



Smart farming in dairy cattle: application of RumiWatch noseband sensors for monitoring of calving events in dairy cows

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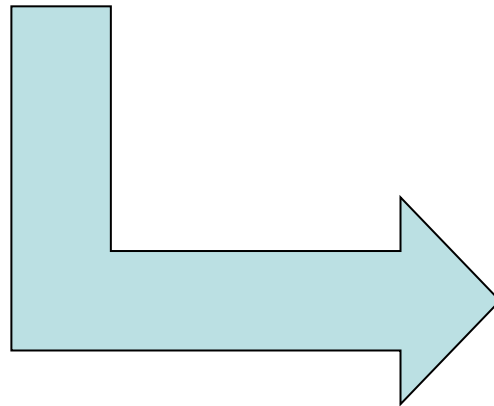


Smart farming in dairy cattle



Animal monitoring over the course of time...

**TECHNOLOGICAL
PROGRESS**

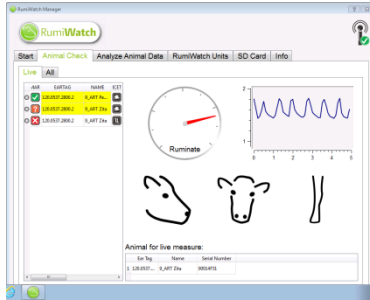


**CHANGING FRAMEWORK
CONDITIONS**



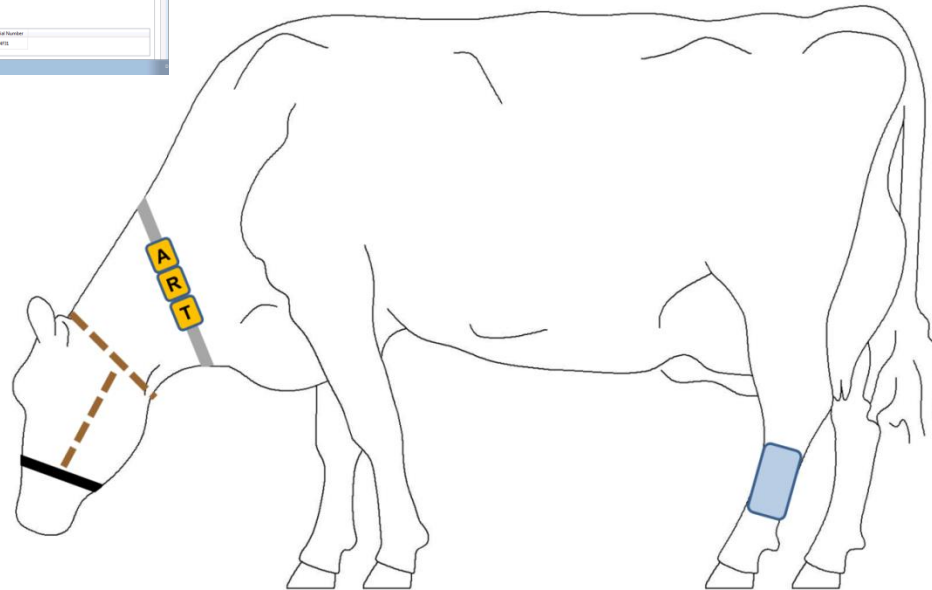


RumiWatch: a management aid for the future



Evaluation software

Analysing and visualising measured data



Noseband sensor

Ruminating, eating, drinking

Pedometer

Walking, standing, lying

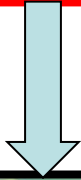


Project history



Agroscope Tänikon (CH):

- Project coordination (since 2010)
- Support for market launch (since 2012)
- Data collection for system development
- System validation
- Field testing
- Training for RumiWatch users



Düsse (GER)

05-07/2014, N=20 cows



Achselschwang (GER)

07-10/2014, N=25 cows



Riswick (GER)

10/2014-01/2015, N=25 cows

3 experimental farms (GER): data collection for health monitoring



Study focus

- **Current situation: RumiWatch is «not smart enough»**
 - Measures 18 parameters of ingestion behavior (NBS) and 13 parameters of motion behavior (pedometer)
 - Lack of data interpretation tool (only measurement, no interpretation)
 - Which parameters are meaningful for health monitoring?
- **Data collection and analysis:**
 - Identify indications on approaching calving events
 - Gain indications on occurring disease traits subsequent to calving (hypocalcaemia, ketosis etc.)
 - Making (critical) behavioral changes detectable
- **End-consumer product:**
 - Early warning system - app (smartphone, tablet, PC)
 - Usability for “everyday dairy farming”



Experimental design

- **Investigation under status quo conditions**

- ⇒ No modification of feeding regime and working routines
- ⇒ No pre-selection of animals based on previous medical records
- ⇒ Full randomization, every cow considered a potential «risk cow»

- **Recording of RumiWatch data and reference data**

- ⇒ Between lactation days -7 until 21 («special needs cows»)
- ⇒ RumiWatch sensor data (noseband sensor, pedometer)
- ⇒ Reference data (milk yield, feed intake, veterinary recordings etc.)

- **Current analysis and results**

- ⇒ Data collection at LVFZ Achselschwang, Germany (July-Oct 2014)
- ⇒ 24 Fleckvieh cows (6 primiparous, 18 multiparous)



