Lessons learned in research on nutritional management of robot milked cows

Balchem Real Science Lecture Series
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What are the opportunities for nutritional management in automated milking (robot) barns?

- Encourage voluntary milking visits throughout the day
  - Promote labor and robot efficiency
- Meet production needs throughout lactation
  - Encourage high peaks and persistency

What have learned in research related to these opportunities?

- There are many approaches – not one size fits all
- Cows need to be motivated to go and milk
- DMI (and its prediction) is key
- Cow behavior may dictate milking and feeding success
- There are opportunities to ‘precision’ feed

What have learned in research related to these opportunities?

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What do ‘average’ robot rations in Canada look like?

	PMR						AMS Concentrate						P-value[1]	
Item	National	East	QC	ON	West	SEM[2]	National	East	QC	ON	West	SEM[2]	PMR	AMS
N	149	7	17	75	50	—	157	8	23	76	54	—	—	—
DMI (kg/d)	21.1 ± 0.17	22.8^{a}	20.5^{bc}	21.5^{ab}	20.6^{c}	0.76	4.3 ± 0.09	4.12^{ab}	4.75^{a}	3.91^{b}	4.69^{a}	0.37	0.005	<0.001
DM (%)	42.6 ± 0.52	40.4	41.0	43.0	43.1	2.32	88.3 ± 0.13	87.2	87.9	88.5	88.4	0.56	0.46	0.13
CP (% of DM)	16.1 ± 0.13	16.4^{ab}	17.2^{a}	15.8^{b}	16.1^{b}	0.59	19.3 ± 0.32	15.9^{b}	19.9^{a}	20.5^{a}	17.6^{b}	1.39	0.02	<0.001
ADF (% of DM)	22.4 ± 0.21	21.2^{c}	24.5^{a}	21.9^{c}	22.9^{ab}	0.93	9.62 ± 0.25	8.0	10.4	9.6	9.6	0.69	0.001	0.36
NDF (% of DM)	35.3 ± 1.16	35.5	37.3	36.3	32.6	5.54	19.7 ± 0.92	18.3	22.6	19.5	18.3	3.68	0.53	0.48
NFC (% of DM)	38.3 ± 0.31	37.4^{ab}	38.0^{ab}	39.1^{a}	37.0^{b}	1.34	44.2 ± 0.90	54.0^{a}	44.2^{ab}	41.6^{b}	47.4^{a}	3.69	0.02	0.001
Starch (% of DM)	21.6 ± 0.35	20.7^{b}	19.3^{b}	23.3^{a}	19.4^{b}	2.31	32.2 ± 1.04	45.3^{a}	25.6^{b}	29.1^{b}	36.5^{a}	3.99	<0.001	<0.001
Sugar (% of DM)	4.59 ± 0.20	4.77^{ab}	5.40^{ab}	3.95^{b}	5.43^{a}	1.83	4.90 ± 0.14	4.21^{ab}	3.79^{b}	5.38^{a}	4.50^{b}	0.56	0.005	0.002
EE[3] (% of DM)	4.43 ± 0.09	3.89^{b}	3.73^{b}	4.05^{b}	5.17^{a}	0.36	3.64 ± 0.10	3.39^{ab}	3.09^{b}	3.87^{a}	3.58^{ab}	0.43	<0.001	0.02
Ash (% of DM)	8.00 ± 0.18	7.20^{b}	8.11^{ab}	7.56^{b}	8.96^{a}	0.69	5.82 ± 0.25	4.24	5.26	6.03	5.94	0.94	0.008	0.31
Ca (% of DM)	0.89 ± 0.01	0.86^{b}	1.02^{a}	0.89^{b}	0.85^{b}	0.07	0.82 ± 0.03	0.43^{c}	0.85^{ab}	0.96^{a}	0.67^{b}	0.13	0.01	<0.001
P (% of DM)	0.38 ± 0.01	0.39	0.40	0.37	0.39	0.03	0.62 ± 0.01	0.64^{ab}	0.67^{a}	0.67^{a}	0.52^{b}	0.05	0.16	<0.001
K (% of DM)	1.50 ± 0.02	1.39^{bc}	1.64^{a}	1.45^{c}	1.56^{ab}	0.11	0.94 ± 0.02	0.80^{b}	0.99^{ab}	1.02^{a}	0.84^{b}	0.07	0.04	<0.001
Cl (% of DM)	0.52 ± 0.01	0.59^{a}	0.60^{a}	0.48^{b}	0.55^{a}	0.05	0.50 ± 0.03	0.41^{ab}	0.70^{a}	0.50^{ab}	0.45^{b}	0.13	0.009	0.07
Mg (% of DM)	0.35 ± 0.01	0.34	0.37	0.35	0.34	0.03	0.38 ± 0.02	0.28^{b}	0.55^{a}	0.36^{b}	0.34^{b}	0.07	0.41	<0.001
Na (% of DM)	0.41 ± 0.01	0.40	0.44	0.42	0.40	0.05	0.35 ± 0.02	0.22^{ab}	0.45^{a}	0.36^{ab}	0.30^{b}	0.09	0.71	0.061
NE_L (Mcal/kg DM)	1.61 ± 0.09	1.50^{ab}	1.52^{c}	1.62^{b}	1.66^{a}	0.17	1.70 ± 0.02	1.79	1.77	1.69	1.66	0.08	0.002	0.19

