DairyCare

cost

Current and future prospects for the automatic recording and control of ruminant foraging on farms

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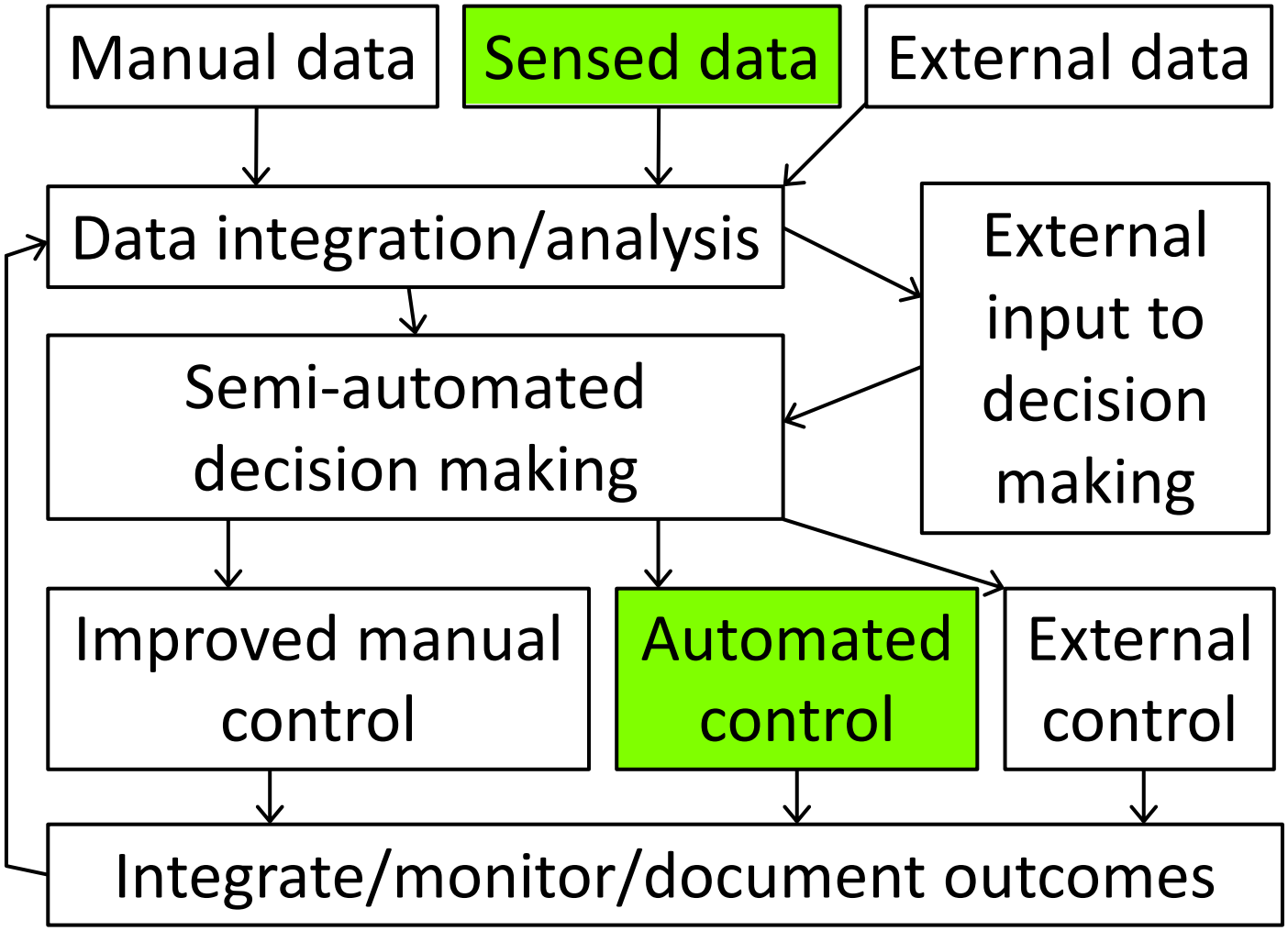
Outline

- Measuring ruminant foraging behaviour
  - Current on-farm foraging related PLF
  - Where are the gaps?
  - What technologies might fill the gaps?
- Controlling ruminant foraging behaviour
  - Grazing management
  - Facilitating diet selection

Precision Livestock Farming

- Livestock production has been **intensified** to help us control production (at the **group** level)
- **Precision livestock farming** (PLF) is changing this:
  - Gather data from **individual animals** so we can then manage them as individuals
  - Much closer monitoring and control
  - Increased use of robotics
  - Greatest **initial** uptake is in the dairy sector

Precision farming



What about feeding-related behaviours?

