Application of Ionophores in Beef Cattle

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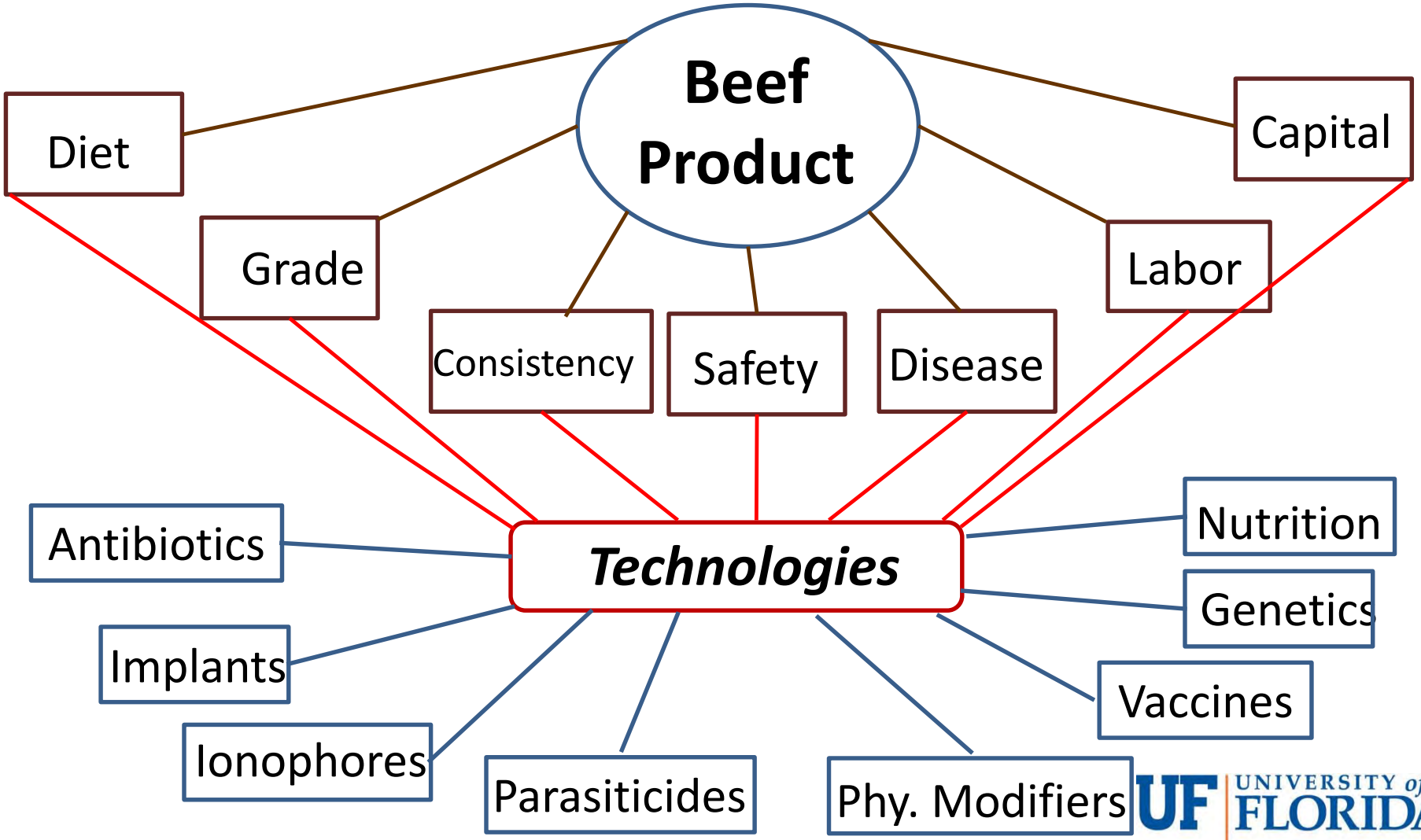
Relationships of Technologies to Beef



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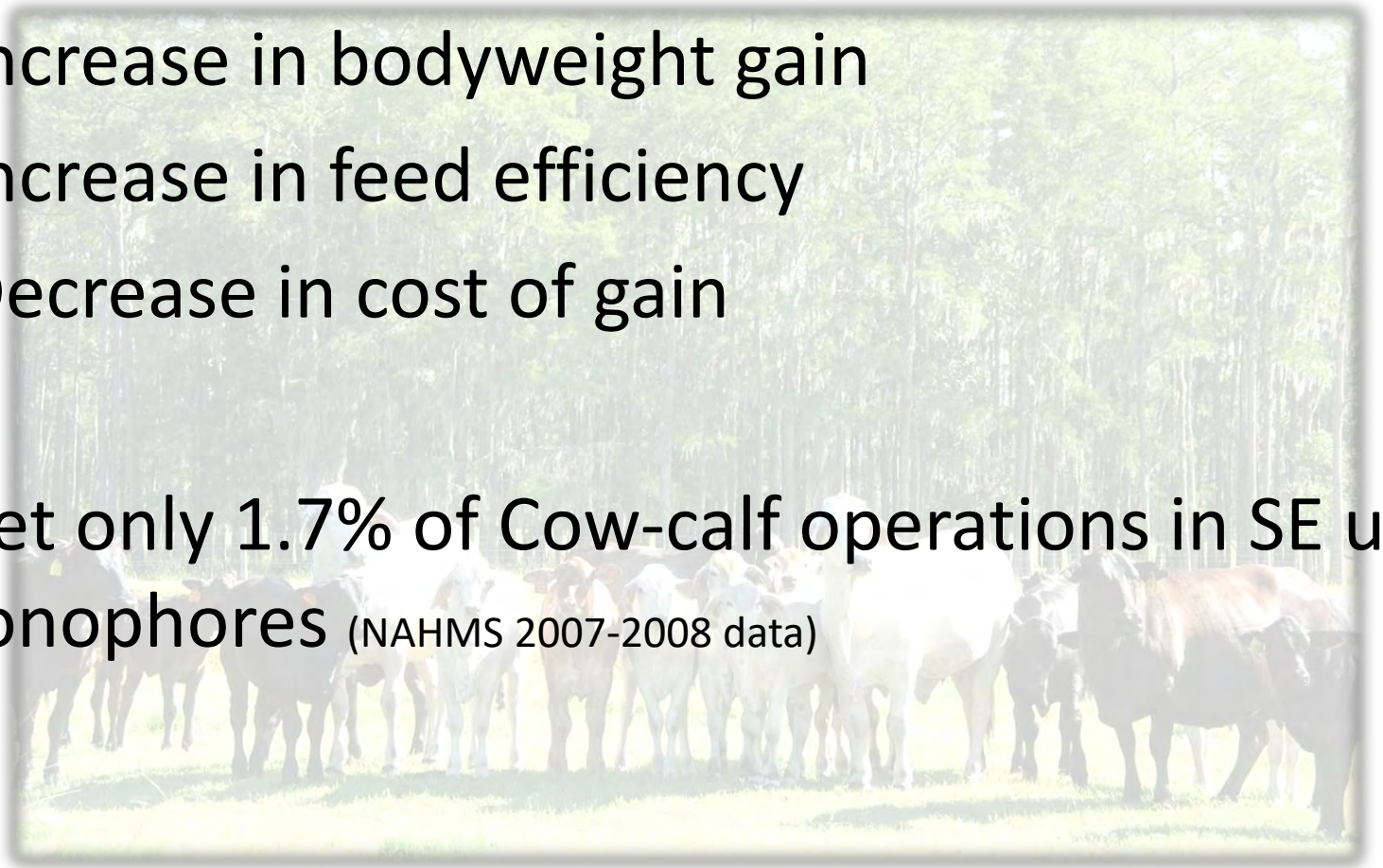
Why Use Ionophores

- Increase in bodyweight gain
- Increase in feed efficiency
- Decrease in cost of gain

- Yet only 1.7% of Cow-calf operations in SE use ionophores (NAHMS 2007-2008 data)