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Van Soest et al. 2024. J. Dairy Sci. https://doi.org/10.3168/jds.2023-24355

Does robot diet ingredient and nutrient content associate with milk production?

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Van Soest et al. 2024. J. Dairy Sci. https://doi.org/10.3168/jds.2023-24355

Does robot diet ingredient and nutrient content associate with milk production?

- Milk yield (37.0±0.3 kg/d) was associated with…
  - PMR fat concentration
    - Every percentage point increase (4.4±0.09%) was associated with +1.0±0.3 kg/d more milk
  - Major forage source in PMR:
    - Farms that primarily fed barley silage (n=16) or corn silage (n=95) tended to produce +2.2±1.1 kg/d or +1.2±1.2 kg/d more milk than farms that fed haylage (n=42), respectively.

Van Soest et al. 2024. J. Dairy Sci. https://doi.org/10.3168/jds.2023-24355

Does robot diet ingredient and nutrient content associate with milking visits?

- Greater milking frequency (2.8±0.4 milkings/d) was
  - positively associated with free flow traffic cow systems (+0.62 milkings/d) and feed push-up frequency (+0.13 per 10 push-ups, average =12.9±8.6 times/d),
  - while being negatively associated with PMR NFC content (-0.017 milkings per 1% increase; average = 38.3±0.31%)

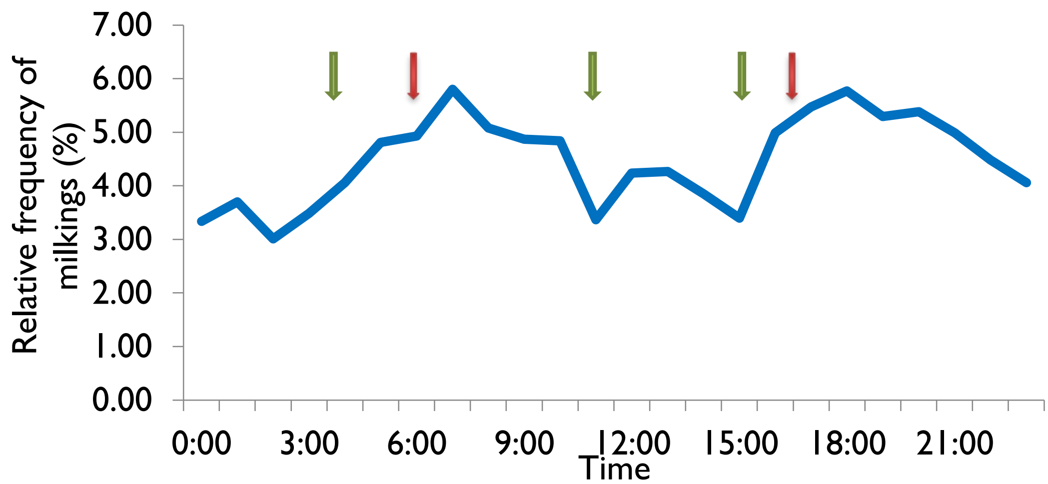
Van Soest et al. 2024. J. Dairy Sci. https://doi.org/10.3168/jds.2023-24355

What have learned in research related to these opportunities?