Control diagram adapted from Banhazi, 2011

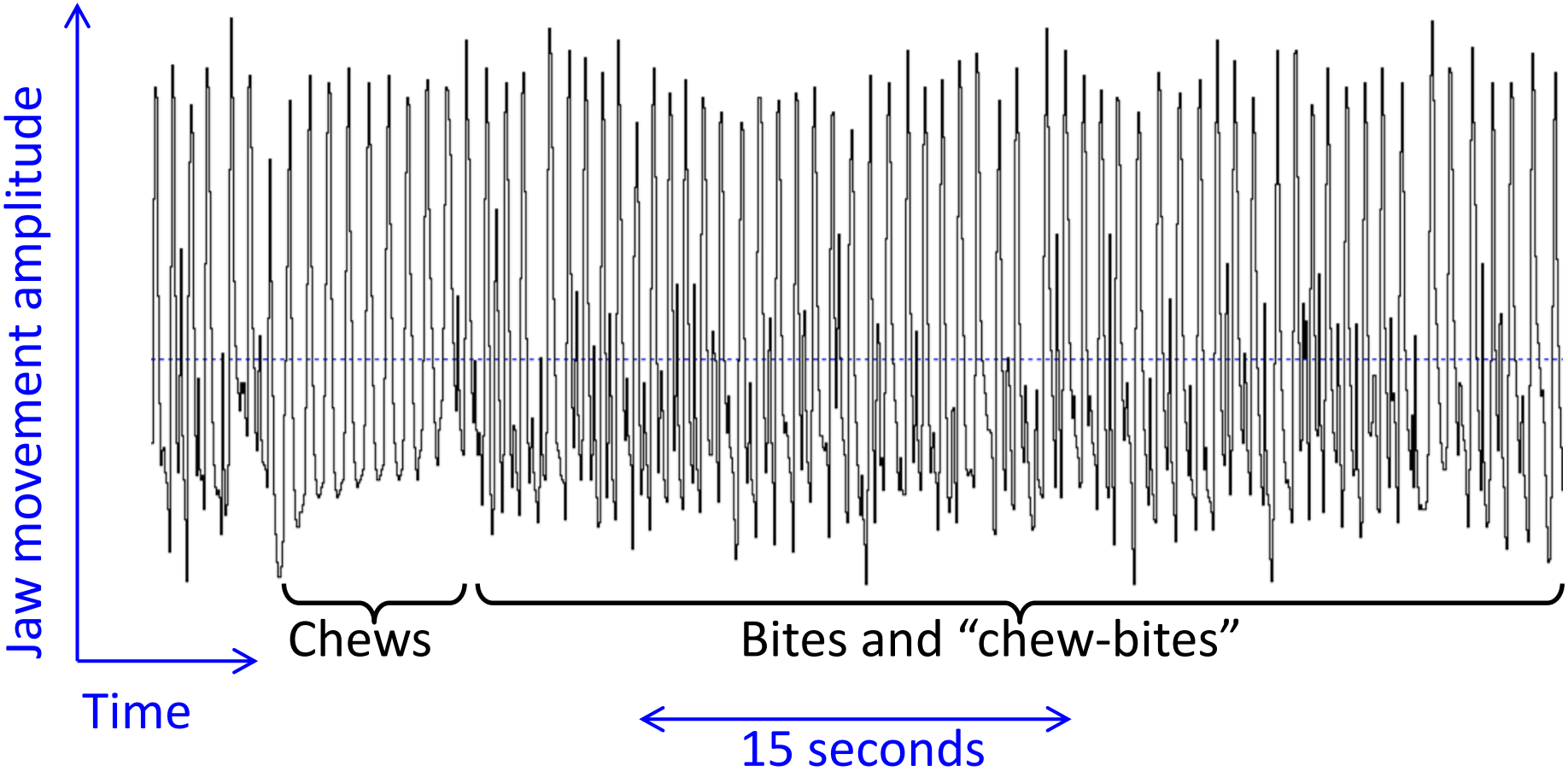
Jaw movement recorder

The development of a **noseband sensor** allowed the opening and closing of the jaws to be recorded

