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Intelligent sow breeding management

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Presentation overview

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1. Why precision breeding?
2. How to achieve precision breeding?
3. Our approach to precision breeding
4. Commercial farm results
5. Other applications of the use of computer vision in swine production
6. Conclusion

Why precision breeding?

Why precision breeding?

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Common breeding protocol

- Daily estrus detection taken as the indicator of the best timing for insemination (twice a day in gilts)
  - Worker dependent
  - Duration of estrus varies from sow to sow (1 to 4 days in general)
  - Ovulation occurs around 2/3 of the estrus period
- We breed 1, 2 or even 3 times in the standing heat period to ensure fertilization

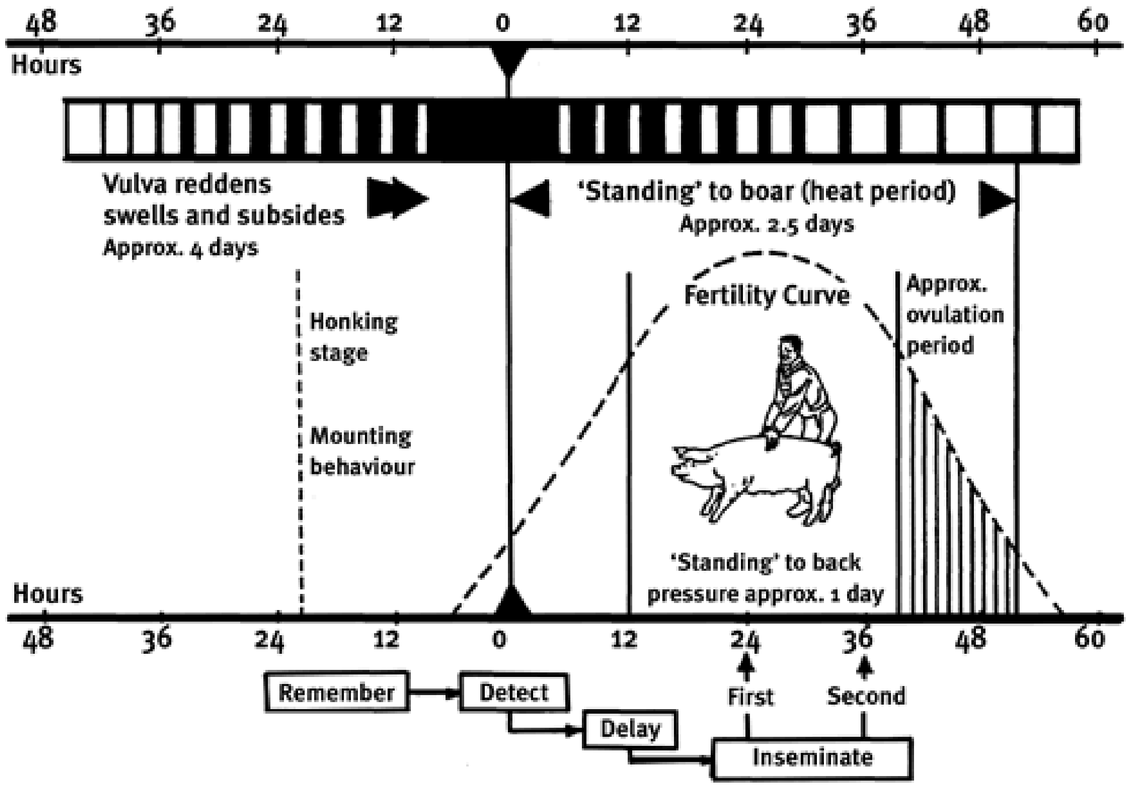

Fig. 1 Common breeding protocol, taken from https://www.daf.qld.gov.au/business-priorities/animal-industries/pigs/improving-your-herd-with-genetics/ai-sows

Could we do any better?

Why precision breeding?

Non-invasive single-dose precision breeding in sows could help decrease dependency on skilled labor, save time, improve reproduction results, optimize the use of the best boars, and ultimately accelerate genetic improvement.

Why precision breeding?

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Finding the optimal moment to **breed sows only once per estrus cycle** without artificially manipulating the reproduction cycle is an old challenge that has never been addressed with a **simple, commercially viable technique**.

This was the objective of our research and development team for the last 10 years.

How to achieve precision breeding?

Explanation based on our previous work

G. Germain, J. Labrecque, J. Rivest, The effect of timing of a single-dose insemination on sow fertility, 9th European Conference on Precision Livestock Farming (26-29 August 2019), pp. 27- 33.

Context

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After inseminating **tens of thousands of sows with a single dose**, our clients have generated a **unique database** that allow us to **understand better the effect** of a single-dose artificial insemination on sow fertility.

Materials and Methods

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Table 1: Number of analysed estrus cycles per farm and average parity

Farms	Estrus cycles (n)	Average Parity	Analysis start date
Farm 1	74	NA	October 2018
Farm 2	2473	4.81 ± 1.84	October 2016
Farm 3	780	4.55 ± 1.88	May 2018
Farm 4	2071	5.42 ± 2.44	October 2017
Farm 5	809	3.93 ± 2.26	May 2017
Farm 6	627	4.54 ± 2.48	February 2018
Farm 7	5594	4.33 ± 1.76	December 2017
Farm 8	235	3.64 ± 1.27	June 2018
Farm 9	105	4.20 ± 1.93	June 2018
Total	**12,280**		

Results and discussion

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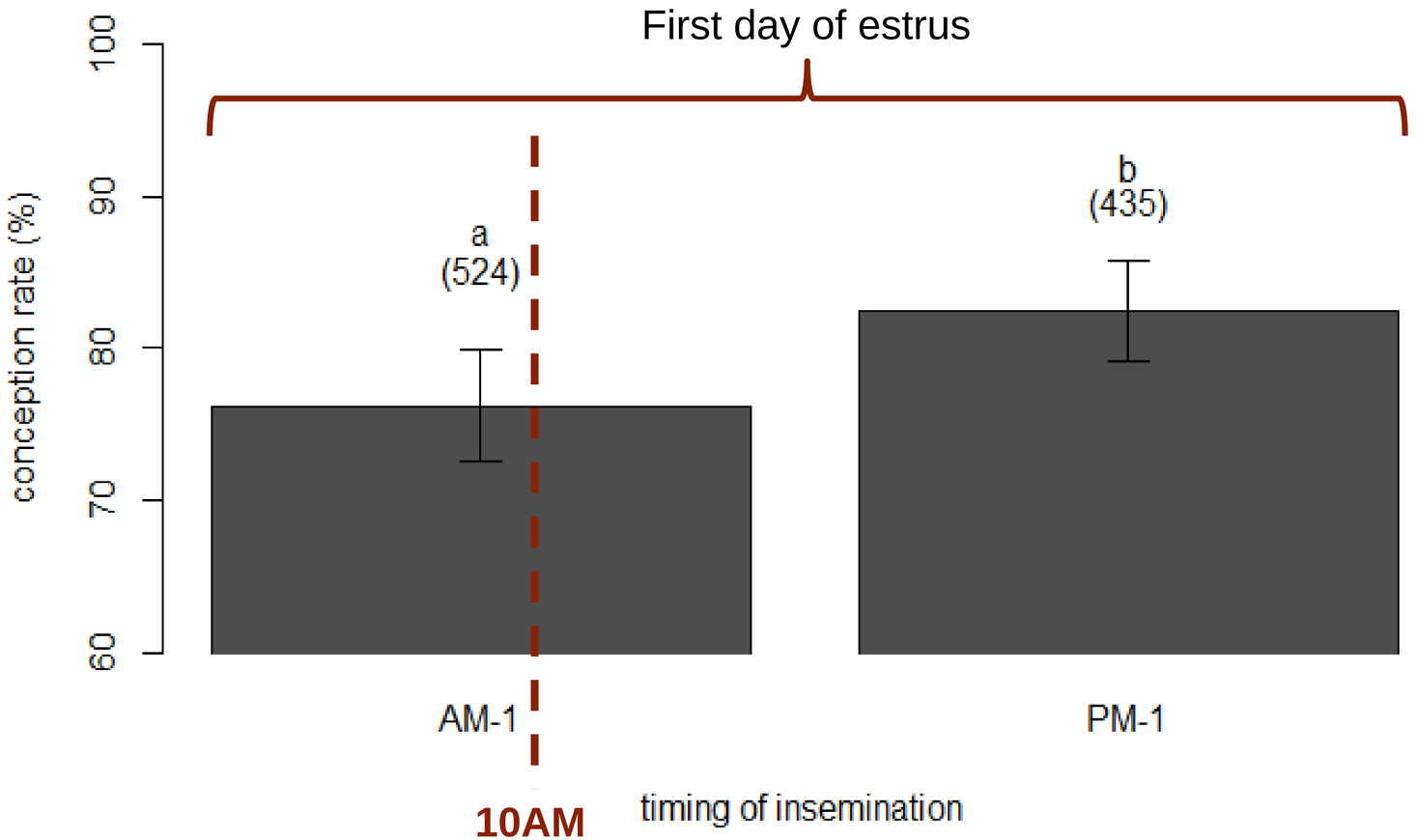
Agro-Technological Products and Solutions

