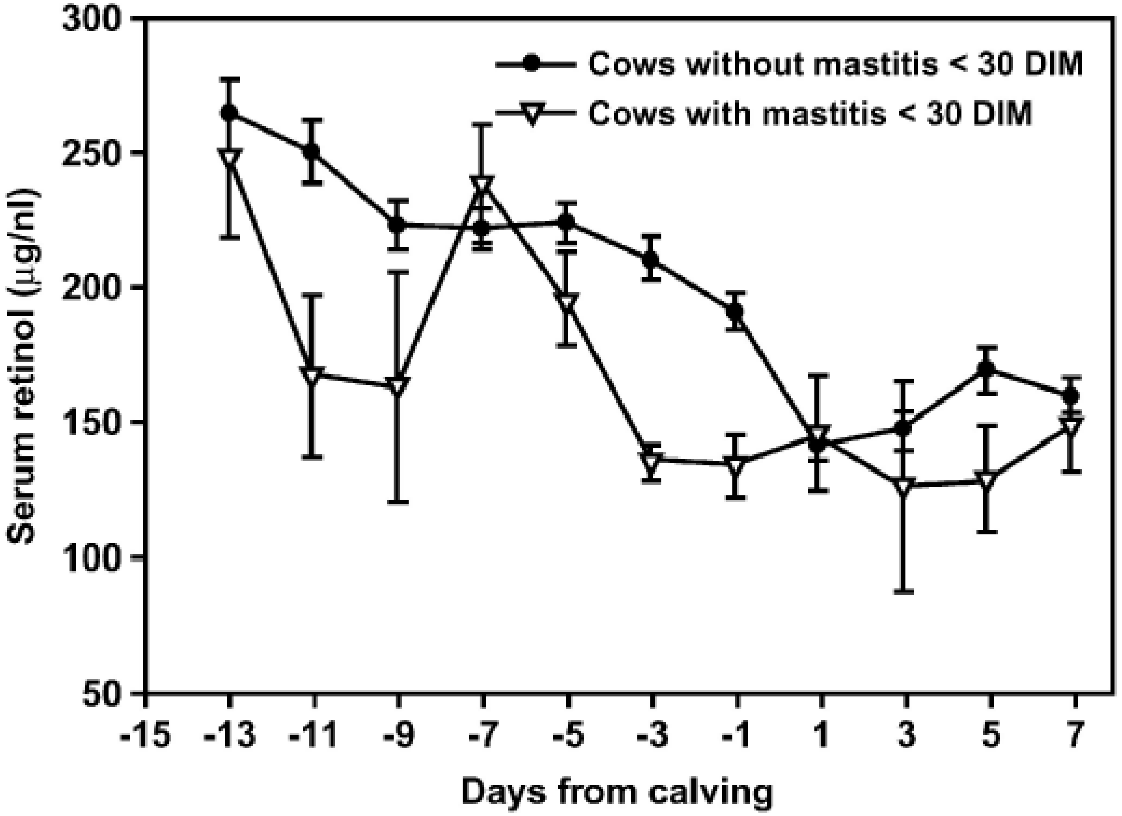
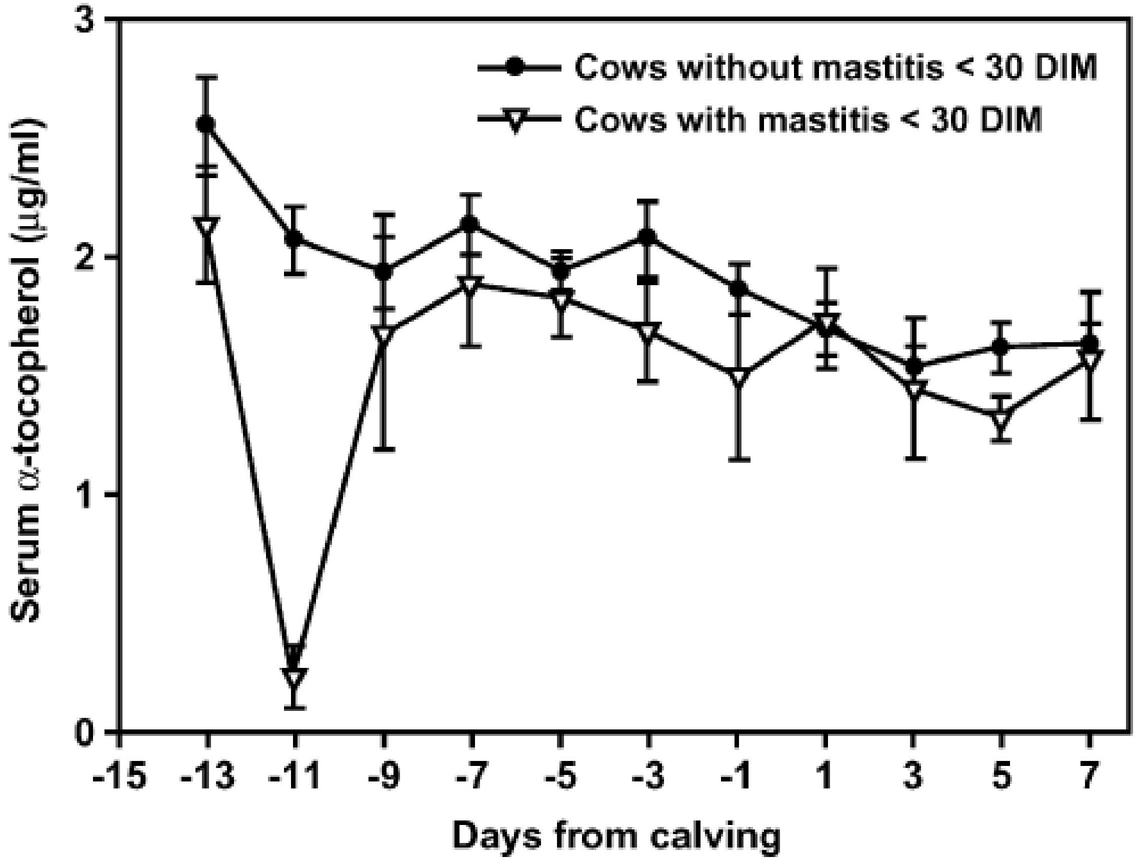
Vitamin A and Mastitis



- Survey study of 1057 cows over 1 year period
- Increasing serum retinol by 100 ng/mL was associated with 60% decrease in clinical mastitis in first 30 DIM
- Measured last week of pregnancy

LeBlanc et al., JDS 2004; 87:609-619

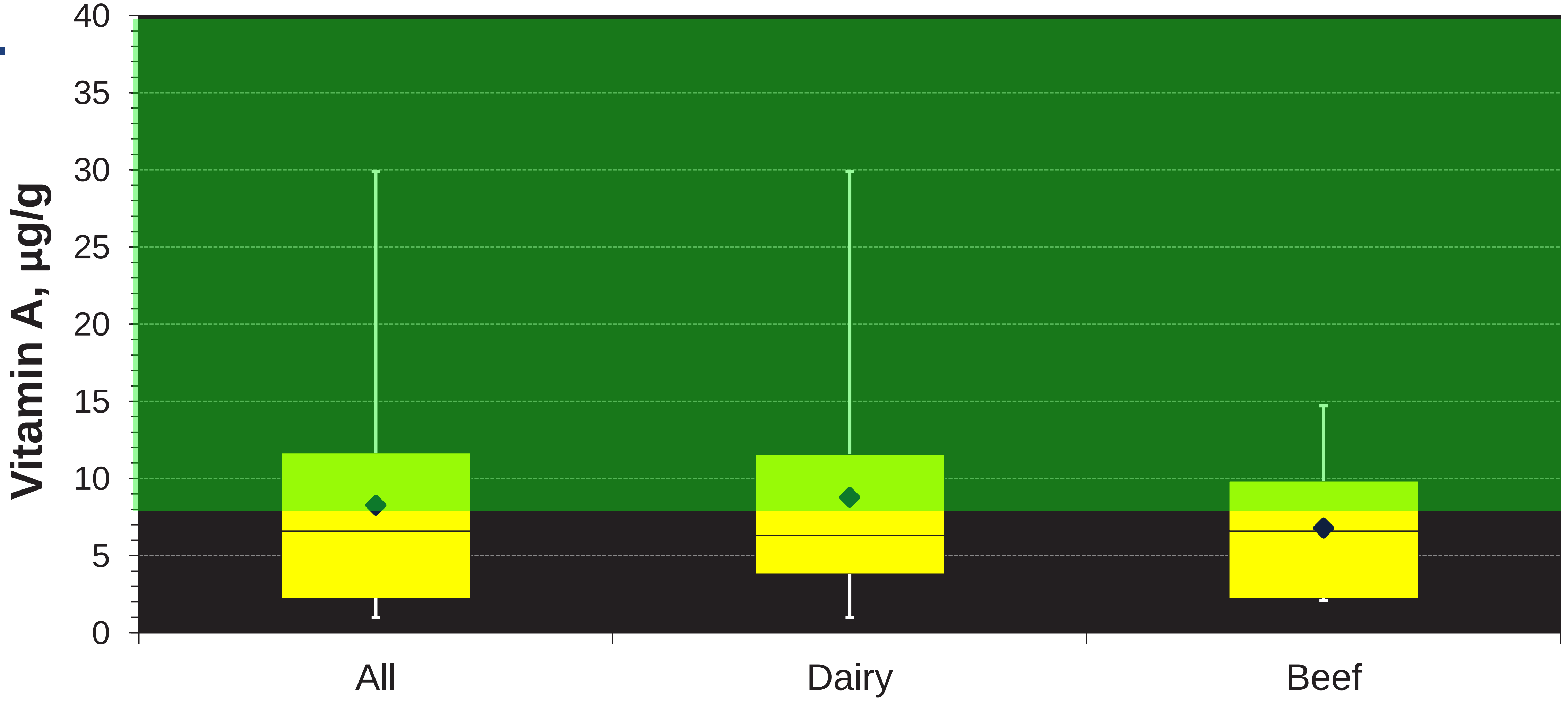
Vitamin E and Mastitis



- Serum vitamin E was lower in cows that had clinical mastitis within 30 DIM
- Increasing serum vitamin E 1 µg/mL reduced risk of retained placenta
- No effect on mastitis