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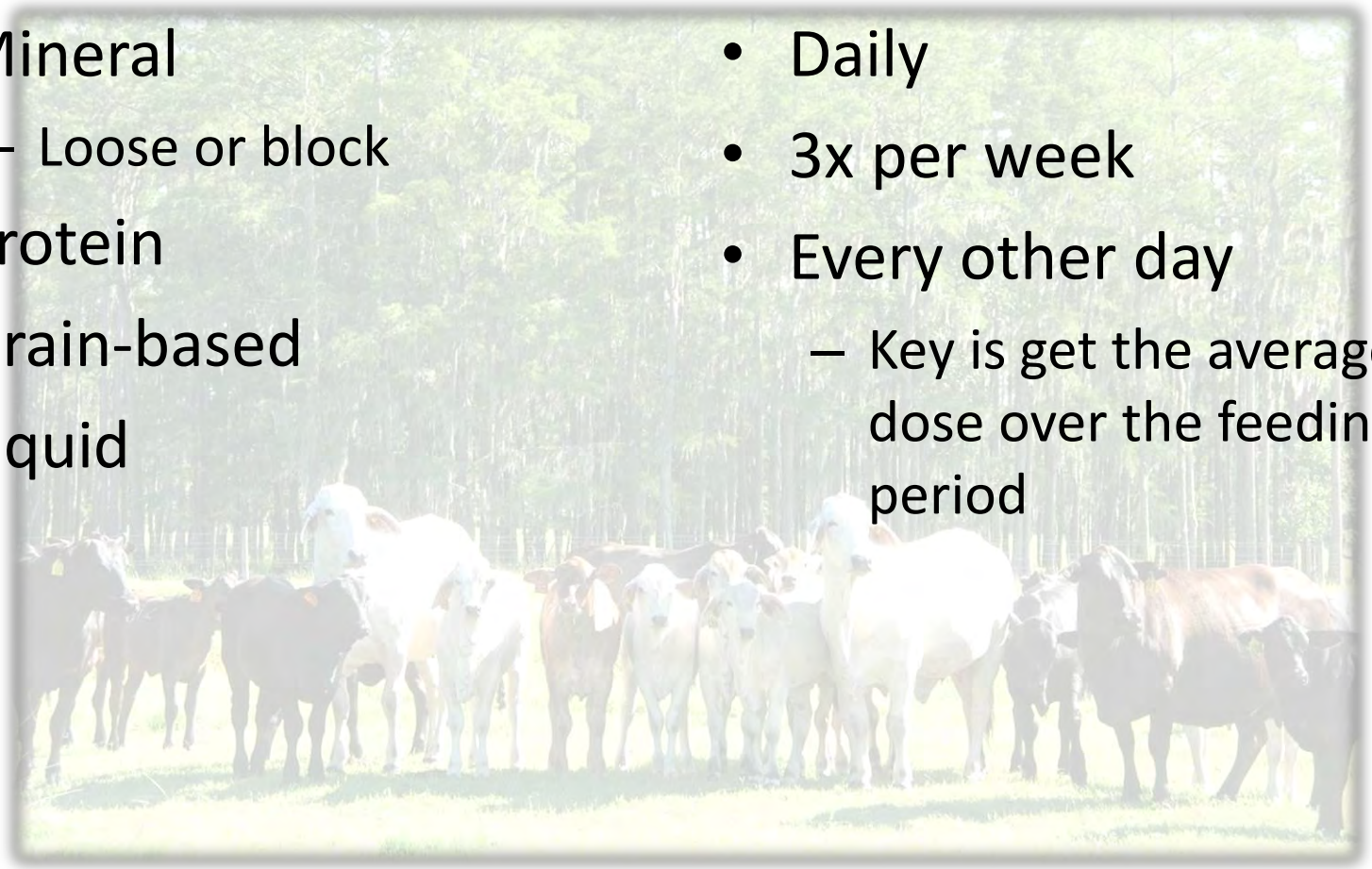
Delivery of Ionophores

- Mineral
  - Loose or block
- Protein
- Grain-based
- Liquid



- Daily
- 3x per week
- Every other day
  - Key is get the average dose over the feeding period

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Ionophores

- Sub-class of antimicrobial products
- Affect bacteria in the rumen
- Alter total rumen metabolism to:
  - shift in ruminal microbial populations
  - increase efficiency of appropriate bacteria
  - increase production of organic acids
  - Increase total microbial protein
  - Decrease waste: ruminal methane and ammonia
  - Decrease coccidiosis, bloat, acidosis

Species Affected

- Ionophore resistance related closely to cell wall structure (Russell and Strobel, 1989)
- Generally Gram-positive bacteria
  - Acetate, butyrate, H_2 and formate producers
  - *Streptococcus bovis* and *Ruminococcus albus*
  - Single cell membrane
- Gram-negative have additional "protective" outer membrane

Ionophores

- Monensin – Rumensin
- Lasalocid – Bovatec
- Laidlomycin proprionate – Cattlyst
- Applications:
  - Cows
  - Backgrounding
  - Stocker
  - Replacement heifer development
  - Feedlot

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Ionophores

- 24 trials with 1,057 steers + 0.198 lb/d (16.3% increase over control)
- 11 trials with 853 steers & heifers +0.198 lb/d (15.5% increase over control)
- 24 trials with 914 steers & heifer + 0.181 lb/d (13.5% increase over control)

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Results

ADG Improvement 0.20 lbs/day

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Ionophores

	Stocker Gain, lb/d	
	7/20 to 10/13	7/25 to 9/26
Pasture		0.99[a]
Past + Supp	0.93[a]	1.04[a]
Monensin-200 mg	1.15[b]	1.50[b]

[abcdef] Means with different superscripts differ P<0.05

Bermudagrass Stocker Gain, lb/d	
Pasture	1.02[a]
Past+Corn	1.24[b]
P+C – 25 mg	1.55[c]
P+C – 50 mg	1.61[d]
P+C – 100 mg	1.72[e]
P+C – 200 mg	1.56[f]

Rouquette et al., 1980
Oliver, 1975

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Ionophores

Feedlot Application of Ionophore

	Monensin		Lasalocid	
Level, mg/d	ADG, lb/d	DMI, lb	ADG, lb/d	DMI, lb
0	2.38	18.72	2.67	20.0
	Improvement, % of Control		Improvement, % of Control	
5.5	+4.6	-1.5	+0.8	-1.6
11	+4.6	-1.5	+3.4	-2.2
22	+1.9	-5.4	+5.2	-2.5
33	0.0	-8.1	+3.4	-3.9

Potter and Wagner 1986

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Effect of Monensin Dosage on Animal Performance in Cattle Consuming Forage

(Potter et al., 1976)

	0	50	100	200	300	400
			mg/head/day			
ADG, lb/d	1.09	1.18	1.20	1.29	1.19	1.16
Feed Consumed, lb/d	15.2	15.6	15.4	15.4	14.4	14.5
Feed/Gain	13.92	13.07	12.91	11.91	12.26	12.84

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Effect of Lasalocid on Heifers Grazing Wheat Pasture

(Anderson and Horn, 1987)

	0 mg/hd/d	100 mg/hd/d	200 mg/hd/d	SEM
OM Intake, % BW	3.36	3.12	3.33	.141
OMD, %	82.86	81.42	81.27	.449
Total VFA, mmol/L	96.95 [a]	109.35 [a]	128.58 [b]	8.90
ADG, lb/d	1.76[a]	1.74[a]	1.98[b]	.06

[a,b] Means in a row with different superscript are different ($P < .05$)

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Effect of Laidlomycin propionate and Protein on Growing Steer Performance

(Bohnert et al., 2000)

	Control		L P			*P*- value	
	10.5 % CP	12.5 % CP	10.5 % CP	12.5 % CP	SEM	CP	LP
Gain, lb	209	230	234	269	8.8	.01	.02
DMI, lb/d	13.9	14.6	14.5	14.8	0.33	.08	.36
ADG, lb/d	2.29	2.71	2.56	3.96	.09	.01	.02
G:F	.167	.185	.179	.200	.005	.01	.01