Field study

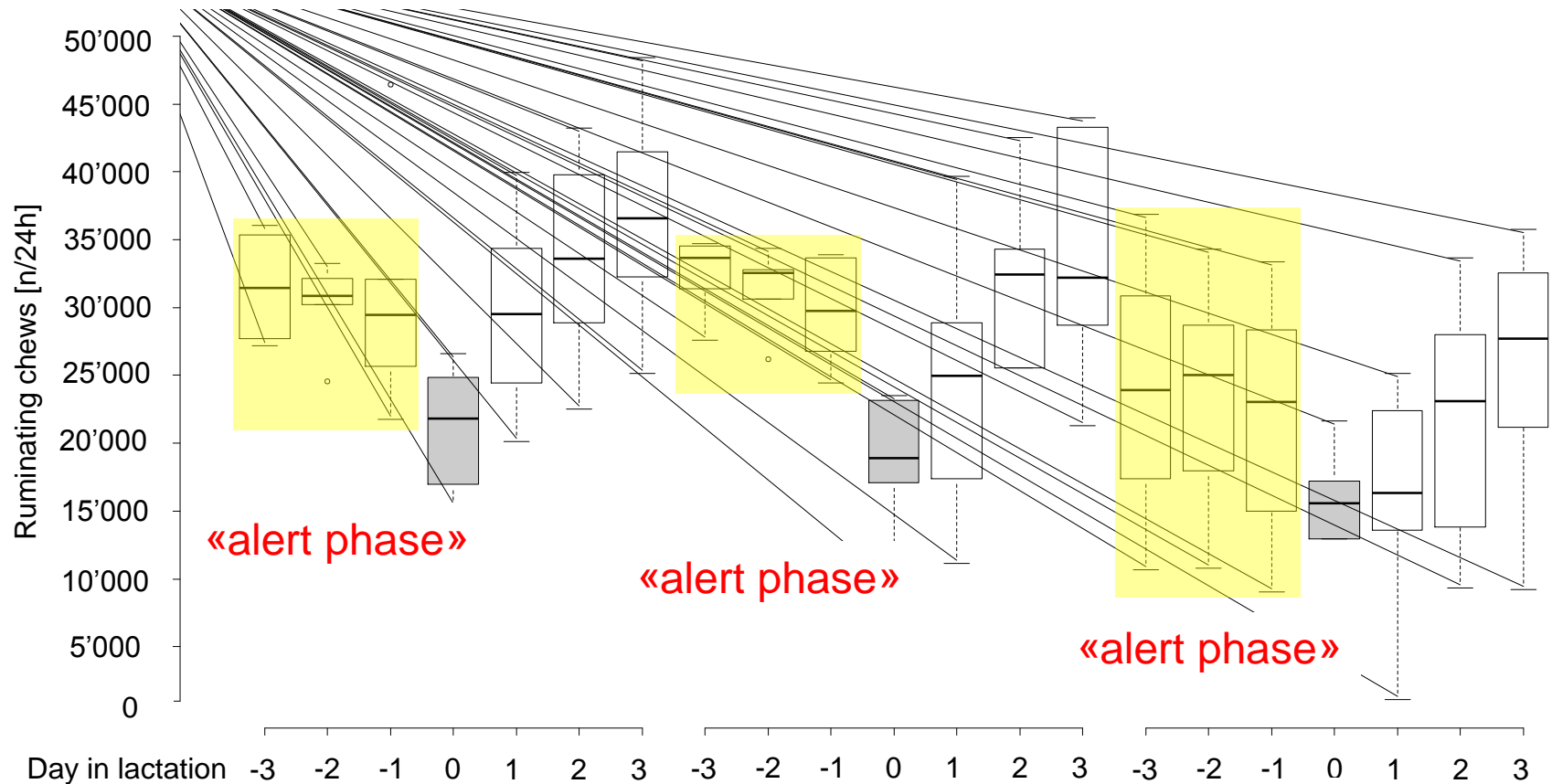


Fleckvieh cow with RumiWatch noseband sensor



Rumination

Ruminating chews (n=24 cows, 152 24-h-recordings)