1-day estrus



Interval	Conception Rate (%)
AM-1	76.23
PM-1	82.41

The precision of the interval between the onset of estrus and the time of ovulation decreases when estrus detection is carried once a day (Almeida *et al.*, 2000)

Results and discussion

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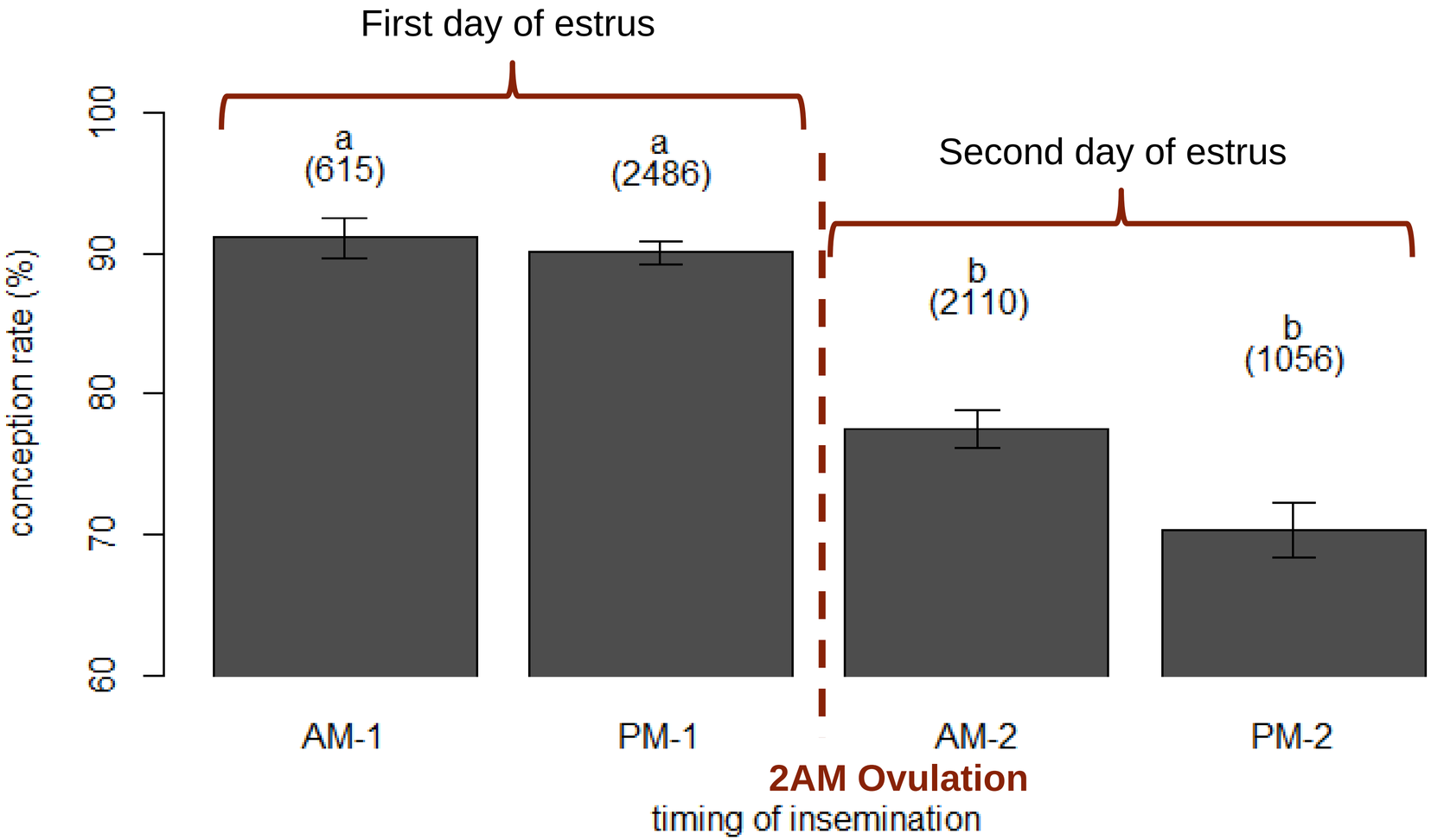
2-day estrus



