Tracking bull reproductive dominance by measuring male-female interactions using Bluetooth Low Energy

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Introduction

Natural mating with multiple sires is a common practice in beef cattle grazing systems

- *Pros*:
  - Reduction of herd sorting and paddock numbers
  - Reduction of reproductive failure: total or partial infertility of one sire can be compensated by others
  - Increase in the number of cows that conceive when there are many cows in heat at the same time
- *Cons*:
  - Difficulty in identifying calf sires (except when different breeds are used)
  - Potential injuries of bulls from fighting each other
  - **Dominance of one or a few bulls can lead to a reduction in genetic diversity**

How can we track bull dominance?

- Visual observation of cattle behavior: *time consuming*
- DNA testing: *sample collection and cost*
- **Can we use PLF tools to track bull dominance?**

Proximity sensors provide data on interactions between individual animals…

Study design

- Agrosilvopastoral cattle farm in southern Spain (217 ha divided into 13 paddocks)
- 53 Limousin and crossbred cows equipped with a BLE beacon
- 3 Limousin bulls equipped with a BLE reader plus a GNSS tracker
- Data gathering from December 1st to February 28th (2020-2021)
- Estrus/mating detection based on visual observation of behavior and Estrotec® adhesives
- Calf parentage testing based on 19 SNPs (blood samples)

id_itm	lat	lng	id_tag	quality	time_stamp
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3771FB	38,2374	-4,5614	AAB038	5	08/12/2020 7:22
3771FB	38,2374	-4,5614	AAB039	5	08/12/2020 7:22
3771FB	38,2374	-4,5614	AAB042	5	08/12/2020 7:22
3771FB	38,2374	-4,5614	AAB055	5	08/12/2020 7:22
3771FB	38,2374	-4,5614	AAB058	5	08/12/2020 7:22
3771FB	38,2374	-4,5614	AAB064	5	08/12/2020 7:22
3771FB	38,2374	-4,5614	AAB068	5	08/12/2020 7:22
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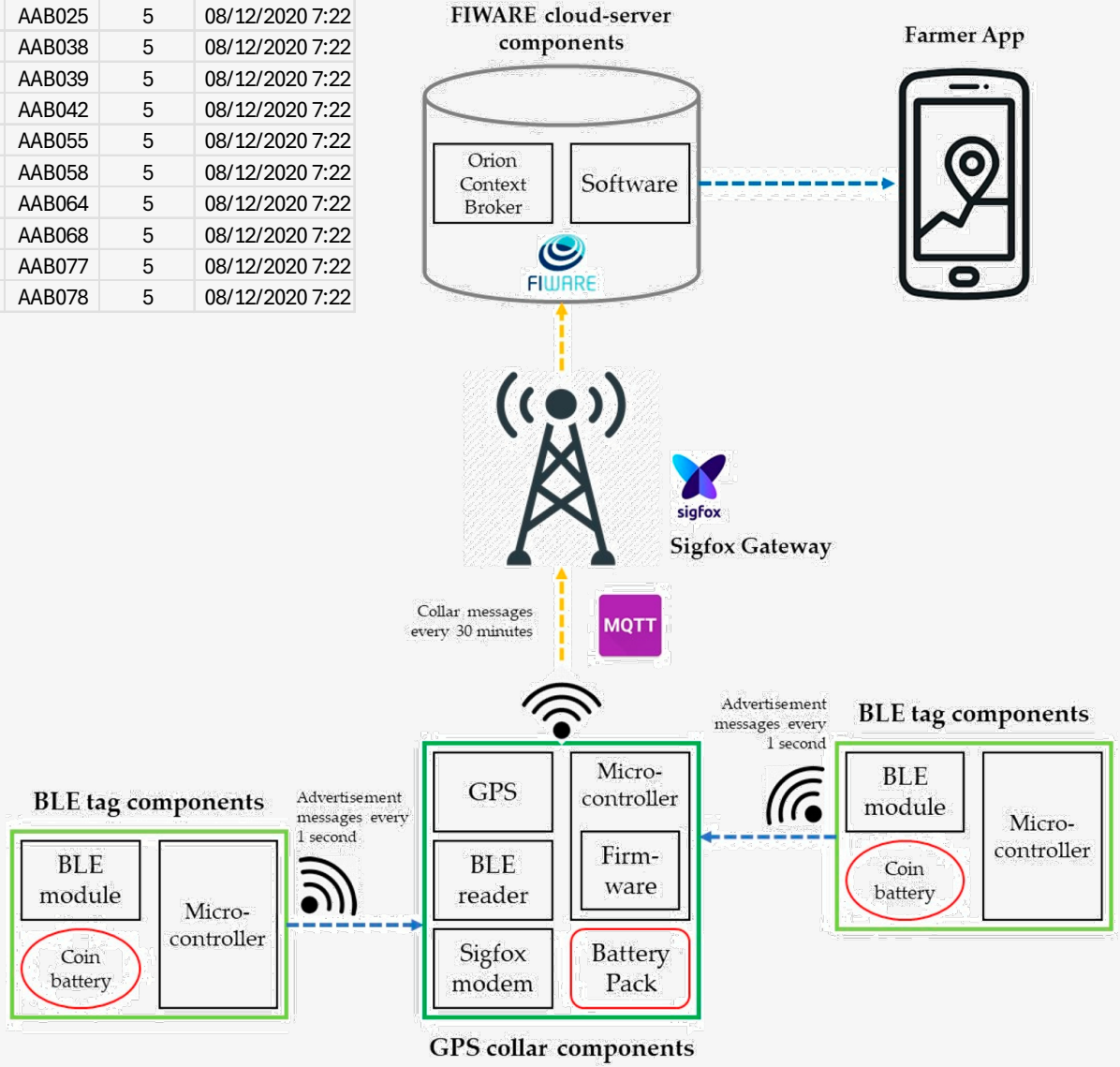