LeBlanc et al., JDS 2004; 87:609-619

Vitamin A and Stillbirth



Van Saun, 2016

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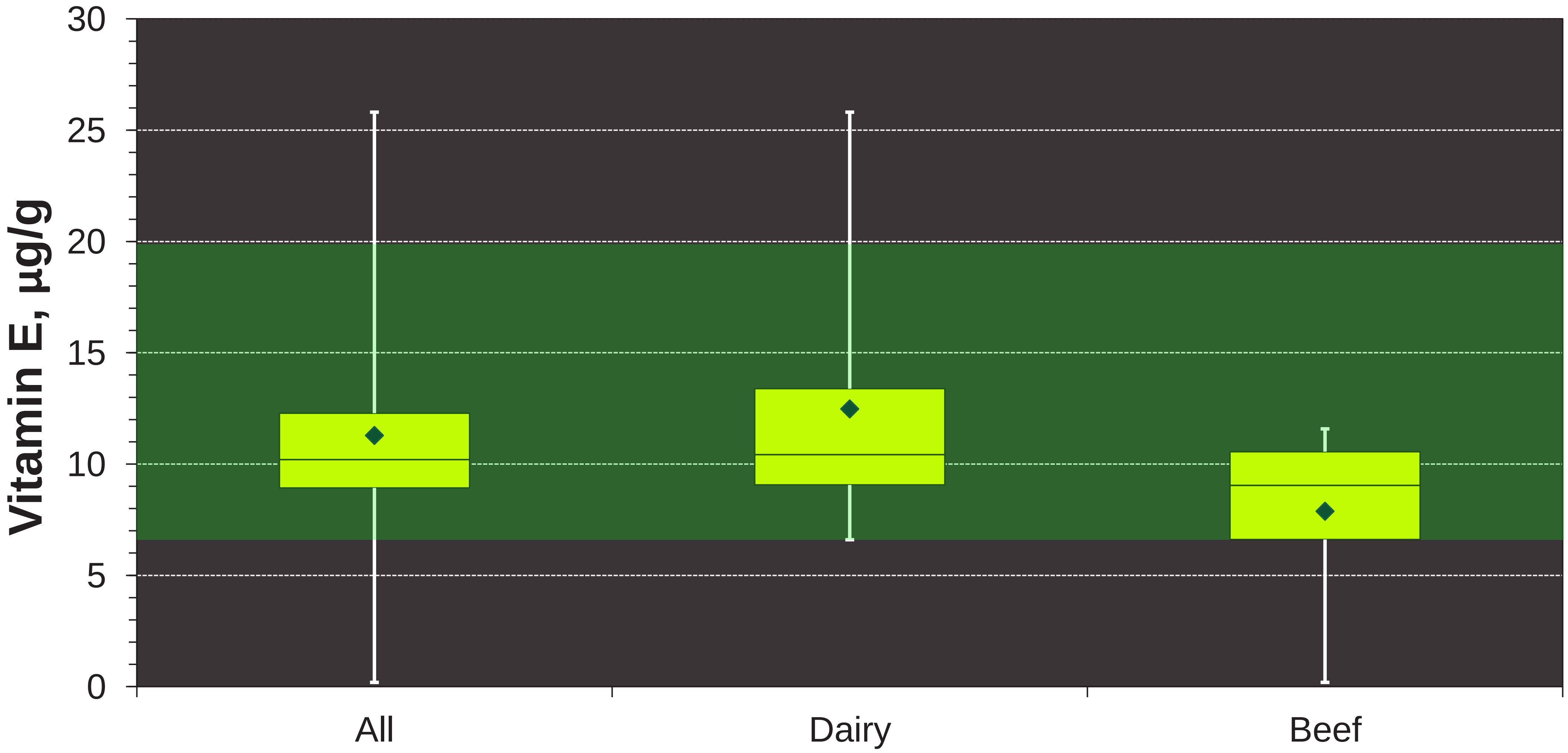
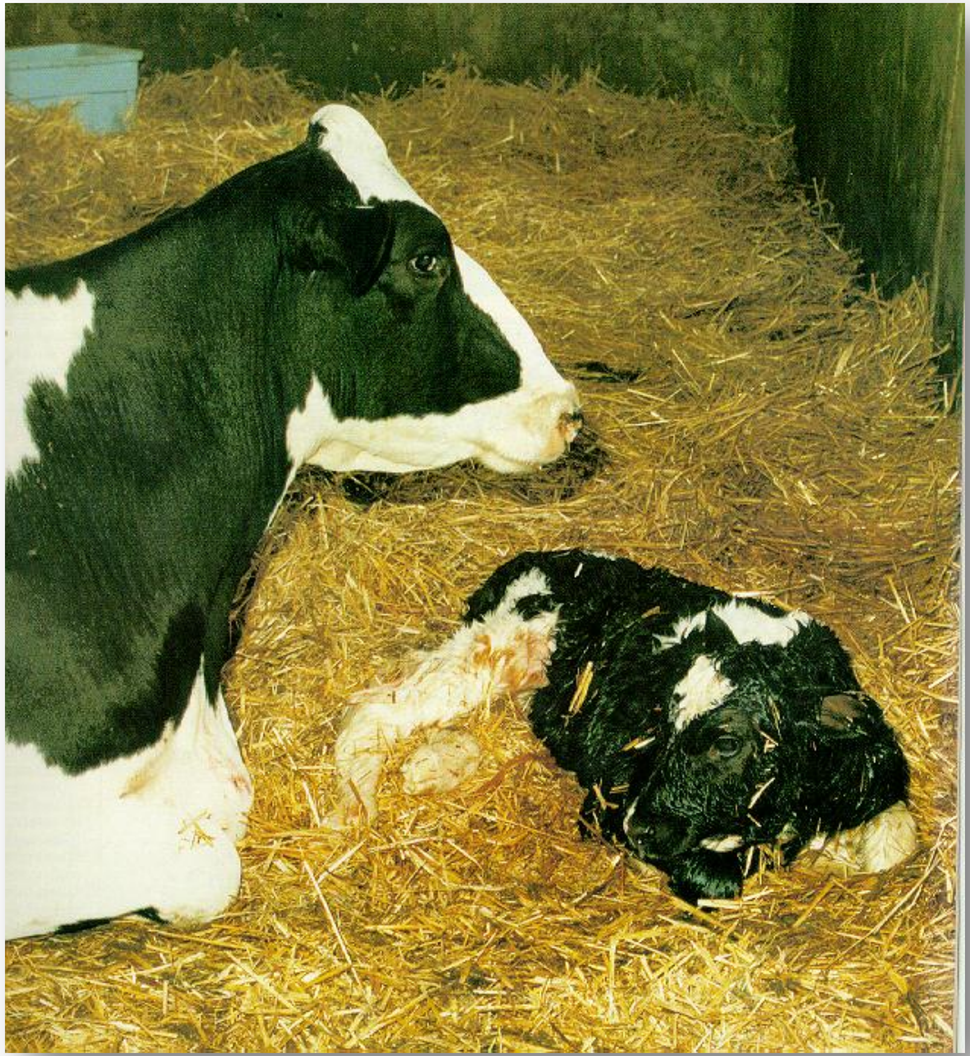
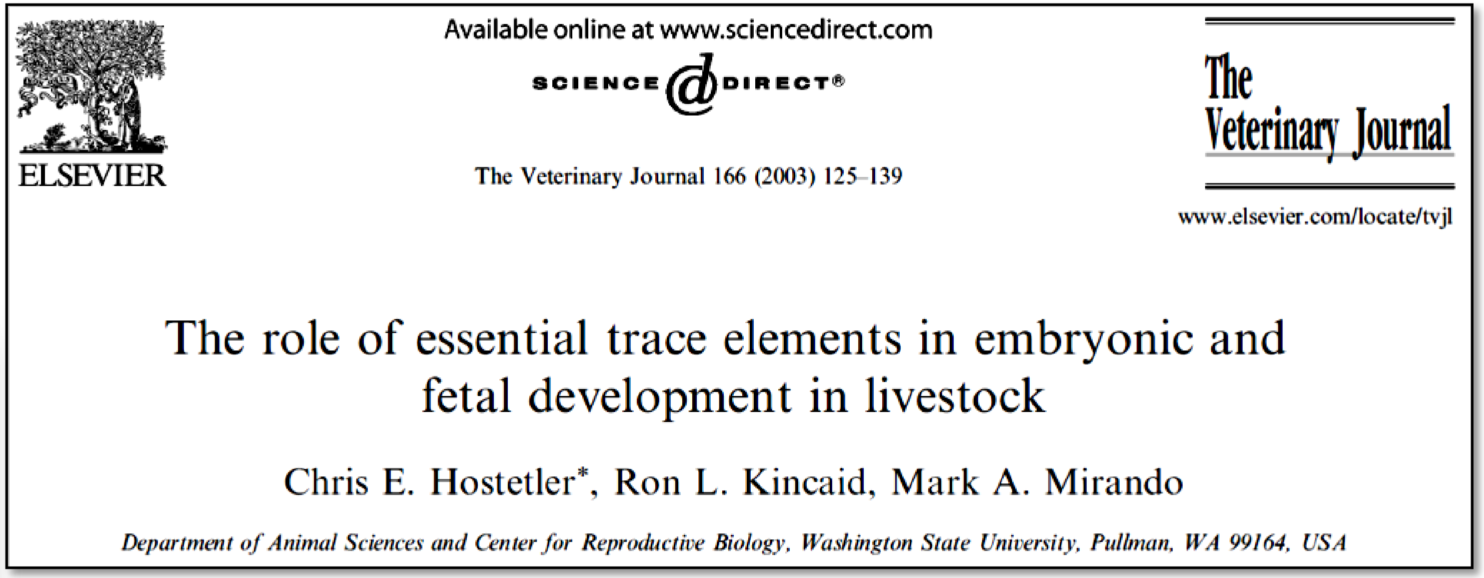
Vitamin E and Stillbirth



