UF College of Veterinary Medicine
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DAIRY SCIENCE RESEARCH

USING DIGITAL TECHNOLOGY TOOPTIMIZE HEALTH ANDREPRODUCTIVE MANAGEMENT

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Department of Animal Sciences

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Results Beyond Education

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Technology is Only as Useful as What you do with It

+

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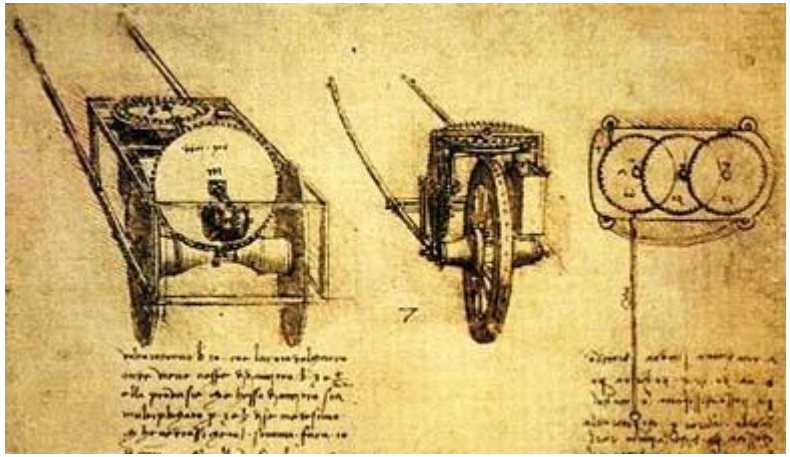
The quest for monitoring: pedometer technology



Leonardo da Vinci (XV century)

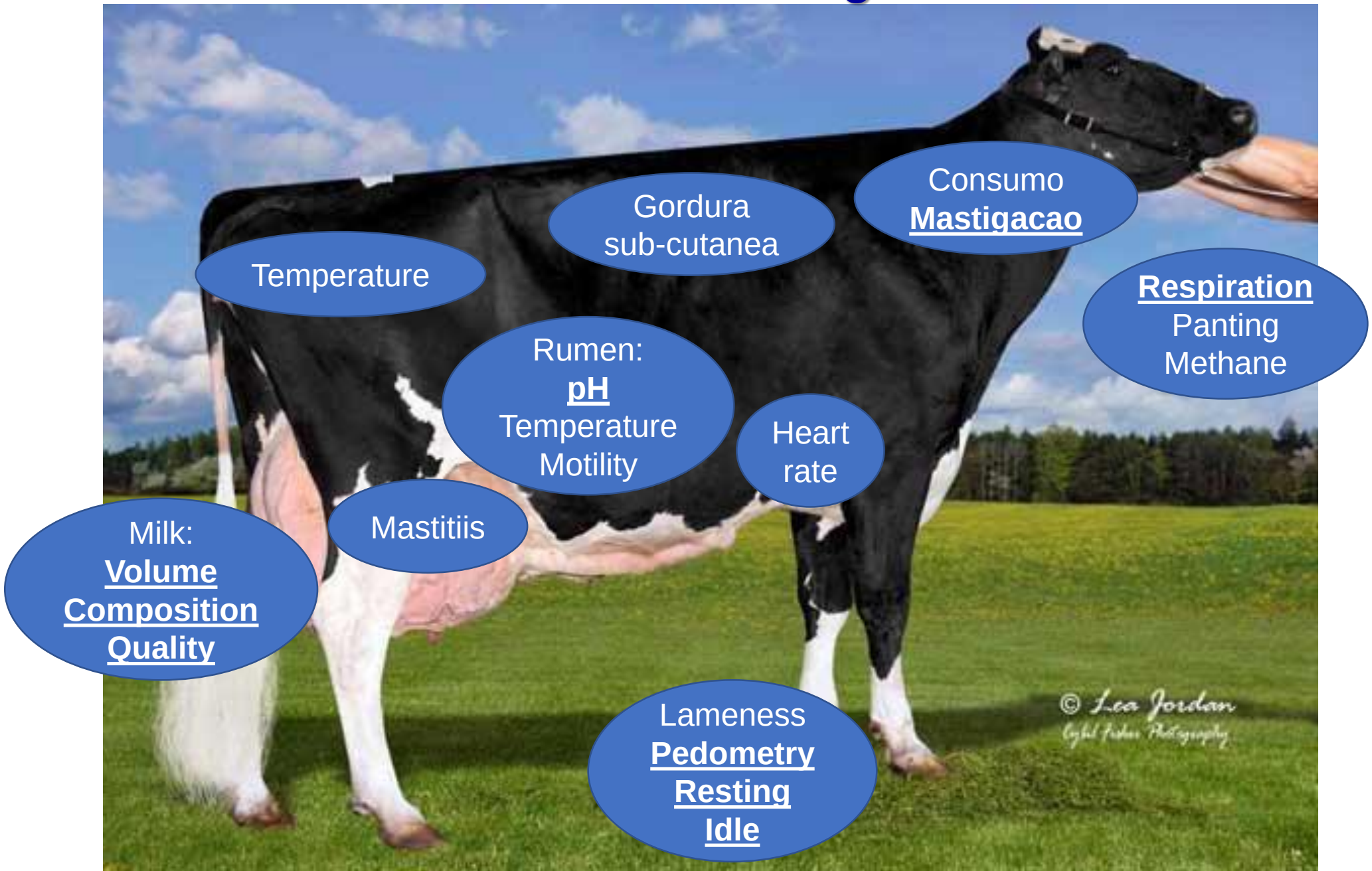
Abraham-Louis Perrelet (1780)

Yoshiro Hatano (1985)

https://us.musewearables.com/blogs/news/fitness-tracking-and-recognition-in-smartwatches

$27.07+tax, Thingle Inc., Walmart

Automated Monitoring of Cows



Automated Monitoring Systems for Livestock

SMARTBOW
I BUSINESS.

Medria ELEVAGE
Monitoring solutions

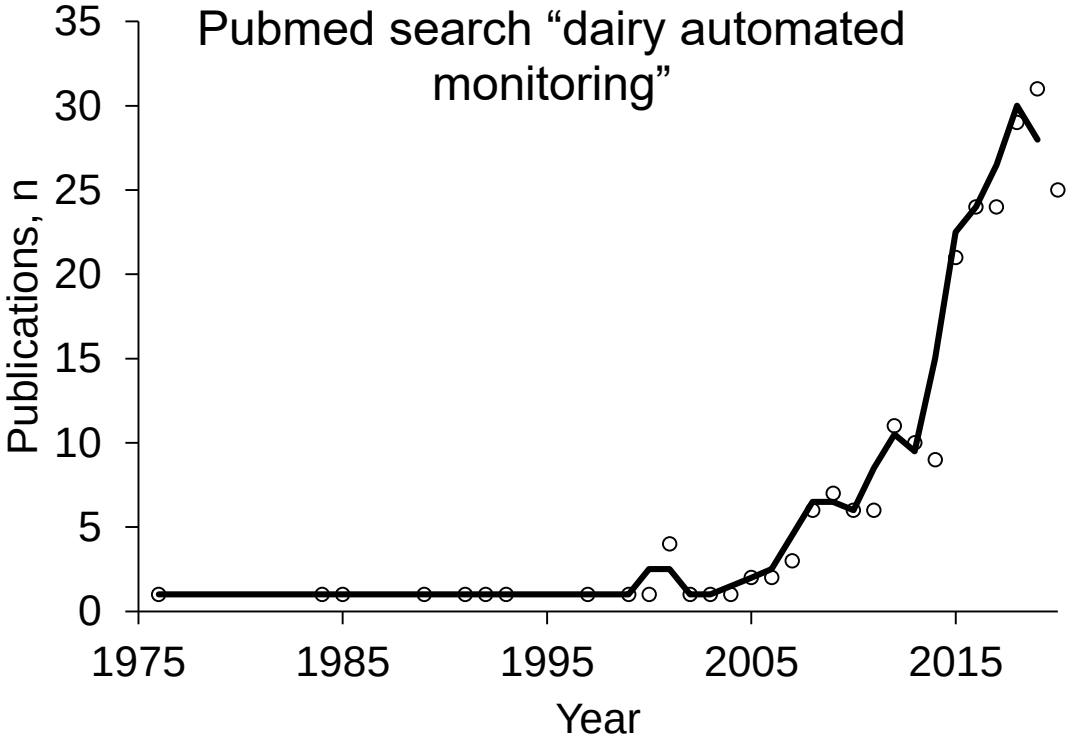
COW MED

SCR
PRECISE DAIRY FARMING

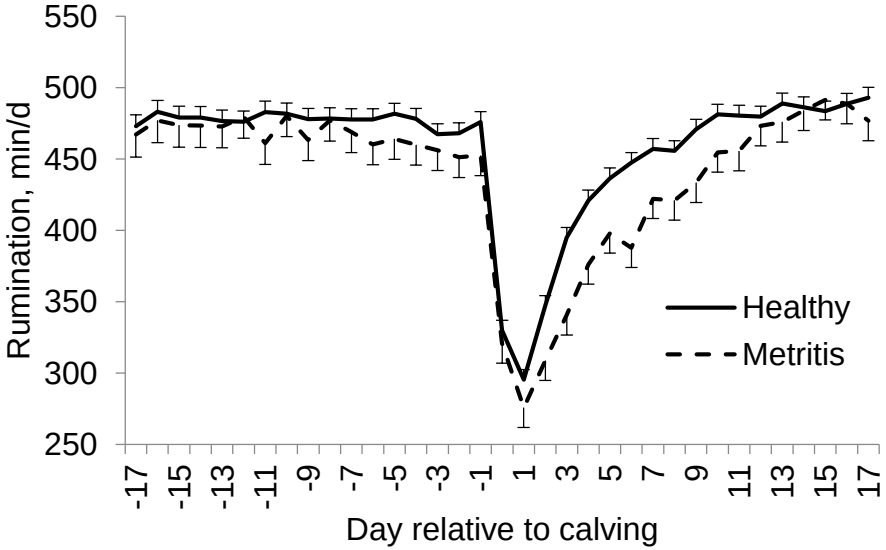
CowManager

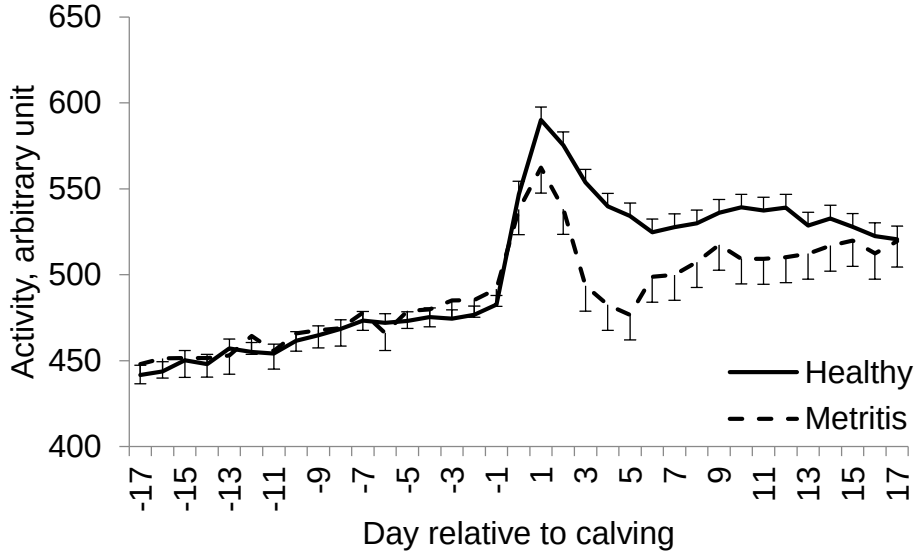
Vetcheq

San'Phone®

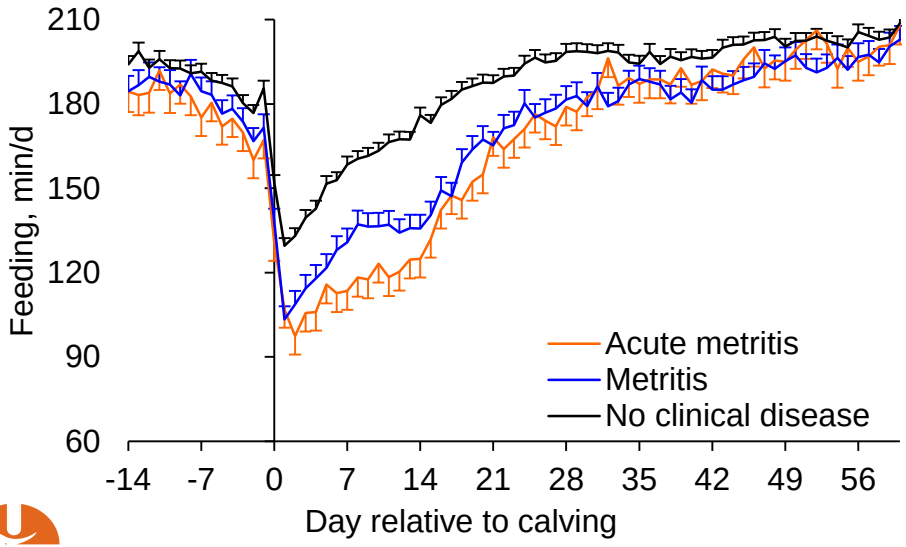


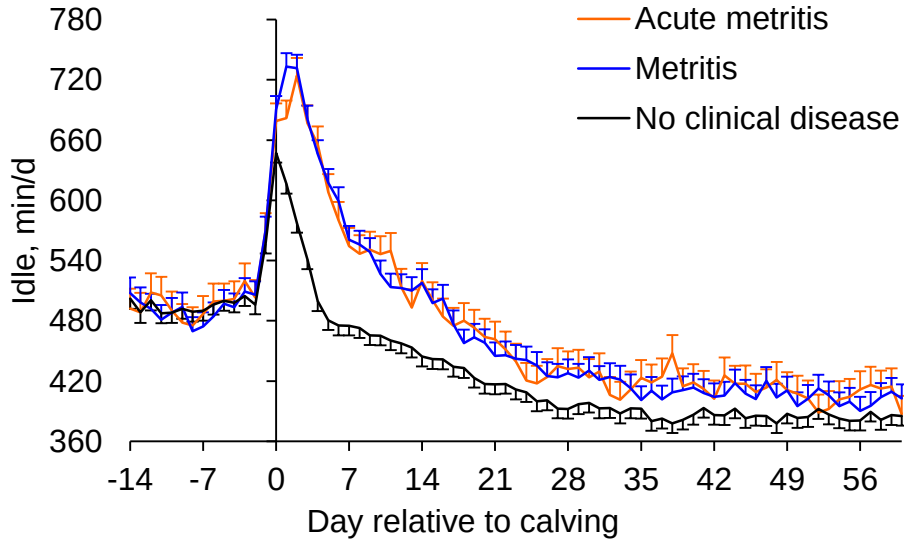
How AMD can assist in health monitoring? Association with Diseases





Liboreiro et al. (2015)



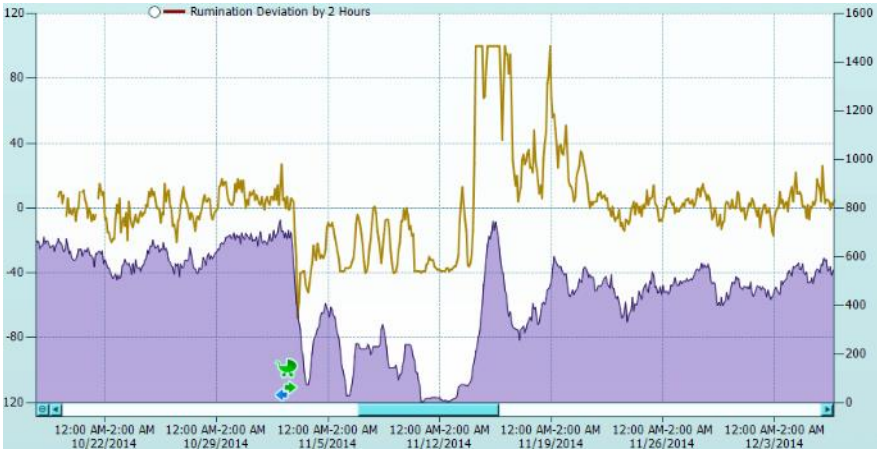


Merenda et al. (2021)

Behaviors associated with calving and health disorders and their diagnostic value

- Evaluation of vaginal temperature, rest time and rumination for the prediction of parturition (Ouellet et al., 2016):
  - Within 24 h: Se = 77%, Sp = 77%
  - Within 12 h: Se = 70%, Sp = 72%
  - Within 6 h: Se = 68%, Sp = 68%
- Evaluation of the use of the health index (based on rumination and activity) and rumination patterns for the diagnosis of postpartum diseases (Stangaferro et al., 2016a,b,c):
  - Metabolic disorders (ketosis, DA): Se ~64.2 at 100%,
  - Infectious diseases (metritis, mastitis): Se ~42.1 to 78%
    Sp ~74.5 to 98%

How can AMD assist in health monitoring?
Early Diagnosis



0.0 a -3.2 d

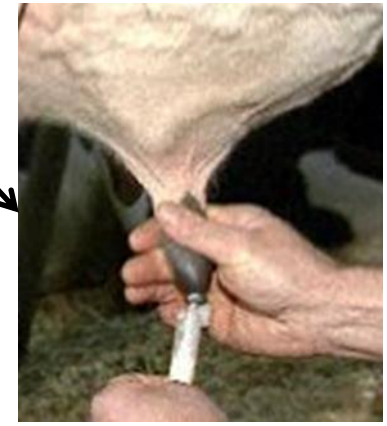
Metabolic & digestive

-0.4 a -1.4 d

Metritis

-0.2 a -1.5 d

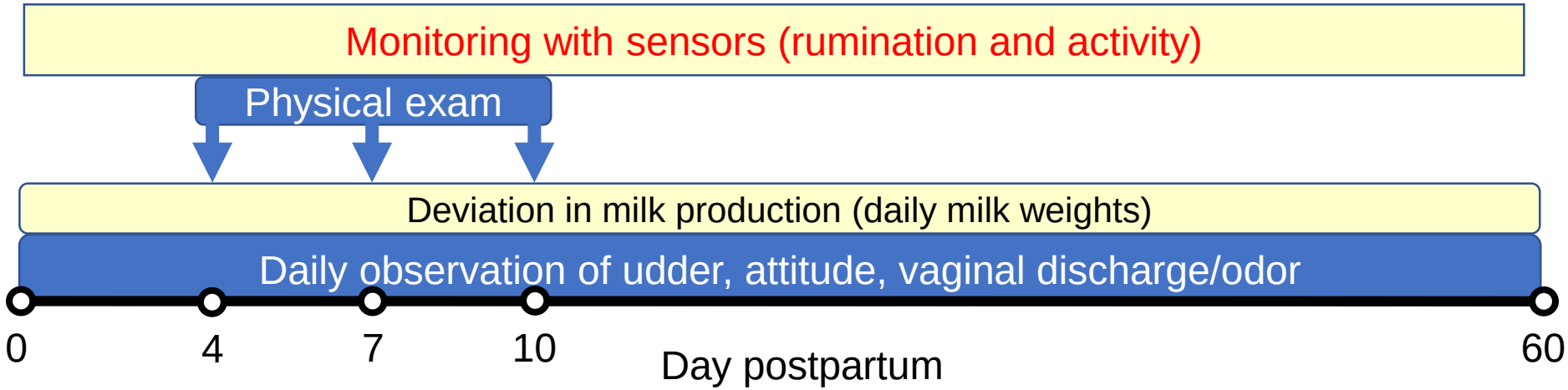
Mastitis



Stangaferro et al. (2016a,b,c)

How can AMD assist in health monitoring?