- There are many approaches – not one size fits all
- Cows need to be motivated to go and milk

What motivates a dairy cow to milk in an robotic (automated) milking system?

Milking times are often linked to periods of PMR feeding activity…



Data adapted from Deming et al. 2013. Can. J. Anim. Sci. 93:427-433

How do we stimulate cows to access their PMR throughout the day?

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- Provide diets that encourage a quick return to eating
  - High forage quality!

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How do we stimulate cows to access their PMR throughout the day?

- Provide diets that encourage a quick return to eating
  - High forage quality!
- Proper feeding management

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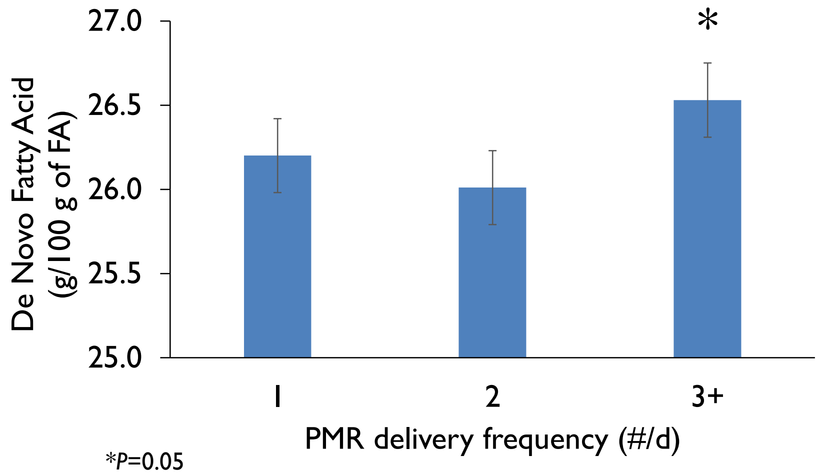
How do we stimulate cows to access their PMR throughout the day?



*P=0.05

Castro et al. 2022. J. Dairy Sci. 105:5097-5108

Need to ensure feed is present when cows go to the bunk!

Ensuring feed is available ensures cows are not limited in their consumption!

- Feed needs to be consistently pushed up and available
  - 197 robot farms across Canada
    - Mean = 12.8 feed pushes/day (SD = 8.3)
    - For every 5 extra feed pushes…
      - +0.35 kg/d (0.77 lb/d) milk yield

Matson et al. 2021.
J. Dairy Sci. 104:7971-7983

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- DMI (and its prediction) is key

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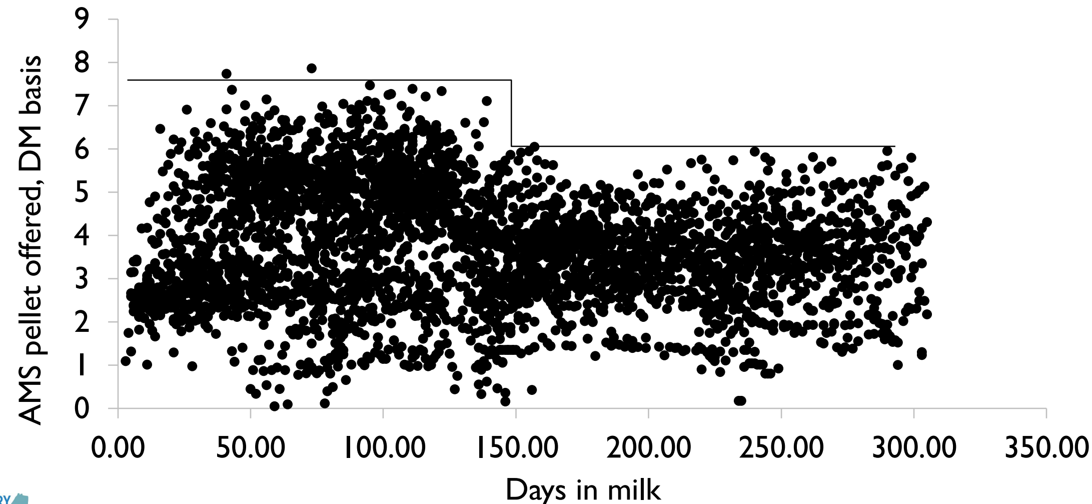
Cows will adjust their PMR intake in response to their intake of robot concentrate