Van Saun, 2016

Perinatal Mineral Status

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The Veterinary Journal 166 (2003) 125–139

The Veterinary Journal

www.elsevier.com/locate/tvjl

The role of essential trace elements in embryonic and fetal development in livestock

Chris E. Hostetler*, Ron L. Kincaid, Mark A. Mirando

Department of Animal Sciences and Center for Reproductive Biology, Washington State University, Pullman, WA 99164, USA

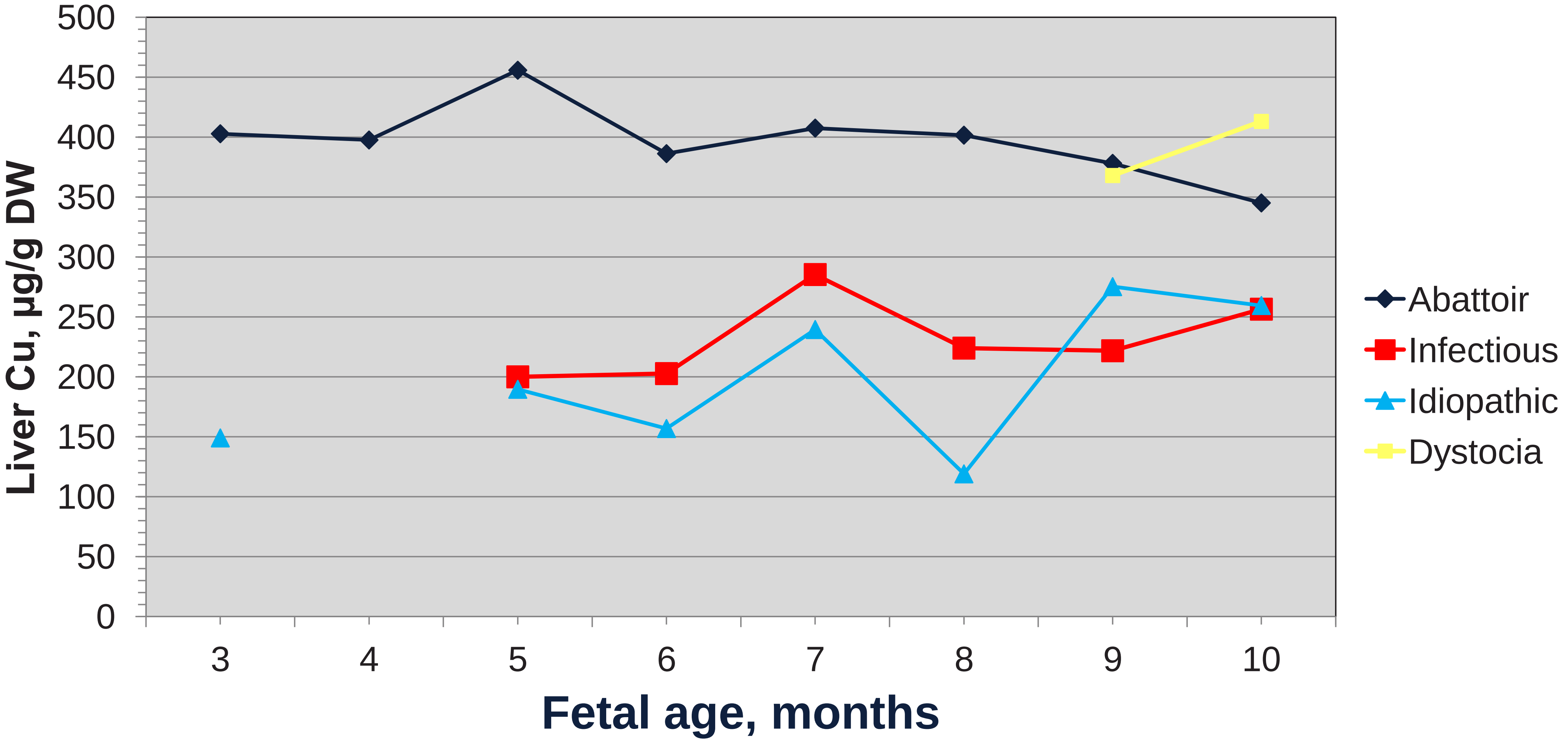
Dependent Upon:

- Placental Transfer
- Colostrum
- Maternal Nutrient Status

Bovine Fetal Hepatic Trace Mineral Concentration (µg/g dry weight)

Mineral	JVDI 1994;6		Van Saun, 2010		Bell and House, 1995	Adult Cow
	Abattoir	Abortion	Abattoir	Abortion		
Copper	438.3	207.3	403.6	253.2		100-400
Iron	1402.5	700.6	1110.9	748.1		125-900
Manganese	9.19	3.29	6.02	4.0		9-12
Selenium			2.6	1.5	2.1	0.7-2.5
Zinc	927	359.4	807.6	414.0		100-600

Abortion Sample Comparison



Van Saun, 2018

Mineral Comparisons

NRC 2021, Dairy Cattle Requirements

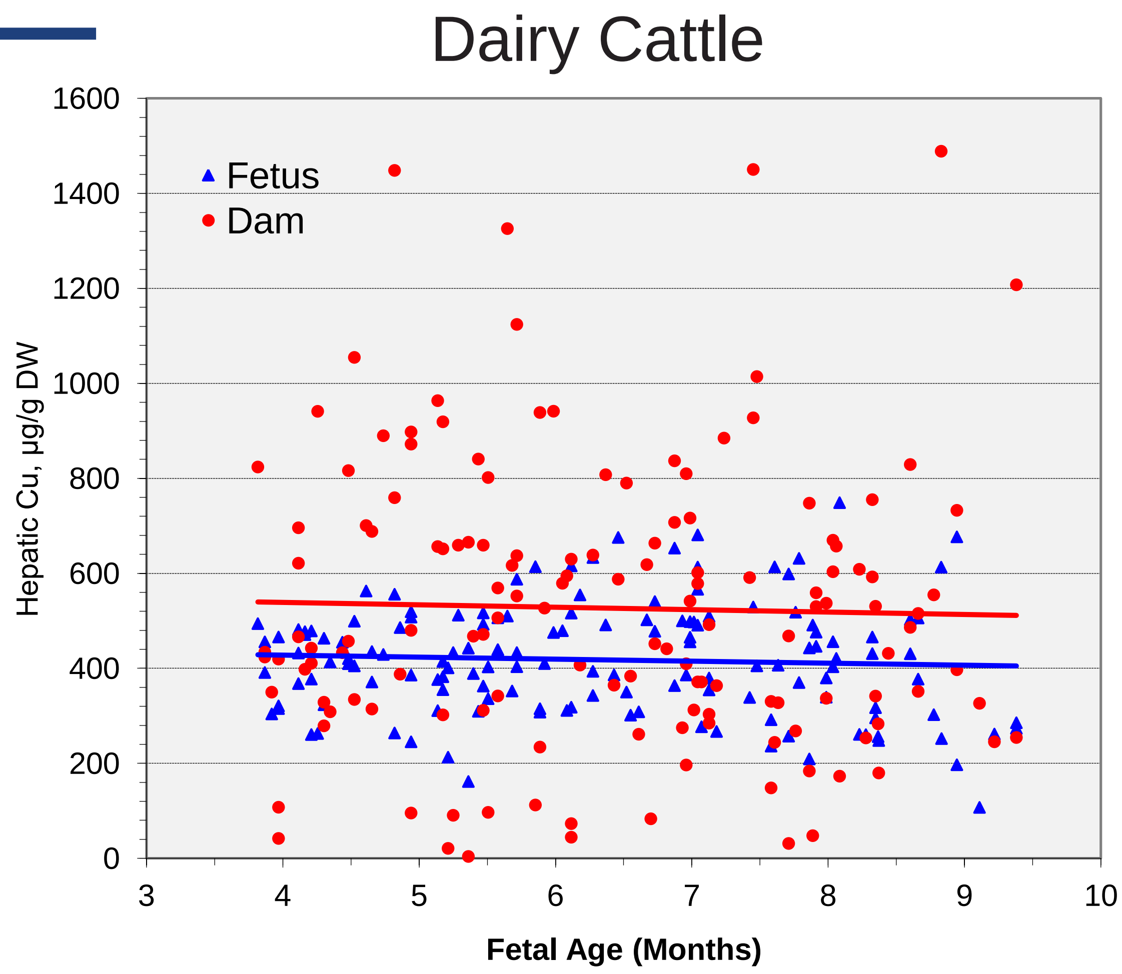
Mineral	Units	Requirement		Milk	Colostrum
Total Solids	g/100 g	100	13	12.5	23.9
Calcium	g/100 g	1.0	0.13	0.12	0.26
Phosphorus	g/100 g	0.70	0.09	0.10	0.17
Magnesium	g/100 g	0.07	0.009	0.01	0.04
Potassium	g/100 g	0.65	0.085	0.115	0.14
Sodium	g/100 g	0.40	0.052	0.033-0.048	0.07-0.14
Copper	mg/kg	10	1.3	0.03-0.06	0.06-0.39
Iron	mg/kg	100	13	0.1-0.4	0.2-2.0
Manganese	mg/kg	40	5.2	0.012-0.05	0.02-0.09
Selenium	mg/kg	0.3	0.039	0.018-0.04	0.04-0.056
Zinc	mg/kg	40	5.2	0.30	1.2-17.2

