



Faculty of Health and Medical Sciences



## Analysing data at the herd level to optimise individual animal interventions:

Applications to parasite control and rumen pH monitoring

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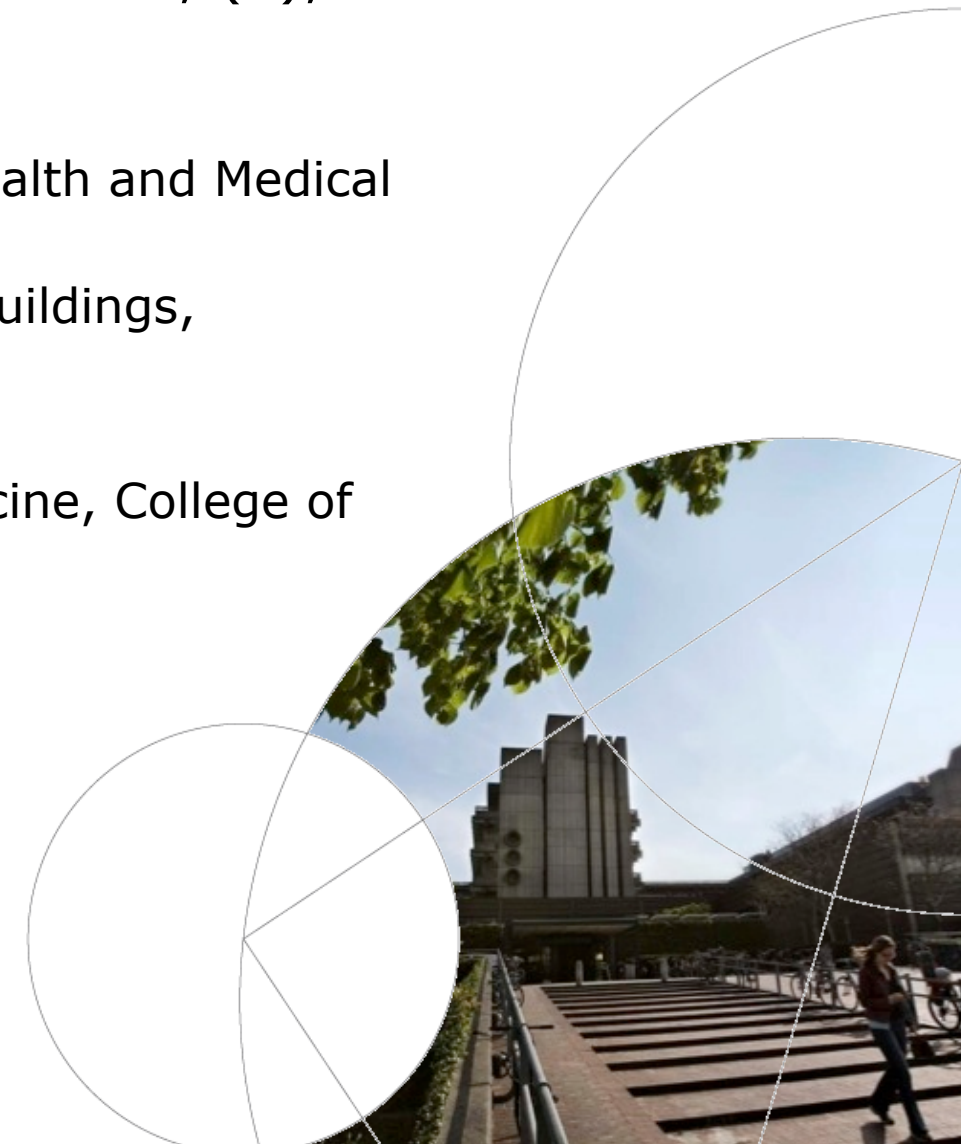
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## Background

- The nature (and availability) of data is changing rapidly
  - Retrospective data for research
  - Real-time data to inform production
- Typically, more and more data is available .... but what to do with it?
- Two examples: (1) parasitology data (2) rumen pH data



## Example 1: Faecal worm egg counts (FWECS)

What does this picture show?

Three calves?

With individual FWECS

A herd of 3 calves?

With some group mean FWECS

A field (probably) full of *Ostertagia*?

With some indication of pasture contamination by the 3 calves



## Individual animal vs. herd inference

- There is often a choice between analysis of group data at the level of individual or herd
  - Sampling theory tells us that grouping together all the data makes our estimates more reliable
  - But interventions are often applied at the individual animal level, and are difficult to base on herd estimates
- Hierarchical models can bring together all of the data, summarise it at the herd level, and use it to make decisions at the animal level
  - Markov chain Monte Carlo (MCMC) is a statistical method that is ideally suited to hierarchical modelling
    - Theoretically incredibly flexible
    - Languages such as WinBUGS and JAGS allow an almost infinite number of variations on common models
    - Often in a Bayesian framework

WinBUGS is freely available from:

<http://www.mrc-bsu.cam.ac.uk/software/bugs/the-bugs-project-winbugs/>

JAGS is freely available from:

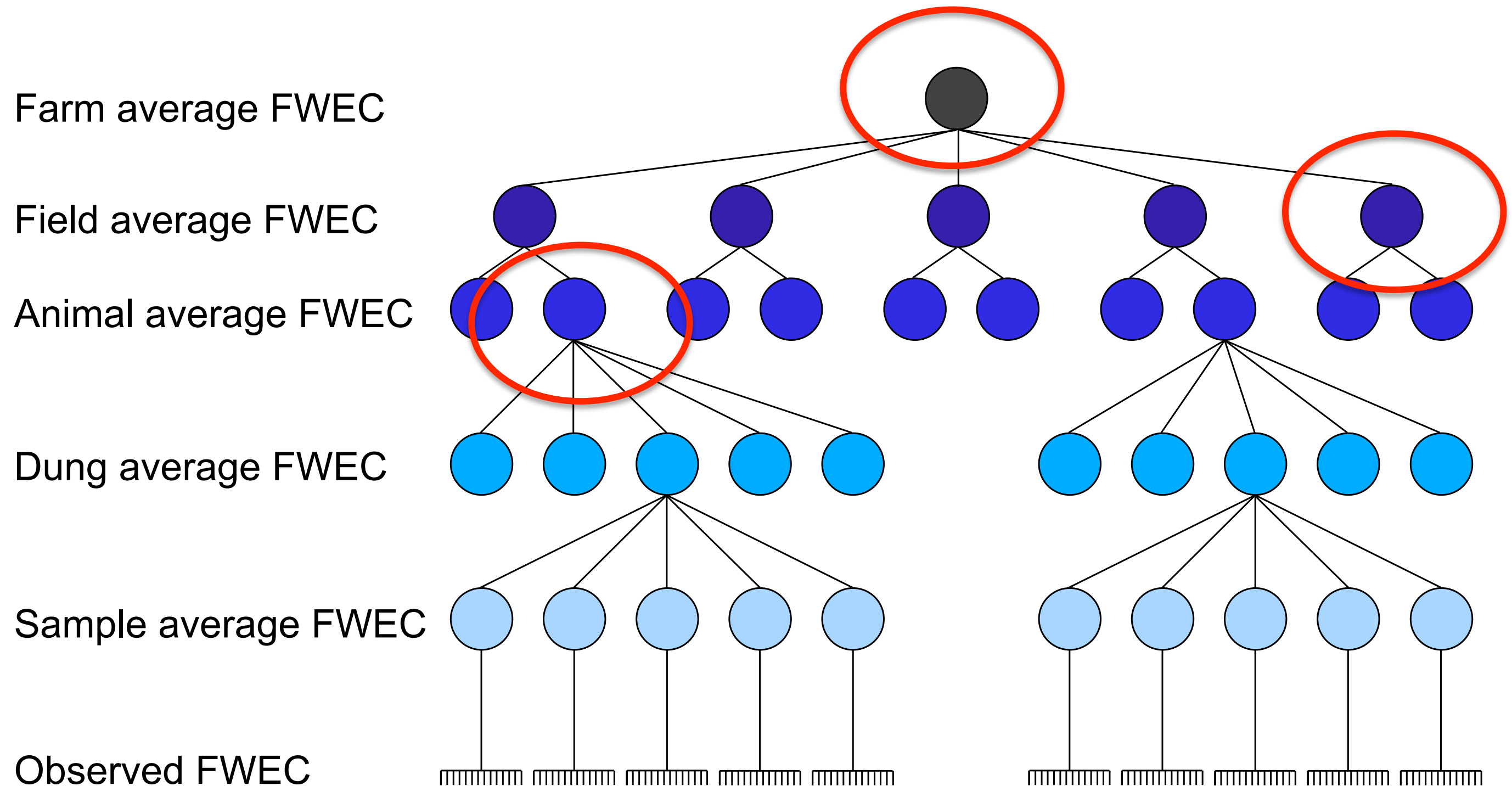
<http://mcmc-jags.sourceforge.net>

<http://cran.r-project.org/web/packages/runjags/index.html>