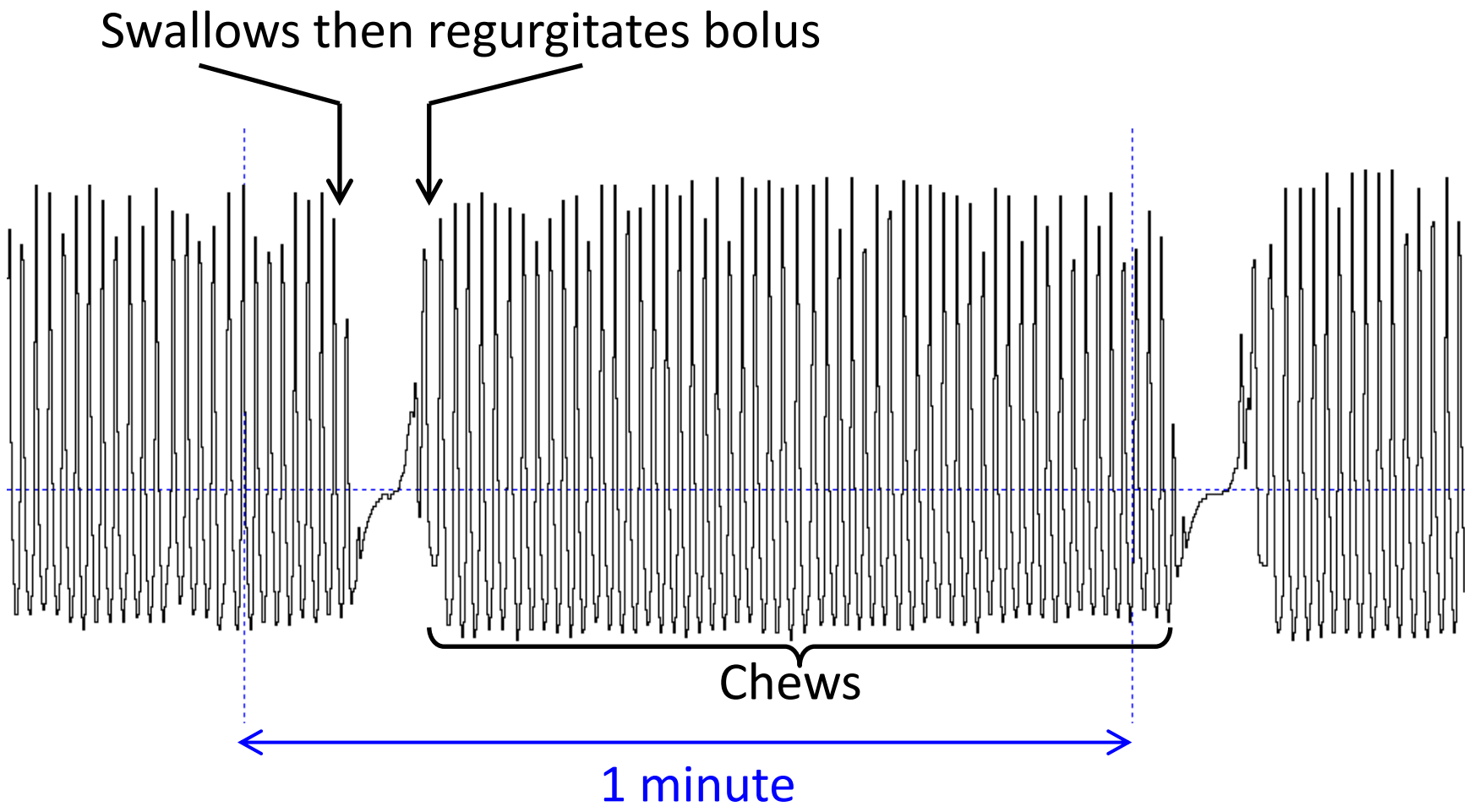
20Hz (<2MB per day)

- This formed the basis of the **'IGER Behaviour Recorder'** and **Graze** analysis software

Cattle grazing jaw movements



Rumination jaw movements



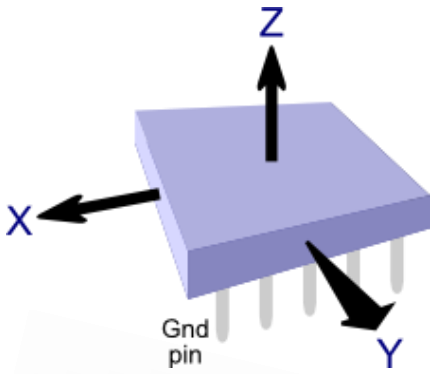
RumiWatch

- RumiWatch (ITIN+HOCH GmbH) combines a jaw movement sensor with a leg-mounted pedometer
- Oil-filled tube, pressure sensor and accelerometer (10hz)
- Device processes the data
- Summarizes eating, ruminating and drinking
- “Automatic health monitoring”

RumiWatch

Accelerometers everywhere!