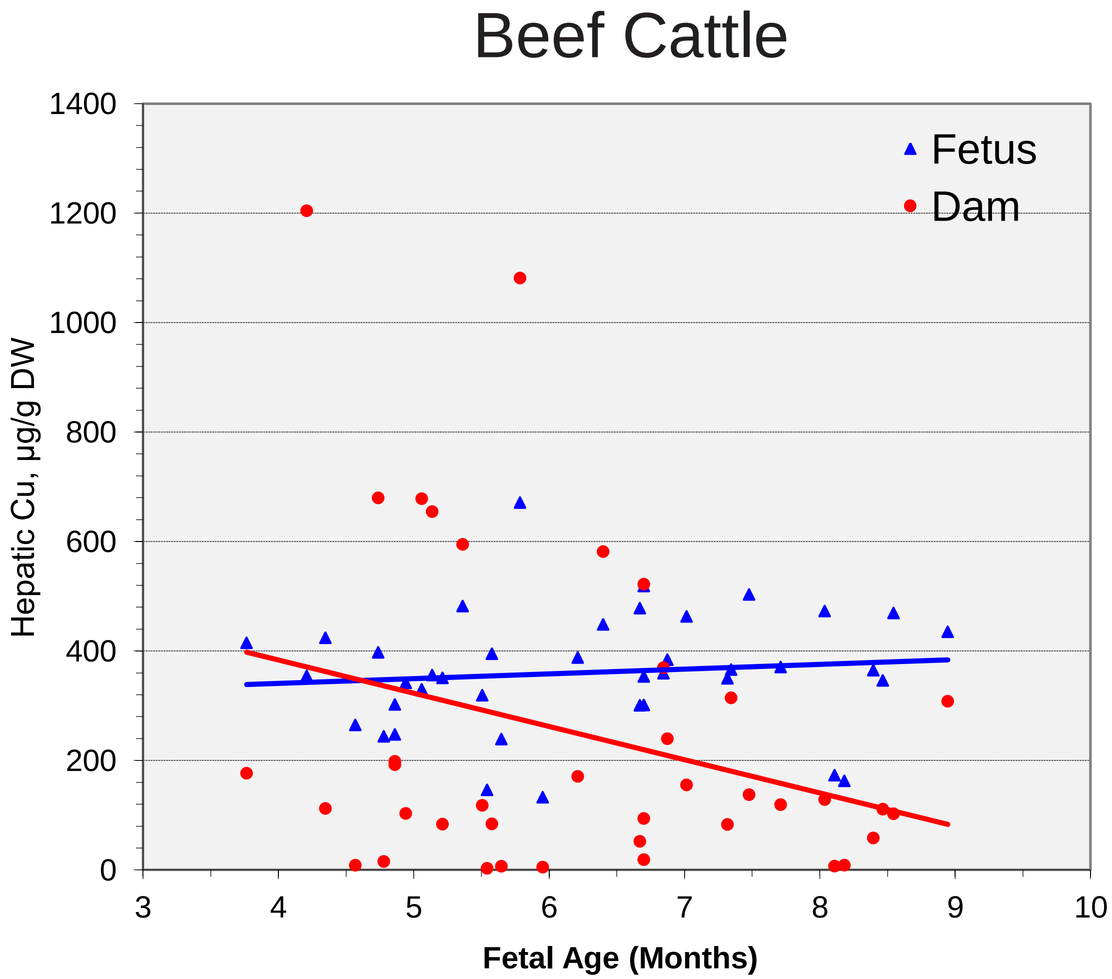
Comparison of least squared mean (± Standard error of mean) bovine calf liver mineral concentrations (µg/g dry matter basis) adjusted for breed (dairy and beef) (data from Van Saun, 2016a,b).

Mineral	Abattoir	Abortion	Stillbirth		Model Effects P < F	
			No Dystocia	Dystocia	Overall	Source
N =	185	71	27	35		
Calcium	248.8 ± 43.0[b]	1047.6 ± 64.5[a]	434.7 ± 105.7[b]	395.0 ± 145.3[b]	< 0.0001	< 0.0001
Magnesium	704.1 ± 9.8[a]	519.1 ± 14.7[c]	500.6 ± 24.1[c]	612.7 ± 33.2[b]	< 0.0001	< 0.0001
Copper	389.3 ± 10.9[a]	225.6 ± 16.3[c]	304.0 ± 26.8[b]	454.6 ± 36.8[a]	< 0.0001	< 0.0001
Manganese	5.88 ± 0.22[a]	4.22 ± 0.34[b]	4.51 ± 0.55[b]	5.08 ± 0.76[ab]	0.0034	0.0004
Molybdenum	0.63 ± 0.052[c]	1.31 ± 0.077[ab]	1.07 ± 0.13[b]	1.51 ± 0.17[a]	< 0.0001	< 0.0001
Selenium	2.59 ± 0.15[a]	2.15 ± 0.22[ab]	1.62 ± 0.36[b]	1.93 ± 0.50[ab]	< 0.0001	0.049
Zinc	761.4 ± 28.6[a]	436.9 ± 43.0[b]	376.0 ± 70.4[b]	754.1 ± 96.7[a]	< 0.0001	< 0.0001

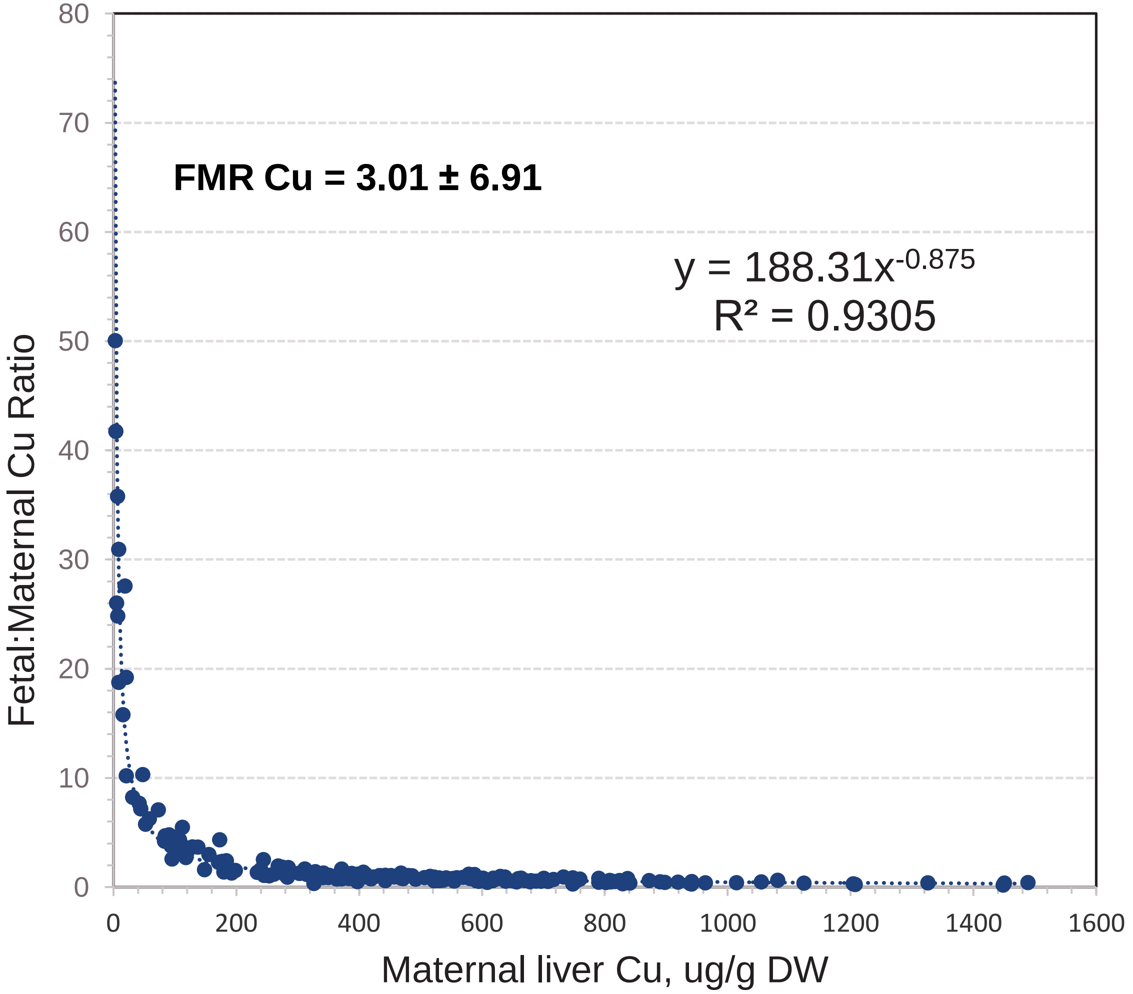
[1]Not significant, P>0.2; [abc]Means within a row with different superscripts differ P<0.05