- Experiment conducted in one FL dairy herd (4,000 cows)
- Cows were fitted with monitoring devices ~60 d before calving (n = 615)
  - “Blind”: Milk production, visual observation, and checking at 4, 7, and 10 DEL
  - “Rumination”: Information about rumination 2x/d + “Blind”



  - No differences between treatments regarding survival and reproductive and productive performances
  - In herds with aggressive monitoring programs, automated monitors may not improve transition performance

Silva et al. (2020)

Incidence of Health Disorders in Cows With and Without Altered Rumination

Variable, %	NO AlterRum n = 275	AlterRum n = 335	*P*-value
Retained placenta	0.7	3.8	0.02
Metritis	18.9	36.4	<0.001
Ketosis	2.1	10.4	<0.001
Hypocalcemia	1.1	2.9	0.12
Displaced abomasum	0	4.4	---
Mastitis	2.5	10.1	<0.001
Other diseases	12.3	28	<0.001
Morbidity	32	61.5	<0.001

Silva et al. (2020)

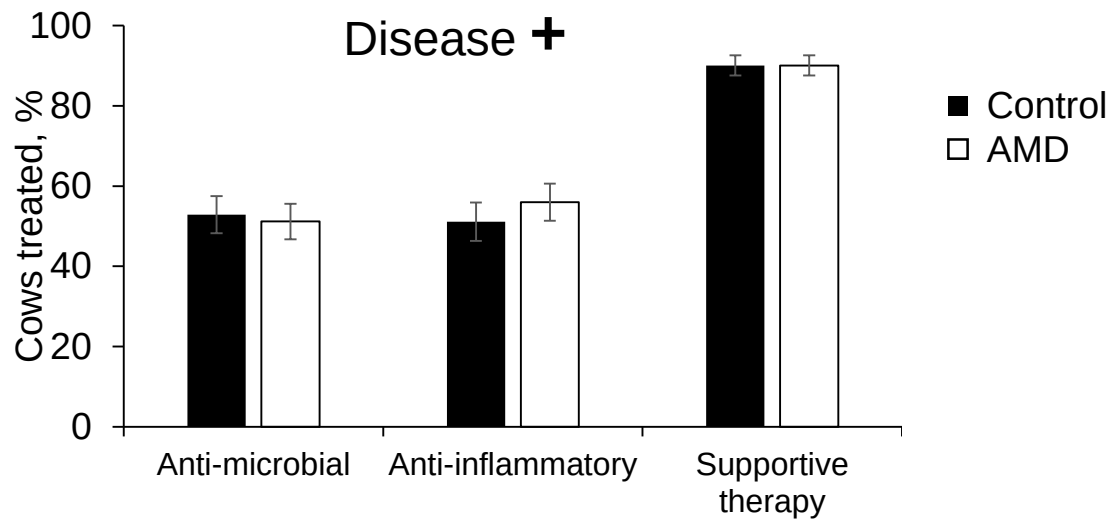
Effects of the Monitoring Strategy on Production, Culling and Pregnancy

Variable	Blind	AMD	*P*-value
Morbidity, %	47	49.1	0.59
Altered rumination, %	53.9	55.9	0.61
Production by 30 DIM, kg/d (±SEM)	36.0 ± 0.5	35.3 ± 0.5	0.31
Production by 80 DIM, kg/d (±SEM)	42.7 ± 0.5	41.8 ± 0.6	0.31
Removal by 60 DIM, %	5.3	6.8	0.45
Removal by 150 DIM, %	10.1	10.9	0.73
Pregnancy 90 d after 1st servicie, %	36.2 (270)	33.8 (251)	0.56

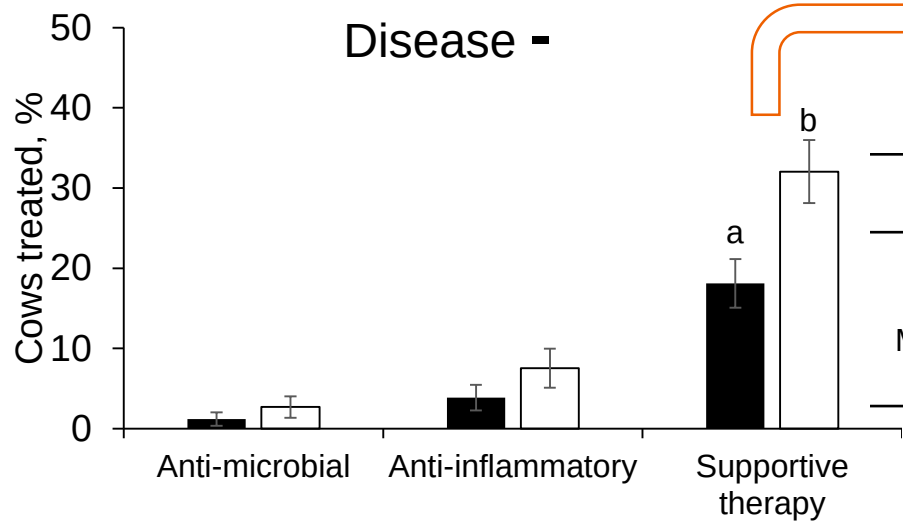
Effect of the Monitoring Strategy on Frequency of Treatments

Variable		Blind	AMD	*P*-value
Support therapy	Treated cows, %	52	61.1	0.02
	Treatments (±SEM)	2.2 ± 1.1	2.0 ± 1.1	0.3
Antimicrobials	Treated cows, %	22.7	25.2	0.46
	Treatments (±SEM)	1.4 ± 0.6	1.4 ± 0.6	0.87
Antiinflammatory	Treated cows, %	23.3	28.3	0.16
	Treatments (±SEM)	2.1 ± 0.8	2.0 ± 0.8	0.6
All treatments	Treated cows, %	53.3	61.4	0.04
	Treatments (±SEM)	3.7 ± 2.4	3.5 ± 2.4	0.6

How can AMD assist in health monitoring?



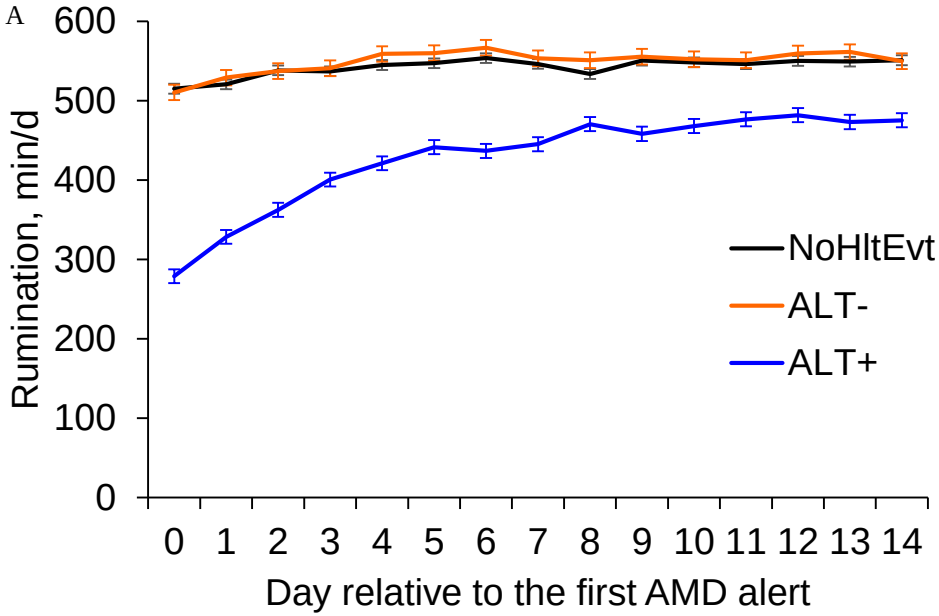
What to do with cows with AMD alert and no clinical disease?

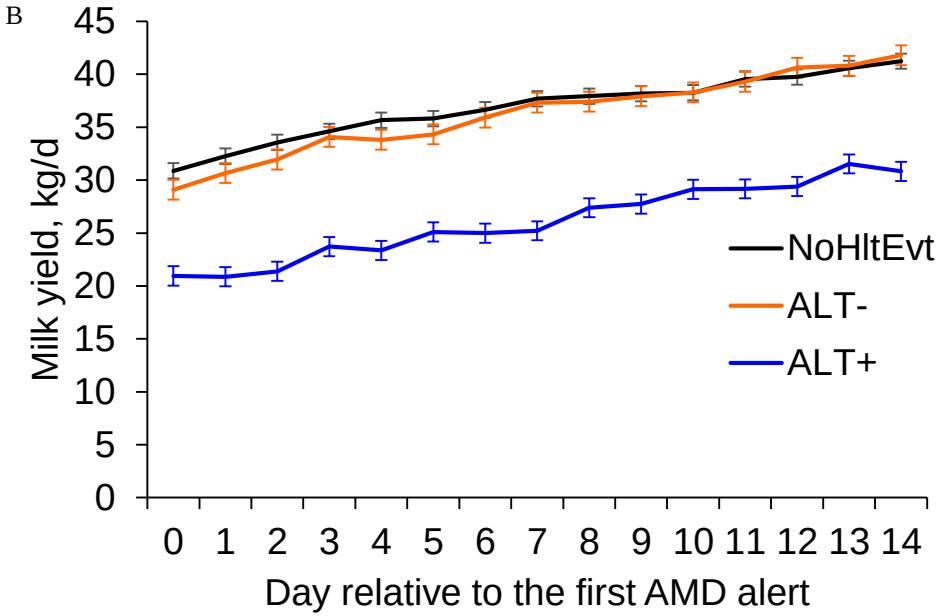


Outcomes	ST	No ST
Rem. 60 DIM, %	4.8 ± 2.7[a]	0.4 ± 0.4[b]
Milk yield (150 DIM), kgx10^3	6.5 ± 0.2[a]	6.8 ± 0.1[b]

Silva et al. (2020)

How can AMD assist in health monitoring? Severity of Disease and Treatment Decision

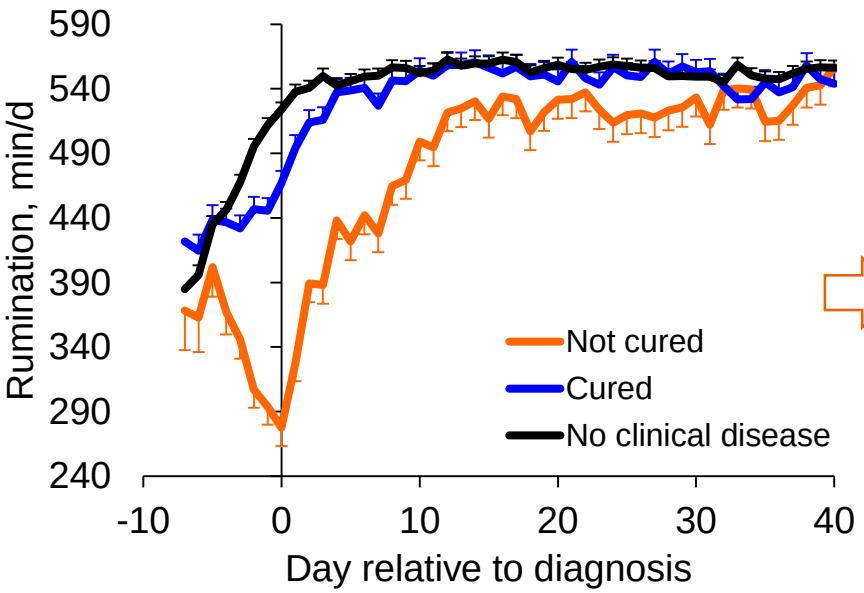




Class	n	Removal within 150 DIM, %	Pregnant to 1st + 2nd AI, %	Milk yield 154 DIM, kg/d
NoHltEvt	316	5.0[a] ± 1.2	48.7[a] ± 2.9	6,666.8[a] ± 103.3
ALT-	135	5.7[a] ± 2.0	49.6[a] ± 4.5	6,663.1[a] ± 162.6
ALT+	159	19.0[b] ± 3.3	33.6[b] ± 3.9	5,266.9[b] ± 148.2

Silva et al. (2020)

How can AMD assist in health monitoring? Monitor/Predict Treatment Success



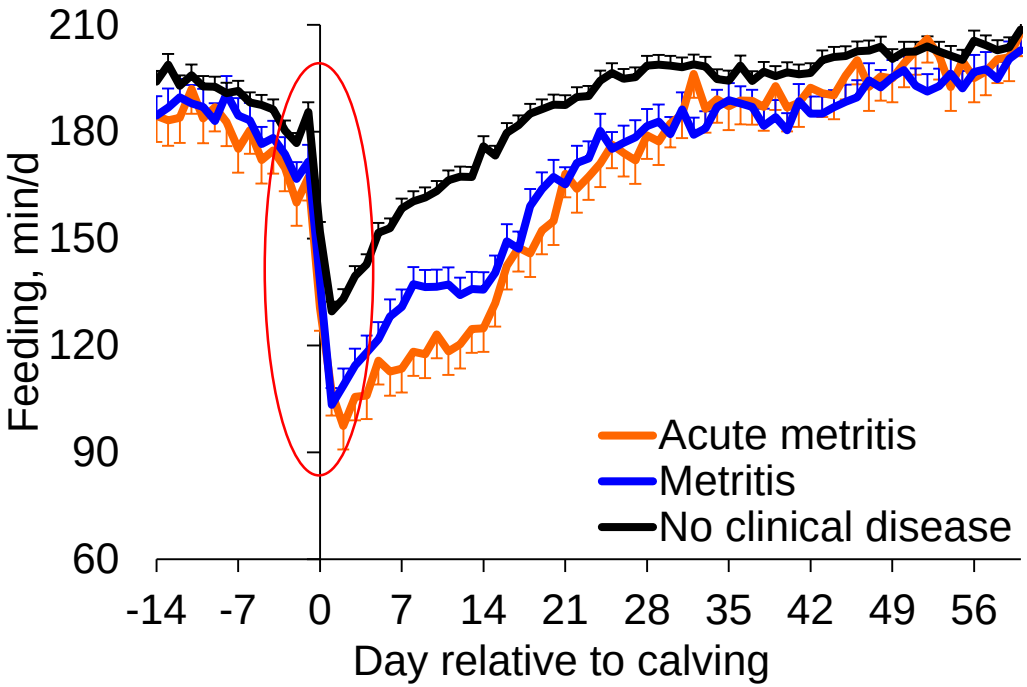
Merenda et al. (2021)

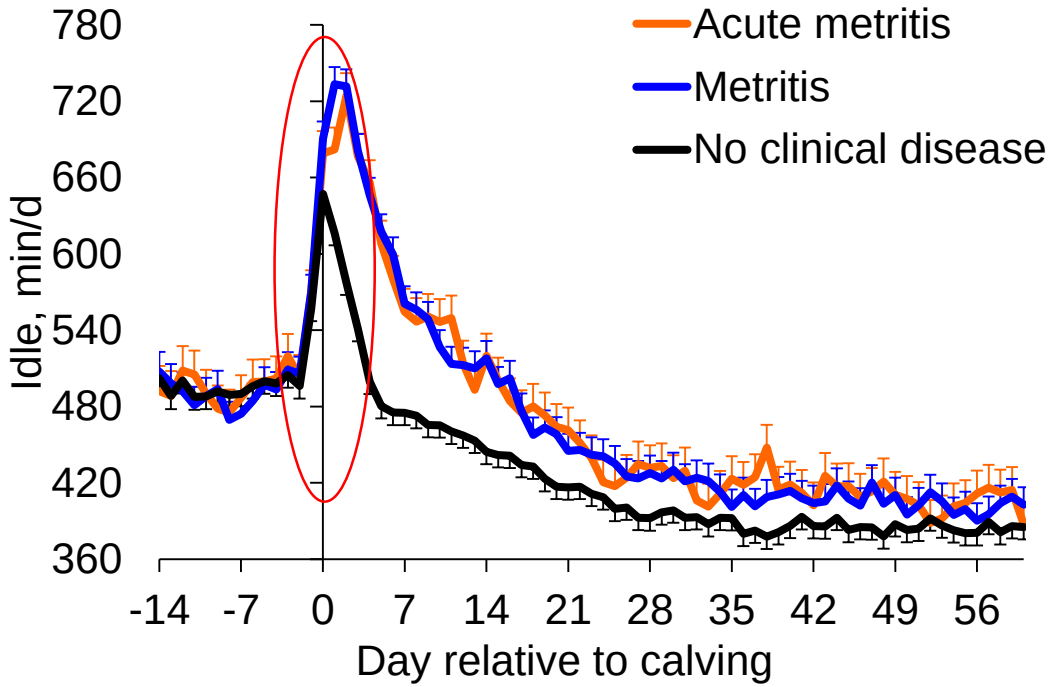
	AUC	Test characteristics, %				
		Se	Sp	PPV	NPV	Acc.
	Clinical cure 11 d after diagnosis					
Training	0.93	83	90	96	68	85
Testing	0.67	47	84	85	46	60

