



Detection of early behavioural signs of disease as a way to manage animal health

Isabelle Veissier, Nicolas Wagner, Marie-Madeleine Mialon, Romain Lardy, Dorothee Ledoux, Alice de Boyer Des Roches, Mathieu Silberberg, Bruno Meunier, Violaine Antoine, Jonas Koko

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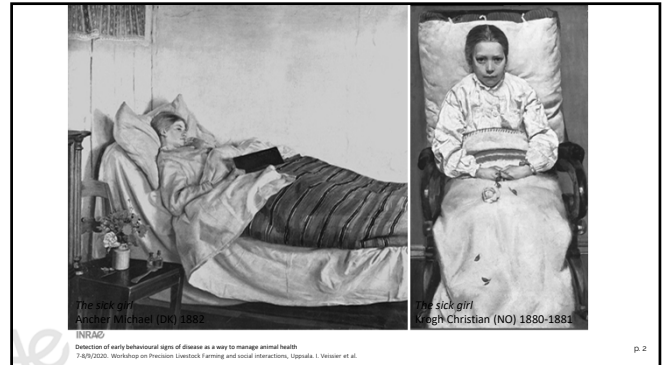


► Detection of early behavioural signs of disease as a way to manage animal health

Isabelle Veissier, Nicolas Wagner, Marie-Madeleine Mialon, Romain Lardy, Dorothée Ledoux, Alice De Boyer De Roches, Mathieu Silberberg, Bruno Meunier
(UMR Herbivores, Université Clermont Auvergne, INRAE-VetAgro Sup, France)

Nicolas Wagner, Violaine Antoine, Jonas Koko
(Limos, Université Clermont Auvergne Université, France)

Workshop on precision livestock farming and social interactions in dairy cattle, Uppsala 7-8 September 2020



► Sickness behaviour (in humans and non-human animals)

Infection can cause a range of behavioural modifications leading to a lethargic state

- Reduced activity
 - Increased sleeping and at times when it is normally awake,
 - Reduced feed and water intake,
 - Less interaction with conspecifics or with humans (Hart, 1988; Dantzer & Kelley, 2007; Byrd & Lay, 2018)
- = 'sickness behaviour'

Can we use sickness behaviour as an early sign of a health disorder?
Can PLF technology be used for this?



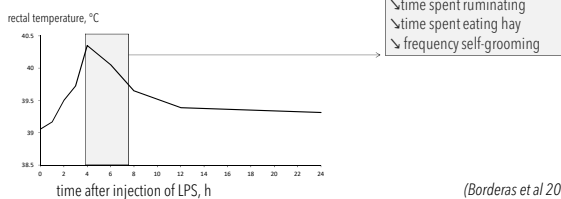
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Evidence that cattle behaviour is altered under disease or pain

► Sickness behaviour in calves (fever)

Injection of LPS in calves



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► Sickness behaviour in cows (1/2)



	Control	Heat load	Metritis
Brush use No. events/d	4.5	-0.062 /THI unit	
Duration/d	88 s		44 s

(Mandel et al 2013, 2017)

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➤ Sickness behaviour in cows (2/2)

Intramammary inoculation of E Coli in lactating cows

Phase	Before inoculation	Pre-clinical	Acute phase	Remission (immune resp.)
E.Coli in milk	-	↗↗	-	-
SCC			↗↗	↗
Body core T°			↗↗	
Inflamm. Prot.*	-	-	-	↗↗
Behaviour	-	↗lying	↗lower head ↘attention ↗cortisol	-

(De Boyer et al. 2017)

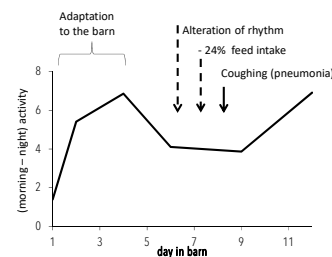
Behavioural signs may occur earlier than clinical signs

* haptoglobin, SAA

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➤ Disruption of circadian rhythm under disease



(Veissier et al. 1999)

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➤ 'Animal don't talk' but their behaviour talks for them

- Cow and calf behaviour can be modified under illness or pain
- The changes can be subtle:
 - No specific behaviour is produced
 - But the frequency / duration of behaviours change
- Farmers regularly look at their animals (at least once a day):
can they always detect such subtle changes?



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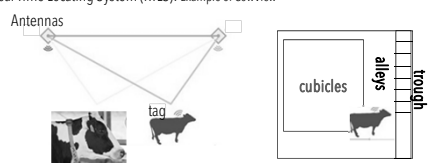
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Use of Precision Livestock Technologies to detect subtle changes in behaviour due to sickness

➤ Precision Livestock Techniques to monitor animal behaviour

Accelerometers to detect lying, standing, eating
Image analysis
Feed bins detecting when and how much an animal is eating
...