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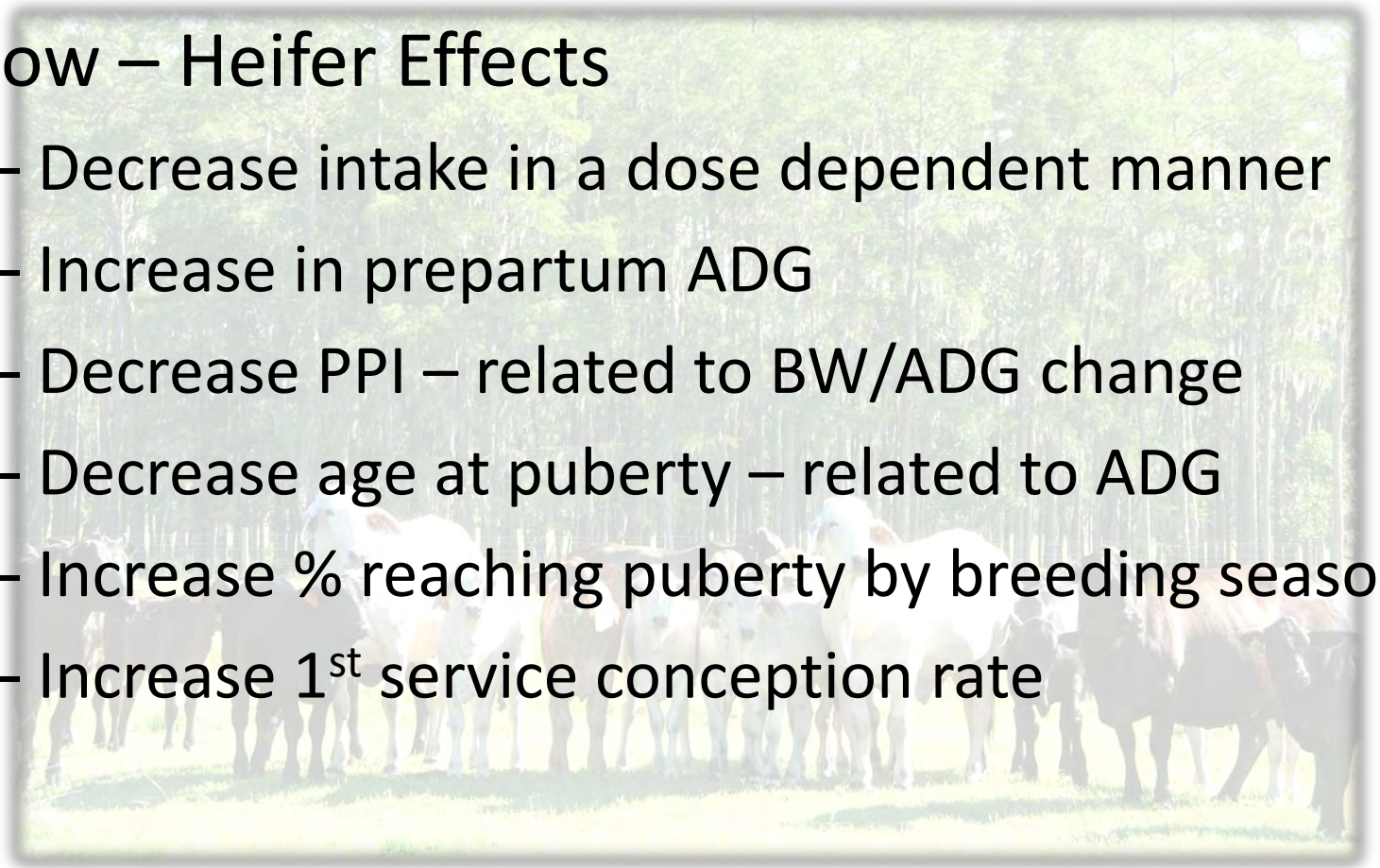
Effect of Ionophores on Finishing Animals Receiving High Concentrate Diets

- Increase in daily BW gain
- Reduction in feed consumption
- Improved feed efficiency
- Alter Fermentation Profiles
- No Effect on Carcass

Ionophores

- Cow – Heifer Effects
  - Decrease intake in a dose dependent manner
  - Increase in prepartum ADG
  - Decrease PPI – related to BW/ADG change
  - Decrease age at puberty – related to ADG
  - Increase % reaching puberty by breeding season
  - Increase 1st service conception rate



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Effect of Diet and Additive on Brangus Heifer Growth and Reproduction

	Control	Control+ Monensin	High Energy
Pregnancy rate	19/30 63.3%	17/29 58.6%	16/26 61.5%
Age at puberty, days	514 a	490 b	479 b
BW at puberty, lbs	734 a	695 b	697 b

a,b means with different letters differ P<0.03.

McCartor et al. 1979

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Ionophores – Impact

		Effect
Cow Herd	Weaning Weight, %	--
	Breakeven Selling Price, %	--
	Impact on Cost of Production, $	--
Stocker	Average Daily Gain, %	7.74
	Breakeven Selling Price, %	1.46
	Impact on Cost of Production, $	11.51
Feedlot	Average Daily Gain, %	2.90
	Feed:Gain, %	-3.55
	Breakeven Selling Price, %	1.18
	Impact on Cost of Production, $	12.43

Source: Lawrence and Ibarburu, 2006

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What About "Naturally Raised" Programs?

- Most will not allow the use of:
  1. Antibiotics-Antimicrobial
  2. Ionophores
  3. Implants
  4. Paracitides
- Are you willing to give up the production advantage?
- Does the possibility of a "premium" outweigh the decrease in production

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Parameters of Ionophore Use

1. Quality of forage dictates response

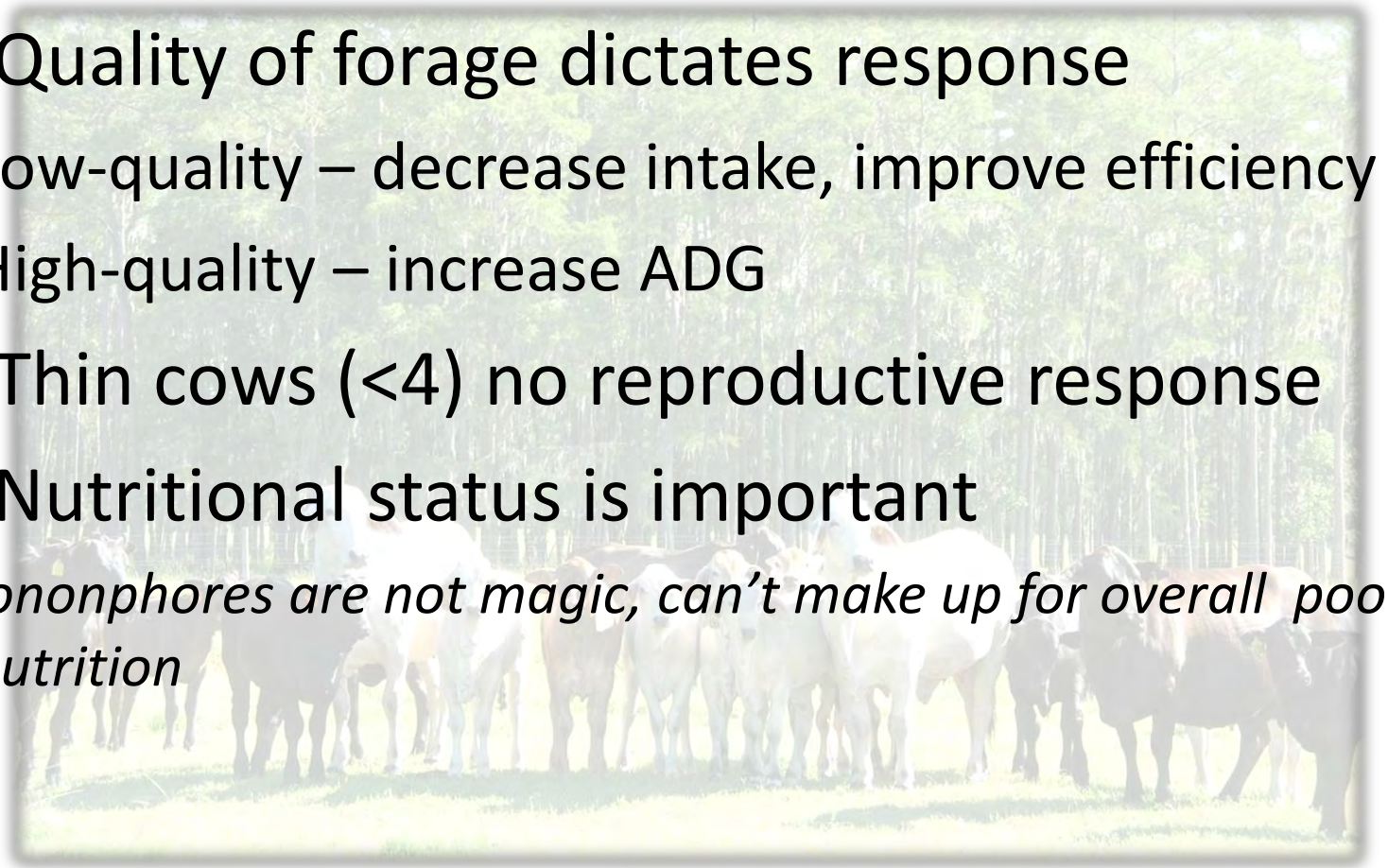
   Low-quality – decrease intake, improve efficiency

   High-quality – increase ADG

2. Thin cows (<4) no reproductive response

3. Nutritional status is important

   iononphores are not magic, can't make up for overall poor nutrition



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Summary

- Ionophores are under utilized
- Positively effect growing animal performance
- Positively effect developing heifer performance
- Positively effect mature cow performance