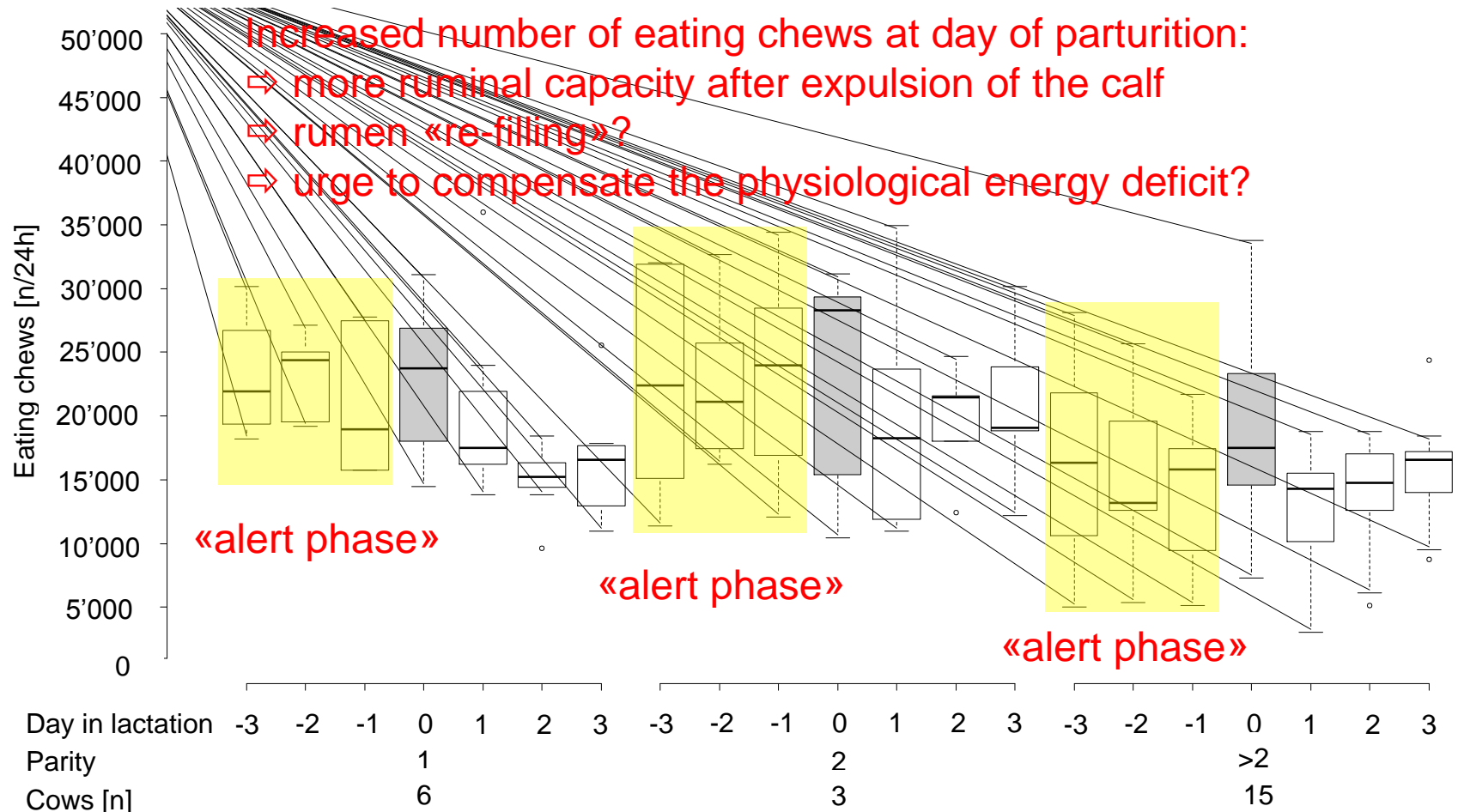


Ruminating chews are lowest at day of parturition, equivalent to rumination time



Eating activity

Eating chews (n=24 cows, 152 24-h-recordings)