Maroto et al. (2019)

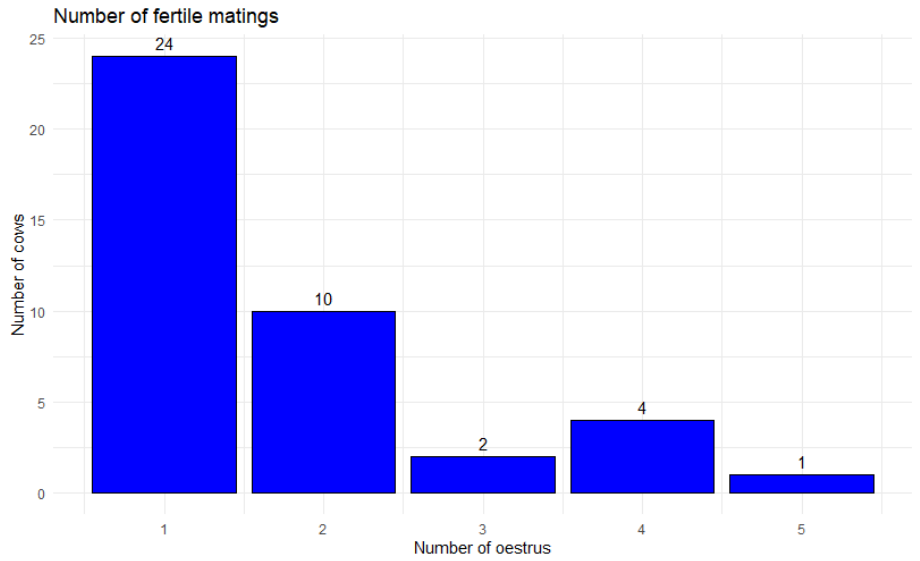
How the PLF system works?

- Temporal resolution of the reader: **30 minutes**
- Max. **10 beacons per message**
- Optimized to be compatible with battery duration (above one year) and LPWA connectivity

