Factors Affecting Lamb Growth: An Evaluation using Cross Classified and Multiple Memberships models

Eliana Lima[1], Martin Green[1], Fiona Lovatt[1], Janet Roden2, Peers Davies[3], Jasmeet Kaler[1]

[1]University of Nottingham, United Kingdom [2]Innovis Breeding Sheep Ltd , United Kingdom [3]University of Liverpool, United Kingdom

1. Background and research questions

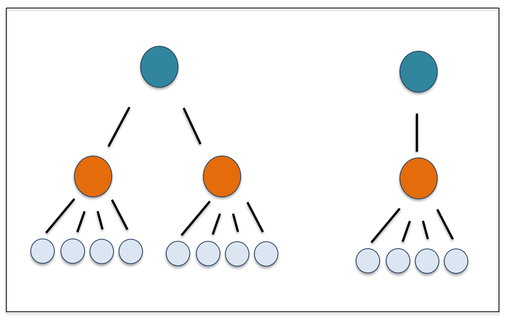
- With current concerns about the sustainability of red meat production and increasing global demand for food, there is need to understand key factors that influence the efficiency of growth of animals, in this case lambs
- Livestock growth has traditionally been modelled using conventional hierarchical mixed effect models
- ***Questions*:**
  - **What are the major disease and management factors that influence lamb growth?**
  - **Can we improve upon conventional mixed models to more accurately capture determinants of lamb growth?**

2. Methods

- 808 lambs from one flock weighed over 5 months (= 4172 weight recordings); disease events and lamb paddock allocation recorded
- **3 mixed model structures compared** and the Deviance Information Criterion (DIC) used to select the model with the best fit
- Final estimates for all models parameters made in a Bayesian framework using Markov Chain Monte Carlo

Diagrammatic representation of model structures

Hierarchical model



Level 3 – Ewes (n=554)

Level 2 – Lambs (n=808)

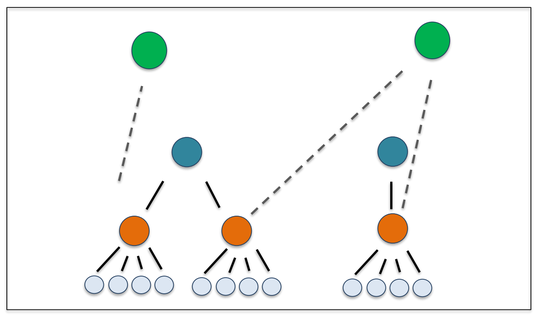
Level 3 – Weight recordings (n=4217)

$$Y_{ijk} = \beta_0 + \beta_1 X_{ijk} + \beta_2 X_{jk} + \beta_3 X_k + u.age_{jk} + v_k + u_{jk} + e_{ijk}$$

Classical hierarchical model; with a random slope term for "age" to allow variation between-lambs in growth rates over time

DIC= 19154.6

Cross classified model



Level 4 – lamb groups over time

Level 3 – Ewes (n=554)

Level 2 – Lambs (n=808)

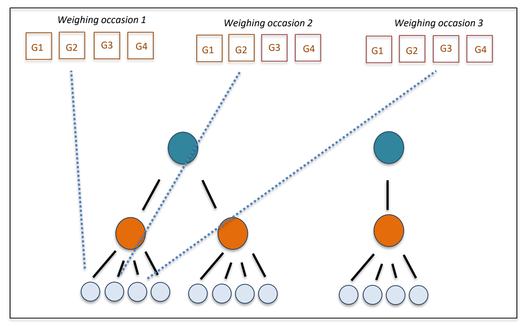
Level 3 – Weight recordings (n=4217)

$$Y_{ijkh} = \beta_0 + \beta_1 X_{ijk} + \beta_2 X_{jk} + \beta_3 X_k + w_h + v_k + u_{jk} + e_{ijk}$$

Cross classified model; this accounted for the combination of groups to which a lamb was allocated over time, but not the time spent in each specific group