## A hierarchical model

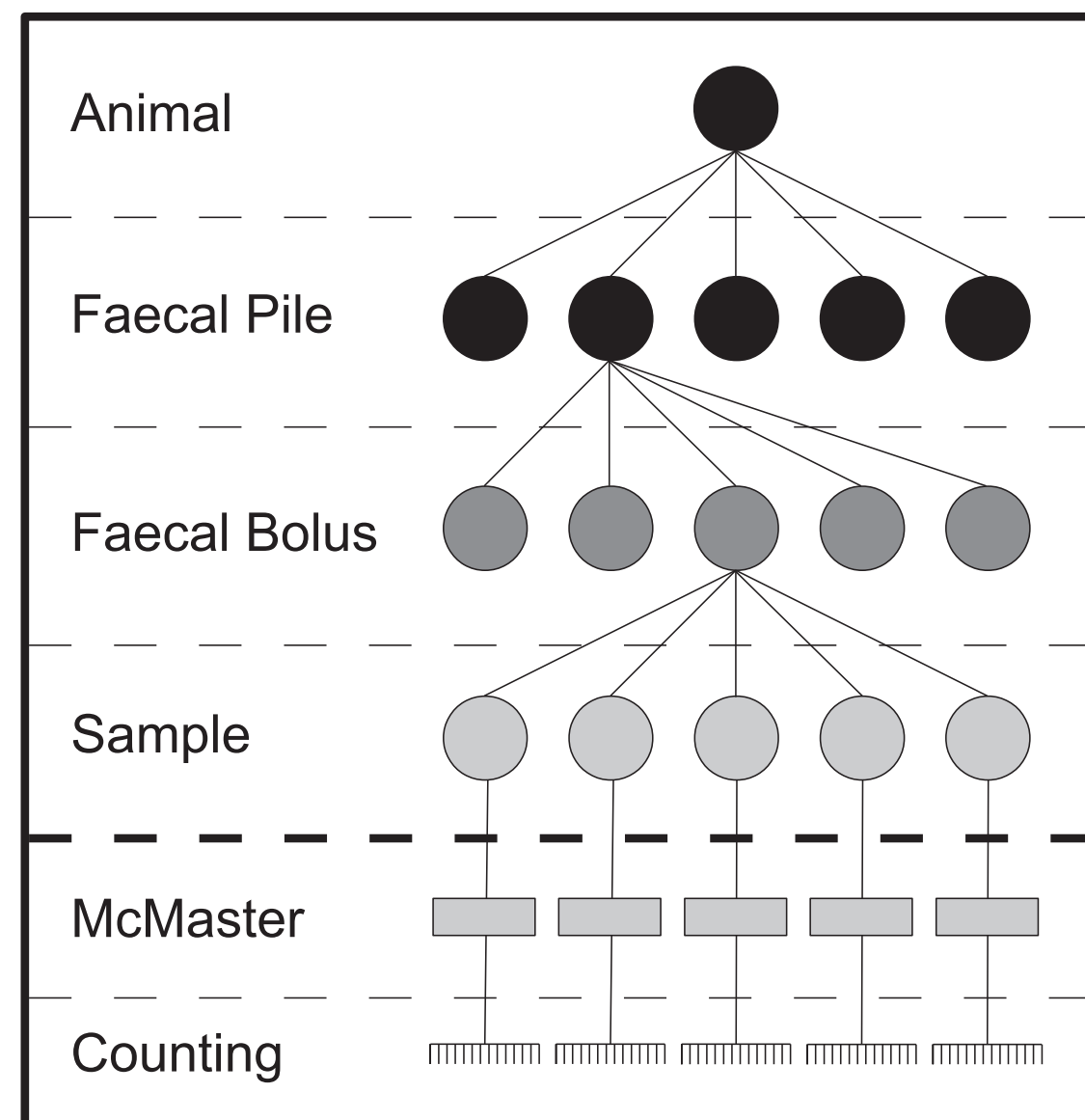
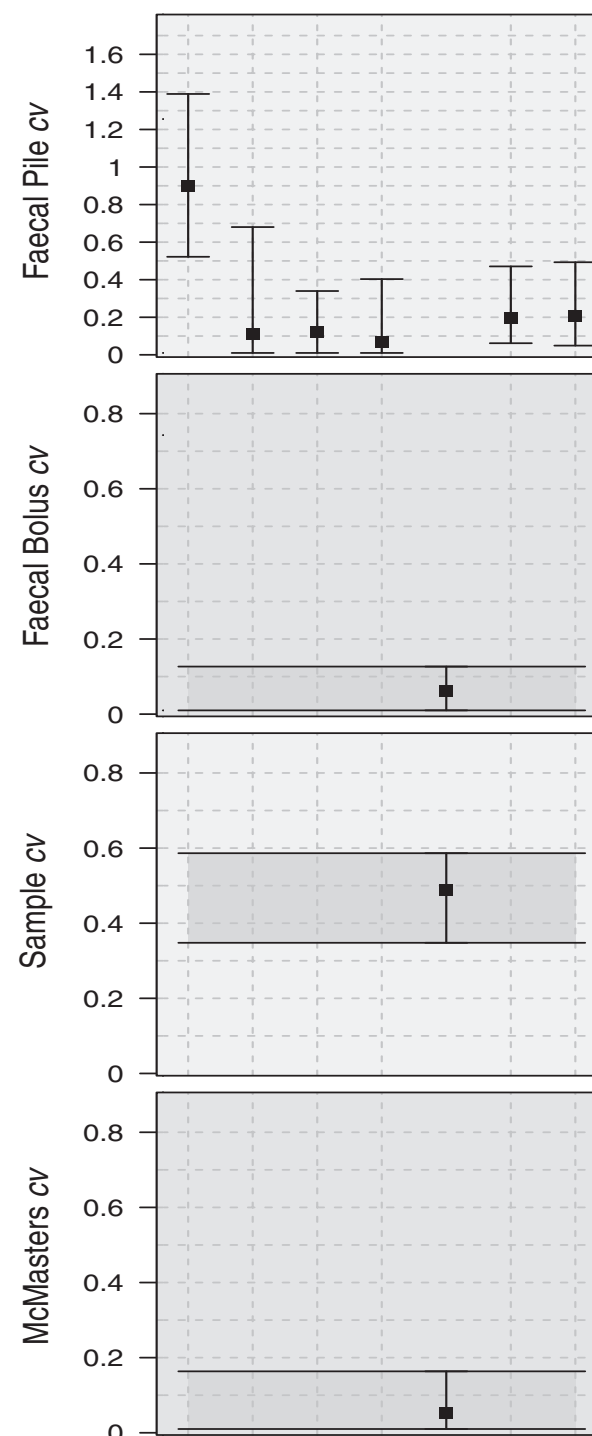