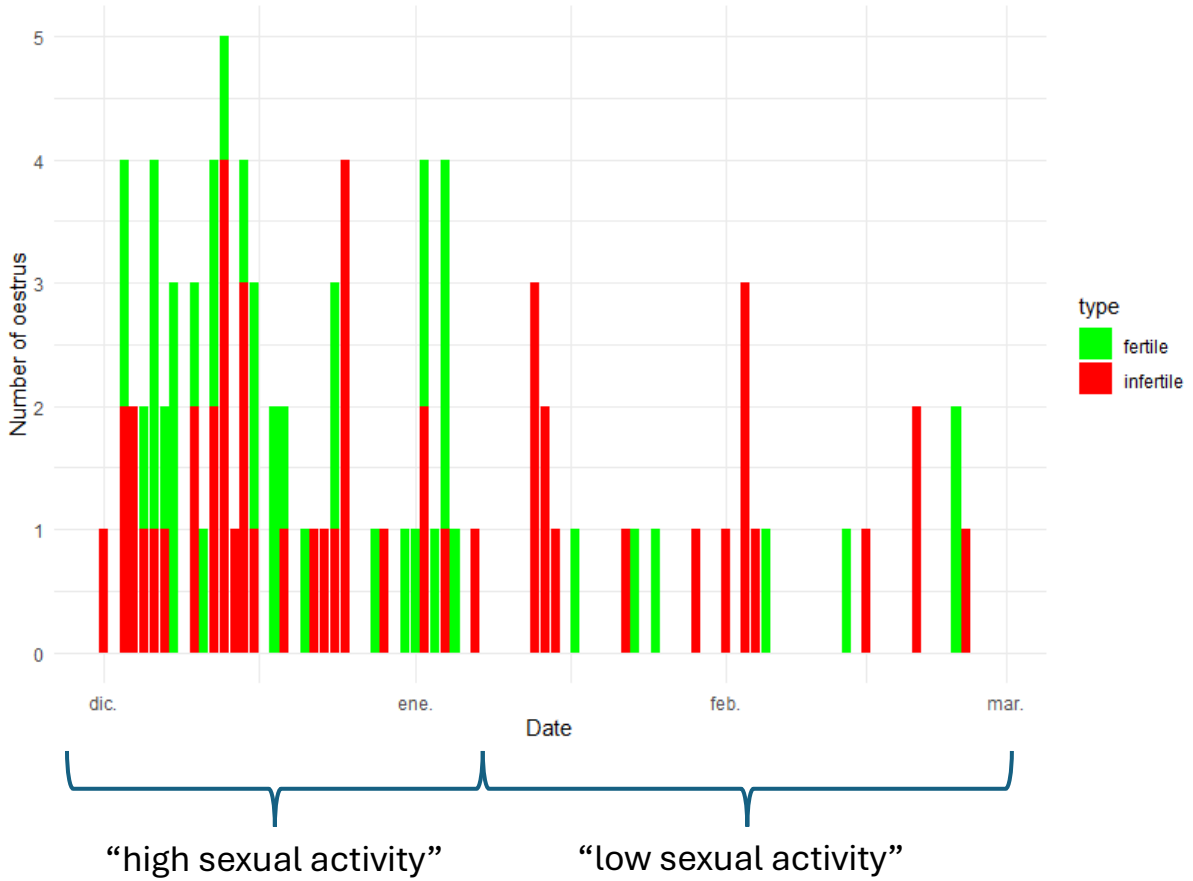
VS

Results

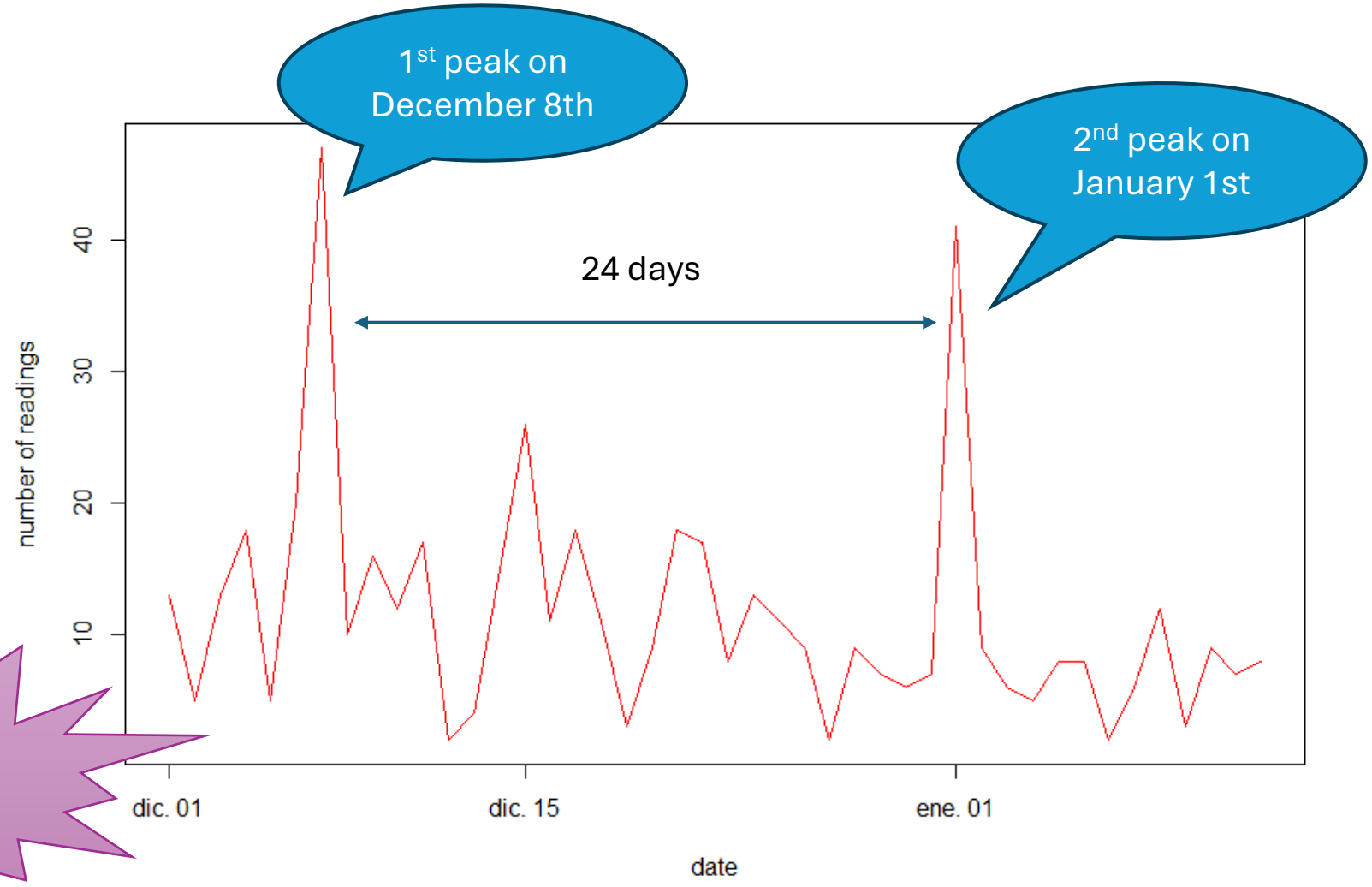
- 4 cows out of 53 did not show any estrus signs during the monitored period
- 92 estruses registered (61 monitored by sensors)