Study	DIM (Average ± SD)	Traffic flow	Substitution Ratio (kg DM drop in PMR for every 1 kg of concentrate)
Bach et al., 2007	191 ± 2.13	Free	**1.14**
Hare et al., 2018	227 ± 25 123 ± 71	Guided	**1.58**
Henriksen et al., 2018	32-320 14-330	Free	**0.58 – 0.92**
Henriksen et al., 2018	29-218 17-267	Free	**0.69-0.50**
Menajovsky et al., 2018	141 ± 13.6	Guided	**0.78 - 0.89**
Henriksen et al., 2019	Mid (15 to 240) Late (240 to 305)	Free	**1.1** **2.9**
Paddick et al., 2019	90.6 ± 9.8	Guided	**0.97**
Schwanke et al, 2019	47.1 ± 15.0	Free	**0.63**
Schwanke et al, 2022	123.9 ± 53.2	Free	**0.54**
Schwanke et al, in prep	218 ± 49	Free	**0.77**

Cows will adjust their PMR intake in response to their intake of robot concentrate

- Adjustment in PMR intake relative to concentrate…
  - Likely varies across DIM
  - May be greater in guided traffic barns
  - Highlights the importance of having accurate DMI predictions

Cows will adjust their PMR intake in response to their intake of robot concentrate AND their needs



T. DeVries - Unpublished data

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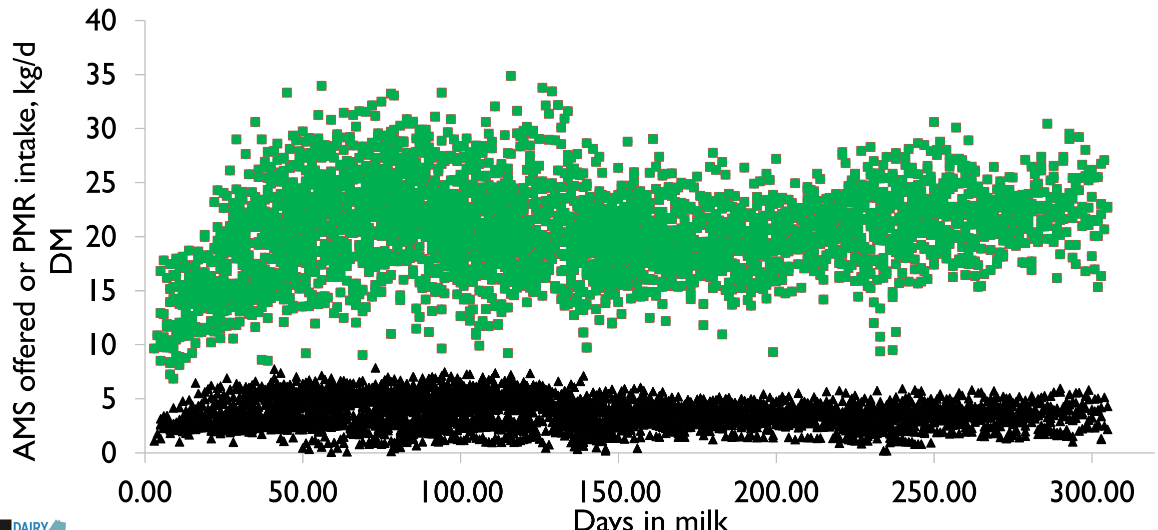
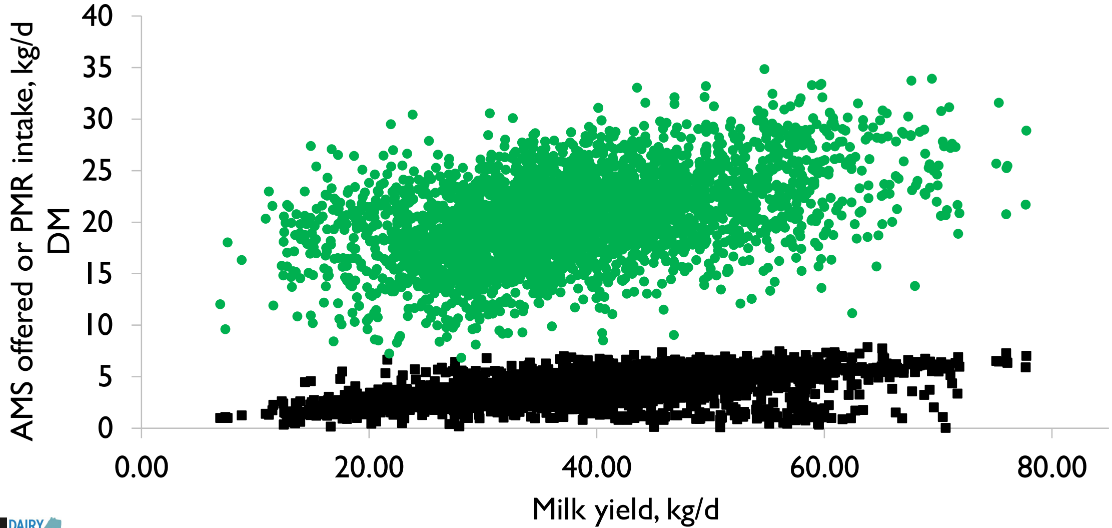