Item, % (n)	Group			*P*-value		
	No metritis	Cured	No Cure	Group	Metritis	Cure
Removal from herd by 60 DIM	2.7[a,A]	4.3[a,B]	10.7[B]	< 0.001	< 0.001	< 0.001
AHR (95% CI) of pregnancy	Ref.	0.80 (0.72, 0.88)	0.63 (0.53,0.74)	< 0.001	< 0.001	< 0.001
Milk yield (mult.), kg ± SEM	42.0 ± 0.22	40.6 ± 0.28	37.7 ± 0.54	< 0.001	< 0.001	< 0.001

Use of Automated Technologies to Predict Health Disorders

- Differences in rumination and activity among cows with metritis, acute metritis, and cows with no clinical diseases:

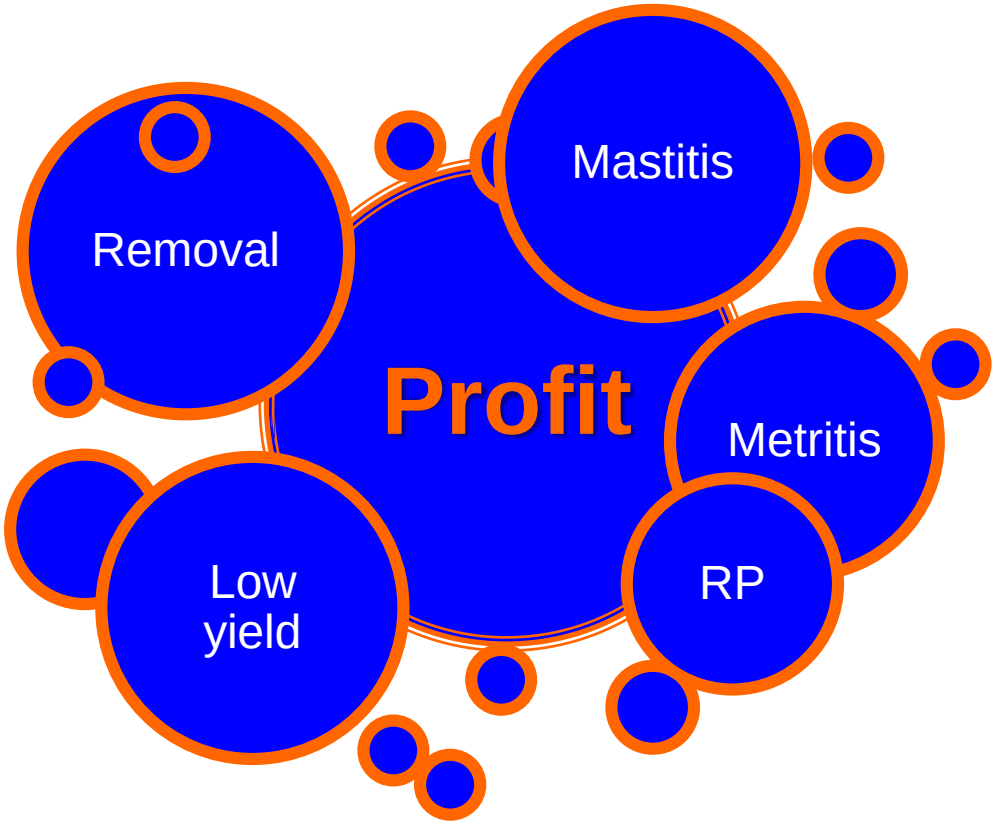




Merenda et al. (2021)

Predicting Health Disorders

- Data from 4 experiments conducted in 4 farms were used
  - No metabolic parameters beyond BCS were used
- Using data from 2 farms (n = 2,821) we created algorithms to predict health disorders and removal within 2 DIM:



Test Characteristics on the "Training" Herd

	Incidence, %	AUC	Se, %	Sp, %	PPV, %	NPV, %	Accuracy, %
Removal							
30 DIM	4.4%	0.96	92.9	97.7	52.0	99.8	97.5
60 DIM	6.1%	0.91	95.7	71.5	12.4	99.7	72.4
Metritis	26.2%	0.72	72.1	62.4	40.3	86.4	64.9

Test Characteristics on the "Testing" Herd

- Same estimates were applied to cows from 2 independent dairies (n = 1,483):

	Incidence,%	AUC	Se, %	Sp, %	PPV, %	NPV, %	Accuracy, %
Removal							
30 DIM	3.1	0.71	70.6	69.0	4.3	99.2	69.0
60 DIM	6.6	0.66	35.0	93.2	15.7	97.5	91.1
Metritis	25.5	0.67	58.2	71.7	42.9	82.5	68.1

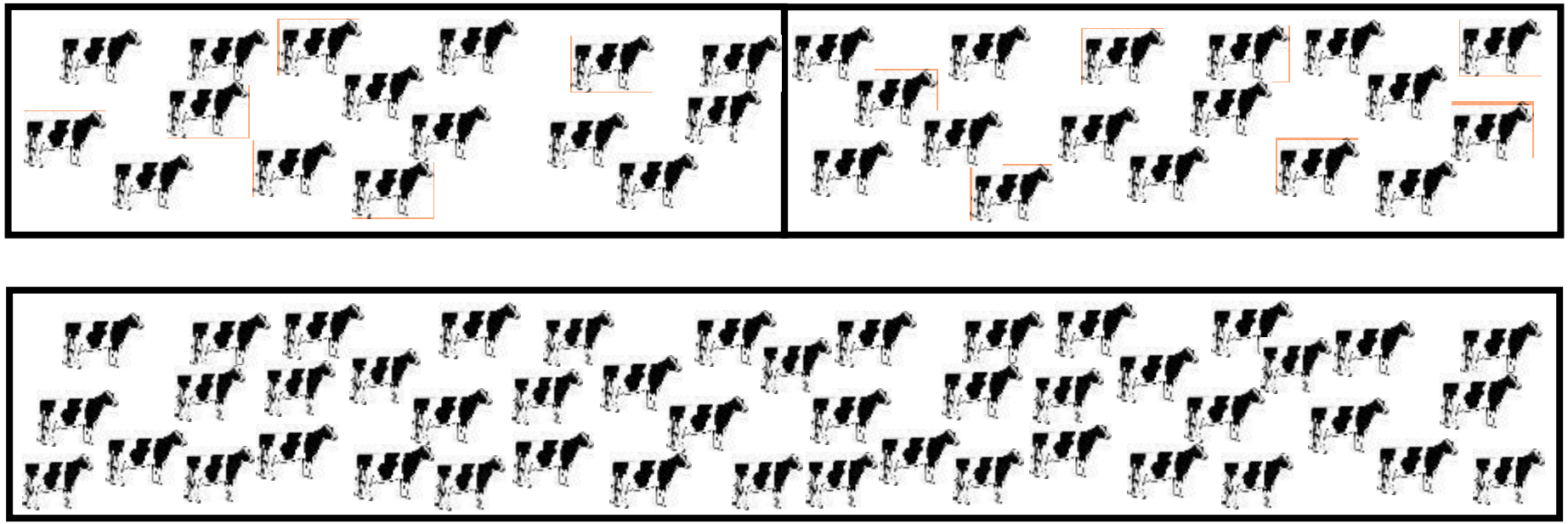
Possible to identify a cow that is unlikely to have the event

- Similar to repro algorithms, health/removal/performance algorithms should use the cow as its own baseline

Ruíz-Munoz et al. (*In preparation*)

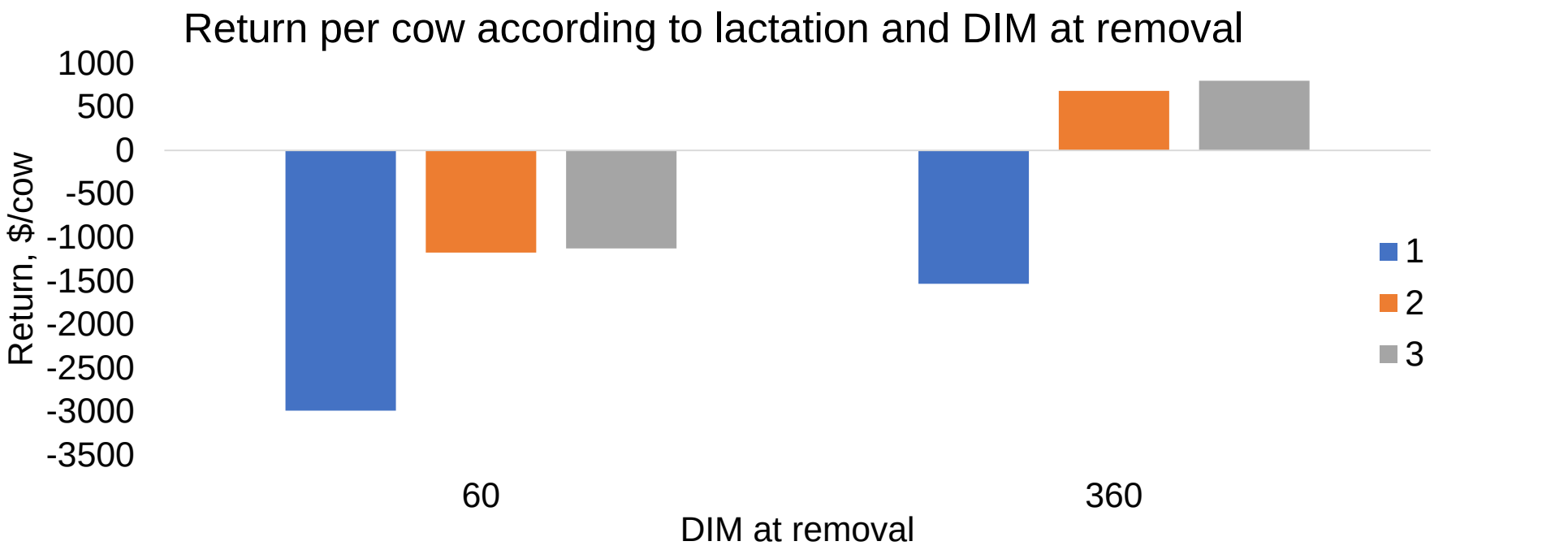
Predicting the Risk of Peripartum Diseases

- Identifying cows unlikely to have a health disorder facilitates the management of postpartum cows and helps us focus on cows at risk for health events



- Predictive models for specific diseases are unlikely to have high accuracy due to variability in definition, recording, etc.
- Predictive models for “removal”, “failure to conceive”, “low production” may be more accurate because the definitions of these events are more consistent

Predicting the Risk of Removal within 60 DIM at Dry-Off



61,880 lactations from 3 FL dairy herds

- Our focus should be on predicting, at dry-off, which cows will not succeed in the subsequent lactation
- This is likely to yield the greatest economic benefit for the producer

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Association of Genotype/Phenotype and Resumption of Estrus Cycles and Estrus Intensity

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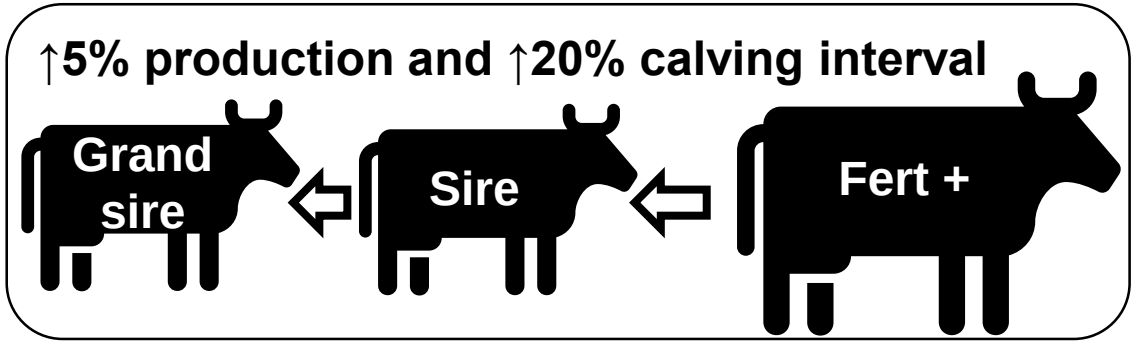
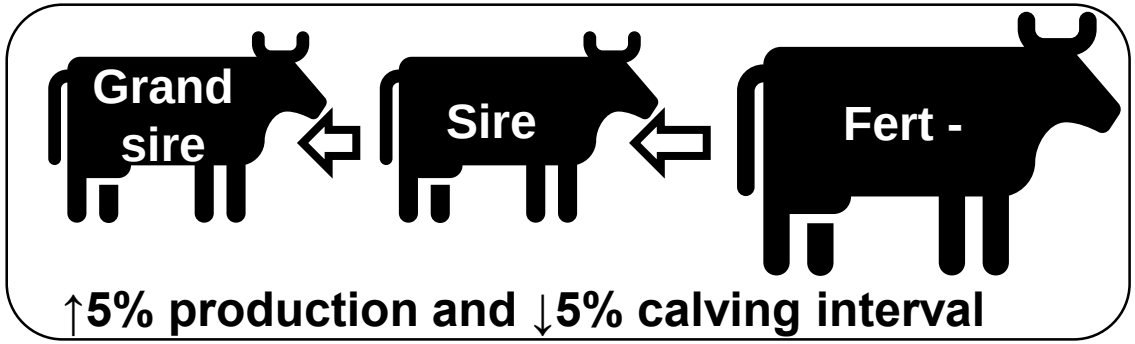
Genetic Merit for Fertility and Phenotype





↑ IGF-1 postpartum

↑ Risk of CL by 3 weeks postpartum

↑ Estrus duration

↑ Ovulatory follicles

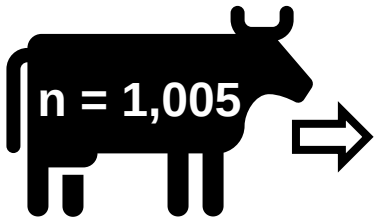
↓ Inter-ovulatory and luteolysis-ovulation intervals

↑ PUFA and ↑ ω-6

(Cummins et al., 2012a; Cummins et al., 2012b; Moore et al., 2017; Rojas Canadas et al., 2020)

Animal and Environmental Factors associated with Estrus Characteristics

- Reproductive traits (i.e. DPR, HCR, CCR)



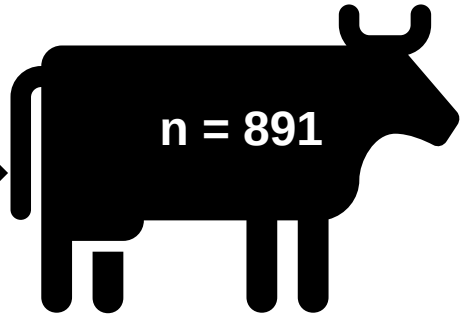
Genomic estimates
(2 mo of age)

Hazard of estrus after $PGF_{2\alpha}$

Estrus duration and intensity

Ovulation, ovulatory follicle, estradiol

88% 1st lact.