- 41 estruses were labelled as fertile (last estrus observed and calving occurring between 266 and 294 days after estrus date)



Oestrus distribution over time



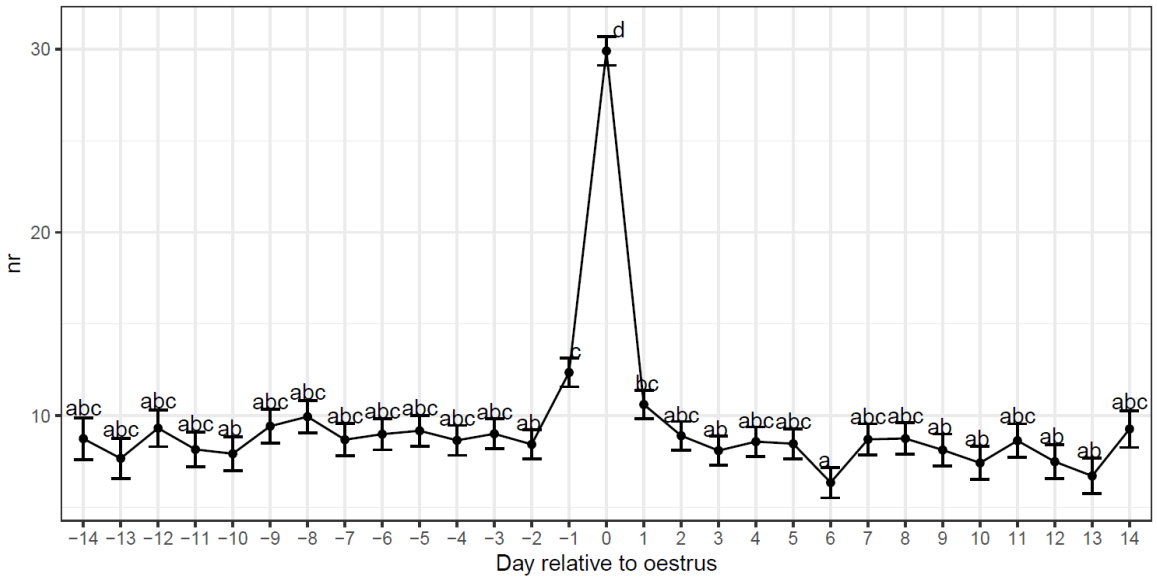
Proximity sensors work well for estrus detection

