Potential benefits and risks of using Precision Livestock Farming technologies to manage animal welfare -Recent developments at INRAE

Isabelle Veissier, Nicolas Wagner, Marie-Madeleine Mialon, Romain Lardy, Dorothee Ledoux, Mathieu Silberberg, Bruno Meunier

INRAE

Potential benefits and risks of using Precision Livestock Farming technologies to manage animal welfare – Recent developments at INRAE

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Animal Welfare Research Network, Precision Livestock Farming Workshop, 20 November 2020, Reading

Animal welfare management

On the long term, one need to have an idea of the level of welfare in order to improve animal living conditions: **welfare assessment**

On the short term, one should be informed of deviations from normal: **welfare monitoring**

deviation → warning → management action :

- Collection of more information to understand the causes of the deviation
- Isolation of an animal from its group in case of infectious disease or severe aggressions from other animals
- Remedial action: Medical treatment, adjustment of barn ambiance

…

Rationale

Welfare: a matter of what the animal feels, generally seen through animal behaviour

Ex: sickness behaviour

This girl is sick → she feels sick
(health) (welfare)

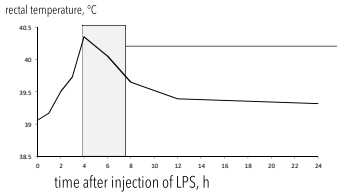
Can we grasp this feeling?

The sick girl
Ancher Michael (DK) 1882

The sick girl
Krogh Christian (NO)
1880-1881

Sickness behaviour in calves (fever)

Injection of LPS in calves



↗time lying inactive
↘time spent ruminating
↘time spent eating hay
↘ frequency self-grooming

(Borderas et al 2008)

Sickness behaviour in cows (2/2)

Intramammary inoculation of E Coli in lactating cows

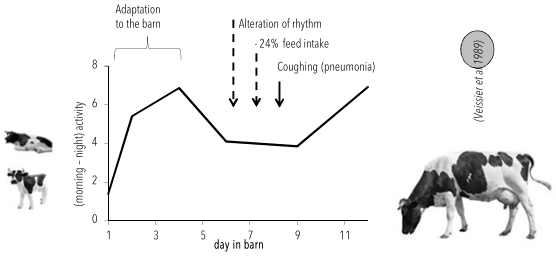
Phase	Before inoculation	Pre-clinical	Acute phase	Remission (immune resp.)
E.Coli in milk	-	↗↗	-	-
SCC			↗↗	↗
Body core T°			↗↗	
Inflamm. Prot.*	-	-	~	↗↗
Behaviour	-	↗lying	↗lower head ↘attention ↗cortisol	-

(De Boyer et al, 2017)

* haptoglobin, SAA

Behavioural signs may occur earlier than clinical signs

Disruption of circadian rhythm under disease



(Veissier et al 1989)

Behavioural signs may occur earlier than clinical signs

'Animals don't talk' but their behaviour talks for them

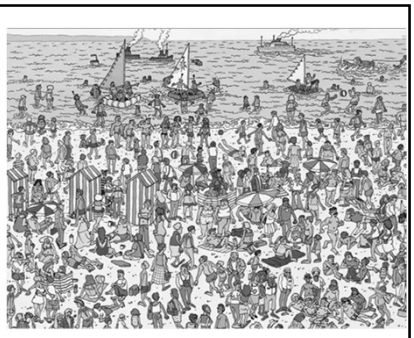
- Cow and calf behaviour can be modified under illness or pain
- The changes can be subtle:
  - No specific behaviour is produced
  - But the frequency / duration of behaviours change
- Farmers regularly look at their animals (at least once a day): can they always detect such subtle changes?

PLF technologies in use

- Real-Time Locating Systems (RTLS)
- Accelerometers
- Cameras coupled with image analysis
- Sound recording
- Temperature and humidity recording
- Weighing scales to weigh animals or control their feed intake
- Specific sensors to monitor biomarkers such as ruminal pH in cows, hormones or gases in a barn
- Electronic identification of large animals (cattle, pigs) thanks to Radio Frequency Identification (RFID)
- …

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



Where's Wally?