Questions

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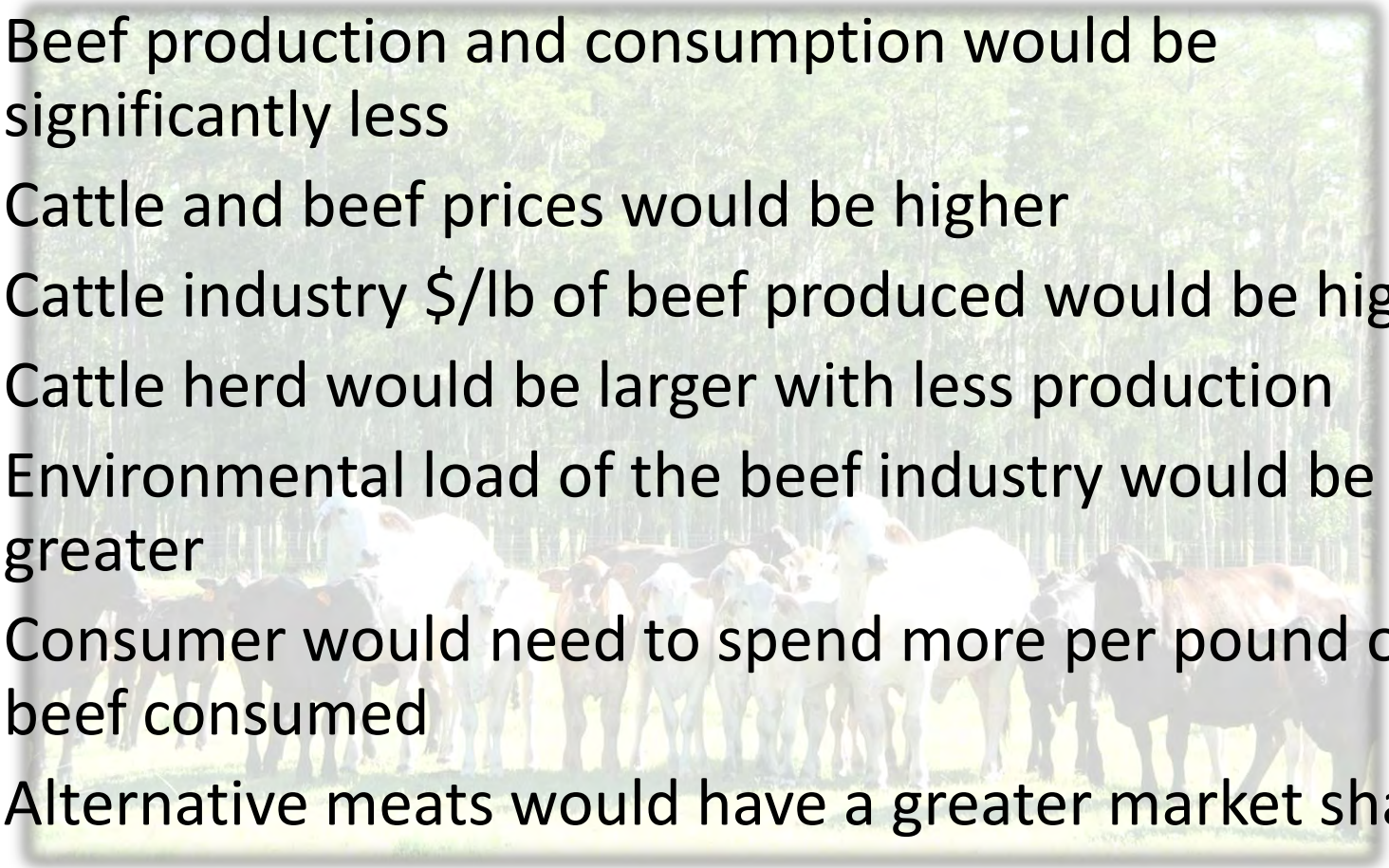
Questions

Beef Industry Landscape Without Technologies

1. Beef production and consumption would be significantly less
2. Cattle and beef prices would be higher
3. Cattle industry $/lb of beef produced would be higher
4. Cattle herd would be larger with less production
5. Environmental load of the beef industry would be greater
6. Consumer would need to spend more per pound of beef consumed
7. Alternative meats would have a greater market share



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Ionophores

- Monensin – Rumensin
- Lasalocid – Bovatec
- Laidlomycin Propionate – Cattlyst
- Narasin
- Salinomycin
- Virginiamycin
- Avoparcin

(Bergen and Bates, 1984; Nagaraja et al., 1987)

How Do Ionophores Work: In General

- Hydrophilic center binds a cation (Na^+, K^+, H^+)
- Hydrophobic exterior delocalizes charge
- Complex enters lipid bilayer to transport cation
- Two types of transport
  - Mobile carrier
  - Pore former

Monensin as the Model

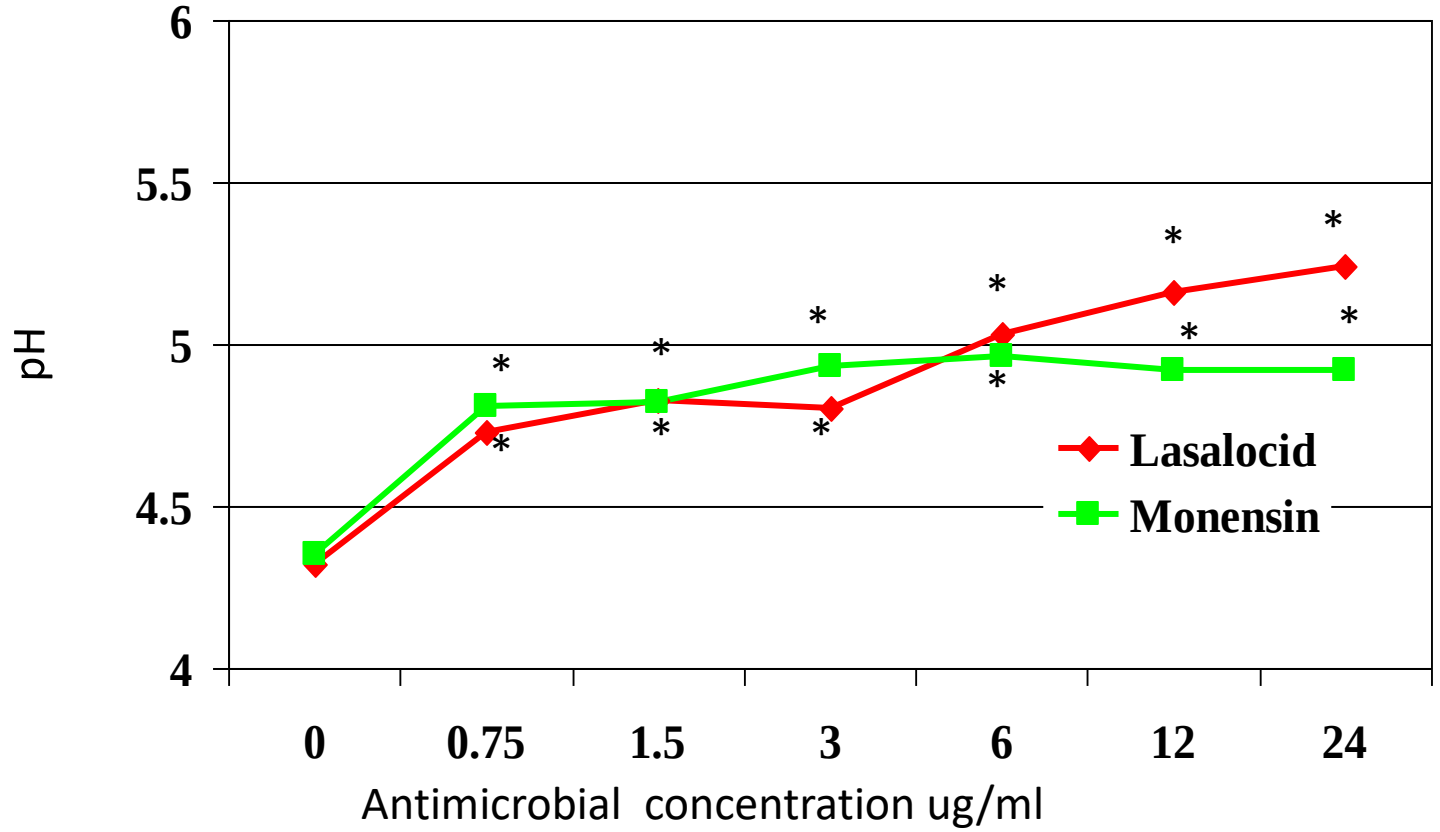
- Monensin enters membrane and antiports K^+/H^+
- Influx of H^+ decreases pH
- Decreased pH allows influx of Na^+
- ATPase upregulates to restore $[H^+]$ and $[Na^+]$
- Membrane potential and ion gradients are destroyed