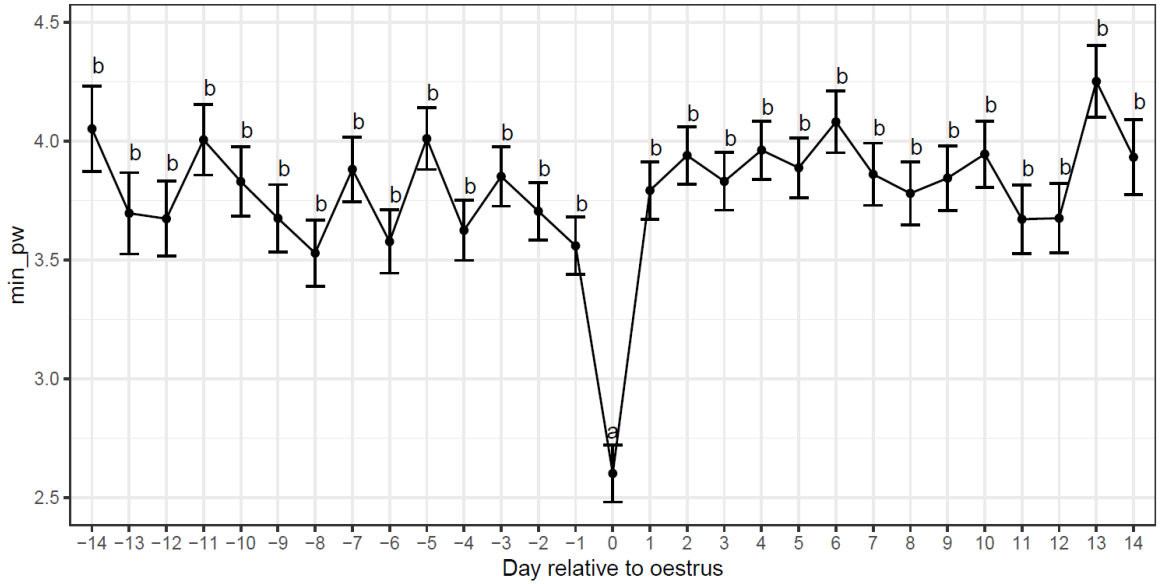


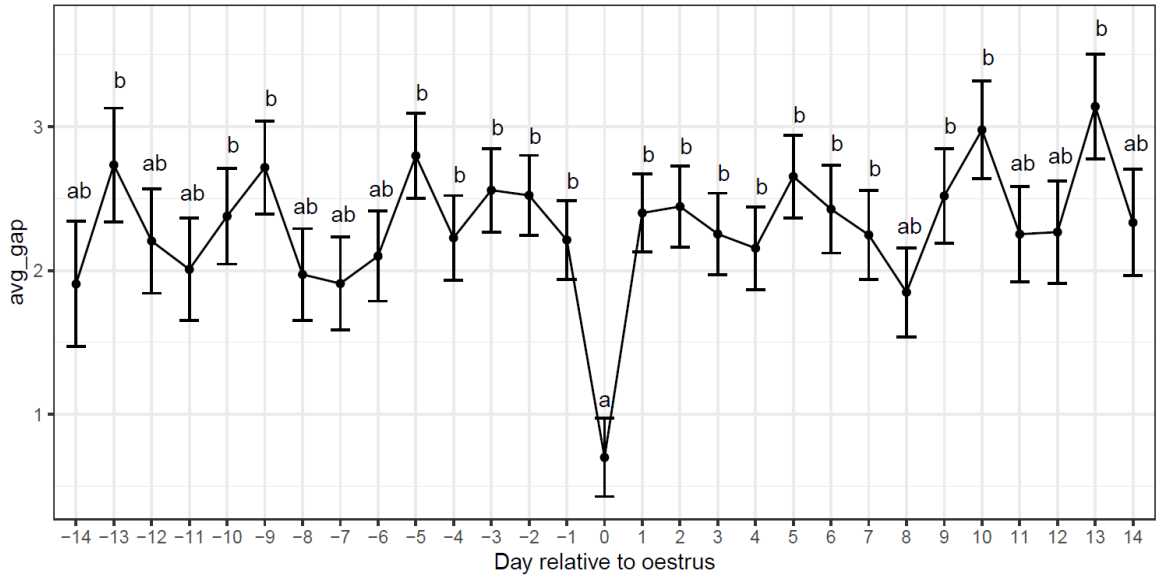
Reminder: we "only" measure proximity!!!