- The development of cheap triple-axis accelerometers is revolutionizing the capture of animal behaviour data
- Includes human behaviour:
  - Nintendo Wii Remote (games)
  - Smart phones (e.g. VR apps)
  - Smart watches (fitness)



Leg-mounted accelerometers

- Leg-mounted accelerometers are used in several commercial systems
- Used in on-farm oestrus detection and health monitoring
- Record activity, steps, lying and standing behaviour
- e.g. IceRobotics IceQube
- Based on their earlier IceTag which was a research tool

Accelerometer-based foraging recording – ear tags

- SmartBow Eartag
  - Rumination and cow location
- SensOor (Agis Automatisering)
  - Behaviours classified based on ear movement

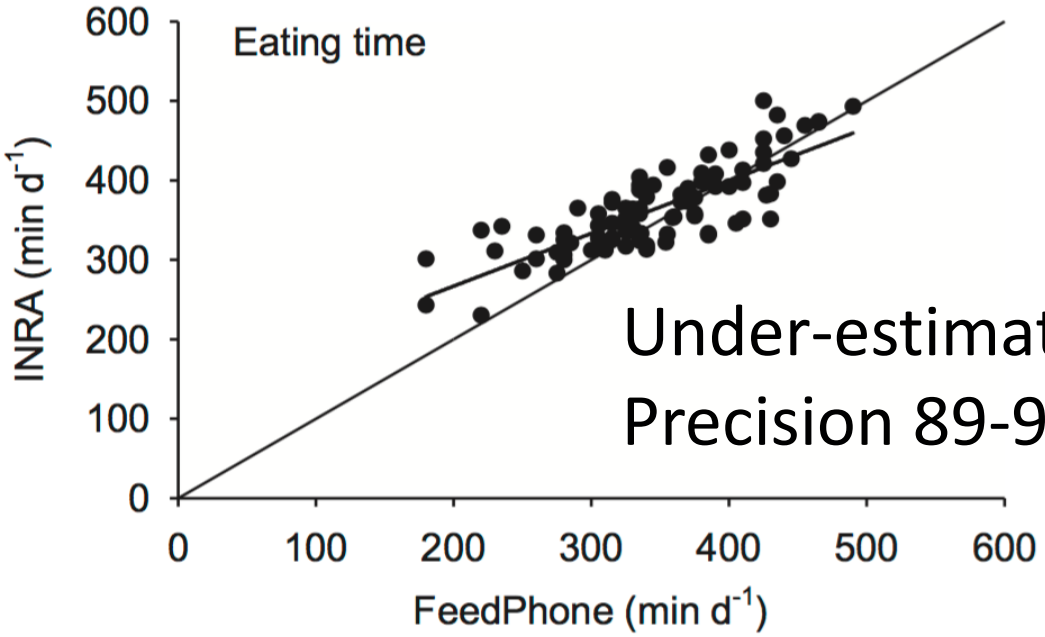
Behaviour	Kappa	Concordance
Ruminating	0.85	0.93
Eating	0.77	0.75
Resting	0.86	0.97
Active	0.47	0.35

SensOor

Bikker *et al.*, 2014. *J. Dairy Sci.* **97**(5): 2974-9

Accelerometer-based foraging recording – neck mounted

- FeedPhone (Medria)
  - Collar mounted sensor
  - Eating time and rumination time



Under-estimates eating

Precision 89-90% at 'day' level

FeedPhone

Delagarde and Lemonnier, 2015. *Proc. EGF Wageningen*

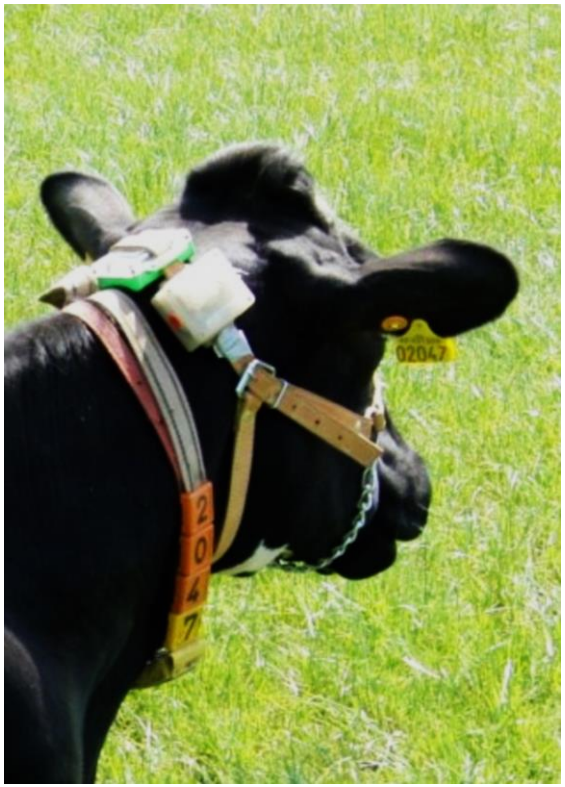
On-farm feed intake?

- Feed intake recording systems based on feed bins on load cells
- Insentec RIC bins used by researchers
- Grow Safe system is used on some genetic evaluation farms, it is still too expensive for ‘ordinary’ farms

GrowSafe SYSTEMS

Intake from accelerometers?