IGF-1, glucose, NEFA, BHB

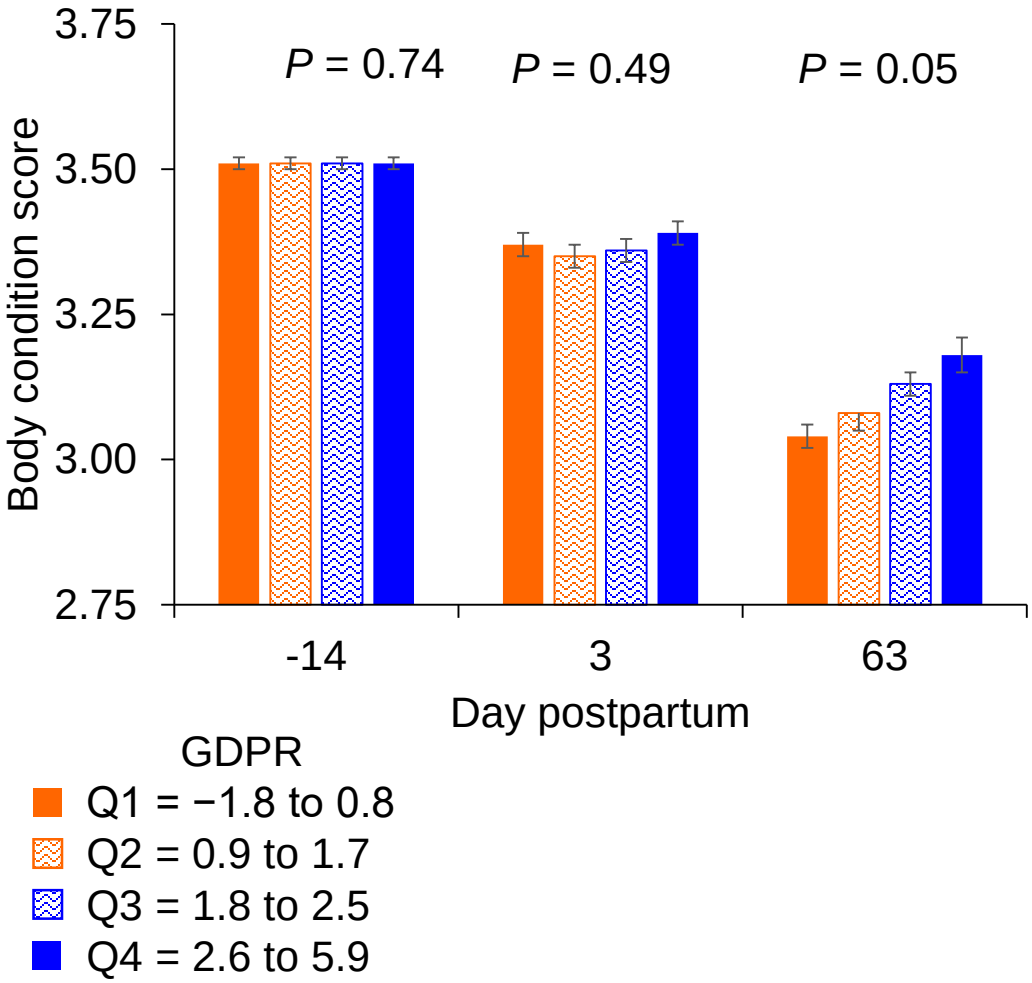
Hazard of estrus by 63 DIM

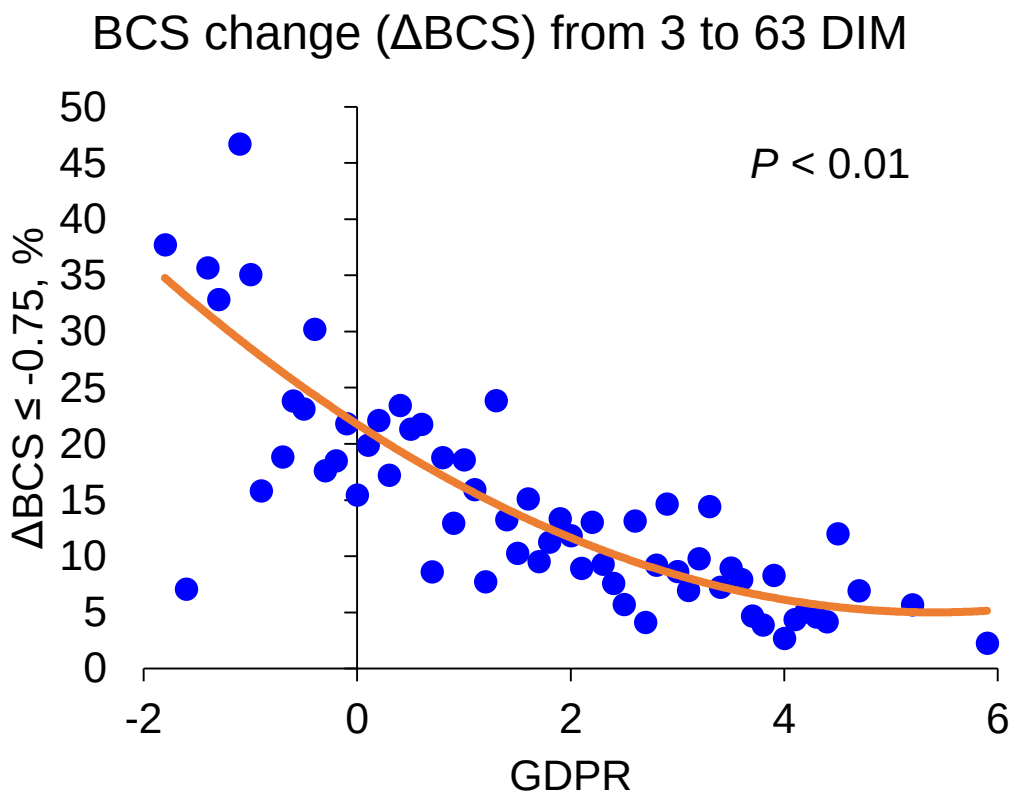
Estrus duration and intensity

Characteristics of **Estrus**

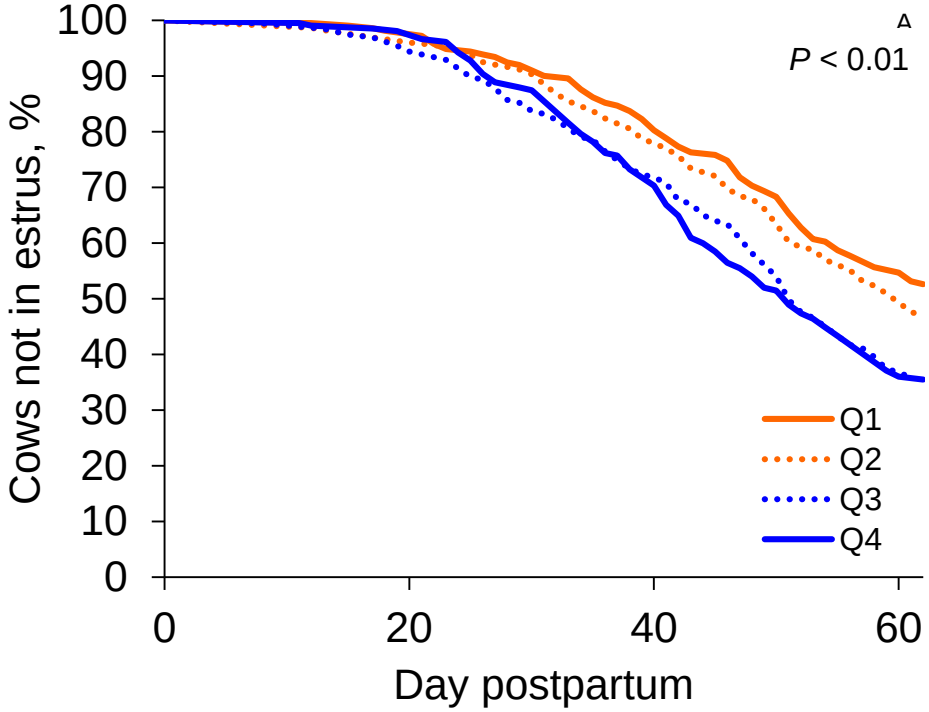
Veronese et al. (2019a,b)
Chebel and Veronese (2020)

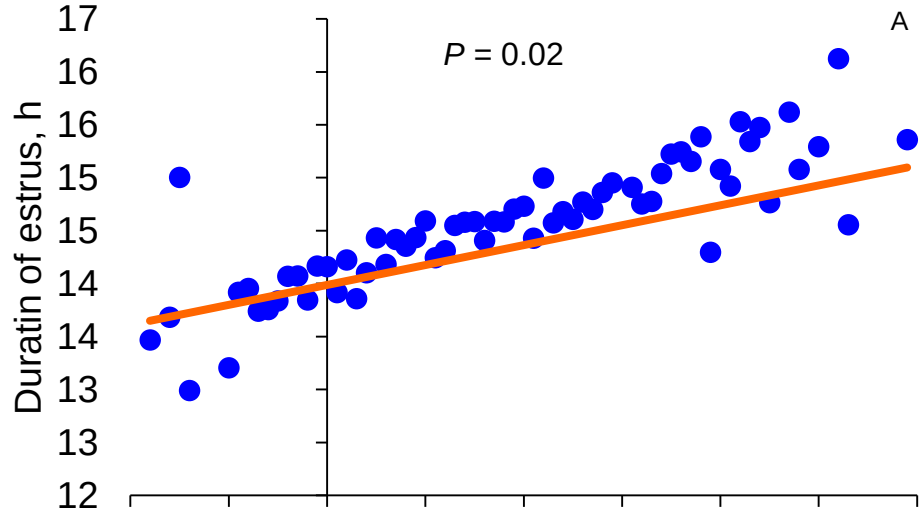
Association between GDPR and Body Condition Score

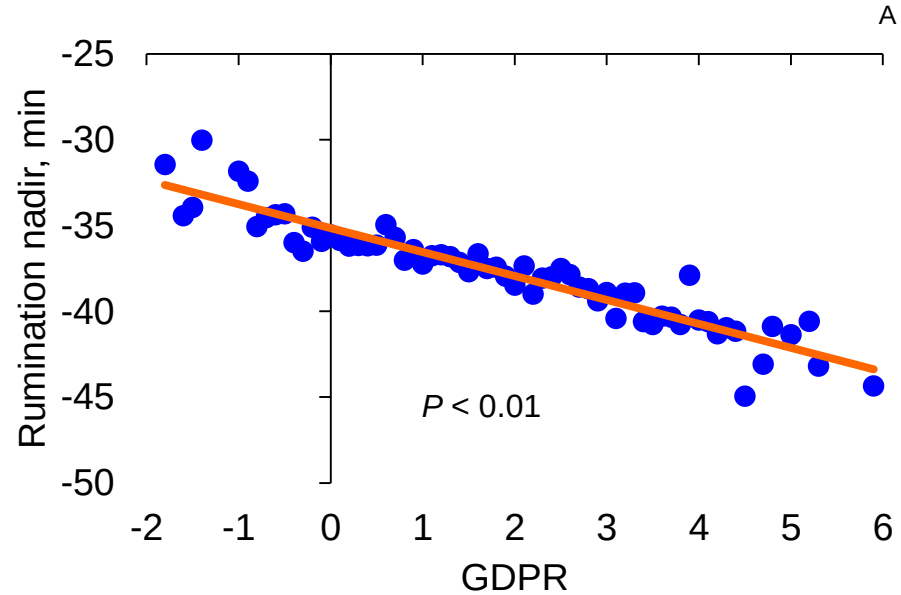




Association between GDPR and Hazard and Intensity of First Estrus (62 DIM)







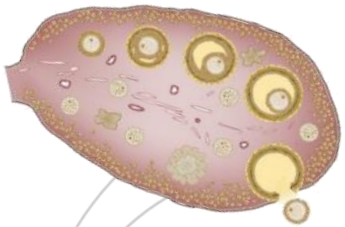
GDPR

- Q1 = −1.8 to 0.8
- Q2 = 0.9 to 1.7
- Q3 = 1.8 to 2.5
- Q4 = 2.6 to 5.9

Greater Estrus Intensity is Observed among Animals with ⬆ Genomic Daughter Pregnancy Rate

⬆ GDPR Heifers

↑Follicle growth



↑E2

⬆Duration
⬇Rumination nadir

Effects on uterus?

↑PSPB

⬆ GDPR Cows

- ⬇BCS change
- ⬆IGF-1 [ ]
- ⬆Glucose [ ]
- ⬇ NEFA [ ]

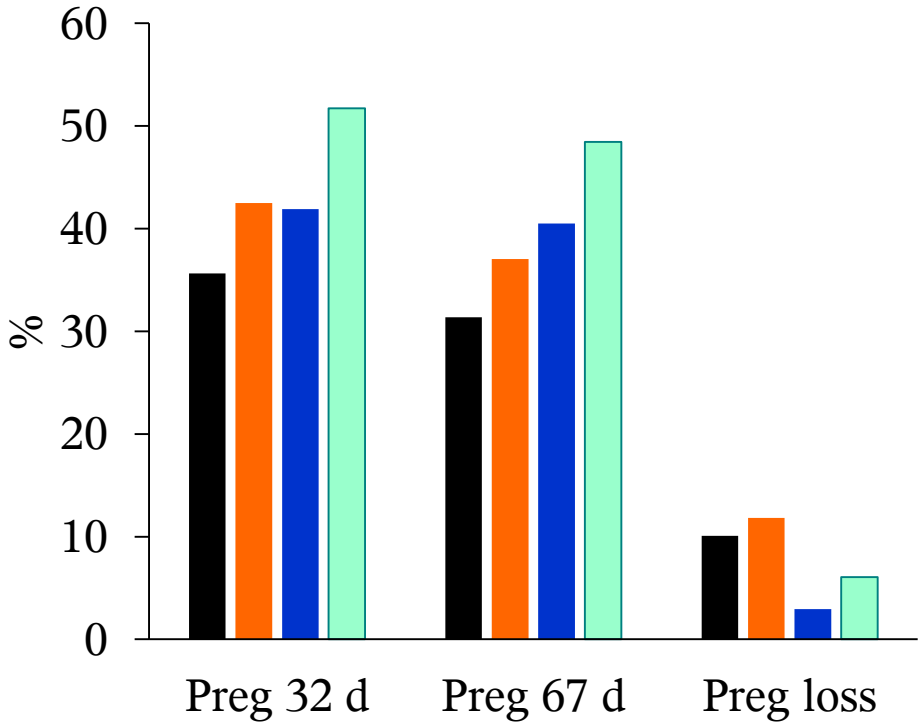
⇨

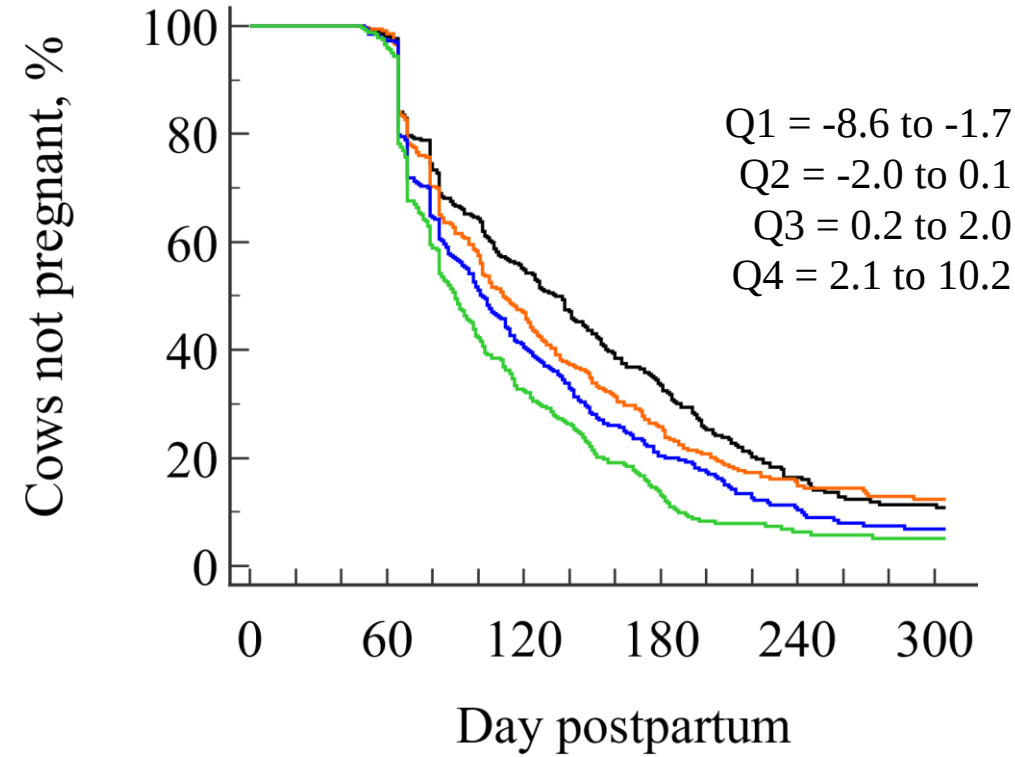
- ⬆ Hazard of estrus
- ⬆ Number of estrus
- ⬆ Duration
- ⬇ Rumination nadir
- ⬆ Activity peak

Veronese et al. (2019a,b)
Chebel and Veronese (2020)

Association between GDPR and Pregnancy

- Cows from two herds (n = 791, n = 548) were genotyped by STgenetics (Navasota, TX) Zoetis Inc. (Parsippany-Troy Hills, NJ)
- Cows classified according to quartiles of GDPR





- Highest GDPR increased pregnancy to first AI and reduced days open by ~40 d

Gonzalez et a., 2023 (JDS 106:5788–5804)

Animal and Environmental Factors associated with Estrus Characteristics

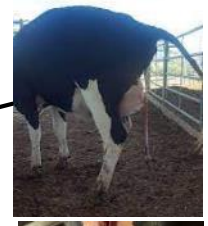
- Data from 4 experiments conducted in 4 dairies in Florida
- Cows (nulliparous = 1,201, parous = 2,438) fitted with automated monitors -21 d relative to calving

Characteristics of **Estrus**

Peripartum Events associated with Postpartum Estrus Characteristics

Reduced hazard of estrus postpartum

→Greater rumination nadir and reduced likelihood of activity peak ≥ 80

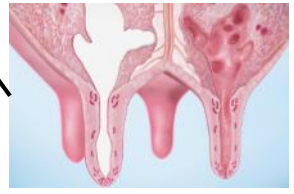


→Reduced likelihood of activity peak ≥ 80

→Reduced duration

Source: Zinpro

→Reduced duration, greater rumination nadir, reduced likelihood of activity peak ≥ 80



Mirzaei et al. (*In preparation*)

