Creating the cash cow

Milk feeding, weaning, and AMFs

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VVMA
August 29, 2024

Overview

- Brief recap
- AMF
- Milk feeding
- Weaning

RESULTS

52% were involved in feeding and weaning protocols

94% wanted to be involved in feeding and weaning protocols

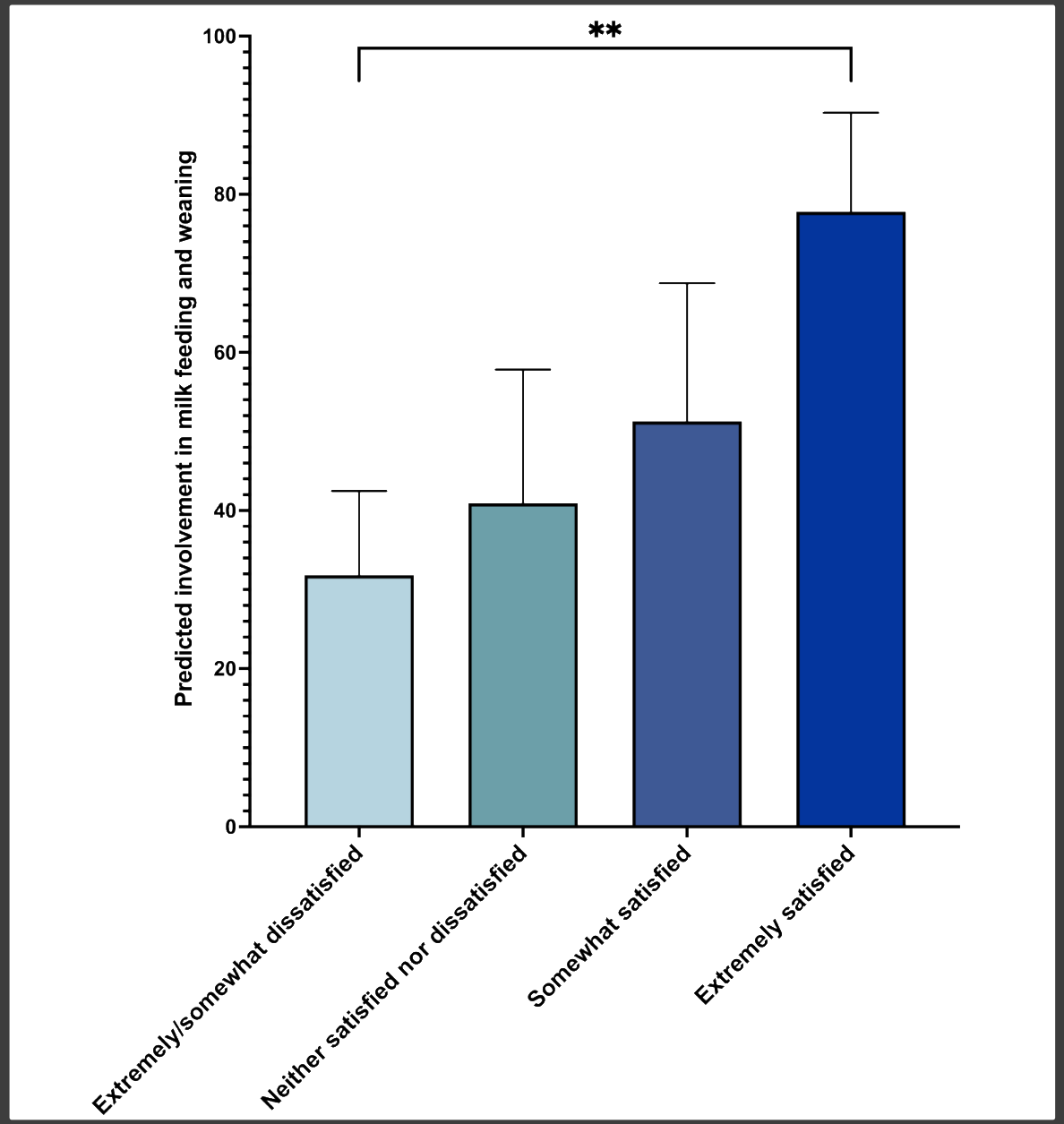
40% felt unsatisfied with their milk feed/wean knowledge

72% of veterinarians wanted to learn about AMFs

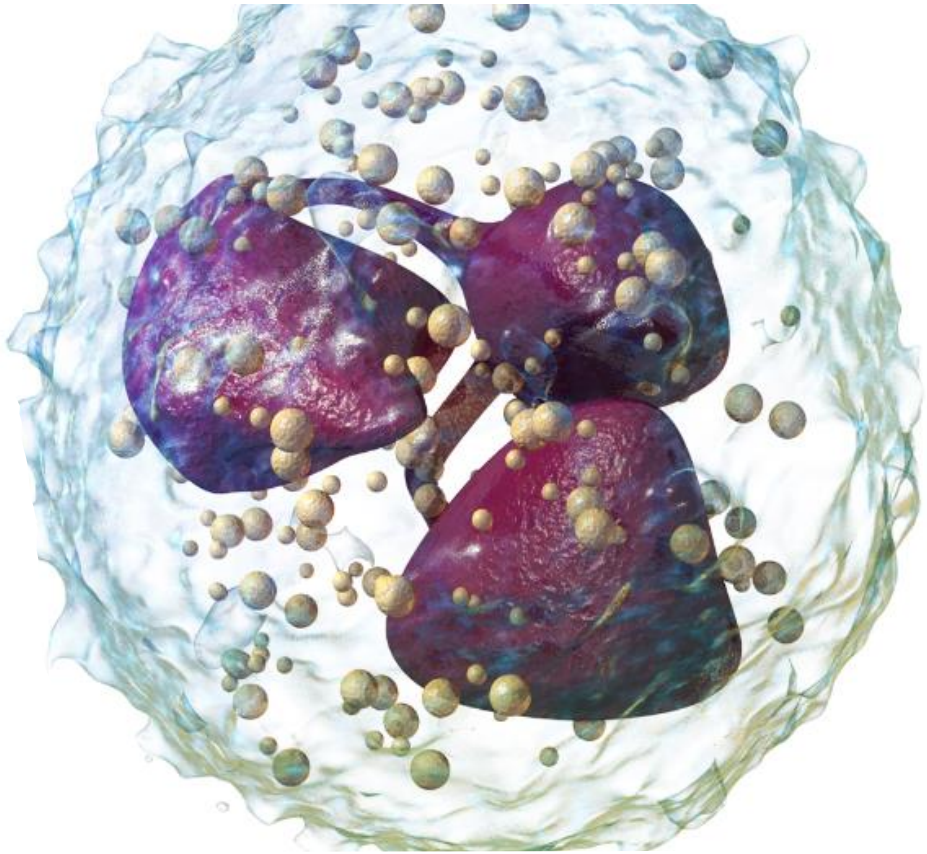
Edwards et al., *in prep*

What factors are associated with involvement in milk feeding and weaning decision making?

Veterinarians that were extremely satisfied with their level of knowledge regarding milk feeding recommendations had 6.27 times greater odds for being involved in milk feeding and weaning protocols ($P = 0.007$) compared to those that were extremely dissatisfied



Edwards et al., *in prep*



Low plane of nutrition:

- Altered immune responses
- Worsened neutrophil oxidative burst
- Delayed development of adaptive immune response
- Increased risk for BRD
- More severe responses to Cryptosporidium infection

Ollivett et al., 2012
Ballou et al., 2012
Ballou et al., 2018
Dubrovsky et al., 2019

Milk feeding

ECONOMIC IMPACT OF GROWTH

J. Dairy Sci. 95:783–793
doi:10.3168/jds.2011-4391

Preweaning milk replacer intake and effects on long-term productivity of dairy calves

F. Soberon, E. Raffrenato, R. W. Everett,[1] and M. E. Van Amburgh[2]
Department of Animal Science, Cornell University, Ithaca, NY 14853

2 farms (~700 heifers and ~1400 heifers)
ADG varied from 0.66 to 3.4 lb/day

Soberon et al., 2012

ECONOMIC IMPACT OF GROWTH

Farms	Preweaning ADG	Increased Milk Production – 1st lact
Farm 1	+ 1 lb	386 lb

Soberon et al., 2012

ECONOMIC IMPACT OF GROWTH

Farms	Preweaning ADG	Increased Milk Production – 1st lact
Farm 1	+ 1 lb	386 lb
Farm 2	+ 1 lb	505 lb

Soberon et al., 2012

ECONOMIC IMPACT OF GROWTH

Farm 1	Preweaning ADG	Increased Milk Production
First lact.	1 lb	386 lb

Soberon et al., 2012

ECONOMIC IMPACT OF GROWTH

Farm 1	Preweaning ADG	Increased Milk Production
First lact.	1 lb	386 lb
Second lact.	1 lb	403 lb
Total up to third	1 lb	1035 lb

- Preweaning average daily gain accounts for **22% of the variation** in first-lactation milk yield

Soberon et al., 2012

ECONOMIC IMPACT OF GROWTH

- For every additional 100 g/d increase in average daily gain before weaning, animals produce **155 kg extra milk** in first lactation

Soberon and Van Amburgh, 2013

ECONOMIC IMPACT OF GROWTH

A meta-analysis of the effects of preweaned calf nutrition and growth on first-lactation performance[1]

S. L. Gelsinger, A. J. Heinrichs,[2] and C. M. Jones
Department of Animal Science, The Pennsylvania State University, 324 Henning Building, University Park 16802

- **ADG less than 1 lb/d:** No difference in milk production
- **ADG between 1 – 2 lb /d:** milk production increases
- **Increase of 1 lb/d of DMI at weaning: + 627 lb of milk**

ECONOMIC IMPACT OF GROWTH

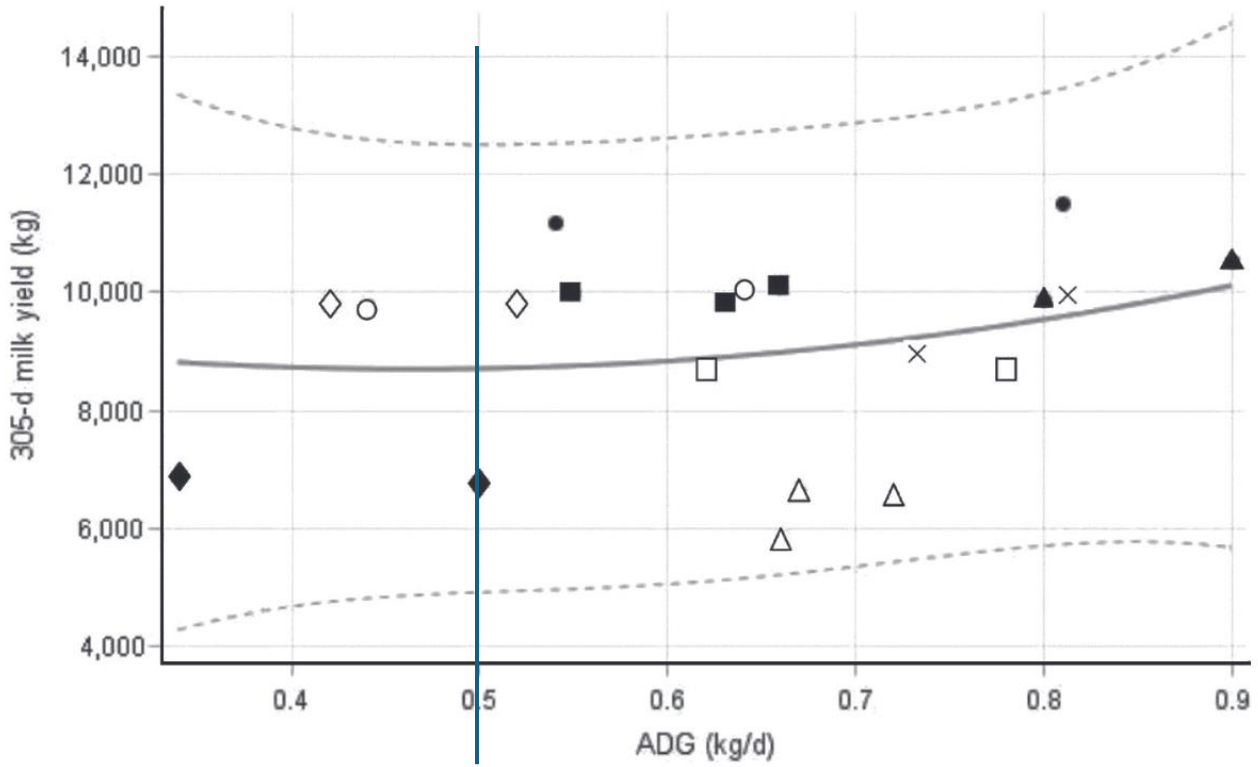


Figure 2. Mean milk production response to preweaning growth rates from treatments of experiments included in this meta-analysis. ◊ = Castells et al., 2015; □ = Kiezebrink et al., 2015; Δ = Margerison et al., 2013; ○ = Davis Rinker et al., 2011; × = Moallem et al., 2010; ♦ = Morrison et al., 2009; ■ = Raeth-Knight et al., 2009; ▲ = Terré et al., 2009; and ● = Shamay et al., 2005. The model of milk yield = ADG + ADG^2 is represented by the solid line, with 95% confidence limits shown by the dashed lines.

Gelsinger et al., 2016

The DCHA Gold Standard

GROWTH RATE

TARGET GROWTH RATE

- 24 hours to weaning (56 days of age):
  - **At least double birth weight**
  - **At least 4 – 5 inches** (10 – 12.7 cm) of height growth

The DCHA Gold Standard

Hypothetical situation (average Holstein farm):

Birth weight:
~ 85 lb or 38 kg

Weaning age:
8 weeks = 56 days

The DCHA Gold Standard

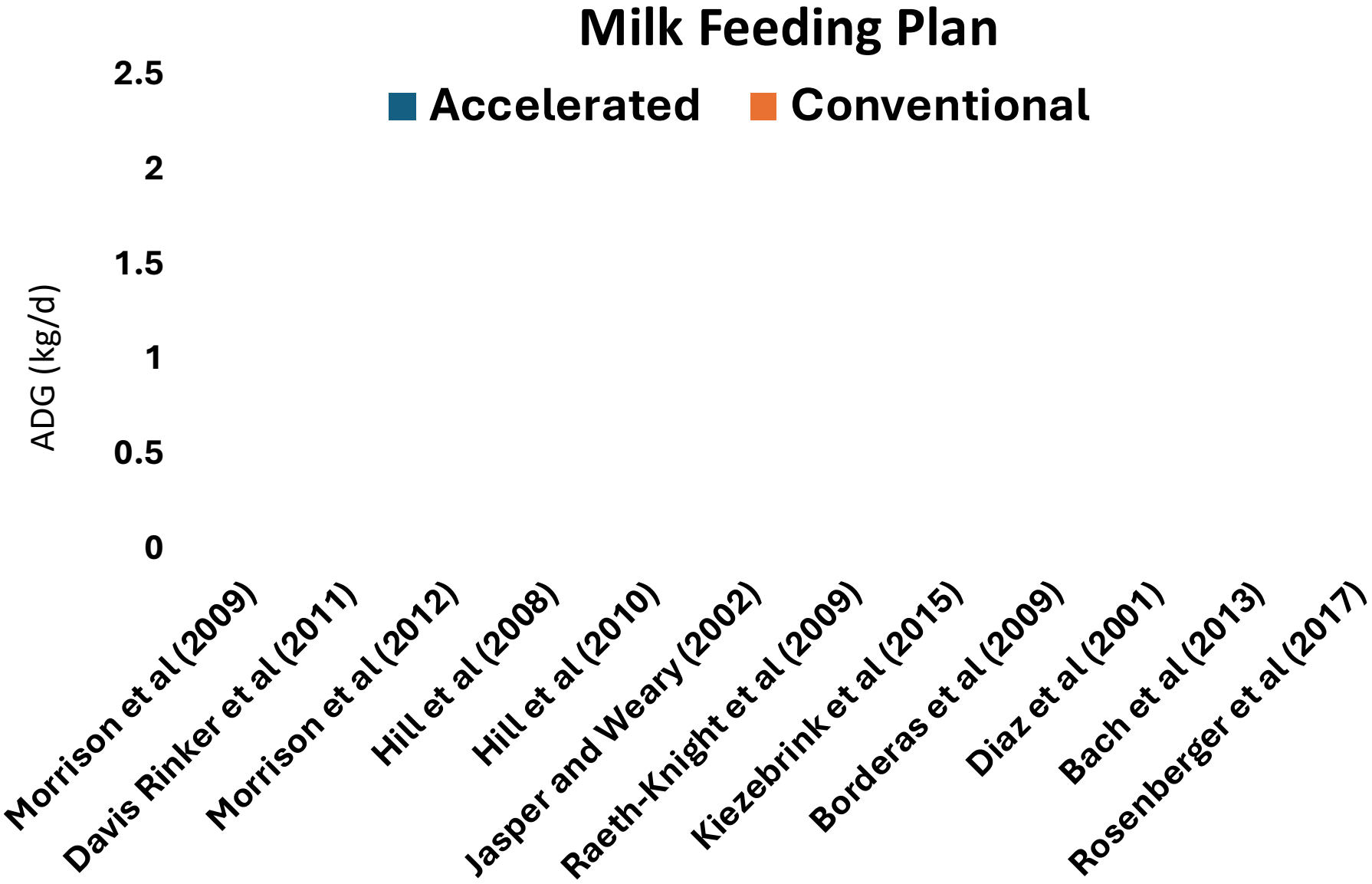
Hypothetical situation (average Holstein farm):

Birth weight:
~ 85 lb or 38 kg

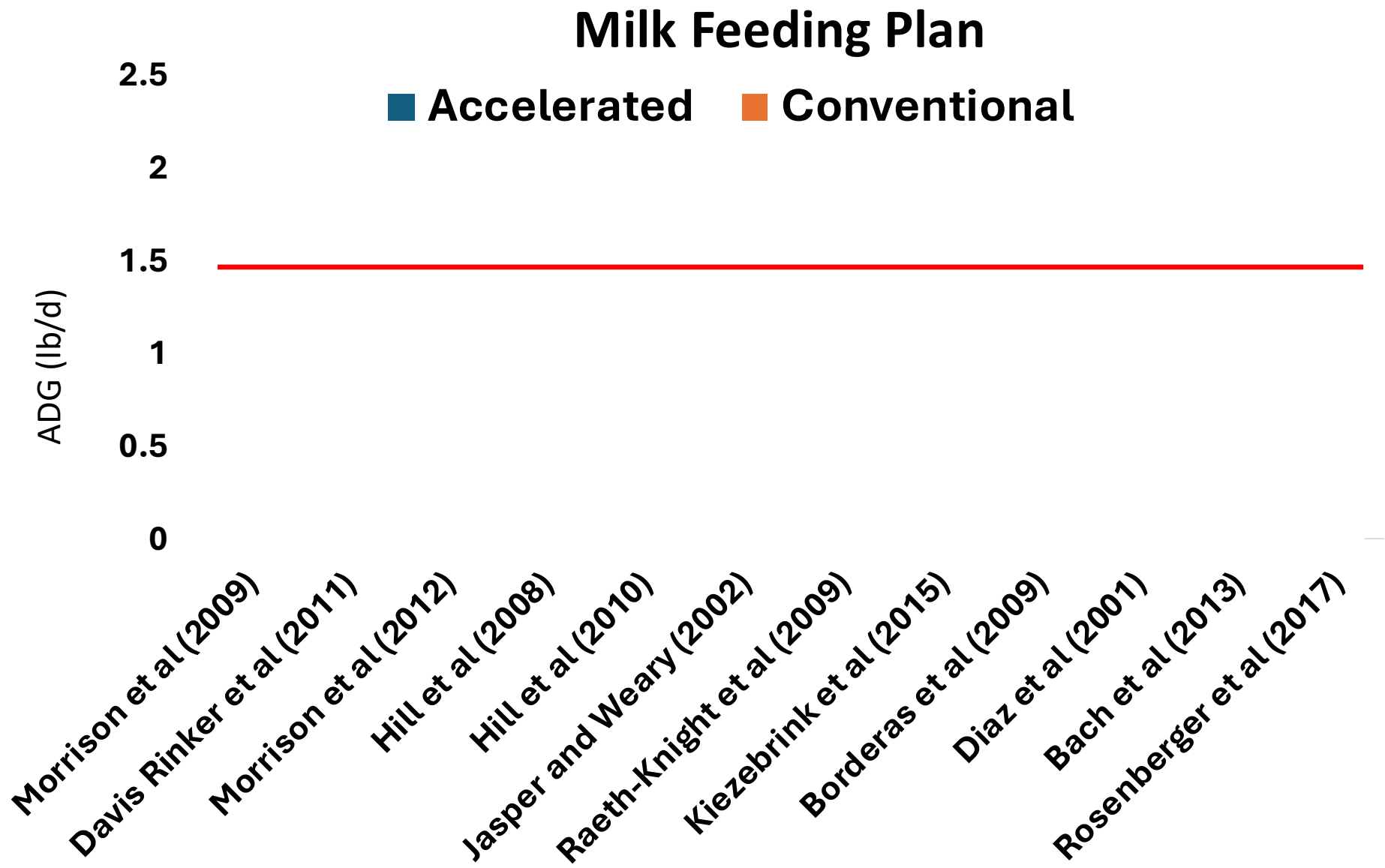
Weaning age:
8 weeks = 56 days

Target ADG:
85 lb/56 days = 1.5 lb/d

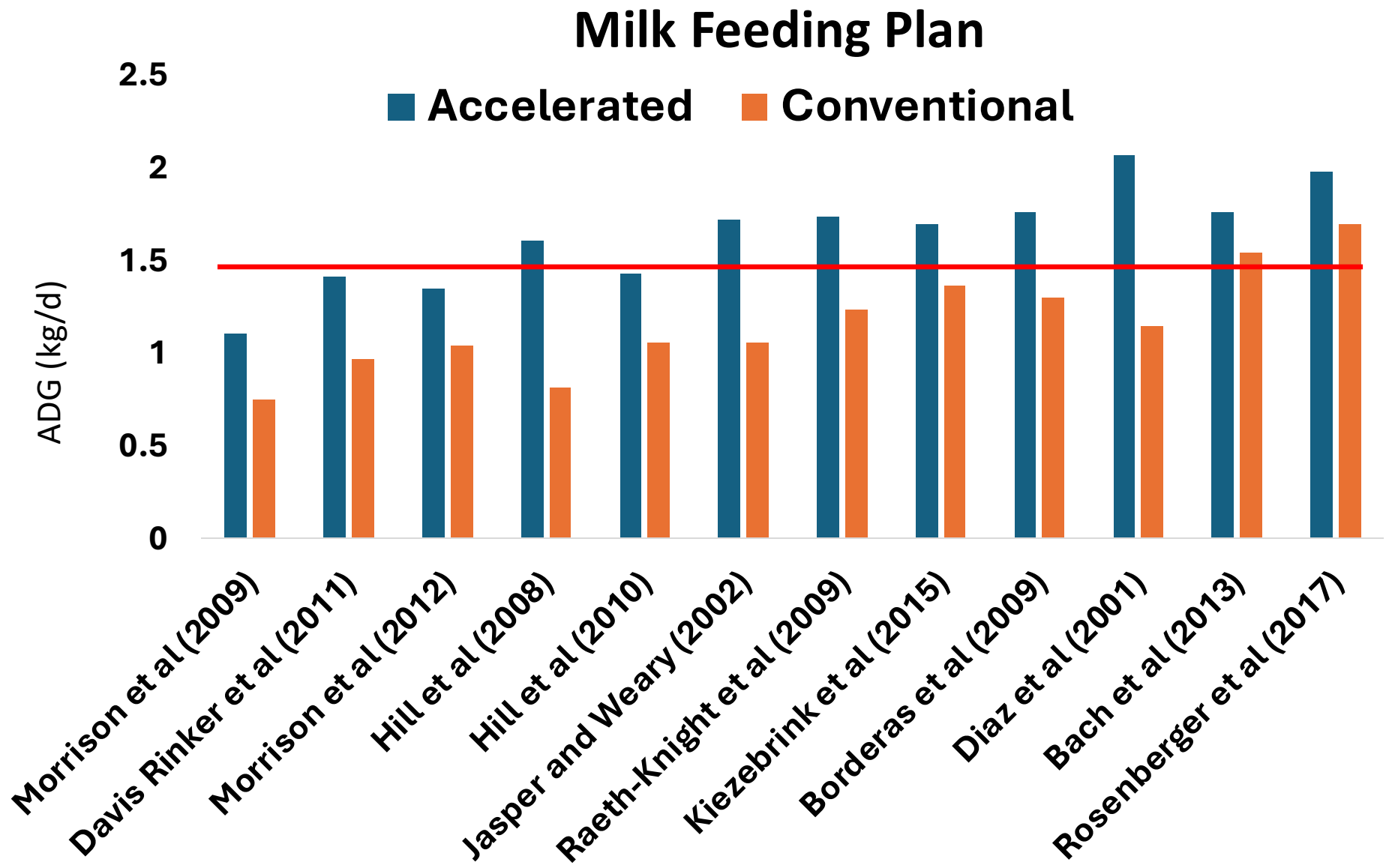
How can we double birth weight?



How can we double birth weight?



How can we double birth weight?



Milk feeding options

Birth

Days 2-5

Day 6

Day 56 = weaning

Colostrum

Transitional milk

Whole milk

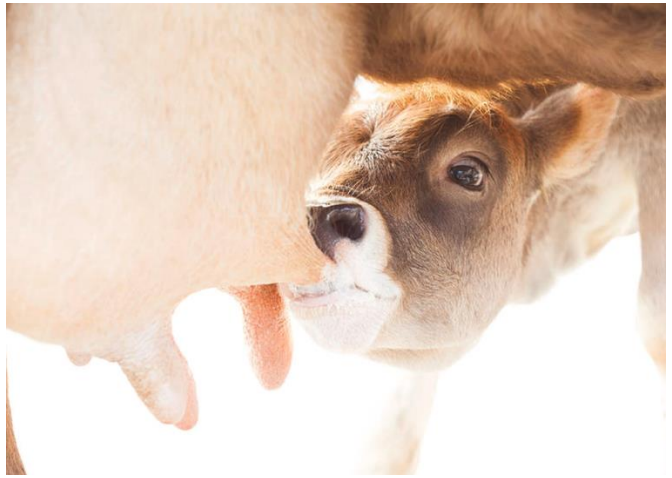
Acidified milk

Milk replacer

High CP:Fat ratio
Ex: 24:18

How much milk should we feed them?

- Nurse calf 5 - 10 times/d
- Nursing bouts last 5 - 10 min
- Provides about 10 kg of milk/d



In nature..

- Nurse calf 5 - 10 times/d
- Nursing bouts last 5 - 10 min
- Provides about 10 L (22 lb) of milk/d

What do we do?

- Feed 2 times a day
- Feed using a bucket
- Provide about 4 L (1 gall) of milk

What is the optimal amount of milk?

Milk feeding programs

Conventional Feeding Programs

Milk at 10-12% birth weight
(40 kg calf = 2 litres 2X per day)

Rates of gain – 0.3 to 0.5 kg per day

Conventional milk feeding thoughts

The role of milk:

- ✓Meet nutrients necessary for maintenance and slow growth

The role of starter:

- ✓For rumen development and supplemental growth from an early age

The role of forage:

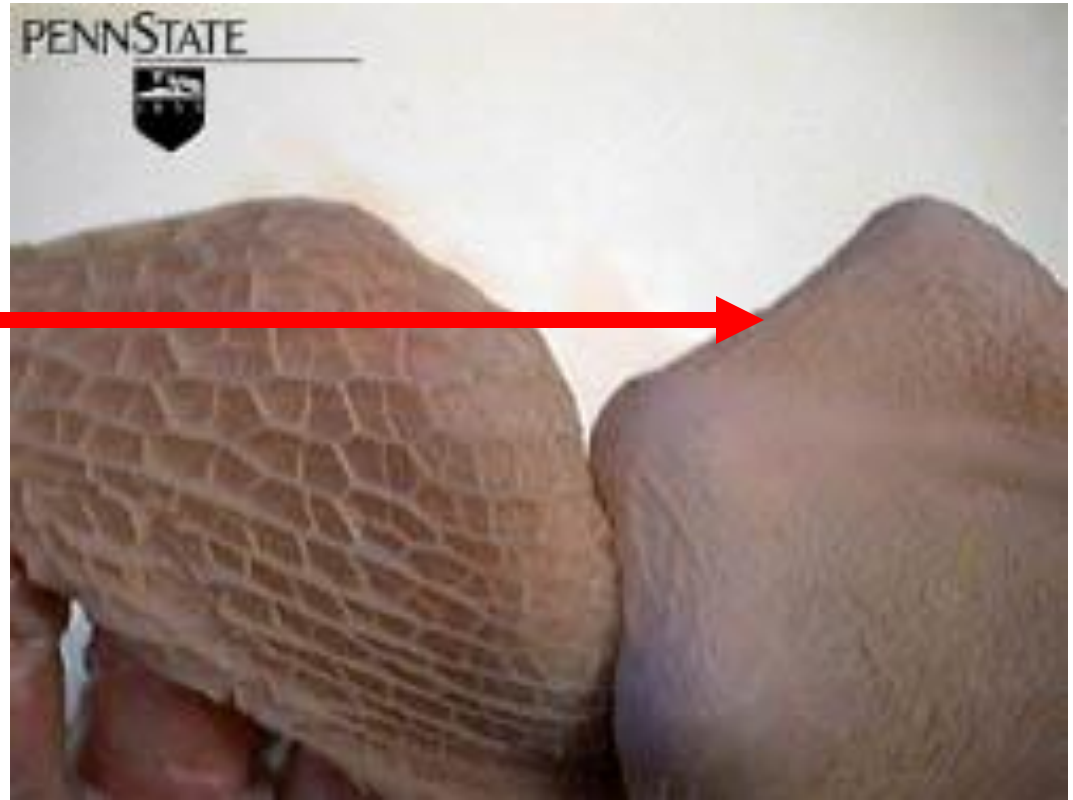
- ✓Thought to decrease starter intake and consequently decrease rumen development

Dairy calves fed milk and grain

(Note rumen papillae)

Dairy calves fed only milk from birth until 8 weeks of age

Note pale color and lack of rumen papillae development



But let's compare with accelerated feeding

Conventional Feeding Programs

Milk at 10-12% birth weight
(40 kg calf = 2 litres 2X per day)

Rates of gain – 0.3 to 0.5 kg per day

Accelerated Feeding Programs

Milk above 15% BW = 7L or more per day for Holstein

Rates of gain – 0.7 kg per day +

Accelerated milk feeding facts

The role of milk:

✓Research has shown calves require greater quantities of milk for proper growth

The role of starter:

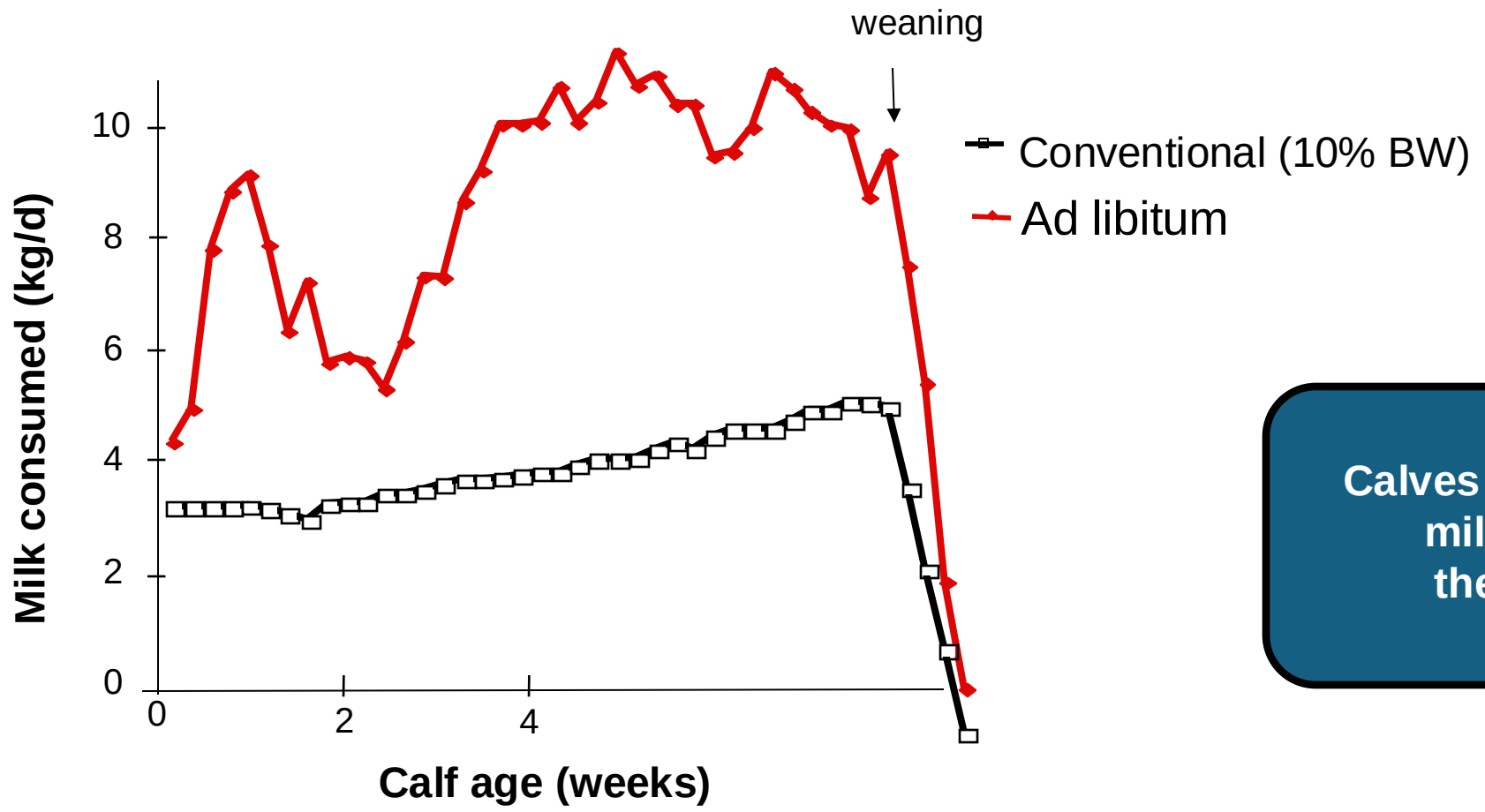
✓Important in rumen development

The role of forage:

✓To increase physical size of rumen

	Hay plus starter	Starter
Full rumen weight, kg	12.77	7.99
Weight without contents, kg	1.89	1.60
Rumen pH	5.49	5.06

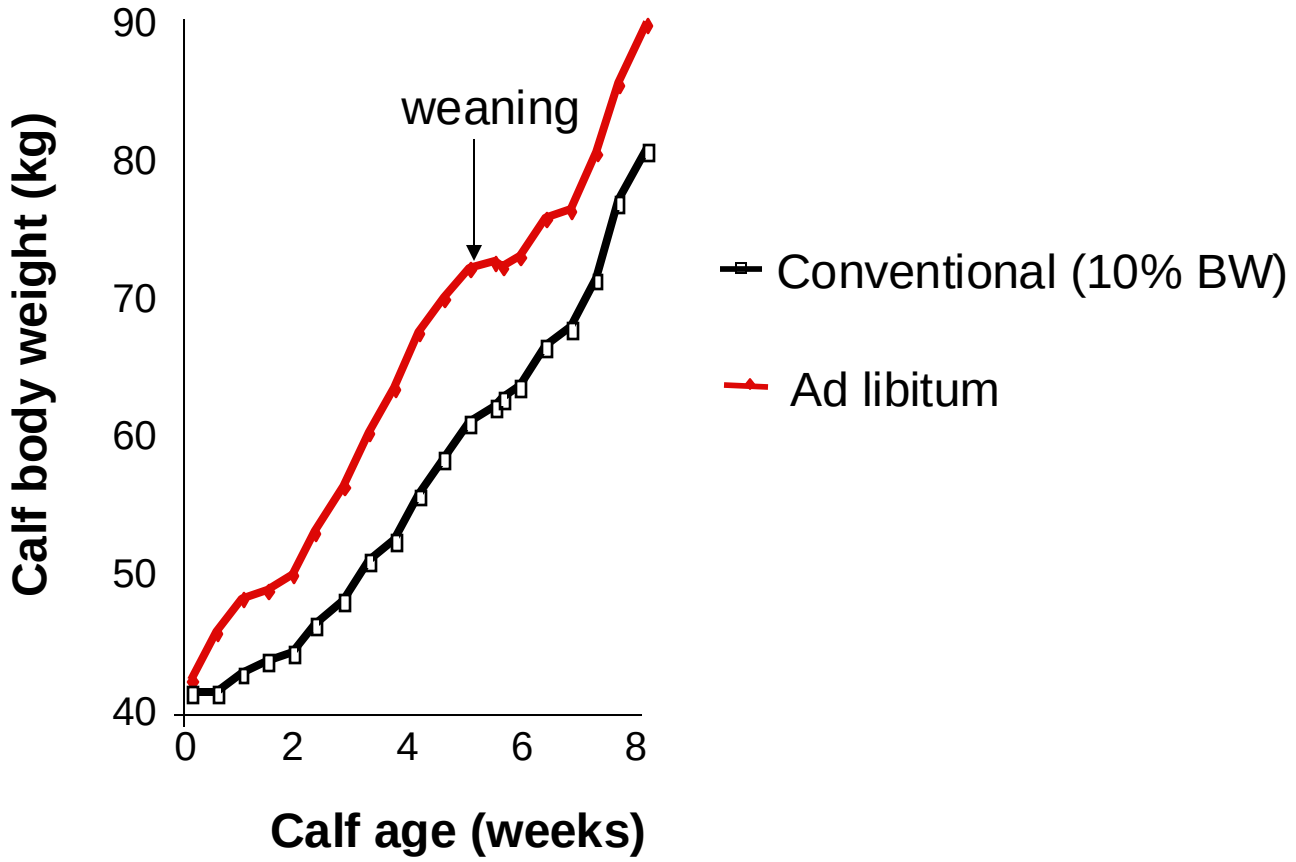
What happens when we allow calves to drink more milk?