- Oudshorn *et al.* (2013) investigated the use of accelerometers to measure grazing time
- Combined this with manually recorded bite counts to estimate herbage intake
- IGER Jaw Movement recorder can discriminate bites *vs* chews, but it not practical for on-farm use
- Is there an alternative?



Oudshoorn *et al.*, 2013. *Comput. Electon. Agr.* **99**: 227-235

Bioacoustics

Microphone → Radio transmitter → Radio receiver connected to video camera i.e. the sound you will hear in the video is transmitted from the cows head

Noseband → 'IGER' Behaviour Recorder

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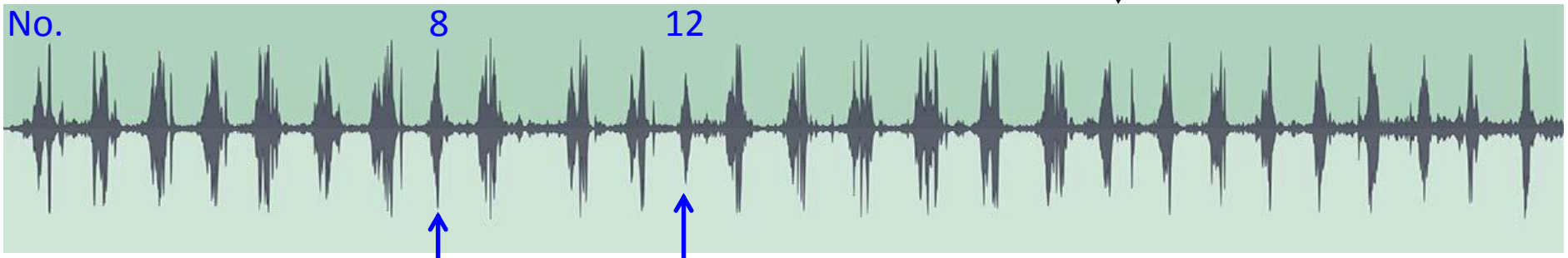
Bioacoustics