Animal and Environmental Factors associated with Estrus Characteristics

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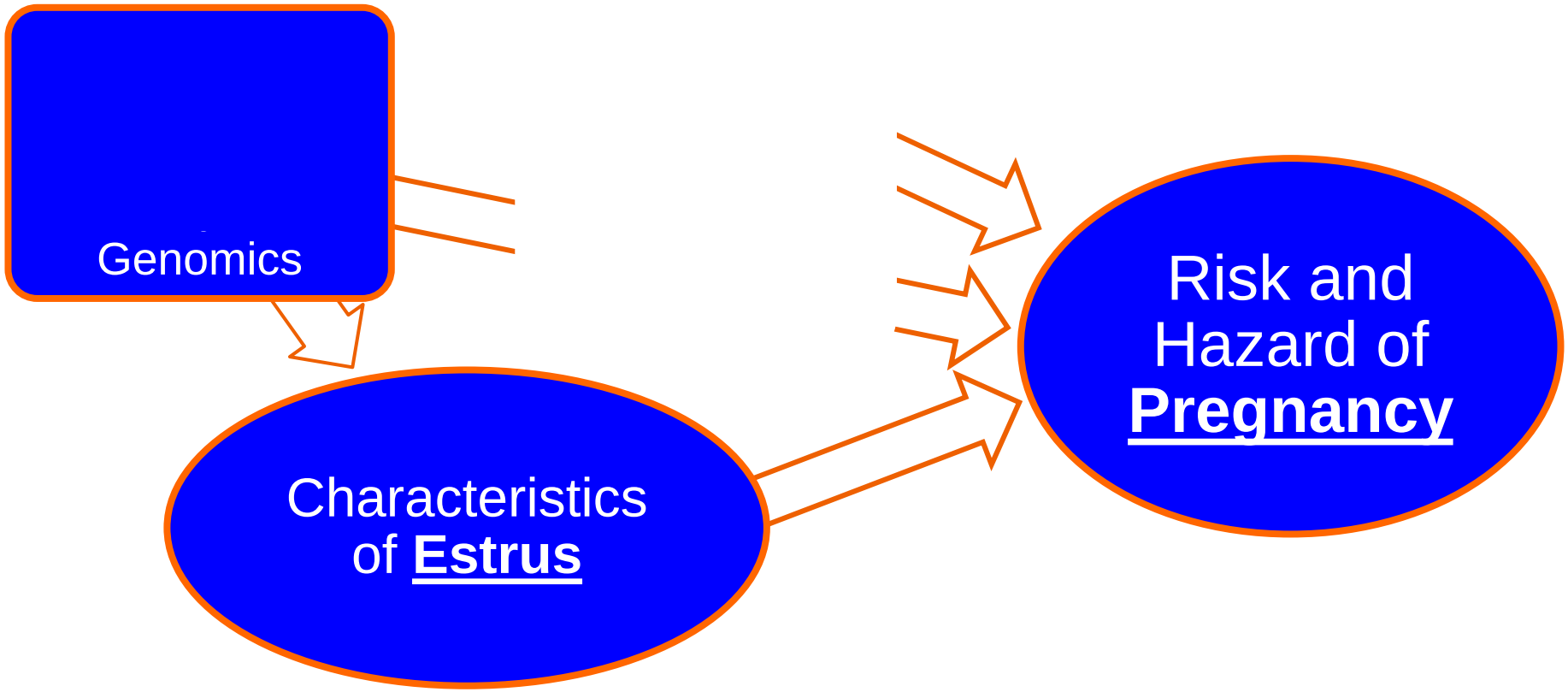
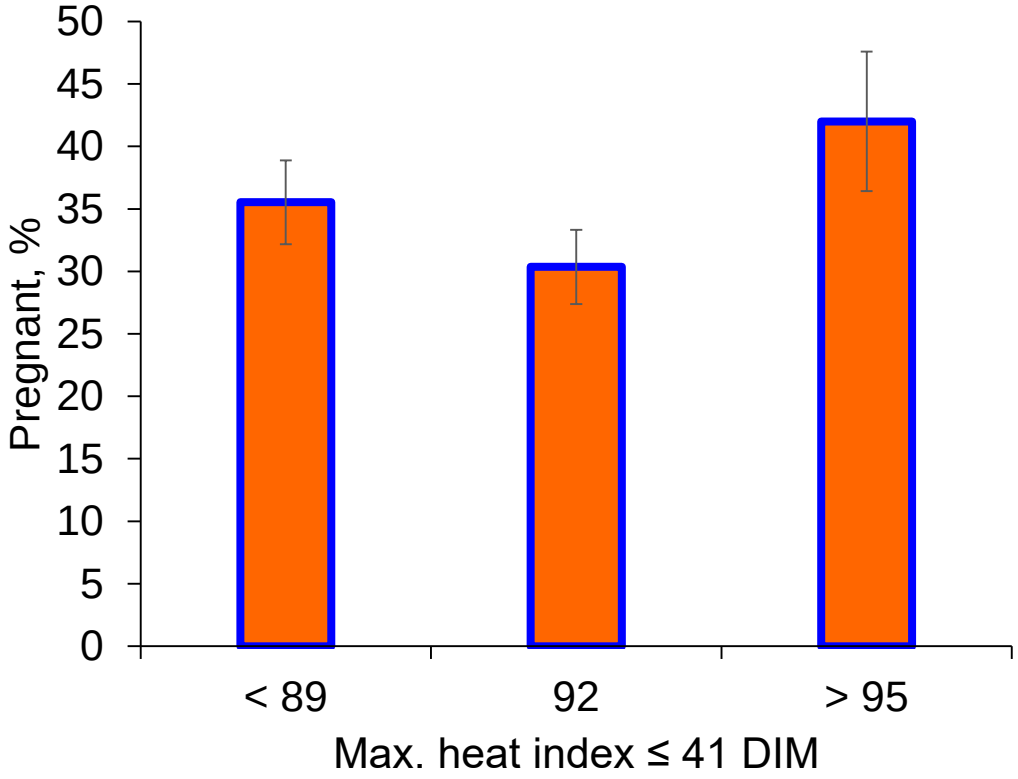
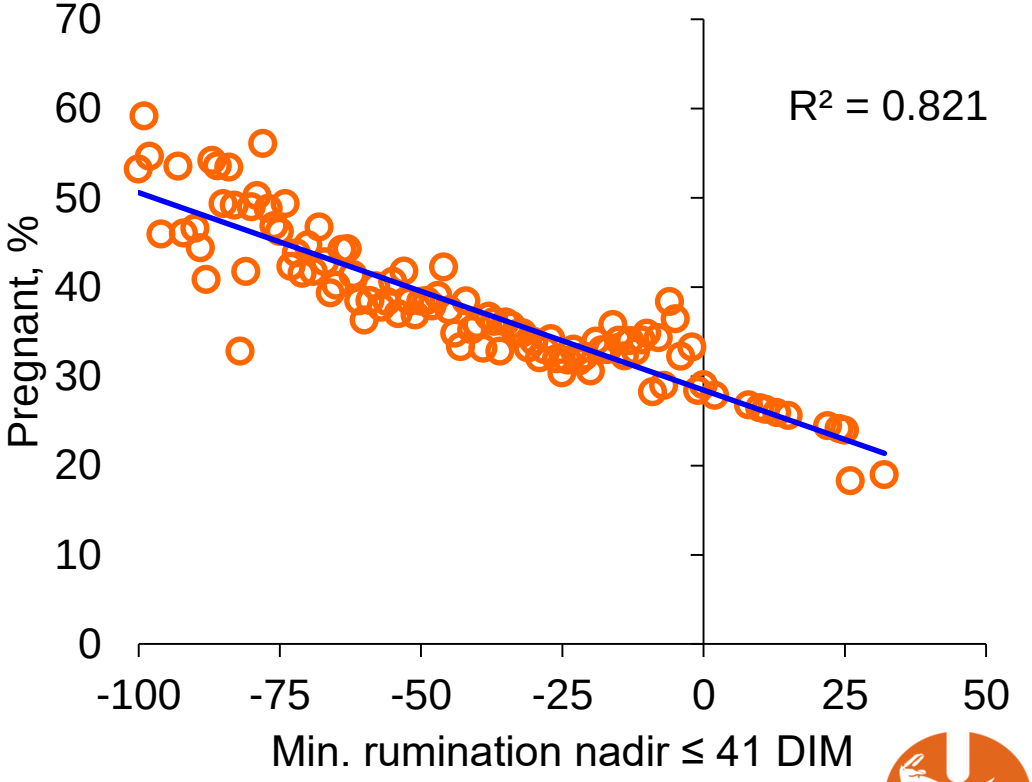
- Cows (nulliparous = 1,201, parous = 2,438) fitted with automated monitors -21 d relative to calving



Association between Estrus Characteristics and the Risk of Pregnancy 66 d after 1st AI

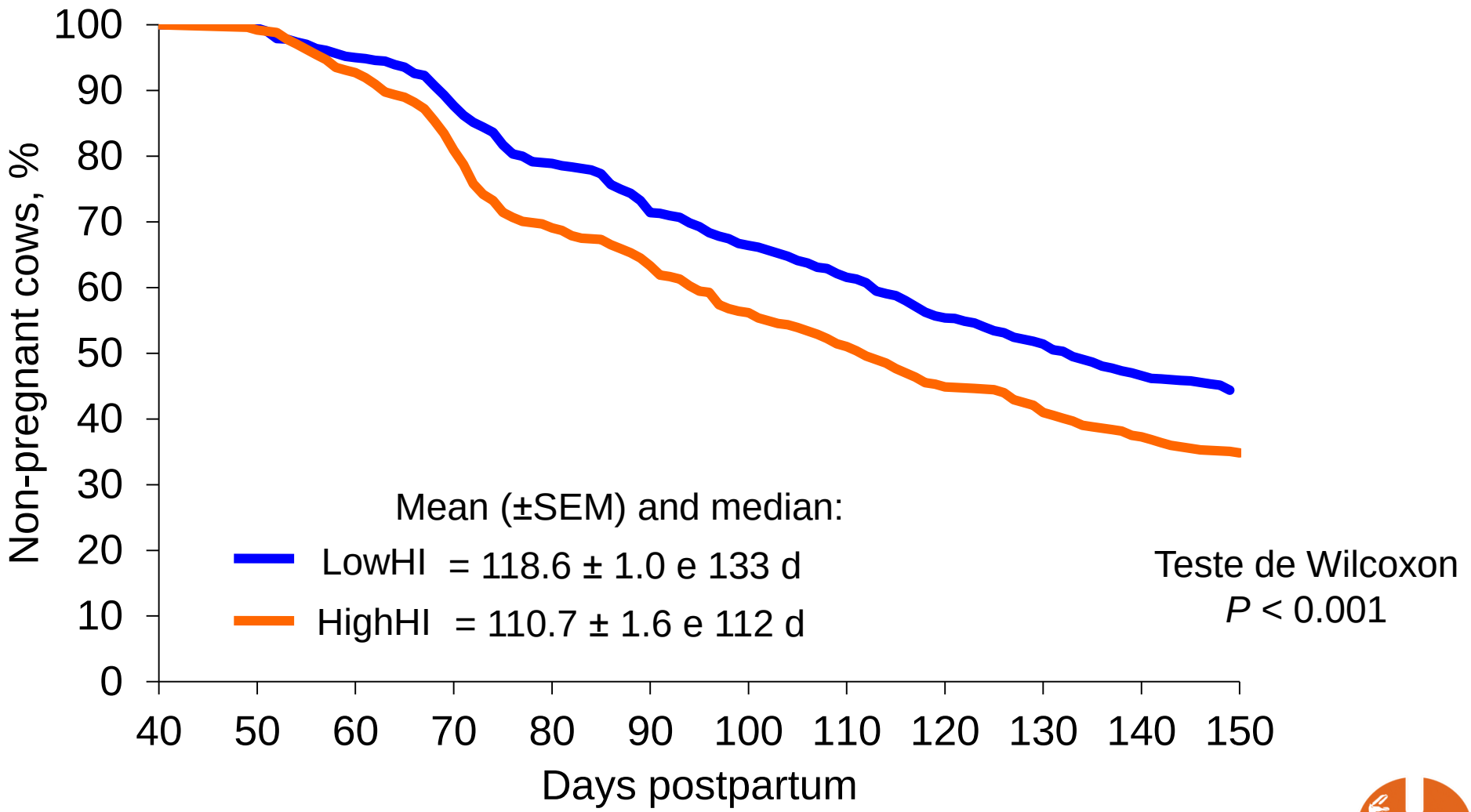
- Service ≥ 45 DIM (69.2 ± 10.9 DIM) = closest estrus -9 d relative to service (avg = -41.5 ± 23.6 d)





Mirzaei et al. (*In preparation*)

Association between Maximum Heat Index by 41 DIM and Pregnancy Rate



Mirzaei et al. (*In preparation*)

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DAIRY SCIENCE RESEARCH

Targeted reproductive management for lactating Holstein cows: Reducing the reliance on exogenous reproductive hormones

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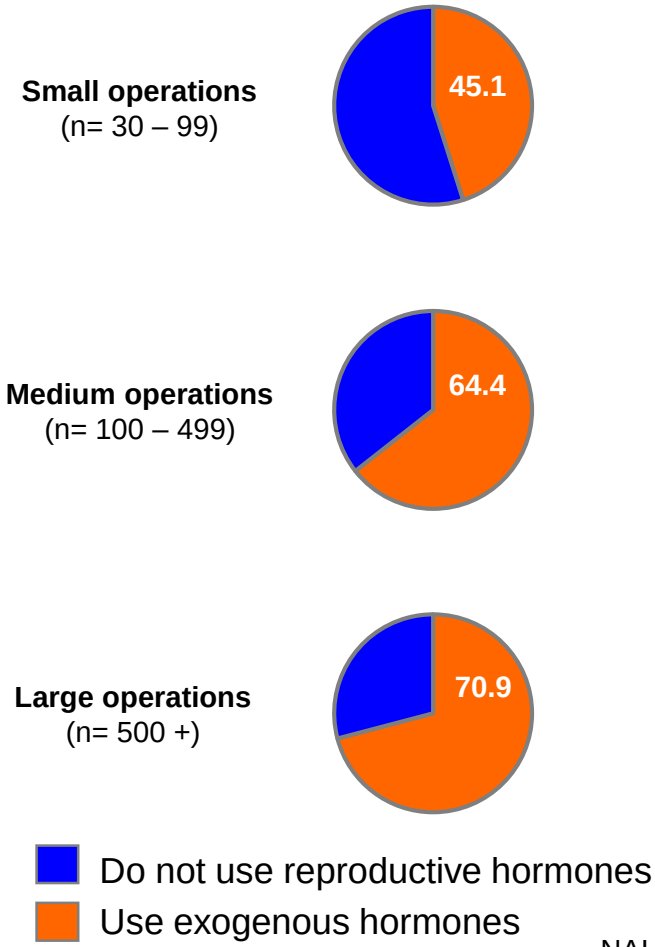
Traditional Reproductive Management

1st AI → 100% TAI (7 handlings) → 30 to 60% re-AI in estrus → 40 to 70% TAI 2nd AI

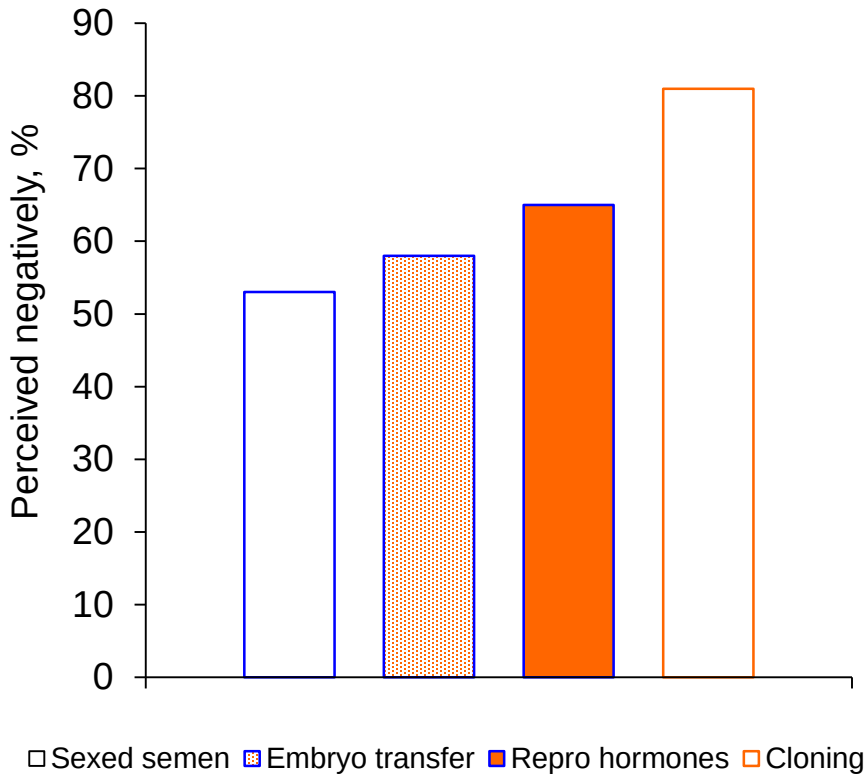
45%+ P/AI

35%+ P/AI

Use of Reproductive Hormones and Public Perception



NAHMS (2014)



Pieper et al. (2016)

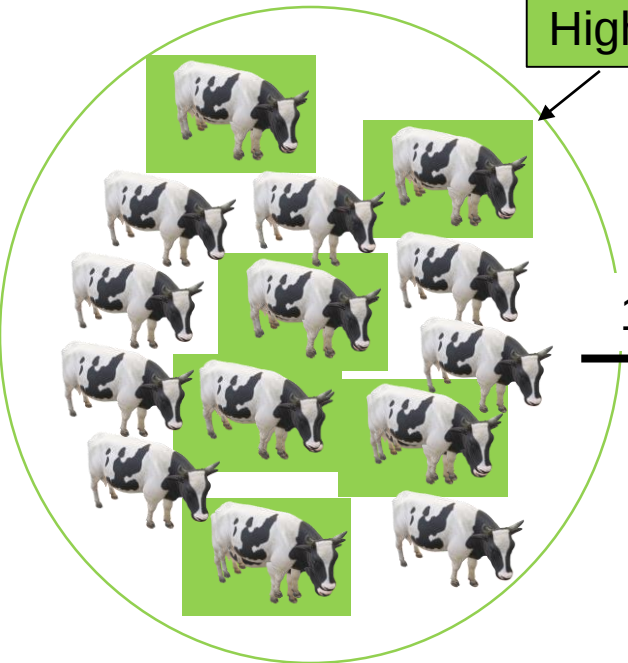
Selective Reproductive Management

1st AI → 100% TAI (7 handlings) → 30 to 60% re-AI in estrus → 40 to 70% TAI 2nd AI