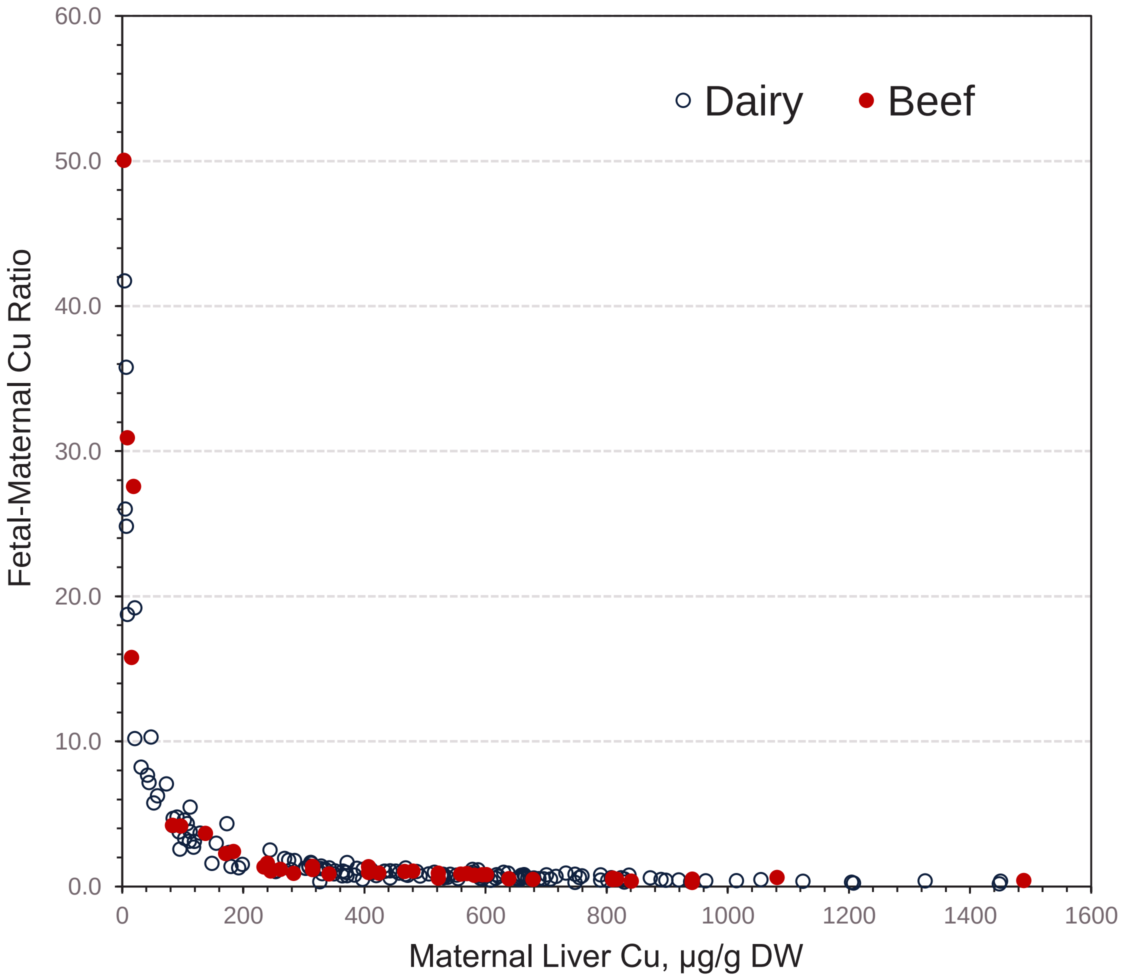
Liver Copper Concentration





Liver Copper Comparisons





Van Saun, 2019

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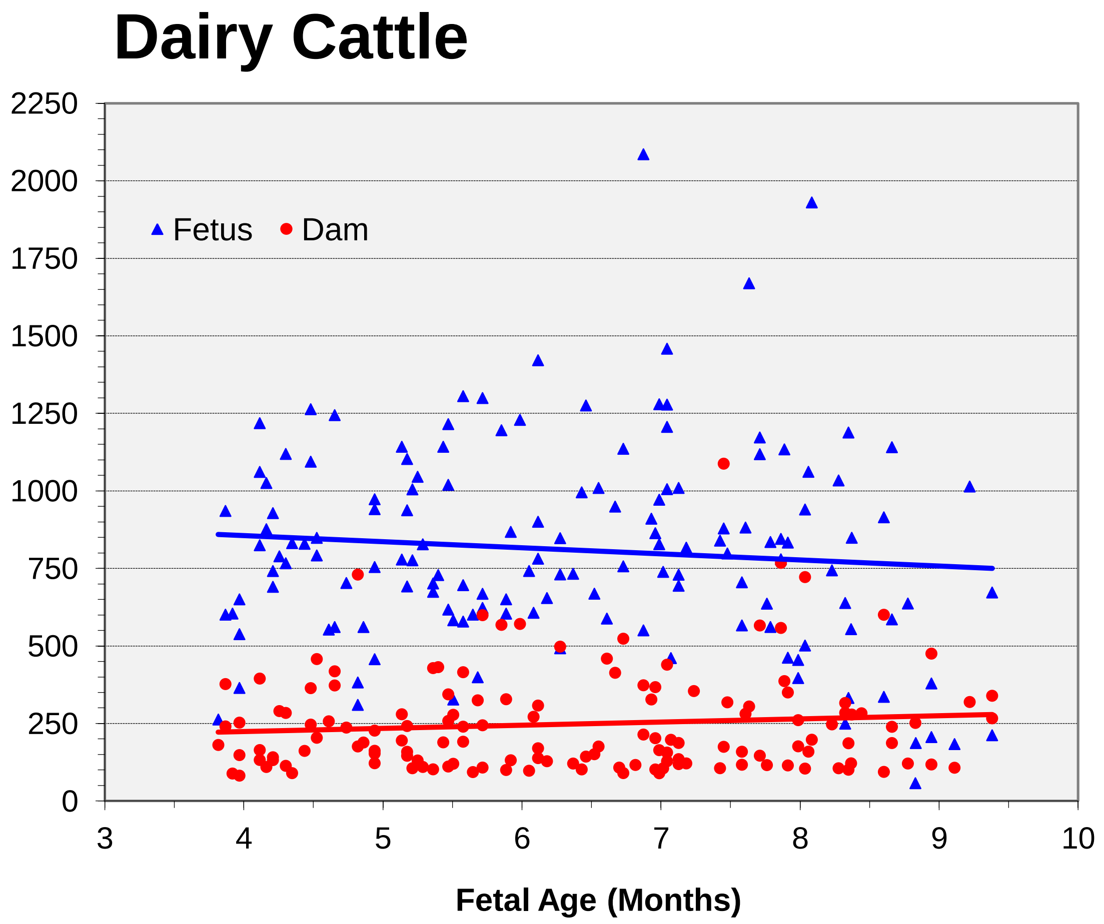
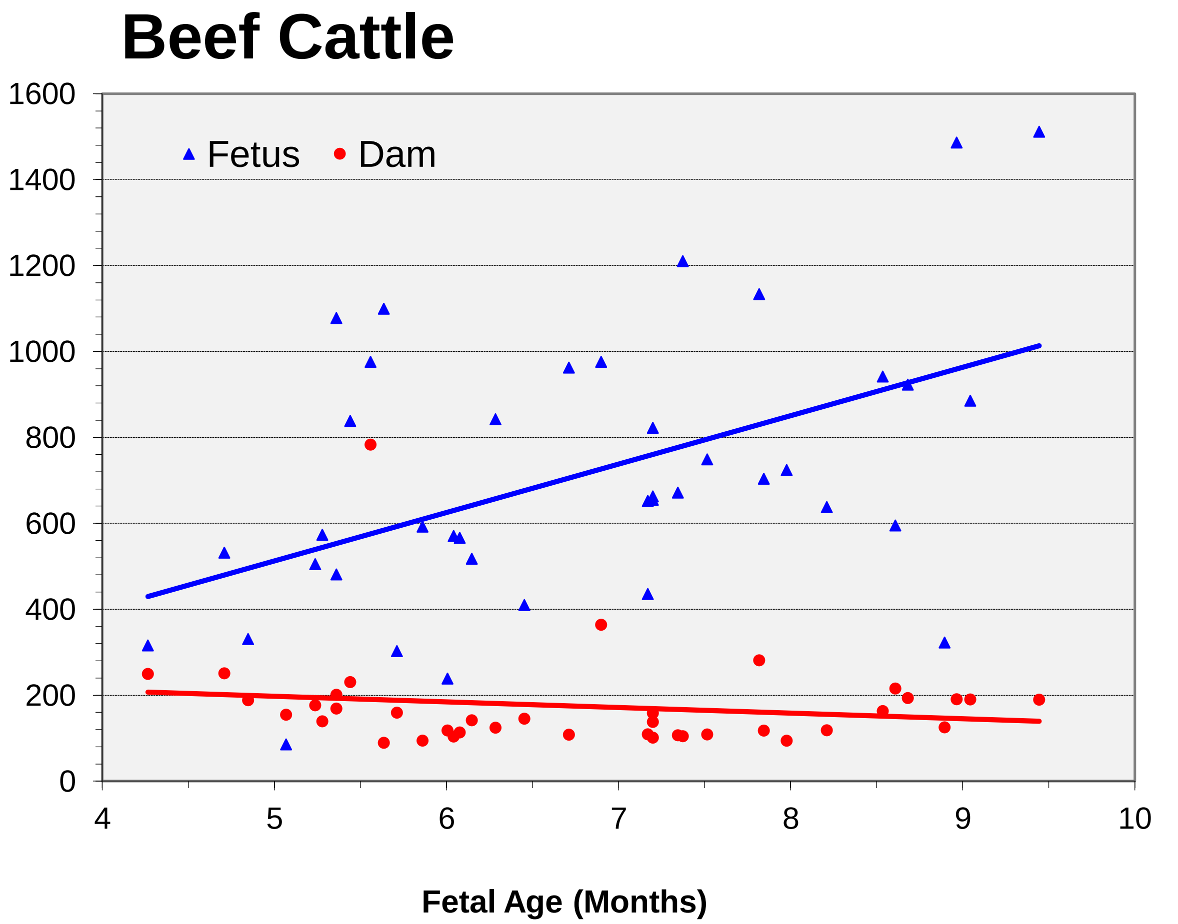
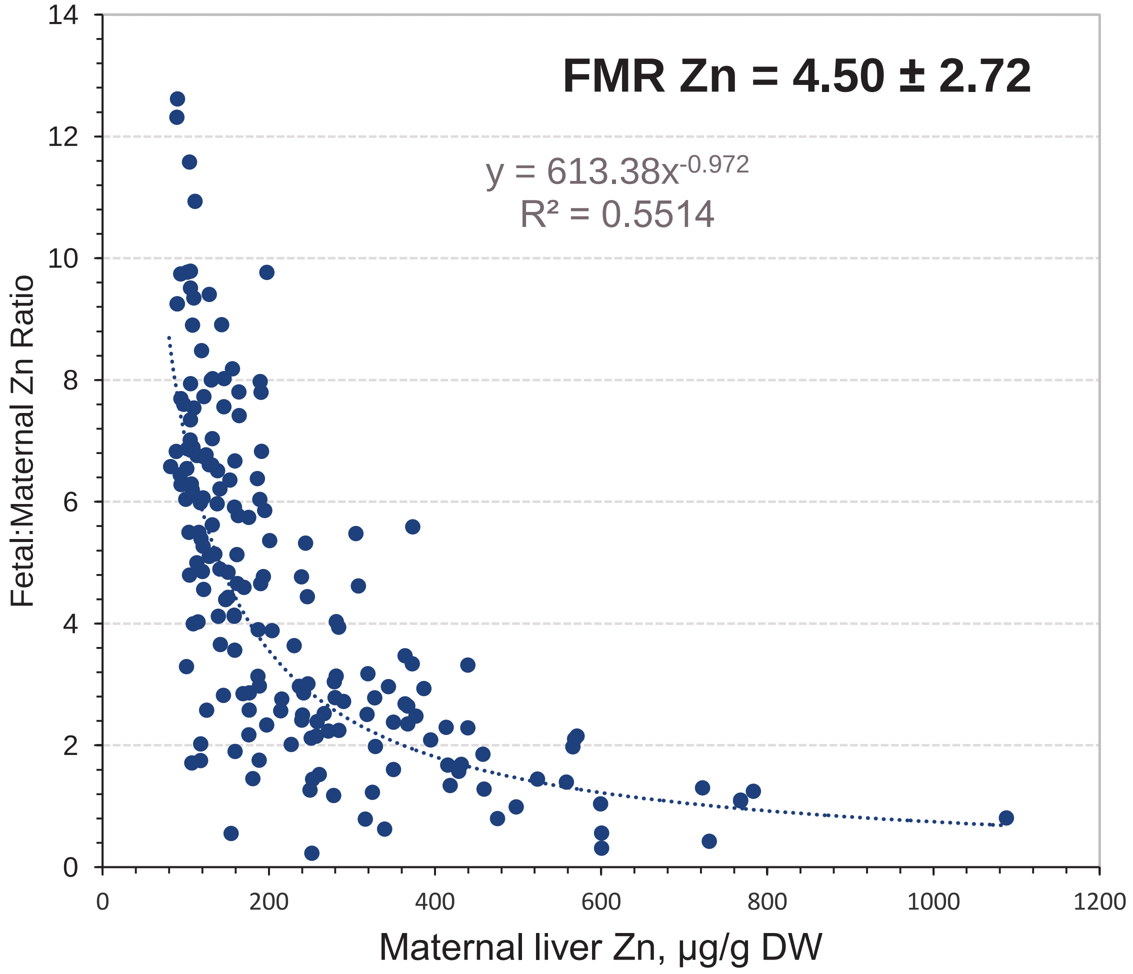
Zinc Comparisons