Interval	Conception Rate (%)
AM-1	91.11
PM-1	90.08
AM-2	77.46
PM-2	70.32

Results and discussion

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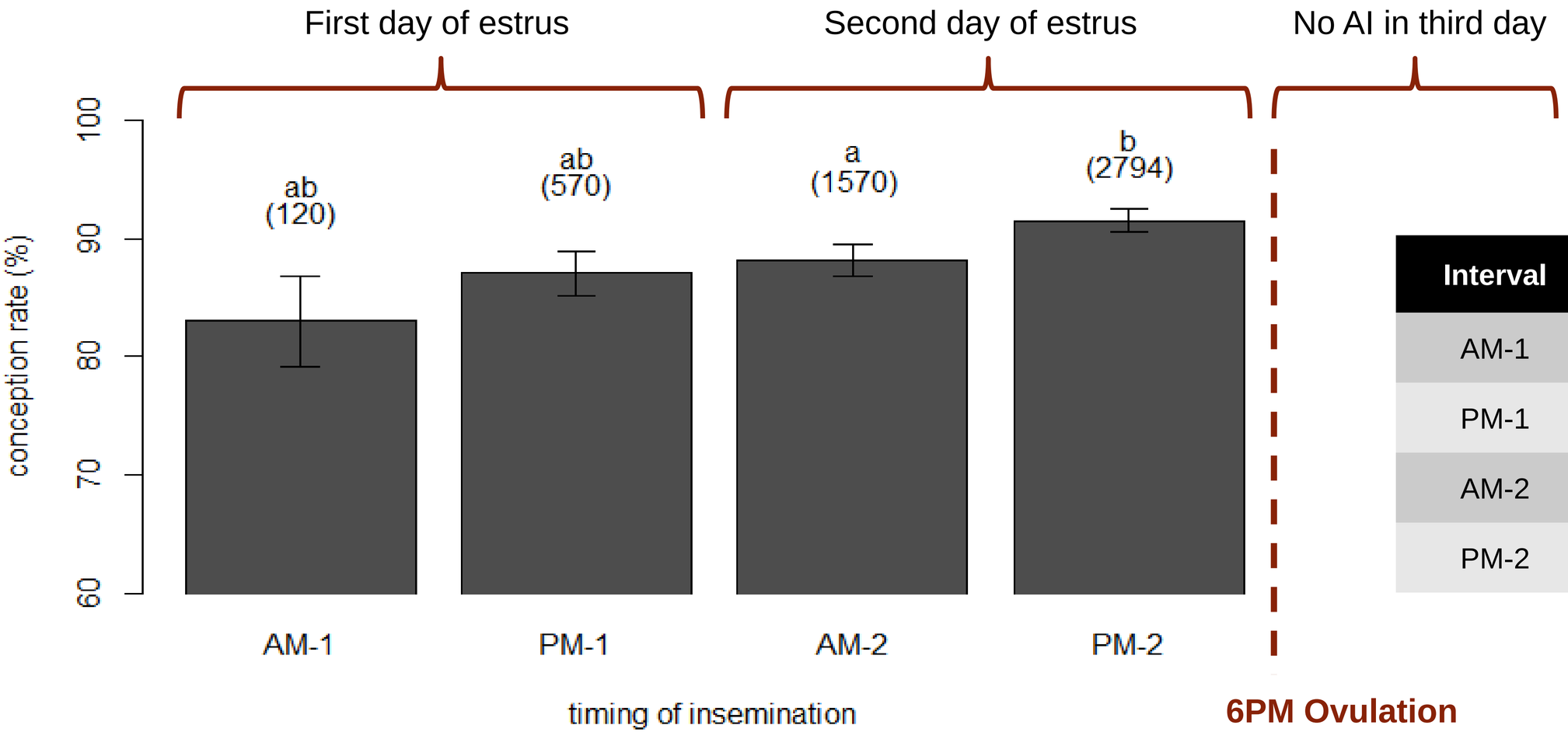
3-day estrus



Interval	Conception Rate (%)
AM-1	83.02
PM-1	87.05
AM-2	88.13
PM-2	91.52

6PM Ovulation

The PigWatch system could have created a bias in the study by predicting the length of the estrus cycle and targeting a supposedly optimal timing of insemination, resulting in fewer very early or very late inseminations.

Conclusion

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- The timing of a single-dose insemination in sows seems to be very important to optimize fertility
  - Some sows should be inseminated on their first day of estrus while others should be inseminated on their second day of estrus
  - What about sows that have estrus longer than 3 days?
- A half-day difference can have a great impact on conception rate:
  - 12,6% decrease when inseminated half a day too late
  - 3,4% to 6,2% decrease when inseminated half a day too early

Conclusion

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- Difference between our evaluation and literature:
  - Similar conclusions but our data suggests that the optimal timing before ovulation would be of the order of half a day rather than 24 hours
  - In our study insemination timing is evaluated by looking at conception rate rather than comparing with ovulation timing
  - In multiple commercial farms rather than a single research farm
- Sets the bases for further improvement of precision breeding methods

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Our approach to precision breeding

Explanation based on our previous work

J. Labrecque, J. Rivest, A Real-Time Sow Behavior Analysis System to Predict an Optimal Timing for Insemination, 10th International Livestock Environment Symposium with 1st U.S. Precision Livestock Farming Symposium, Session XII: Disease or stress detection, September 26, 2018.

Our approach

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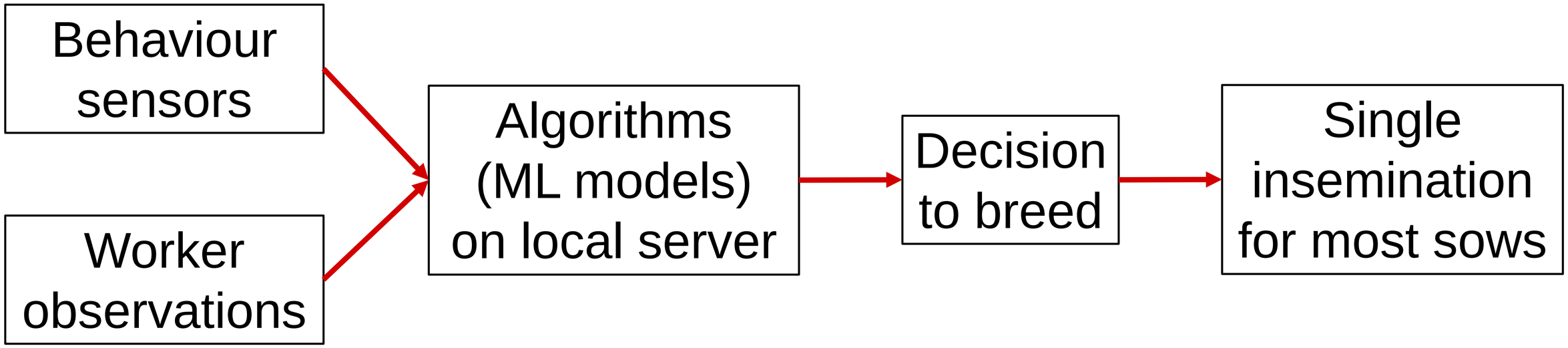
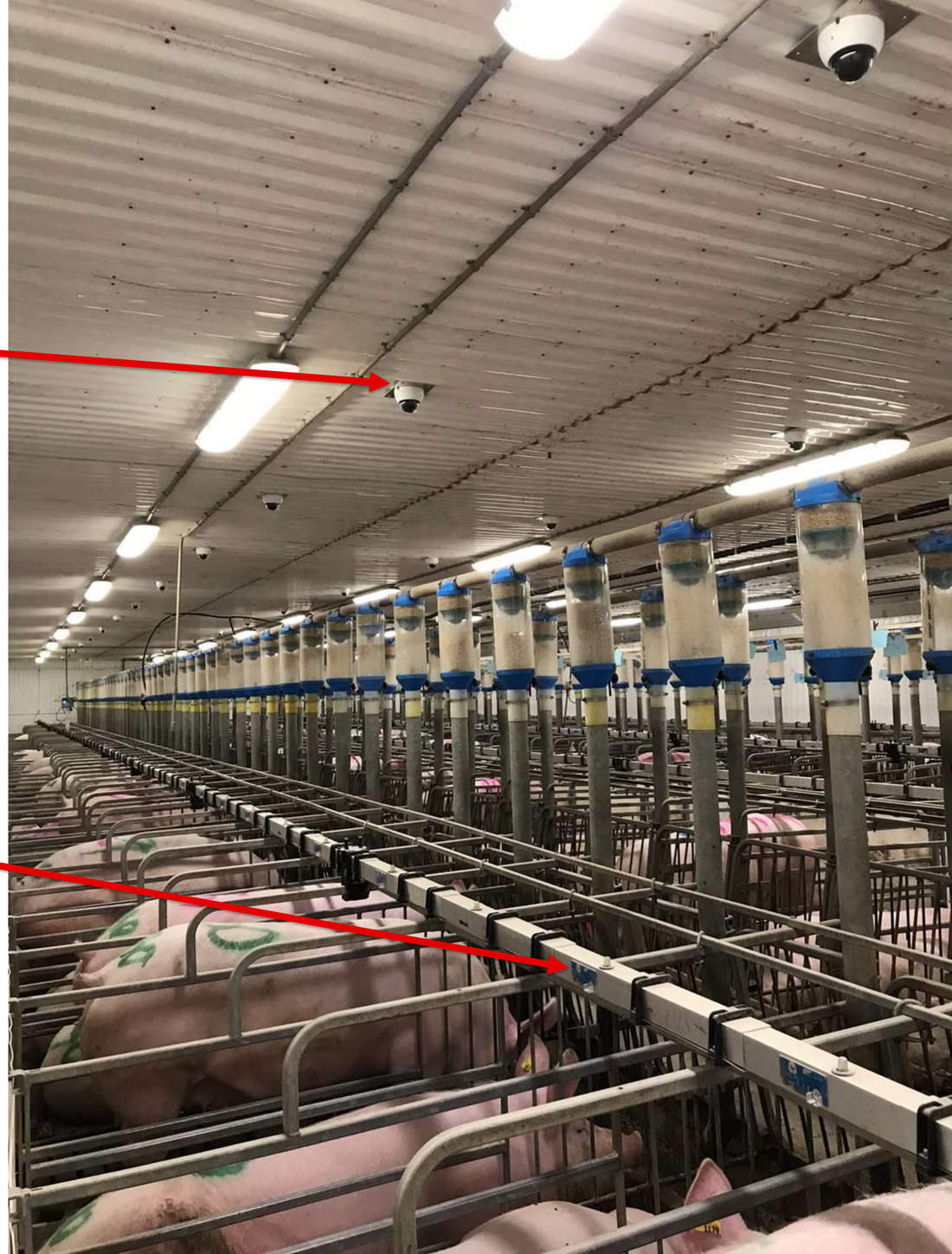
To **complement the farmer's estrus observation** with **sow behavior data** to statistically determine a **high-fertility window** during which a **single insemination** would yield good fertility results.