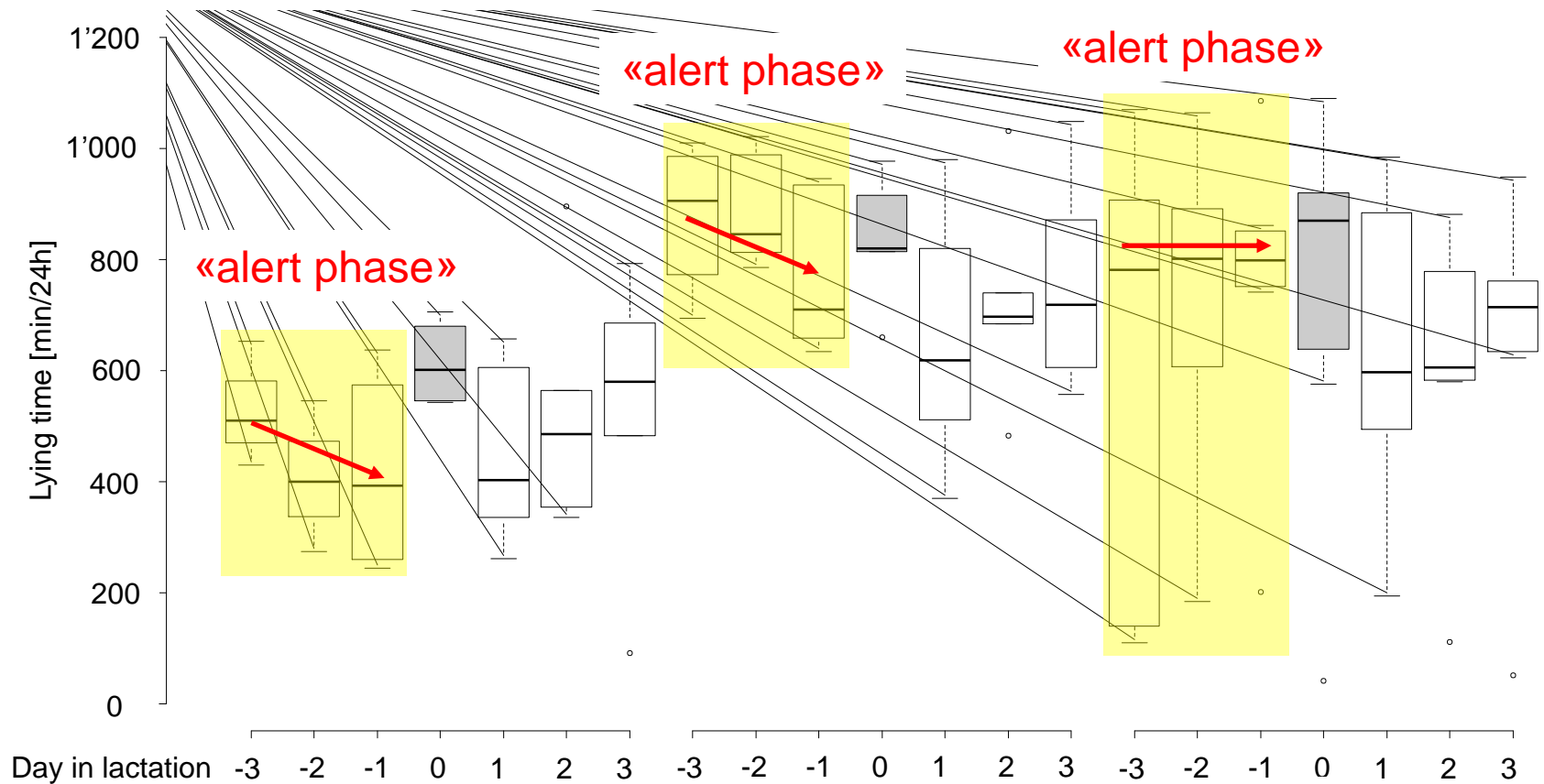


ANOVA: day in lactation $p = 0.0002$, parity $p = 0.0261$



Lying behavior

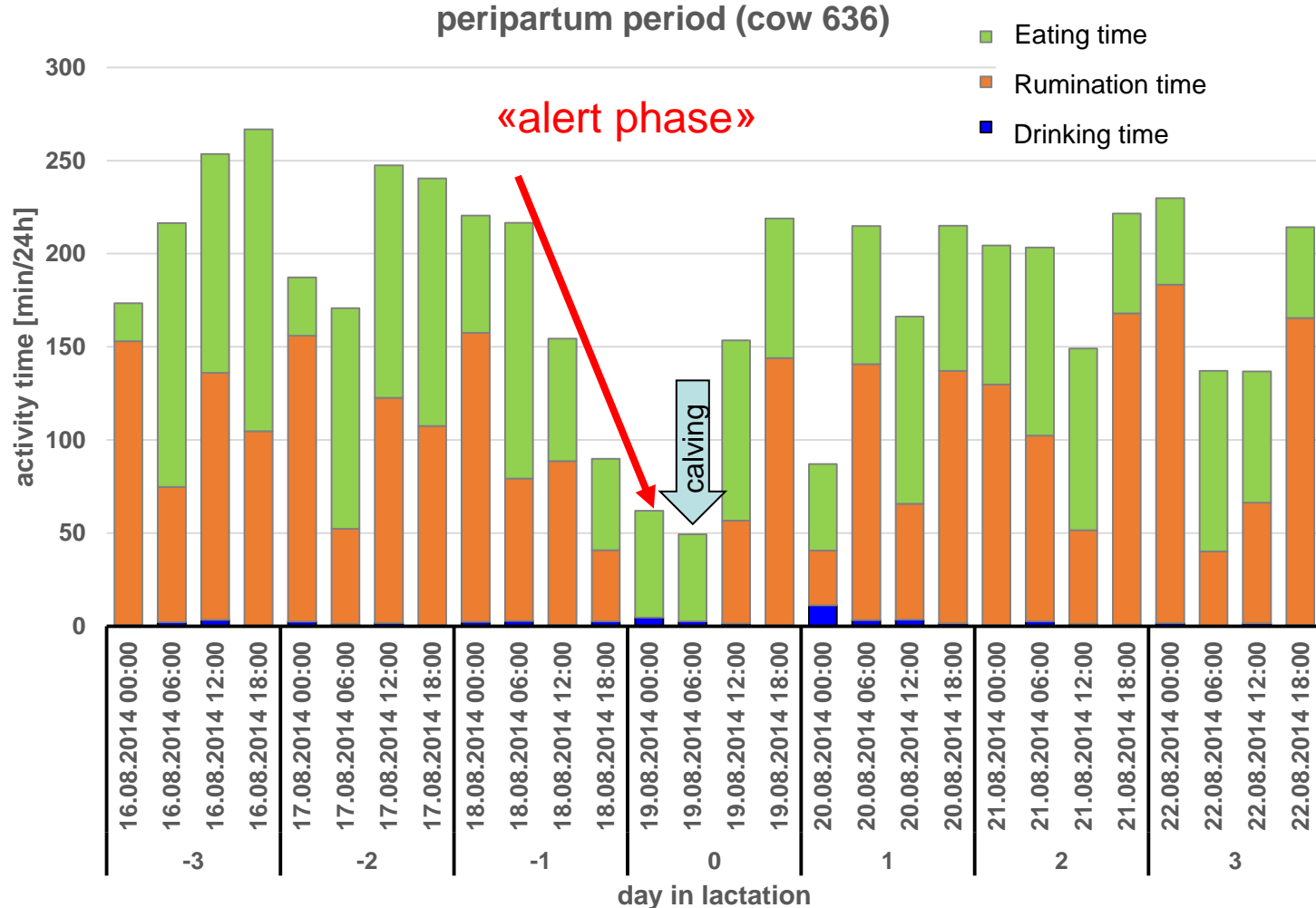
Lying time (n=20 cows, 118 24-h-recordings)



Increased lying times at day of parturition ⇒ expulsion of the calf



Peripartum period behavior



RumiWatch offers possibility for detailed analysis of behavioral patterns



Conclusions

- **Changes in peripartum ingestive behavior:**
 - Day of parturition is lowest point in rumination time
 - Contrary, eating time shows increase at day of parturition
 - Equal tendencies found in ruminating and eating chews, respectively
 - Significant differences in day-to-day-variability for all parameters
- **Further steps in analysis:**
 - Investigate feasibility to predict calving time, not only day of parturition
 - Compare to results found in other farms (3 experimental farms in total)
 - Develop a real-time model for detection ⇨ «alert system»



Thank you very much!



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www.agroscope.ch
www.rumiwatch.com



Outlook

- **Further development of RumiWatch:**
 - Generating usability for commercial dairy farming is highest priority
⇒ health monitoring
 - Heat detection may require more detailed studies
 - Several research groups involved in development process
 - Agroscope Posieux: grazing behavior, intake estimation
 - Vetsuisse Bern: lameness detection
 - FiBL: grassland management, low input farming

We keep going!



Data analysis

First steps to find indications on behavioral changes:

- Analysis of different RumiWatch parameters recorded in the peripartum period (here: lactation days -3 to 3)
 - Generalized linear mixed effects model (lme4 procedure in R)
 - Target variable: RumiWatch output parameter (RUMINATETIME etc.)
 - Fixed effects: day in lactation (-3 to 3), parity (1 | 2 | >2)
 - Random effect: animal (the genetically individual cow)
- ⇒ Investigation of influences and interactions



RumiWatch output parameters

Noseband sensor (1/2)

| Behavior | Parameter | Dimension |
|------------|-----------------------------|-----------|
| Rumination | Ruminating time | min |
| | Ruminating chews | n |
| | Ruminating boluses | n |
| | Ruminating chews per minute | n/min |
| | Ruminating chews per bolus | n/bolus |
| Eating | Eating time | min |
| | Eating chews | n |
| Drinking | Drinking time | min |
| | Drink gulps | n |

Analyzable temporal resolutions: 1min, 10min, 30min, 1h, 3h, 6h, 12h, 24h



RumiWatch output parameters

Noseband sensor (2/2)

| Behavior | Parameter | Dimension |
|----------|-----------------------------------|-----------|
| Other | Other activity time (idling etc.) | min |
| | Other chews (idling etc.) | n |
| | Head activity index | - |
| | Head uptime | min |
| | Head downtime | min |
| | Head temperature average | °C |
| | Head temperature minimum | °C |
| | Head temperature maximum | °C |
| | Head activity changes | n |

Analyzable temporal resolutions: 1min, 10min, 30min, 1h, 3h, 6h, 12h, 24h



RumiWatch output parameters

Pedometer (1/2)

| Behavior | Parameter | Dimension |
|----------|---------------------|-----------|
| Lying | Lying time | min |
| | Ly down incidences | n |
| Standing | Standing time | min |
| | Stand up incidences | n |
| Walking | Walking time | min |
| | Walking steps | n |