Fitting this using MCMC allows us to obtain information at every level *simultaneously* – and estimates the variance partitions too!



# Applications of hierarchical modelling to FWEAC

We have used these types of models to partition variance in FWEAC

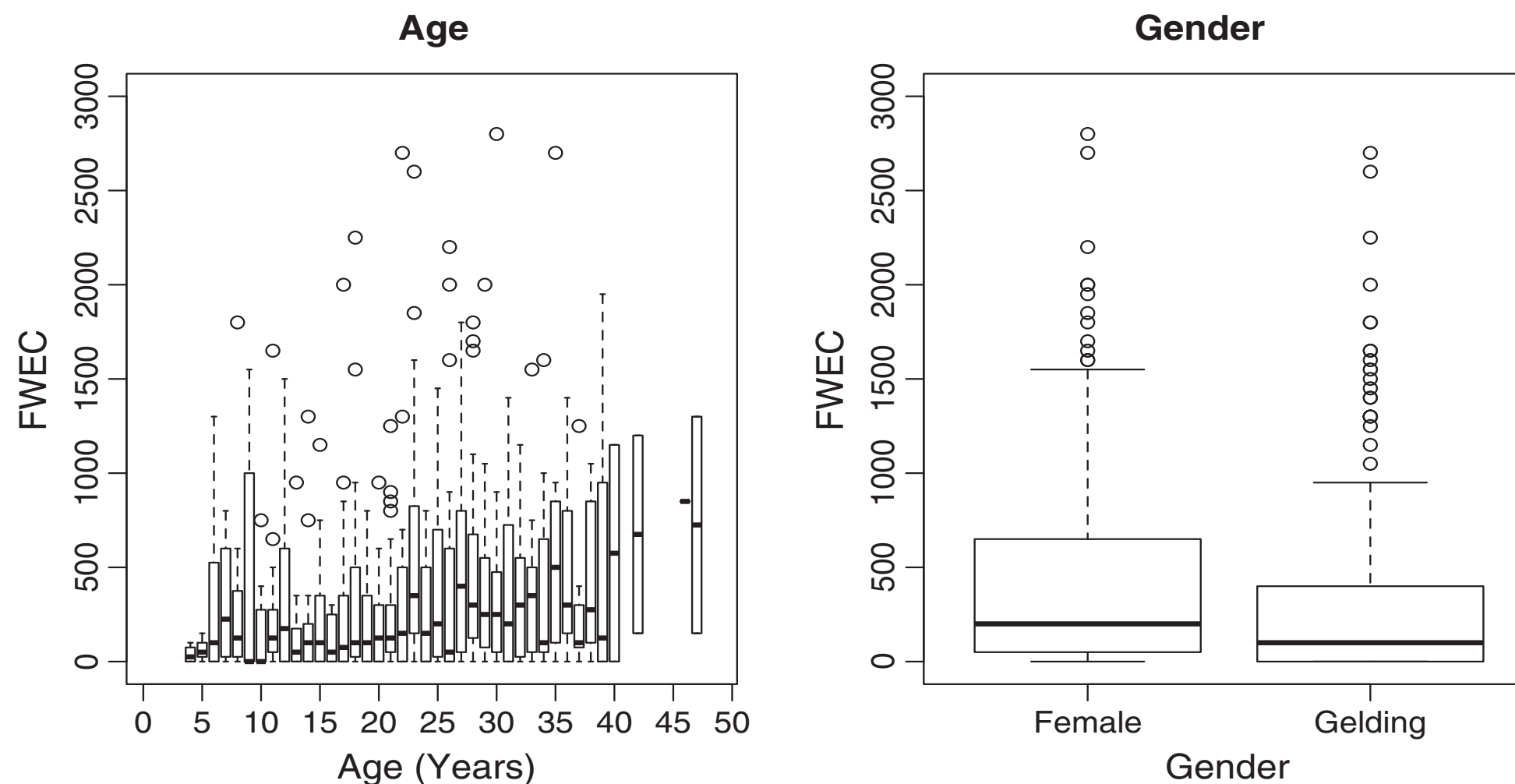


Denwood, M. J., Love, S., Innocent, G. T., Matthews, L., McKendrick, I. J., Hillary, N., Smith, A., & Reid, S. W. J. (2012). Quantifying the sources of variability in equine faecal egg counts: implications for improving the utility of the method. *Veterinary Parasitology*, 188(1-2), 120–6. doi:10.1016/j.vetpar.2012.03.005



## Applications of hierarchical modelling to FWEC

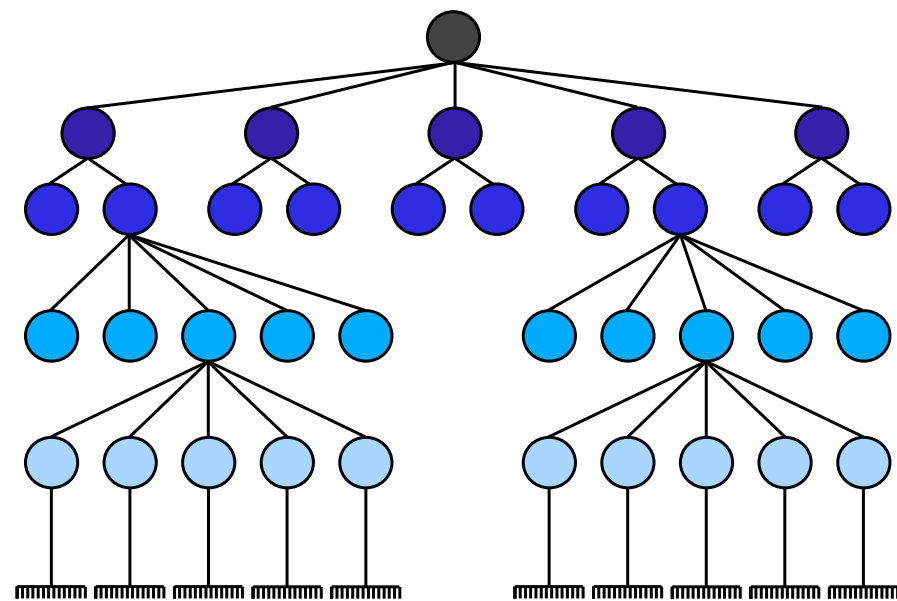
A further advantage of MCMC is the ability to incorporate additional information, such as the effect of age and/or gender



Corbett, C. J., Love, S., Moore, A., Burden, F. A., Matthews, J. B., & Denwood, M. J. (2014). The effectiveness of faecal removal methods of pasture management to control the cyathostomin burden of donkeys. *Parasites & Vectors*, 7(1), 48. doi: 10.1186/1756-3305-7-48



## Applications of hierarchical modelling to FECRT



Faecal egg count reduction tests

Usual focus:

**Change in field mean FWEC**

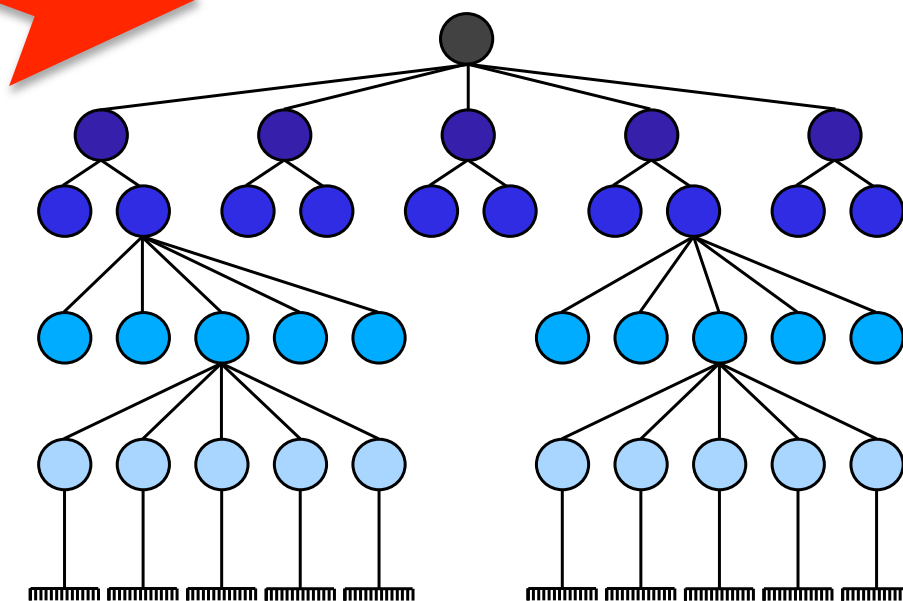
But isn't there other useful information?

**DOSING**

Change in variability within an animal?

Change in variability between animals?  
(i.e. variability in efficacy)

Individual animal efficacy?  
(i.e. which animals to re-dose  
with a different anthelmintic)





## Example 2: Rumen pH

Rumen boluses allow a pH reading to be taken every 15 minutes for months (until the bolus fails)

This results in a lot of numbers

Too acidic a pH (or 'ruminal acidosis') has been suggested as a cause of poor rumen function and therefore productive losses

But what do the numbers mean?

How low is too low?

And does it matter how long the pH stays low?

Or how quickly it changes?