Ionophores Affect on Rumen Fermentation

- pH
- Volatile Fatty Acid concentration
- Acetate:Propionate Ratio
- Methane Production
- Dietary Protein Sparing
- Lactic Acid Production

Effect of Ionophore on in vitro pH from Glucose Fermentation

(Nagaraja et al., 1987)



* Different from 0 ug/ml

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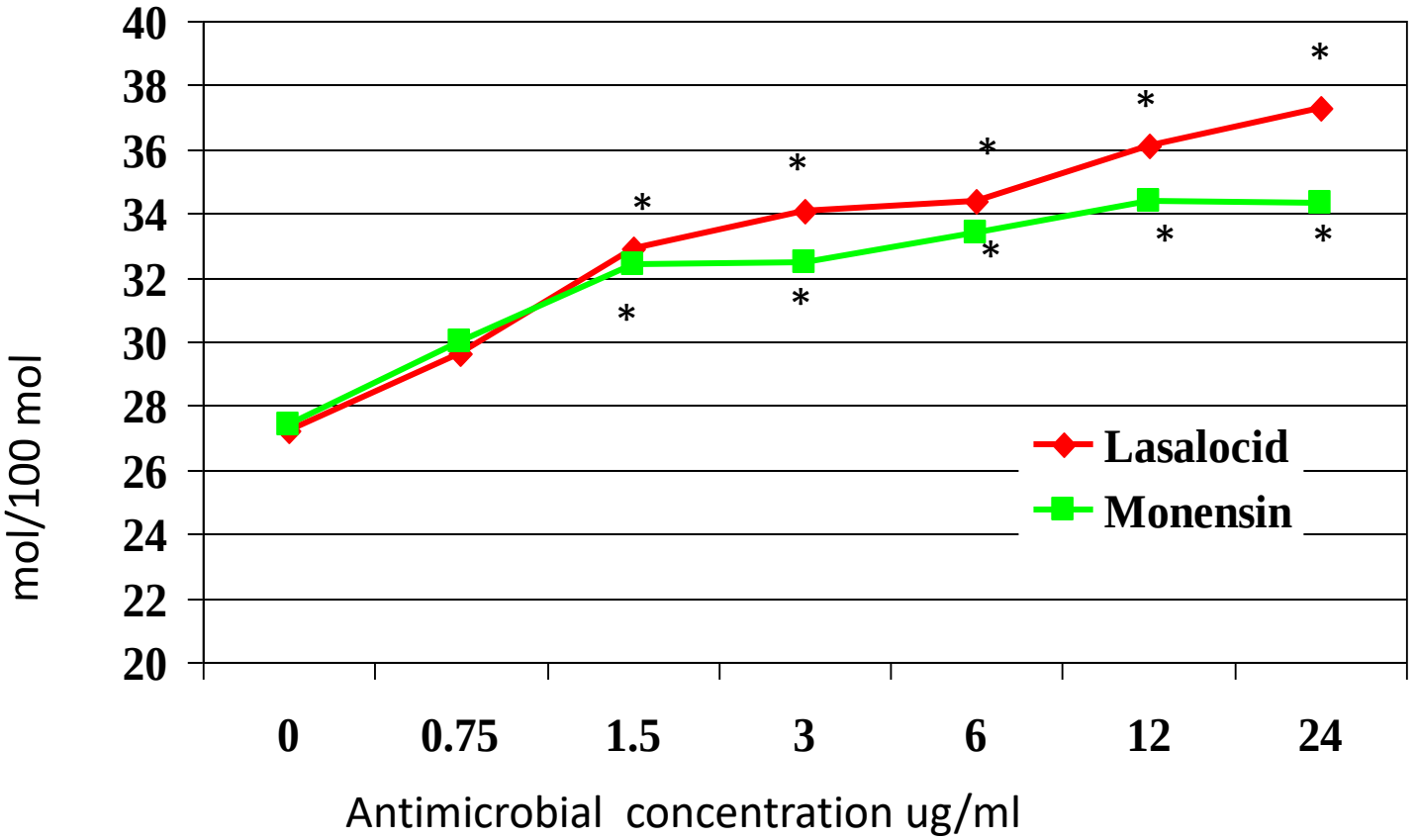
Effect of Ionophore on in vitro Molar Proportion of Propionate

(Nagaraja et al., 1987)



* Different from 0 ug/ml

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Effect of Laidlomycin propionate (LP) and Monensin (M) on rumen characteristics

(Bohnert et al., 2000)

Item	Con	LP	M	SEM	C vs I	LP v M
pH	6.62	6.64	6.69	.03	.34	.31
NH_3N, m*M*	5.28	5.2	4.28	.20	.07	.02
A:P	4.0	3.4	3.4	.1	.01	.82

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Effect of Laidlomycin propionate and Monensin on microbial nitrogen activity

(Bohnert et al., 2000)

Item	Con	LP	M	SEM	C v I	LP v M
Microbial specific activity nmol·mg protein^{-1}·min^{-1}						
Net NH_3N production	40.1	29.3	24.3	3.8	.03	.40
Net AAN degradation	30.8	21.4	16.0	3.0	.02	.25

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Effect of Monensin and Laidlomycin propionate on in vitro fermentation

(Domescik and Martin, 1999)

Item	Control	Mon	LP	SEM
Ground Corn diet		5 ppm	5 ppm	
CH_4, m*M*	17.5^{a}	8.8^{b}	14.1^{c}	.56
H_2, m*M*	$.09^{a}$	1.03^{b}	$.63^{b}$	.09
Lactate , m*M*	$.19^{a}$	$.09^{b}$	$.08^{b}$	.02
Alflafa Hay diet				
CH_4, m*M*	24.3^{a}	8.7^{b}	18.7^{c}	1.07
H_2, m*M*	.07	.1	.08	.01

^{abc} Means in row with different superscripts differ (P < .05)

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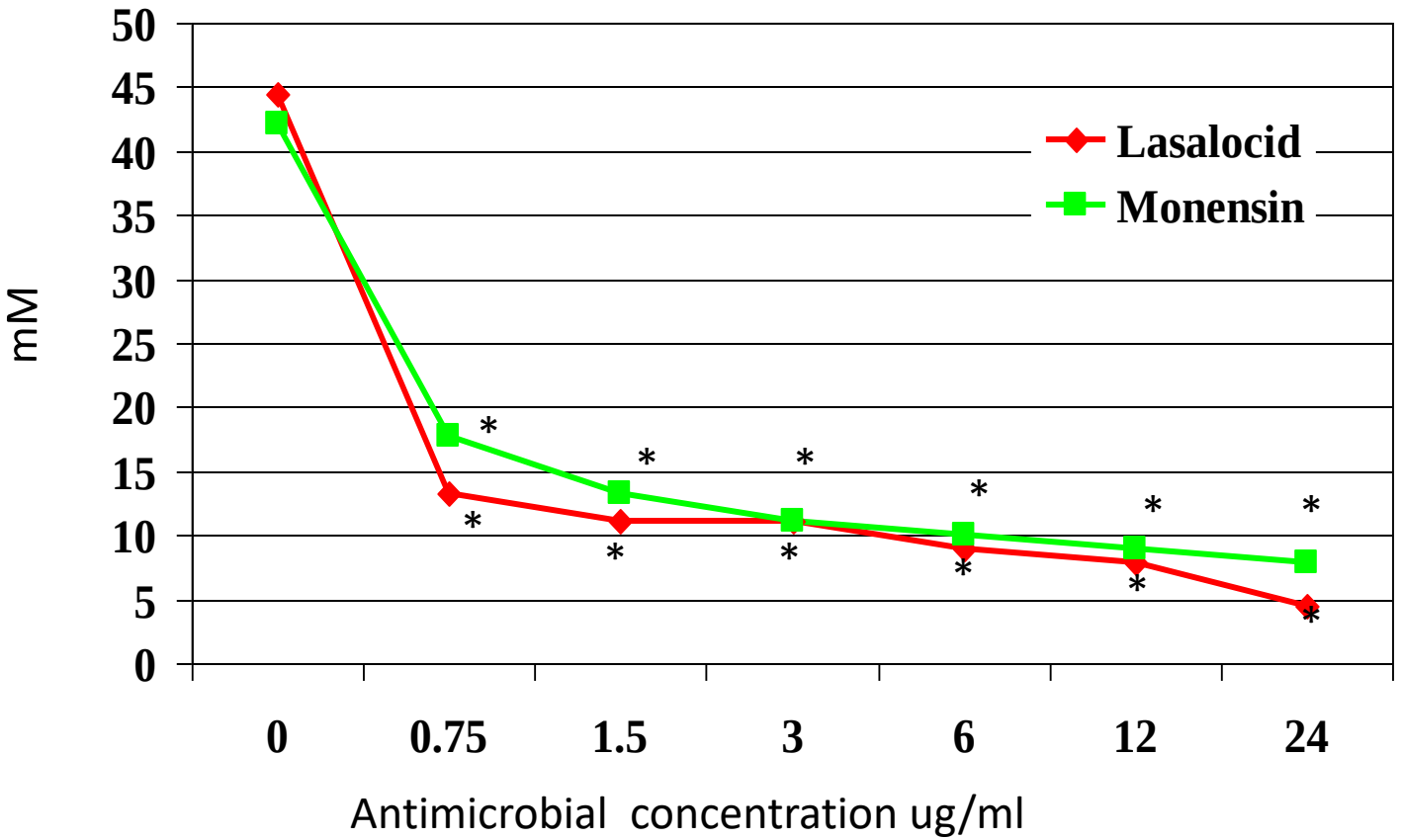
Effect of Ionophore on in vitro L(+) Lactic Acid Concentration