Calves drink more milk when they can!

Jasper & Weary, 2002; J. Dairy Sci. 85: 3054-3058.

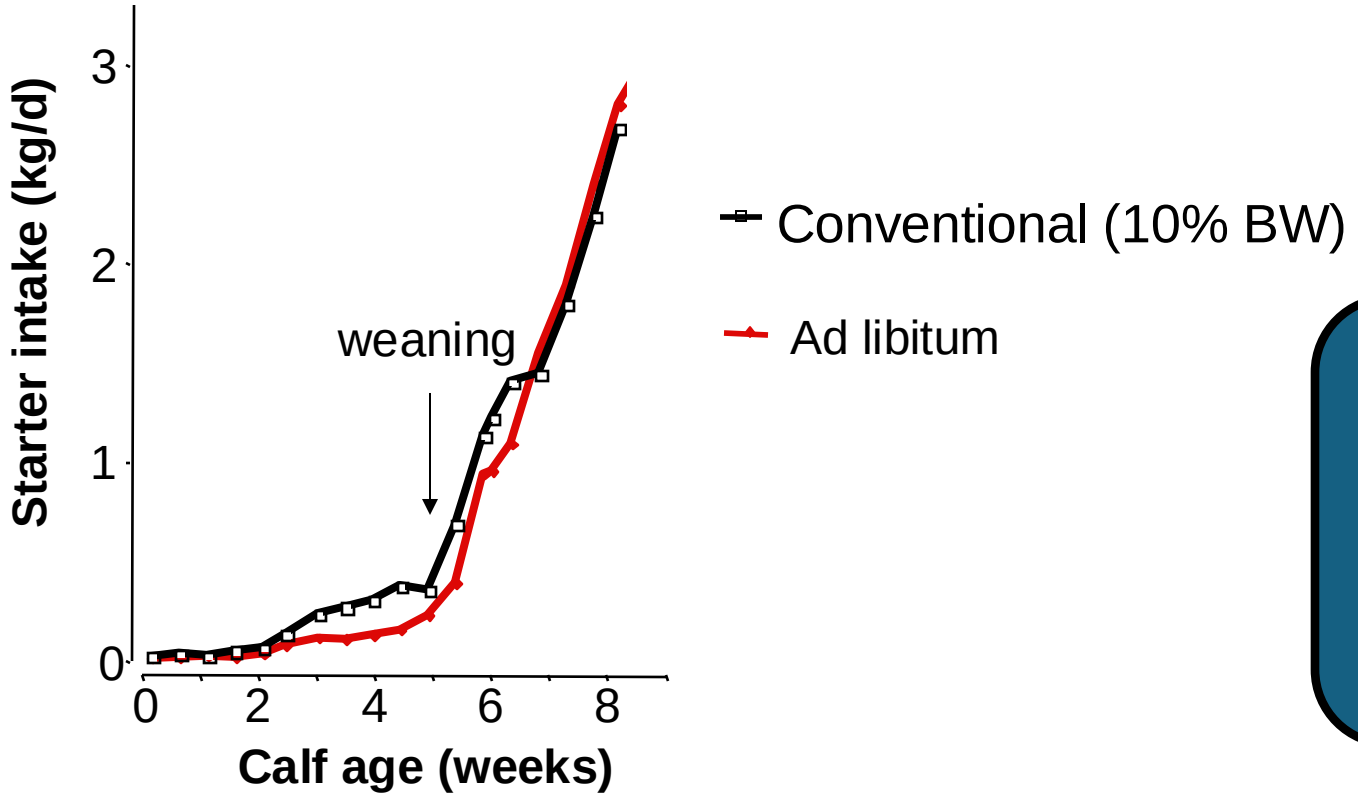
What happens when we allow calves to drink more milk?



Providing more milk allows for faster growth

Jasper & Weary, 2002; J. Dairy Sci. 85: 3054-3058.

What happens when we allow calves to drink more milk?



Higher milk intake slows starter intake before weaning, but not after weaning

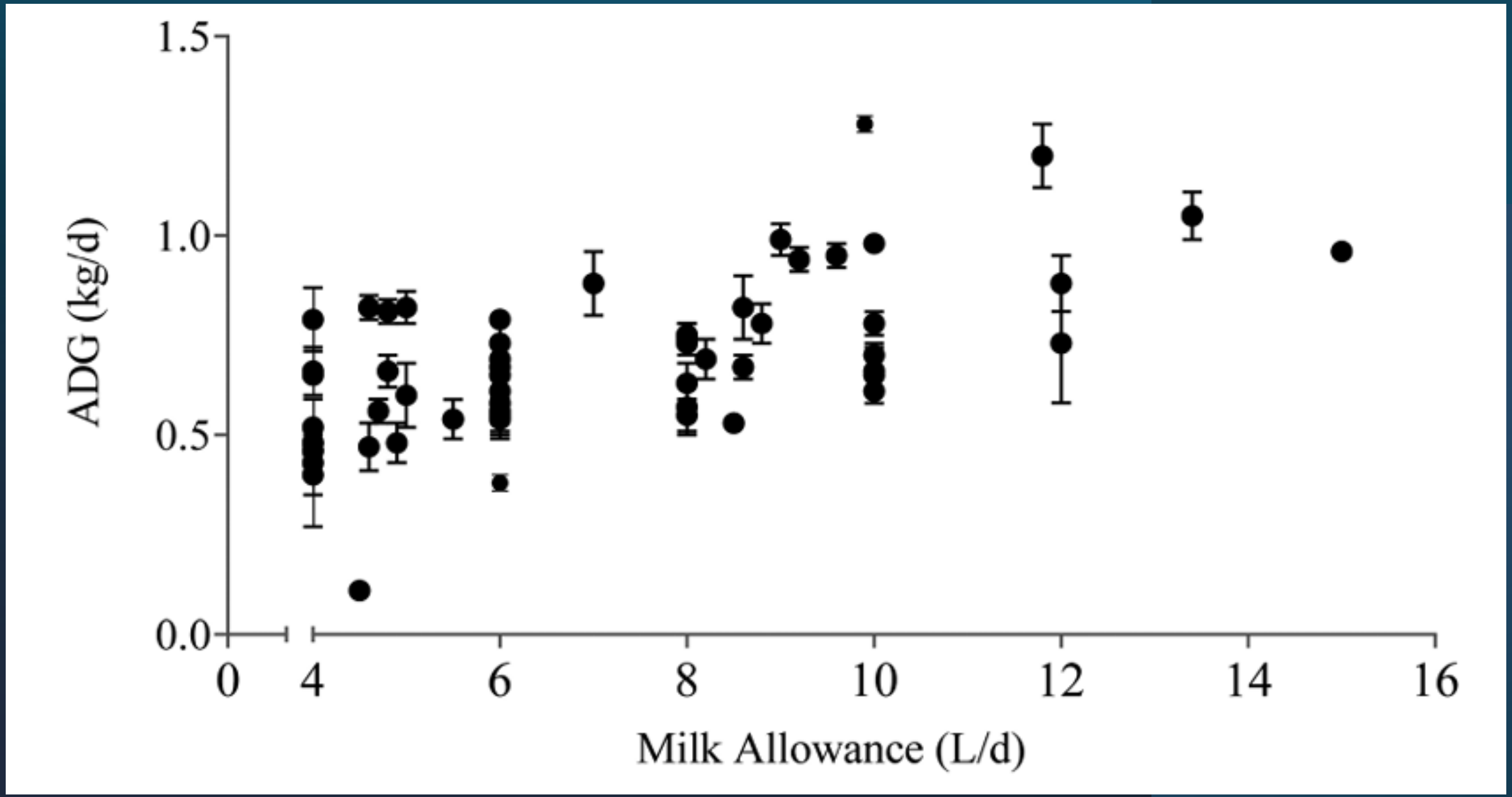
Jasper & Weary, 2002; J. Dairy Sci. 85: 3054-3058.

J. Dairy Sci. 106:5853–5879
https://doi.org/10.3168/jds.2022-22900

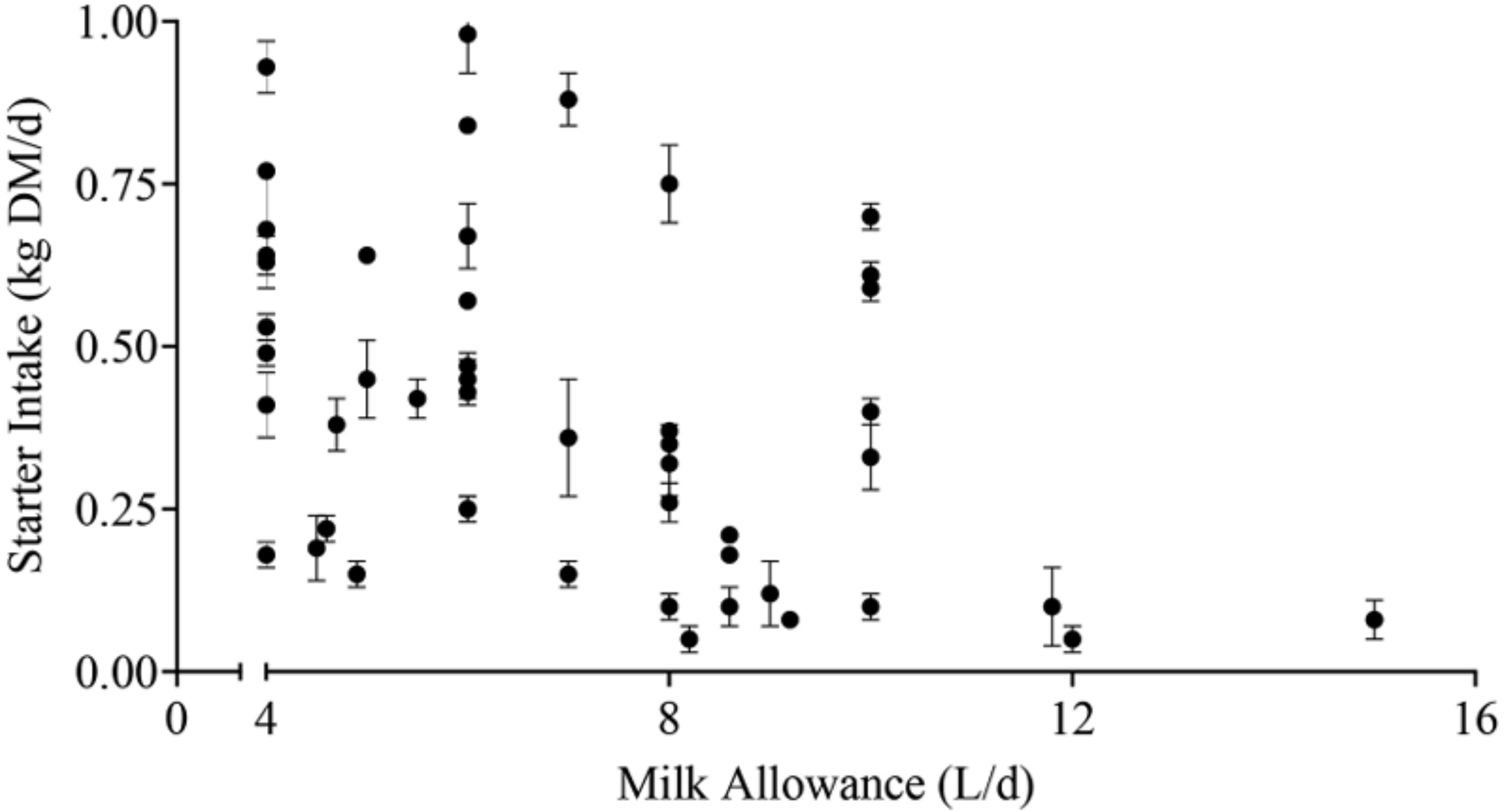
Invited review: The effect of milk feeding practices on dairy calf behavior, health, and performance—A systematic review

A. Welk,[1]* N. D. Otten,[2] and M. B. Jensen[1]†
[1]Department of Animal and Veterinary Sciences, Aarhus University, 8830 Tjele, Denmark
[2]Department of Veterinary and Animal Sciences, Faculty of Health and Medical Sciences, University of Copenhagen, 1870 Frederiksberg C, Denmark

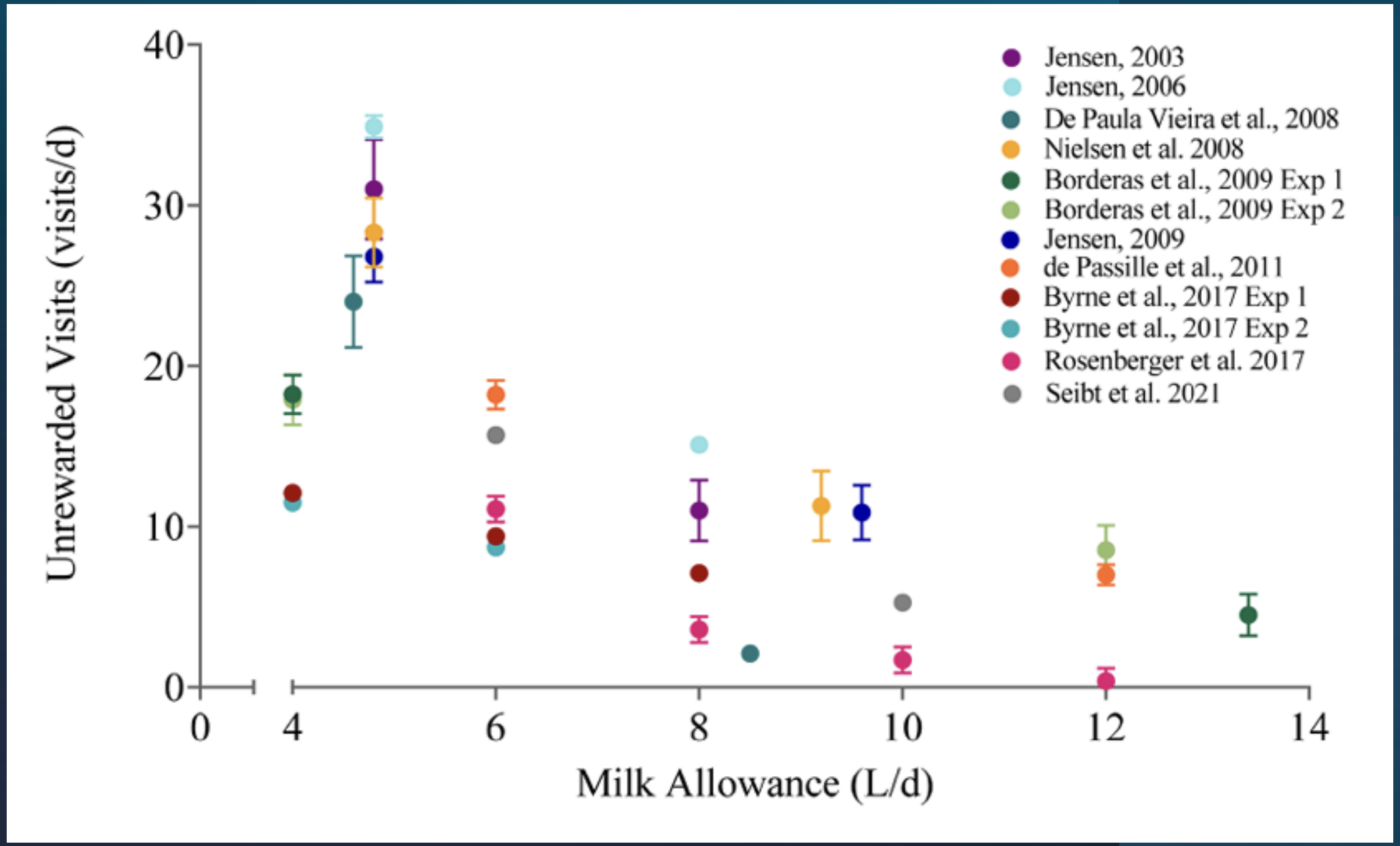
Welk et al., 2023



Welk et al., 2023



Welk et al., 2023



Welk et al., 2023

Milk feeding options

Birth

Days 2-5

Day 6

Day 56 = weaning

Colostrum

Transitional milk

Whole milk

Acidified milk

Milk replacer

High CP:Fat ratio
Ex: 24:18

Nearly 50% of US dairy farms feed milk replacers (USDA, 2014)

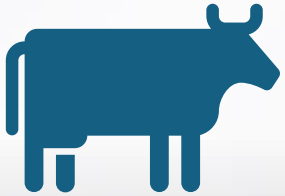
How does fat source in milk replacer affect calf performance?

J. Dairy Sci. 107:2797–2817
https://doi.org/10.3168/jds.2023-23740

Fat composition of milk replacer influences growth performance, feeding behavior, and plasma fatty acid profile in ad libitum–fed calves

J. N. Wilms,[1,2]* V. van der Nat,[1,3] M. H. Ghaffari,[4] M. A. Steele,[2] H. Sauerwein,[4] J. Martín-Tereso,[1] and L. N. Leal[1]

[1]Trouw Nutrition Research and Development, 3800 AG, Amersfoort, the Netherlands
[2]Department of Animal Bioscience, Animal Science and Nutrition, University of Guelph, Guelph, ON, Canada N1G 1W2
[3]Adaptation Physiology Group, Wageningen University, 6700 AH, Wageningen, the Netherlands
[4]Institute of Animal Science, University of Bonn, 53111 Bonn, Germany

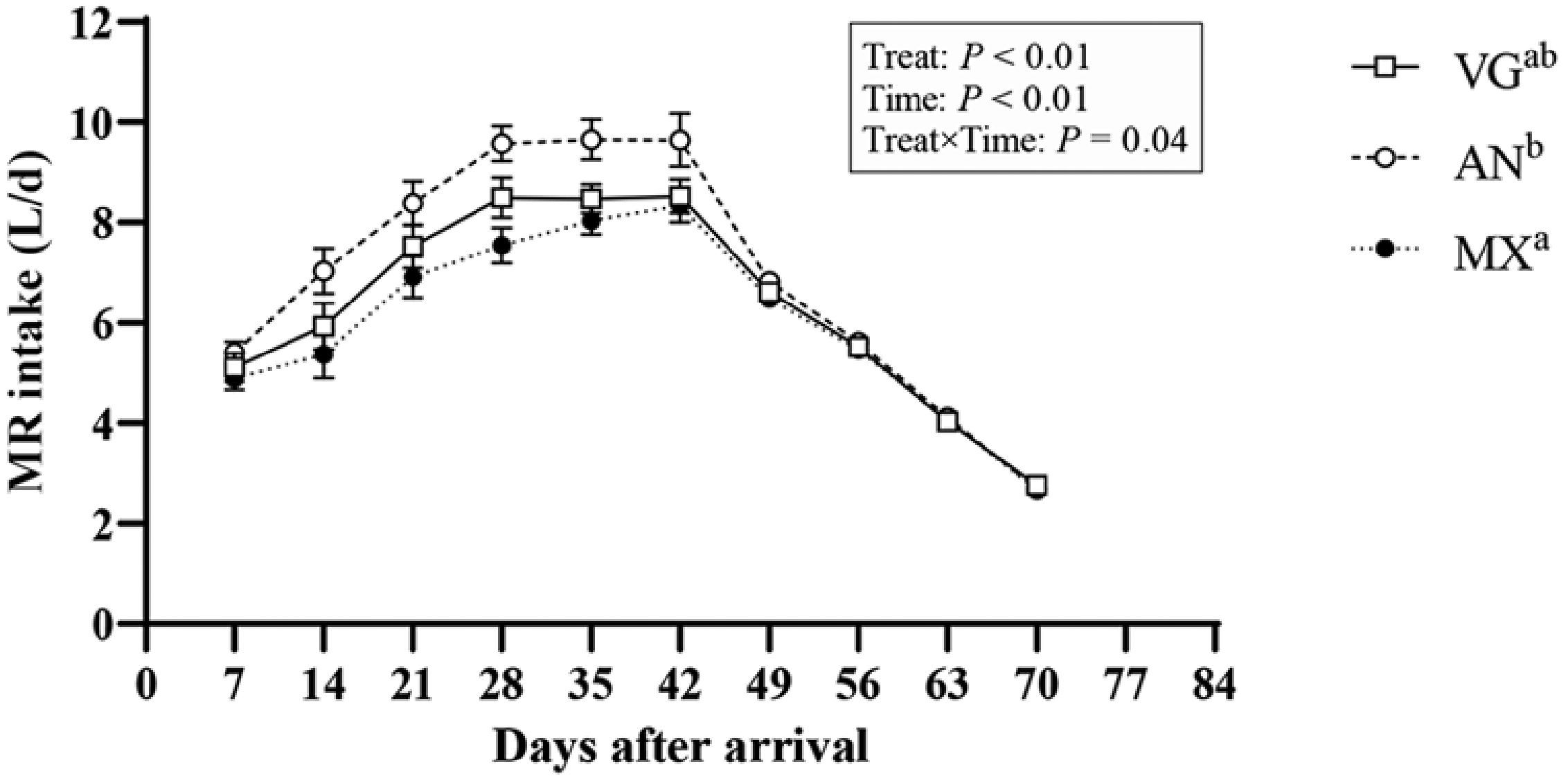


63 male calves fed ad libitum until d 42

Fed calves 1 of 3 milk replacer fat formulations:

- **VG**: only vegetable fats, 60% unhardened rapeseed oil mixed with 40% of Racomelt fat blend from Cargill
- **AN**: only animal fats, including 65% of packers lard and 35% of liquid dairy cream
- **MX**: mix of animal and vegetable fats, including 80% of packers lard and 20% of coconut fat

Wilms et al., 2023

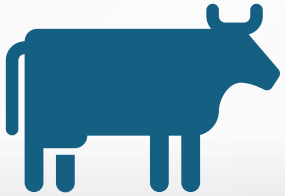


Wilms et al., 2023

Variable	VG	AN	MX	Treatment *P*-value
ADG preweaning (g/d)	775[b]	915[a]	790[b]	0.02

Variable	VG	AN	MX	Treatment *P*-value
ADG preweaning (g/d)	775[b]	915[a]	790[b]	0.02
Starter intake preweaning (g/d)	35.3	38.9	37.8	0.80
Starter intake during weaning (g/d)	1,028	1,171	1,213	0.21
Starter intake after weaning (g/d)	3,598	3,804	3,865	0.37

How does fat level in milk replacer affect calf performance?



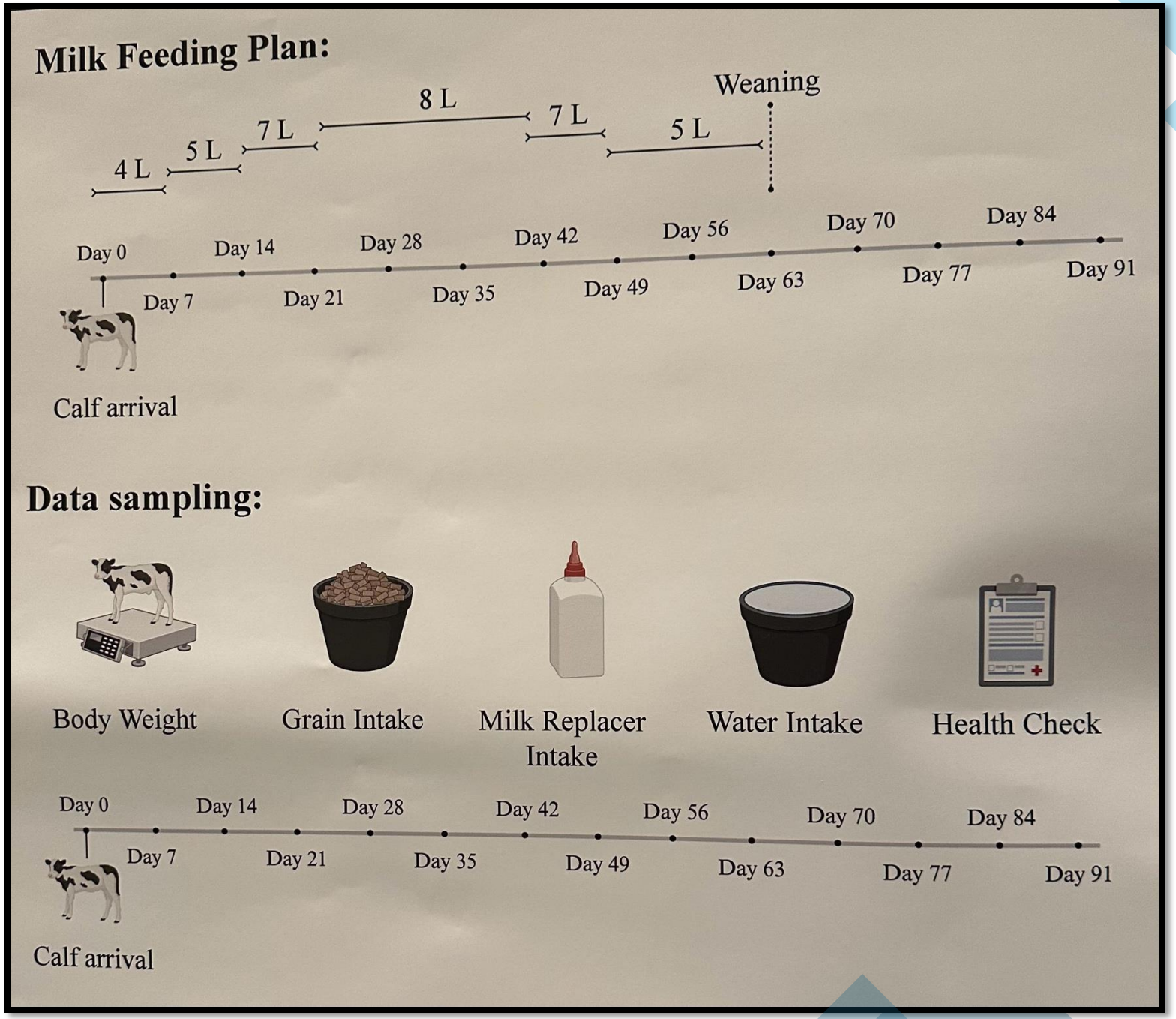
128 individually housed male calves

1 of 3 treatments:

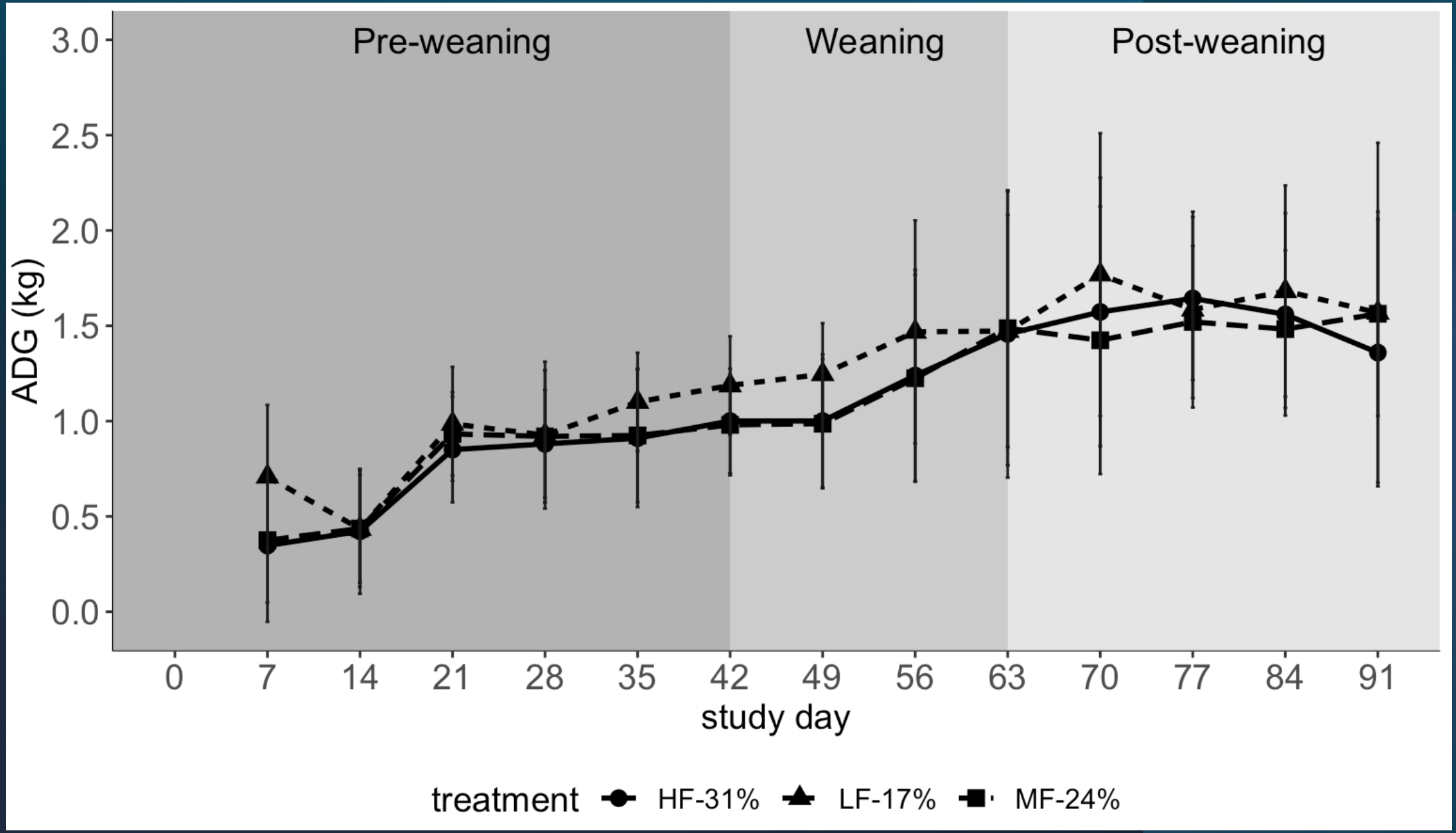
- Low fat = 17% Fat **(LF-17%)**
- Moderate fat = 24% Fat **(MF-24%)**
- High fat = 31% Fat **(HF-31%)**