Analyzable temporal resolutions: 1min, 10min, 30min, 1h, 3h, 6h, 12h, 24h



RumiWatch output parameters

Pedometer (2/2)

| Behavior | Parameter | Dimension |
|----------|--------------------------|-----------|
| Other | Foot activity index | - |
| | Foot uptime | min |
| | Foot downtime | min |
| | Foot temperature average | °C |
| | Foot temperature minimum | °C |
| | Foot temperature maximum | °C |
| | Foot activity changes | n |

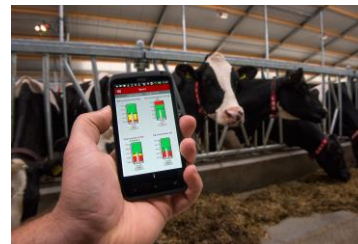
Analyzable temporal resolutions: 1min, 10min, 30min, 1h, 3h, 6h, 12h, 24h



Automatization: a short-cut focus

Functional classification:

- Automatization as executive measure (*executive function*)
 - Automated feeding, milking, manure removal
 - Main function: execution = «hard skills»
 - Farmer intent: making work (physically) easier
- Automatization as management aid (*evaluative function*)
 - Herd management software, animal monitoring devices
 - Main function: analysis = «soft skills»
 - Farmer intent: making work and its results (qualitatively) better





Automatization: a short-cut focus

Current and future challenge:

- Connecting evaluative und executive functions of automation
 - «ISO-BUS indoor livestock production»
 - «Smart Farming» example: automated feeding system responds to animal monitoring system



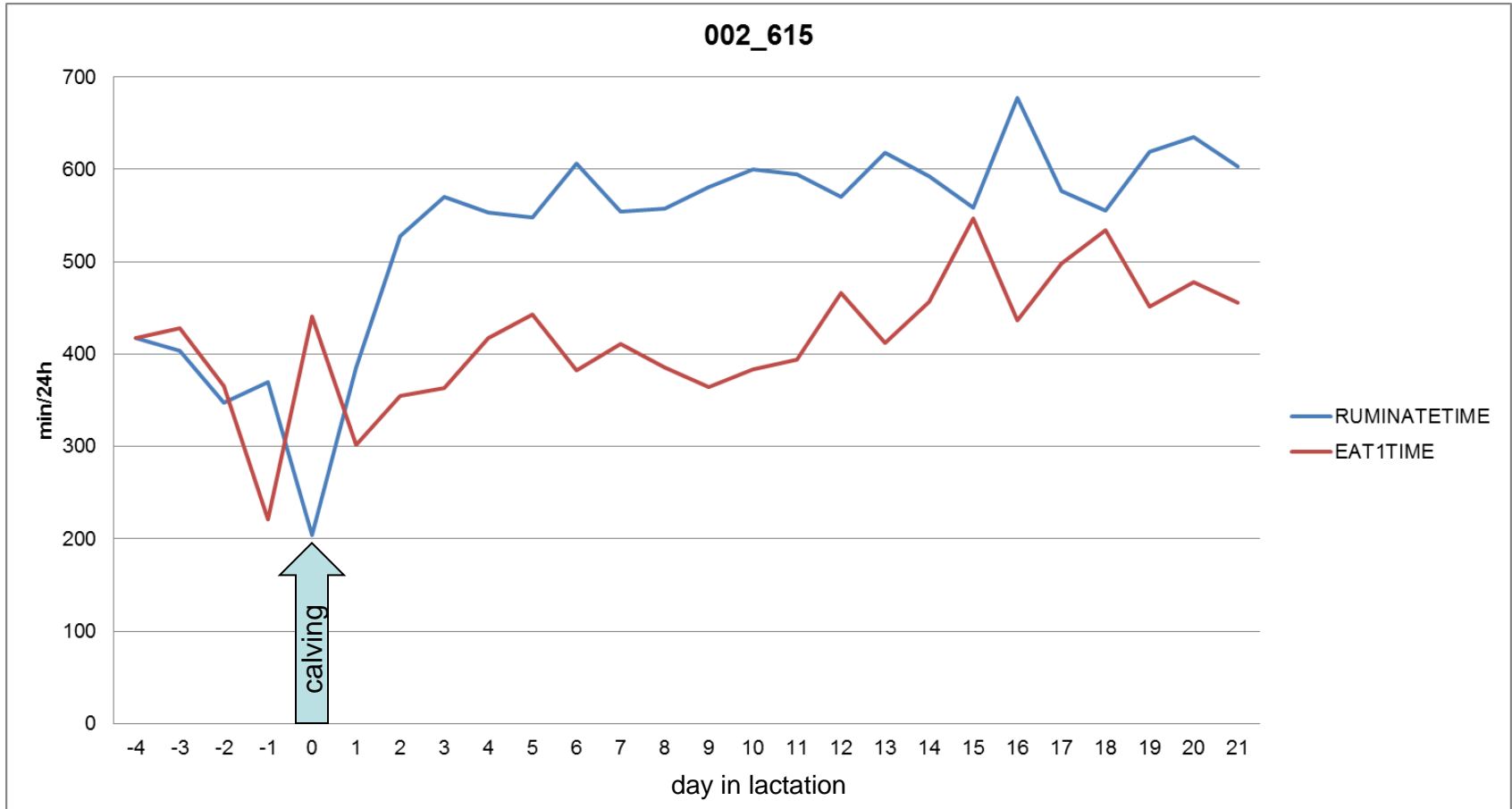
RumiWatch message:
Insufficient ruminating activity