Real Time Locating System (RTLS): Example of CowView



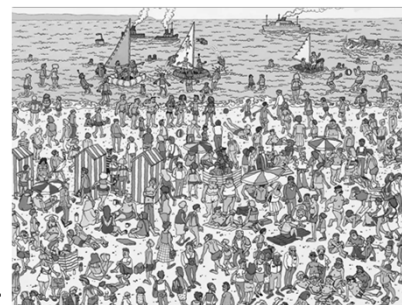
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With PLF techniques,

- one has access to information 24h/h on individual animals
- large amounts of data are produced that need to be processed to become meaningful, and by thus likely to help farmers to take decisions



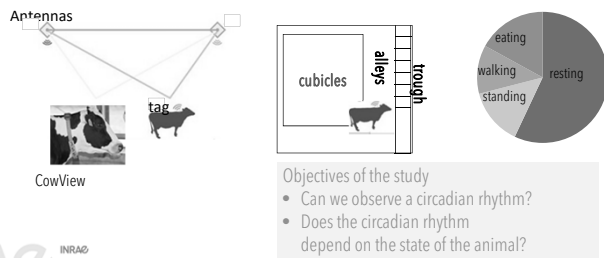
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► Use of RTLS (CowView) to study circadian rhythm

RTLS

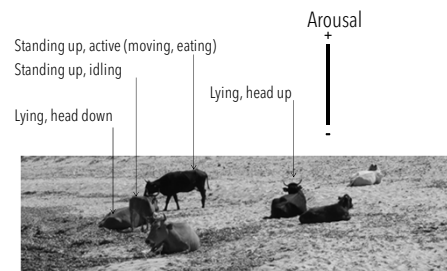


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► Cows' main activities



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► Calculation of arousal level (1/2)

Raw data : activity of each animal per scan (1 scan / s)

Weighted sum

$$\sum_{i=1}^n (\text{time spent in activity } i) \times (w_i) \leftarrow \text{weight reflecting the level of arousal associated to the activity}$$

To obtain weights: Factorial Correspondence Analysis

observation: each hour (0-1 h; 1-2 h; ...; 23-24 h)

variables: number of scans x animals in each activity

► 1st axis : activities are sorted according to arousal:

$$-0.23 \text{ resting} + 0.16 \text{ in alleys} + 0.42 \text{ eating}$$

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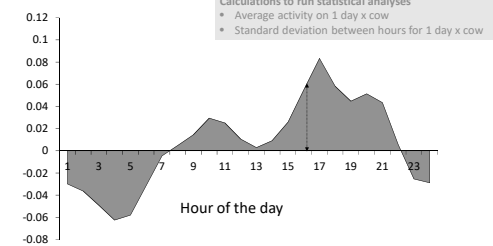
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► Calculations to describe the circadian activity (2/2)

1st results on 1 farm 350 cows x 5 mo

Activity level



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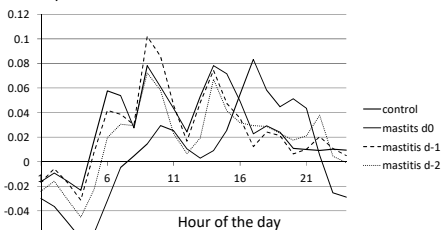
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► Mastitis

1st results on 1 farm 350 cows x 5 mo

Activity level



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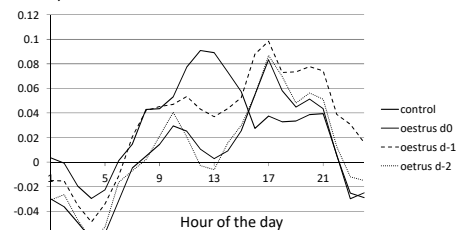
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► Oestrus

1st results on 1 farm 350 cows x 5 mo

Activity level



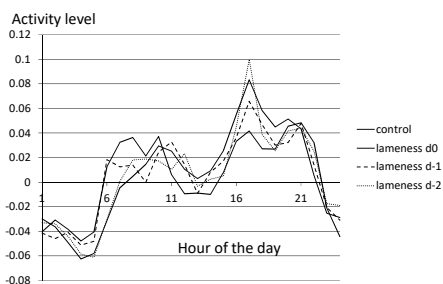
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Lameness

1st results on 1 farm 350 cows x 5 mo



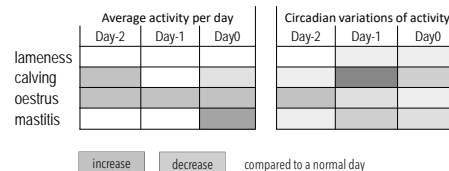
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Disruption of the rhythm

1st results on 1 farm : 350 cows 5 mo (DK)



increase decrease compared to a normal day

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How to detect when the behaviour is getting abnormal?