All with 26% crude protein

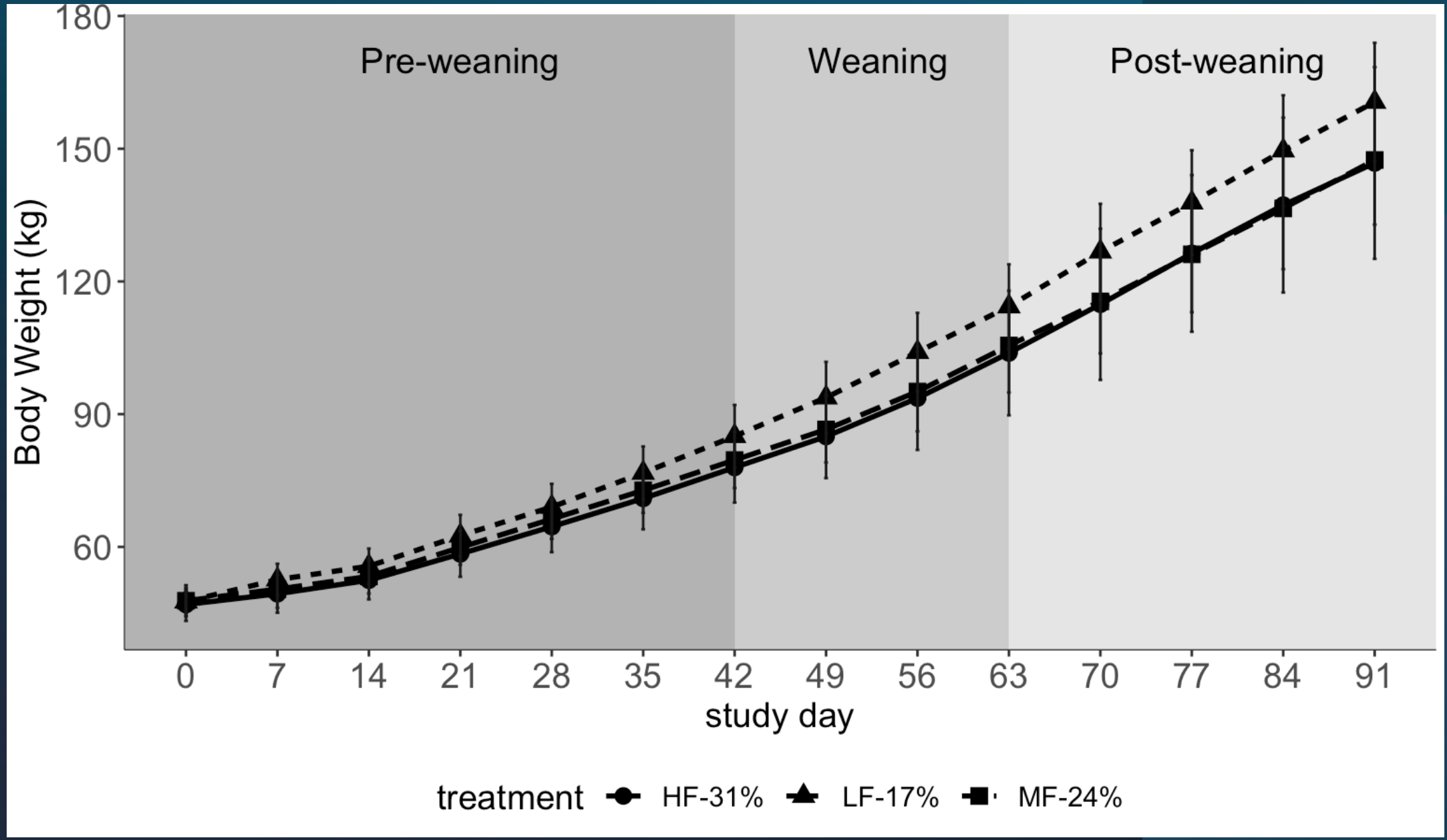
Lovatti et al., *in prep*



Lovatti et al., *in prep*



Lovatti et al., *in prep*



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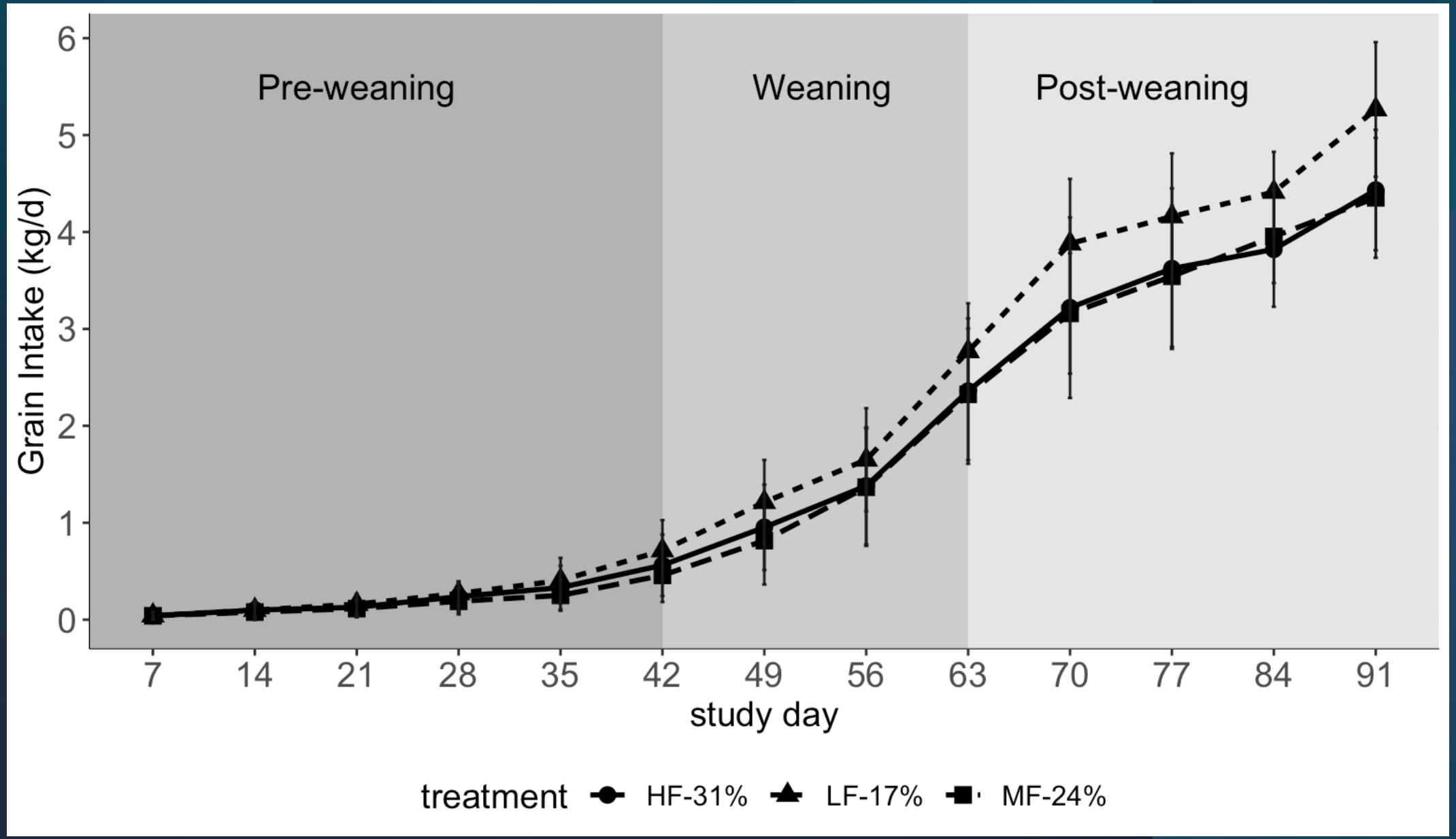
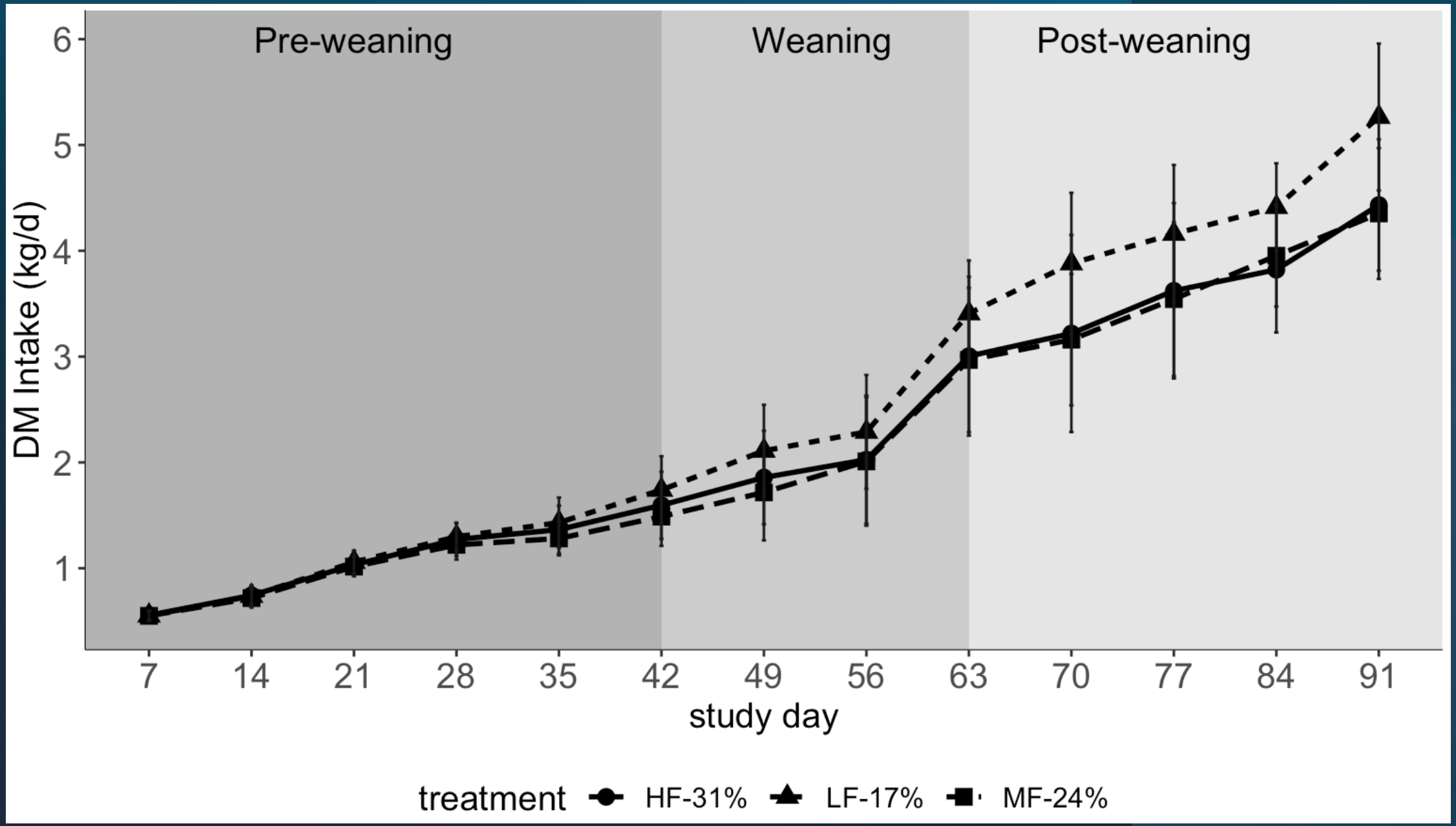


Lovatti et al., *in prep*



Lovatti et al., *in prep*

Feed Efficiency*	LF-17%	MF-24%	HF-31%	P-values
Pre-weaning (1-41d)	0.78[a]	0.72[b]	0.67[c]	<0.0001
Weaning (42-63d)	0.38	0.41	0.41	0.40
Post-weaning (64-91d)	0.28[b]	0.31[a]	0.30[a]	0.04
Total period	0.48	0.48	0.46	0.13

***Feed Efficiency = average daily gain / average dry matter intake**

Lovatti et al., *in prep*

J. Dairy Sci. 104:12079–12093
https://doi.org/10.3168/jds.2021-20516

Intestinal adaptations to energy source of milk replacer in neonatal dairy calves

A. C. Welboren,[1] B. Hatew,[2] J. B. Renaud,[3] L. N. Leal,[4] J. Martín-Tereso,[4] and M. A. Steele[1,2]*
[1]Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada, N1G 2W1
[2]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada, T6G 2P5
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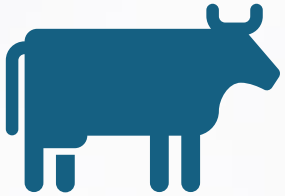
[4]Trouw Nutrition Research and Development, PO Box 299, 3800 AG, Amersfoort, the Netherlands



34 calves blocked by dam and parity and randomly enrolled, fed twice daily at 18% bodyweight

1 of 2 treatments:

- High lactose (**HL**): 46.1% lactose, 18.0% crude fat, and 23.9% CP of DM
- High-fat MR (**HF**): 39.9% lactose, 24.6% crude fat, and 24.0% CP of DM

Welboren et al., 2021

Table 1. Ingredients and nutrient composition of the milk replacers fed to calves in the first week of life[1] (n = 34)

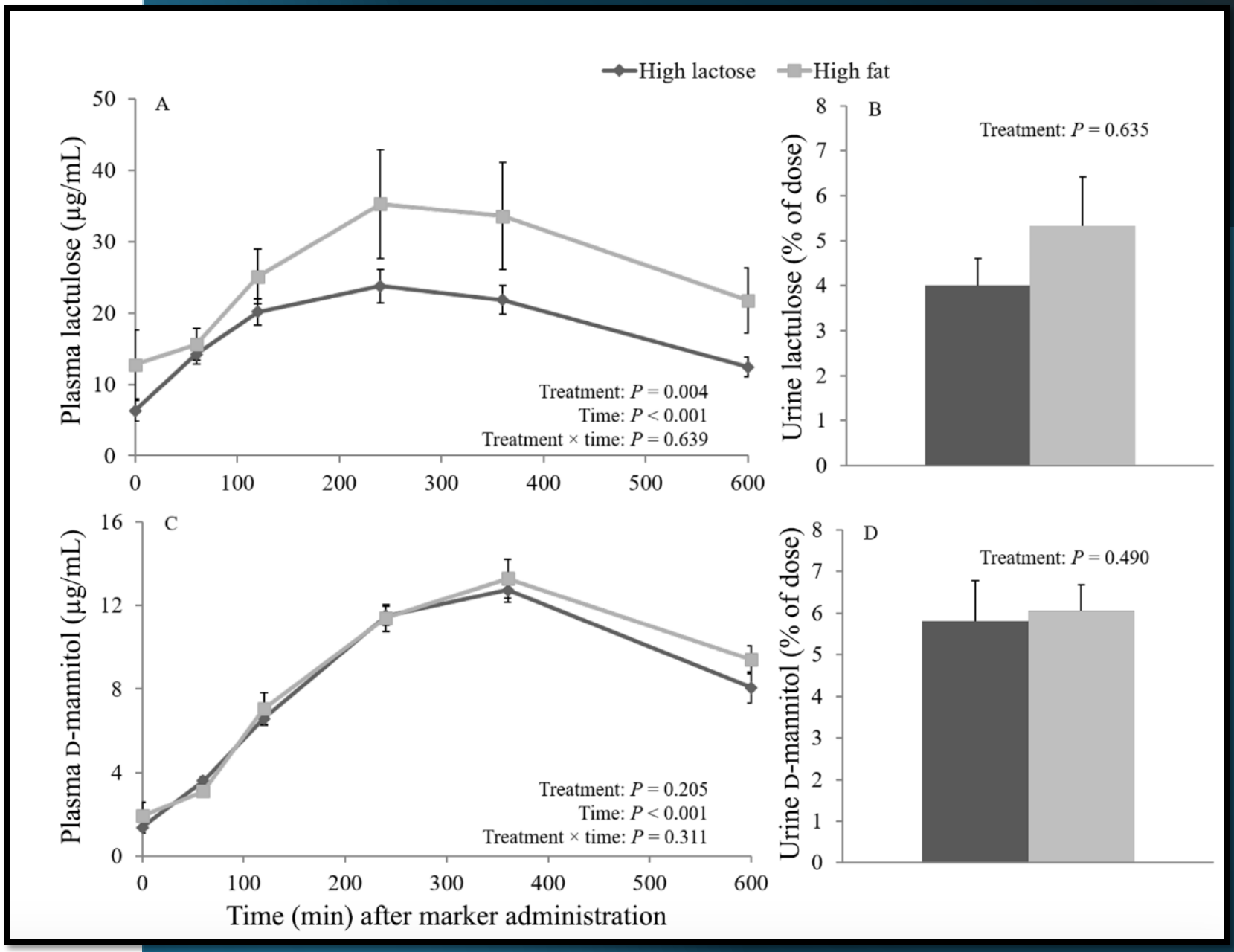
Item	High lactose	High fat
Ingredient (%)		
Skim milk powder	29.5	29.5
Fat blend (palm and coconut oil, 2:1)	16.7	22.6
Delactosed whey	10.5	13.2
Whey powder	30.1	14.7
Whey permeate powder	3.0	7.3
Whey protein concentrate	4.8	7.0
Hydrolyzed wheat protein	4.0	4.1
Premix	1.5	1.7
Nutrient (% of DM unless otherwise noted)		
DM (%)	97.5	97.5
Lactose	46.1	39.9
Crude fat	18.0	24.6
CP	23.9	24.0
Crude ash[2]	7.9	7.7
ME (Mcal/kg of DM)	4.23	4.49
Osmolality (mOsm/kg)	489.5	457.0

[1]Milk replacer (15% solids) was fed at 18% of metabolic body weight twice daily from 24 h until 7 d of age.

[2]Milk replacers were formulated to contain 17.0 vs. 16.5, 13.0 vs. 12.4, 8.0 vs. 8.0, and 7.3 vs. 7.1 g/kg of DM of K, Cl, Ca, and P in the high-lactose and high-fat milk replacer, respectively.

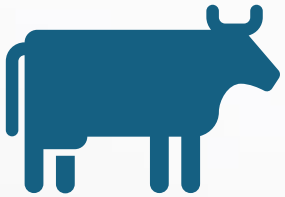
Welboren et al., 2021

Partially replacing lactose with fat to mimic the macronutrient composition of whole milk may benefit GIT development (greater GIT weight with high fat) but may also impair gut barrier function



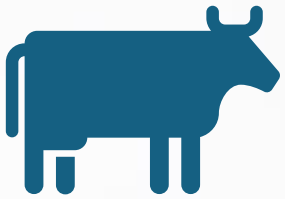
Welboren et al., 2021

Milk replacer summary



Feeding lower fat milk replacers when feeding **at least 2 gallons per day** may be a good strategy to improve gain in preweaned calves

Milk replacer summary



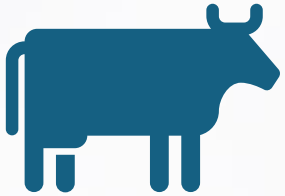
Feeding lower fat milk replacers when feeding **at least 2 gallons per day** may be a good strategy to improve gain in preweaned calves

But the age-old question… will feeding more milk (at least 2 gallons) make weaning more difficult?

Effects of amount of milk fed, and starter intake, on performance of group-housed dairy heifers during the weaning transition

J. Haisan,[1] M. A. Steele,[1] D. J. Ambrose,[1,2] and M. Oba[1]*

[1]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, T6G 2P5, Canada; and [2]Livestock Research Section, Alberta Agriculture and Forestry, Edmonton, T6H 5T6, Canada



55 female calves were individually housed and randomly assigned to differing planes of milk nutrition

1 of 2 treatments fed until 48 days of age:

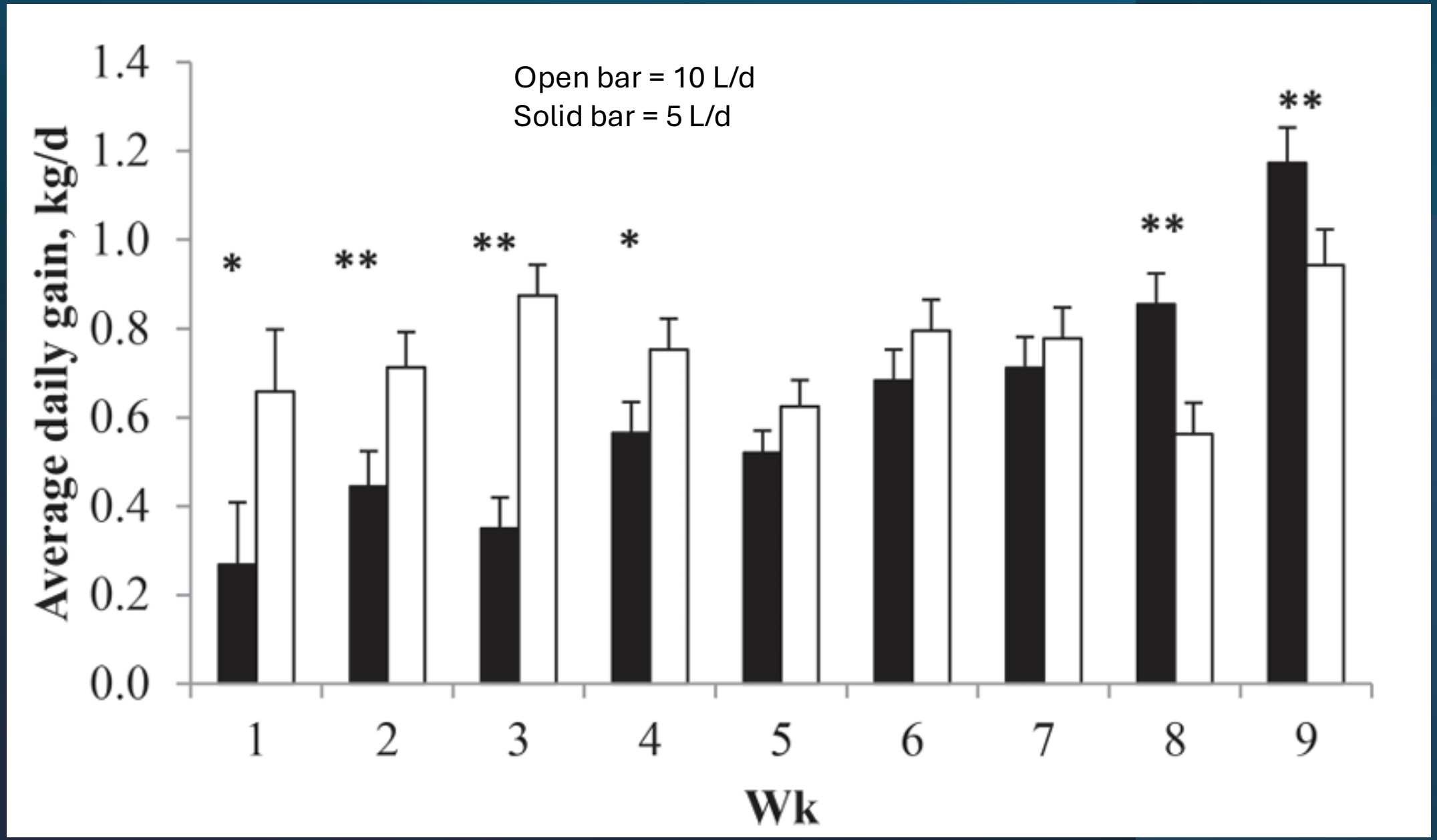
- High milk: 10 L/d whole milk
- Low milk: 5 L/d whole milk

Haisan et al., 2018

At d 48, milk was reduced 10% per day, such that all calves were weaned from milk at d 58

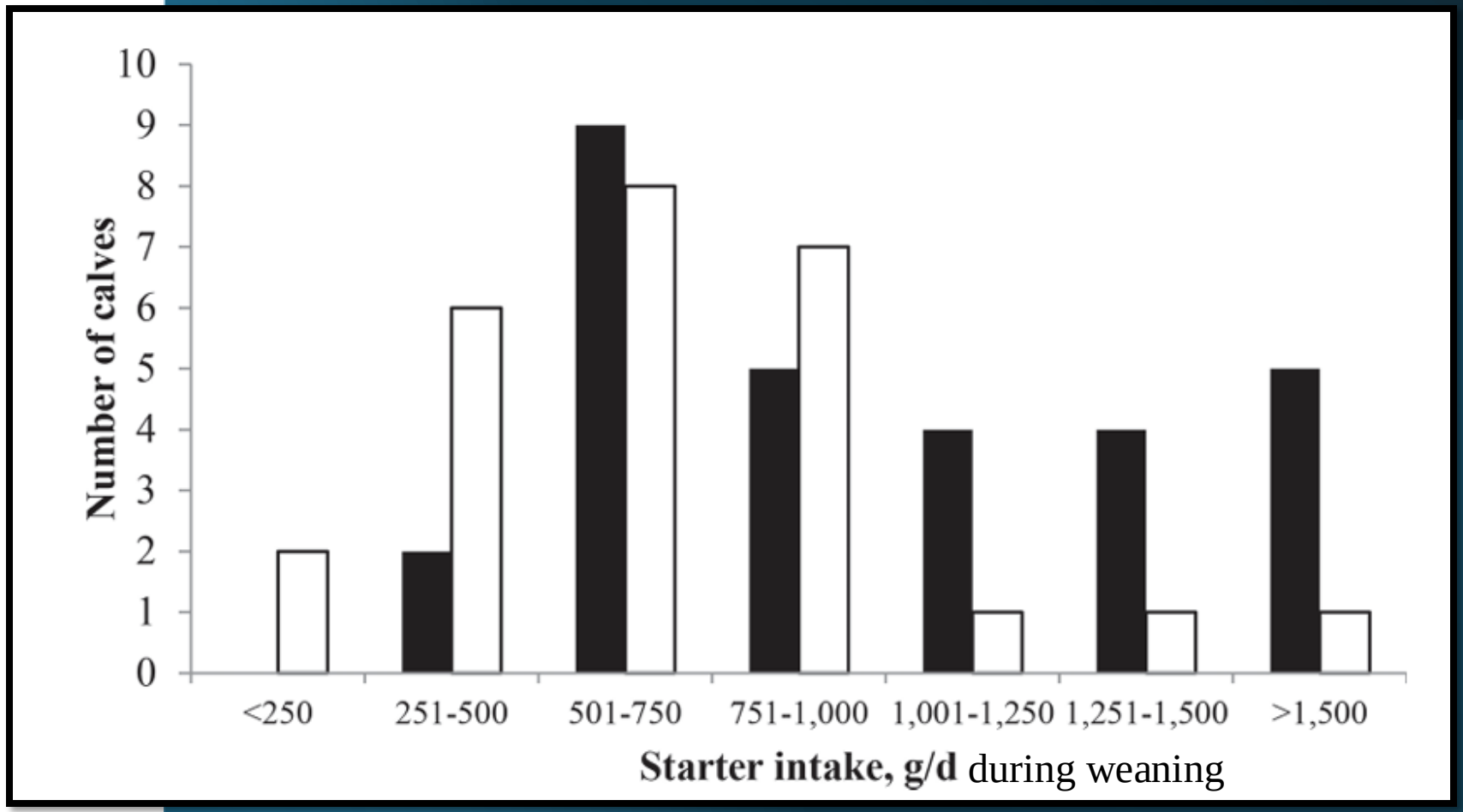
10 day weaning period

Haisan et al., 2018



Haisan et al., 2018

Early life starter intake contributes less to bodyweight gain compared with starter intake right before weaning



Haisan et al., 2018

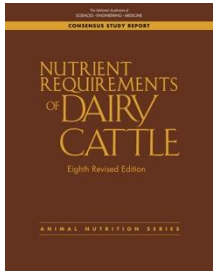
Modeling milk allowance and growth

CalfSim Software

Requirements:
- Energy and protein
• Maintenance and gain
DAILY BASIS!
- Starter intake

ME calculations:
- Milk and MR
- Starter (Quigley et al., 2019)

NASEM



Animal/Envir. Inputs:
- Birth weight (kg);
- Weaning age (days);
- Temp (°C)

Whole Milk/MR Inputs:
- CP (%), Fat (%), Ashes (%), Solids (%).

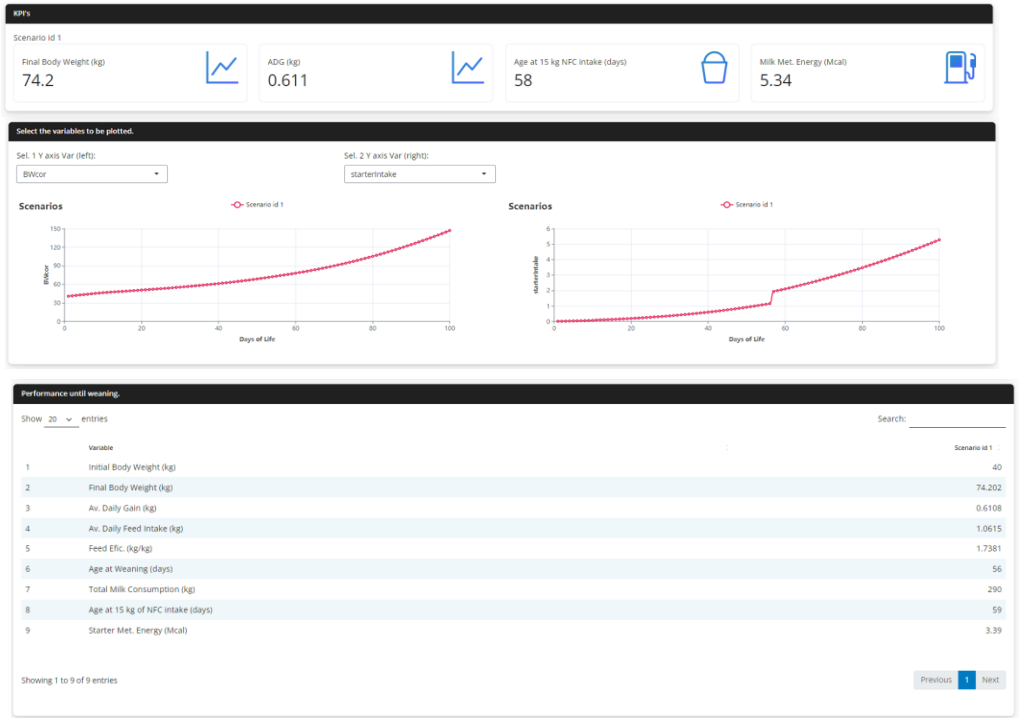
Starter composition:
- CP (%), Fat (%), NDF (%), NFC (%), etc.

Functions

Nutritional Plan: Milk/MR allowance (daily)

Model Engine

Model Output - GUI



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CalfSim | Inputs | Dashboard | Predictions vs Observations | Nutrient Requirements NASEM (2021)

Animal, Management, Environmental, and Liquid Diet Inputs.

Birth Weight (kg): 40

Weaning Age (days): 65

Number of Scenarios: 1

Aver. Temp. (C): 15

Whole Milk or Milk Replacer: Whole Milk

Protein (%):	Fat (%):	Ashes (%):	Total Solids (%)	Price ($/cwt):
3.2	3.8	0.78	12.5	22

Starter Composition.

Starter Composition Inputs: (•) Manual ( ) Lab results

Form of Starter: (•) Pelleted ( ) Texturized

Starter Intake Equation: (•) NASEM (2021) ( ) Silva et al. (2019)

CP (%): 15 | 21.2 | 30
15 16.5 18 19.5 21 22.5 24 25.5 27 28.5 30

NDF (%): 5 | 12.9 | 30
5 7.5 10 12.5 15 17.5 20 22.5 25 27.5 30

NFC (%): 30 | 55.8 | 70
30 34 38 42 46 50 54 58 62 66 70

Fat (%): 2 | 3.9 | 9
2 2.7 3.4 4.1 4.8 5.5 6.2 6.9 7.6 8.3 9

Ash (%): 3 | 6.2 | 9
3 3.6 4.2 4.8 5.4 6 6.6 7.2 7.8 8.4 9

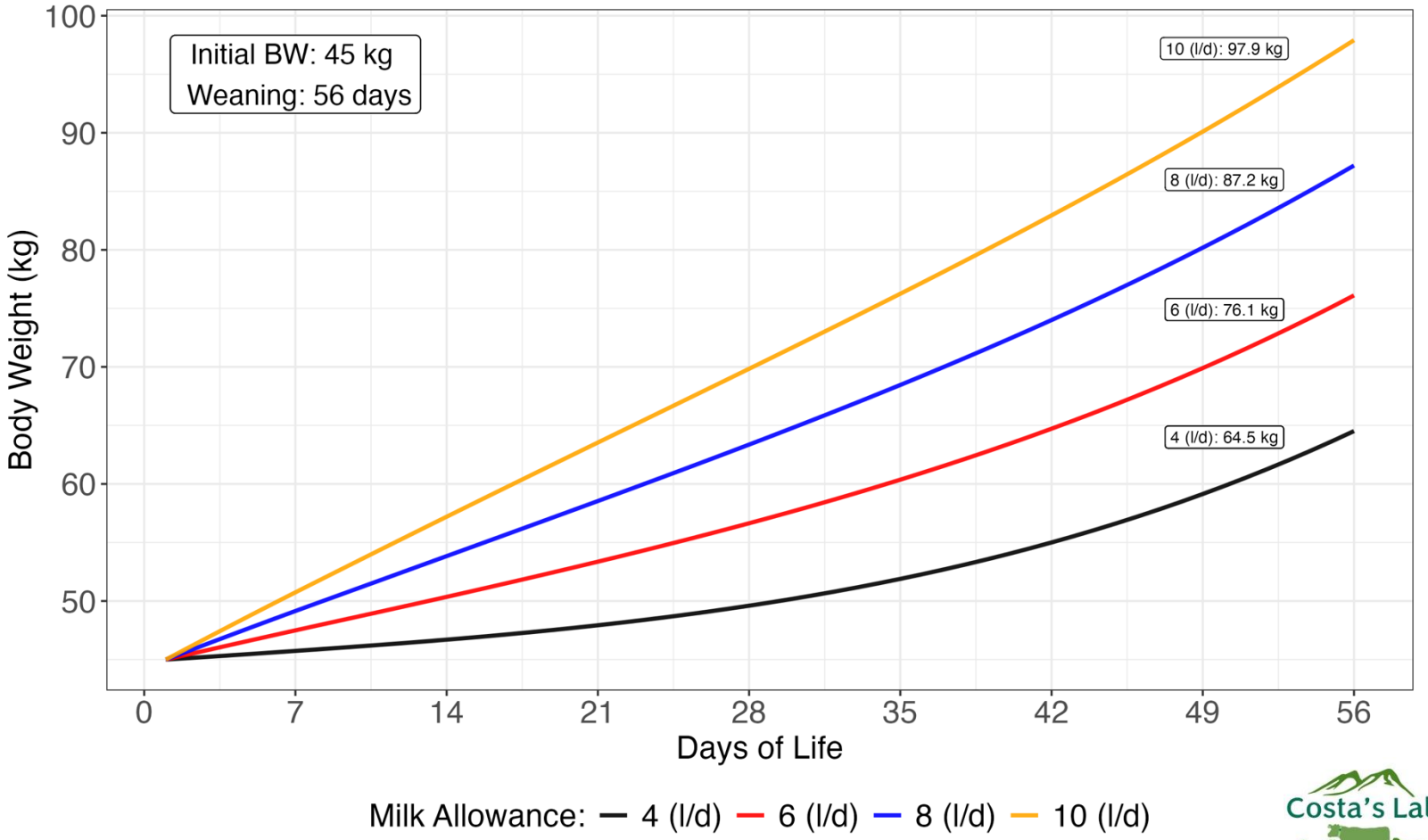
Cost ($/DM): 1 | 3.5 | 10
1 1.9 2.8 3.7 4.6 5.5 6.4 7.3 8.2 9.1 10

Remember: All components must sum up 100. The ash content will be calculated automatically.

CalfSim Tool – 4 Scenarios of Milk Replacer Allowance based on NASEM 2021

4L vs 6L vs 8L vs 10L

- NASEM (2021) requirements
- Energy Milk Replacer: 4.6 Mcal/kg
- Energy Starter: 3.12 Mcal/kg
- Birth BW: 45 kg
- Mean temperature: 20°C
- Performance until 70 days



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If more milk is better, then we still need to consider:

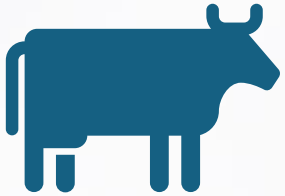
- Does processing of starter matter?
- How does this affect starter intake?
- How should we wean them?