45%+ P/AI

35%+ P/AI

Resumed cyclicity
High intensity estrus



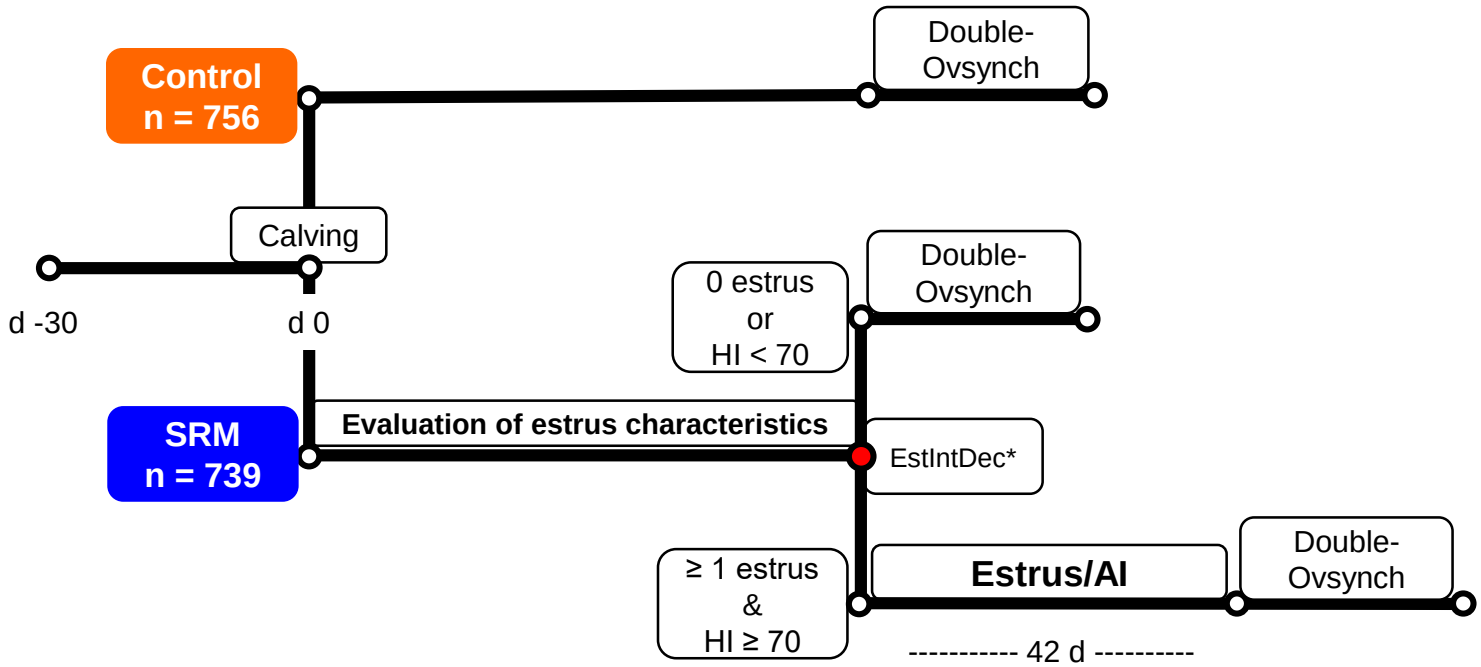
1st AI → TAI as needed
AI in estrus when possible → >60% re-AI in estrus → <50% TAI 2nd AI

Selective Reproductive Management

Herd characteristics before the start of the experiment

Variables	Farm A	Farm B
Average number of lactating cows	3,008	5,571
Breed	Holstein	Holstein
Housing type	Naturally-ventilated, freestall barn	Tunnel-ventilated, freestall barn
Rolling herd average 305-d milk yield, lb	26,864	28,519
Pregnancy to first AI, %	49 (P) & 51 (M)	35

Experimental Design
(1st Insemination)



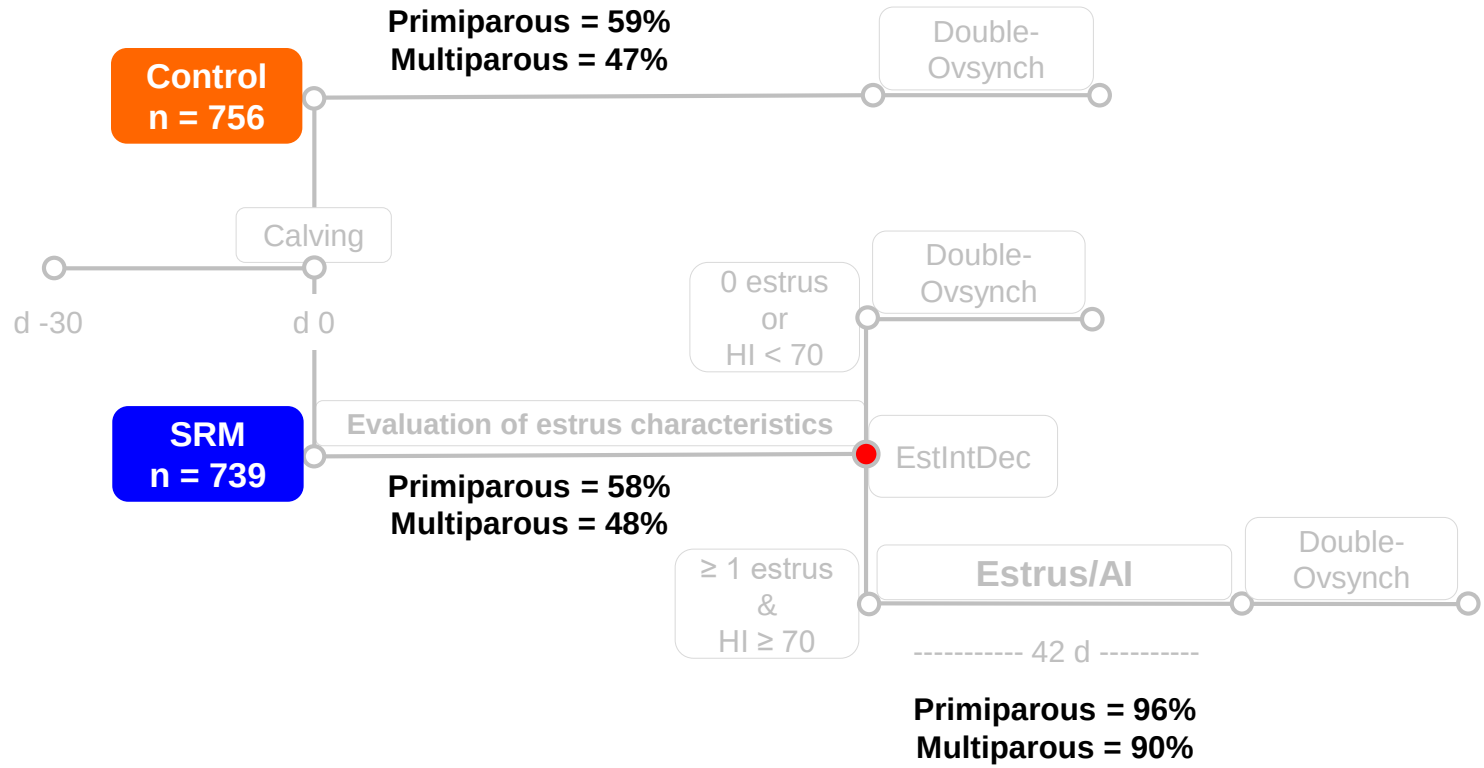
*EstIntDec

Estrus intensity decision, DIM	Primiparous	Multiparous
Farm A	54	40
Farm B	55	41

Control DIM at fixed time AI	Primiparous	Multiparous
Farm A	79	65
Farm B	83	69

Gonzalez et al., 2023 (JDS 106:5788–5804)

Risk of Cows Having High Intensity Estrus Postpartum



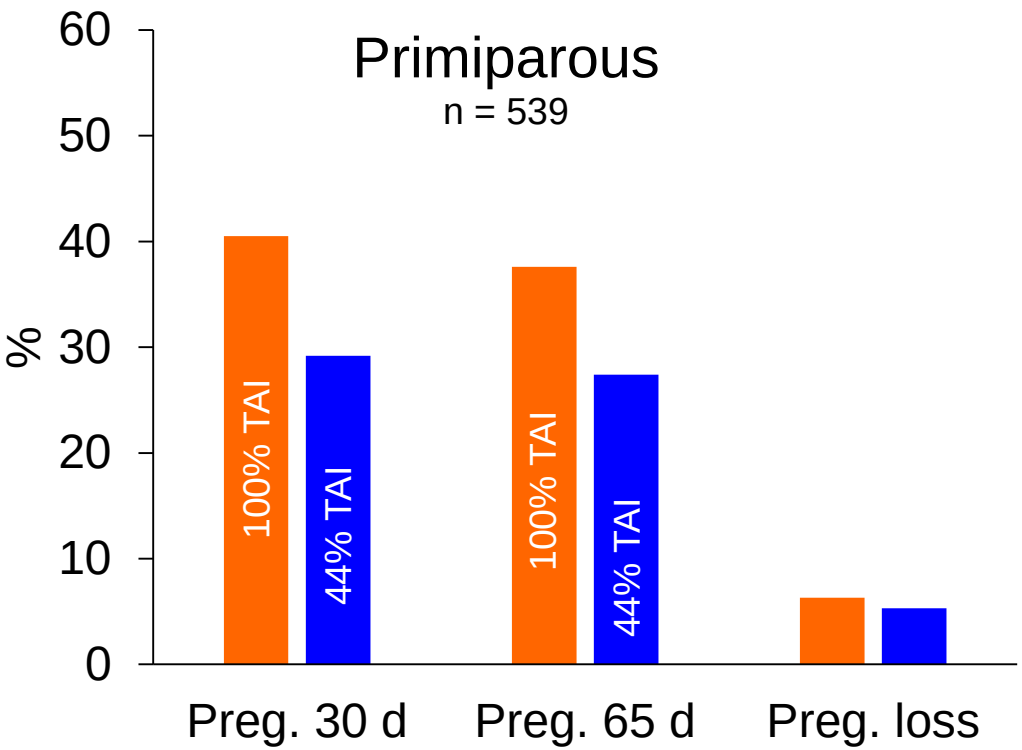
DIM at 1st A:

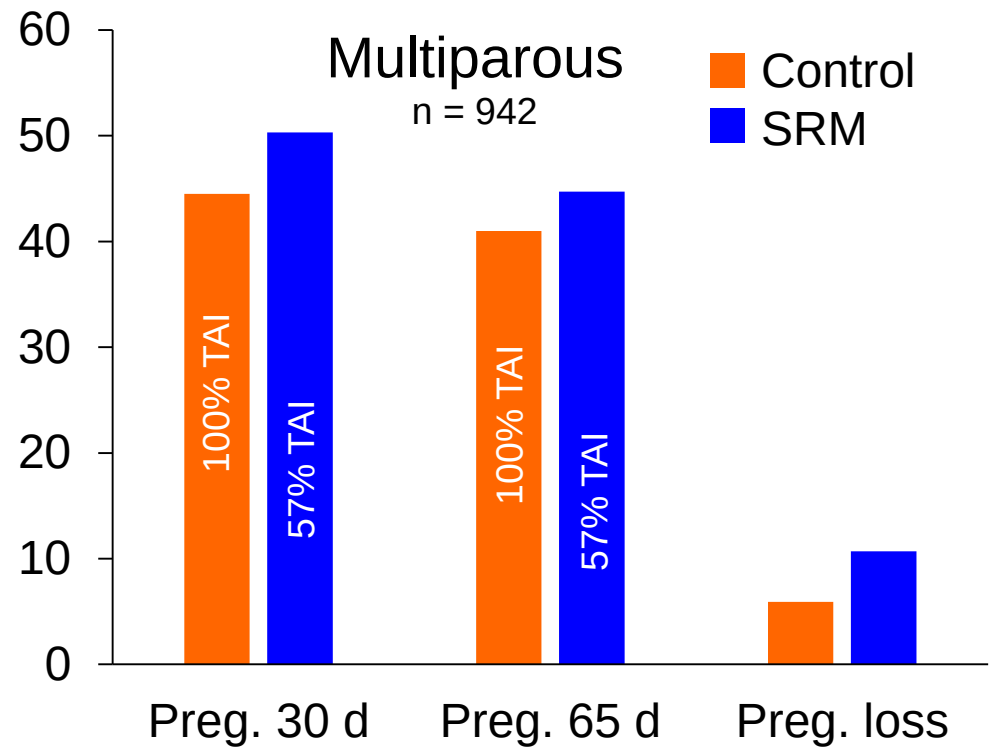
71.8 ± 0.3

72.2 ± 0.5

Gonzalez et al., 2023 (JDS 106:5788–5804)

Effect of Treatment on Pregnancy and Pregnancy Loss (1st insemination)

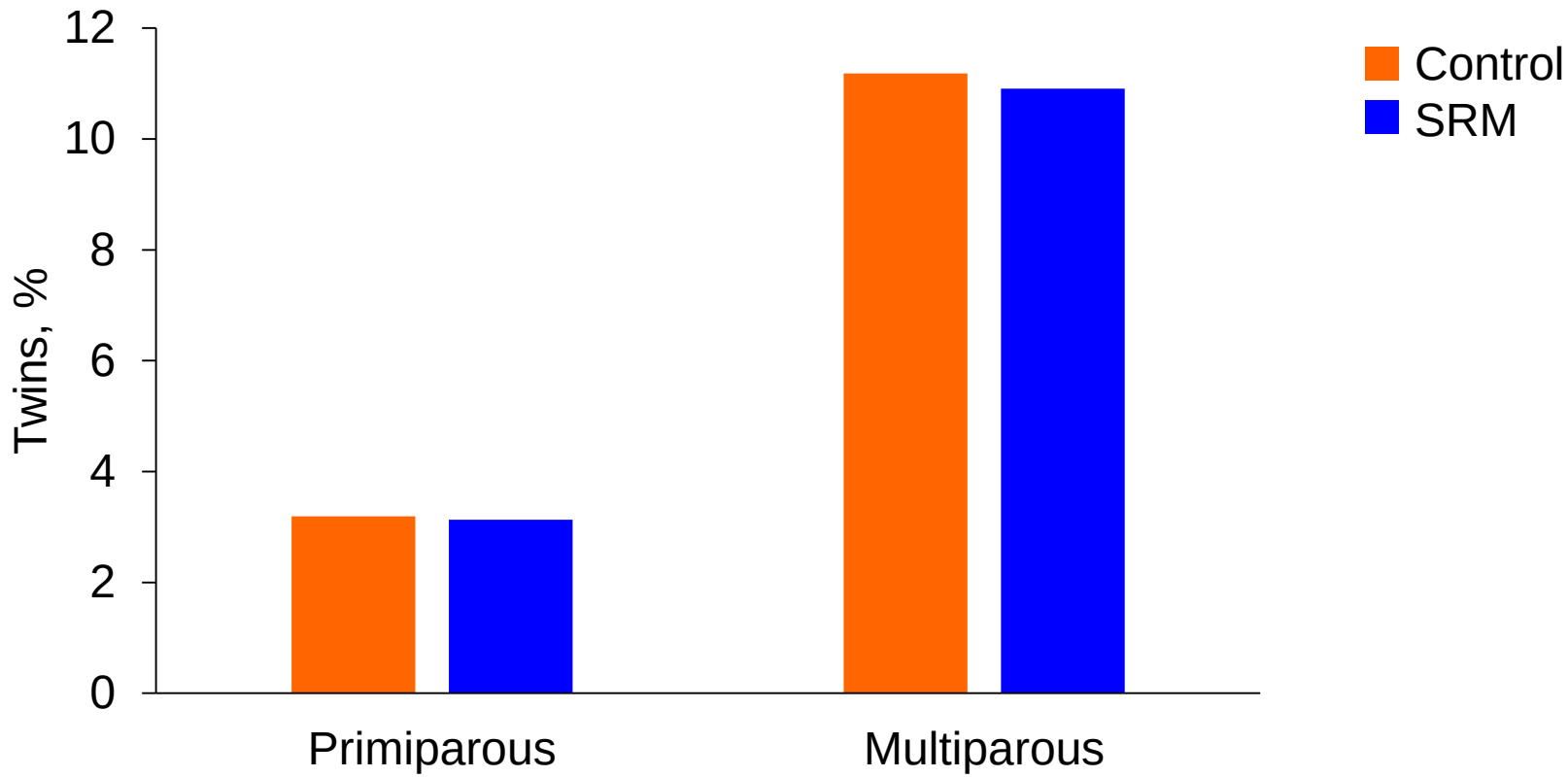




	P – value		
Variables	TRT	Parity	TRT x Parity
Preg.30 d	0.22	< 0.01	< 0.01
Preg. 65 d	0.15	< 0.01	< 0.01
Preg. loss	0.14	0.44	0.28

Gonzalez et al., 2023 (JDS 106:5788–5804)