Cow calved on October 15th (+287 days)

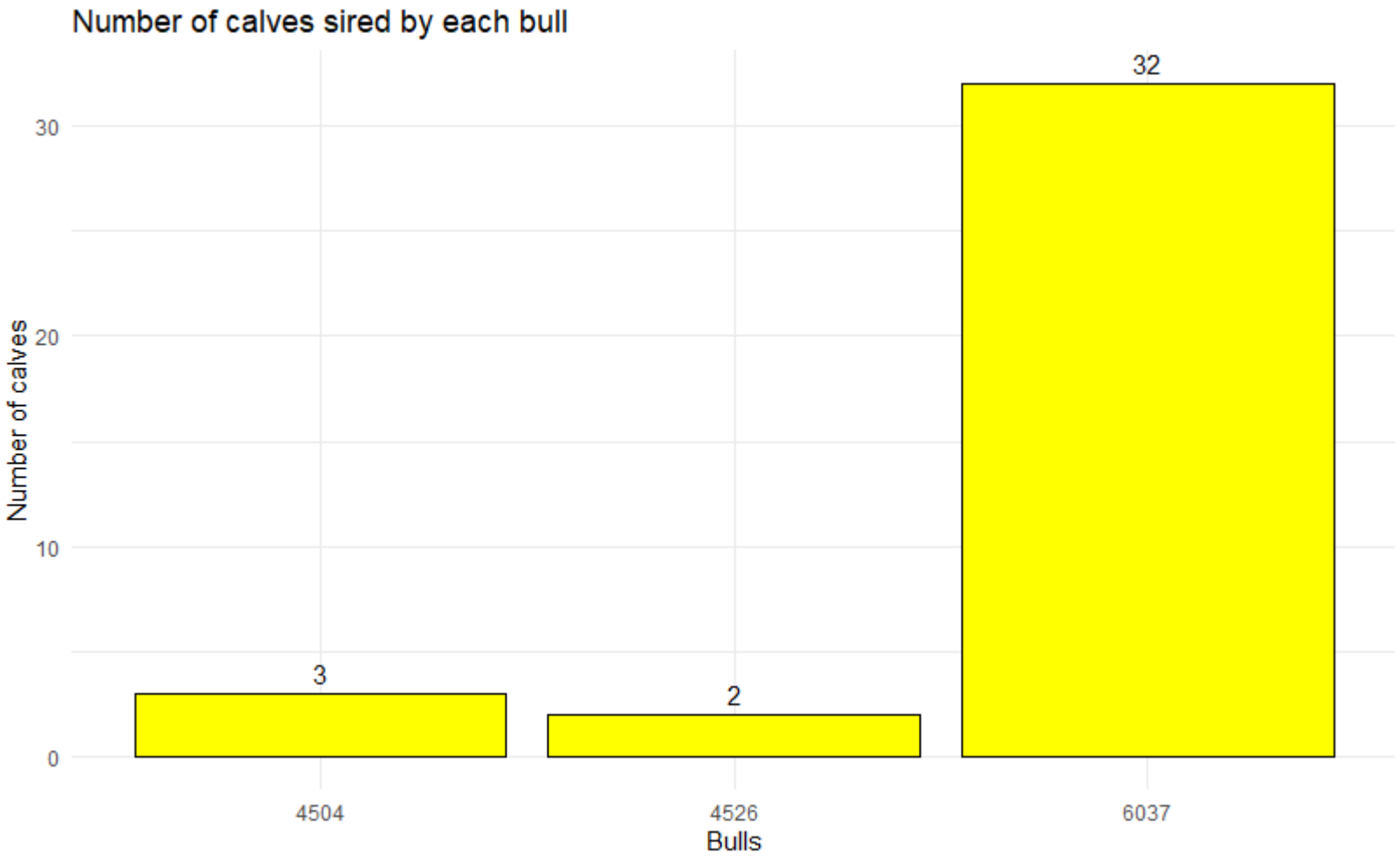
We can compute several estrus indicators







What about tracking dominance?