J. Dairy Sci. 103:2186–2199
https://doi.org/10.3168/jds.2019-17372

Effect of amount of milk replacer fed and the processing of corn in starter on growth performance, nutrient digestibility, and rumen and fecal fibrolytic bacteria of dairy calves

J. K. van Niekerk,[1] A. J. Fischer-Tlustos,[1]* L. L. Deikun,[2] J. D. Quigley,[2] T. S. Dennis,[2] F. X. Suarez-Mena,[2] T. M. Hill,[2] R. L. Schlotterbeck,[2] L. L. Guan,[1] and M. A. Steele[1]*†

[1]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, T6G 2P5, Canada
[2]Nurture Research Center, Provimi, Cargill Animal Nutrition, Brookville, OH 45309

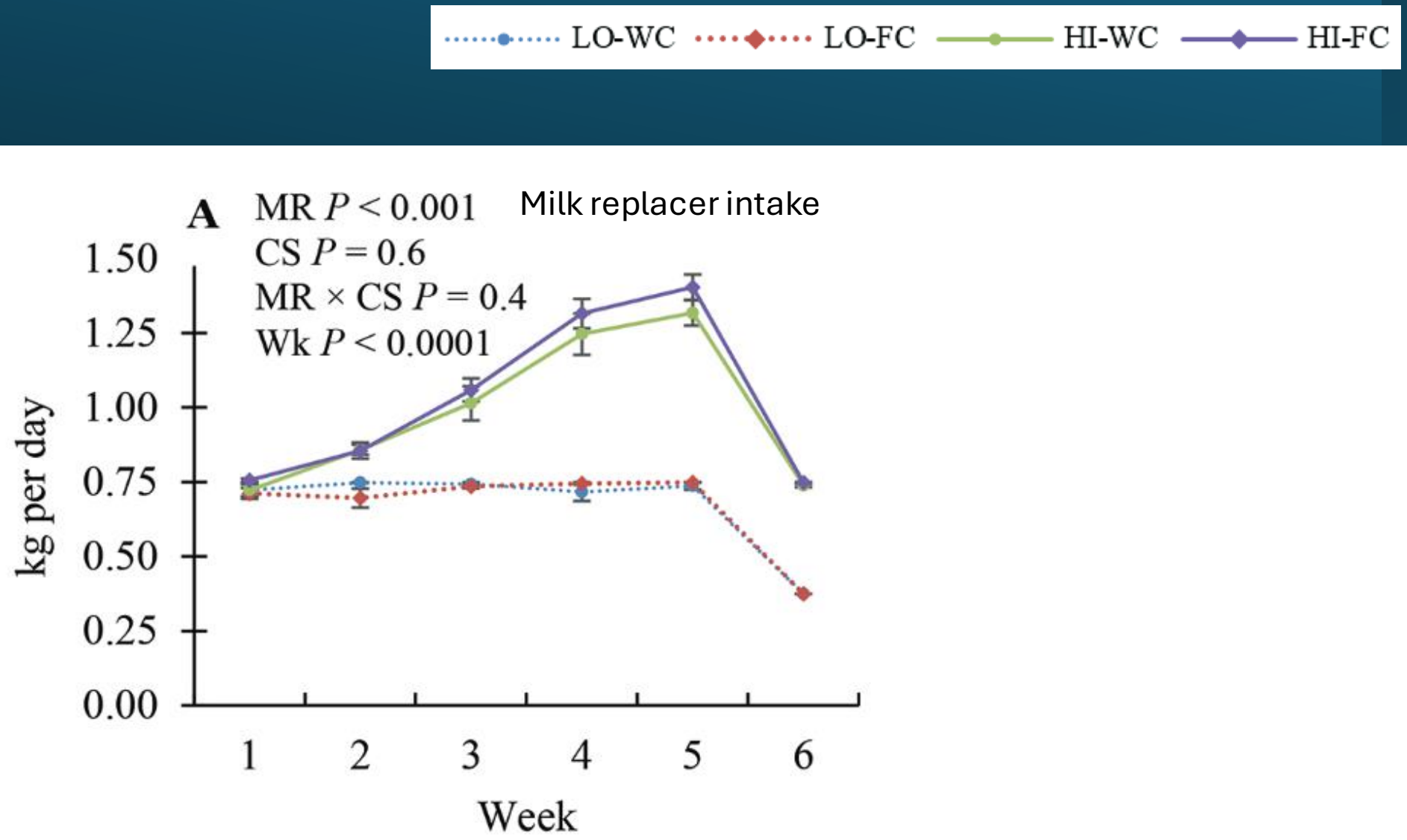


24 calves blocked by dam and parity and randomly enrolled

2 x 2 factorial:

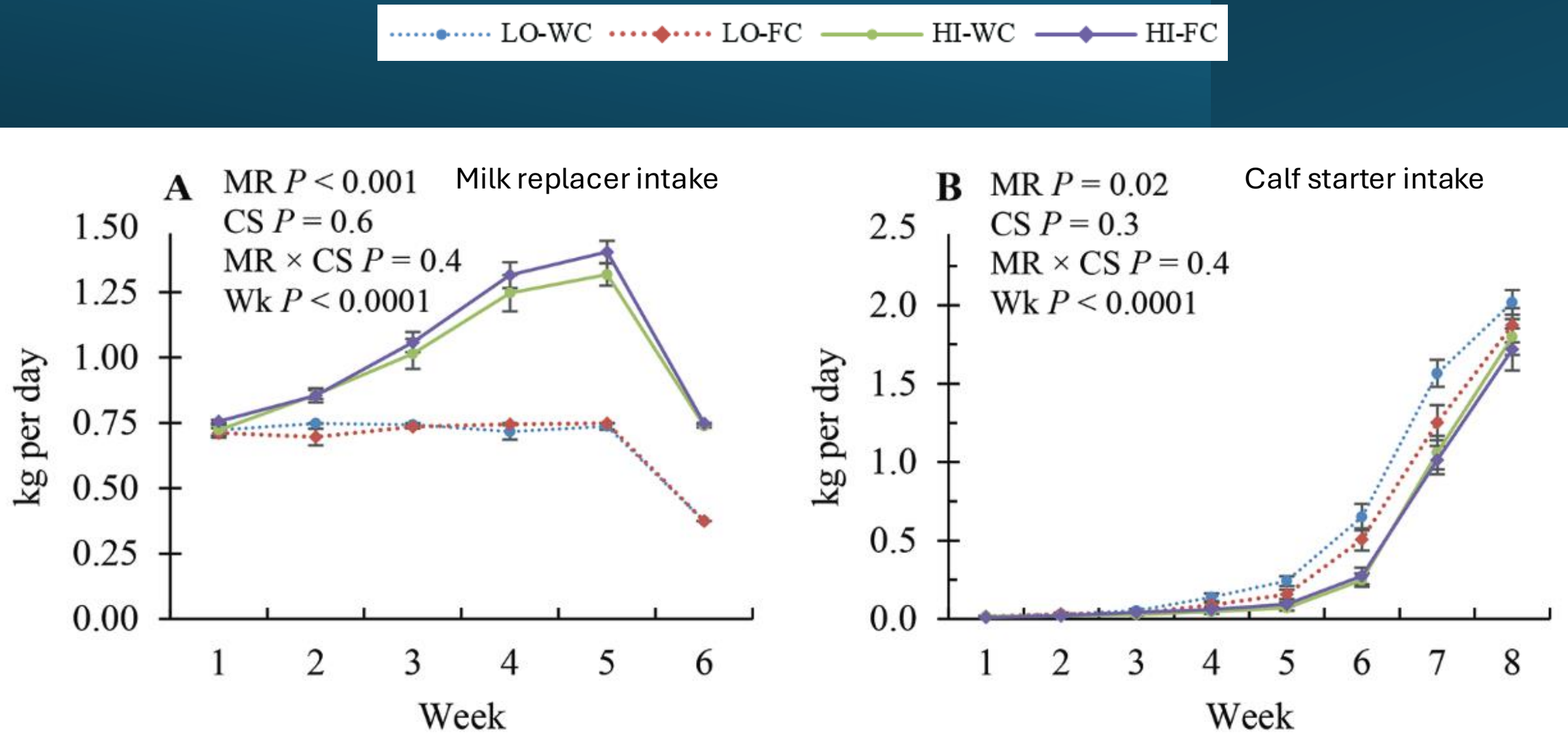
- Low MR (LO): 0.749 kg of MR powder/d
- High MR (HI): 1.498 kg of MR powder/d
- Whole corn (WC) in texturized CS
- Flaked corn (FC) in texturized CS

Van Niekerk et al., 2020

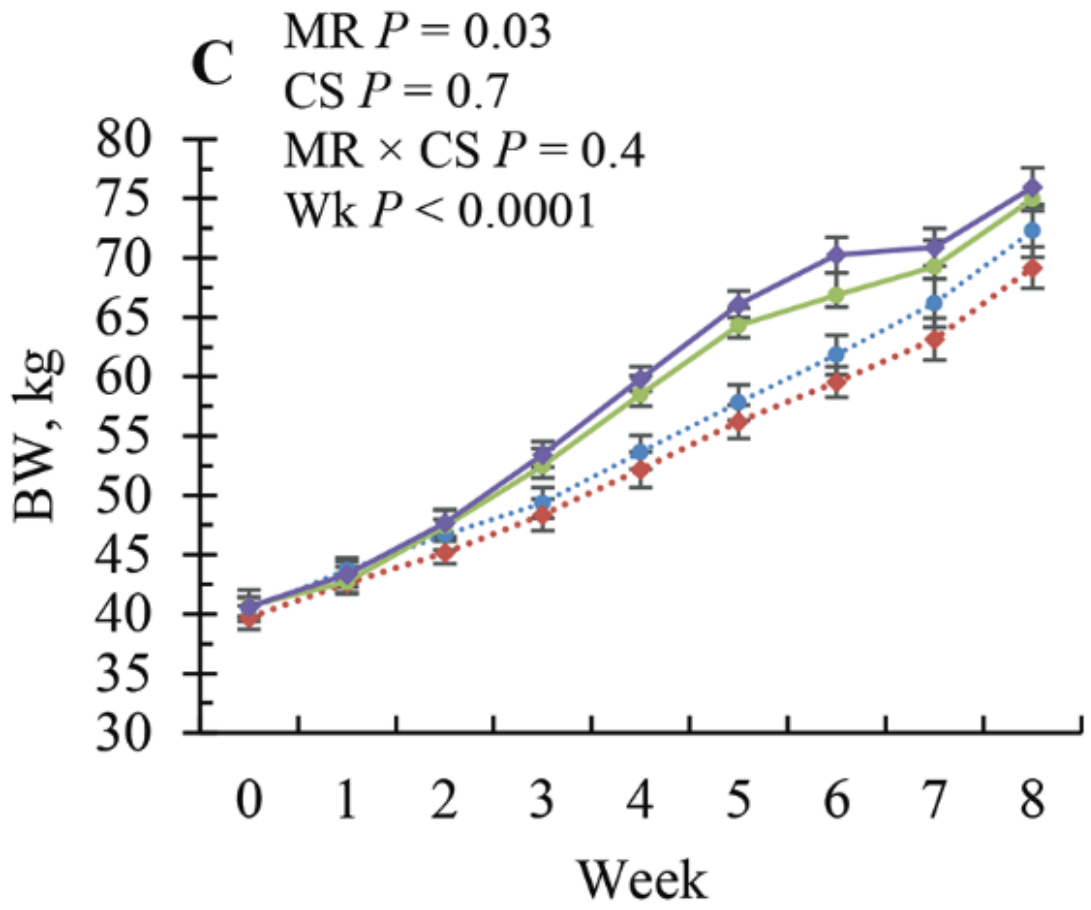


Milk replacer intake

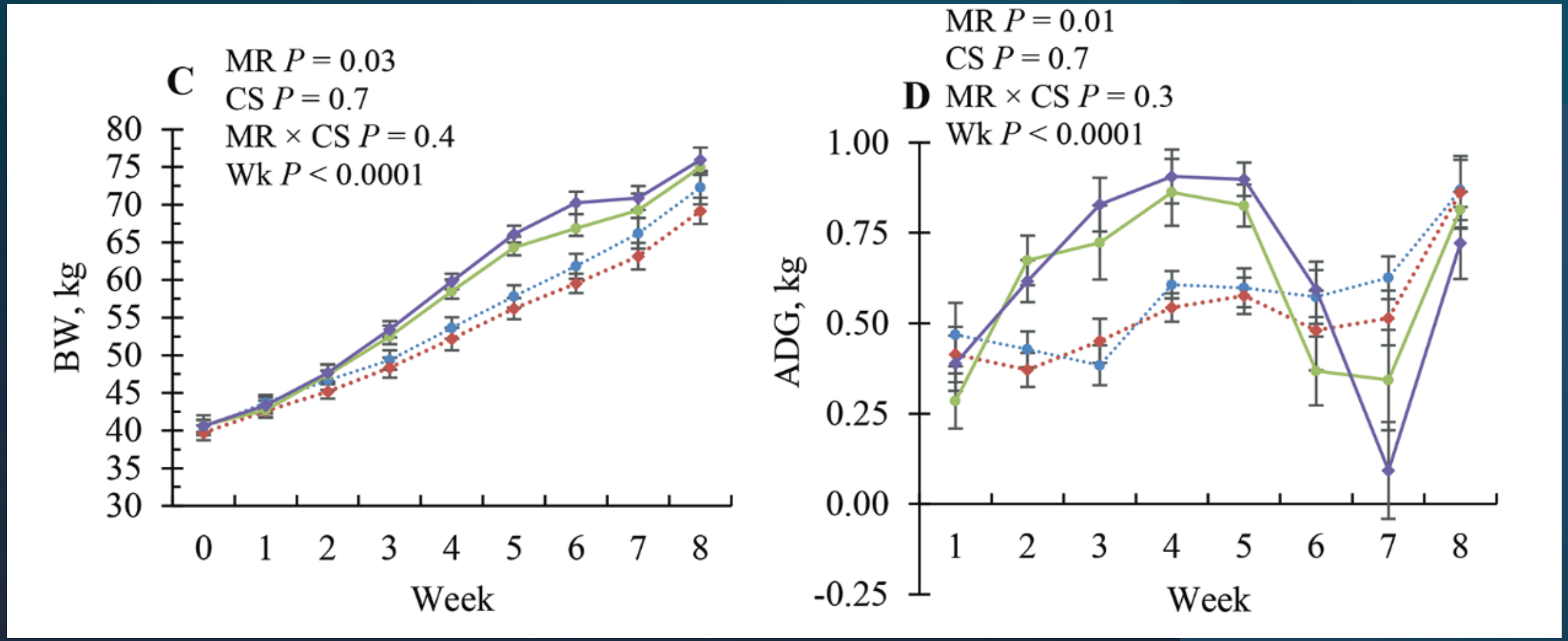
Van Niekerk et al., 2020



Van Niekerk et al., 2020



Van Niekerk et al., 2020

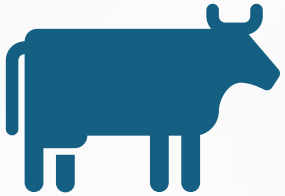


Van Niekerk et al., 2020

J. Dairy Sci. 90:876–885

Pre- and Postweaning Performance of Holstein Female Calves Fed Milk Through Step-Down and Conventional Methods

M. A. Khan,*[1] H. J. Lee,*[2] W. S. Lee,* H. S. Kim,* S. B. Kim,* K. S. Ki,* J. K. Ha,† H. G. Lee,† and Y. J. Choi†
*Dairy Cattle Research Division, National Livestock Research Institute, Cheonan, 330-880, Republic of Korea
†School of Agricultural Biotechnology, Seoul National University, Seoul, 151-742, Republic of Korea



40 calves enrolled

Milk feeding:

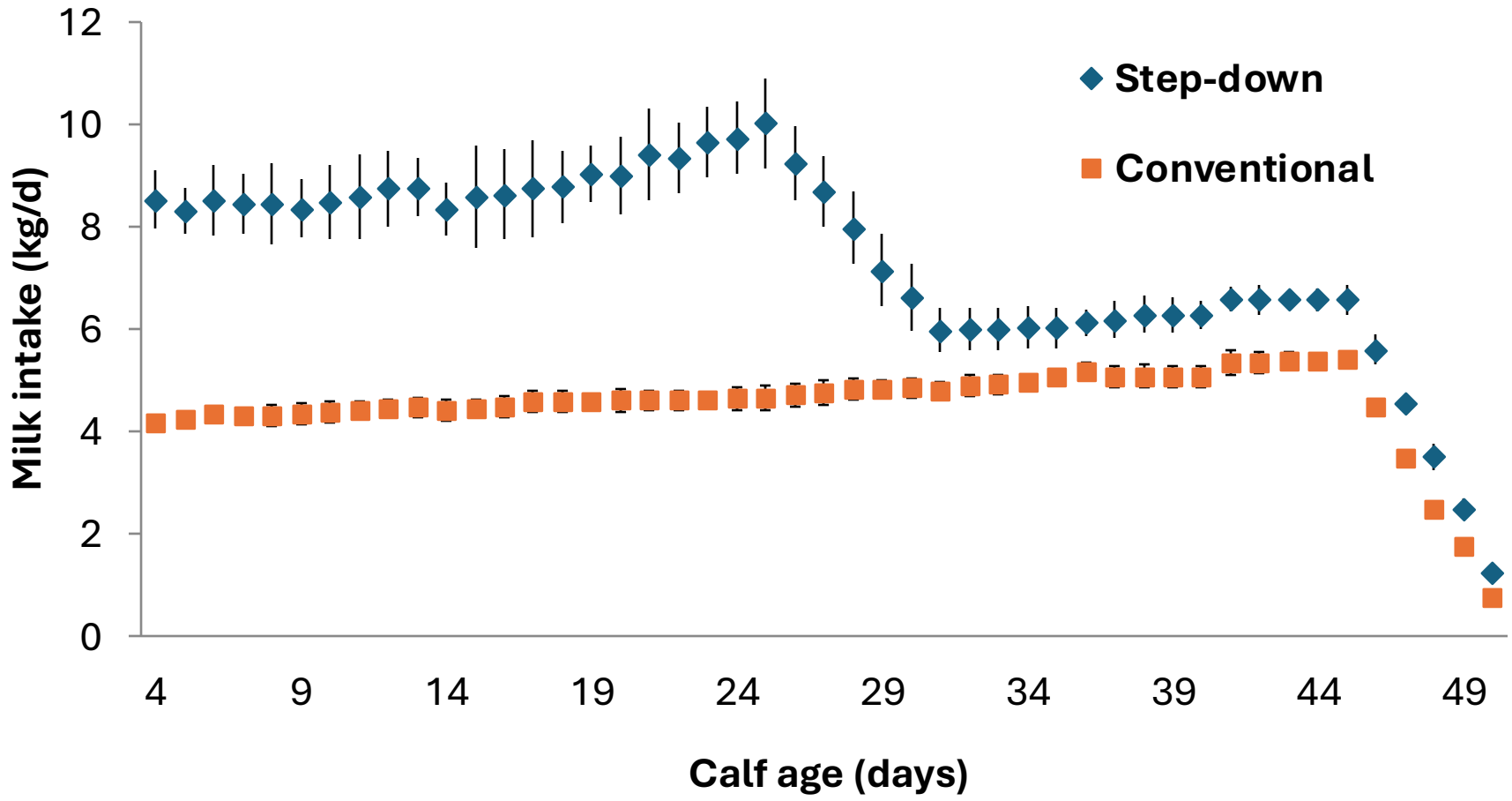
- Conventional: 10% bodyweight until 45 d
- Stepdown: 20% bodyweight until 25d, then gradually dilute milk with water from d 26-30 10% each feeding
- Fed at this rate for the remaining 15 d until 45 d

Khan et al., 2007

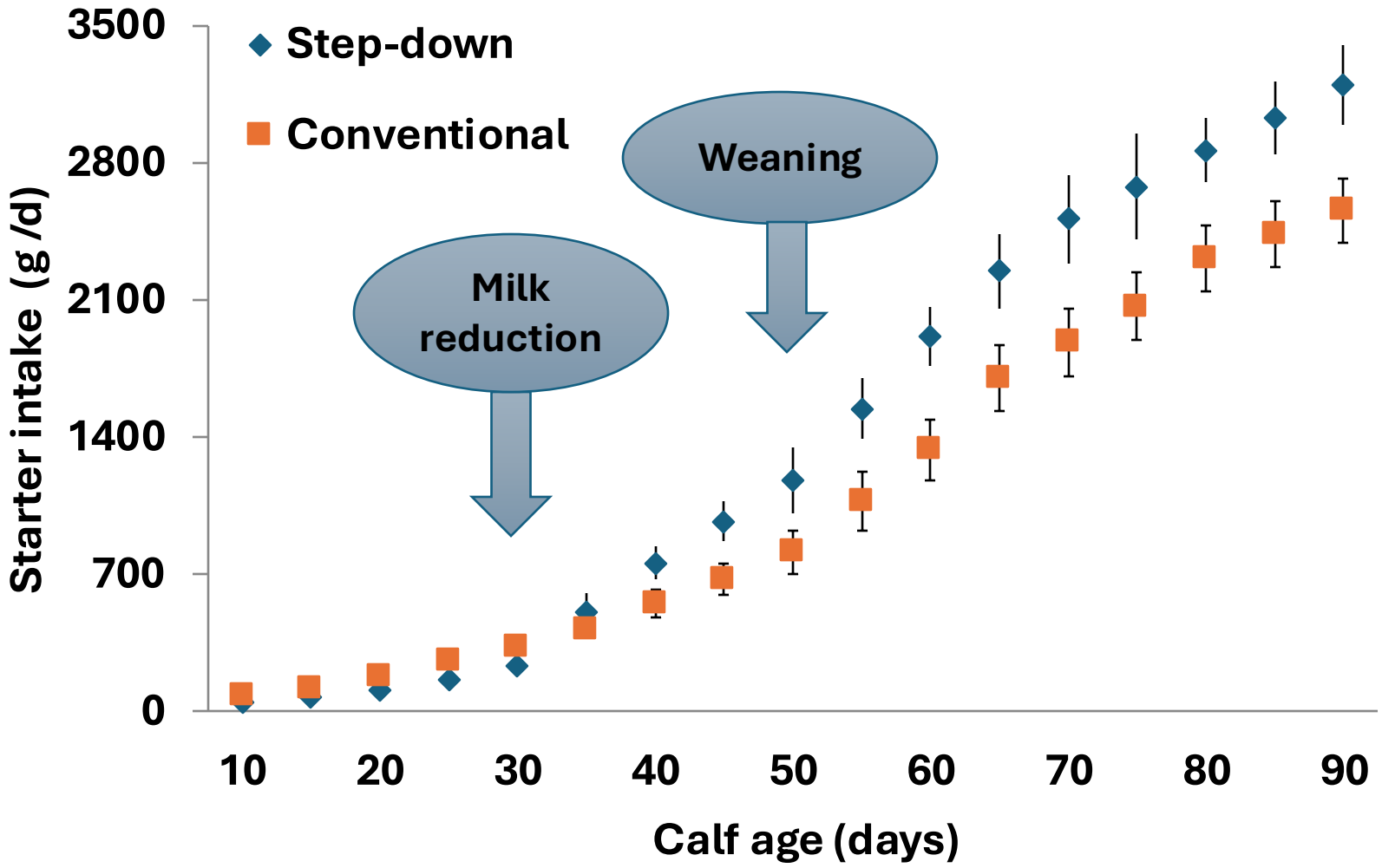
Weaning:

- From d 45-50 all calves weaned by gradually diluting milk with water by 10% each day so on day 50 all calves received 100% water

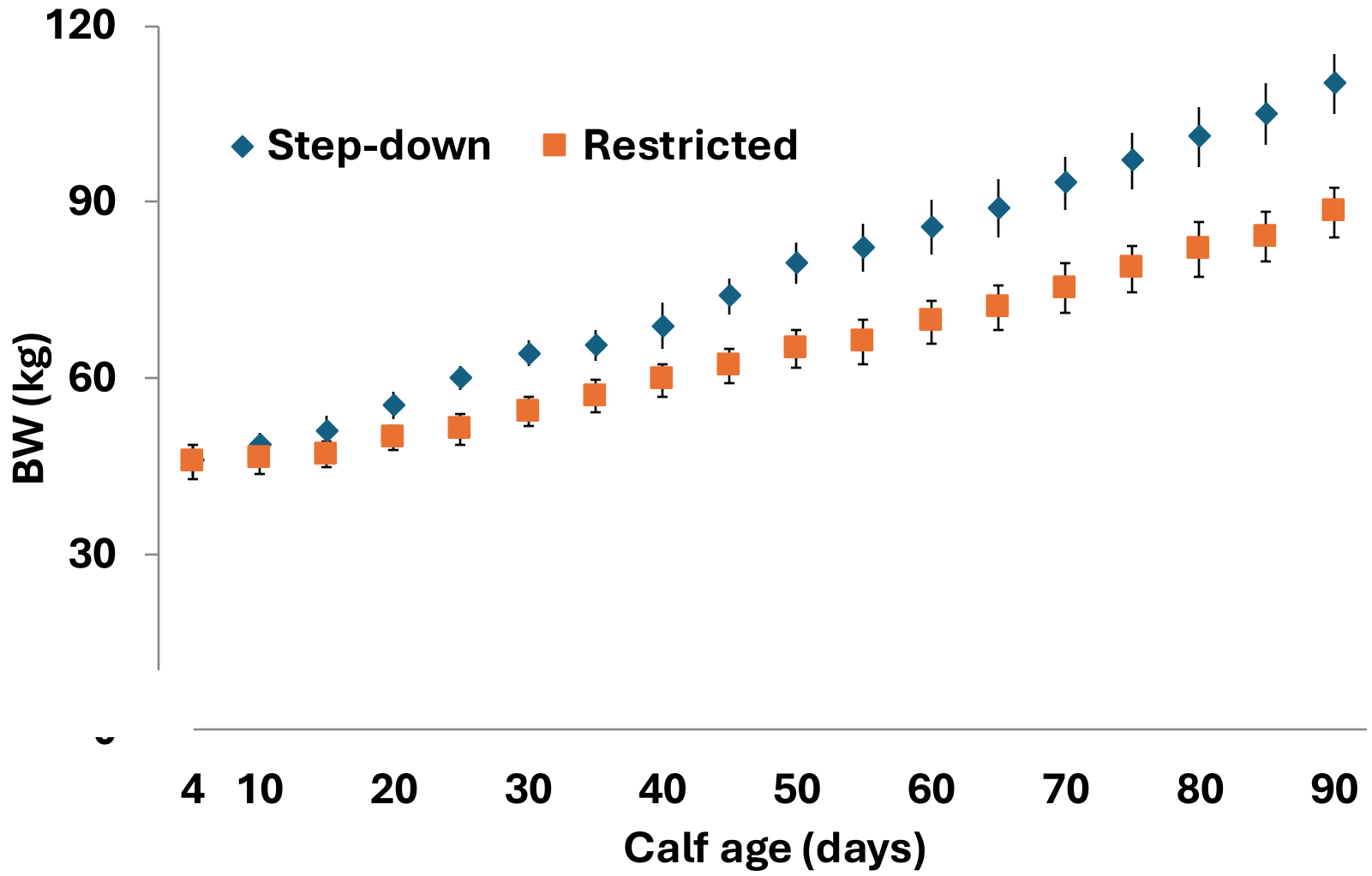
Khan et al., 2007



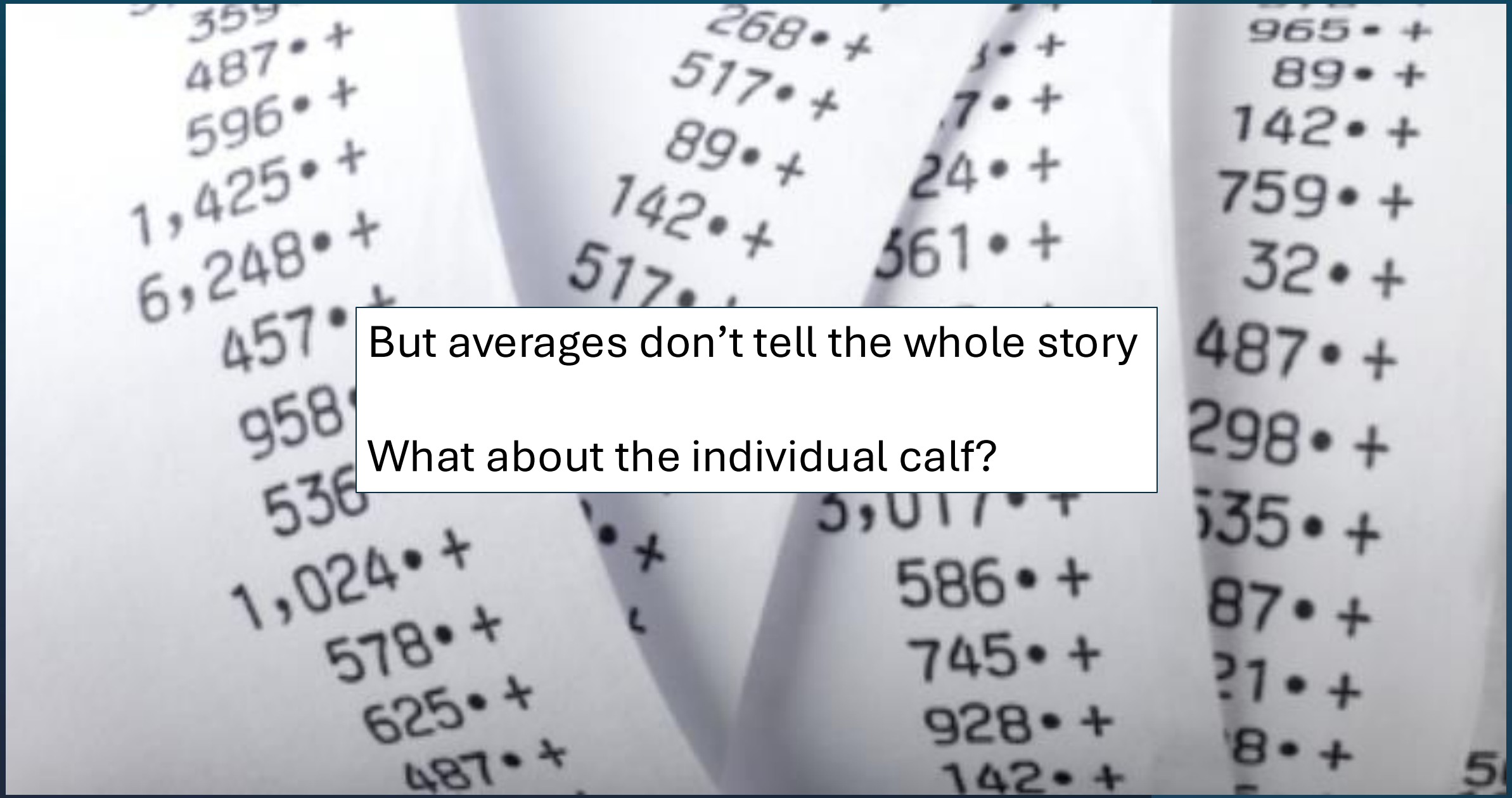
Khan et al., 2007. J. of Dairy Sci., 90, 3376-3387.



Khan et al., 2007. J. of Dairy Sci., 90, 3376-3387.



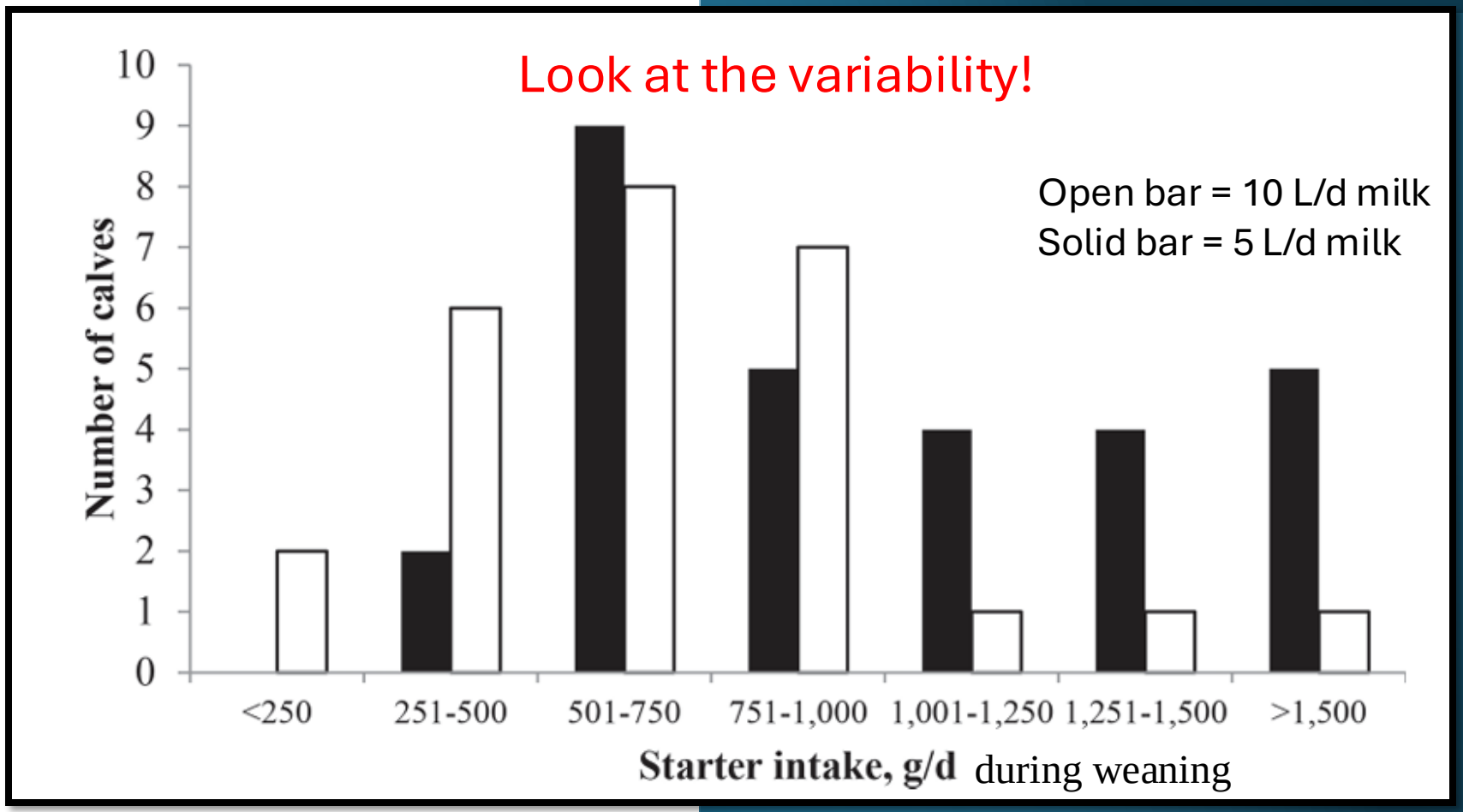
Khan et al., 2007. J. of Dairy Sci., 90, 3376-3387.