Feeder response:
Increase effective fiber in ration



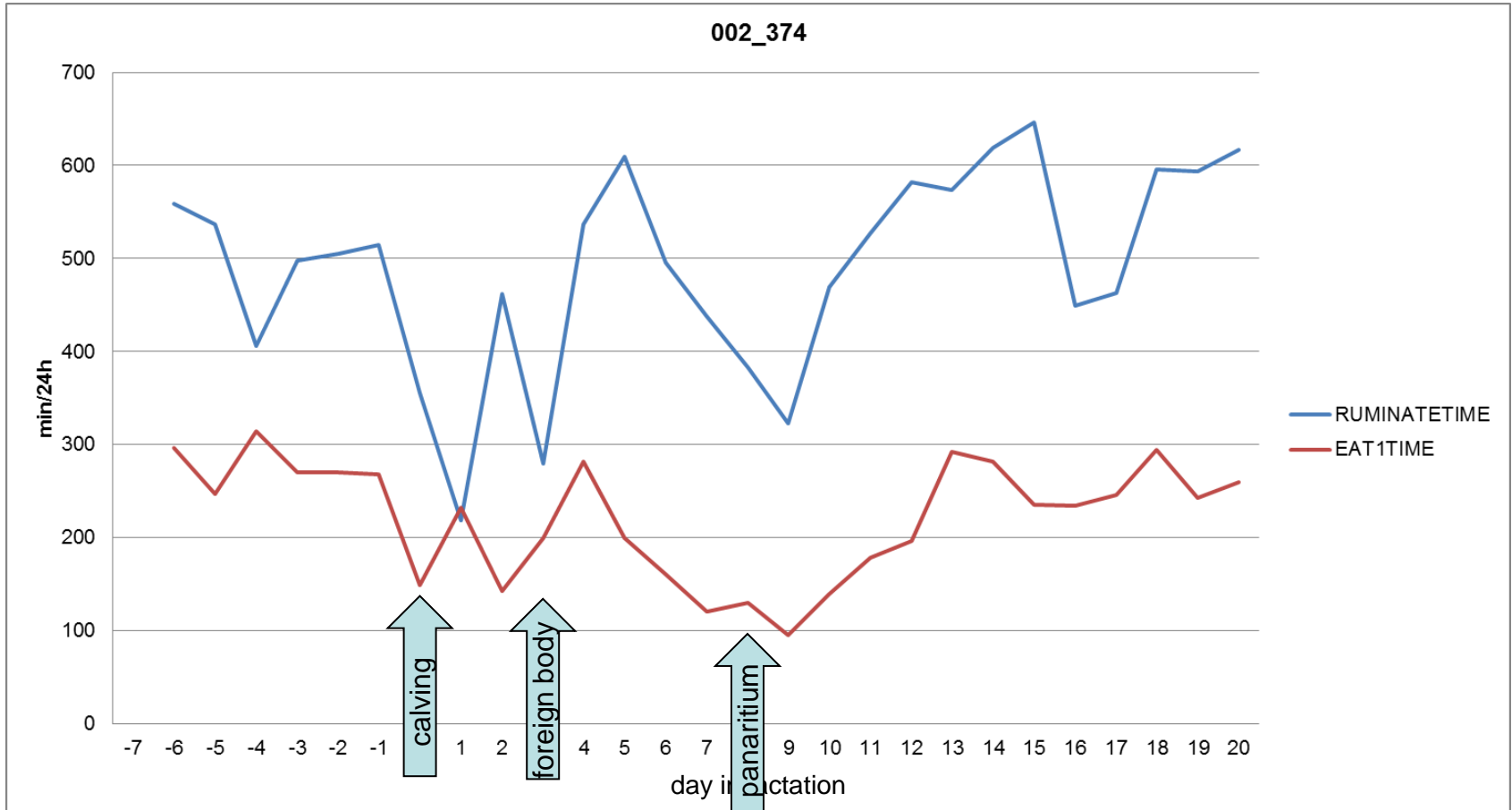
RumiWatch health monitoring



Healthy start in lactation



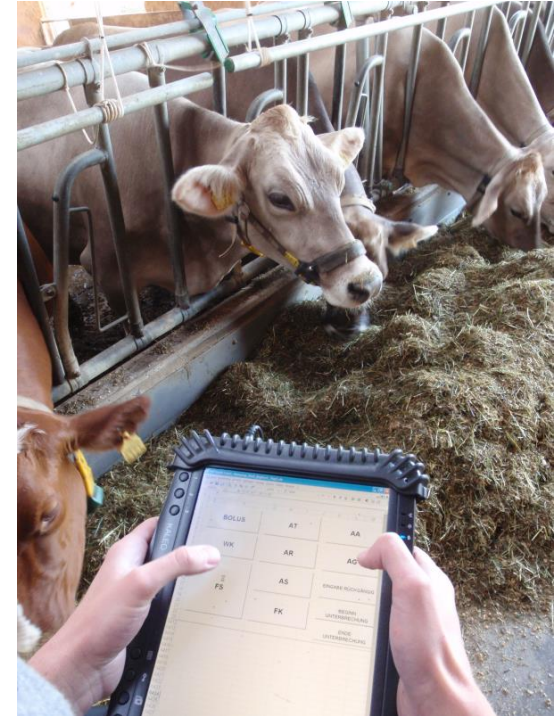
RumiWatch health monitoring



Start in lactation with health disorders



RumiWatch validation



Direct observation of ruminating and eating behavior

Registration of chews via tablet PC



RumiWatch validation

- Comparison of classification: RumiWatch vs. direct observation
 - Classification of chews *per 1-min-segment*

| | | Direct observation [min] | |
|----------------------------------|-------------------------------|--------------------------|--------|
| | | Ruminating | Eating |
| RumiWatch evaluation [min] | 1-min-segments | 884 | 848 |
| | Ruminating classification | 859 | 30 |
| | Eating classification | 25 | 807 |
| | Other activity classification | 0 | 11 |
| Agreement [%] | | 97.2 | 95.2 |

Direct observation = 100% (gold standard)



Experimental design

- **Focus of analysis**

- ⇒ Magnitude, direction, and tendency of behavioral changes measurable by RumiWatch
- ⇒ What is the most striking parameter (health & calving indicator)?
- ⇒ What would(n't) you expect?