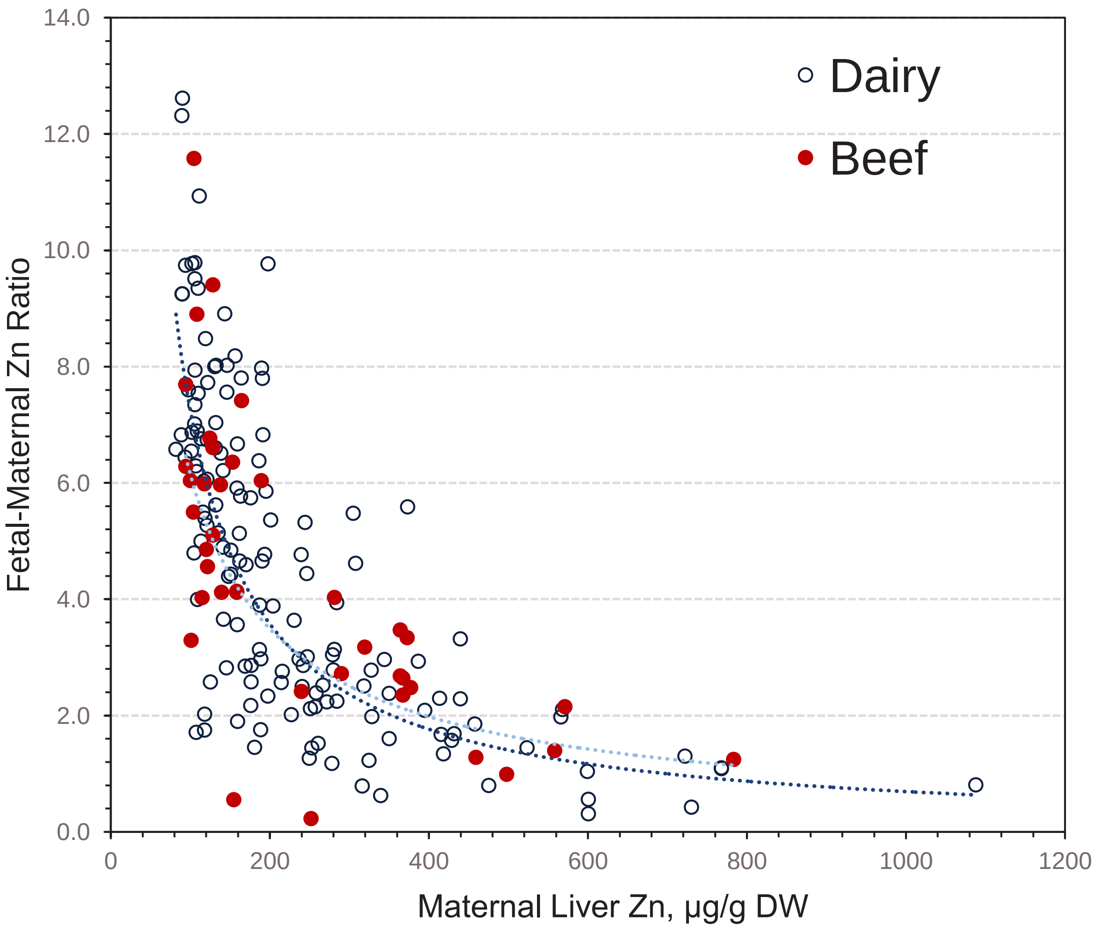




Van Saun, 2010

Liver Zinc Comparisons





Van Saun, 2019

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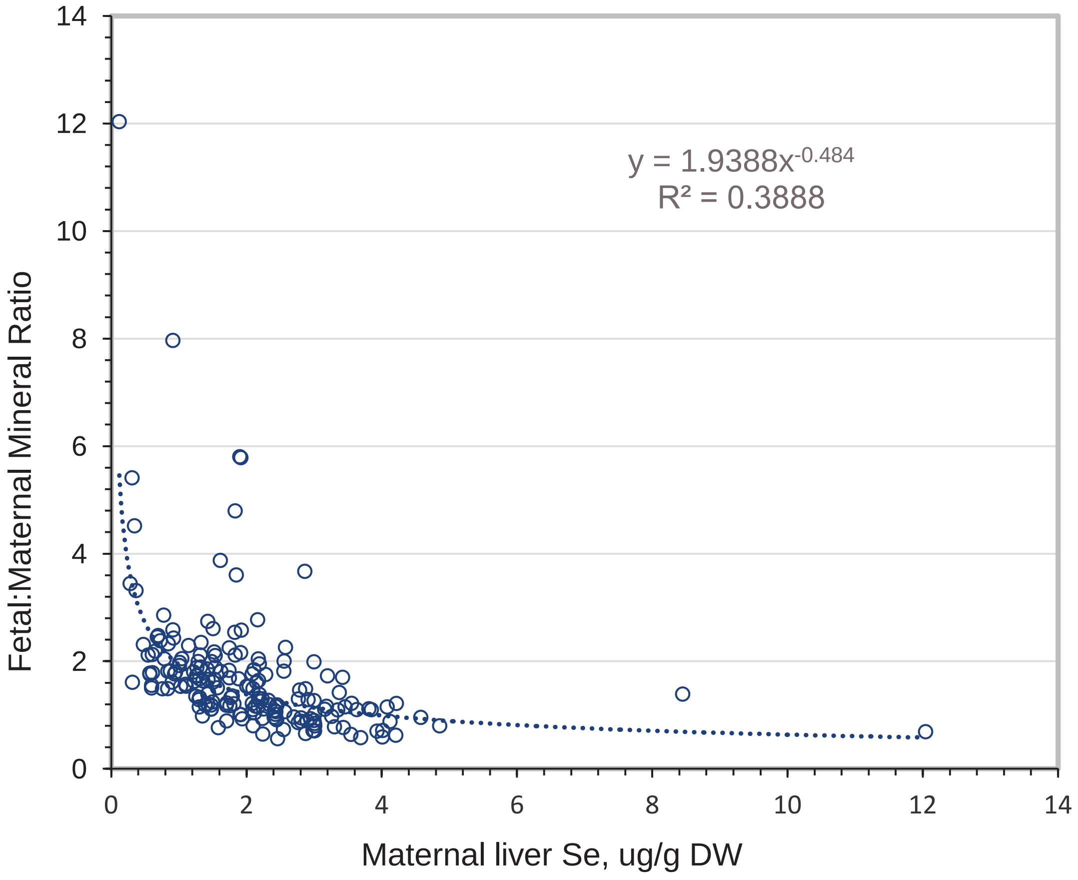
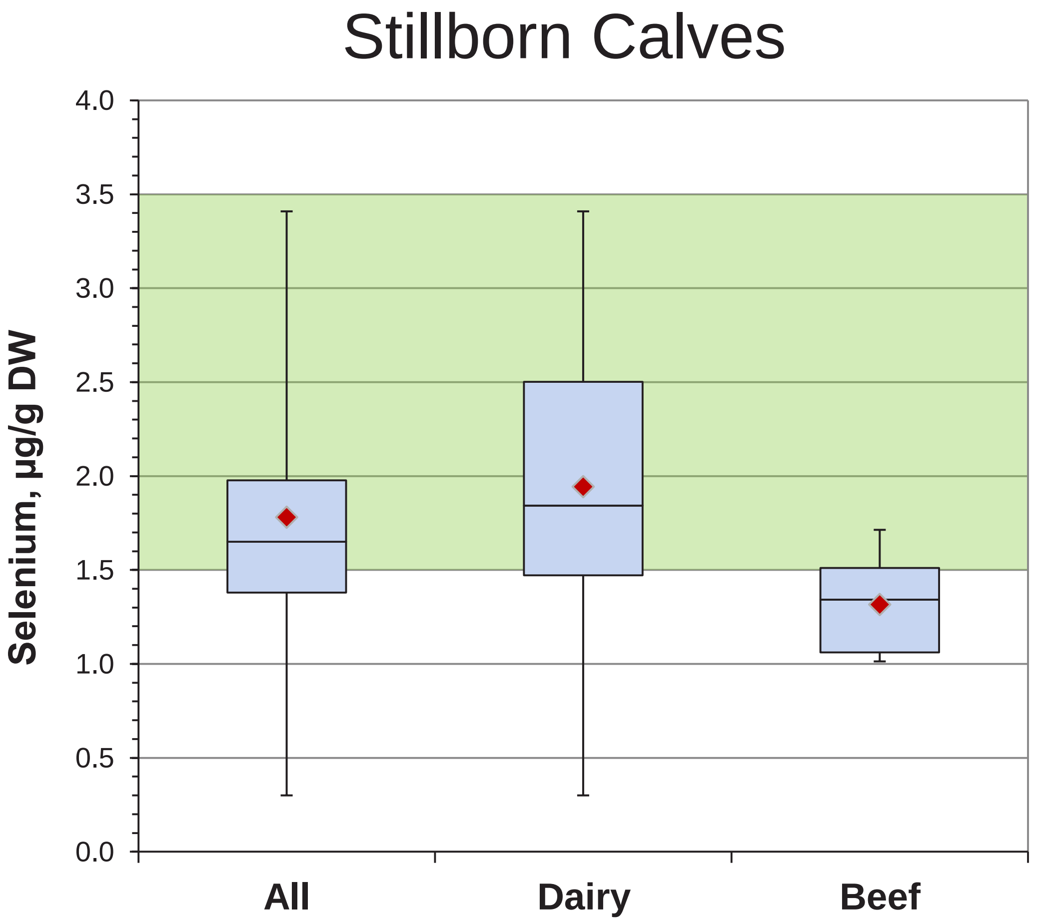
Liver Selenium Comparisons