T. DeVries - Unpublished data

At the end of the day…high producing cows require adequate DMI



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What have learned in research related to these opportunities?

- There are many approaches – not one size fits all
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- Cow behavior may dictate milking and feeding success

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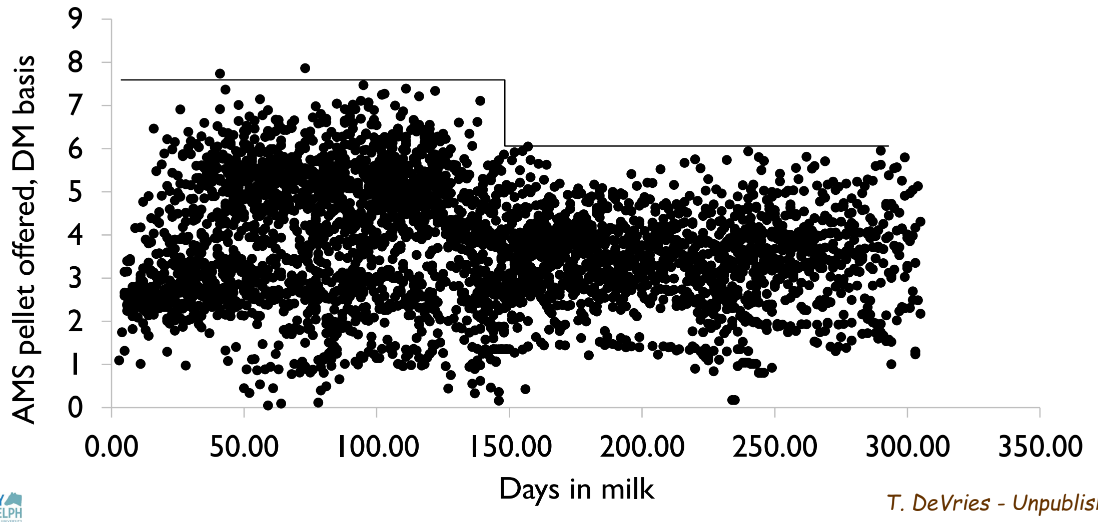
Do cows (consistently) receive the amount of robot feed they are supposed to?



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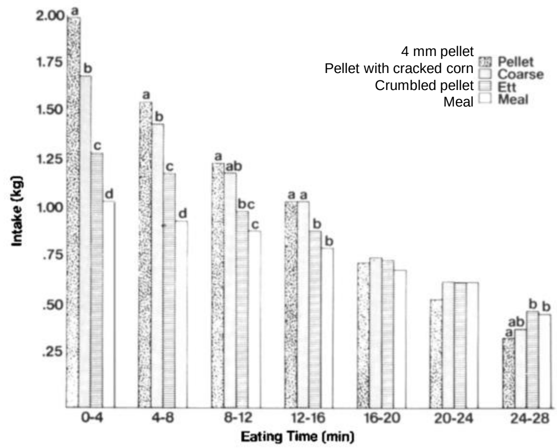
Do cows (consistently) receive the amount of robot feed they are supposed to?