Our approach

2nd version: cameras to track position and posture in real time (smaRt Breeding)

1st version: Motion sensors to track posture and activity in real time (PigWatch)



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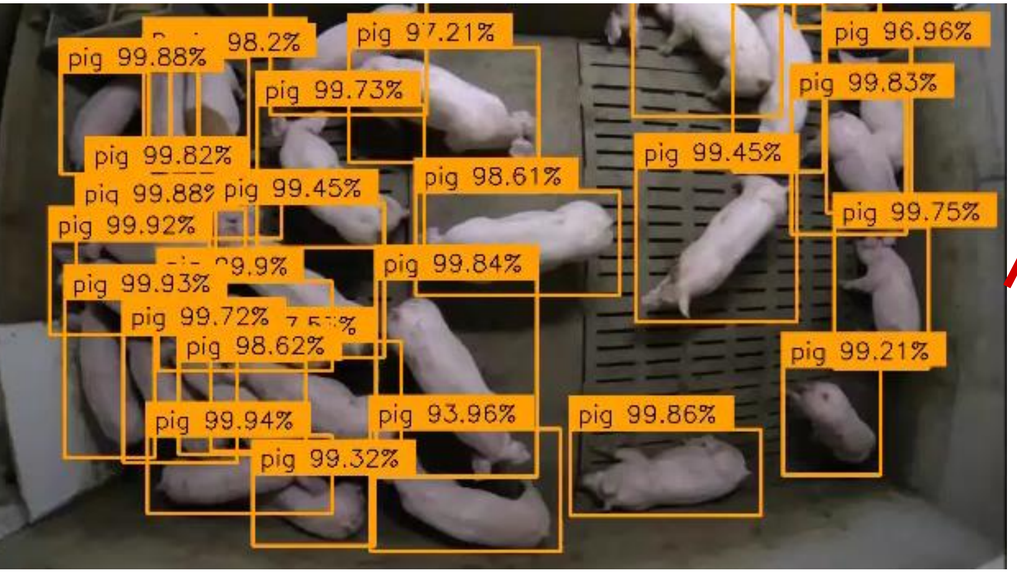
Our approach

Debout = standing ; Couche = lying



Posture and displacement are translated into activity metrics

Our approach

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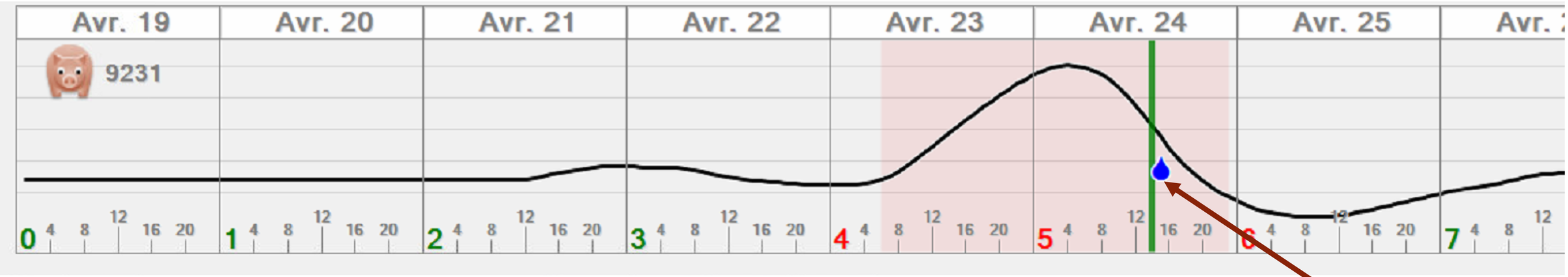
Temporal activity metrics are then analysed for each sow individually



PigWatch / smaRt Breeding monitors behavior 24/7 from weaning and learns about each individual sow's out-of-estrus normal activity

PigWatch / smaRt Breeding waits until the sow's activity changes significantly, meaning that estrus is beginning