- Data collection at LVFZ Achselschwang, Germany (July-Oct 2014)

- 24 Fleckvieh cows

- 6 primiparous
- 18 multiparous

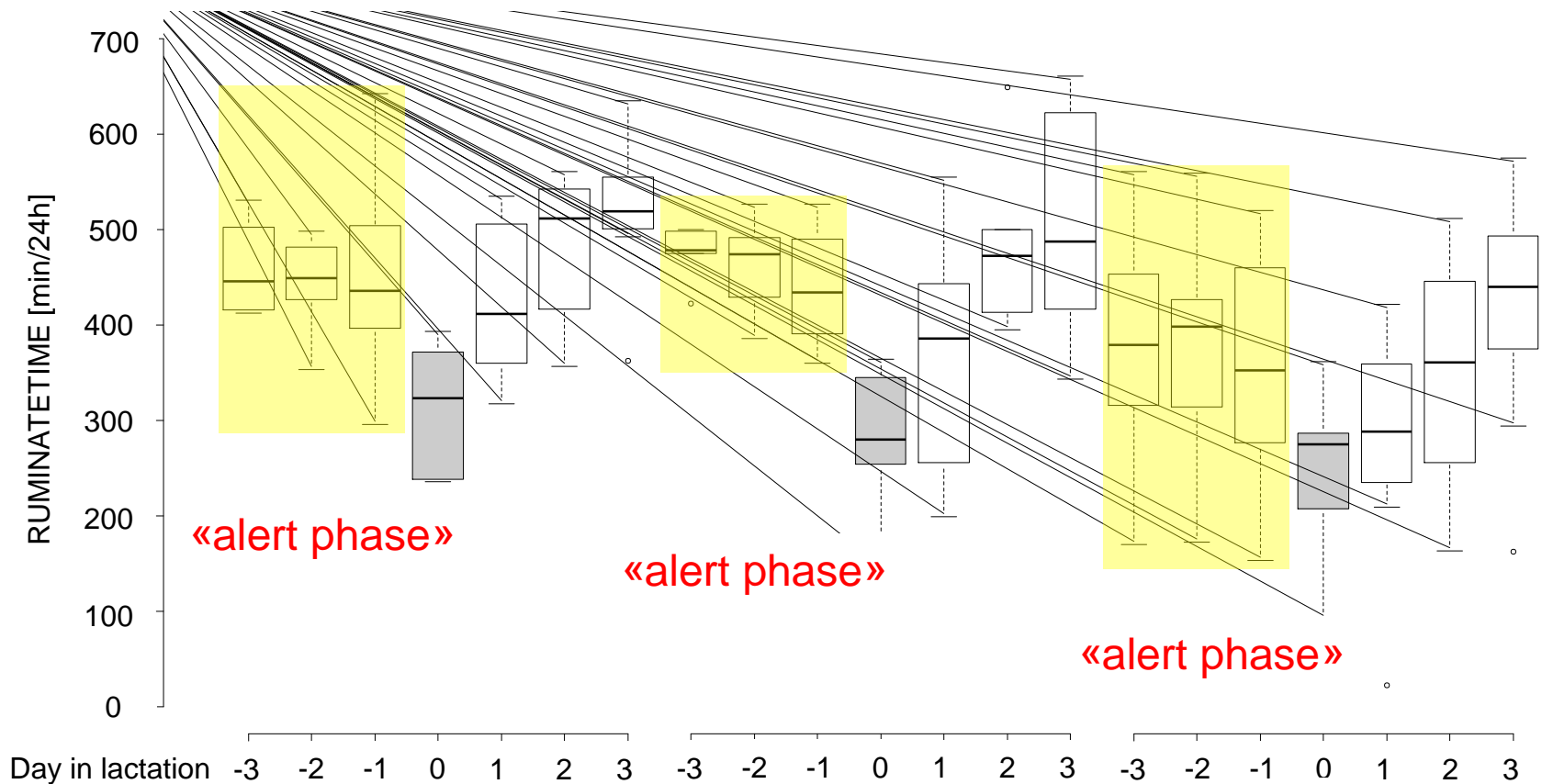
- 7 days before calculated calving date:

- cows moved to calving pens
- equipped with RumiWatch sensors



Results and discussion

Rumination time (n=24 cows, 152 24-h-recordings)



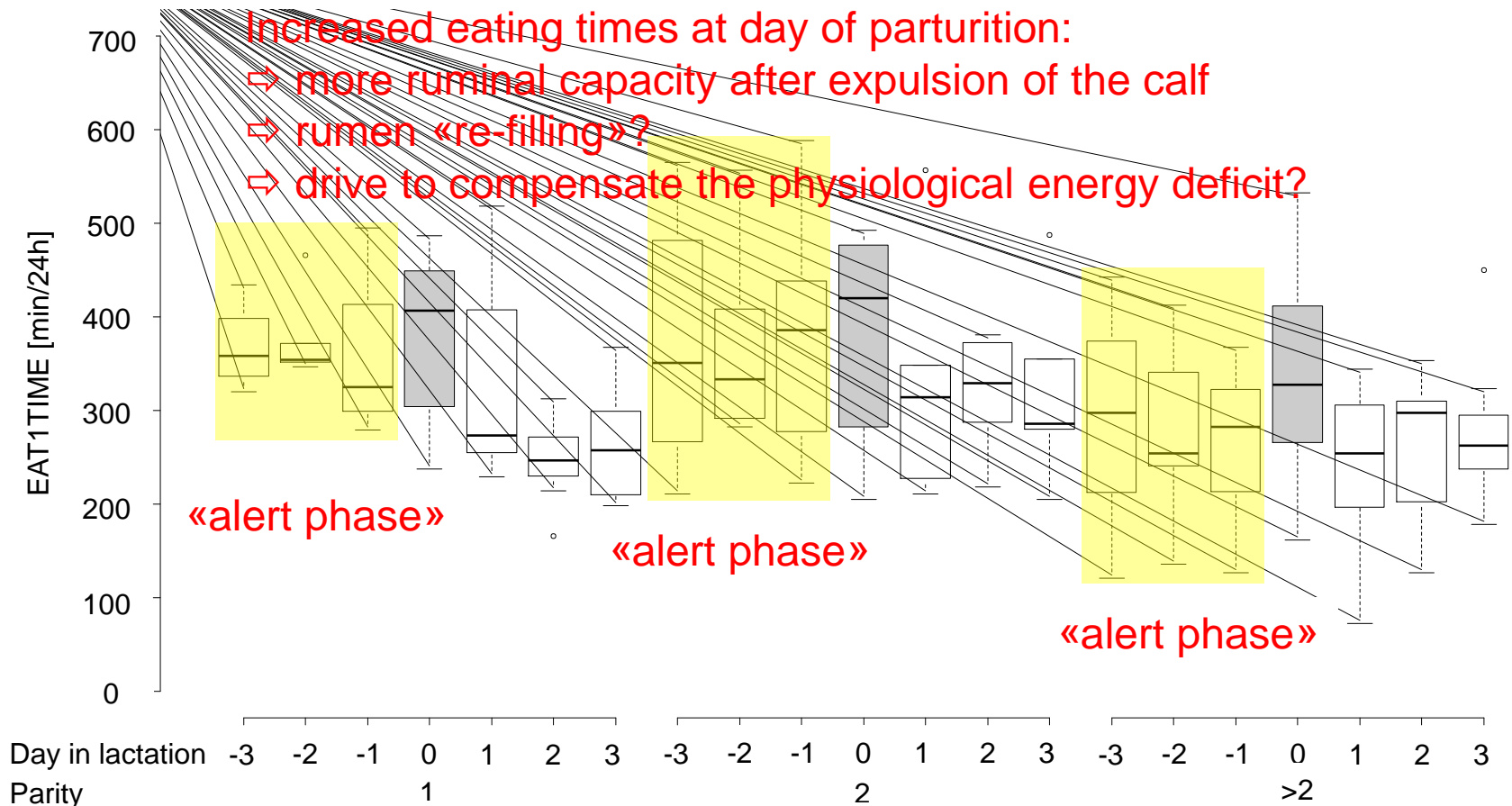
Day of parturition marks lowest point in rumination time