Van Saun, 2019

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antioxidants

MDPI

Review

Redox Biology in Transition Periods of Dairy Cattle: Role in the Health of Periparturient and Neonatal Animals

Angel Abuelo [1,*], Joaquín Hernández [2], José L. Benedito [2] and Cristina Castillo [2]

Reproduction in Domestic Animals

Reprod Dom Anim 49, 7–16 (2014); doi: 10.1111/rda.12230
ISSN 0936–6768

Role for Antioxidants in Reproduction

Review Article

Oxidative Stress in Neonatology. A Review

M Mutinati, M Pantaleo, M Roncetti, M Piccinno, A Rizzo and RL Sciorsci

Department of Emergency and Organ Transplantation (D.E.T.O.), University of Bari "Aldo Moro", Valenzano (BA), Italy

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Role for Nutrition in Prenatal Calf Health?

- Machado et al., 2013
  - Injected Multimin® at 230 and 260 days of gestation
  - 1416 cows, 3 farms
  - Decreased stillborn rate: 6.1 vs. 4.3%, P=.04
- Multinani et al., 2013
  - Oxidative stress during birthing, dystocia
  - Leads to metabolic acidosis
  - Protection from higher antioxidants?

The Veterinary Journal 200 (2014) 299–304

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The Veterinary Journal

journal homepage: www.elsevier.com/locate/tvjl

The effect of injectable trace minerals (selenium, copper, zinc, and manganese) on peripheral blood leukocyte activity and serum superoxide dismutase activity of lactating Holstein cows

CrossMark

V.S. Machado [a], G. Oikonomou [a], S.F. Lima [a], M.L.S. Bicalho [a], C. Kacar [c], C. Foditsch [a], M.J. Felippe [b], R.O. Gilbert [b], R.C. Bicalho [a,*]

The

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Contents lists available at SciVerse ScienceDirect

The Veterinary Journal

journal homepage: www.elsevier.com/locate/tvjl

Effect of an injectable trace mineral supplement containing selenium, copper, zinc, and manganese on the health and production of lactating Holstein cows

CrossMark

V.S. Machado [a], M.L.S. Bicalho [a], R.V. Pereira [a], L.S. Caixeta [a], W.A. Knauer [a], G. Oikonomou [a], R.O. Gilbert [b], R.C. Bicalho [a,*]

Injectable Trace Minerals

	Disease Incidence, %	Adjusted Odds Ratio	P-value
Treatment	Subclinical Mastitis		
Control Diet	10.4	1.3	0.005
TM Injection	8.0	1.0	
Treatment x Parity	Clinical Mastitis		
Control x Primiparous	11.8	0.72	0.33
TMS x Primiparous	15.6	1.00	
Control x Multiparous	25.4	1.39	0.03
TMS x Multiparous	19.7	1.00	

- 2 Injections of trace mineral solution at 230 and 260 days of gestation
- 3 farms with total of 1416 cows enrolled
- All farms fed diets that exceeded NRC recommendations

Machado et al., Vet J 2013; 197:451-456

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J. Dairy Sci. 99:1–16
http://dx.doi.org/10.3168/jds.2015-10040

Supplementing Zn, Mn, and Cu from amino acid complexes and Co from Co glucoheptonate during the peripartal period benefits postpartal cow performance and blood neutrophil function

J. S. Osorio,*† E. Trevisi,‡ C. Li,§ J. K. Drackley,† M. T. Socha,# and J. J. Loor*†[1]

J. Dairy Sci. 95:4568–4577
http://dx.doi.org/10.3168/jds.2012-5404

Immune responses in lactating Holstein cows supplemented with Cu, Mn, and Zn as sulfates or methionine hydroxy analogue chelates

L. M. Nemec,* J. D. Richards,† C. A. Atwell,† D. E. Diaz,† G. I. Zanton,† and T. F. Gressley*[1]
*Department of Animal and Food Science, University of Delaware, Newark 19716

J. Dairy Sci. 97:3728–3738
http://dx.doi.org/10.3168/jds.2013-7331

Effects of hydroxy trace minerals on oxidative metabolism, cytological endometritis, and performance of transition dairy cows

T. Yasui,* C. M. Ryan,* R. O. Gilbert,† K. R. Perryman,‡ and T. R. Overton*[1]

J. Dairy Sci. 93:4239–4251
doi:10.3168/jds.2010-3058

Effects of feeding organic trace minerals on milk production and reproductive performance in lactating dairy cows: A meta-analysis

A. R. Rabiee,*[1] I. J. Lean,* M. A. Stevenson,† and M. T. Socha‡
*SBScibus, PO Box 660, Camden 2570, NSW, Australia
†EpiCentre, Institute of Veterinary, Animal, and Biomedical Sciences, Massey University, Palmerston North, New Zealand
‡Zinpro Corporation, 10400 Viking Dr., Ste. 240, Eden Prairie, MN 55344

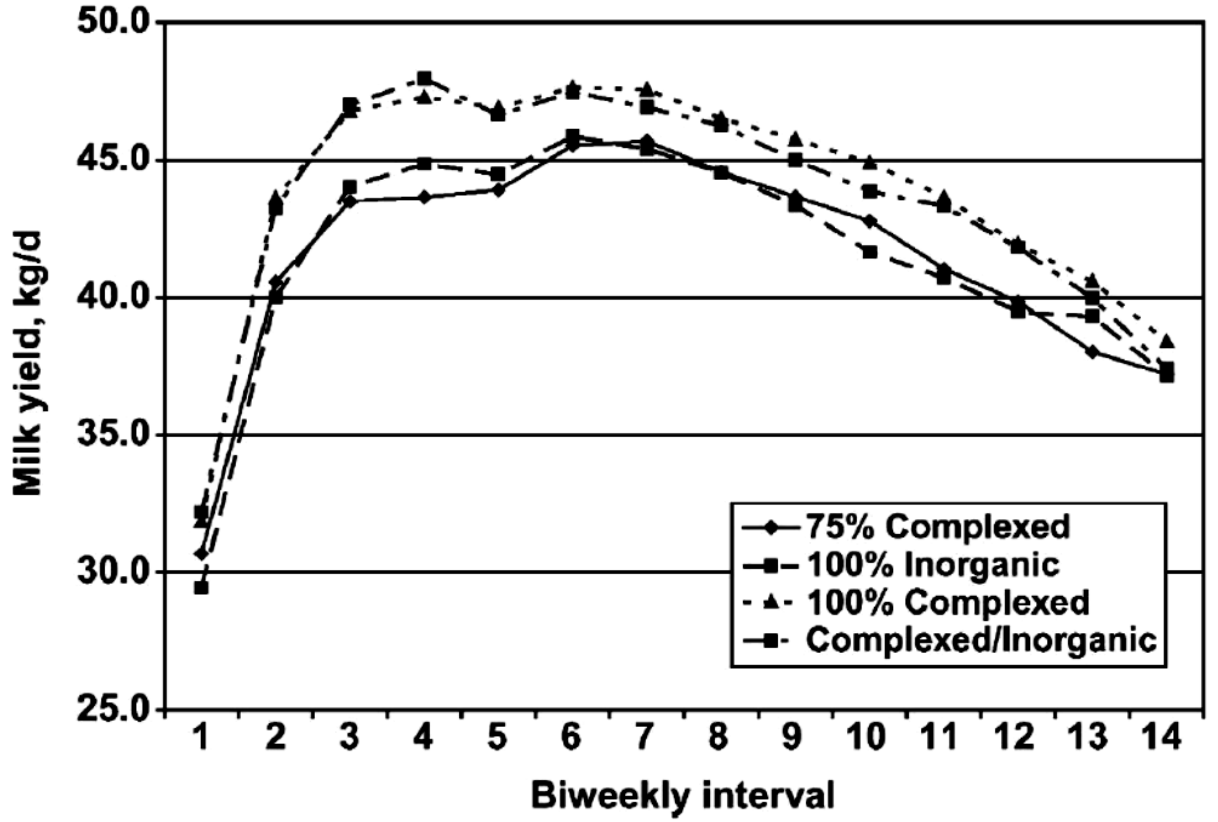
OTM increased milk production by 0.93 kg [95% confidence interval (CI) = 0.61 to 1.25], milk fat by 0.04 kg (95% CI = 0.02 to 0.05), and milk protein by 0.03 kg (95% CI = 0.02 to 0.04) per day