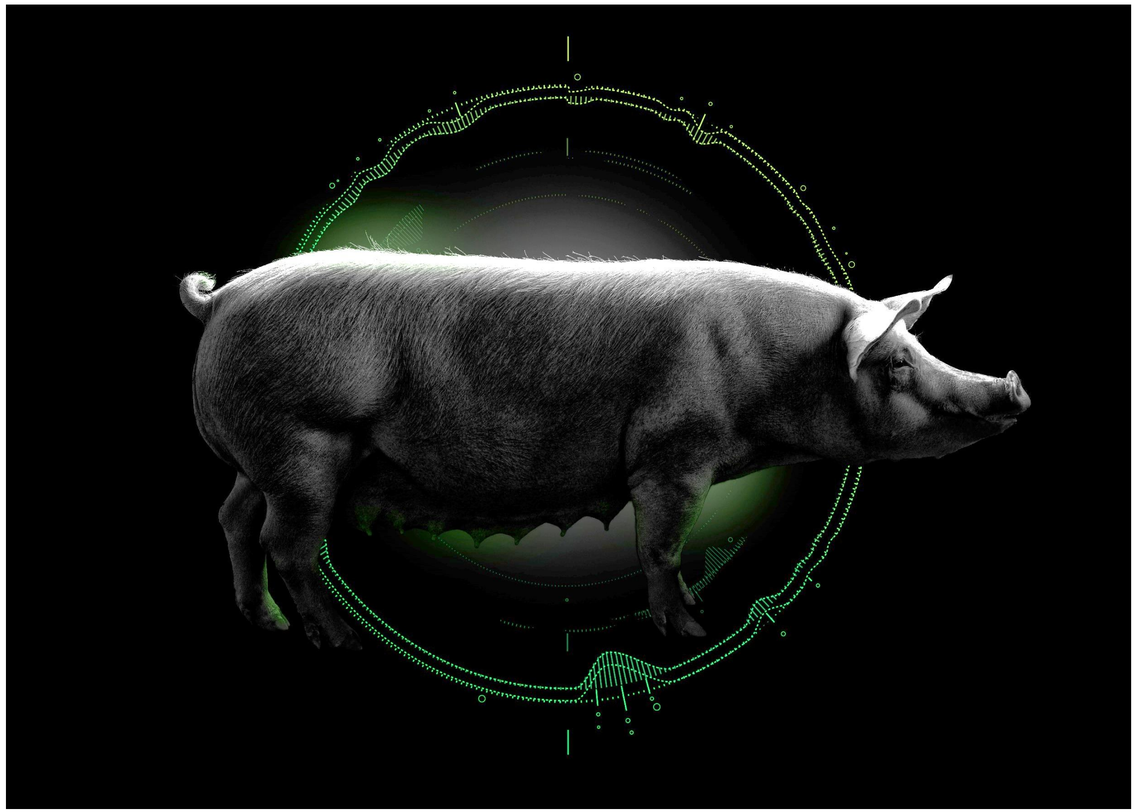
Estrus is a period characterized by a high activity level

Time series analysis allows for a prediction of the best moment to make a single-dose insemination.

Our approach

- Each sow has a unique behavior influenced by her character and environment
- Each sow has a specific estrus length
- All farmers have a different ability to detect heat

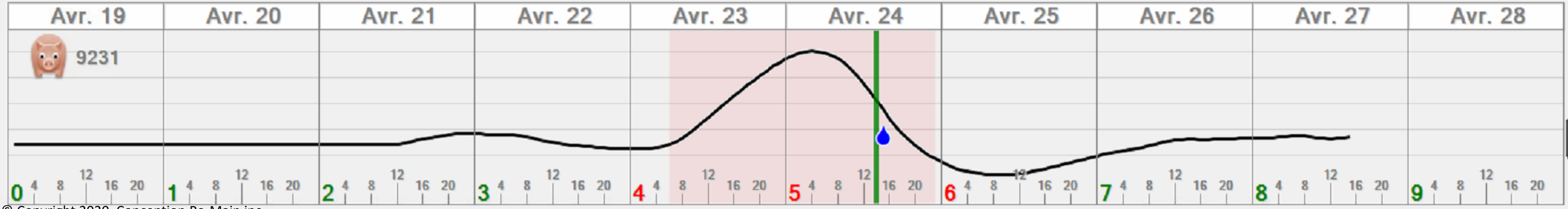
- Our algorithms are designed to deal with these sources of variability and to optimise predictions



PigWatch 2016 - AGR Master 1

47 = 46 + 1 + 0 | 1,33 = 61/46

227	8997	9543		506	9231	8793	9635	8783	9644	9359	9218
A241	A242	A243	A244	A245	A246	A247	A248	A249	A250	A251	A252
477	539	504	8685	370	8959	9805	525	9233	501	9702	505
B241	B242	B243	B244	B245	B246	B247	B248	B249	B250	B251	B252
224	9034	9350	190	493	9460	8754	813	9284	9758	9517	9754
C241	C242	C243	C244	C245	C246	C247	C248	C249	C250	C251	C252
400	510	9605	533	194	250	541	529	521	9753	822	508
D241	D242	D243	D244	D245	D246	D247	D248	D249	D250	D251	D252



User-software interactions

- User inputs the **farm management procedure** for a better understanding of non estrus-related behavior changes: **workshift hours**, **feeding times**, **heat detection time**
- User inputs **daily estrus status** for each individual sow through a simple user interface (beginning and end of observed standing heat)

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Optimize data quality

- All non estrus-related stresses should be avoided by creating a consistent daily routine for the sows, a habit:
  - Fixed-time boar exposure
  - Post-cervical insemination only (no boar during AI)
  - Fixed-time feeding
  - Concentrate disruptive actions around feeding periods
  - Be calm when in presence of the sows

Our approach

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Heat detection is always used to double-check estrus-like behaviour patterns

		Farmer's observation	
		Heat	**No heat**
Behaviour	**Estrus-like pattern detected**	Algo finds best moment to breed	Softwares asks worker to double-check heat, worker refuses heat if no symptom
	No pattern detected	After 24 hours, safe mode activated	Wait for heat

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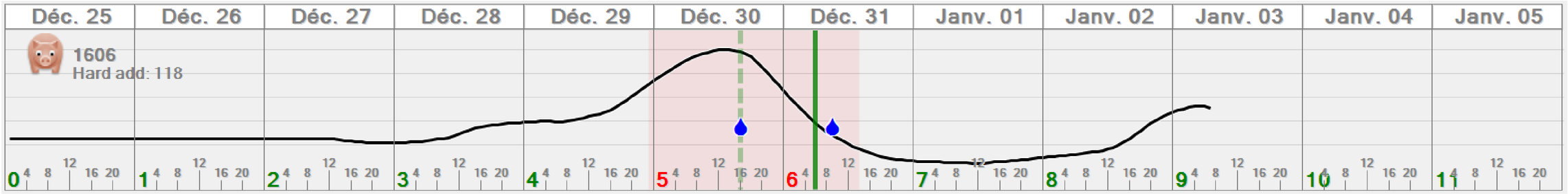
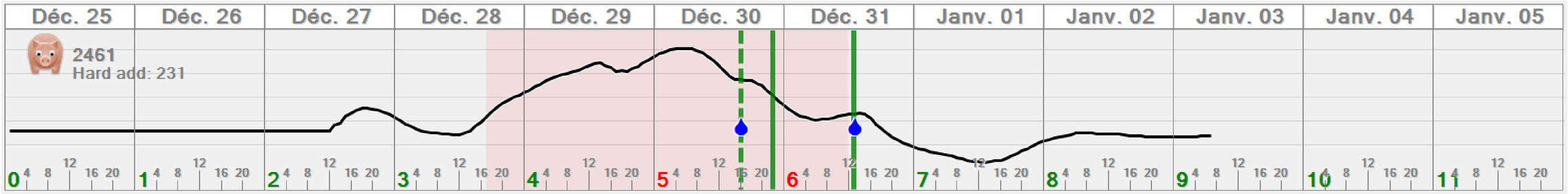
Management of special cases: 2 inseminations

- Better timing on the next morning compared to preventive insemination at the end of the previous day



- Partially noisy data or strange behavior due to mimetism, health issue, fighting, affected by other environmental conditions, sensor failures or simply character