Variability between days -3 to -1 seems to be difficult to interpret



Results and discussion

Eating time (n=24 cows, 152 24-h-recordings)

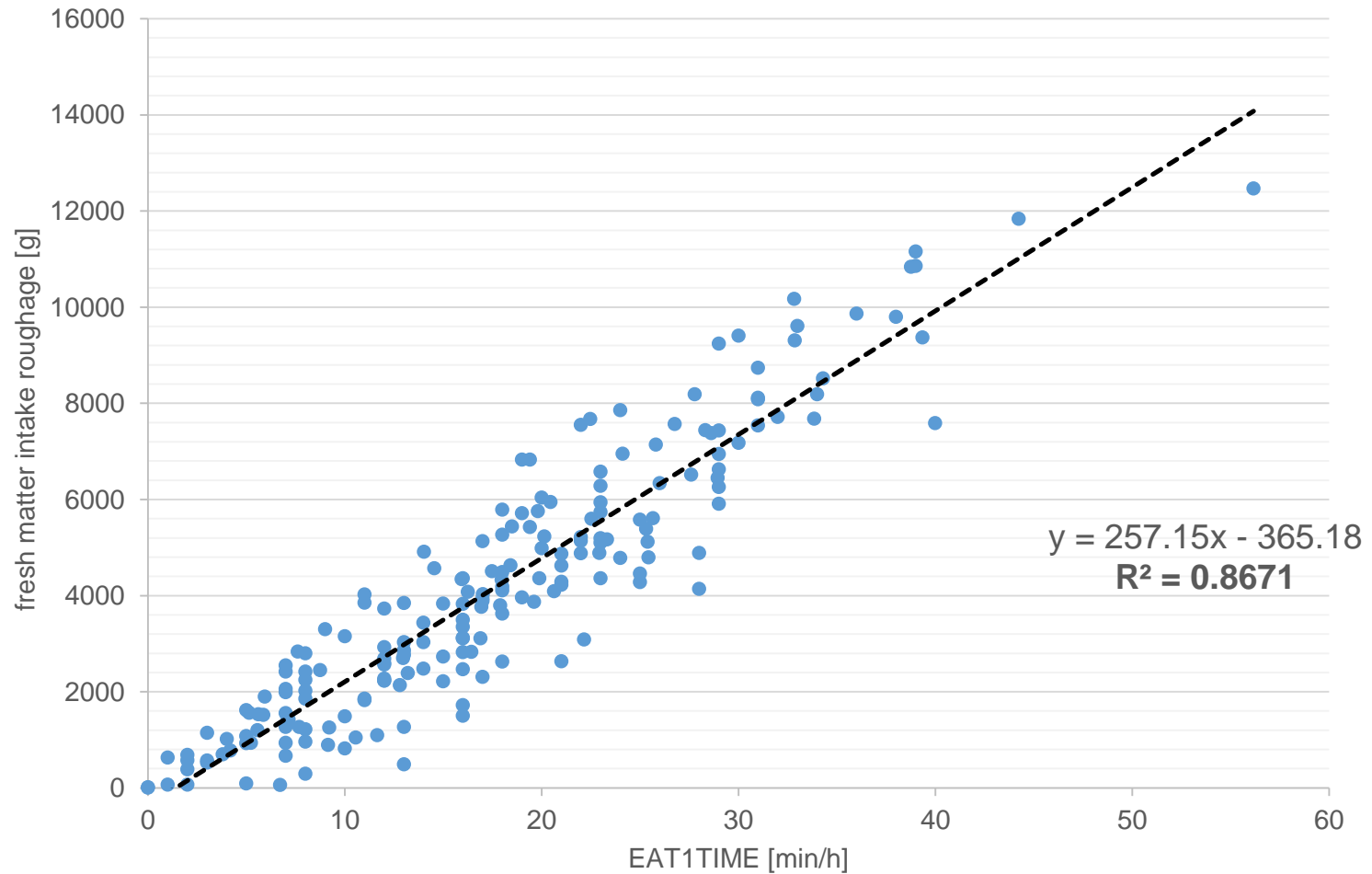


Variability between days -3 to -1 seems to be difficult to interpret



Results and discussion

Eating time vs. roughage intake (**cow 766**)





Results and discussion

Eating time vs. roughage intake (**cow 636**)