- Blood samples were not available for 4 out of 41 calves
- Bull 6037 sired 86% of calves: libido and fertility may also be involved, but this bull was clearly dominant (behavior)

Number of readings (proximity events)

Bull	Estrus days		Non-estrus days
	Cows in heat	Cows not in heat	
4504	8.74^{b}	2.69^{ab}	2.45
4526	8.44^{b}	2.89^{a}	2.51
6037	**10.75^{a}**	**2.56^{b}**	**2.46**
P-value	*0.020*	*0.002*	*0.851*

Effect of “high” vs “low” sexual activity

Bull	Number of cows in heat		
	1	2	≥ 3
4504	5.91	12.20	8.65
4526	7.73	8.50	8.62
6037	**10.09**	**12.50**	**10.50**
P-value	*0.217*	*0.271*	*0.098*

P-value (between number of cows in heat): 0.455
P-value (between periods): 0.056

Bull	Period	
	December: “high activity”	January to March: “low activity”
4504	9.54	5.77[b]
4526	8.88	6.85[b]
6037	**10.62**	**11.23[a]**
P-value	*0.213*	*0.017*

Average gap between readings

Bull	Estrus days		Non-estrus days
	Cows in heat	Cows not in heat	
4504	2.13	4.39	4.17[a]
4526	2.29	4.33	3.65[b]
6037	**2.04**	**4.45**	**3.87[ab]**
P-value	*0.608*	*0.758*	*0.049*

Minimum signal strength

Bull	Estrus days		Non-estrus days
	Cows in heat	Cows not in heat	
4504	3.57	4.37	4.43
4526	3.49	4.31	4.41
6037	**3.40**	**4.40**	**4.37**
P-value	*0.573*	*0.058*	*0.385*

What about parentage?

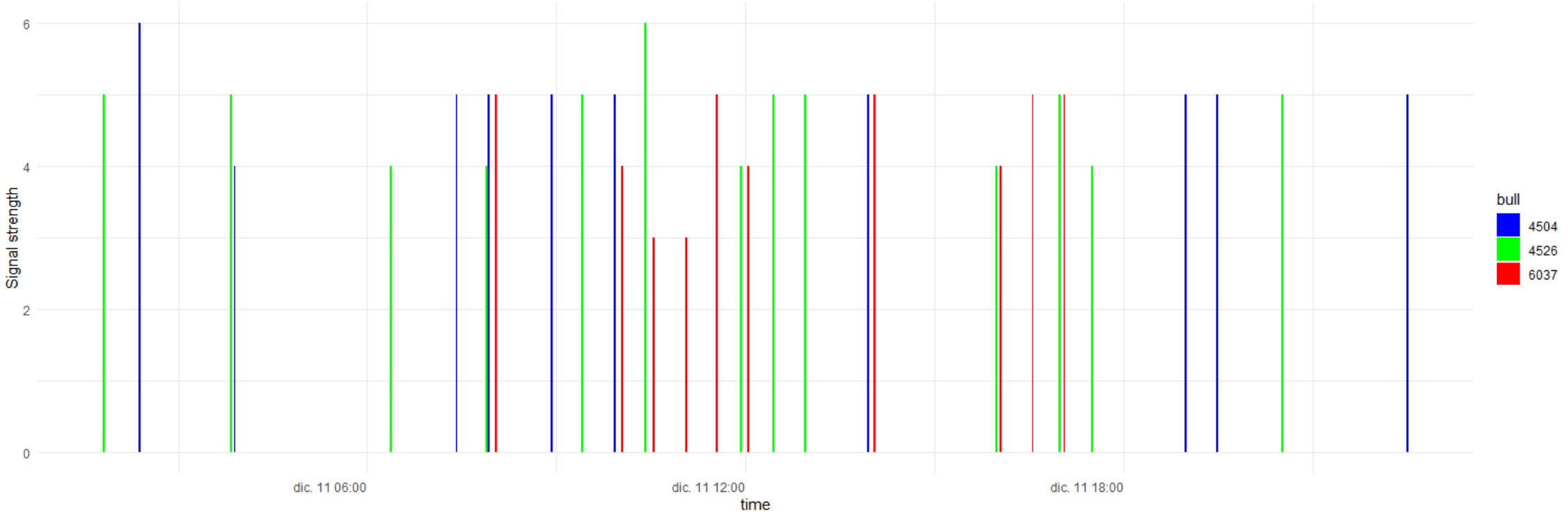
- Bull with most readings in fertile estruses was the sire in 36% of cases