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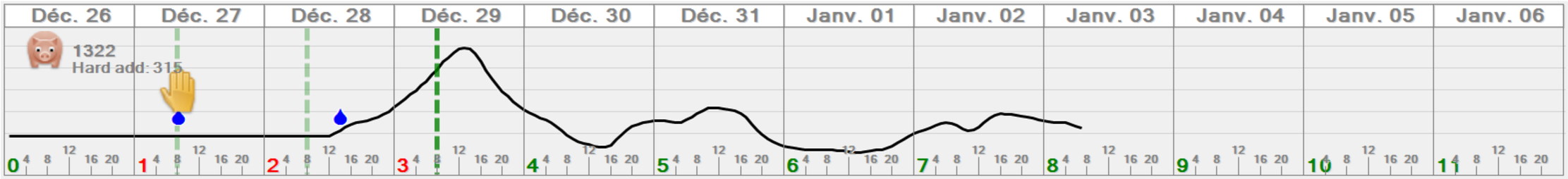
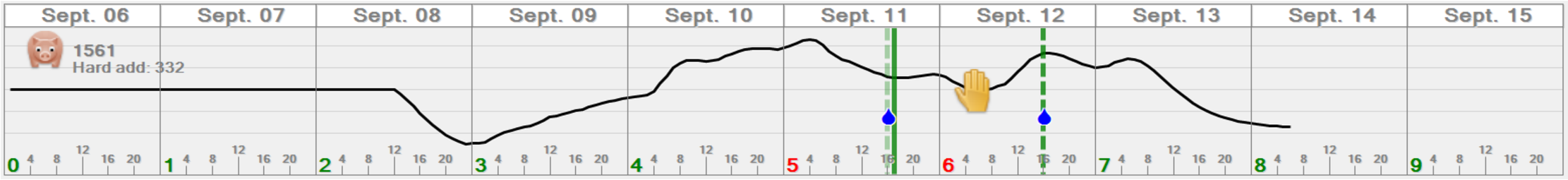
Management of special cases: Safe mode 🤚

- Estrus within first 2 days post-weaning (not enough out-of-estrus data)



- Very noisy data or very strange behaviour due to mimetism, health issue, fighting, affected by other environmental conditions, sensor failures or simply character



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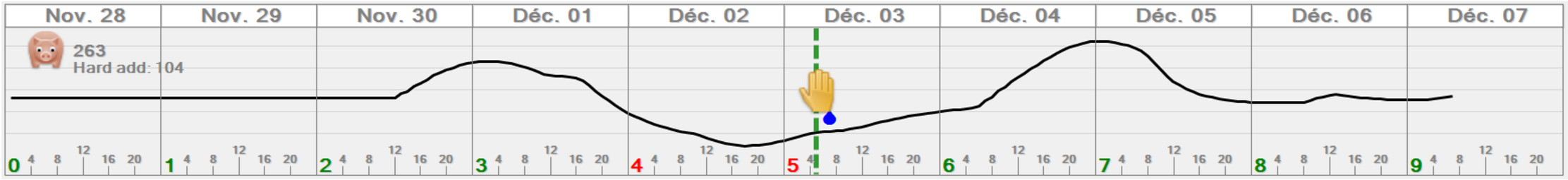
Management of special cases: Safe mode 👋

•Sow detected in estrus by worker for more than 24 hours but no behavioral pattern detected



Cases in which worker's observations were used: Materials and methods

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Farm	Country	Number of cycles	Number of inseminated sows
A	Canada	4048	3722
B	Canada	4898	4459
C	Canada	3272	2758
D	Canada	1360	1292
E	Canada	1376	1322
F	Belgium	815	801
G	Chile	4716	4015
Total	**All**	**20485**	**18369**

Cases in which worker's observations were used: Results

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Farm	Second heat detection asked by the algorithm [%]	Malfunction of a sensor [%]	In heat in the first 2 days post weaning [%]	Erratic pattern of activity [%]	Algorithm cannot recognize any activity pattern suggesting a good moment to breed [%]	Total for the farm [%]
A	305 [7.53]	36 [0.89]	44 [1.09]	78 [1.93]	137 [3.38]	600 [14.82]
B	582 [11.88]	49 [1.21]	47 [1.16]	172 [4.25]	185 [4.57]	1035 [23.07]
C	505 [15.43]	94 [2.32]	75 [1.85]	48 [1.19]	118 [2.92]	840 [23.71]
D	115 [8.46]	40 [0.99]	79 [1.95]	47 [1.16]	67 [1.66]	348 [14.21]
E	99 [7.19]	7 [0.17]	34 [0.84]	57 [1.41]	84 [2.08]	281 [11.69]
F	105 [12.88]	31 [0.77]	28 [0.69]	24 [0.59]	38 [0.94]	226 [15.87]
G	511 [10.84]	38 [0.94]	46 [1.14]	99 [2.45]	184 [4.55]	878 [19.90]
Total	2022 [10.85]	295 [1.44]	353 [1.72]	525 [2.56]	813 [3.97]	4208 [20.54]

Discussion

- **Worker's estrus detection only** is not sufficient to allow for a precise single-dose AI in weaned sows (from experience)
- **Algorithm only** is not currently sufficient to allow for precise single-dose AI in weaned sows due to factors that affect the behaviour of the sows and hide the change of behaviour directly related to estrus
- **The combination of our algorithm and a daily estrus detection** allows to easily manage all weaned sows' estrus cycle and achieve a single-dose insemination for most sows