But averages don’t tell the whole story

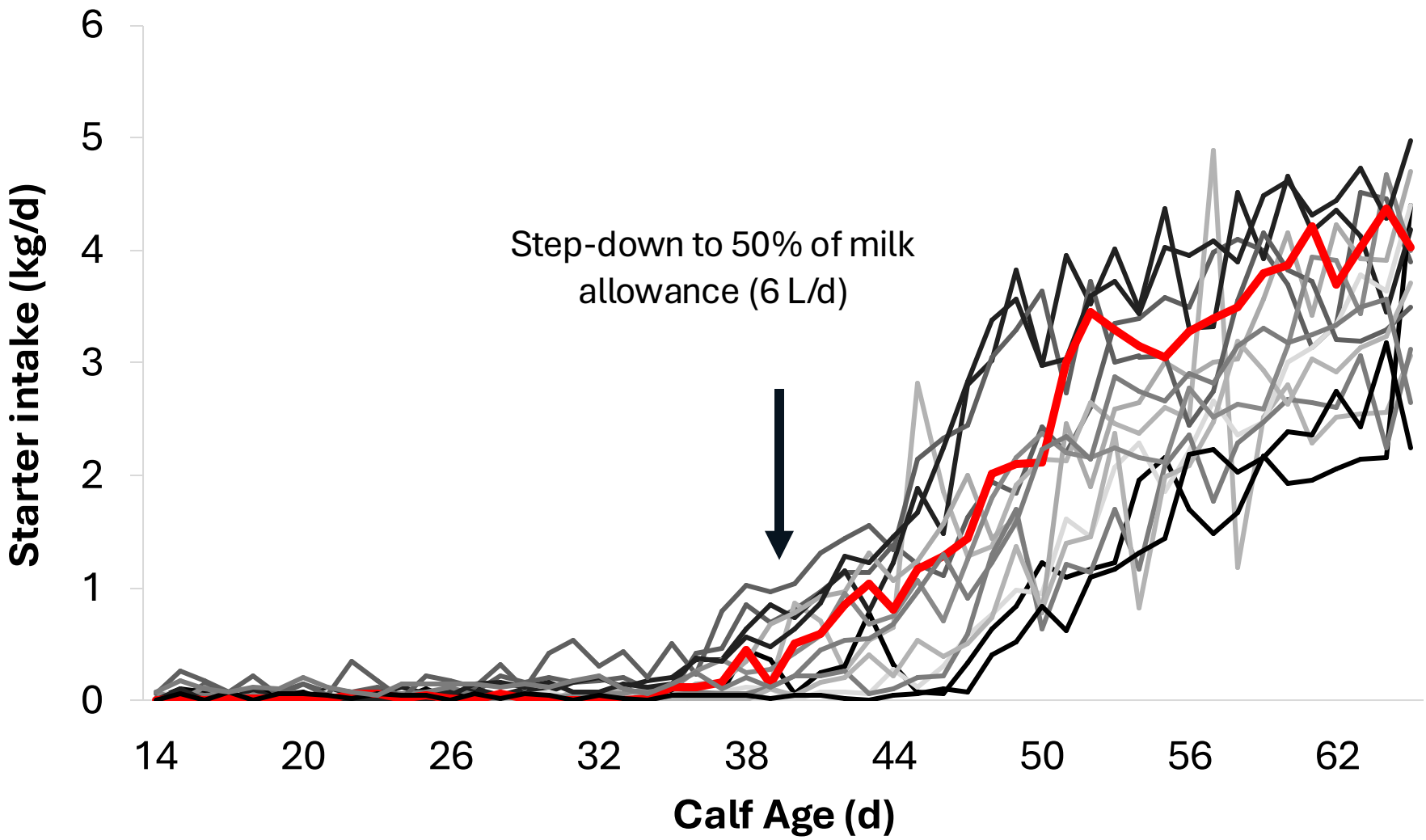
What about the individual calf?

Variability in starter intake during weaning



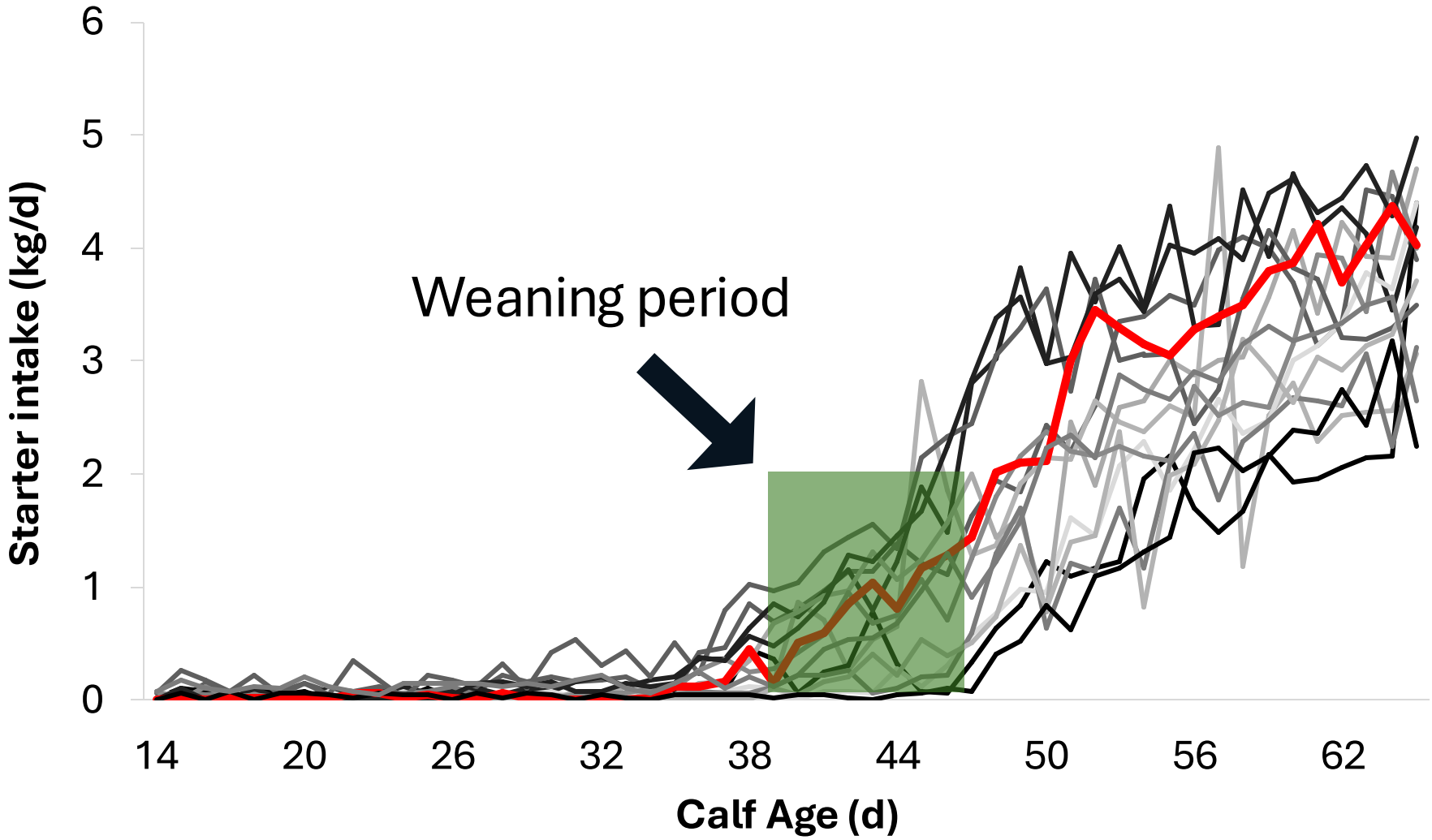
Haisan et al., 2018

Starter intake by calf – **12 L/d milk**



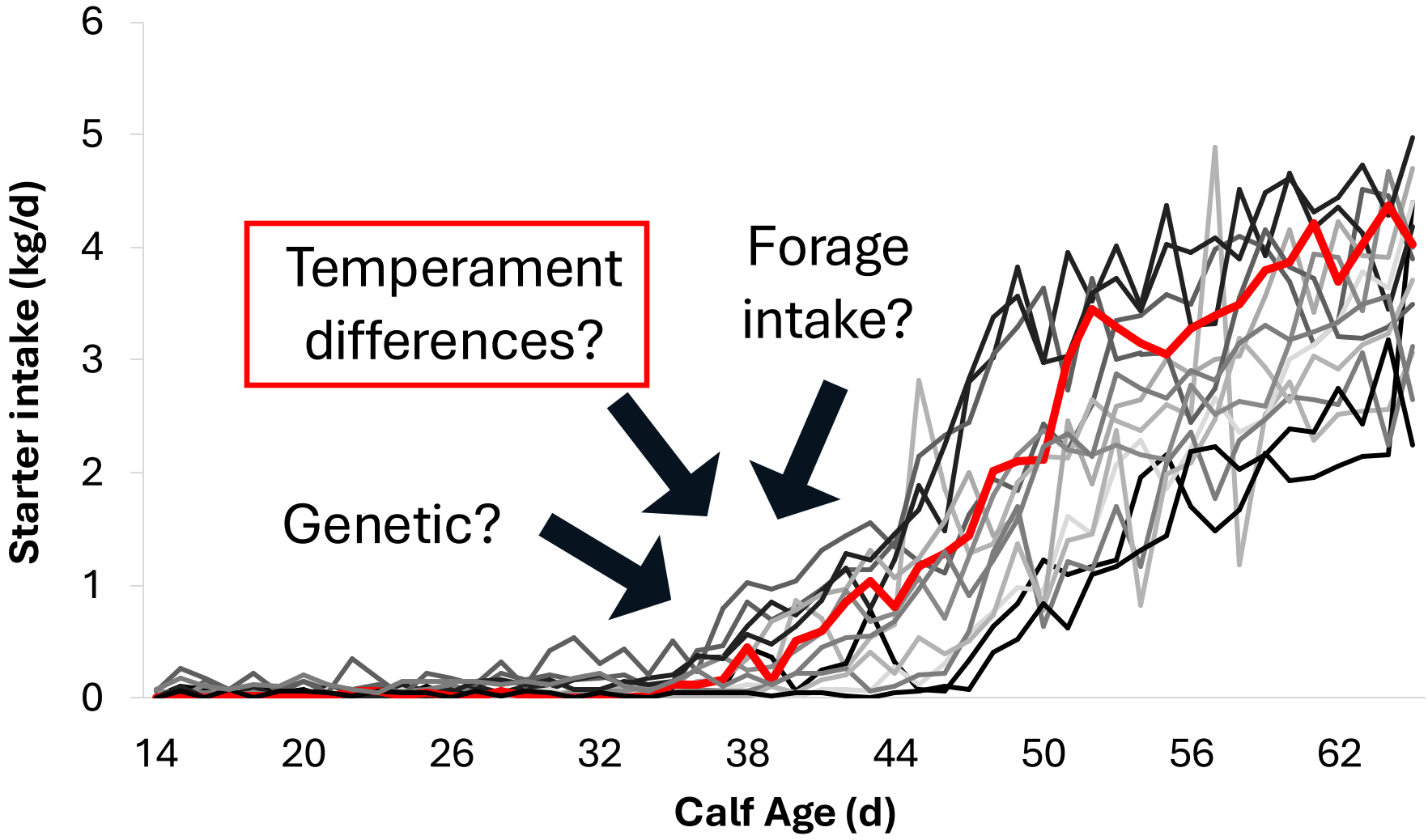
Slide courtesy of J. Costa

So, not all calves eat starter well



Slide courtesy of J. Costa

Why does individual starter intake vary?



Slide courtesy of J. Costa

Personality may be a factor

More exploratory calves:

- found grain sooner
- increased grain intakes
- greater weight gains
- fewer unrewarded visits to the milk feeder

But what do we do about this?

Individualized feeding programs could attend to the needs of each animal

Slide courtesy of J. Costa

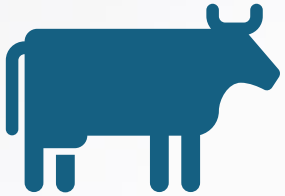
Neave et al., 2018. J. Dairy Sci. 101: 7437-7449

Individualized feeding programs: what if we allowed calves to self-wean?

J. Dairy Sci. 102:5475–5491
https://doi.org/10.3168/jds.2018-15830

Automatic weaning based on individual solid feed intake: Effects on behavior and performance of dairy calves

J. B. Benetton, H. W. Neave, J. H. C. Costa,* M. A. G. von Keyserlingk, and D. M. Weary†
Animal Welfare Program, Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC, Canada V6T 1Z4



48 calves enrolled

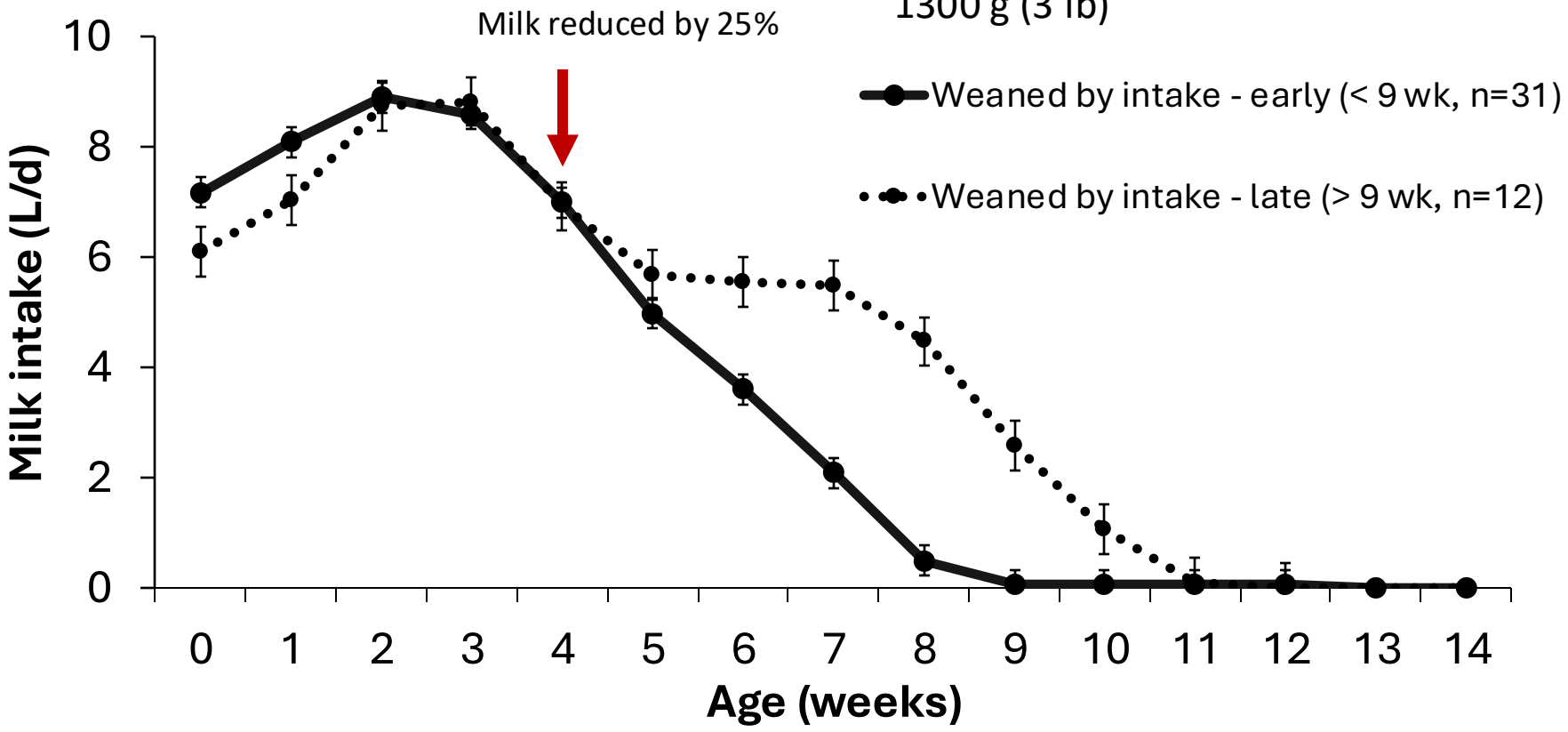
Weaned by intake:

- Fed up to 12 L/d
- Milk allowance was reduced on d 31 by 25% of the individual's average milk intake over the previous 3 d
- Milk was further reduced by 25% when each calf achieved specific daily starter intake targets of 225, 675, and 1,300 g/d (complete weaning)
- Had up to 84 days to achieve 1,300 g

Benetton et al., *2019.* J. Dairy Sci.

Individualized feeding programs

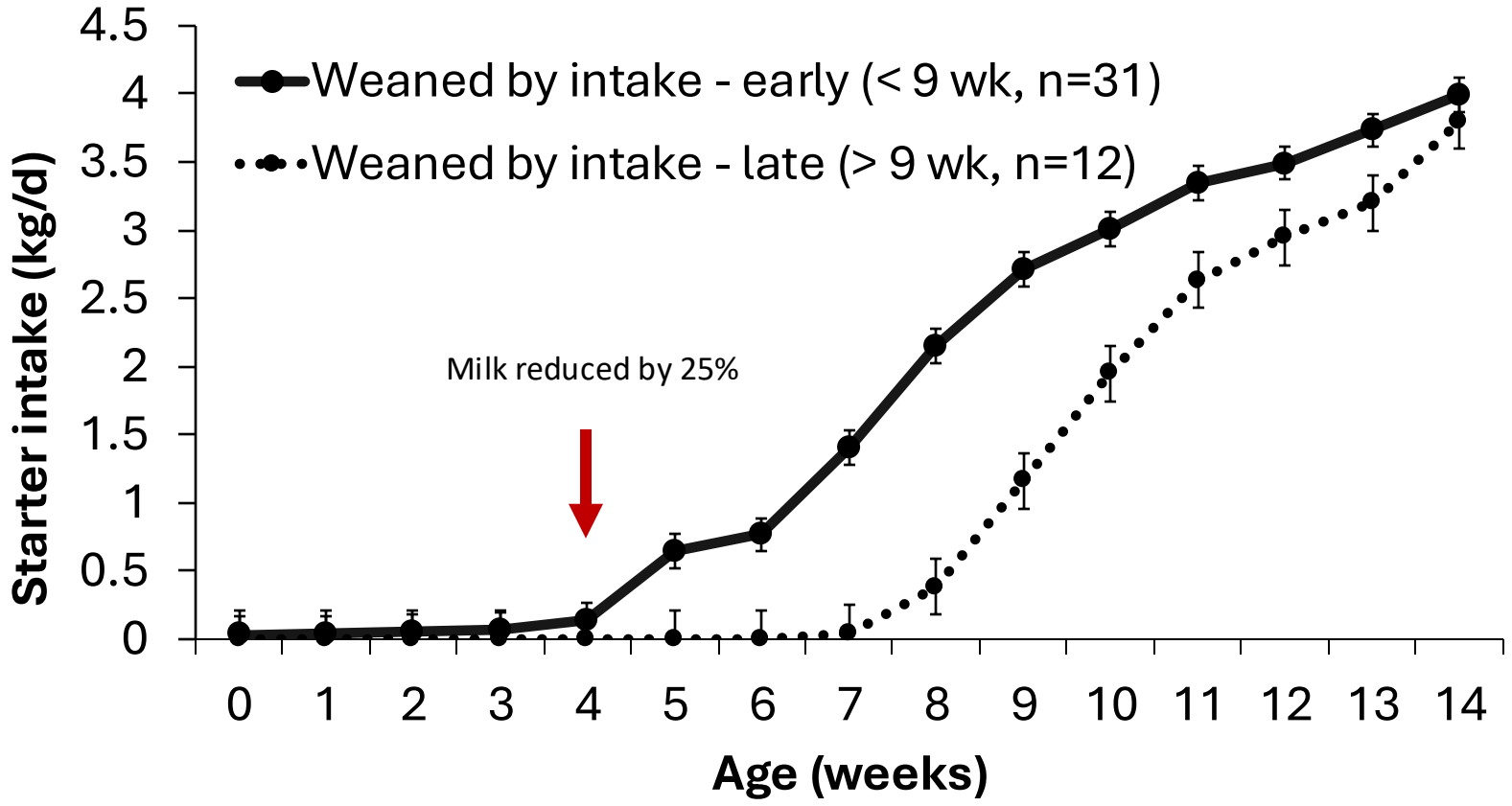
Monitored starter intake and reduce milk by 25% at each target:
225 g (0.5 lb)
675 g (1.5 lb)
1300 g (3 lb)



Benetton et al., ***2019***. J. Dairy Sci.

Individualized feeding programs

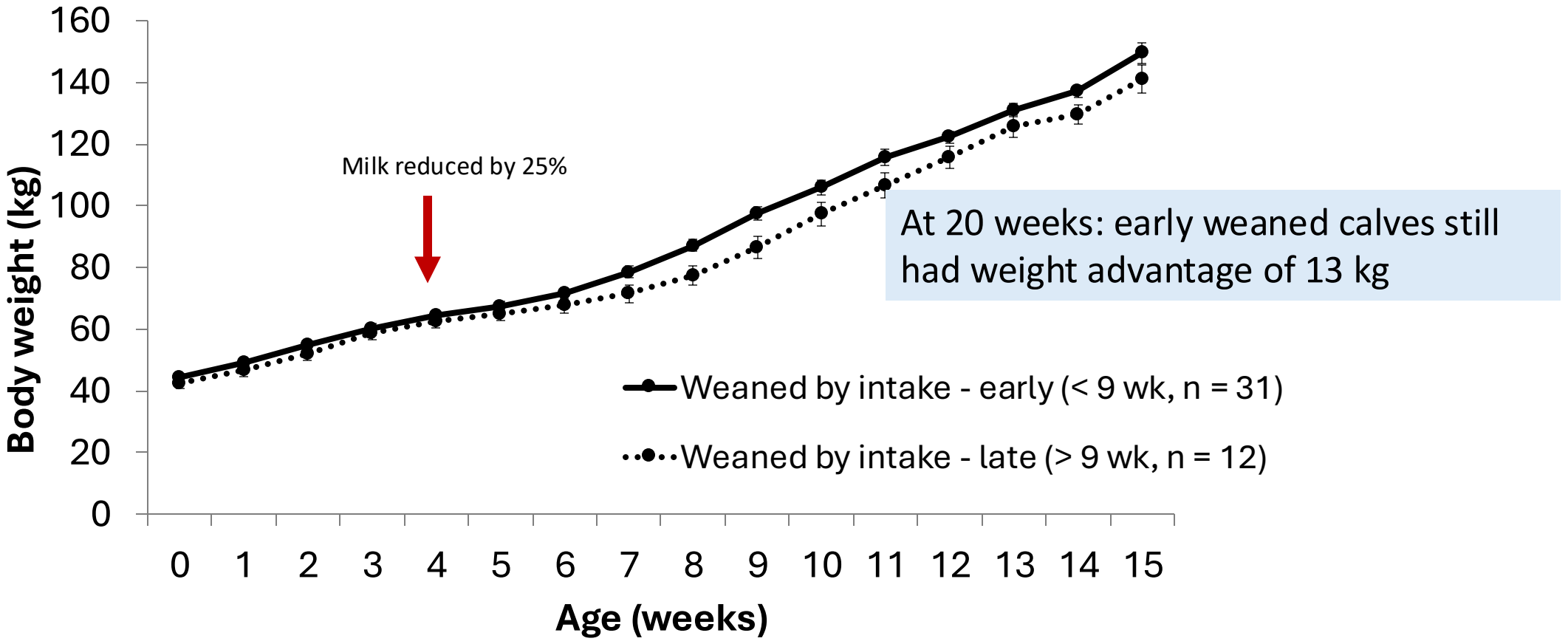
What if we allow calves to self-wean based on starter intake?



Benetton et al., *2019.* J. Dairy Sci.

Individualized feeding programs

What if we allow calves to self-wean based on starter intake?



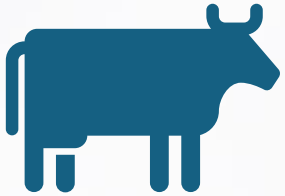
At 20 weeks: early weaned calves still had weight advantage of 13 kg

Benetton et al., *2019.* J. Dairy Sci.

J. Dairy Sci. 105:9119–9136
https://doi.org/10.3168/jds.2021-21468

Effects of intake-based weaning and forage type on feeding behavior and growth of dairy calves fed by automated feeders

A. Welk, H. W. Neave,* H. B. Spitzer, M. A. G. von Keyserlingk, and D. M. Weary†
Animal Welfare Program, Faculty of Land and Food Systems, University of British Columbia, Vancouver, BC, Canada V6T 1Z4



108 calves enrolled

Feeding:

- Fed up to 12 L/d pasteurized whole milk
- Daily starter intake recorded (20% CP texturized)

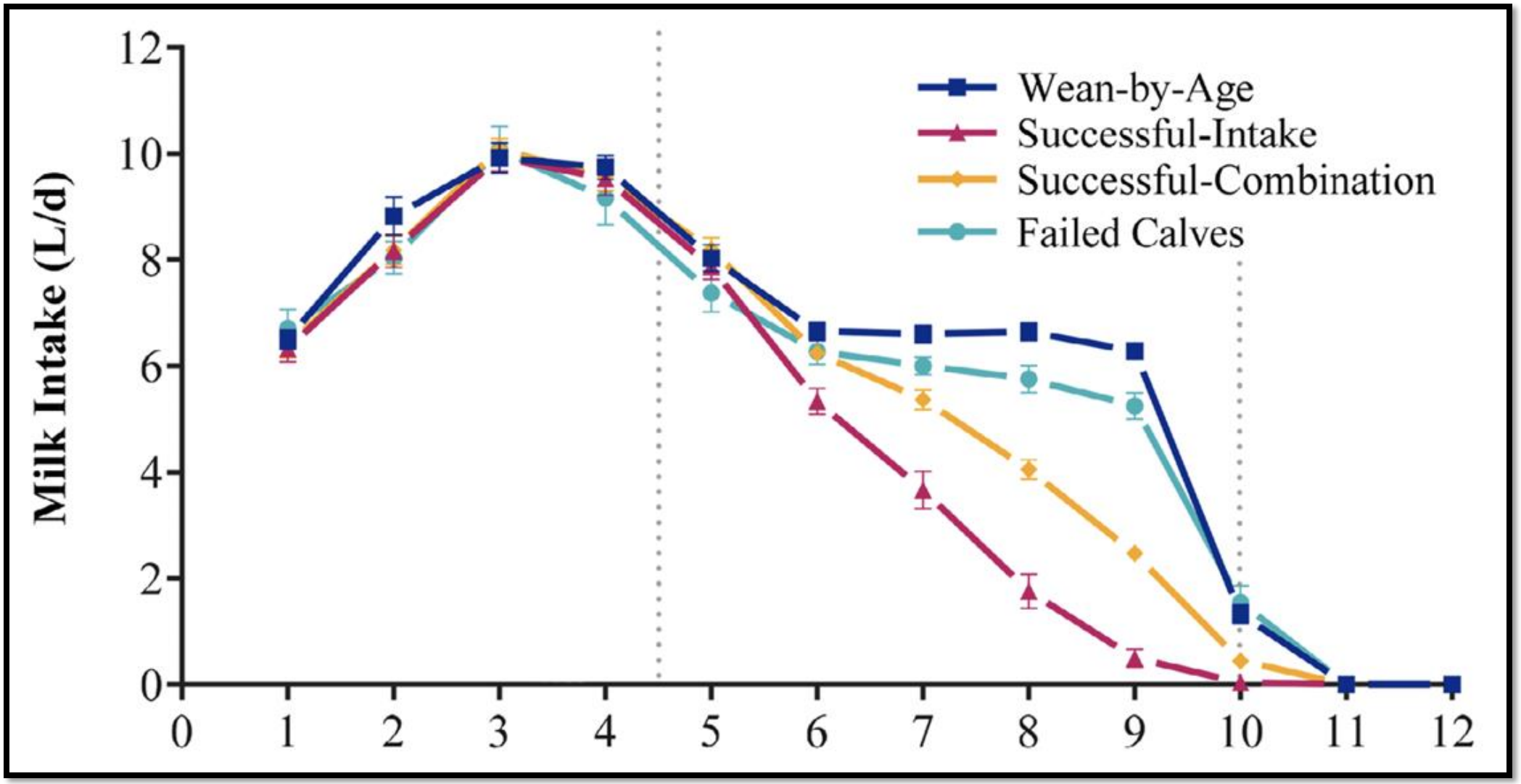
Welk et al., 2022

Weaning:

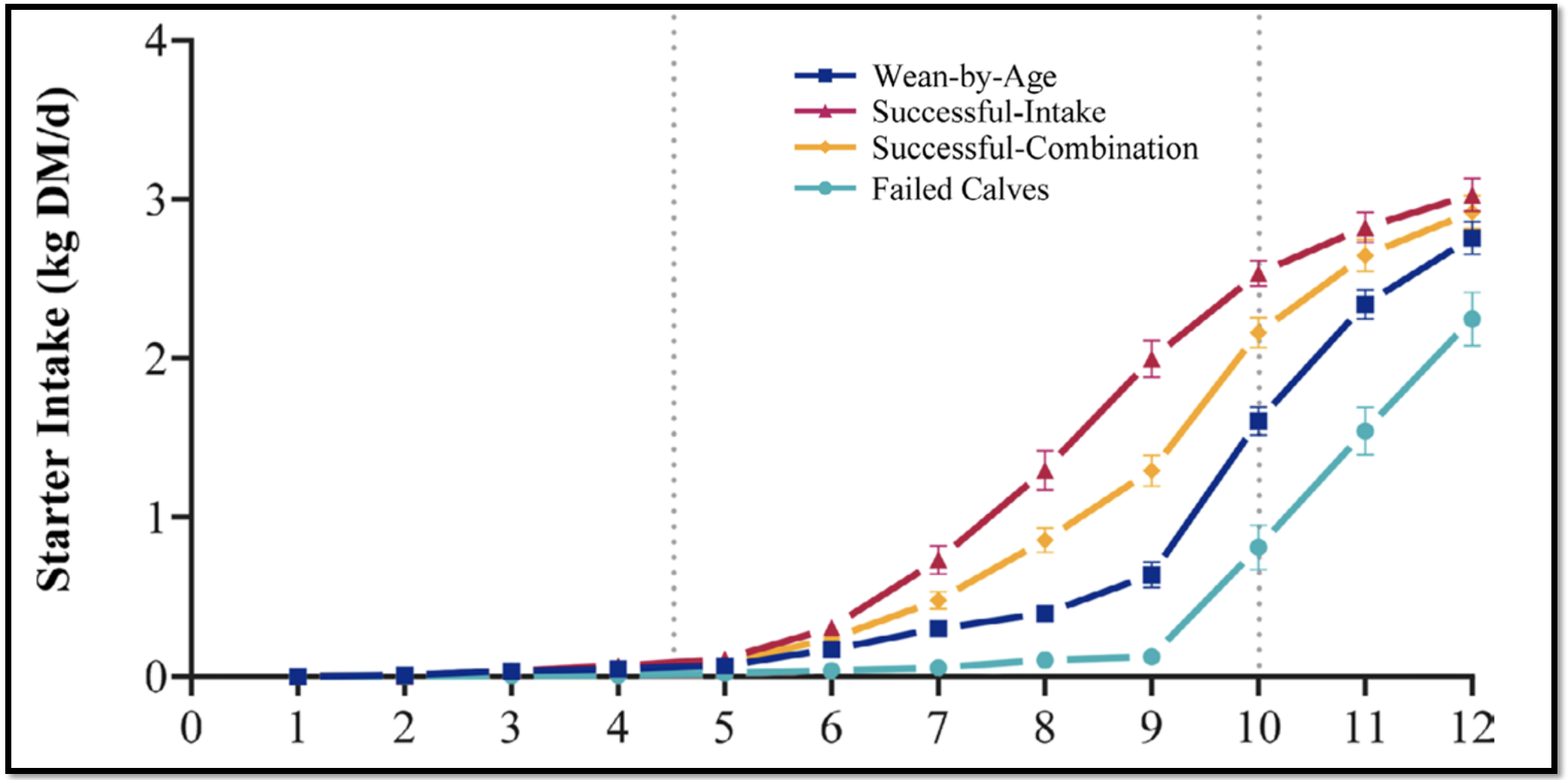
All calves had milk reduced by 8%/d from d 31-33 so that calves were at 75% previous intake at d 33

- ***Wean-by-age***: On d 62 milk allowance reduced 8%/d so completely weaned by 70 d
- ***Wean-by-intake***: reduction of milk by 25% over 3 days each time a calf reached 200, 600, and 1,150 g of DM/d (rolling average across 3 d)
- ***Wean-by-combo***: when calves met 200 g of DM/d DMI, milk allowance reduced so fully weaned by 70 d

Welk et al., 2022



Welk et al., 2022



Welk et al., 2022

Variable	Wean-by-age	Successful-intake	Successful-combo	*P*-value
Preweaning ADG (kg/d)	0.83	0.88	0.85	0.50
Preweaning withers height (cm/d)	0.27^{xy}	0.29^{x}	0.25^{y}	0.09

Welk et al., 2022

Variable	Wean-by-age	Successful-intake	Successful-combo	*P*-value
Preweaning ADG (kg/d)	0.83	0.88	0.85	0.50
Preweaning withers height (cm/d)	0.27^{xy}	0.29^{x}	0.25^{y}	0.09
Weaning ADG (kg/d)	0.71^{b}	0.85^{a}	0.82^{a}	0.03
Weaning withers height (cm/d)	0.21	0.20	0.21	0.52

Welk et al., 2022

Variable	Wean-by-age	Successful-intake	Successful-combo	*P*-value
Preweaning ADG (kg/d)	0.83	0.88	0.85	0.50
Preweaning withers height (cm/d)	0.27^{xy}	0.29^{x}	0.25^{y}	0.09
Weaning ADG (kg/d)	0.71^{b}	0.85^{a}	0.82^{a}	0.03
Weaning withers height (cm/d)	0.21	0.20	0.21	0.52
Post-weaning ADG (kg/d)	1.52	1.43	1.51	0.27
Post-weaning withers height (cm/d)	0.20^{b}	0.27^{a}	0.25^{a}	0.02