- Milking frequency / time since last milking
- Dispensing rate / box time
  - Eating rate of various feed types
  - Maximum meal size

Cow behavior may dictate how much robot concentrate cows can receive…

- Eating rates vary with feed type
  - ~430 g/min may be near maximal for pellet
- Published **average** rates vary from ~200-300 g/min

(Beauchemin et al. 2002, Maekawa et al. 2002, Sporndly and Asberg, 2006, Harper et al. 2016)



Kertz et al., 1981; JDS

Cow behavior may dictate how much robot concentrate cows can receive…

	Milking duration, min			
	5	7	9	11
Dispensing rate, g/min	Maximum amount offered/milking (kg)			
200	1.00	1.40	1.80	2.20
300	1.50	2.10	2.70	3.30
400	2.00	2.80	3.60	4.40
500	2.50	3.50	4.50	5.50
600	3.00	4.20	5.40	6.60

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Dispensing rate, g/min	Milking duration, min 5	7	9	11
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500	2.50	3.50	4.50	5.50
600	3.00	4.20	5.40	6.60

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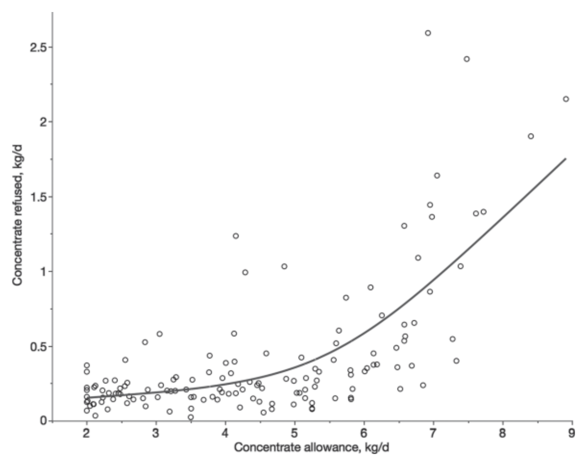
Eating behavior in robot dictates how much 'average' cows can receive…

- The 'average' cow eats concentrate at 250 g/min, in a ~7 min milking, that is about 1.75 kg per milking
- With a target of 3 milkings/day, on average, that is an average of 5.25 kg/cow/d of concentrate



Bach and Cabrera, 2017. J. Dairy Sci. 100:7720-7728

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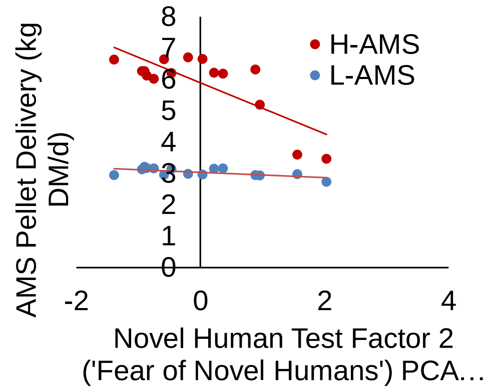
Behavioral individuality ('personality') may affect robot visits and nutritional targets…

- Cows who were more "fearful" were less likely to be delivered the target of 6.0 kg/d (H-AMS); no effect for cows on low allocation (3.0 kg/d: L-AMS)



Schwanke et al. 2022. J. Dairy Sci. 105:6290-6306

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What are the opportunities to 'precision feed' cows in robots?

- Feed tables (of robot concentrate) must be based on stage of lactation and production level
- We have opportunities to supplement cows at times of greater needs

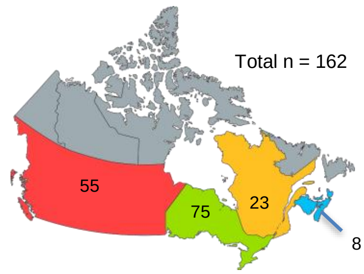
Ketosis has been reported to be more prevalent in robot herds

- Study of 791 dairy herds in Ontario, Canada
  - For multiparous cows, the odds of hyperketolactia (elevated milk BHB) increased by **1.45 fold** on a farm with a robot