Commercial farm results

Belgian farm 1

Number of sows: 265

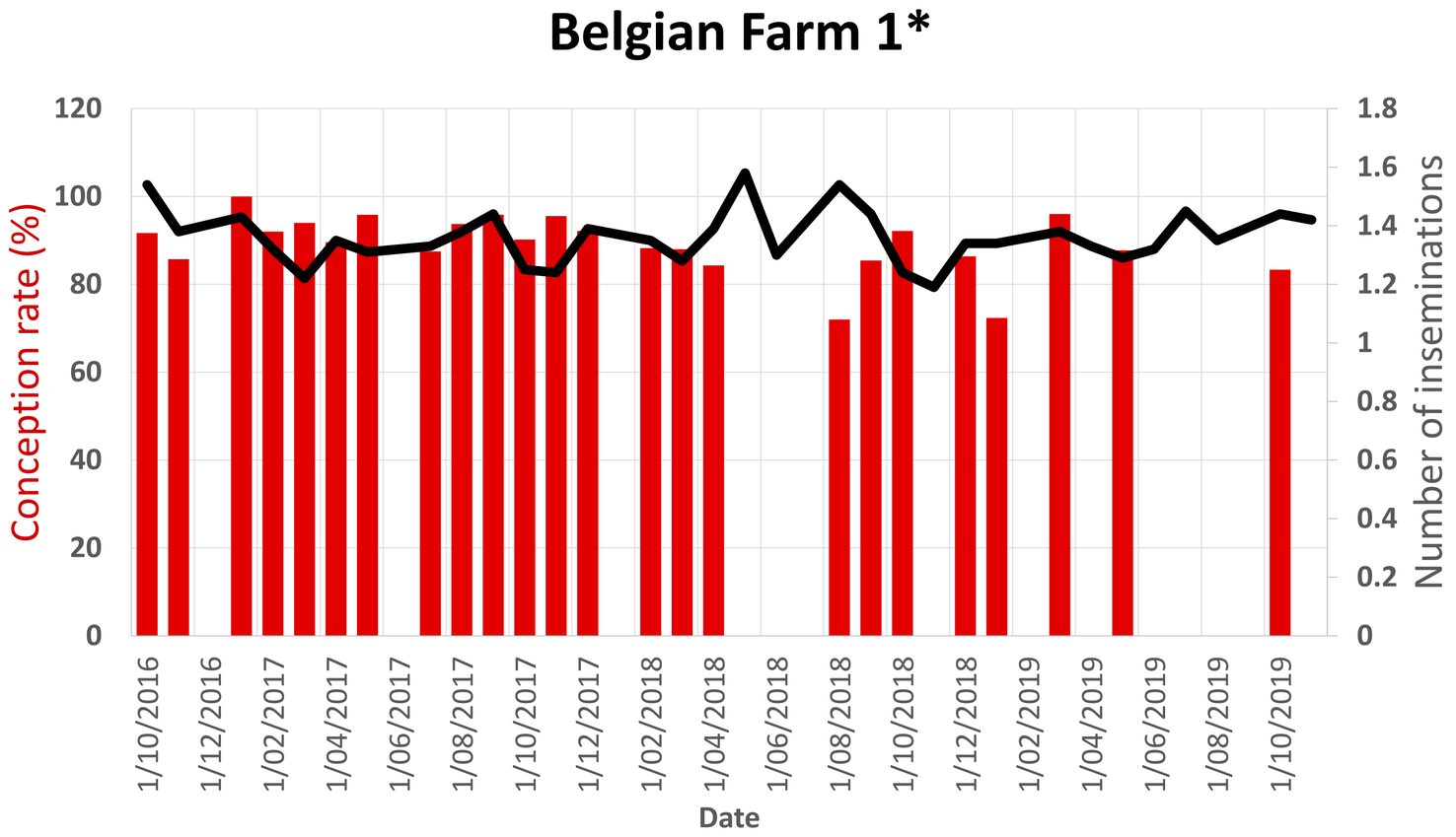
Number of months with the system: 26

Before

Number of doses/cycle: ?2,3
Conception rate: ?88%

After

Number of cycles: 1208
Number of doses/cycle: 1,4 (-0,9)
Conception rate: 89,5% (+1,5)**
Conception rate before June 2018: 91,8% (+3,8)



* Months (batches) at 0% conception rate are batches for which we are unsure of the data input by the client (no sows were signaled as ''return to heat'' or ''empty at preg. check'')
** Conception rate results until June 2019 only. Client has not had time to share newer results yet.

Belgian farm 2

Number of sows: 450

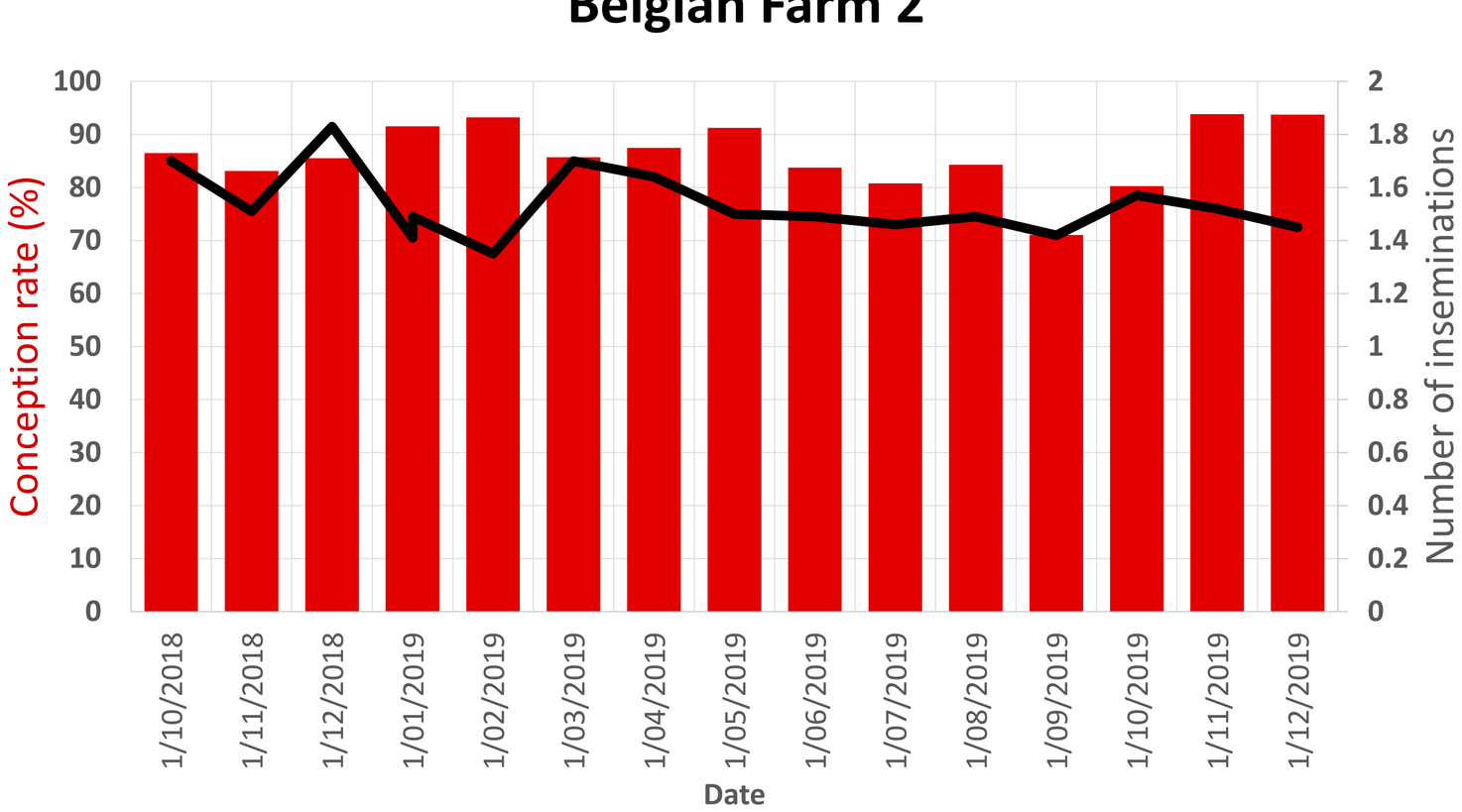
Number of months with the system: 14

Before

Number of doses/cycle: ?2,0
Conception rate: ?87,7%

After

Number of cycles: 1220
Number of doses/cycle: 1,5 (-0,5)
Conception rate: 86,4% (-1,3)*



* This client does not strictly follow the advices of the system. Our simulations show that a better use of the system could improve conception rate by 2% to 5%.

Belgian farm 3 (with cameras)