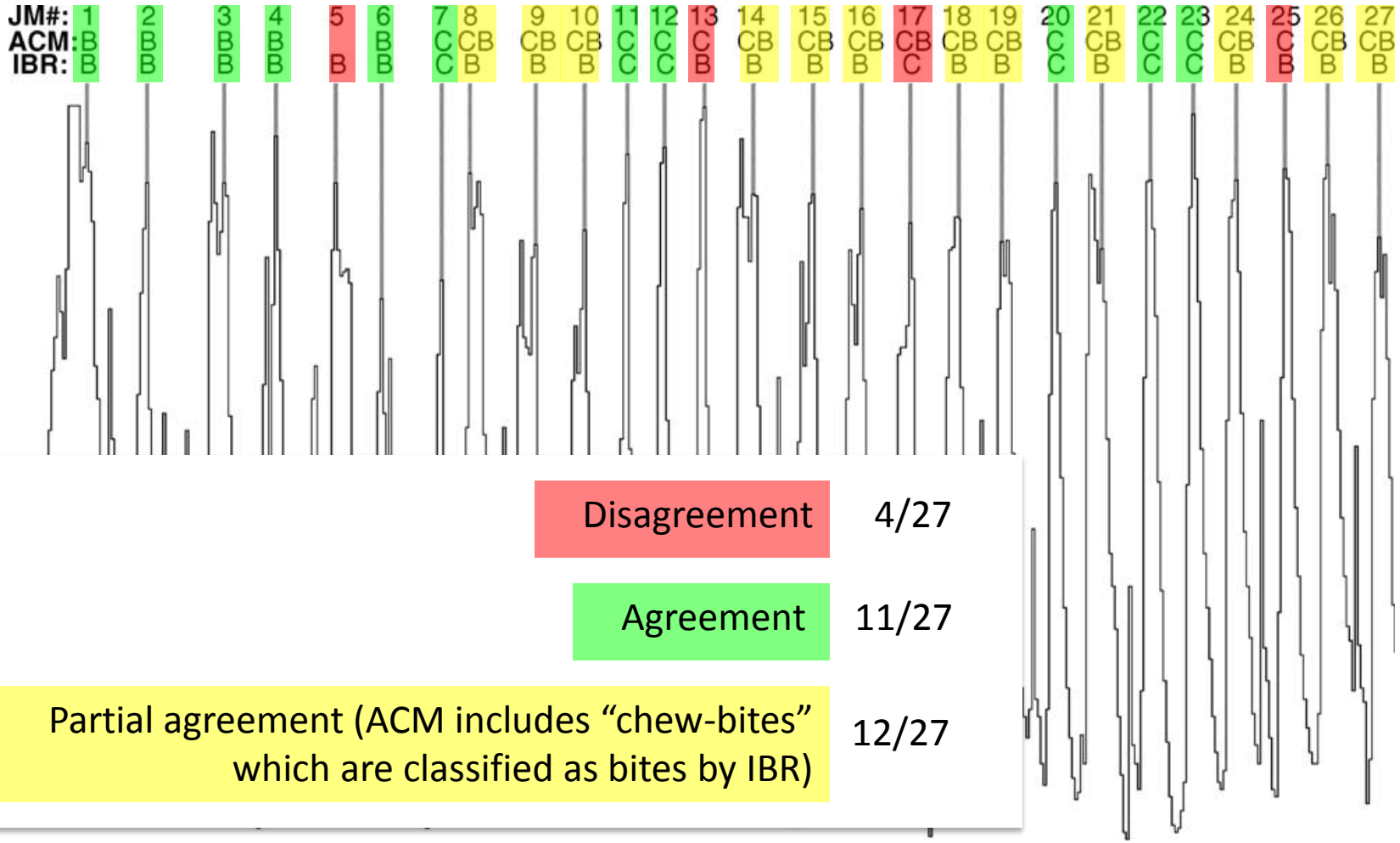
Head up



Mainly chew-bites

Chews

Jaw sensor *vs* bioacoustics



Disagreement	4/27
Agreement	11/27
Partial agreement (ACM includes “chew-bites” which are classified as bites by IBR)	12/27

Jaw sensor *vs* bioacoustics

- Although the jaw sensor misclassified some chews as bites…
- …there was **broad correspondence** in the classification of jaw movement between the two
- Microphones are more robust than the noseband sensor so better suited to use on farms

Bioacoustics potential

- Originally needed the human ear to detect bites and chews, but algorithms have been developed to do this **automatically**
- Research has shown the energy density of chewing sound is proportional to bite mass, so has the potential to monitor **intake**
- Has the potential to detect different **plant species** and differences in **herbage quality**

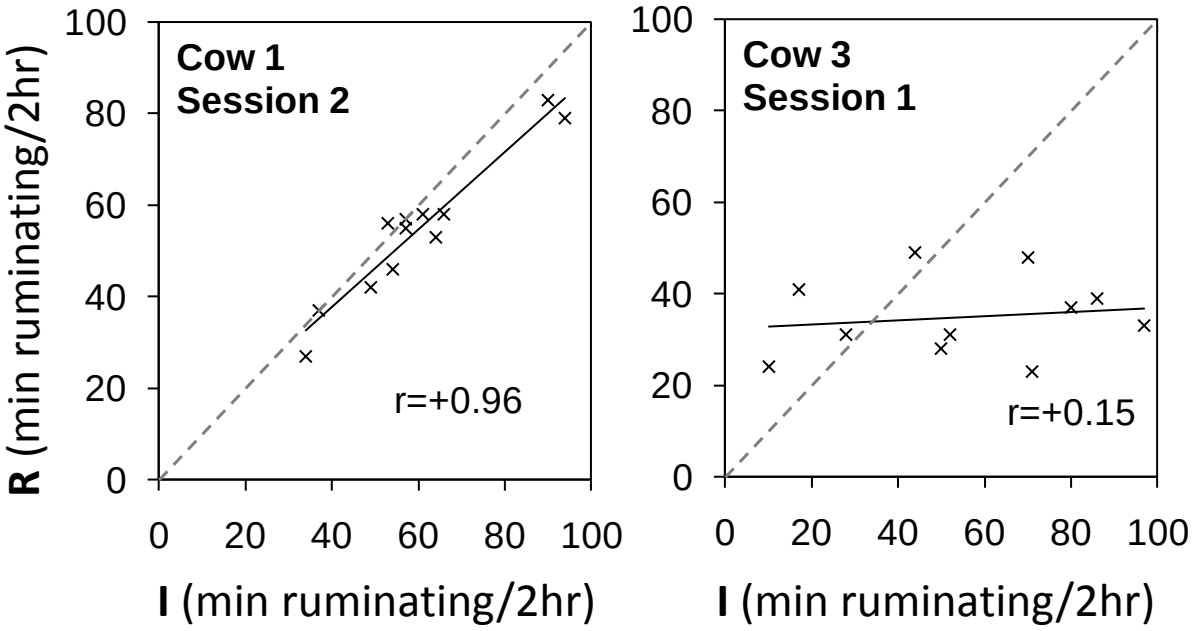
SCR VocalTag

- Bioacoustics are already being used in an on-farm monitoring system
- The SCR ‘VocalTag’ uses bioacoustics to detect **rumination** behaviour
- Used to monitor health and help predict oestrus