(Nagaraja et al., 1987)



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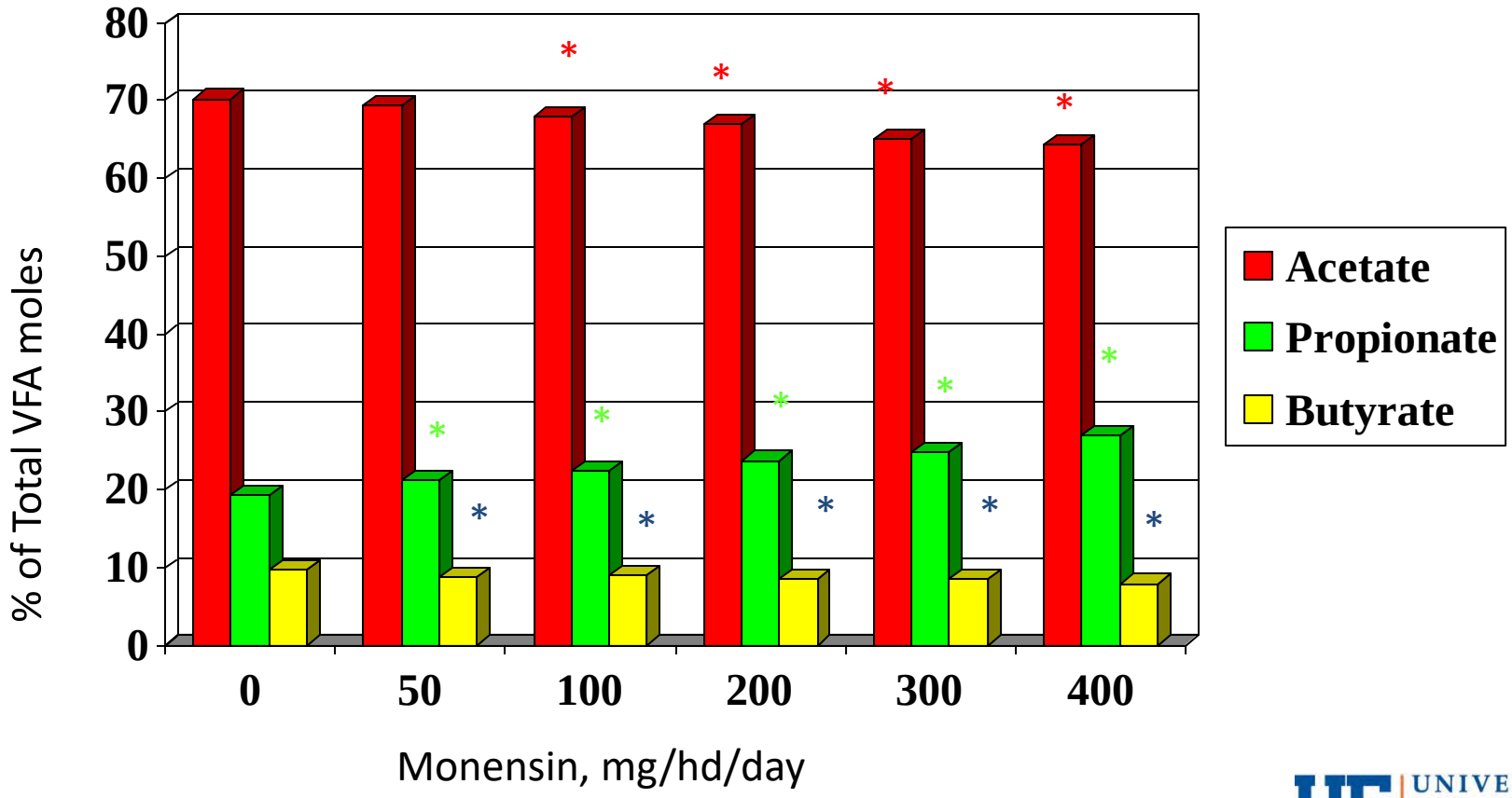
Effect of Ionophores on Grazing Animals

- Increase in daily BW gain
- Alteration in feed consumption
- Improved feed efficiency
- Alter Fermentation Profiles

Effect of Monensin Dosage on VFA Production in Cattle Consuming Forage

(Potter et al., 1976)



* Different from control P < .01

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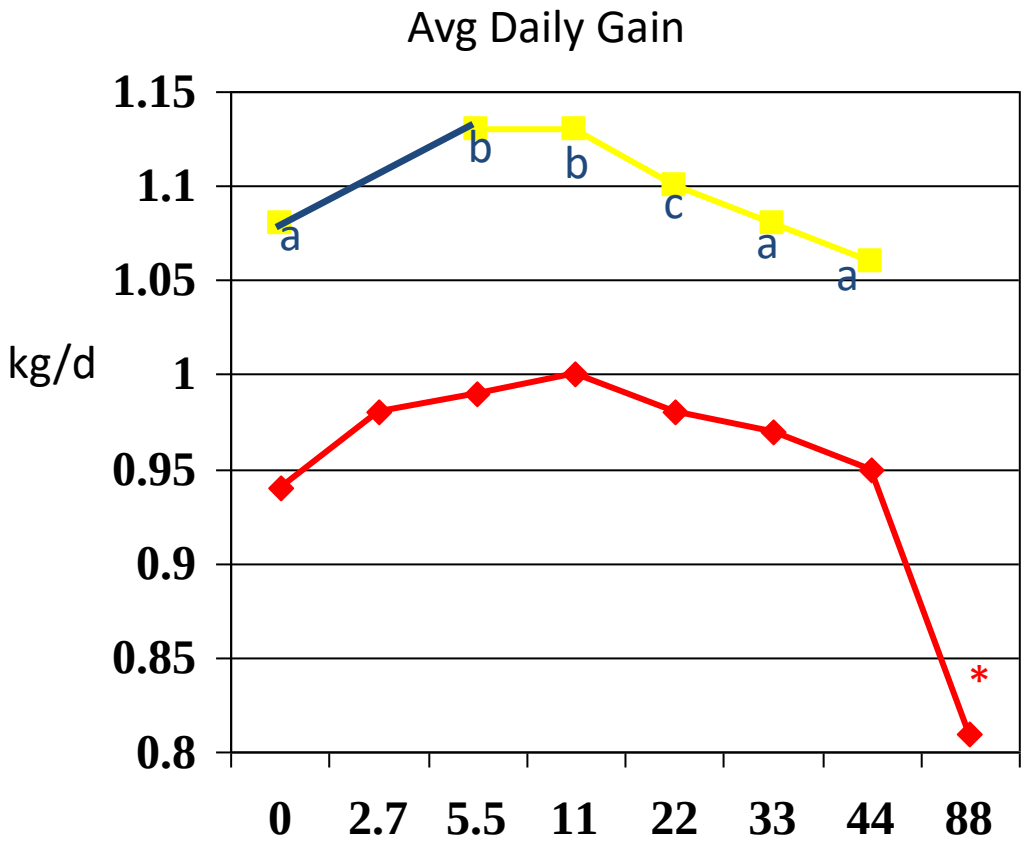
Effect of Monensin on Feedlot Cattle Performance