Number of sows: 300

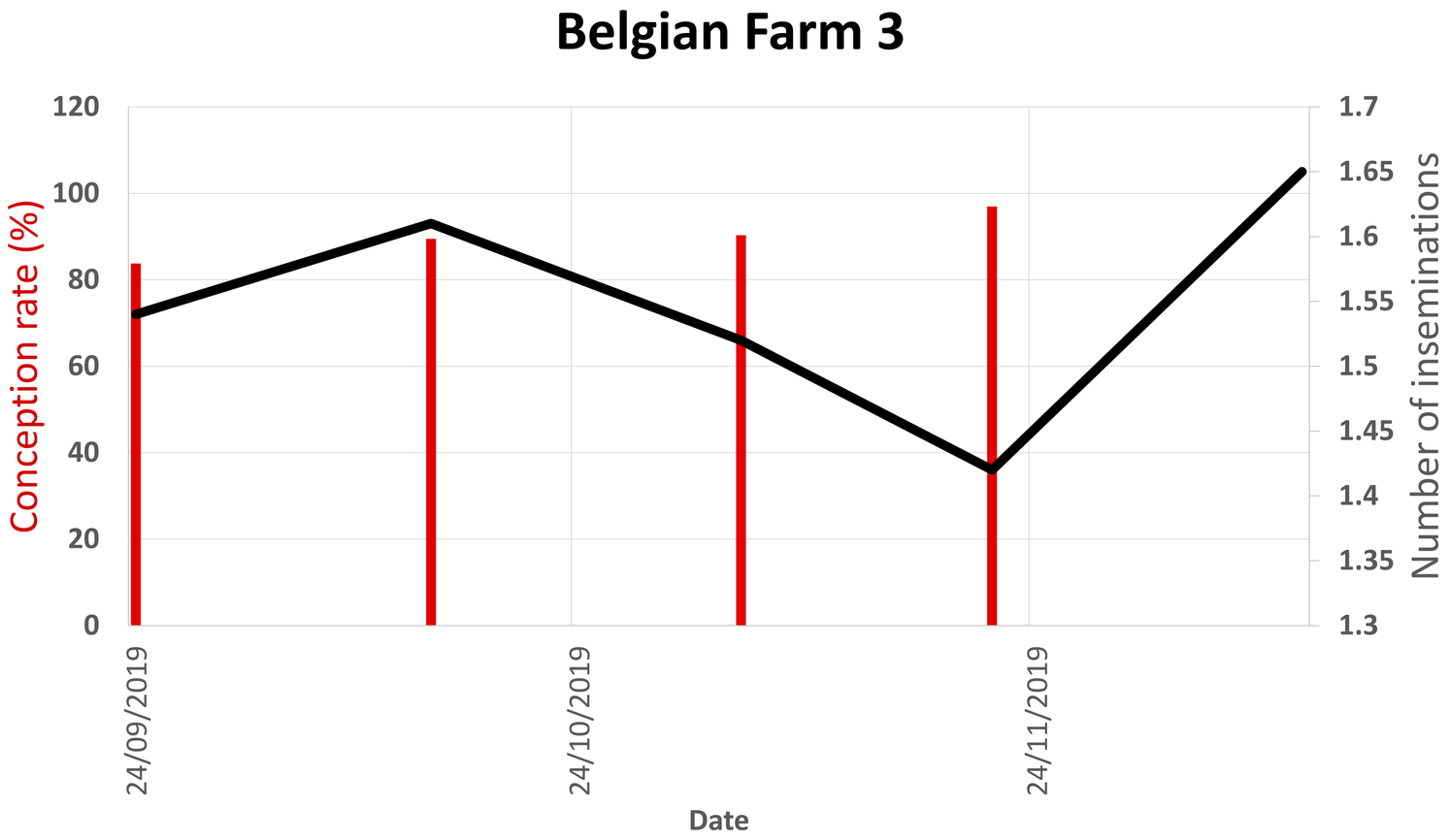
Number of months with the system: 5

Before

Number of doses/cycle: ?2,1
Conception rate: ?80%

After

Number of cycles: 139
Number of doses/cycle: 1,53 (-0,6)
Conception rate: 89,9% (+9,9%)



Worldwide results (since 2017, updated January 2019)

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	Number of cycles	Number of doses/cycle	Conception rate (%)
Total	43 351	1,38	90,1
Standard deviation		0,13	2,91

Number of farms since 2017: 12

Countries: Canada, USA, Belgium, Spain, Chile, Mexico

Size of farms: 150 to 4 500 sows

Other applications of the use of computer vision in swine production

smaRt Tracking

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- Allows to follow sows or pigs in a group
- Will eventually allow extending individual breeding management based on behaviour of sows in pens
- Could also be used for health and welfare management
- Can have many applications in swine farming

smaRt Counting

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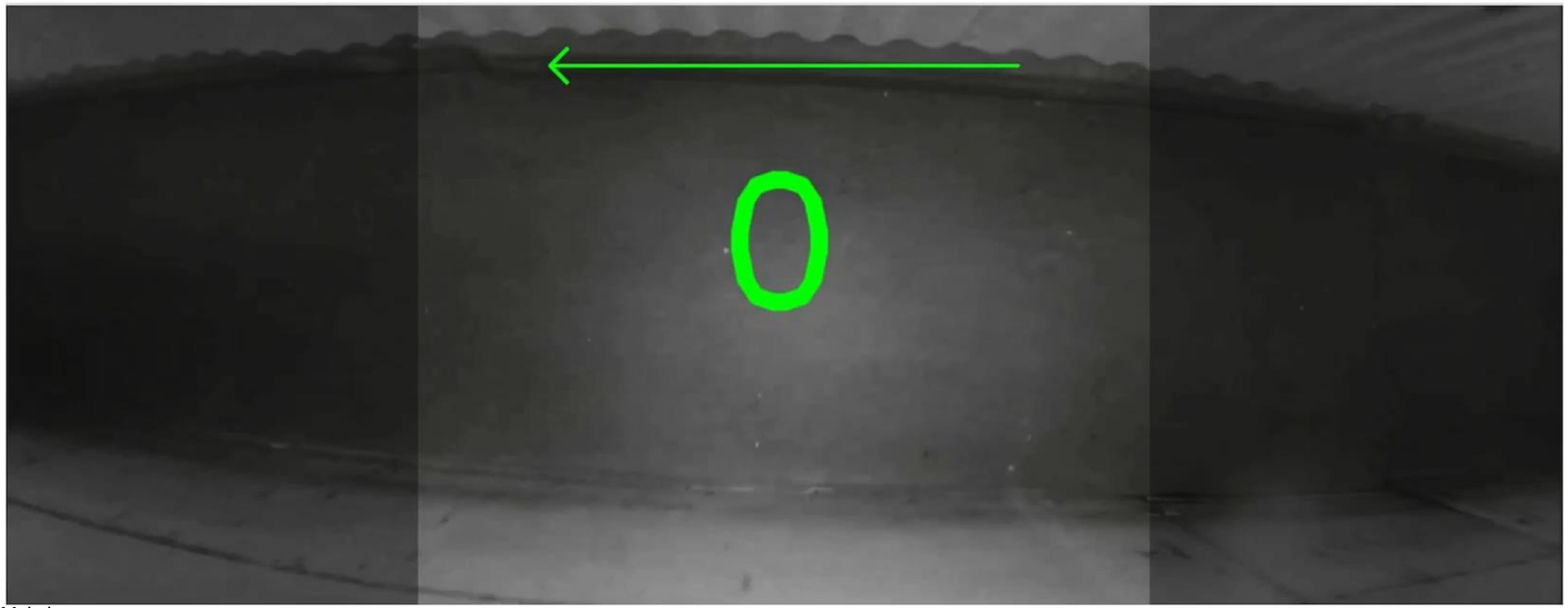
Counting from right to left!



Conclusion

Conclusion

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- smaRt Breeding is a tool combining the farmer's observation and 24/7 individual behaviour analysis allowing to achieve **natural single-dose precision breeding**
- Precision breeding has the potential to decrease dependency on skilled labour, improve reproduction results, optimise the use of the best boars, and ultimately accelerate genetic improvement.
- The effect of a single-dose precision insemination has not been extensively studied in the past because no method could make it possible. The industry needs to optimise single-dose insemination.
- Even though results are already good with our smaRt Breeding system, there is still room for improvement. Improvements will come in the form of software updates.
- Future work will aim to decrease the number of inseminations per sow, to decrease dependency on human heat detection, to increase conception rate, and to manage gilt behaviour, among others.