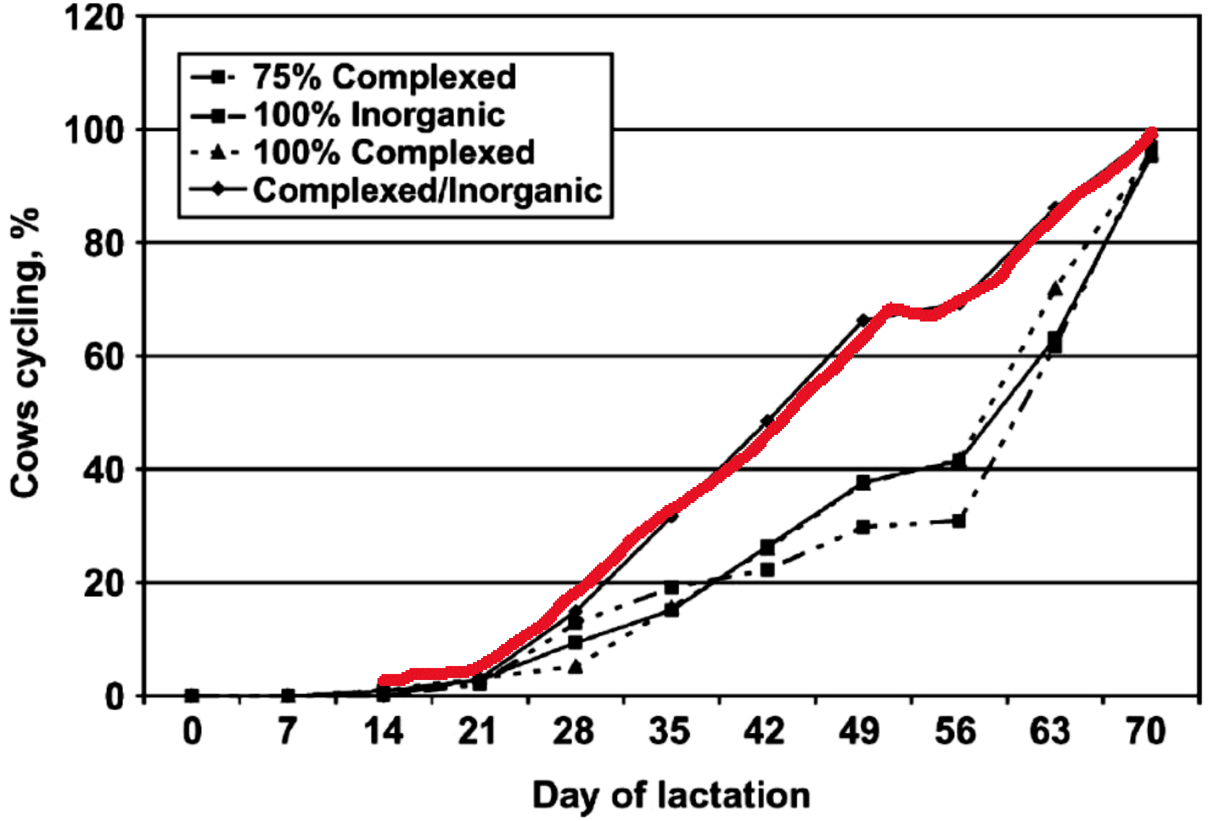
OTM reduced days open (weighted mean difference = 13.5 d) and number of services per conception (weighted mean difference = 0.27) in lactating dairy cows. The risk of pregnancy on d 150 of lactation was greater in cows fed OTM (risk ratio = 1.07), but OTM had no significant effect on the interval from calving to first service and 21-d pregnancy rate

J. Dairy Sci. 89:2679–2693

The Effect of Trace Mineral Fortification Level and Source on Performance of Dairy Cattle

J. E. Nocek,*[1] M. T. Socha,† and D. J. Tomlinson†
*Spruce Haven Farm and Research Center, Auburn, NY 13021
†Zinpro Corporation, Eden Prairie, MN 55344

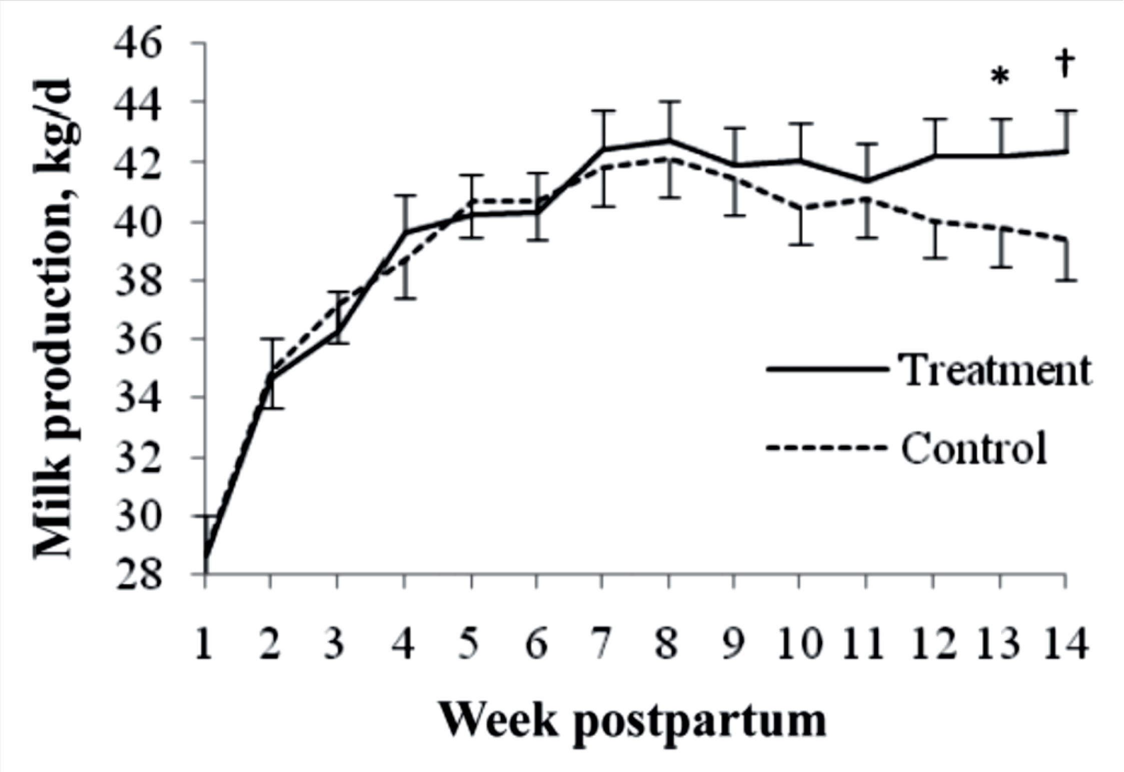




Effect of dietary organic zinc, manganese, copper, and cobalt supplementation on milk production, follicular growth, embryo quality, and tissue mineral concentrations in dairy cows

K. S. Hackbart, R. M. Ferreira, A. A. Dietsche, M. T. Socha, R. D. Shaver, M. C. Wiltbank and P. M. Fricke

J ANIM SCI 2010, 88:3856-3870.
doi: 10.2527/jas.2010-3055 originally published online September 3, 2010



Treatment did not affect (*P* > 0.1) DMI, health events, first-wave follicular dynamics, first cycle luteal measures, embryo quality, liver trace mineral concentrations, or luteal trace mineral concentrations

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Minerals and Reproduction

- Maintain calcium homeostasis by addressing dietary macromineral content, especially relationships between potassium and magnesium and calcium and phosphorus
  - Low calcium prepartum diets
  - Use of DCAD in prepartum diets
- Provide sufficient dietary vitamins and trace minerals from available sources to meet needs of cow, colostrum and fetus in order to minimize negative effects on immune response
  - Fat-soluble vitamins A, D, E most critical

Conclusions

- Maternal mineral/vitamin status prepartum determines fetal and neonatal mineral/vitamin status
- Fetal liver has capacity to concentrate minerals, but not vitamins, for support of postnatal use
- Severity of maternal trace mineral or vitamin deficiencies may result in spectrum of disease conditions from abortion to weak neonates
- Antioxidant status may help support fetal survival during birth and maternal immune response to disease

Thank you!

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Questions?

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