(Raun et al., 1976; Goodrich et al., 1984)



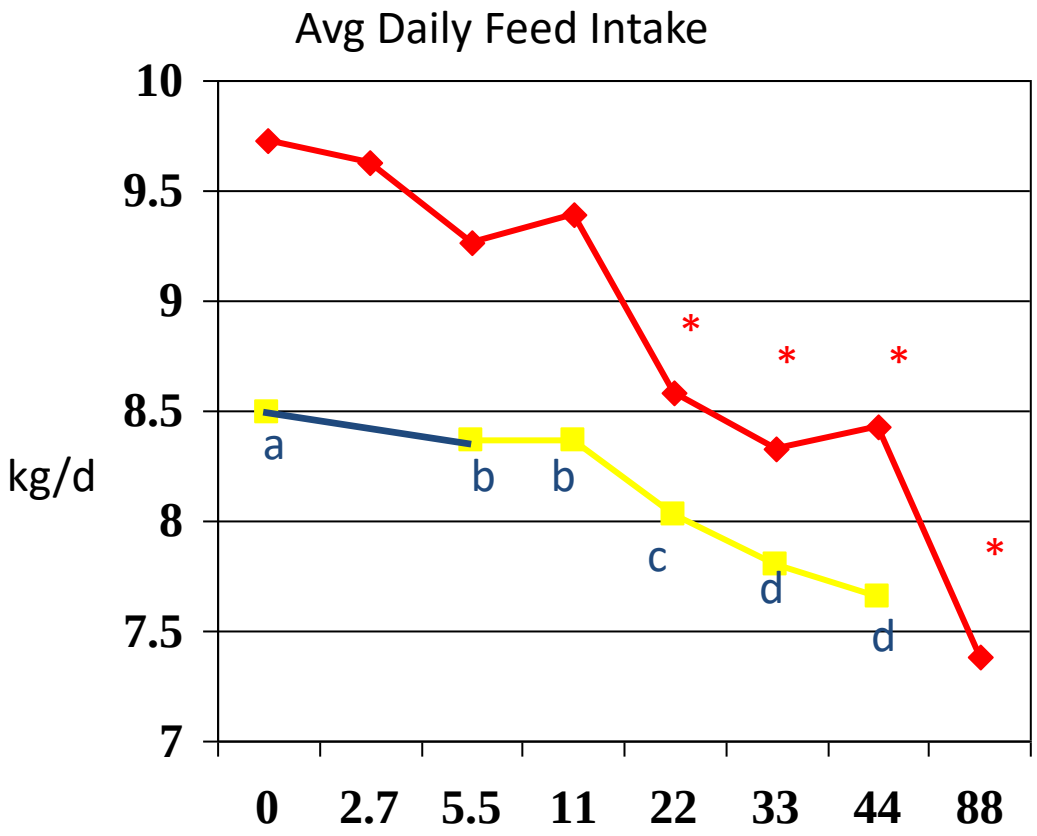
- At or below 44 ppm, no effect
- 88 ppm depressed gain
- Optimum response was 11 ppm

* Means different than control P< .01

a,b,c Means with different superscripts differ P < .05

Effect of Monensin on Feedlot Cattle Performance

(Raun et al., 1976; Goodrich et al., 1984)



- 11 ppm reduced intake 5%
- 33 ppm reduced intake 13%

* Means different than control P< .01

a,b,c Means with different superscripts differ P < .05

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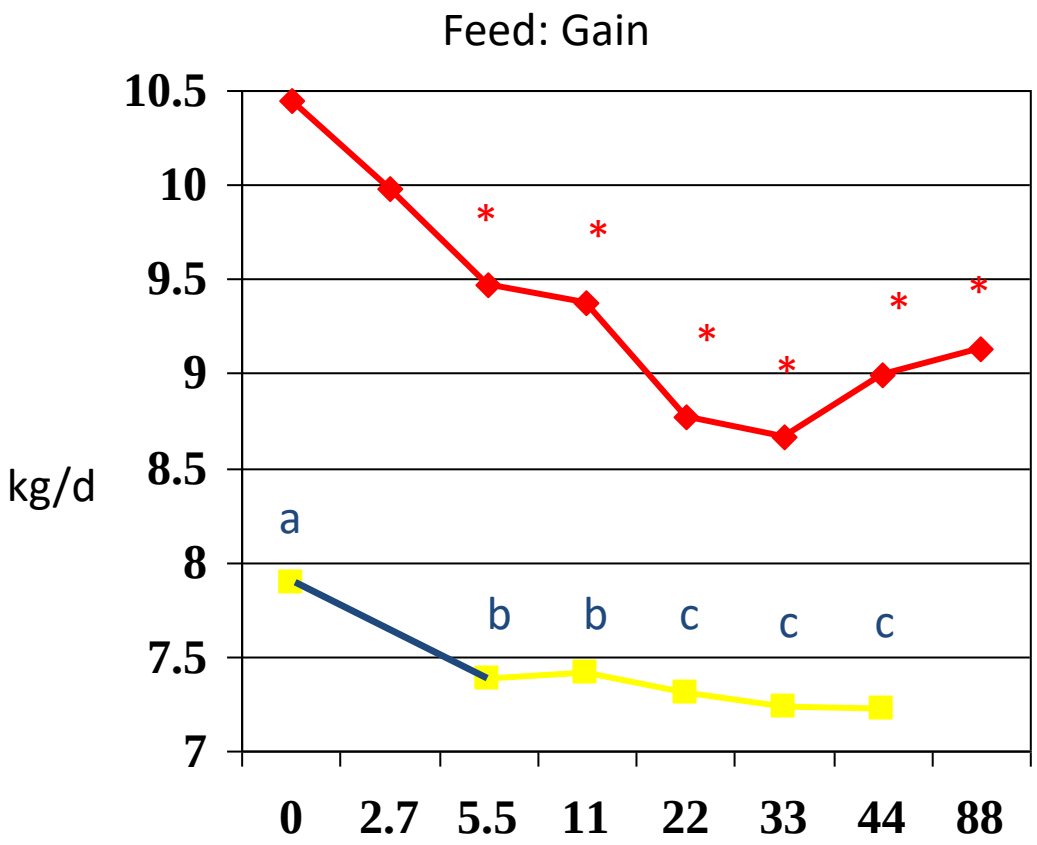
Effect of Monensin on Feedlot Cattle Performance

(Raun et al., 1976; Goodrich et al., 1984)



- All trts improved efficiency
- 33 ppm improved efficiency 17%

* Means different than control P< .01

a,b,c Means with different superscripts differ P < .05

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Combined-Trial Performance of Cattle Fed Diets Containing Laidlomycin Propionate

(Spires et al., 1990)

	Conc. of laidlomycin propionate, mg/kg DM				
	0	6	9	12	SE
DMI, kg/d	10.55^{ab}	10.72^{a}	10.54^{ab}	10.34^{b}	.11
ADG, kg/d	1.20^{a}	1.31^{b}	1.28^{b}	1.31^{b}	.02
Feed/Gain	9.02^{a}	8.31^{bc}	8.37^{b}	8.00^{c}	.12

^{a,b,c} Means in same row with different superscripts differ ($P < .05$)