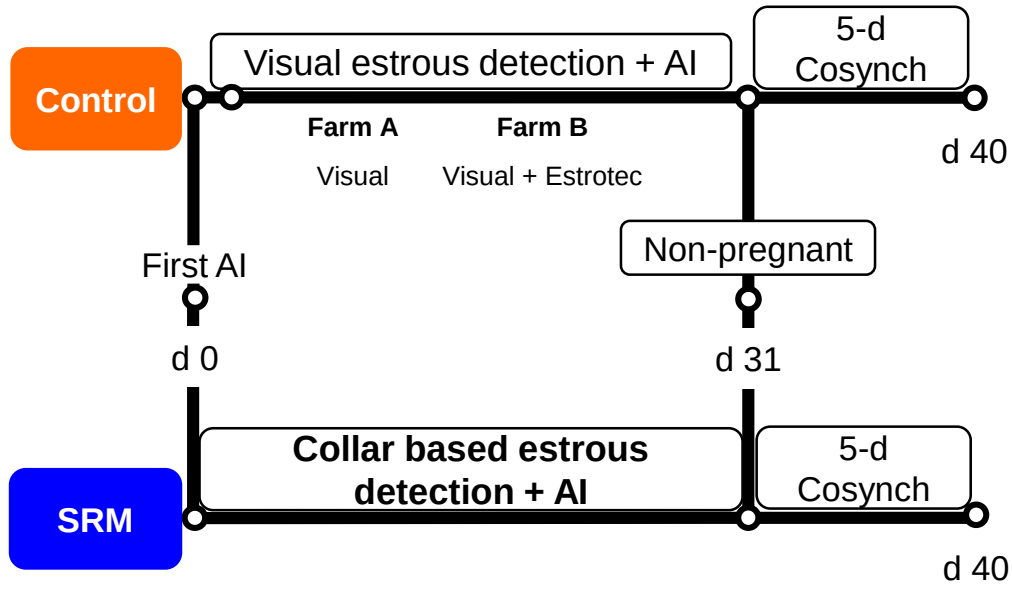
Effect of Treatment on Twining Rate of Cows Pregnant to First AI



P – value		
TRT	Parity	TRT x Parity
0.23	< 0.01	0.95

Gonzalez et al., 2023 (JDS 106:5788–5804)

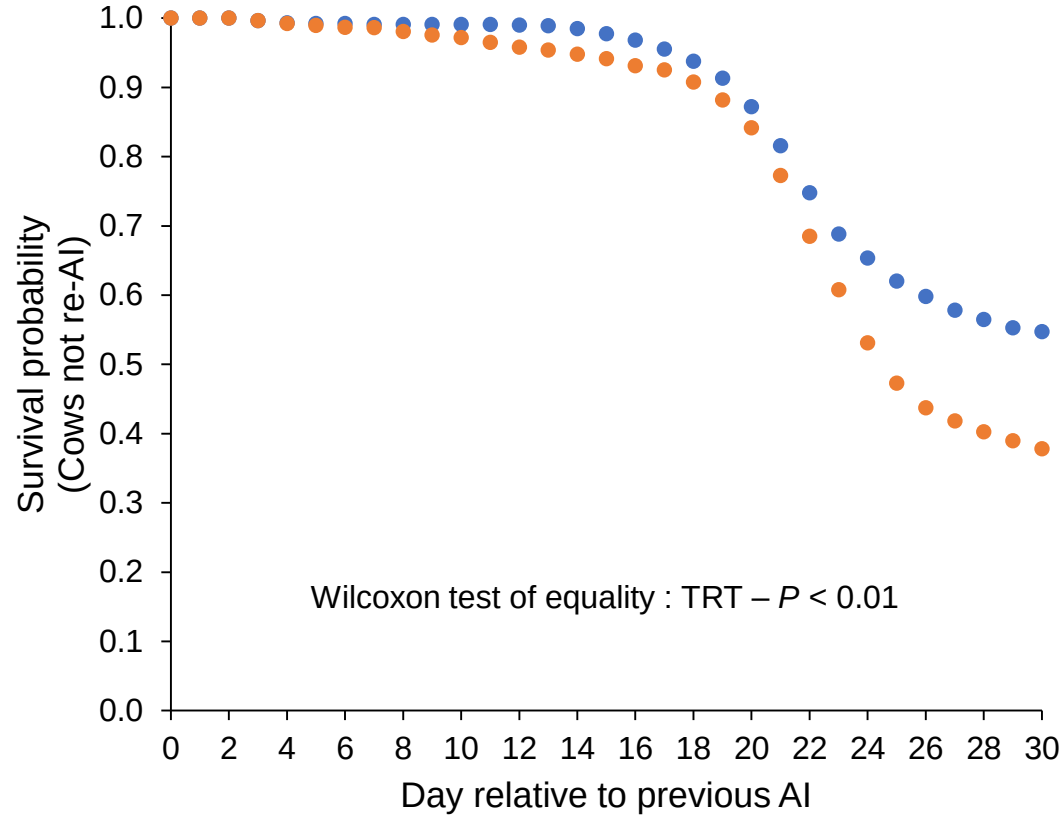
Experimental Design
(Re-insemination)



Gonzalez et al., 2023 (JDS 106:5788–5804)

Effect of Treatment on Hazard of Re-Insemination

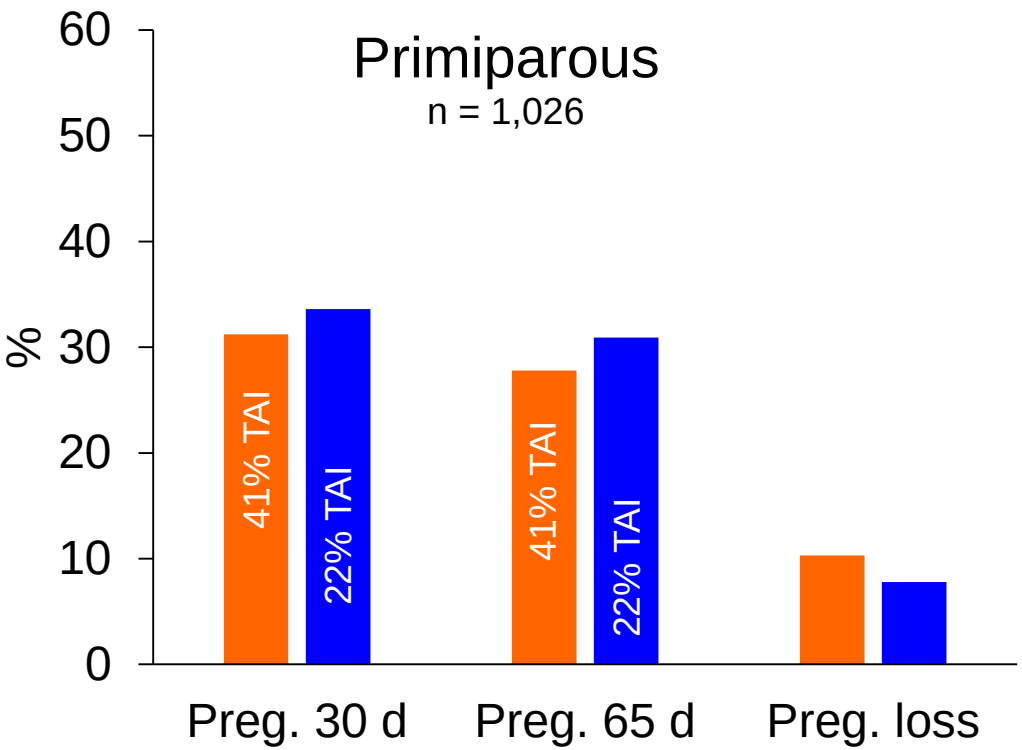
	Adjusted hazard ratio (95% CI)	TRT	Parity	TRT x Parity
Control	Ref.	<0.001	<0.001	0.34
SRM	1.65 (1.45, 1.88)			

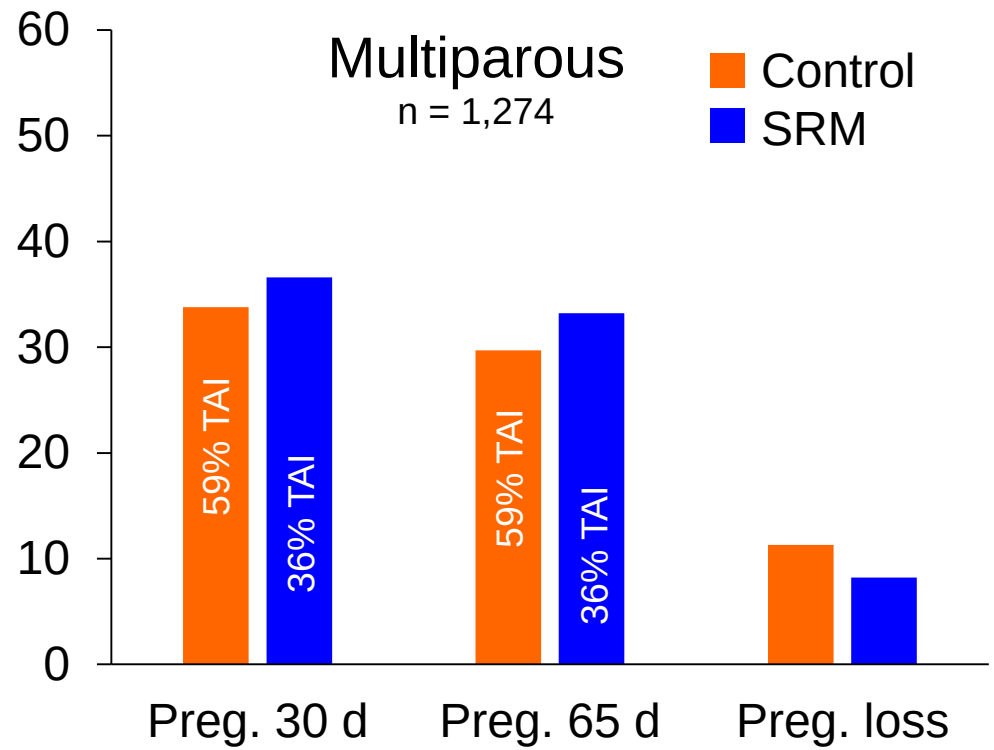


	Mean (±SE)	Median	Censored, %
Control	26.4 ± 0.1	NR	54.7
SRM	24.9 ± 0.2	25	37.8

Gonzalez et al., 2023 (JDS 106:5788–5804)

Effect of Treatment on Pregnancy and Pregnancy Loss (Re-inseminations)

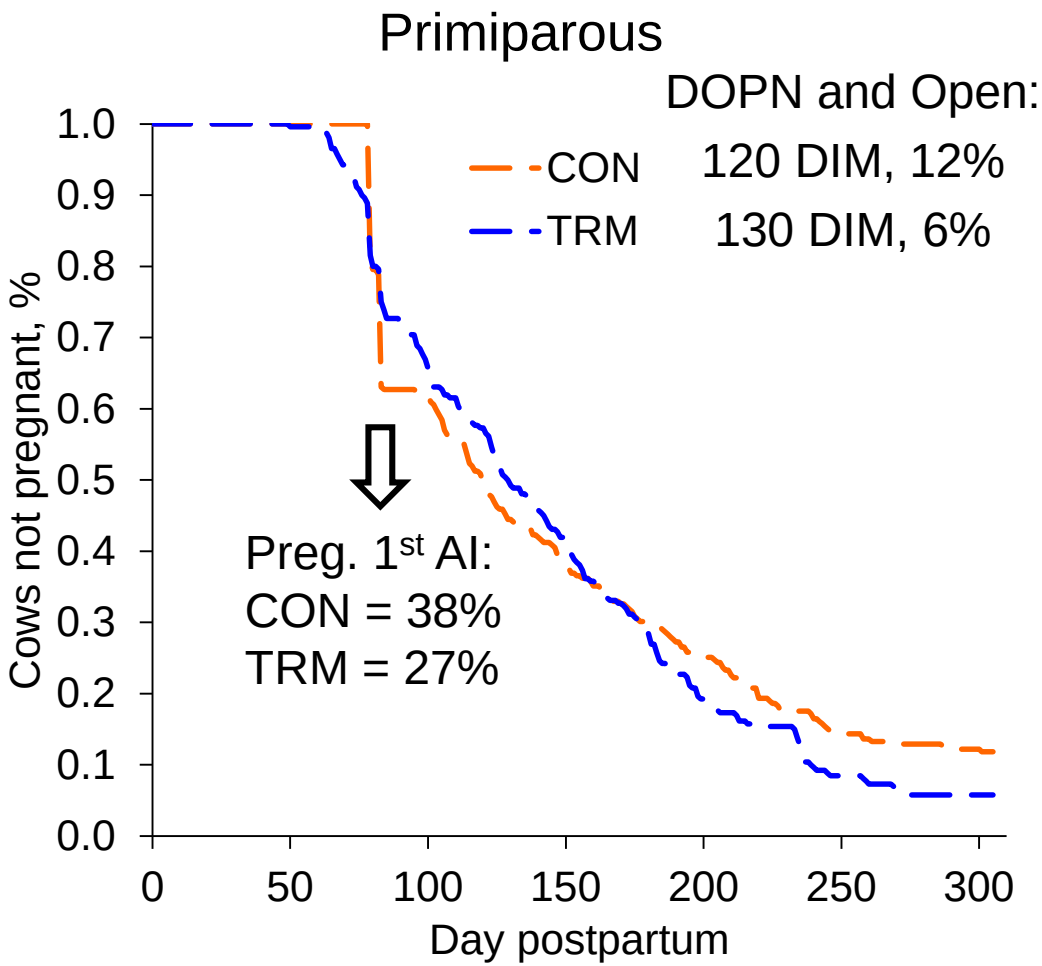


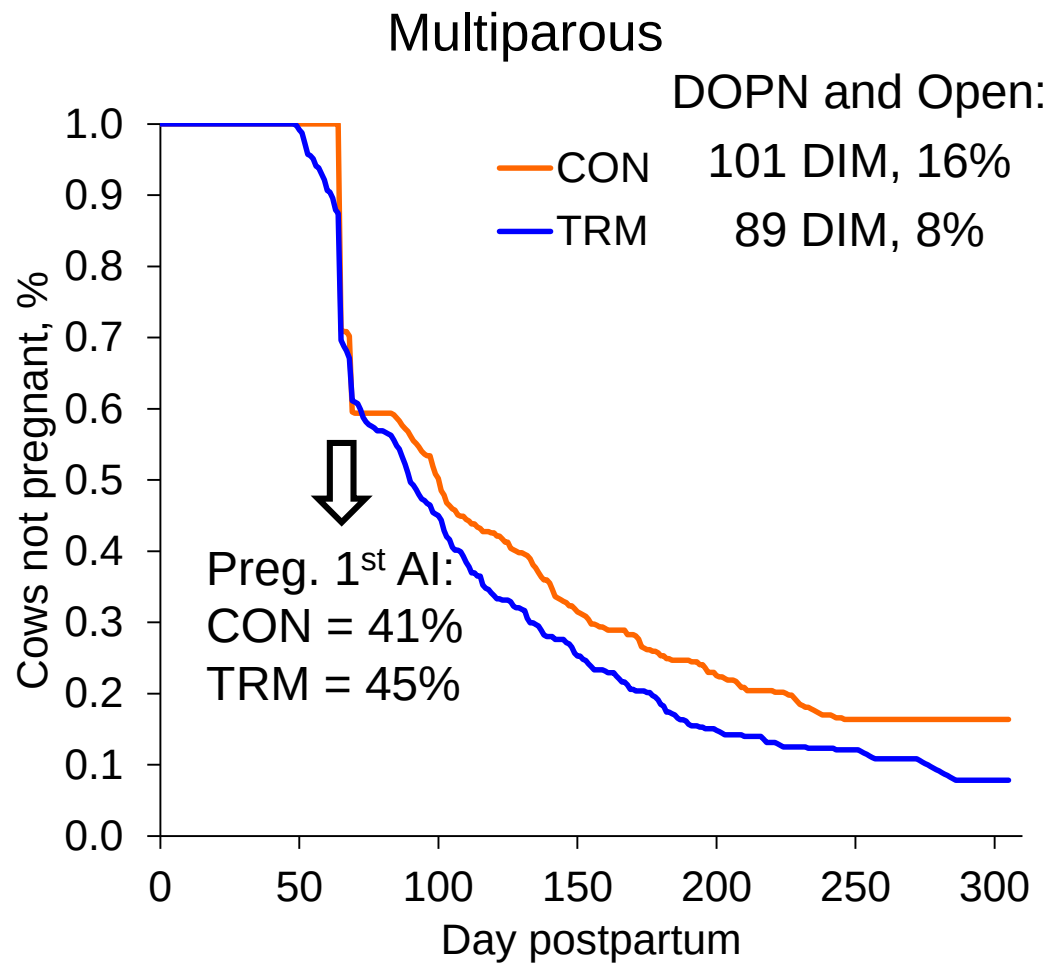


	P – value		
Variables	TRT	Parity	TRT x Parity
Preg.30 d	0.10	0.01	1.00
Preg. 65 d	0.06	0.02	0.71
Preg. loss	0.09	0.50	0.75

Gonzalez et al., 2023 (JDS 106:5788–5804)