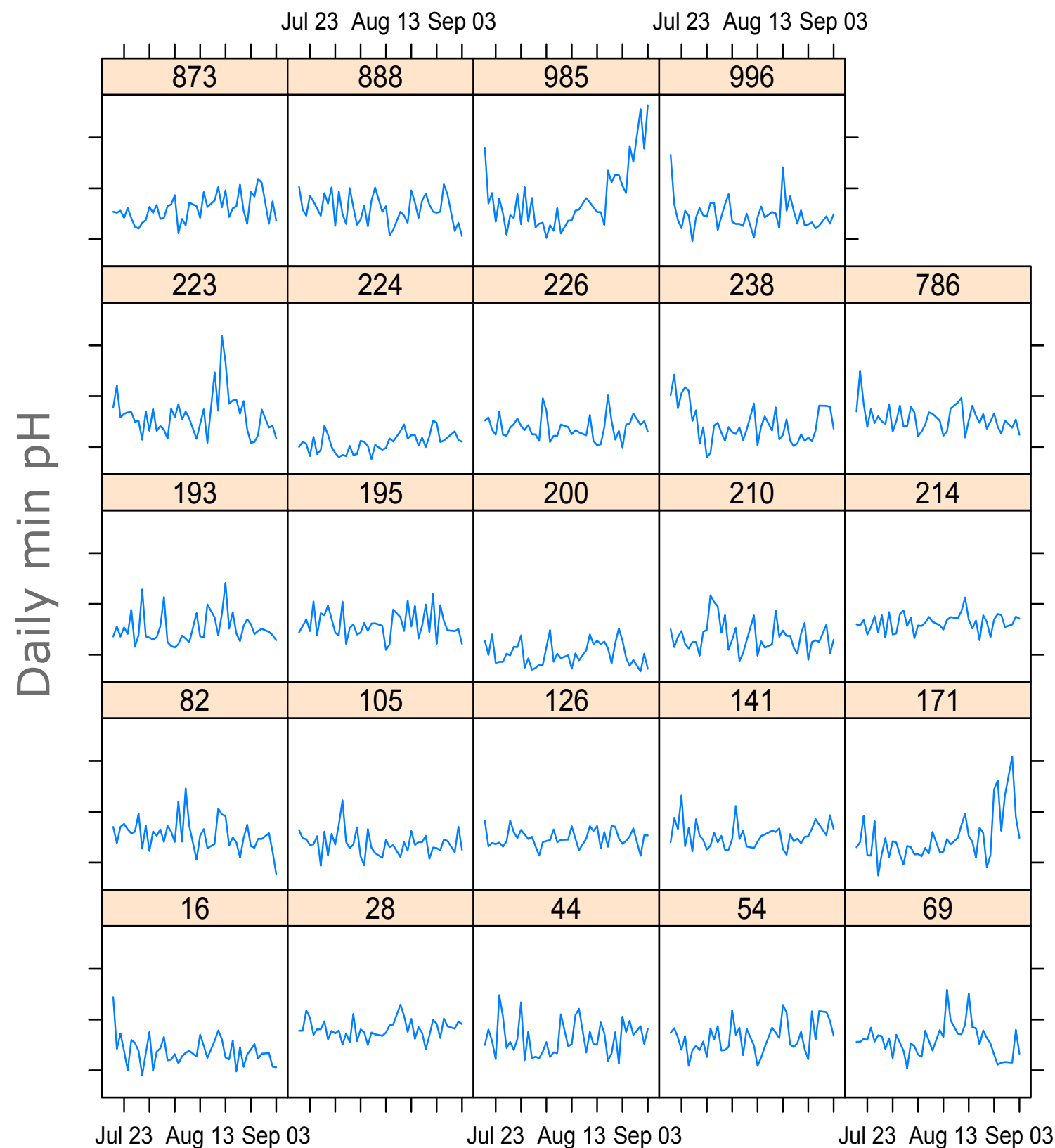
TimeStamp	ph Value	Temperature	raw ADC pH
16/07/13 15:39	7	23.6	252
16/07/13 15:54	6.19	39.9	392
16/07/13 16:09	5.93	41.1	435
16/07/13 16:24	5.68	41.4	478
16/07/13 16:39	5.78	38.3	460
16/07/13 16:54	5.75	39.1	466
16/07/13 17:09	5.68	39.7	479
16/07/13 17:24	5.93	39.9	436
16/07/13 17:39	6.3	40.5	372
16/07/13 17:54	6.4	40.5	356
16/07/13 18:09	6.41	40.8	354
16/07/13 18:24	6.37	40.8	359
16/07/13 18:39	6.36	41.1	361

TimeStamp	ph Value	Temperature	raw ADC pH
16/07/13 15:39	7	23.6	252
16/07/13 15:54	6.19	39.9	392
16/07/13 16:09	5.93	41.1	435
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16/07/13 18:09	6.41	40.8	354
16/07/13 18:24	6.37	40.8	359
16/07/13 18:39	6.36	41.1	361
16/07/13 18:54	6.27	41.1	378
16/07/13 19:09	6.09	38.1	407
16/07/13 19:24	5.98	37.8	427
16/07/13 19:39	5.89	38.6	443
16/07/13 19:54	5.84	39.4	451
16/07/13 20:09	5.74	39.7	468

17/07/13 05:54	6.69	39.9	307
17/07/13 06:09	6.65	40.2	312
17/07/13 06:24	6.71	39.9	303
17/07/13 06:39	6.74	39.9	298
17/07/13 06:54	6.68	39.9	308
17/07/13 07:09	6.73	39.9	299
17/07/13 07:24	6.78	40.2	291
17/07/13 07:39	6.67	35.1	309
17/07/13 07:54	6.74	37	296
17/07/13 08:09	6.79	38.3	288
17/07/13 08:24	6.8	38.6	288
17/07/13 08:39	6.81	38.8	286
17/07/13 08:54	6.83	39.1	282



## Traditional approach to rumen pH: summarisation



The minimum daily pH (x axis) over time (y axis) for 24 dairy cows

Observations:

1. There is fluctuation in the daily minimum pH for all cows
2. Cow 200 tends to have a lower daily minimum pH than most
3. Cows 171, 223 and 985 had a period of higher minimum pH