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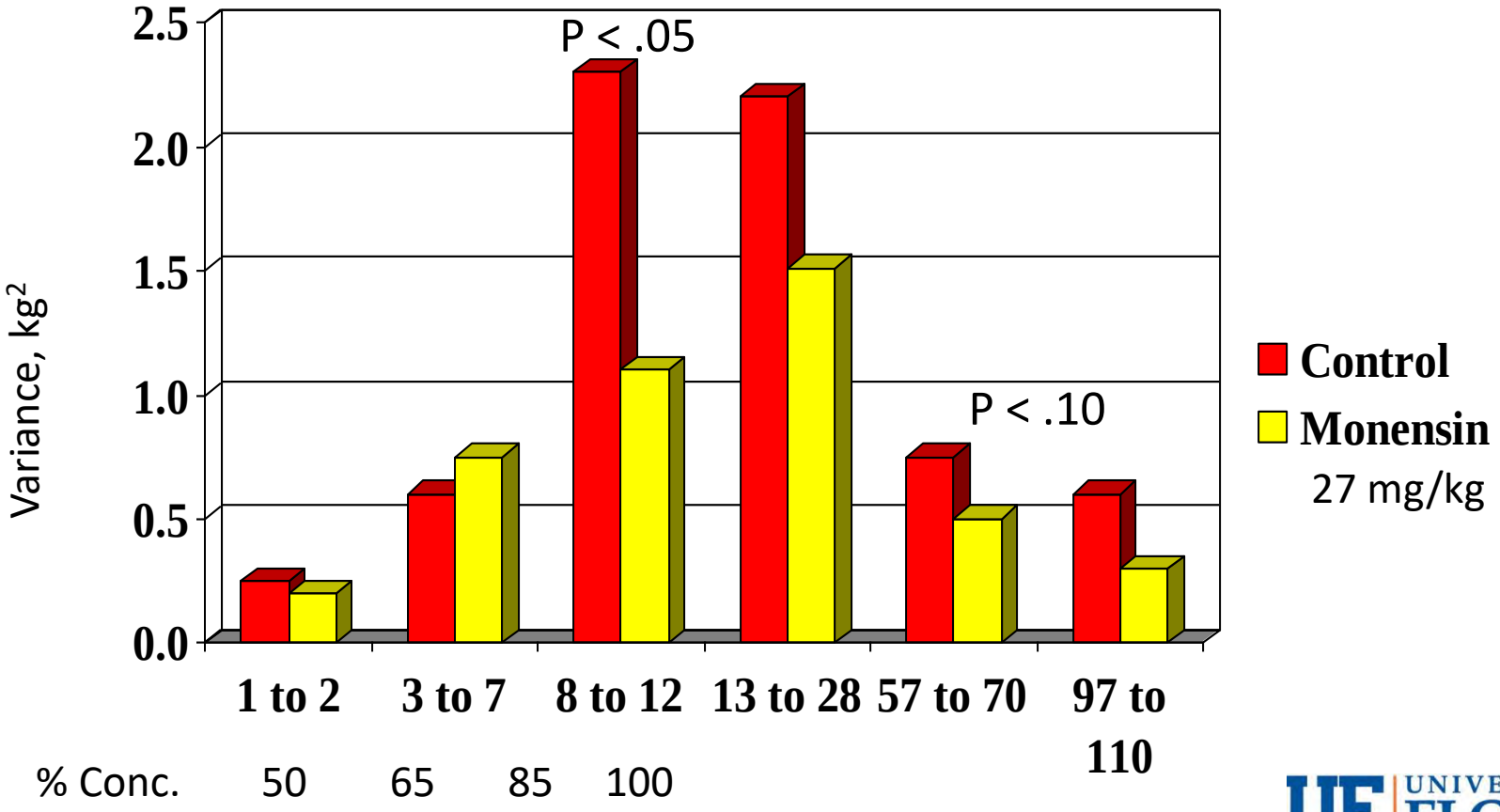
Variance in Feed Intake Among Days Within Period for Steers

(Stock et al., 1995)



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Significant Factors Affecting Efficacy of Monensin in Feedlot Diets

(Goodrich et al., 1984)

- Change in Daily Gain
  - Growth promoting implant
  - Control ADG
  - ME intake
  - Monensin dose
- Change in Daily Feed Intake
  - Control intake
  - ME intake
  - Monensin dose
- Change in Feed/100 kg Gain
  - Control feed/100 kg gain
  - ME Mcal/kg diet DM

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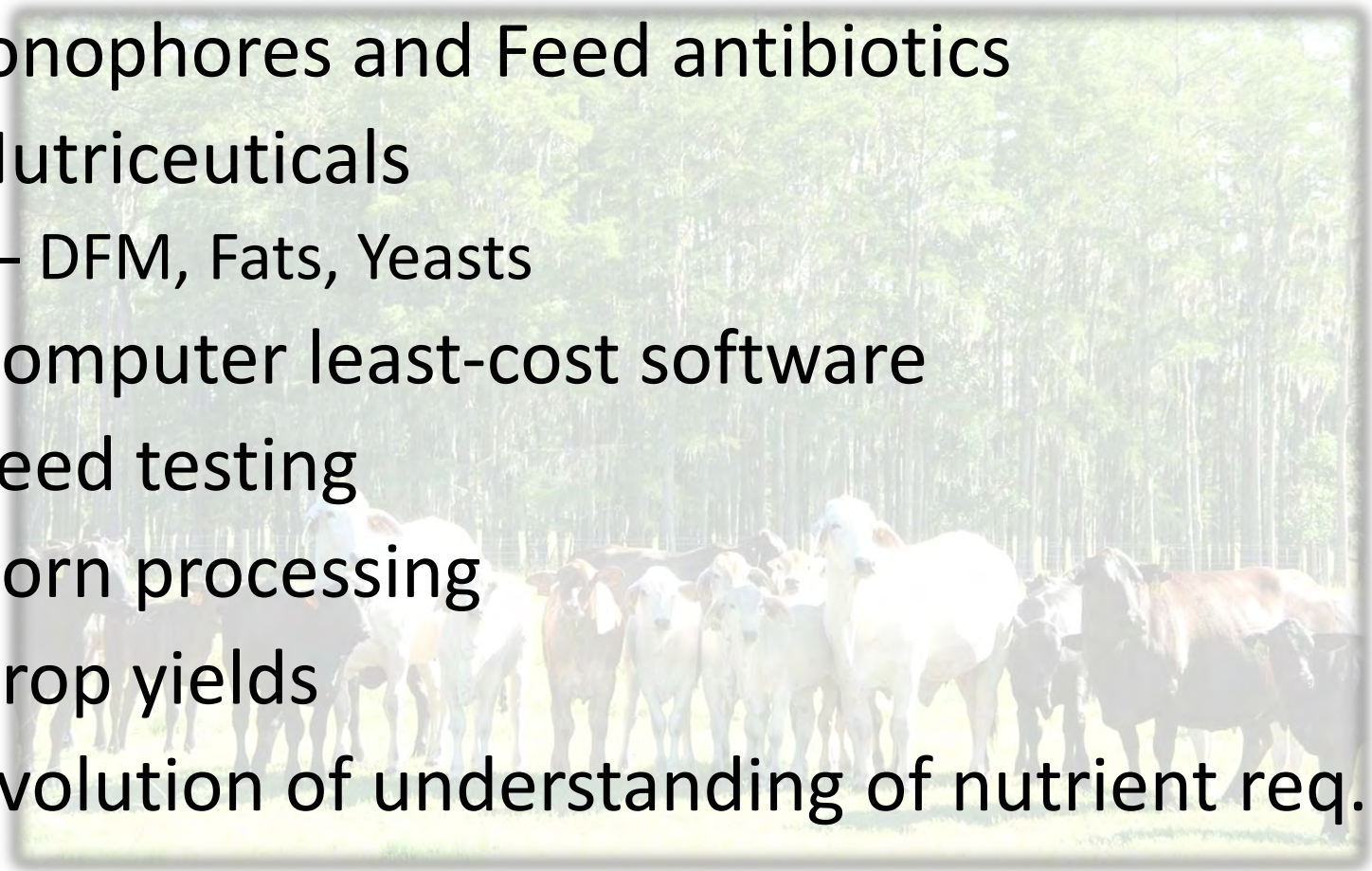
Conclusions

- Ionophores alter the rumen environment
- Alteration of fermentation profile provides more energy from feedstuff resulting in increased production
- Ionophore effects are attenuated by diet and genetic interactions
- Ionophores can be used to manipulate production and desired end-products

Nutrition

- Ionophores and Feed antibiotics
- Nutriceuticals
  - DFM, Fats, Yeasts
- Computer least-cost software
- Feed testing
- Corn processing
- Crop yields
- Evolution of understanding of nutrient req.



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All Technologies – Impact

		Effect
Cow Herd	Breakeven Selling Price, %	46.78
	Impact on Cost of Production, $	225.55
Stocker	Breakeven Selling Price, %	10.40
	Impact on Cost of Production, $	80.79
Feedlot	Breakeven Selling Price, %	11.99
	Impact on Cost of Production, $	126.09

Source: Lawrence and Ibarburu, 2006

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Model of Beef Production

		With Technology	Without Technology	Percent Change
Inventory (million head)	Beef Cows, Jan1	32.9	33.0	0.2
	Total calf crop	37.8	32.5	-14.1
	Steer & heifer harvest	27.2	22.6	-16.5
	Cattle and calves, Jan 1	98.4	93.7	-12.2
	Cattle on feed, Jan 1	13.7	11.4	-16.9
Beef Supply and Use (million lbs)	Production	24,784	20,225	-18.1
	Net imports	2,901	5,123	180.7
	Retail consumption	65.4	59.9	-8.5
Cow-calf Returns ($/cow)	Receipts	584.51	627.28	7.0
	Expenses	446.17	491.29	10.1
	Net Returns	138.34	135.99	-7.9

Source: Lawrence and Ibarburu, 2006

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