Targeted Reproductive Management
Pregnancy Rate





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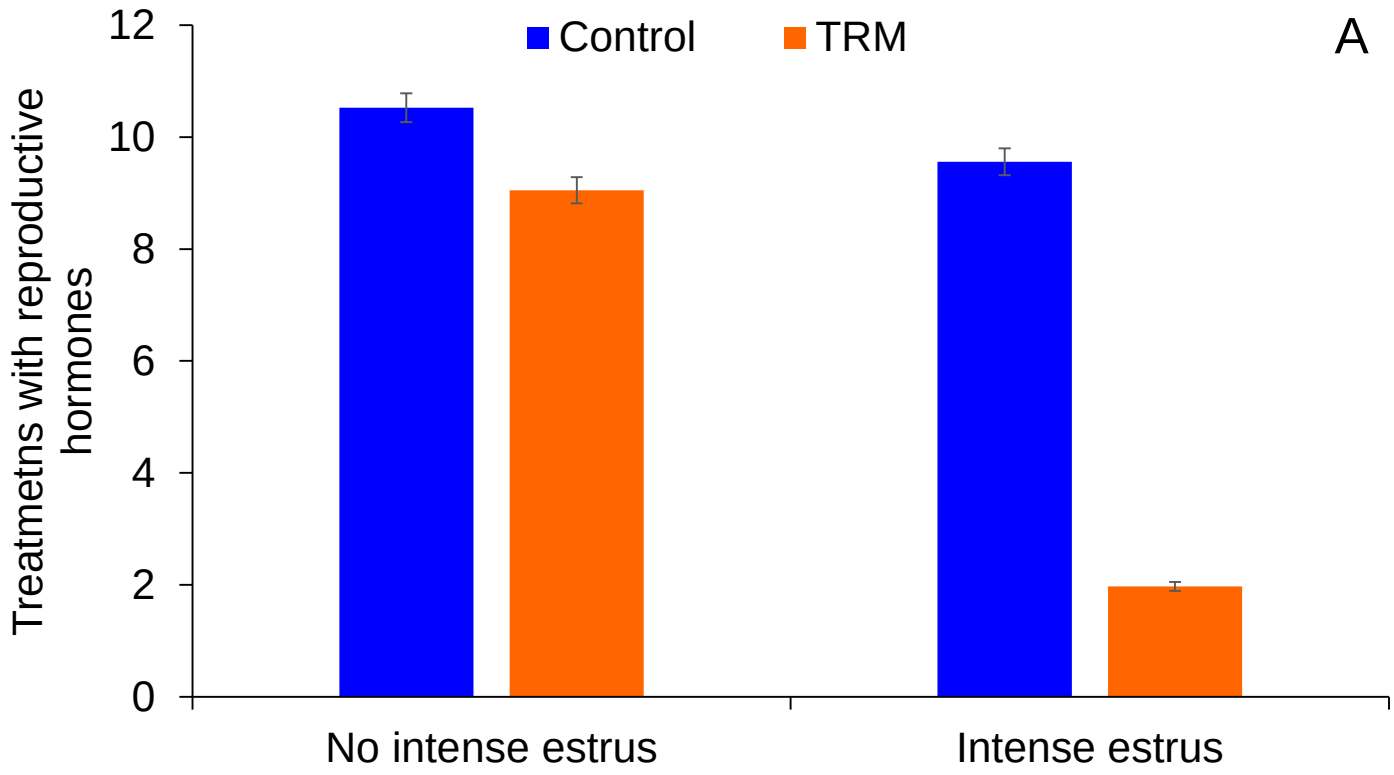
Targeted Reproductive Management Use of Reproductive Hormones



- Identification of cows that resume cyclicity early postpartum allows for targeted reproductive management = reduced hormone use and no loss in efficiency
- Estrus intensity of first lactation cows postpartum is less reliable (HI ≥ 90)

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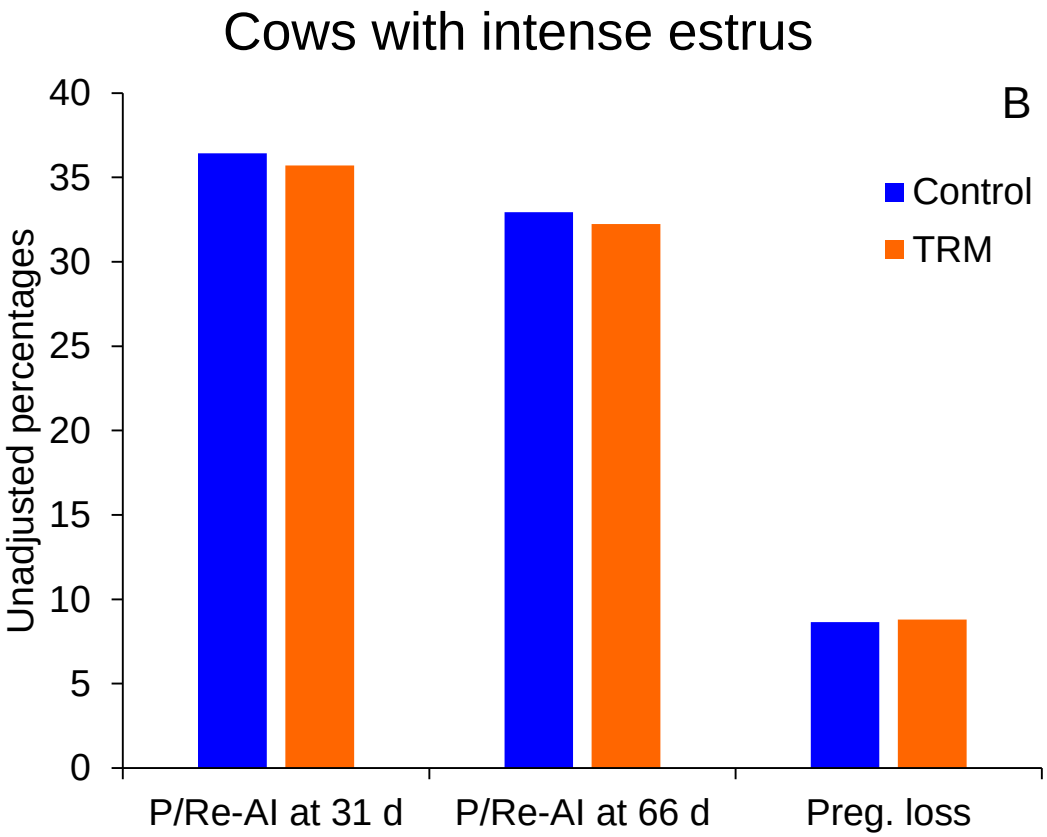
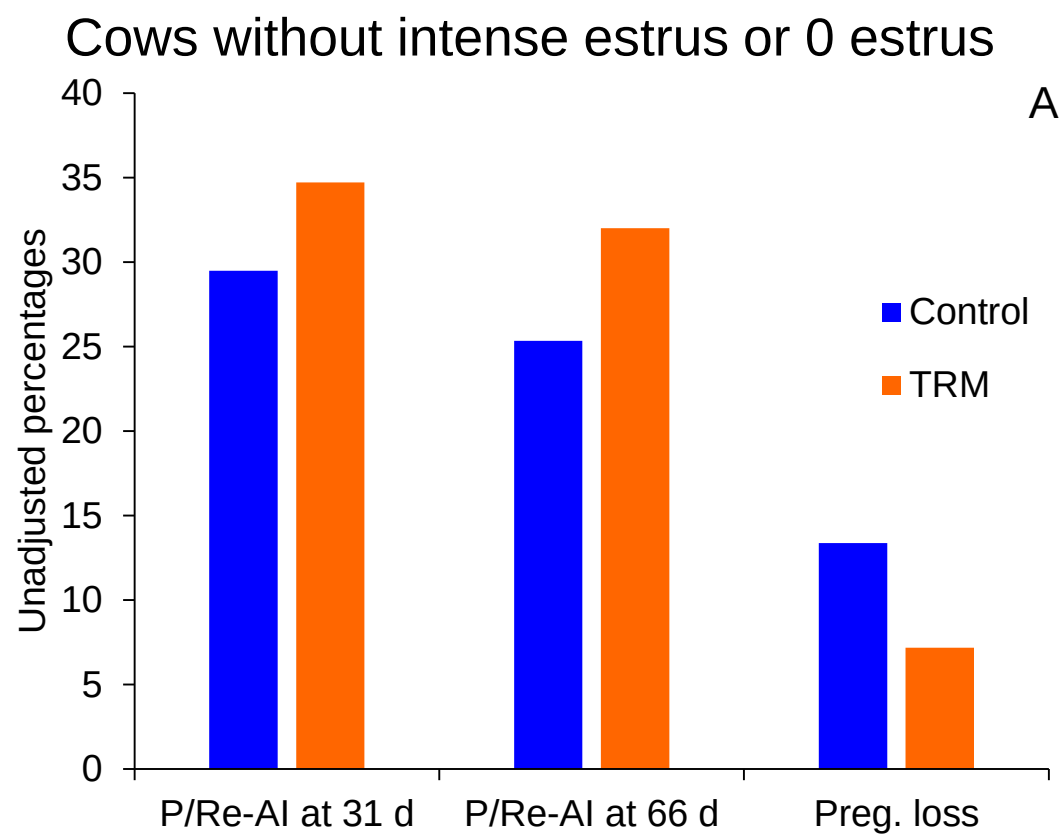
Effect of Treatment and Estrus Intensity on Pregnancy to Re-insemination

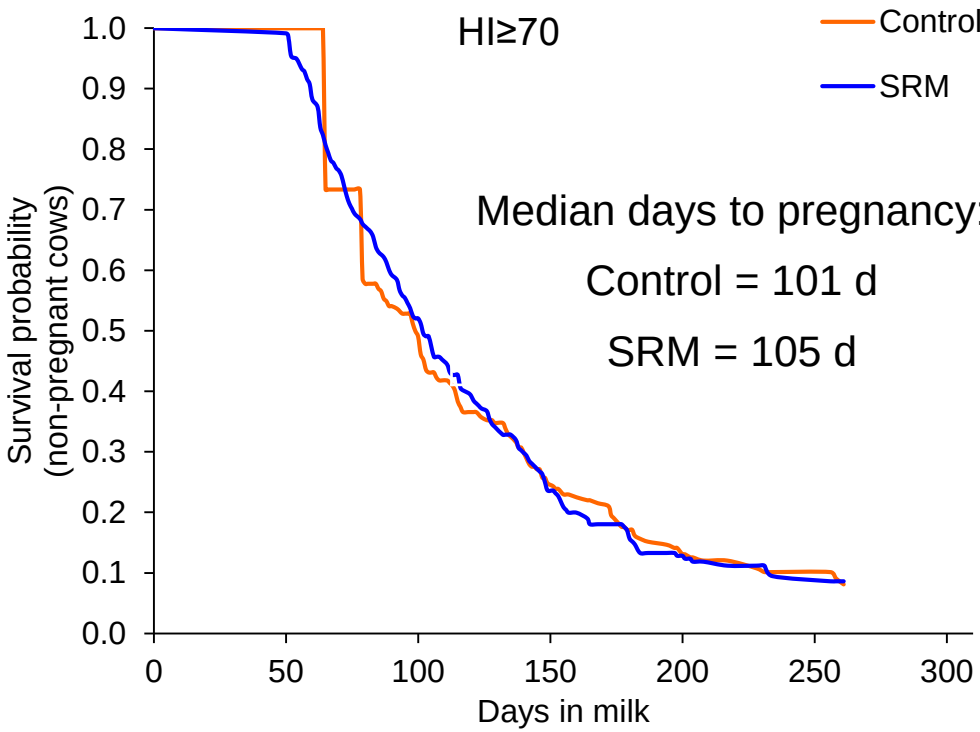


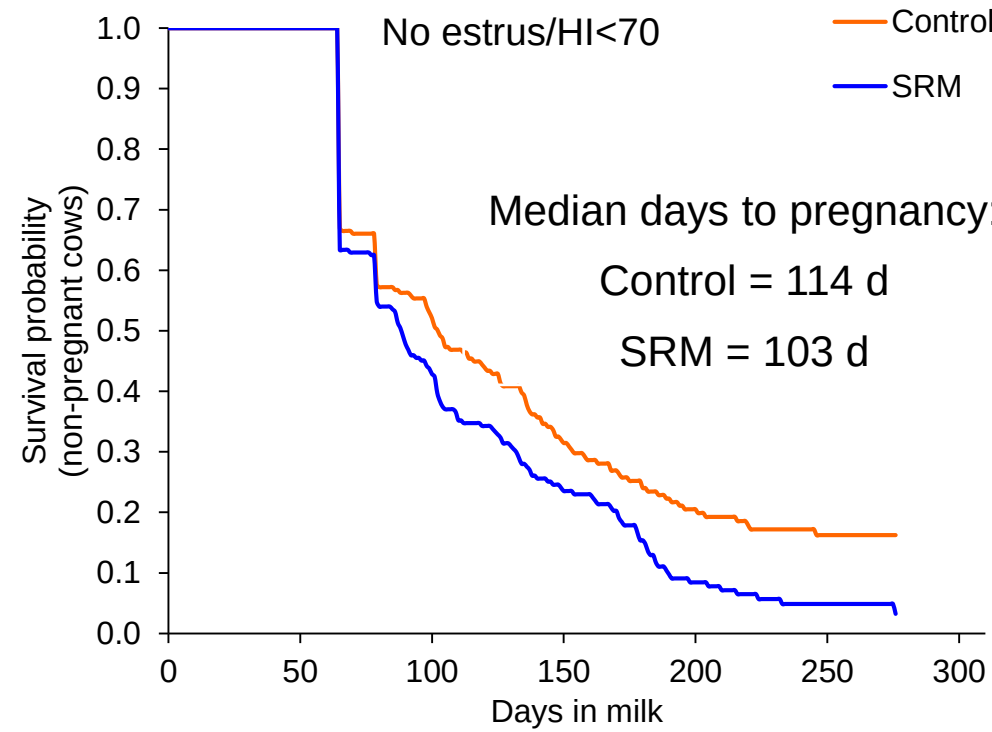


Gonzalez et al., 2023 (JDS 106:5788–5804)

Effect of Treatment and Estrus Intensity on Time to Pregnancy

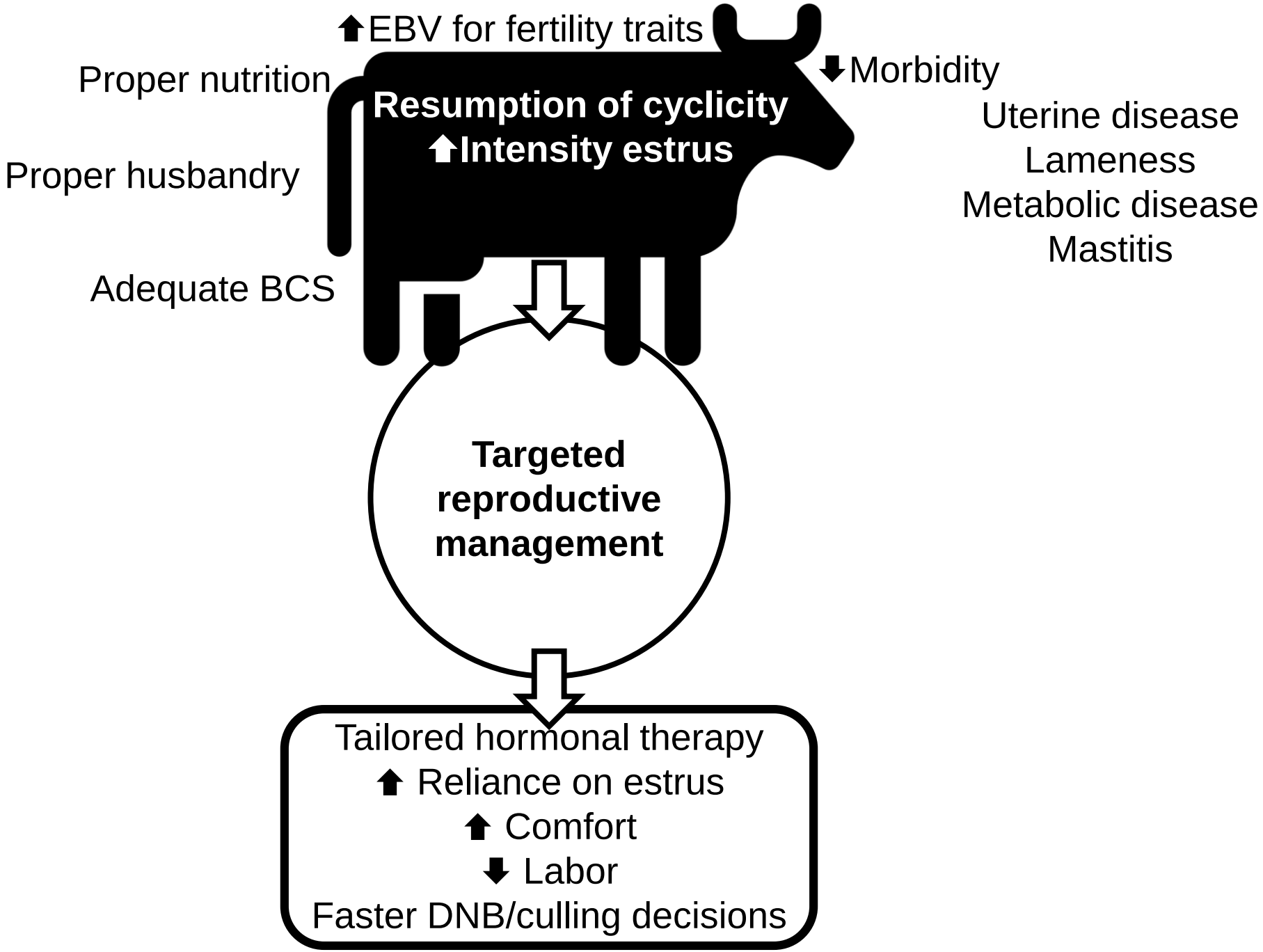
TRT – $P < 0.001$
TRT x Parity – $P = 0.23$
TRT x EstIntDec – $P = 0.08$





- The intensity of estrus is heritable and repeatable
- Cows that have short, low-intensity estrus after calving repeat the same pattern
- The use of AMD in these cows may result in more accurate heat detection

Gonzalez et al., 2023 (JDS 106:5788–5804)


⬆EBV for fertility traits
Proper nutrition
Proper husbandry
Adequate BCS
Resumption of cyclicity
⬆Intensity estrus
⬇Morbidity
Uterine disease
Lameness
Metabolic disease
Mastitis
Targeted reproductive management
Tailored hormonal therapy
⬆ Reliance on estrus
⬆ Comfort
⬇ Labor
Faster DNB/culling decisions

Summary of the main factors associated with reproductive performance

Puberty vs. BW
BW vs. Agee

Semen

Dystocia
Passive transfer of IgG
Morbidity
Feeding strategy
BW and ADG

⬇ Heat stress
BCS dry-off
Comfort

Days on pre-partum diets
Acidogenic diets
ΔBCS in the dry period
Morbitidy

ΔBCS
VWP
Reproductive strategy
Semen
Comfort

Training
Compliance
Precision

Vaccination protocols

Thank you!!!

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