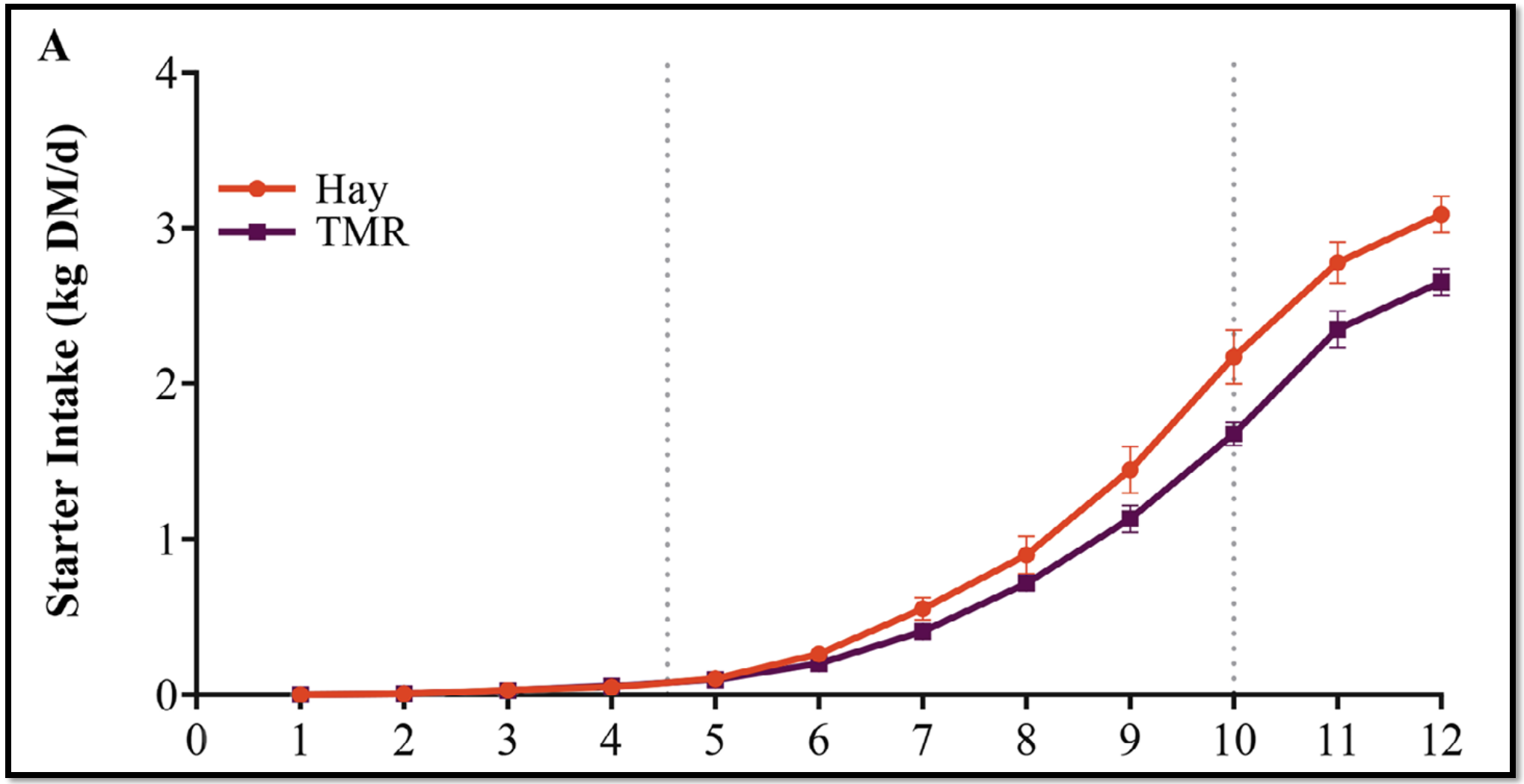
Welk et al., 2022

Variable	Wean-by-age	Successful-intake	Successful-combo	P-value
Final weight (kg)	177.7[b]	123.7[a]	122.3[a]	0.04
Final withers height (cm/d)	97.2[b]	98.6[a]	97.9[ab]	0.07

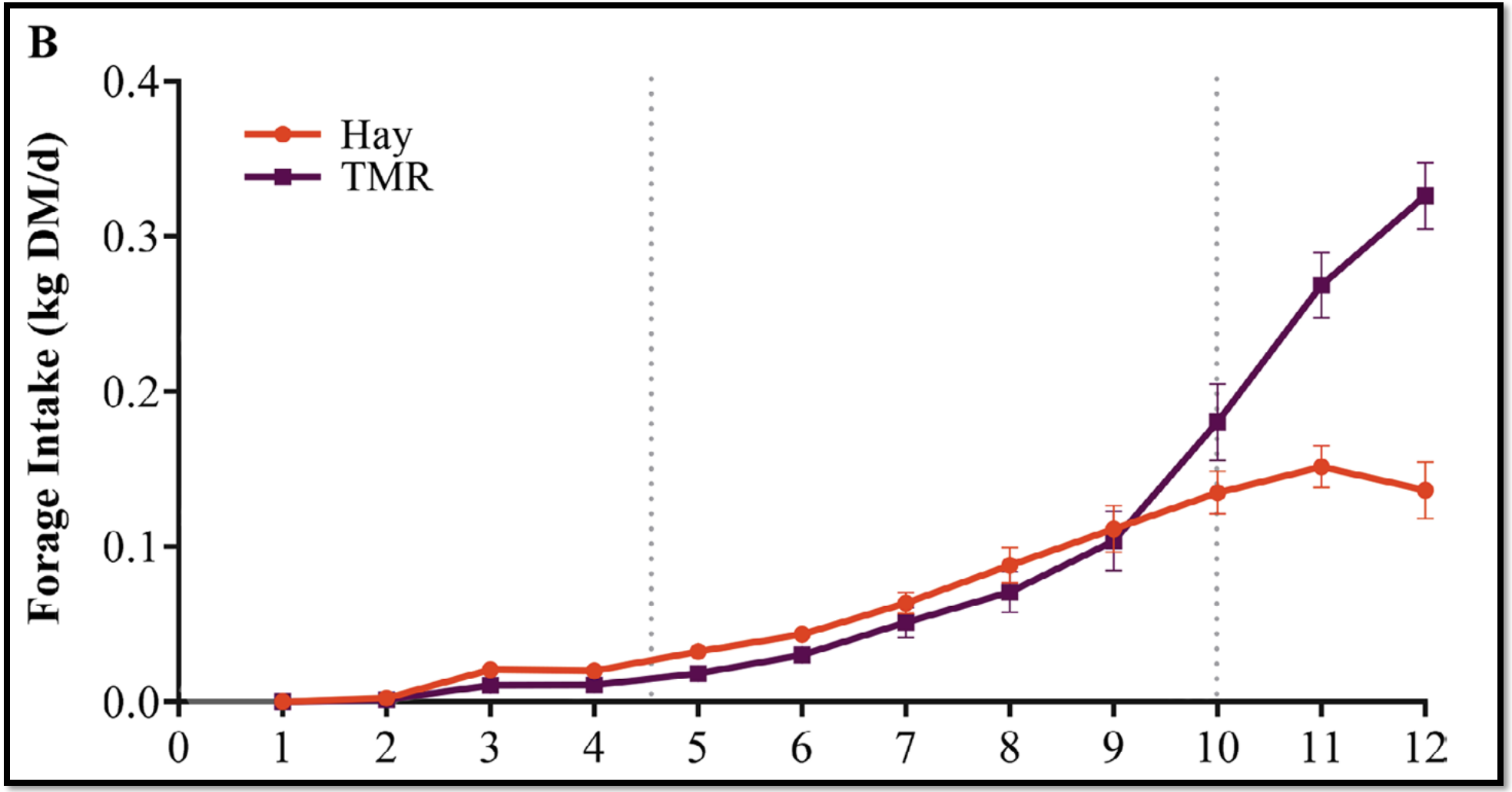
Calves weaned using an intake criterion showed greater solid feed intake, postweaning weights, and structural growth compared with calves weaned at a fixed age

Welk et al., 2022

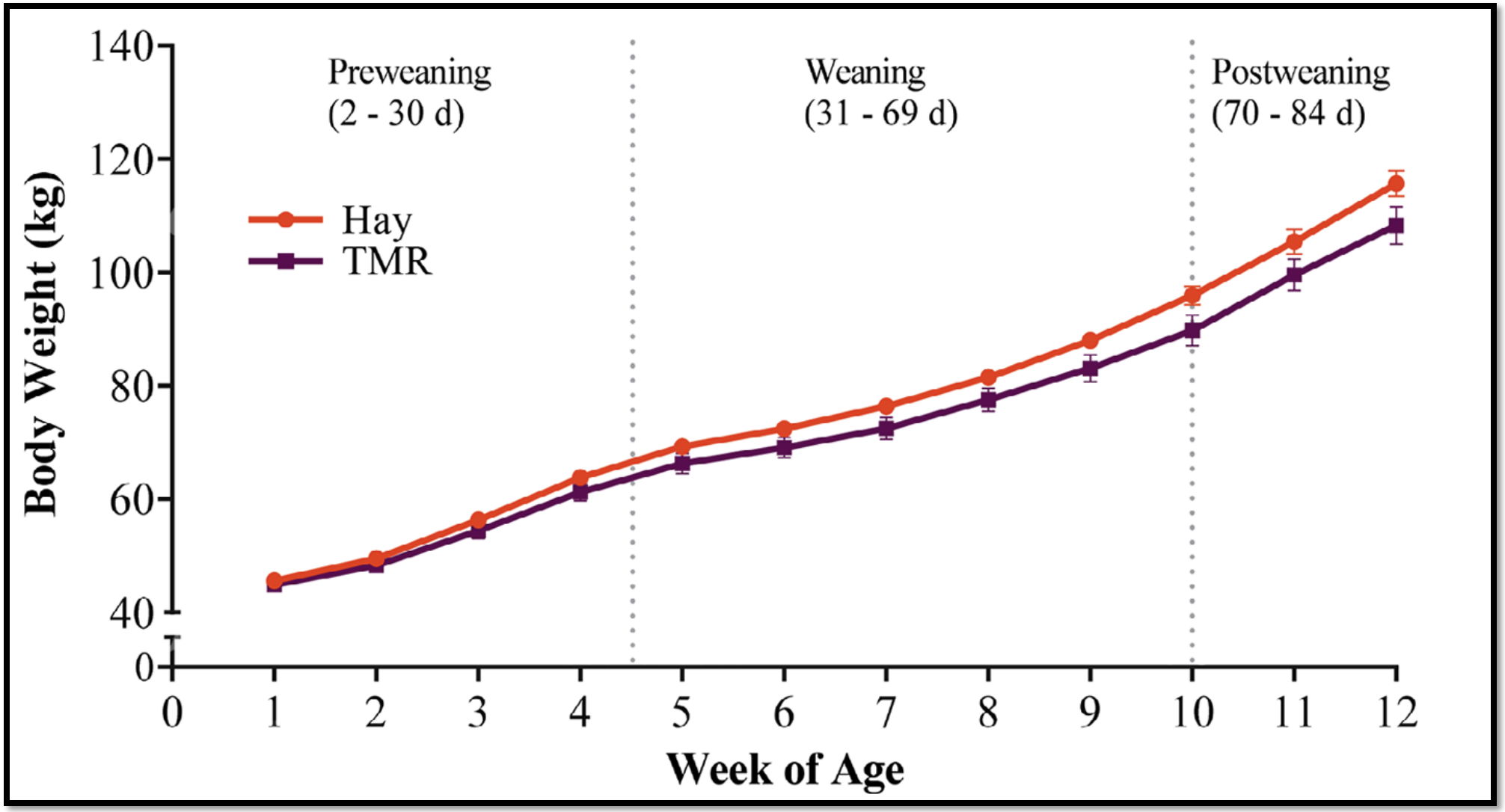
What about forage types?



Welk et al., 2022



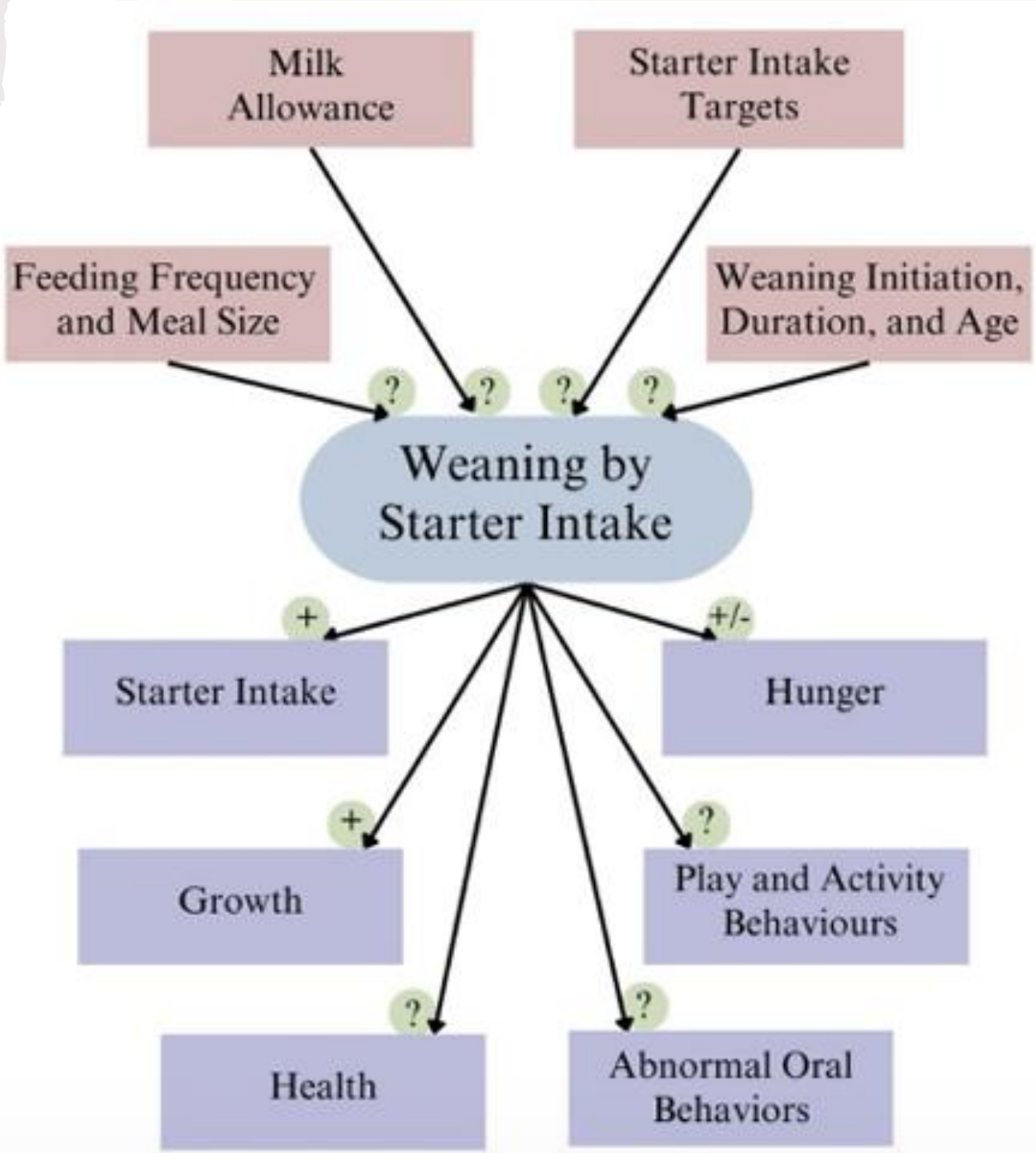
Welk et al., 2022



Welk et al., 2022

Weaning review

44 studies evaluated



Welk et al., 2024

Weaning review

44 studies evaluated

There was consensus for positive effects (or at least no negative effects) on overall growth of calves if weaned:

- At later ages
- Over longer durations
- Based on starter intake
- Weaned using step-down or meal-based milk removal approaches

Welk et al., 2024

Weaning review

44 studies evaluated

- Most studies found improved starter intake in calves weaned over longer durations
- Weaning based on starter intake had superior growth and feed intakes compared with calves weaned at fixed earlier age
- Weaning after 8 wk appears to support superior weight gain, provided preweaning milk allowances are adequate (above 6 L/d)

Welk et al., 2024

Successful weaning

- At least 8 weeks of age
- Step-down protocol
  - More than 2 weeks
  - Multiple steps
- Starter intake of 1.3 kg/d (~3 lb/d)
  - 60% microbial protein

RESULTS

52% were involved in feeding and weaning protocols

94% wanted to be involved in feeding and weaning protocols

40% felt unsatisfied with their milk feed/wean knowledge

72% of veterinarians wanted to learn about AMFs

Edwards et al., *in prep*

Automated milk feeders

Automated milk feeders

Keep group sizes smaller

- In an 18-month study of 10,179 calves on 38 Midwest farms using AMFs, larger group sizes were associated with increased odds of higher nasal scores

Jorgensen et al., 2017 J. Dairy Sci. 100: 9186–9193

Automated milk feeders

Increase frequency of automatic cleaning of AMF

- Cleaning 2x/d resulted in 2.6 times lower odds for diarrhea than cleaning 1x/d (*P* = 0.01)
- Cleaning 3x/d resulted in 3.7 times lower odds for diarrhea than cleaning 1x/d (*P* = 0.02)

Medrano-Galarza et al., 2018. J. Dairy Sci. 101:2293-2308

Automated milk feeders

Provide a sufficiently large meal allowance (≥2.1 qt or ≥2 L per meal)

- Larger meal allowances ensure that calves leave the feeding station feeling satiated
- Calves only allowed small but frequent meal allowances (6.4 L/day offered as 8 meals of 0.8 L/meal) spent more time standing in the feeding station each day
  - A greater proportion of that time was ‘unrewarded’

Jensen et al., 2004

Automated milk feeders

Provide sufficient total solids

- Providing 13% or greater total solids had 2 times lower odds for BRD compared to less than 10%
- Re-calibrate machine each time a new milk replacer skid is opened

Medrano-Galarza et al., 2018. J. Dairy Sci. 101:2293-2308

Automated milk feeders

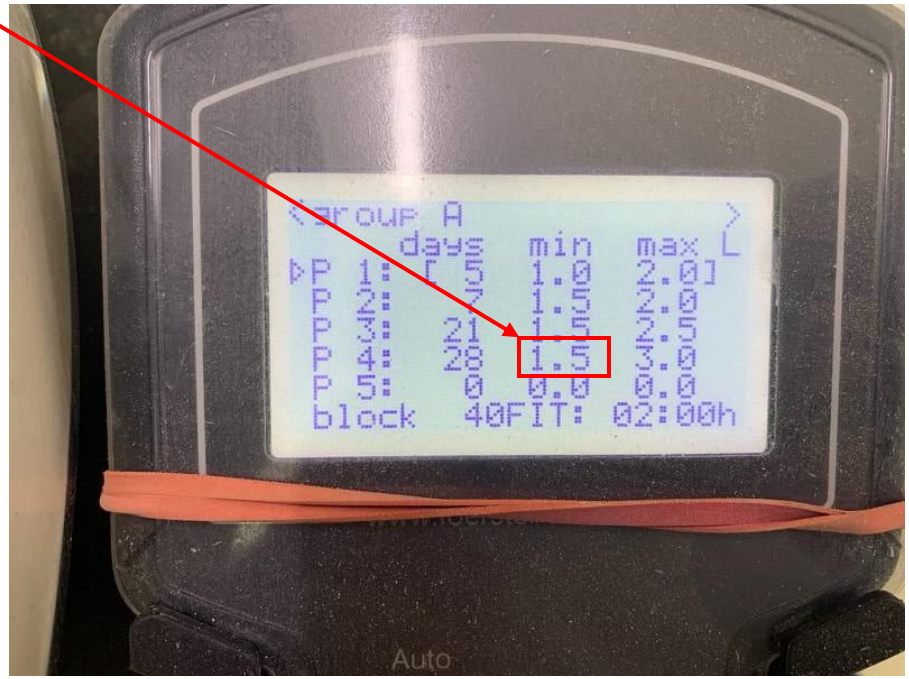
Provide sufficient volume

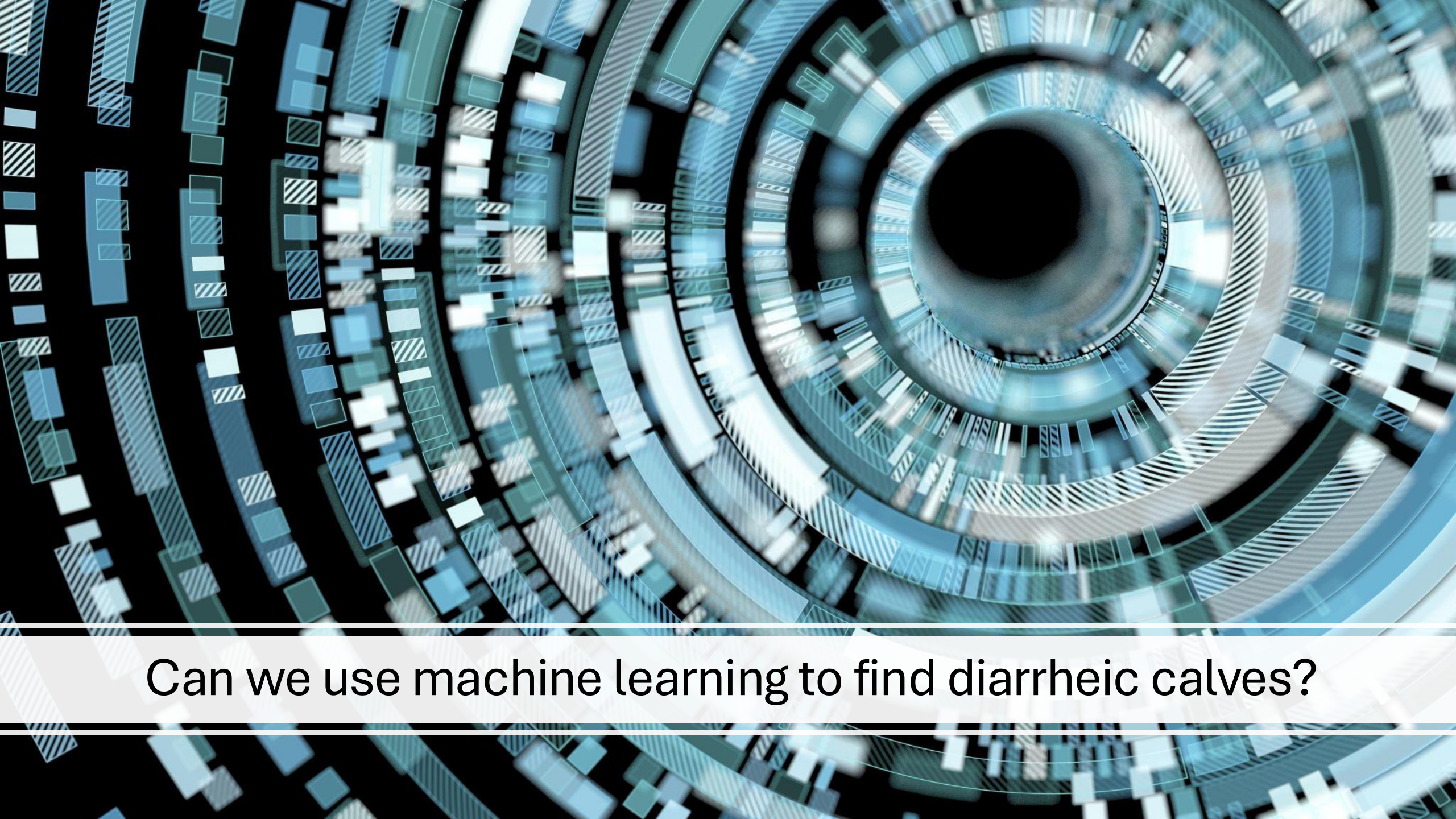
- High milk allowance for the first 35-40 days (at least 2 gallons or ad lib ideally)
- Step-down gradual wean
- Use “40-fit” type programs

Automated milk feeders

If group sizes permit, adjust minimum allowance per visit during weaning

- Changing minimum allowance to 0.5 L for calves being weaned allows calves to return sooner for a meal
- May reduce cross-sucking since it satisfies the desire to suckle



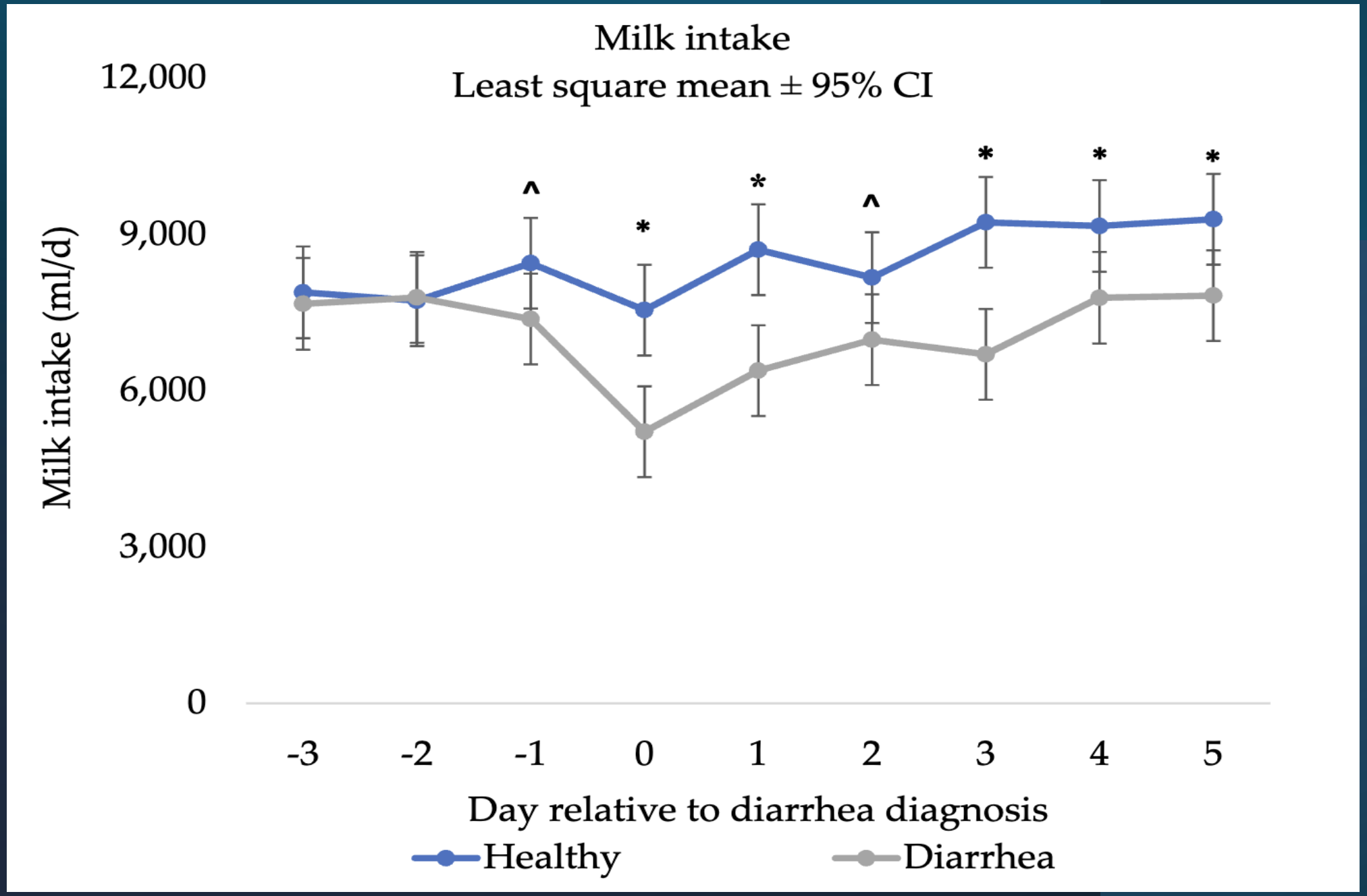


Can we use machine learning to find diarrheic calves?

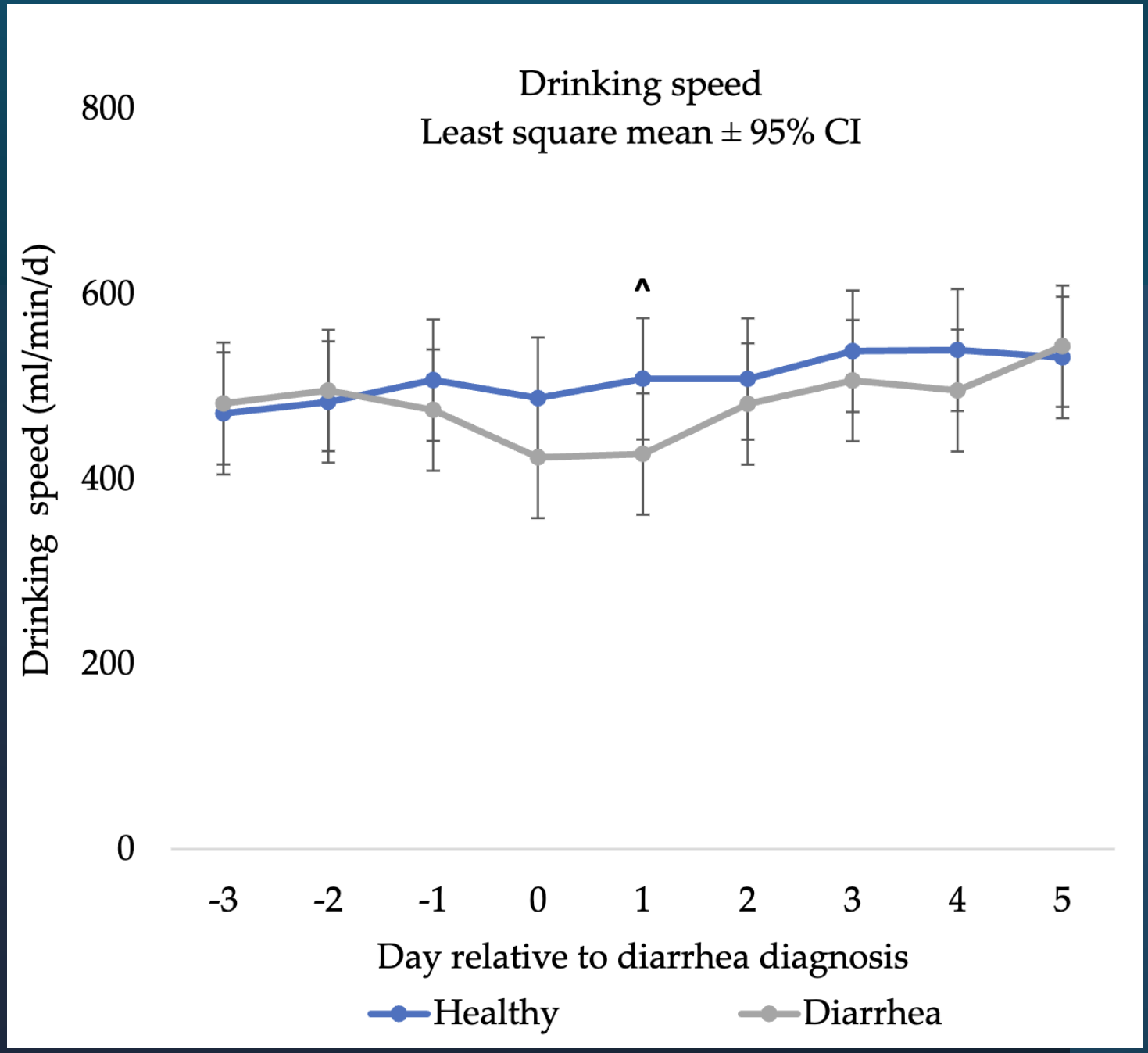
Using AMFs to detect diarrhea

- 174 calves enrolled under 35 days of age
- Case-control study
  - Cases had fecal score 2 or 3 for a minimum of 2 consecutive days (day 2 defined as day of diagnosis; i.e. day 0)
  - Control calves did not have an abnormal fecal score for 2 consecutive days
  - Case and control matched by gender, farm, and age

Conboy et al., 2022



Conboy et al., 2022

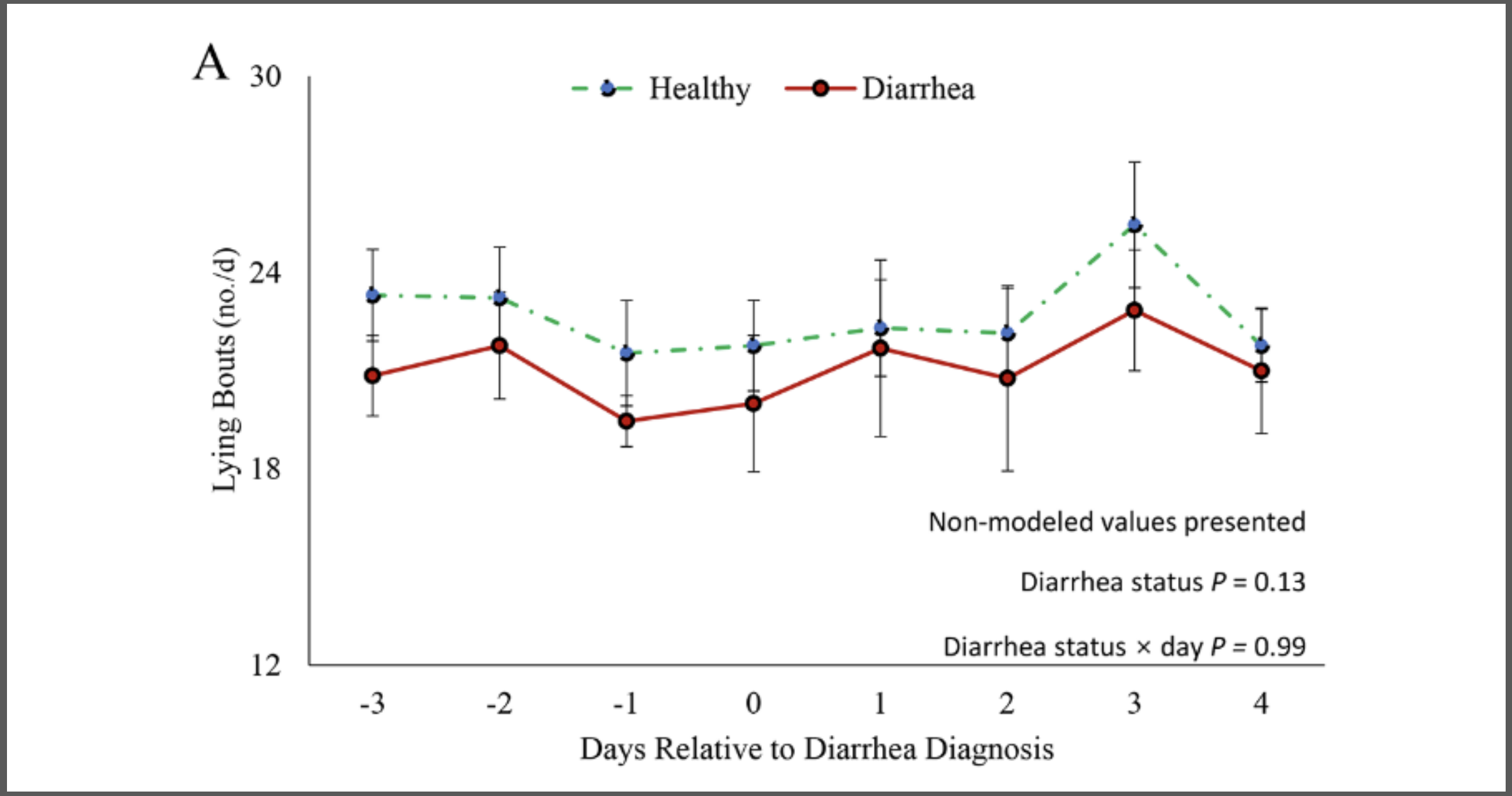


Conboy et al., 2022

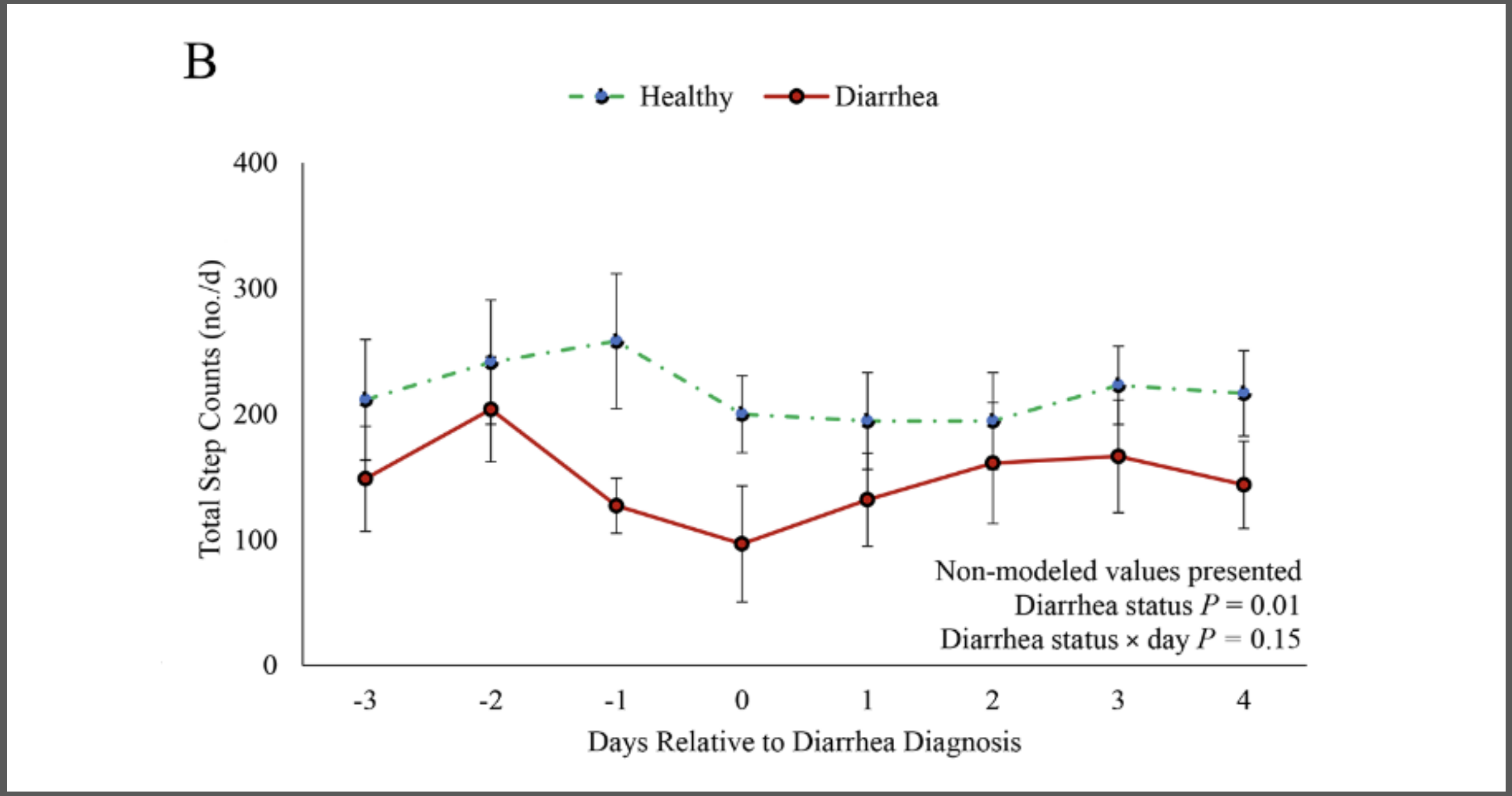
Using AMFs to detect diarrhea

- 26 bull calves enrolled under 35 days of age
- Case-control study
  - Cases had fecal score 2 or 3 for a minimum of 2 consecutive days (day 2 defined as day of diagnosis; i.e. day 0)
  - Control calves did not have an abnormal fecal score for 2 consecutive days