- Two basic cases:
  - Bull 6037 was the sire & bull 6037 has the maximum number of readings: average difference in number of readings = + 9.75 (mostly in January - March)

  - Bull 6037 was the sire but bull 6037 had NOT the maximum number of readings: average difference in number of readings = - 1.75 (mostly in December)

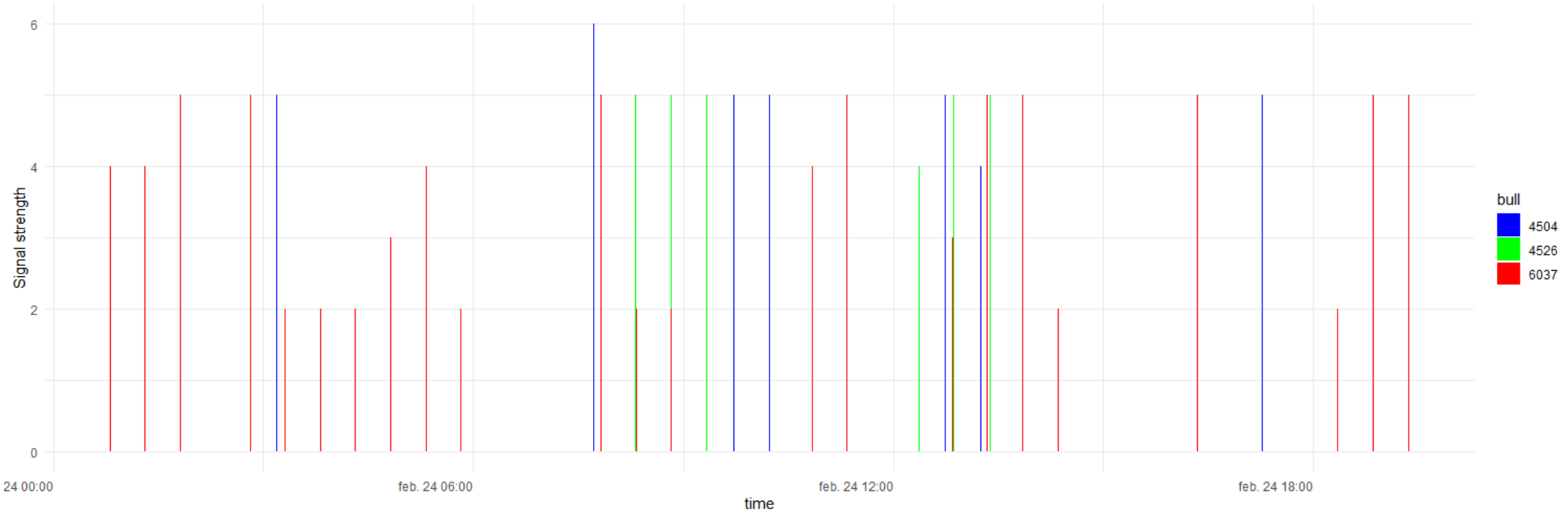
Readings chronological order

Cow with fertile estrus on December 11th



Readings chronological order

Cow with fertile estrus on February 24th



What about GNSS data?

Days	Length	Distance	Straightness	Sinuosity
Estrus	2965 m	201 m	0.064	0.176[a]
Non estrus	3016 m	194 m	0.068	0.164[b]
P-value	*0.464*	*0.761*	*0.693*	*0.025*

Days	Bulls	Length	Distance	Straightness	Sinuosity
Oestrus	4504	2993 m	192 m	0.063	0.168
	4526	3107 m	197 m	0.062	0.164
	6037	2875 m	202 m	0,072	0.177
	P-value	*0.607*	*0.976*	*0.744*	*0.361*
Non oestrus	4504	3002 m	211 m	0.076	0.154
	4526	3087 m	203 m	0.077	0.150
	6037	3039 m	156 m	0.058	0.169
	P-value	*0.938*	*0.365*	*0.439*	*0.111*

Conclusions

- Proximity data gathered with BLE sensors can serve to detect estrus under grazing conditions

- The number of interactions between cows in heat and each bull (BLE beacon readings), especially during periods when few cows are in heat at the same time, can be used as an indicator of dominance

- Further research is needed to explore the effect of bull-to-cow ratio, level of dominance, grazing management practices, etc.

Thank you for your attention!