Tatone et al. 2017. J. Dairy Sci. 100:1308-1318

Hyperketolactia (milk BHB ≥0.15 mmol/L) in Canadian robot herds

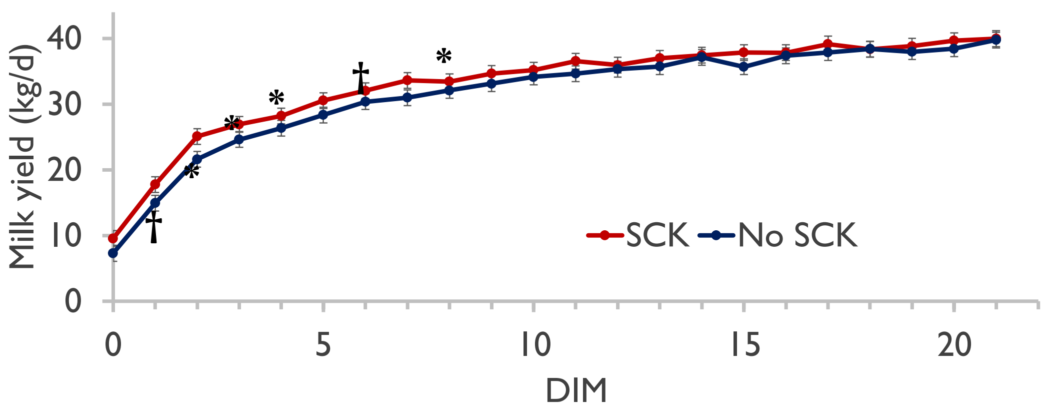
- Mean prevalence: 21.8 ± 10.2%
  - Primiparous cows: 12.2 ± 9.2%
  - Multiparous cows: 26.6 ± 11.3%
- In multiparous cows…
  - Every **1 kg/d increase in** average milk yield in first 45 DIM = **-0.31 percentage point** decrease in hyperketolactia



Van Soest et al. 2024. J. Dairy Sci. in press

Subclinical ketosis in fresh cows in robots

- From 0-7 DIM, SCK cows produced more milk/day

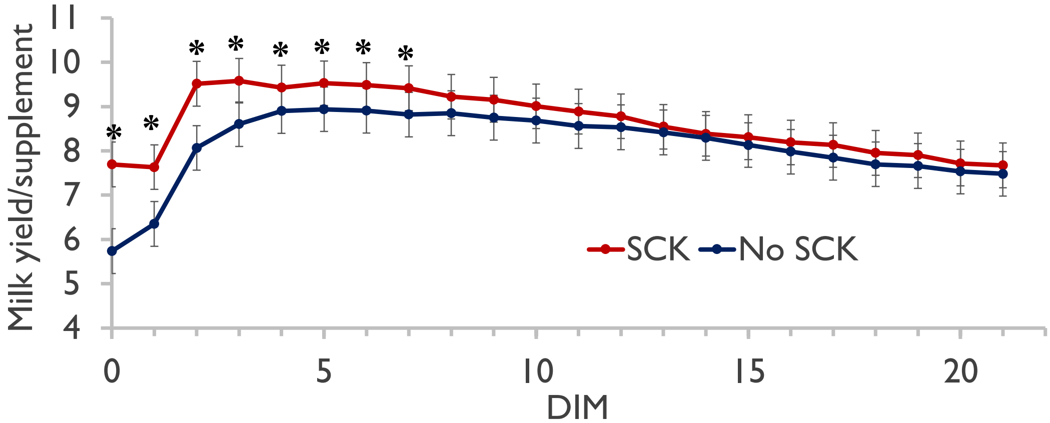


* = *P*<0.05 and † = *P*<0.1

King et al. 2018. J. Dairy Sci. 101:10168-10176

Subclinical ketosis in fresh cows in robots

- SCK cows produced more milk/supplement (0-7 DIM)



King et al. 2018. J. Dairy Sci. 101:10168-10176

What are the opportunities to 'precision feed' cows in robots?

- Feed tables (of robot concentrate) must be based on stage of lactation and production level
- We have opportunities to supplement cows at times of greater needs
  - Increasing energy supplementation in early lactation
    - Sugar (molasses) - *Moore et al. 2020. J. Dairy Sci. 103:10506–10518*
    - Glycerol – *McWilliams et al. J. Dairy Sci. in review*

Take home messages:

- Good nutritional management in robot herds includes…
  - Managing feed so that cows are motivated to go and milk
  - Matching feed tables and PMR to predicted (and actual) DMI
  - Accounting for differences in cow behavior
  - Strategically supplementing cows at times of need

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Thanks to our funders:

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Questions???

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