SCR VocalTag

Commercial bioacoustics

- Comparison of rumination collars (R) with the IGER Behaviour Recorder (I) showed variable results i.e. collars need to be correctly fitted



SCR VocalTag

Rutter *et al.* 2011 *Proc. ISAE Indianapolis*

A bioacoustic problem

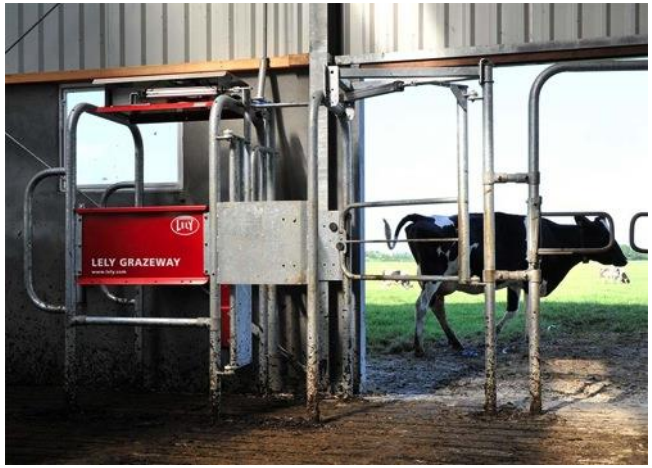
- The microphone can pick up the sound of conspecifics grazing alongside the subject…
- …so may need to be combined with other sensors e.g. accelerometers

Microphone or accelerometer?

- Japanese researchers (pers. comm.) are using head mounted triple-axis accelerometers to determine bites *vs* chews
- Is a microphone just a single-axis accelerometer mounted to a diaphragm?
- Can an accelerometer held against the skull give the same information as 'bioacoustics' if the sampling frequency is high enough?

Controlling pasture access

- Technology is also available to help automate controlled access to grass:



Electronic gates

Timed release gates

Robotic fences

Current strip grazing

- Measure herbage mass (e.g. plate meter) then set an electric fence to offer just enough grass to last to e.g. the next milking
- This is quite difficult, and it is easy to under- or over-estimate and give too little or too much grass
- Is there a technological solution?