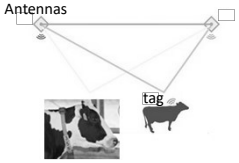
How to detect when the behaviour is getting abnormal?

- *study carried on circadian rhythm of activity* -

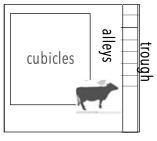
Use of RTLS (CowView) to study circadian rhythm

RTLS

Antennas



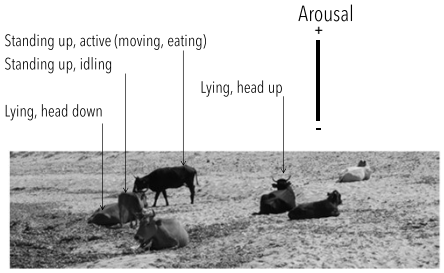
CowView



Objectives of the study

- Can we observe a circadian rhythm?
- Does the circadian rhythm depend on the state of the animal?

Cows' main activities



Calculation of arousal level (1/2)

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

Weighted sum

$$\sum_{i=1}^{n} (\text{time spent in activity i}) \times (w_i)$$ ← 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)

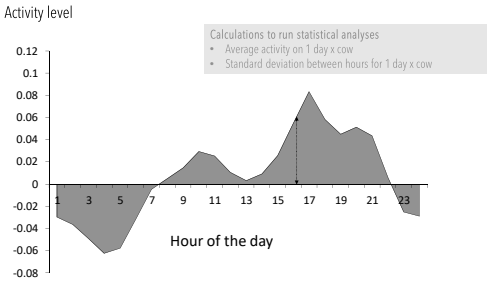
variables: number of scans x animals in each activity

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

-0.23 resting +0.16 in alleys + 0.42 eating

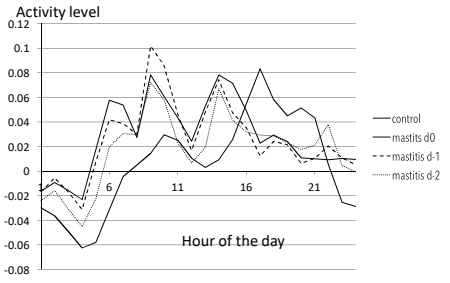
Calculations to describe the circadian activity (2/2)

1st results on 1 farm 350 cows x 5 mo



Mastitis

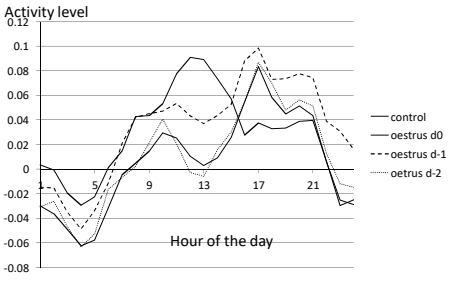
1st results on 1 farm 350 cows x 5 mo



(Veissier et al 2017. DOI : 10.3168/jds.2016-11853)

Oestrus

1st results on 1 farm 350 cows x 5 mo



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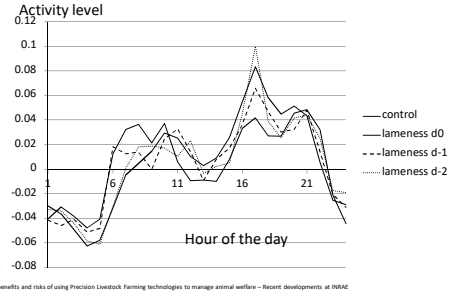
Lameness

1st results on 1 farm 350 cows x 5 mo



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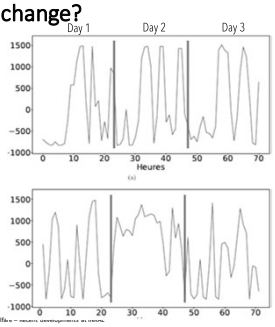
Next: when does the rhythm change?

Statistical approaches allow highlighting differences but not making predictions

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

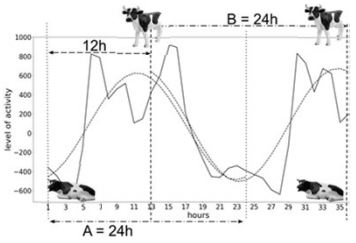
Difficulties: lot of spontaneous variations between

- farms
- cows
- days



FBAT method - principles

- Use of **Fourier Transform** to model the activity on a specific cow*day (24 h)
- Repeat the modelling 12 h later
- Calculate 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. DOI: 10.1016/j.ymeth.2020.09.003)

A ≠ B or A = B ?