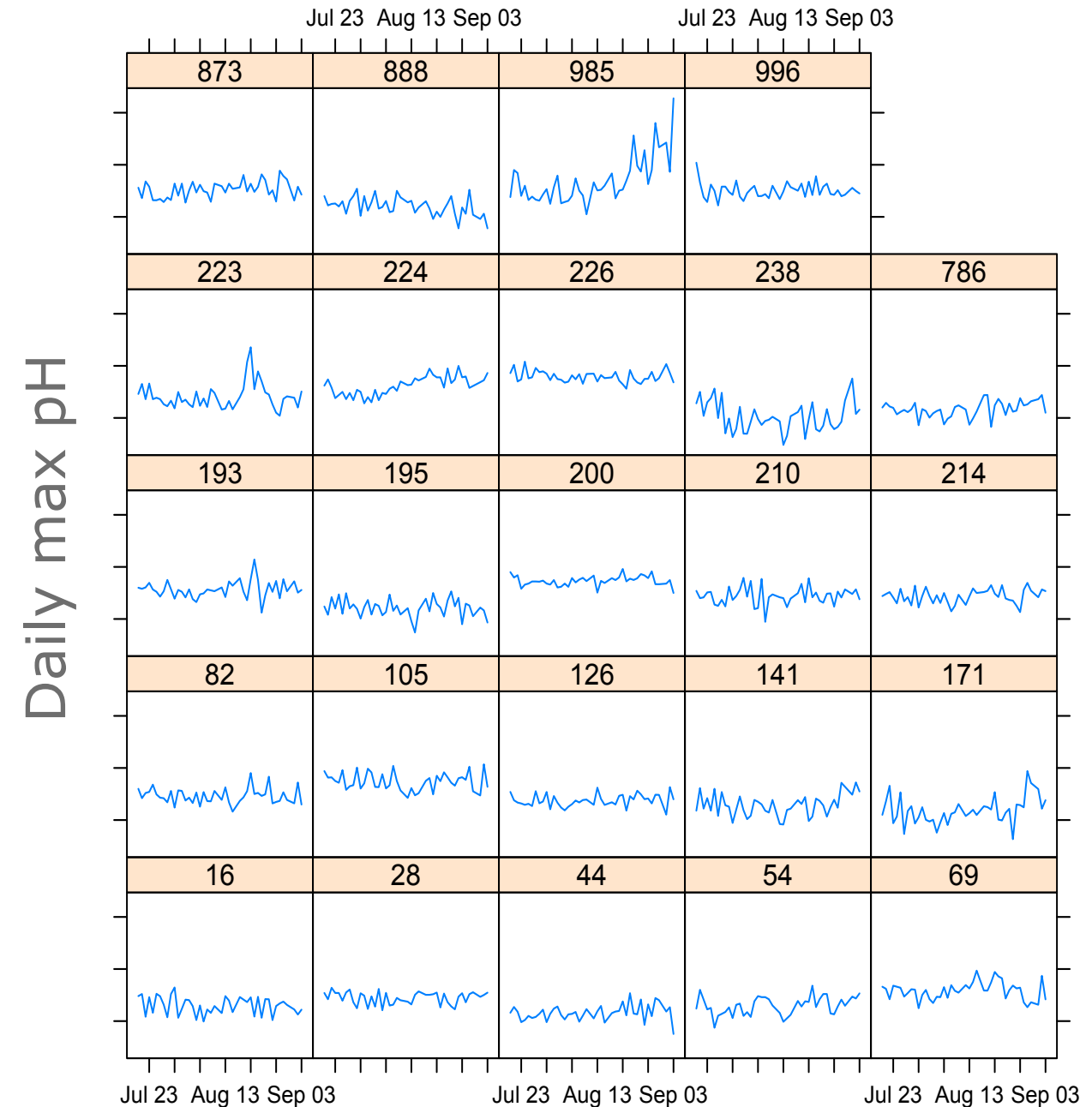
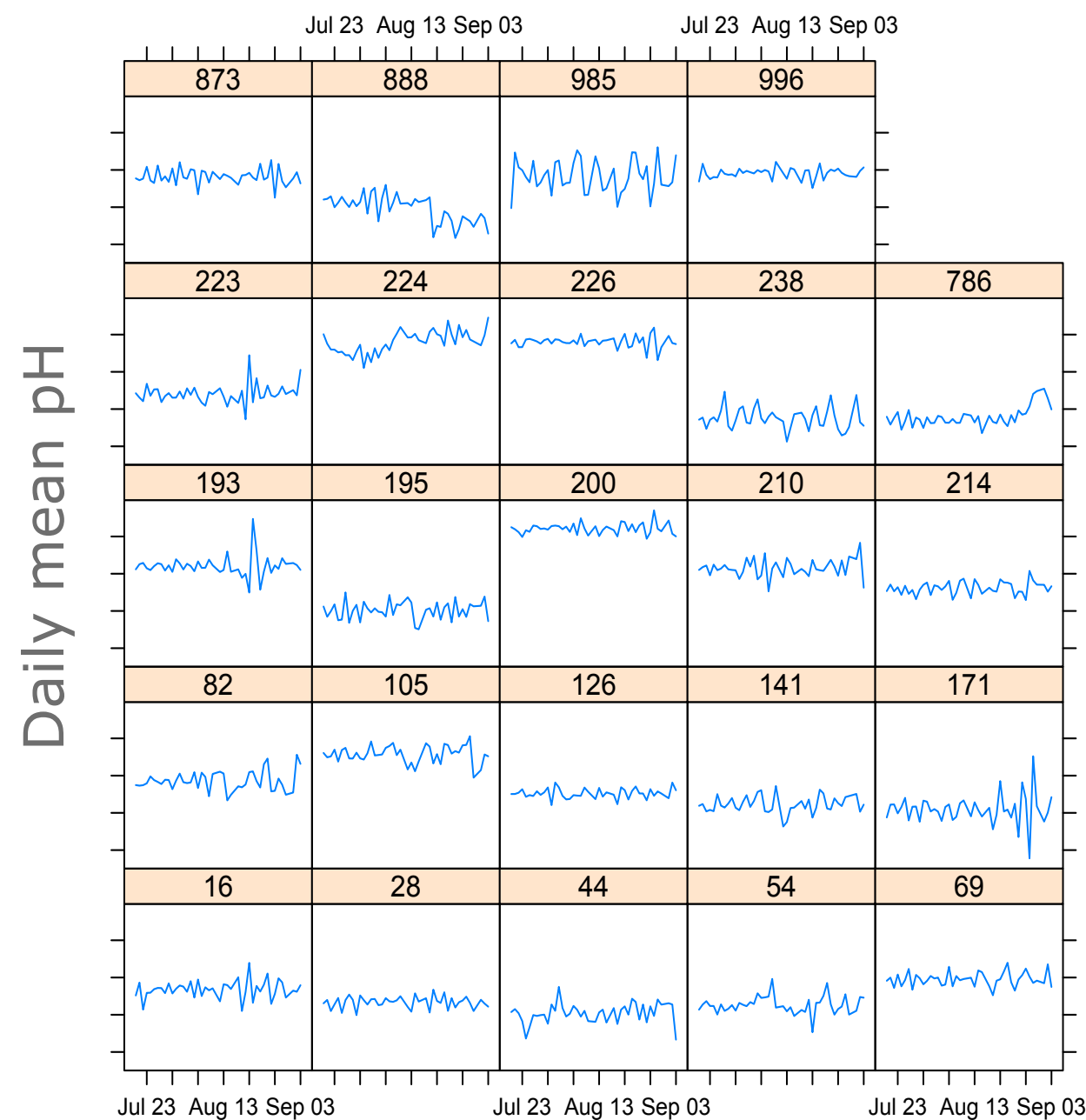
Do any of these observations actually relate to anything?