Rising plate meter

Herbage availability

High herbage availability → Low herbage availability

Few **:** **Many** bites **:** **chews** → **Many :** Few **bites :** chews

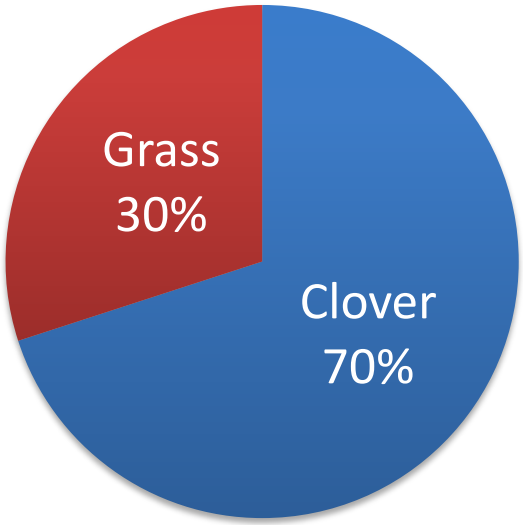
Automated strip grazing

- Set up several strip paddocks, each with a remote release gate

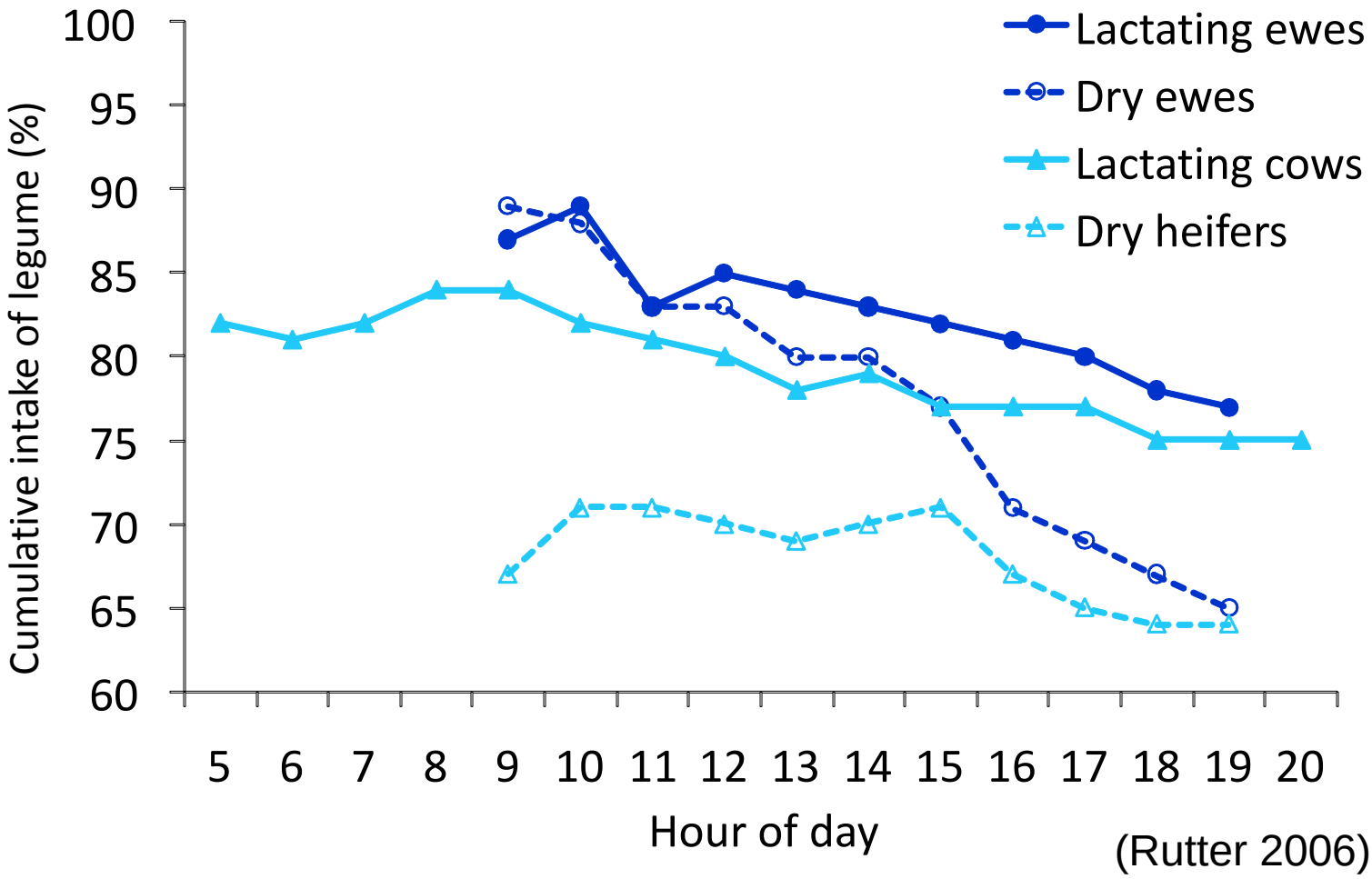
- Monitor grazing behaviour, including bites:chews ratios and possibly bite mass using bioacoustics
- Once the optimal residual sward height is achieved the system opens the gate to the next paddock
- This can happen at any time, not just after the cows have been milked
- Can be ‘smart’ e.g. does not give fresh grass just before the animals are due to be milked

Diet preference studies

- Diet selection and preference studied in sheep and cattle grazing adjacent monocultures of ryegrass and white clover
- Partial preference for clover, typically 70% clover and 30% grass
- Higher proportion of clover in diet of lactating animals



Diurnal pattern of preference



(Rutter 2006)

Evolutionary basis?

- Optimal microbial protein synthesis *in vitro* with 70% clover 30% grass
- Current theory suggests a balance between four evolutionary drivers:
  - animals are trying to optimize their own efficiency of nutrient capture
  - to maintain rumen function
  - to avoid eating high levels of plant toxins
  - to minimise the risk of predation

TMRs prevent diet selection

- Total Mixed Ration's thwart the ability of animals to:
  - Select the diet that they want
  - Optimize their own efficiency of nutrient capture
- This is bad because:
  - It is inefficient, wasting feed and creating pollution
  - It is a welfare problem as the animal is frustrated
- So why do we use TMRs?
  - Domestic ruminants evolved in an environment where 'concentrate' feed was rare so it made sense to eat as much as you could

A technological solution?

- One possible solution is to give the animals two feeds:
  - Grass silage based and clover silage based?
  - A protein-rich TMR and an energy-rich TMR?
- Multiple diets facilitated by robotic feed systems
- Let the animals select their own diet from the two
- They might still occasionally make nutritionally ‘unwise’ choices (too much of one feed = acidosis)
  - Possibly guard against this by controlling access to the feeds (via auto-gates) combined with rumen pH monitoring

Conclusions

- Technology is already starting to have a big impact in intensively managed dairy systems
- Although still needing further R&D, bioacoustics (combined with accelerometry) appears to offer the greatest potential for monitoring variables relevant to the on-farm measurement of eating behaviour
- Precision approaches should improve the ease and efficiency of grazing management
- Technology could help facilitate diet selection and so improve nutrient use efficiency and animal welfare

Any questions?

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