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

Large commercial farm

% events detected

Events	Datasets			
	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

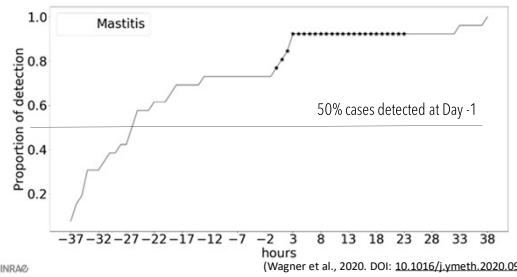
Performances

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

(Wagner et al., 2020. DOI: 10.1016/j.ymeth.2020.09.003)

Does FBAT allow early detection?

****
day of detection by caretakers



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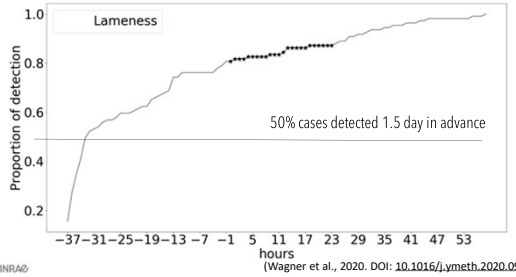

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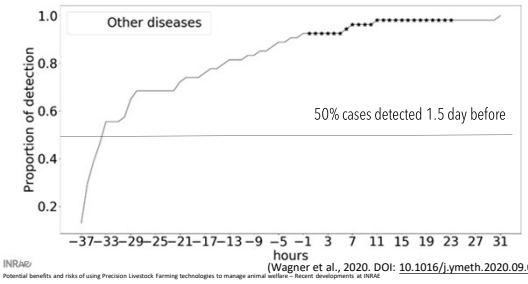

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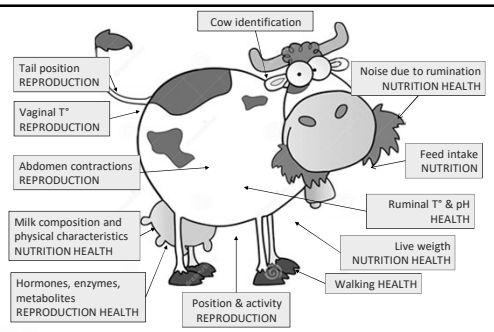
Risks of using PLF to address animal welfare issues

Risks of PLF use for animal welfare

Few PLF tools available for animals outdoors

PLF induces a change in farmer work
- → Risk to lessen the "care relationship" (observations, interactions with animals)
- → Animal less accustomed to human contacts and therefore more difficult to handle?
- → Risk to rely only on what the PLF technologies tell



From http://agriculteur-charolais-rouge.fr/actualites/elevage-cause-nationale-developpement-et-perspectives-des-capteurs.WOLQKAJF.html

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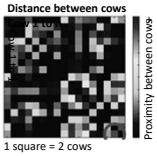
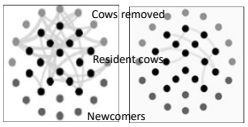
At present: PLF technologies are focused on production (reproduction) and health
- → Risk to define animal welfare based on what the technologies tell thus not taking into account aspects such as emotions, social interactions, etc.

Going further what is proposed by manufacturers : Analysis of social networks

RTLS

CowView





The whole network is weakened when new cows are introduced.
The newcomers are not yet integrated in the network 2 weeks after mixing.

Rocha L.E.C. et al., 2020. DOI: 10.1016/j.applanim.2019.10

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At present: PLF technologies are focused on production (incl reproduction) and health
- → Risk to define animal welfare based on what the technologies tell thus not taking into account aspects such as emotions, social interactions, etc.

→ Urgent need that biologists, IT developers and manufacturers work together to design tools that address animal welfare in its various facets, and make clear what these technologies do and don't do

Buller H. et al. DOI:10.3390/ani10101779

Thanks for your attention