How do they help us improve productivity?



# Traditional approach to rumen pH: summarisation

And what about daily mean pH and daily max pH?

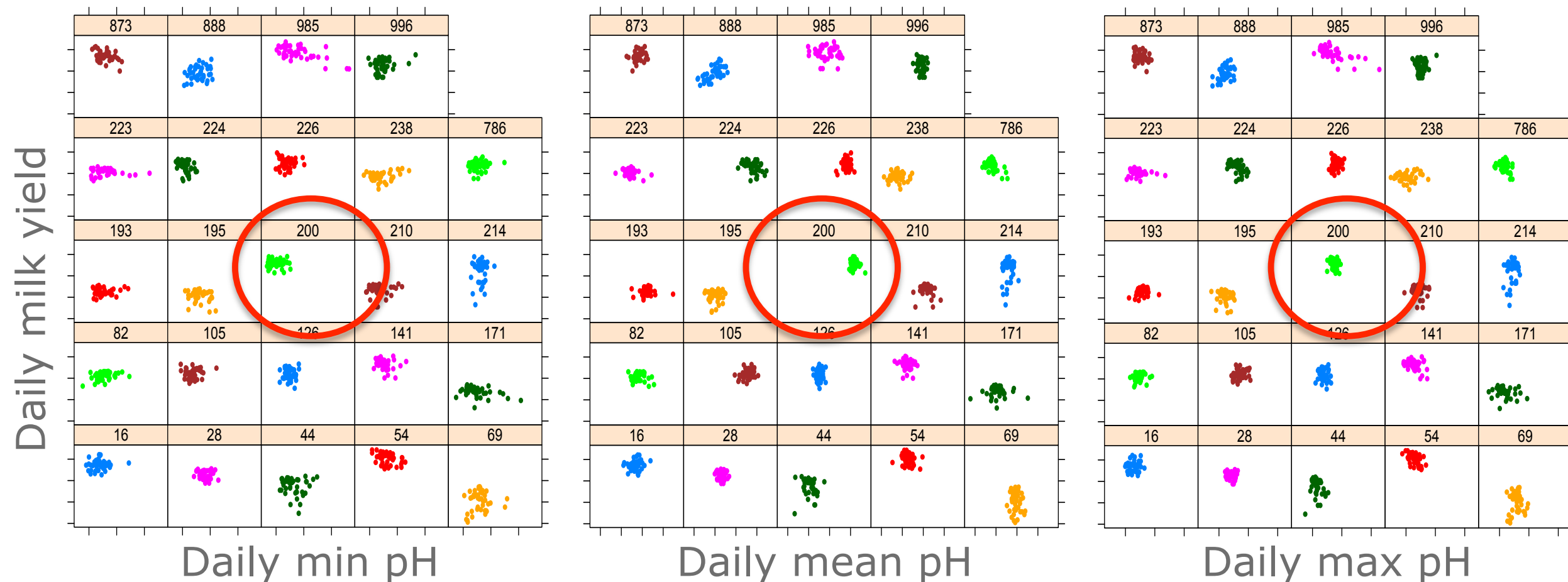


These display more between animal variation than daily min pH!



## Our approach to rumen pH: regression

It is far more useful to relate pH to some measure of productivity  
For example, how do pH patterns relate to changes in milk yield?



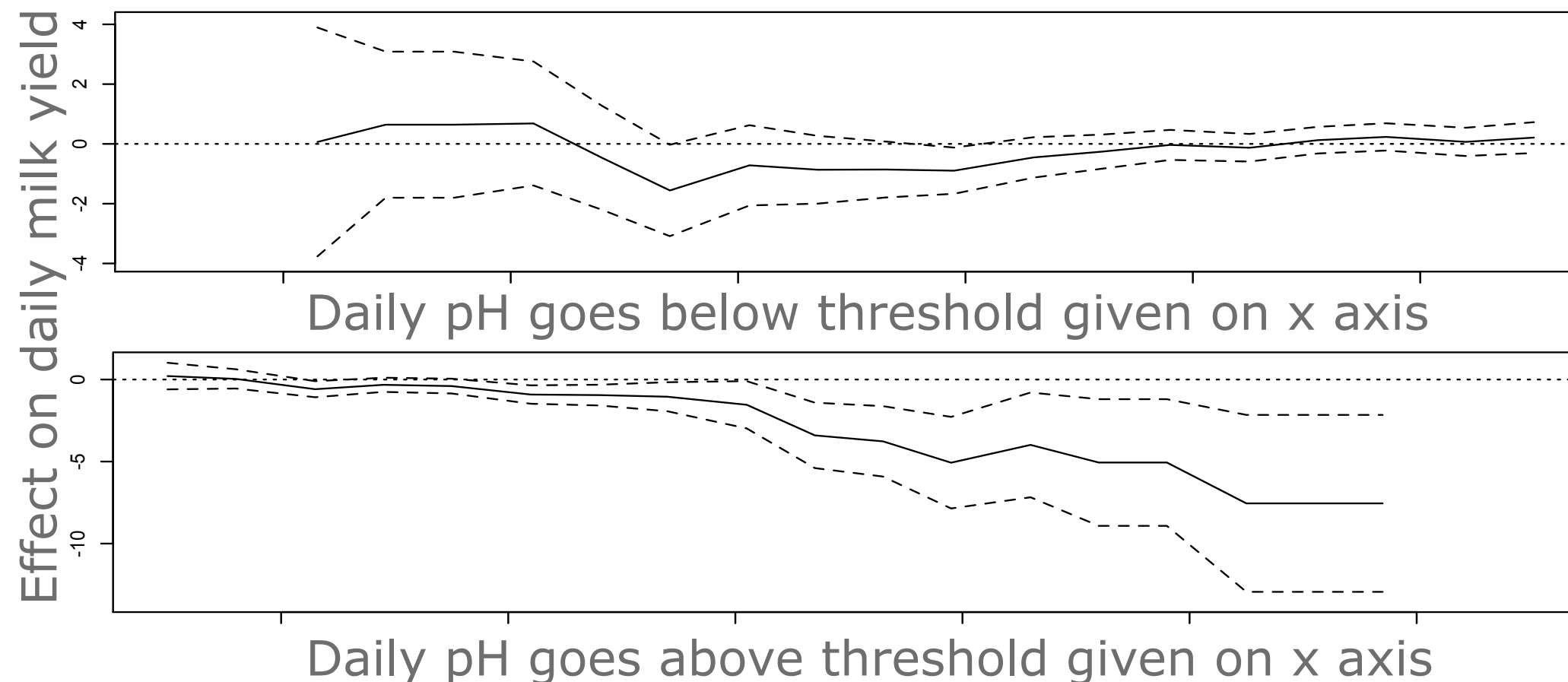
### Observations:

- Yield and pH both vary between animals
- eg: Animal 200: yield+, min pH-, mean pH+, max pH~
- Relatively weak correlation between pH and yield within animals



## Our approach to rumen pH: regression

What about using a 'pathological' pH threshold?



So is 'alkalosis' as/more important than 'acidosis'?!?

Future work: employ an algorithmic approach to identify the most relevant summary statistics, taking into account any variation between individuals

Ultimate aim: a 'real-time' tool for detecting problems on farm

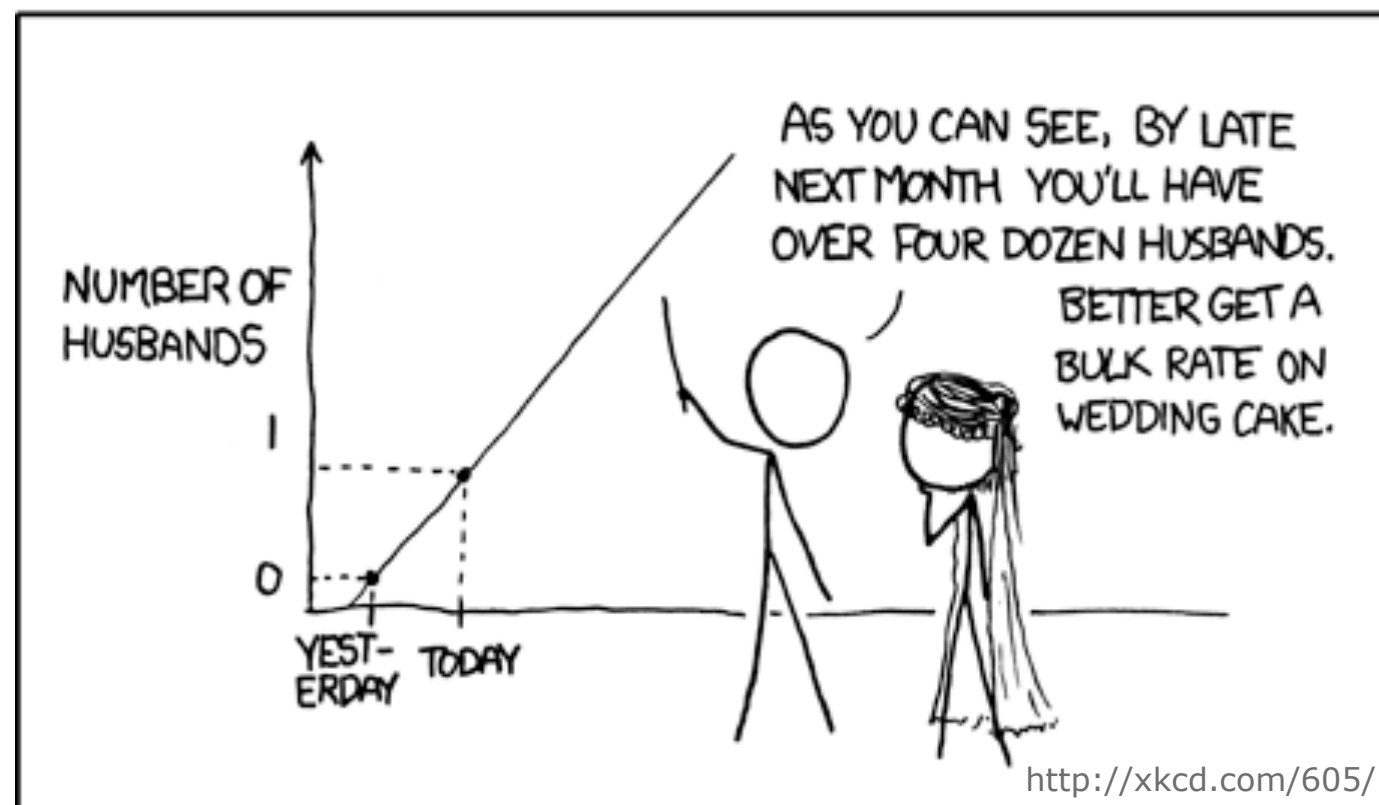




## Summary

- Statistical models can help to get more value out of your data
  - However, care must be taken to use these (relatively) complex statistical methods appropriately...
- Epidemiologists and/or statisticians can be very useful people to collaborate with, especially on project applications....
  - <http://iph.ku.dk/english/research/animal-welfare-and-disease-control/>
  - <http://www.gla.ac.uk/boydorr/aboutthecentre/>
  - <https://www.bioss.ac.uk/consult.html>

### MY HOBBY: EXTRAPOLATING



Questions?

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