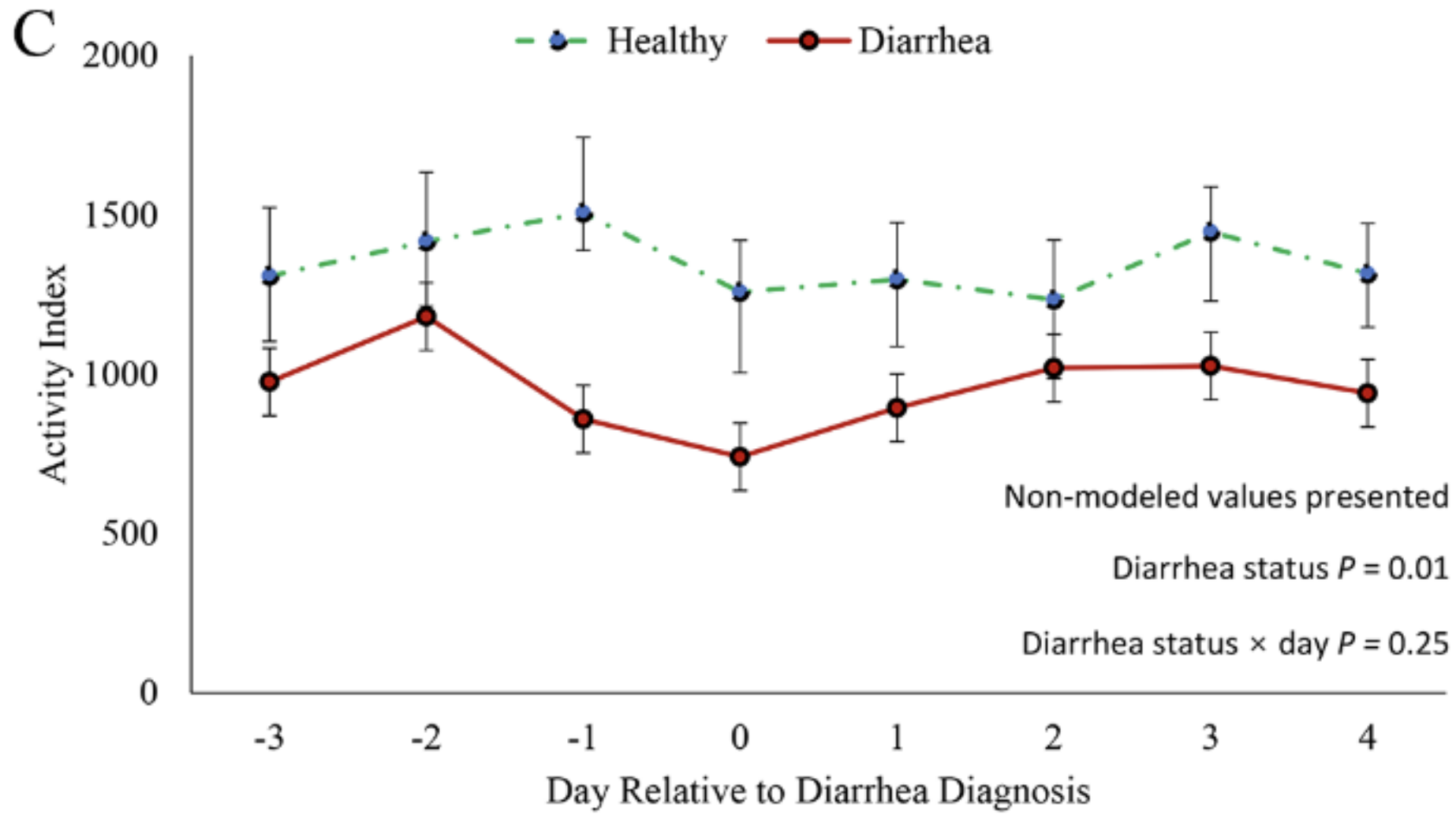
Guevara-Mann et al., 2023



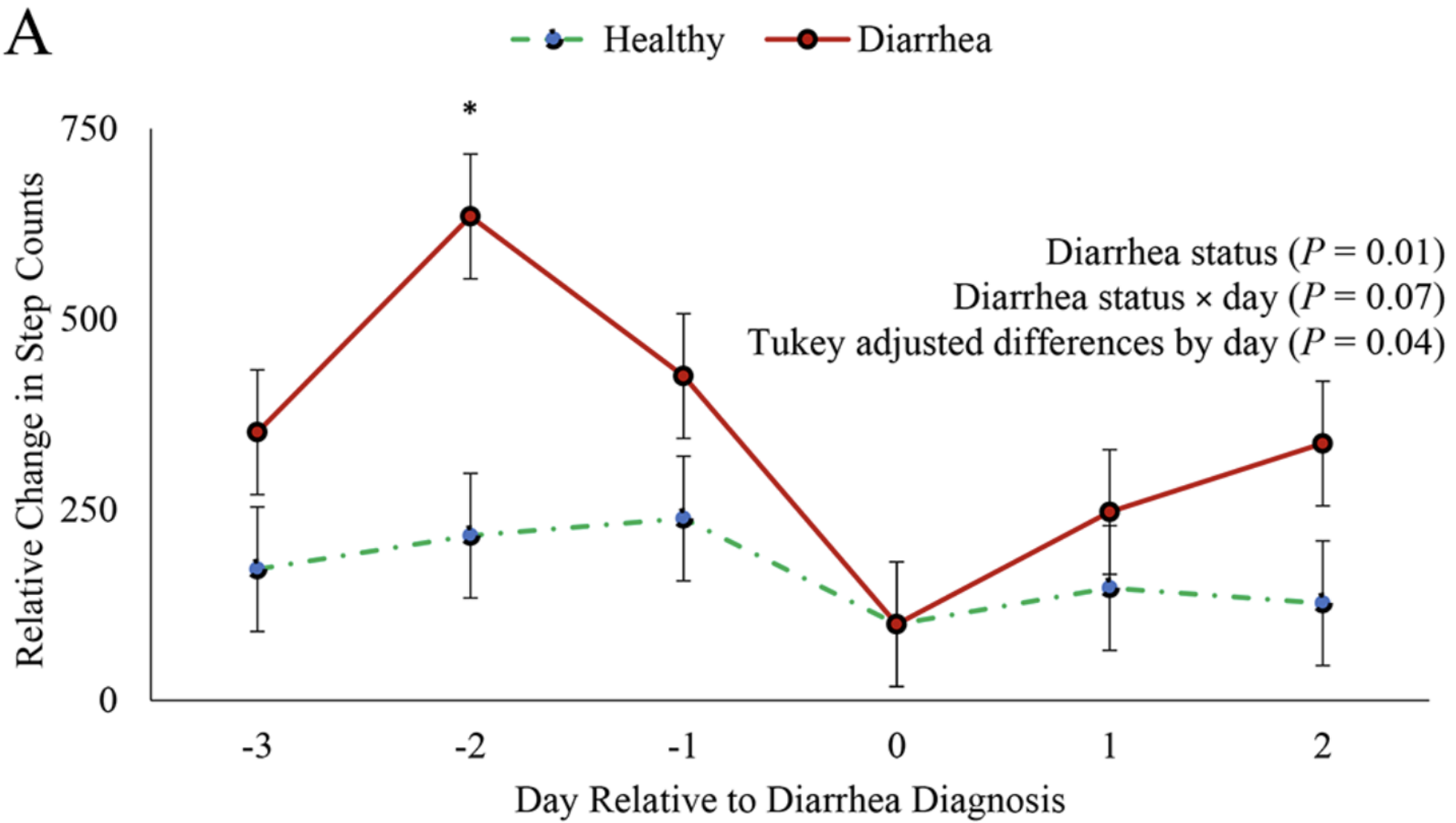
Guevara-Mann et al., 2023



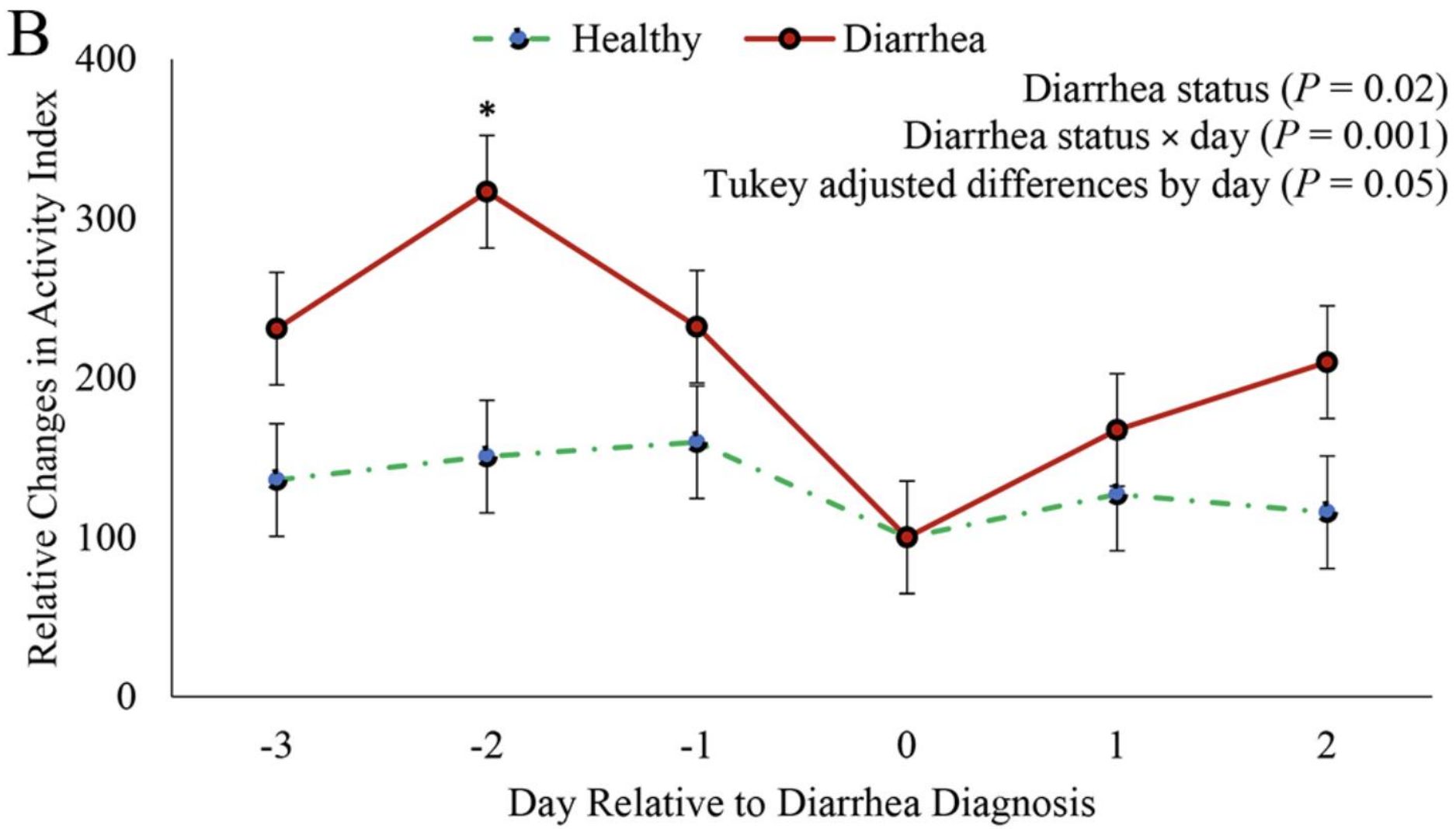
Guevara-Mann et al., 2023



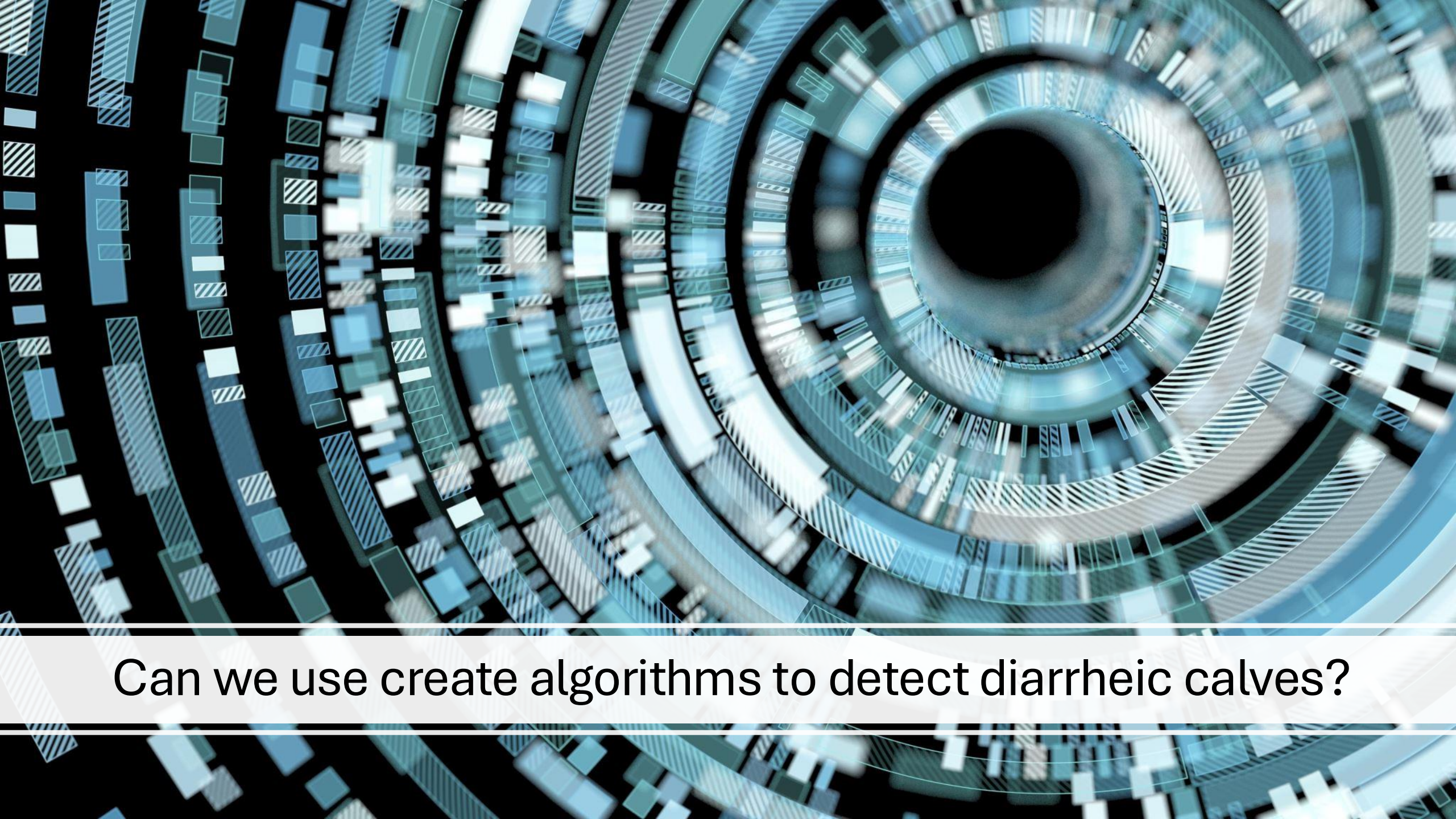
Guevara-Mann et al., 2023



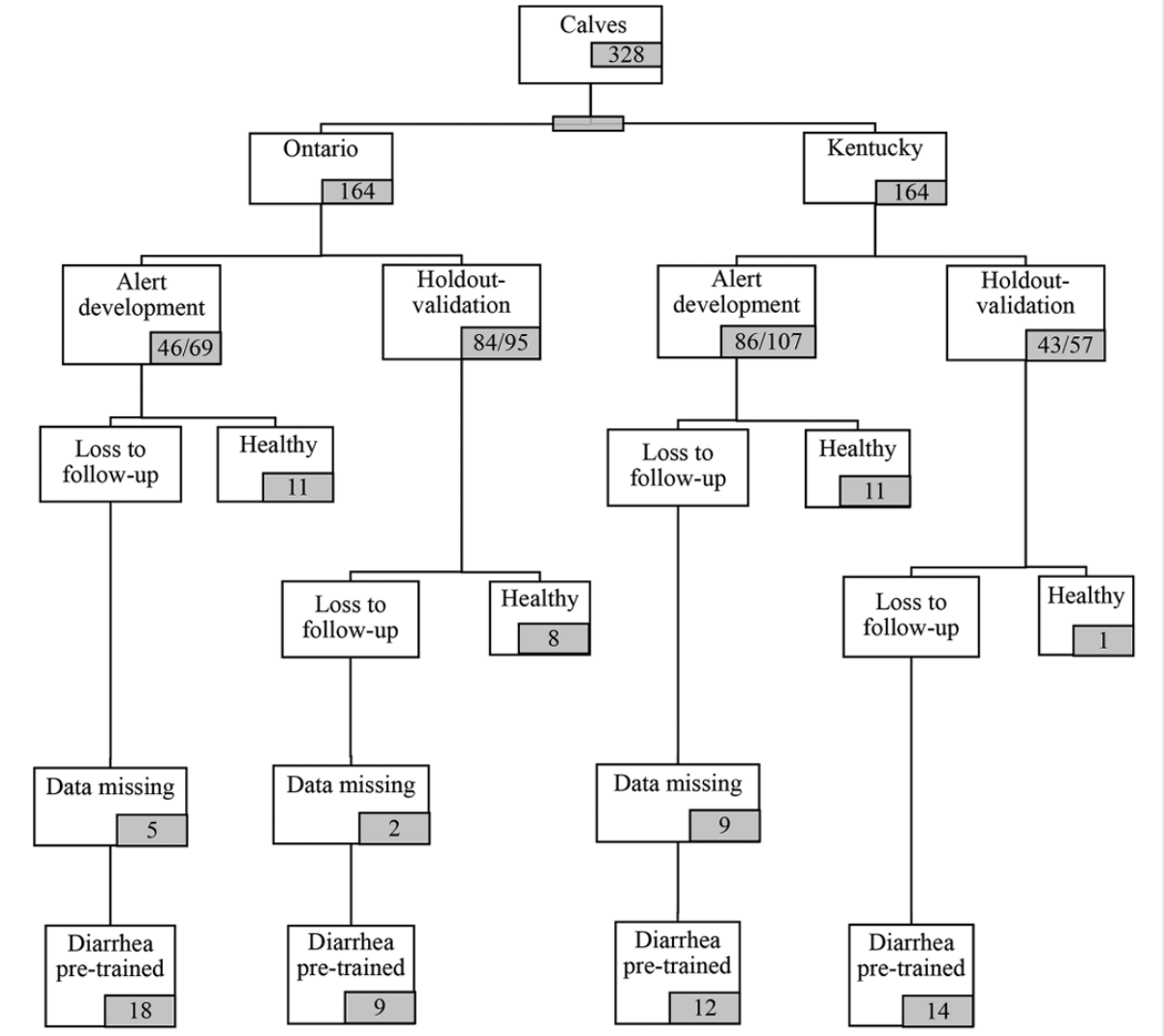
Guevara-Mann et al., 2023



Guevara-Mann et al., 2023



Can we use create algorithms to detect diarrheic calves?



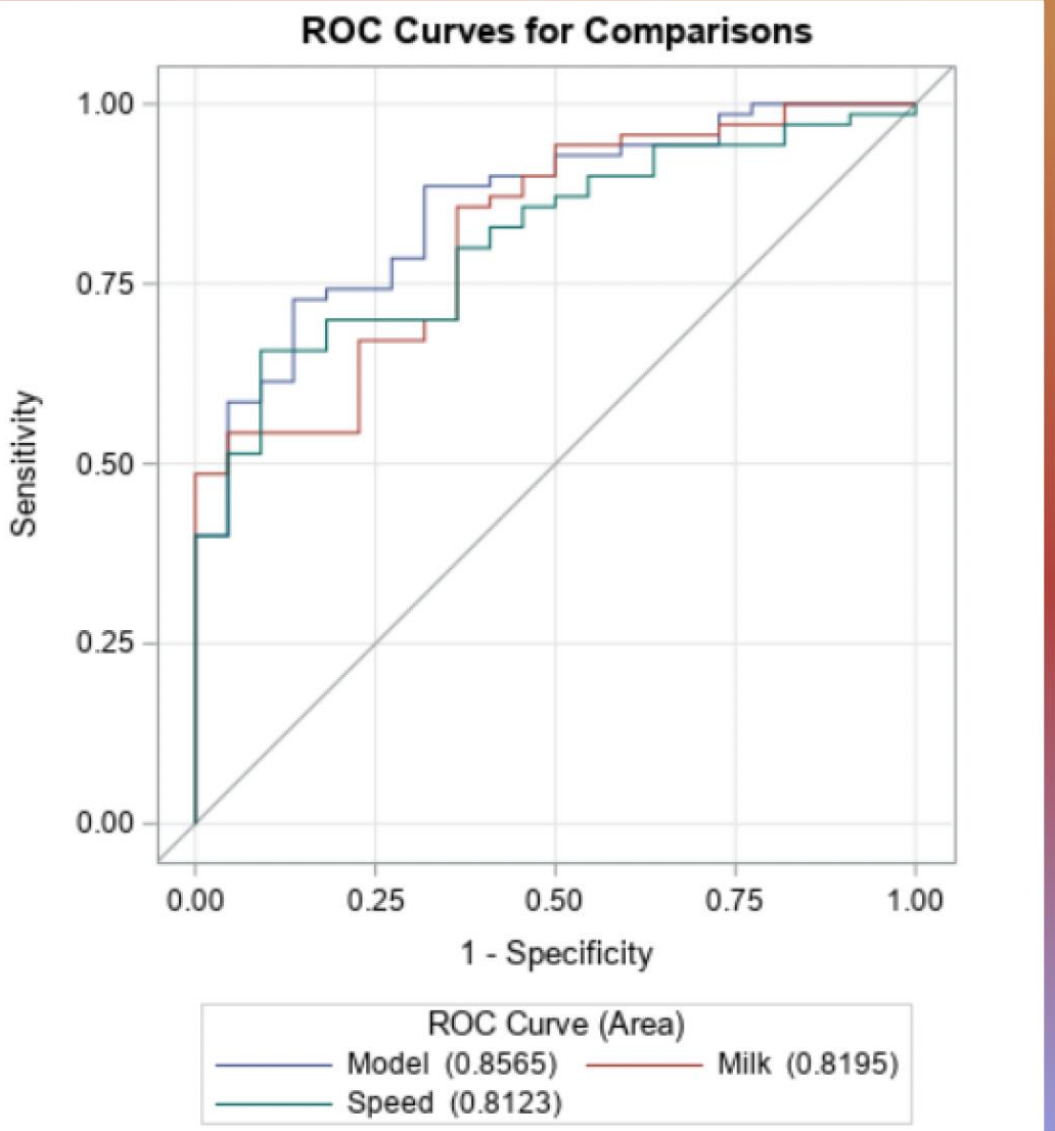
Creating an algorithm

Cantor et al., 2024

Alert works! dividends milk + drinking speed

15 L/d calves

- ✓ Threshold 0.60
  Sensitivity 91% 32/35
- ✓ Accuracy 82% 39/46
- ✓ Precision 89% 32/36
- ✓ Specificity 73% 8/11



Cantor et al., 2024
Slide courtesy of M. Cantor

For ad libitum calves (40-fit program)

$$\text{milk intake dividend change d } 0 = \frac{\text{E}}{\text{F}}$$

Where “E” is milk intake on d - 1 relative to diarrhea diagnosis and “F” is milk intake on d - 2 relative to diarrhea diagnosis (d 0)

Alert test failure: rolling dividend milk

10 L/d

No diagnostic accuracy

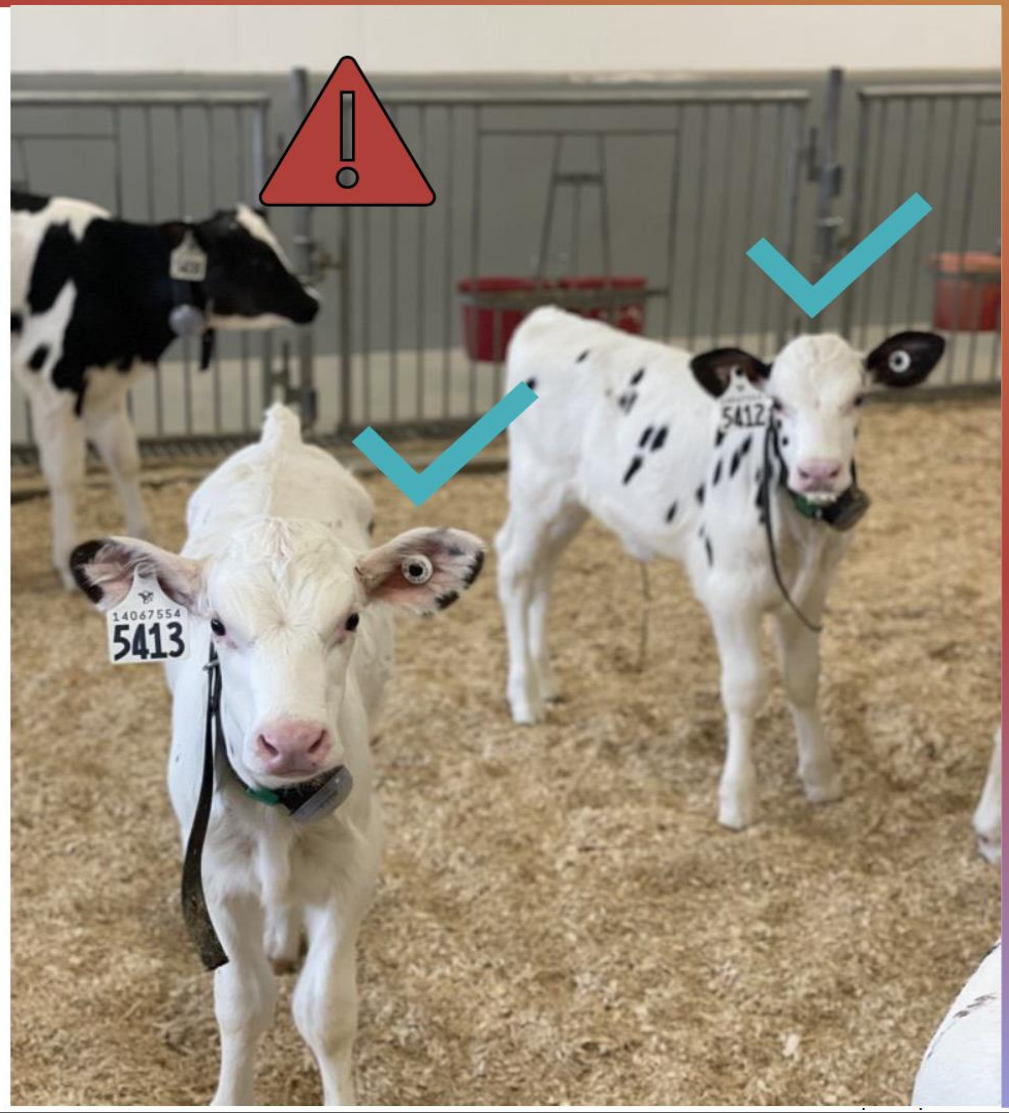
Threshold 0.71

Sensitivity 48% 36/75

Accuracy 52% 45/86

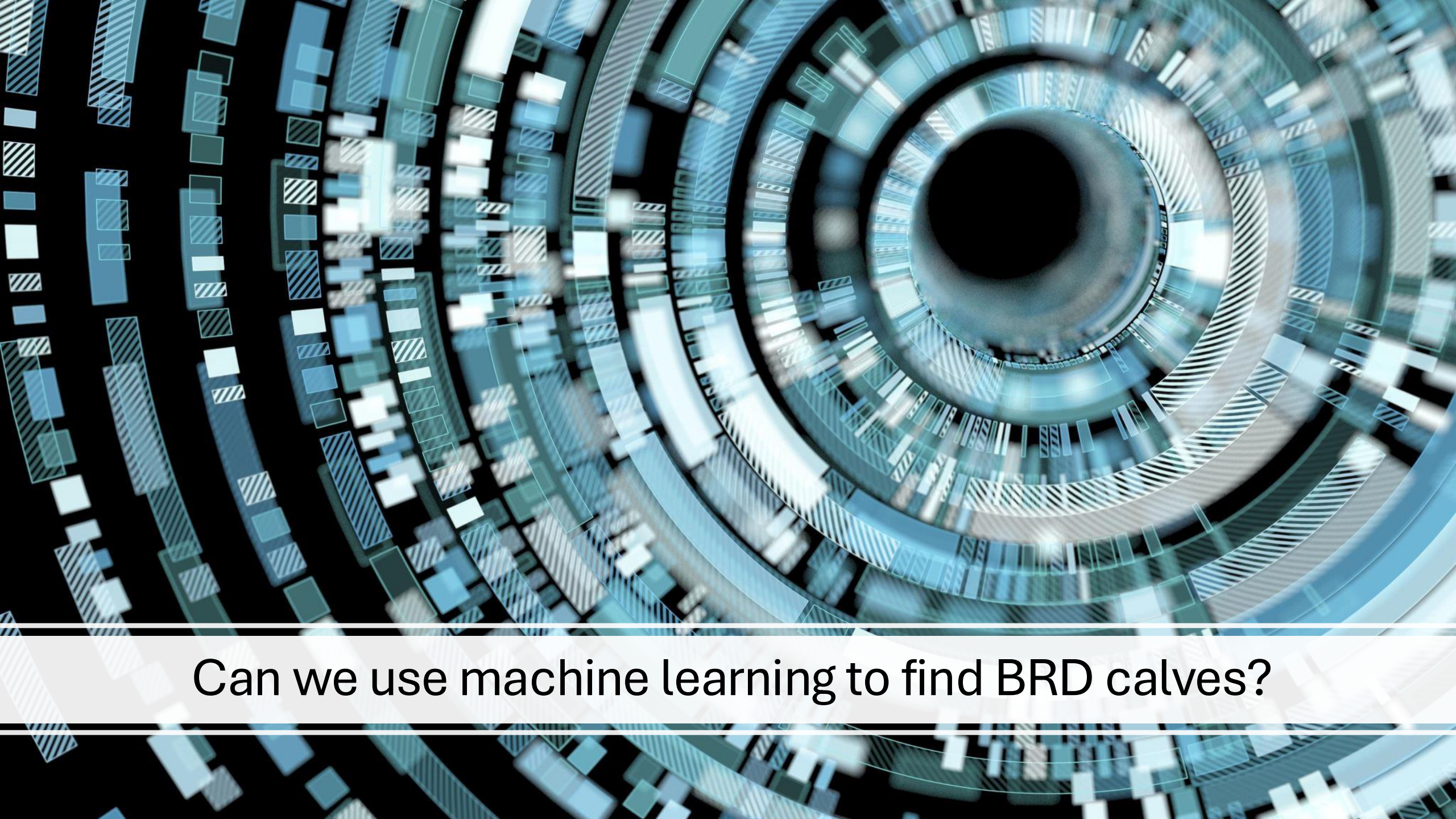
Precision 96% 36/38

Specificity 82% 9/11



Cantor et al., 2024

Slide courtesy of M. Cantor



Can we use machine learning to find BRD calves?