- Example of a study carried on circadian rhythm of activity using PLF technology and Machine Learning -

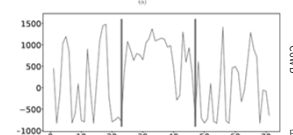
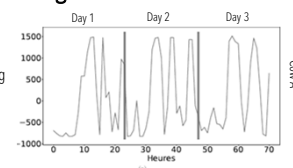
Next: when does the rhythm changes?

Statistical approaches allow highlighting differences but not making predictions

→ Need for modelling 'normal' rhythm then detecting when there is a deviation from this norm

Difficulties: lot of spontaneous variations between

- farms
- cows
- days



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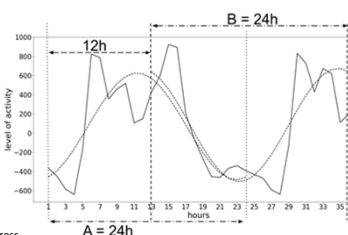
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FBAT method - principles

- Use of **Fourier Transform** to model the activity on a specific cow*day (24 h)
- Repeat the modelling 12 h later
- Calculation of the **Euclidian distance** between the 2 models
- If the distance is above a certain threshold the rhythm is supposed to have changed

(Wagner et al., 2020. Detection of changes in the circadian rhythm of cattle in relation to disease, stress, and reproductive events. To appear in METHODS)



$A \neq B$ or $A = B$?

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FBAT method - performances

- 4 datasets are used (small vs. large, commercial vs. experimental farm)
- Any disorder is noted by caretakers in a Logbook
- The threshold to distinguish normal vs. abnormal rhythm is optimised to match with day without vs. with a disorder detected by caretakers

Performances

% false positive : 20%
% detection of something happening:
60 - 100 %
can be 90-100% in case of a health problem

Large commercial farm

Events	% events detected			
	1	2	3	4
Accidental events	-	-	-	100
Calving	100	-	-	99.4
Oestrus	95.1	85.7	69.2	91.4
Lameness	100	93.8	-	98.2
Mastitis	100	-	-	87.5
Other disease	80	75	-	90.9
LPS injection	81.5	-	-	-
Ruminal acidosis	-	69	-	-
Mixing	68.3	-	-	-
Disturbance	69	71.7	-	59.3

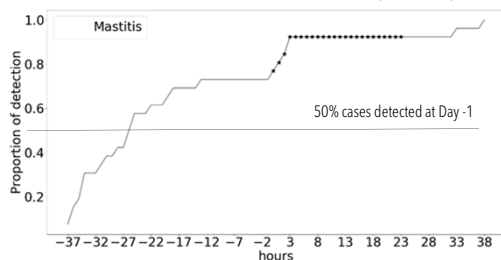
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Does FBAT allows early detection?

day of detection by caretakers



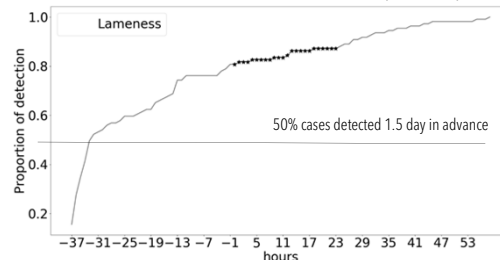
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Does FBAT allows early detection?

day of detection by caretakers



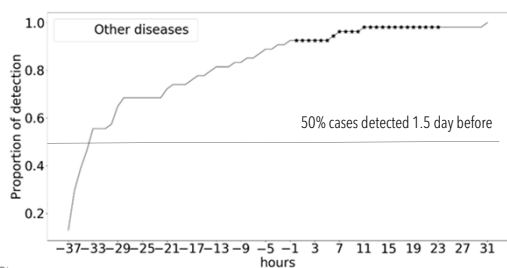
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Does FBAT allows early detection?

day of detection by caretakers



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Therefore,

Disease (especially with fever) **alter behaviour**

- may alter the frequency of maintenance activities (lying, standing, feeding)
- alter specifically less frequent activities (eg grooming)
- alters the circadian rhythm

Monitoring behavioural signs seems valuable to detect **preclinical states** and to take quick action: close observation of the animal, isolation, treatment

→ treatment is easier (less medicine, quick recovery)

The changes in behaviour are not always easy to detect from observation: e.g. grooming is 'rare', rhythm of activity is seen only from continuous observations and requires to remove 'noise' in data

These activities and changes can now be **monitored continuously thanks to PLF technologies**.

This requires **developing algorithms** to extract valuable information

→ collaboration between biologists and IT people.

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