J. Dairy Sci. 105:6070–6082
https://doi.org/10.3168/jds.2021-20798

Daily behavioral measures recorded by precision technology devices may indicate bovine respiratory disease status in preweaned dairy calves

M. C. Cantor[1,2] and J. H. C. Costa[1]*
[1]Dairy Science Program, Department of Animal and Food Sciences, University of Kentucky, Lexington 40546
[2]Department of Population Medicine, University of Guelph, Guelph, ON, Canada, N1G 2W1

Using AMFs to detect BRD

- 66 pairs of calves (case-control), fed 10 L/d
- **Feeding behavior**
    - Daily milk intake
    - Daily milk allotment consumed
    - Drinking speed
    - Rolling 12-d average drinking speed
    - Rewarded visits
    - Unrewarded visits
    - Grain intake

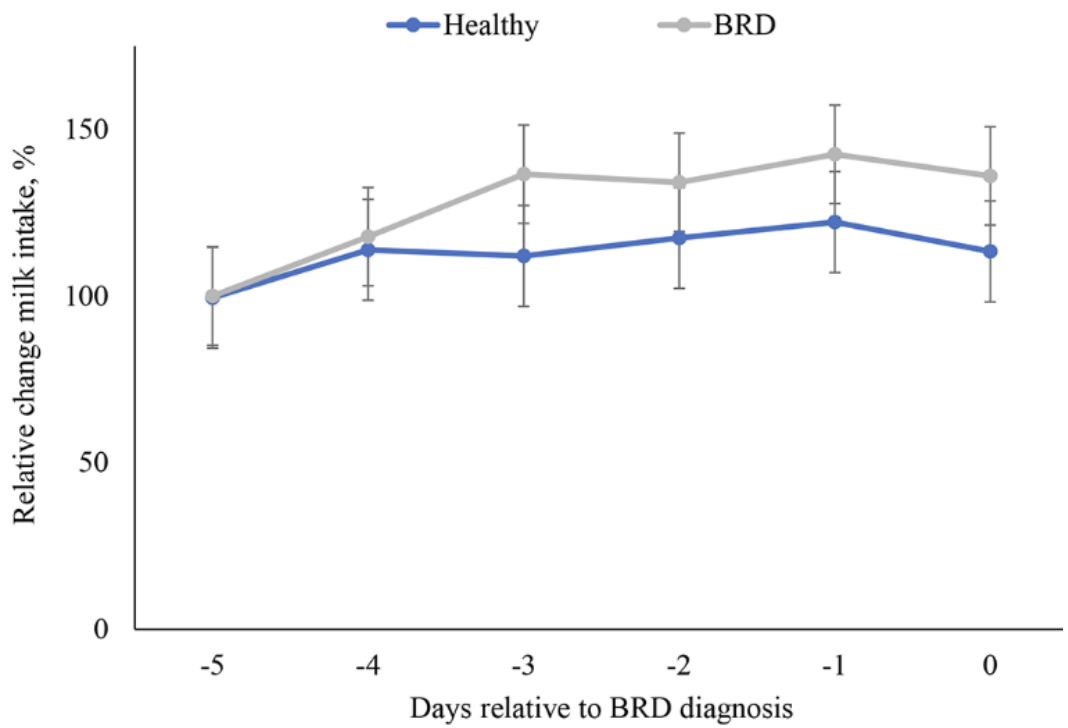
Cantor and Costa, 2022

Using AMFs to detect BRD

- **Activity levels**
  - Lying time
  - Lying bouts per day
  - Total step count
  - Activity index
- **Daily health scoring (Wisconsin system)**

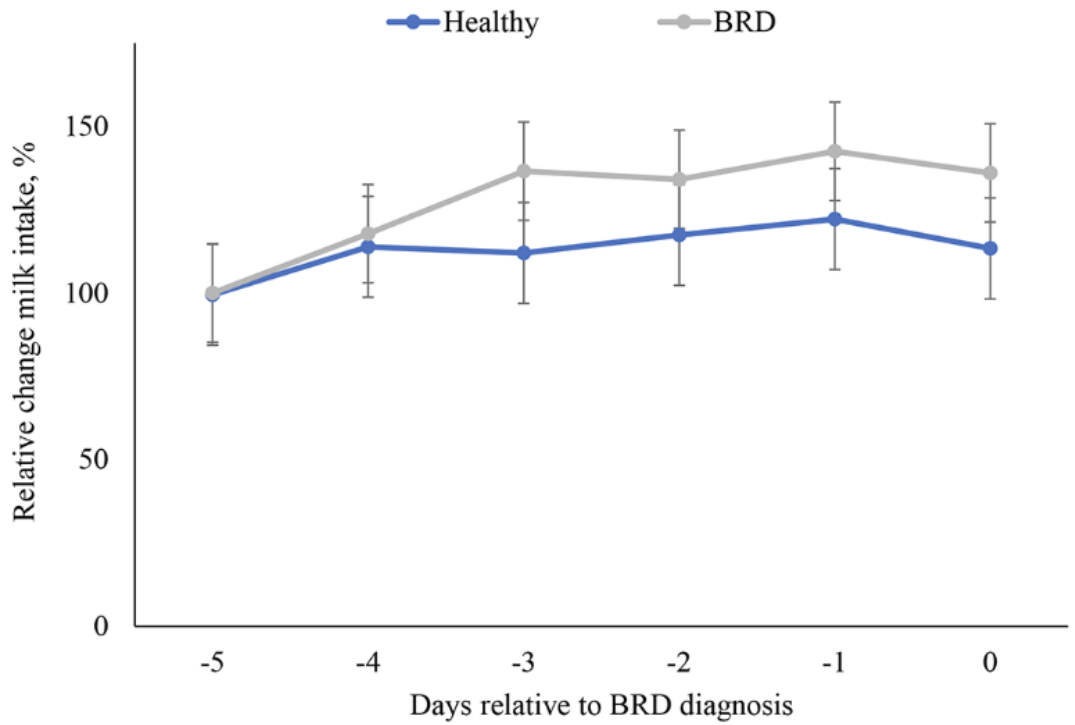
Cantor and Costa, 2022

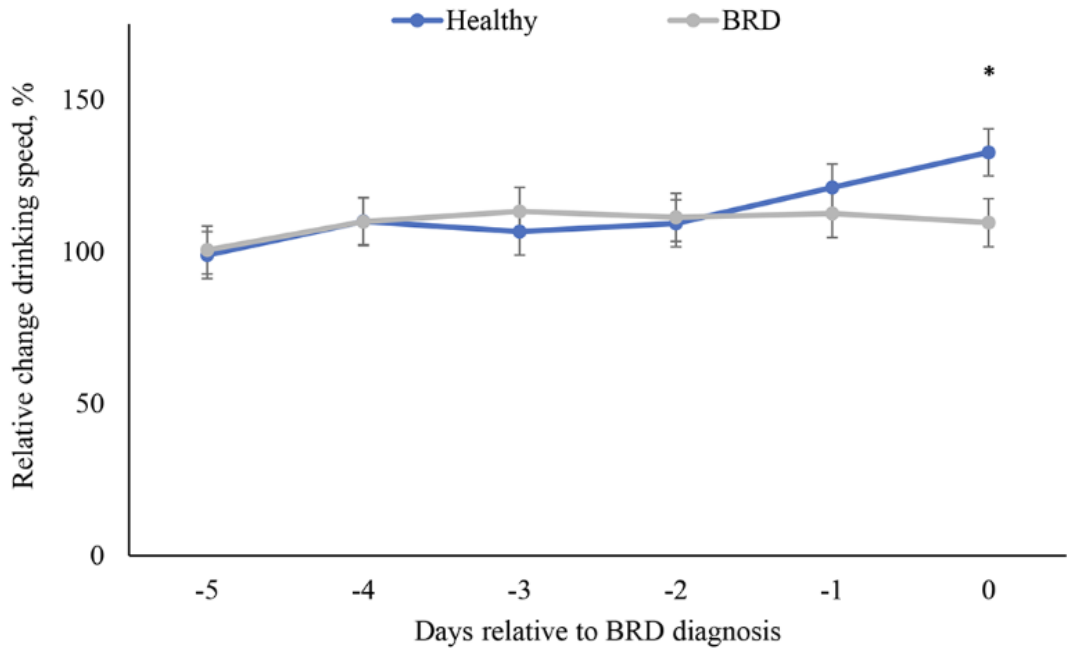
Calves with BRD drink less



Cantor and Costa, 2022

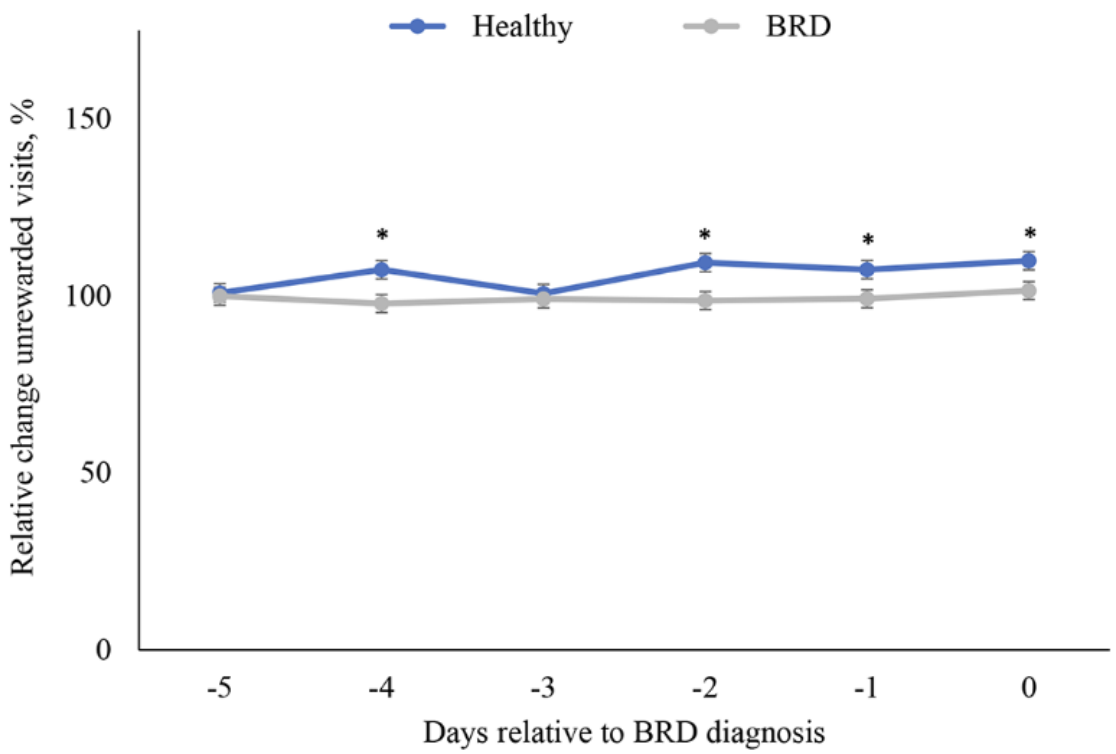
Calves with BRD drink less… and drink slower





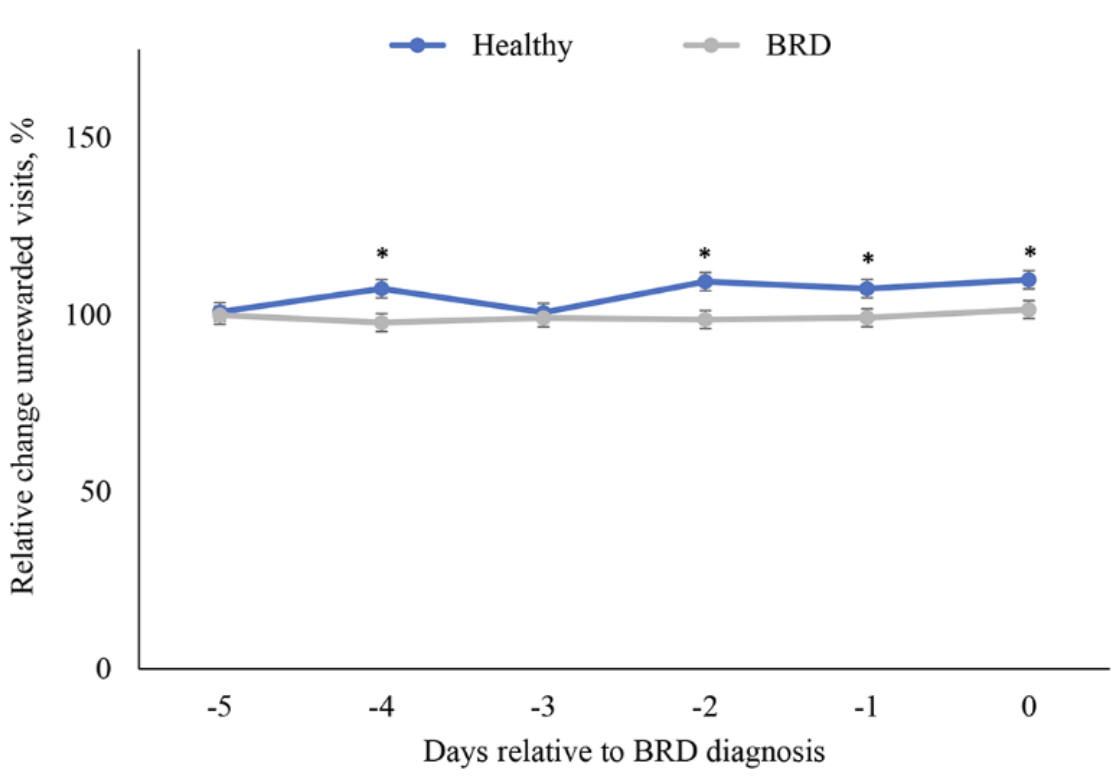
Cantor and Costa, 2022

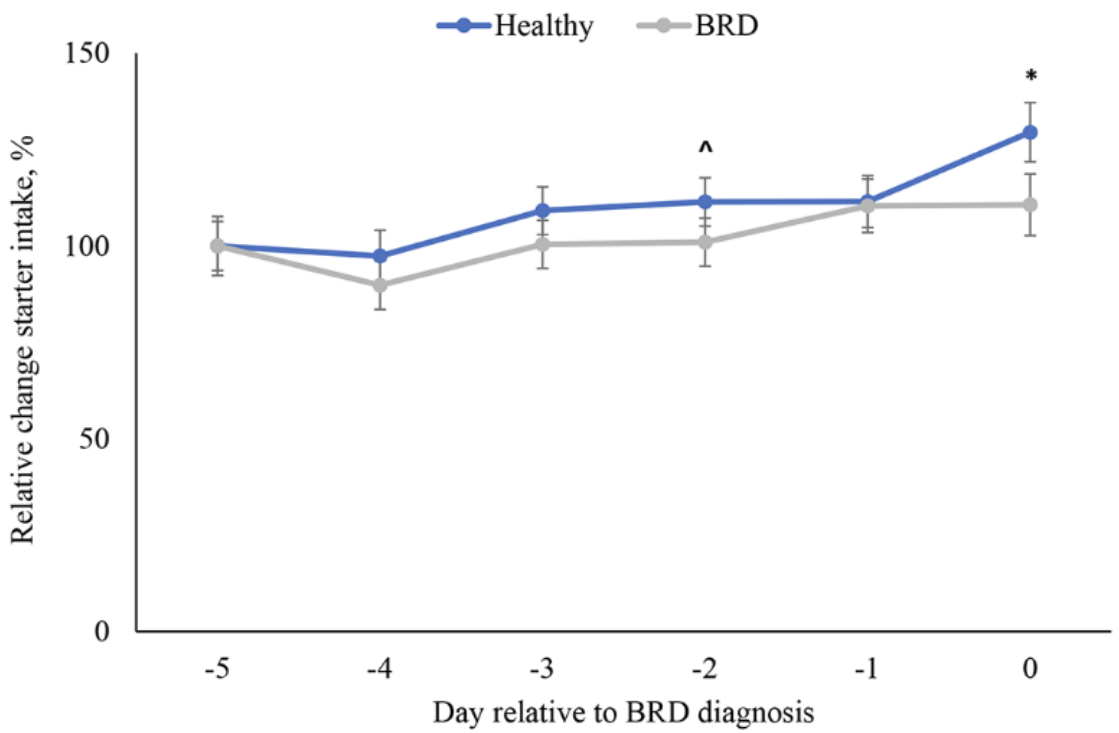
Calves with BRD visit the feeder less often



Cantor and Costa, 2022

Calves with BRD visit the feeder less often and eat less starter





Cantor and Costa, 2022

Before the first case of BRD

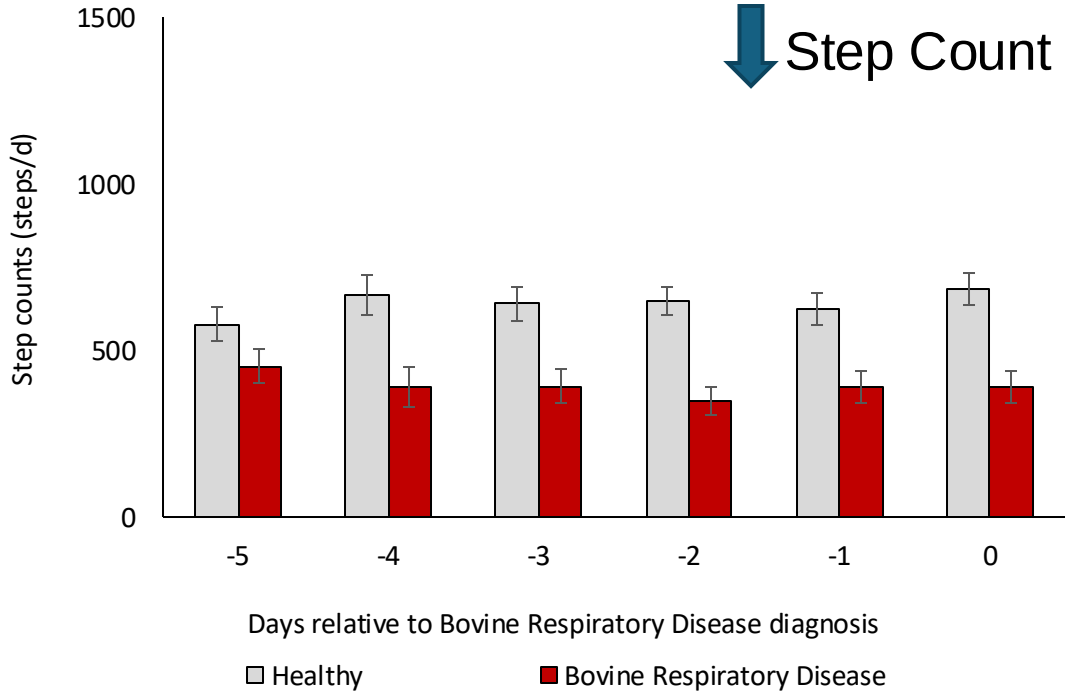
Milk intake (L/d) ↓

Calf starter intake (g/d) ↓

↑ Lying time

↓ Lying bouts

↓ Step Count



Cantor and Costa, 2022

But… calves relapse after the first BRD treatment

It is common for calves to relapse after the first BRD treatment…

So, can we use AMFs to detect calves that will relapse?

OPEN

Feeding behavior and activity levels are associated with recovery status in dairy calves treated with antimicrobials for Bovine Respiratory Disease

M. C. Cantor[1,2], David L. Renaud[2], Heather W. Neave[3] & Joao H. C. Costa[1]✉

But… calves relapse after the first BRD treatment

Variable	Recovered	Relapsed	*P*-value
Milk intake (L/d)	9.05	8.16	0.001
Drinking speed (L/min)	1.02	0.81	0.02

Cantor et al., 2022

But… calves relapse after the first BRD treatment

Variable	Recovered	Relapsed	*P*-value
Milk intake (L/d)	9.05	8.16	0.001
Drinking speed (L/min)	1.02	0.81	0.02
Unrewarded visits/d	2.40	1.53	0.02

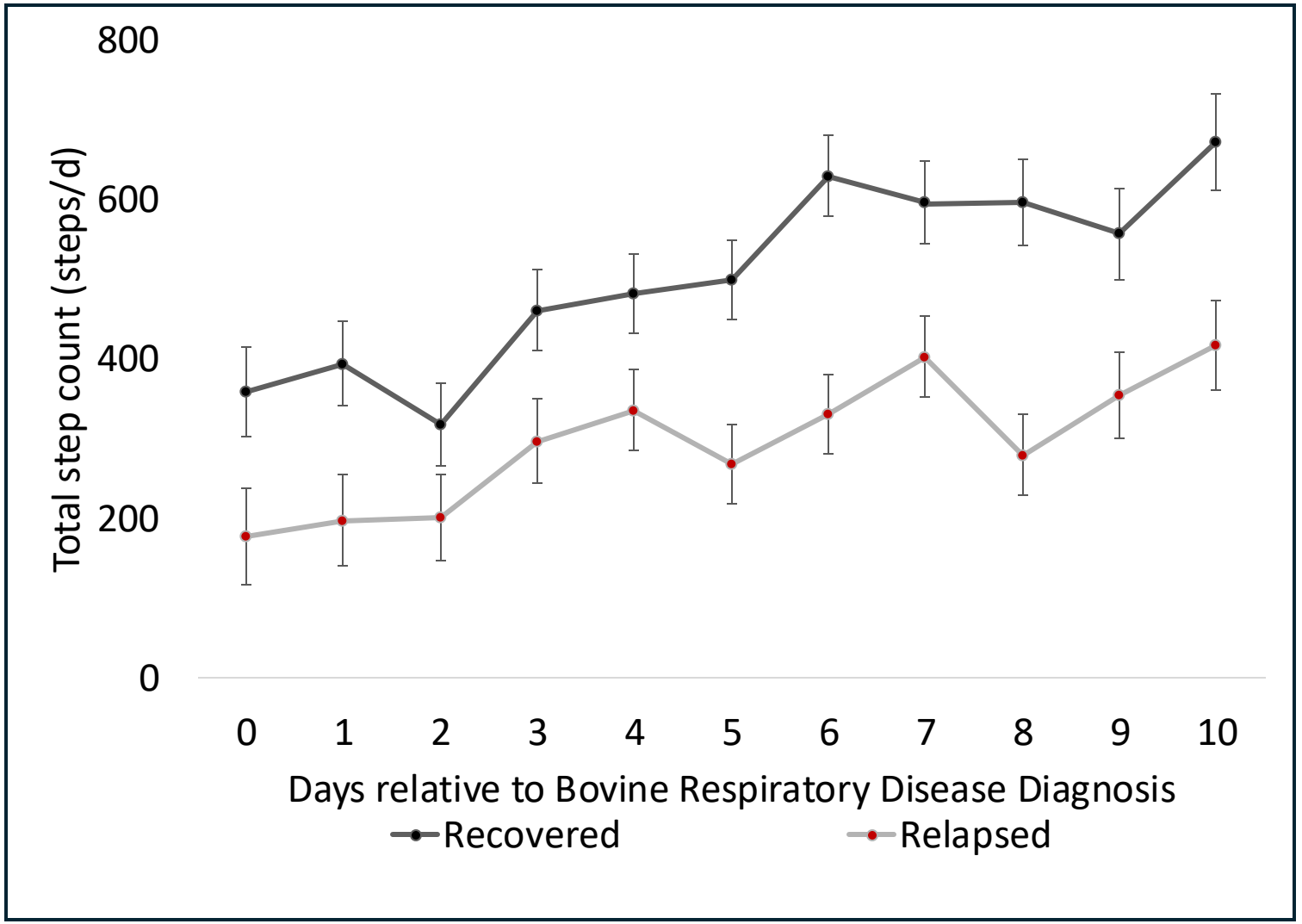
Cantor et al., 2022

But… calves relapse after the first BRD treatment

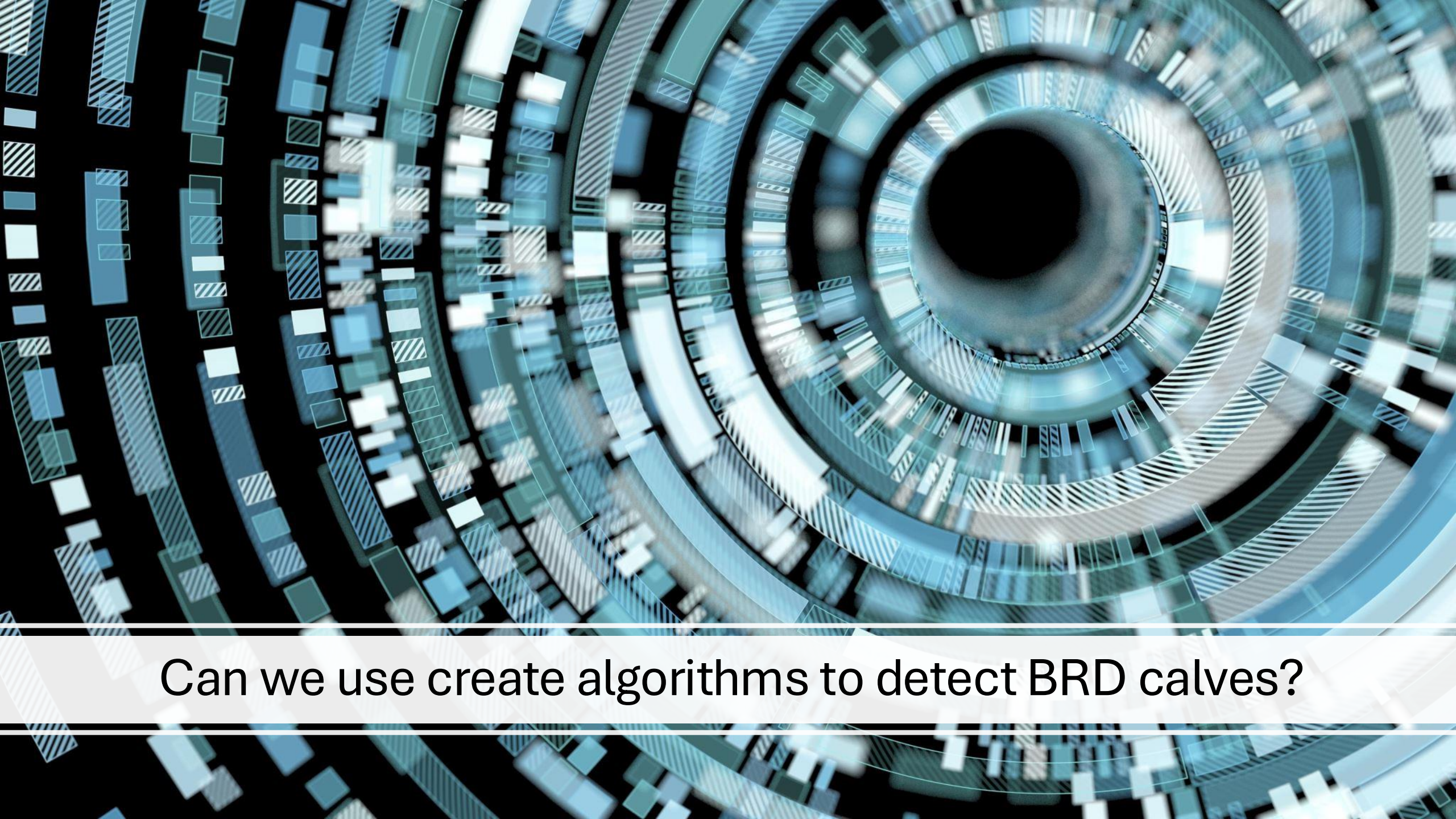
Variable	Recovered	Relapsed	*P*-value
Milk intake (L/d)	9.05	8.16	0.001
Drinking speed (L/min)	1.02	0.81	0.02
Unrewarded visits/d	2.40	1.53	0.02
Starter intake (g/d)	137.50	51.54	0.001

Cantor et al., 2022

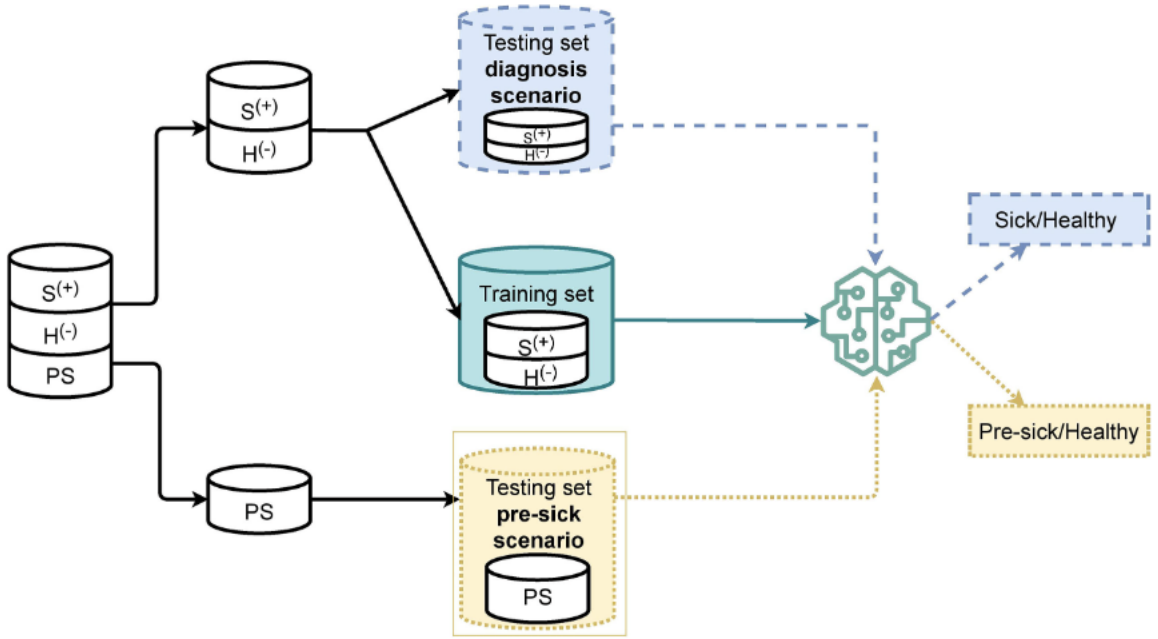
But… calves often relapse after the first BRD treatment



Cantor et al., 2022



Can we use create algorithms to detect BRD calves?



Creating an algorithm

Cantor et al., 2024

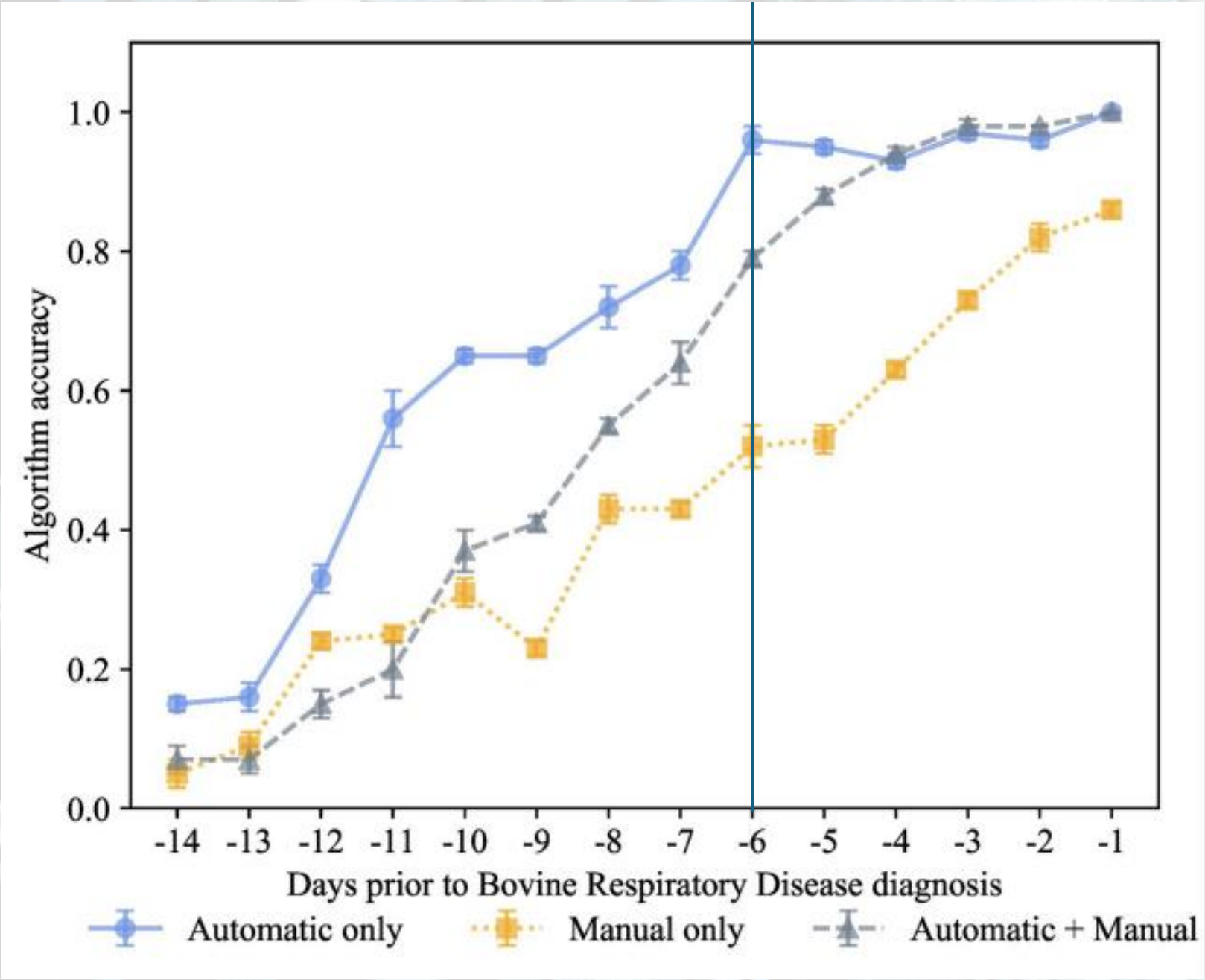
Using Machine Learning and Behavioral Patterns Observed by Automated Feeders and Accelerometers for the Early Indication of Clinical Bovine Respiratory Disease Status in Preweaned Dairy Calves

Melissa C. Cantor[1,2], Enrico Casella[3], Simone Silvestri[3], David L. Renaud[2] and Joao H. C. Costa[1]*

Creating an algorithm

- 106 calves enrolled
- **“Automated features”**
  - Activity behavior monitored with pedometer
  - Feeding behavior monitored with an automated calf feeder
- **“Manual features”**
  - Calves were BRD health scored daily
- Weights taken twice weekly
- Lung ultrasound twice weekly

Cantor et al., 2022

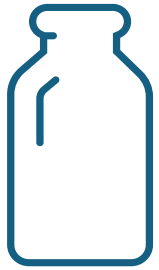


90% accuracy of the automatic algorithm (pedometers and AMF) at 6 days prior to BRD event

Cantor et al., 2022

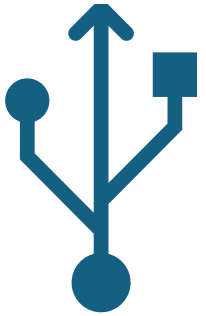
Takeaways

There are economic impacts to preweaning average daily gain



Feed high volumes of milk preweaning to reduce hunger and improve gain

Wean gradually, step-wise, at >8 weeks, and/or based on starter intake



Technology can be used to find sick calves

Questions?

kristen.edwards.dvm@gmail.com