DIC = 19130.3

Multiple membership model



Level 4 – lamb groups at each weighing occasion

Level 3 – Ewes (n=554)

Level 2 – Lambs (n=808)

Level 1 – Weight recordings (n=4217)

$$Y_{ijkf} = \beta_0 + \beta_1 X_{ijk} + \beta_2 X_{jk} + \beta_3 X_k + \sum_{f=1}^{f} mm_{i,f} w + v_k + u_{jk} + e_{ijk}$$

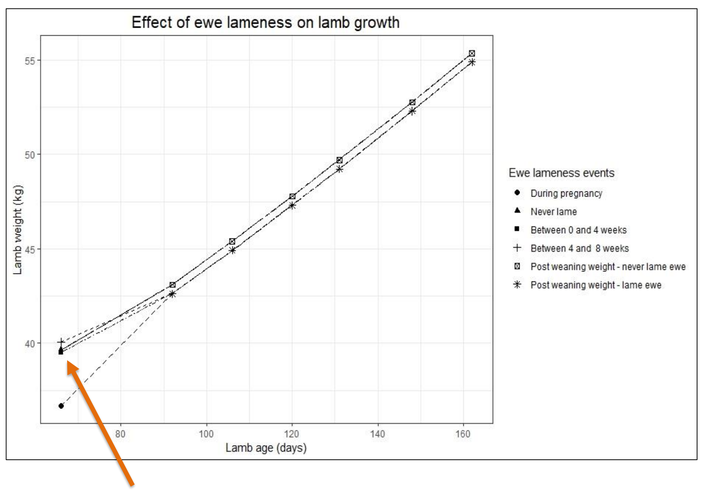
Multiple membership model; this accounted for the time lambs spent in each management group - the random effect weighting (w) represented the proportion of time spent in each group

DIC = 17841.6 (best model)

3. Main Results and Conclusions

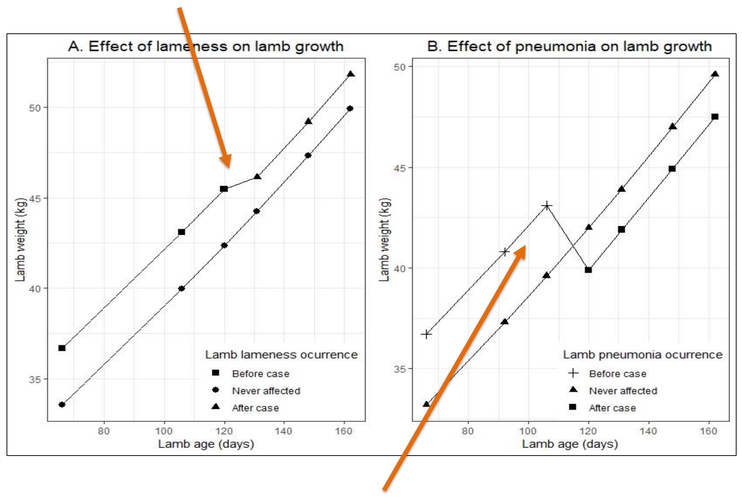
- The **multiple membership structure** resulted in a superior model fit to the conventional growth rate model and was used for final inference
- **Ewe mastitis and lameness during pregnancy** had a negative effect on lamb growth
- **Lamb lameness, joint ill and pneumonia** had a deleterious impact on growth
- **Heavier lambs appeared more likely to be affected by disease** – a consequence of lower disease resilience in animals that are partitioning more resources into growth?

Fixed effect results



Lambs from ewes that were lame during pregnancy were significantly lighter at ~56 days of age compared to lambs from ewes not lame during pregnancy and compared to ewes that were lame between parturition and 56 days into lactation

A. Lambs prior to a case of lameness were heavier than lambs that were never lame. After the lameness event lambs remained a similar weight to those never lame.



B. Prior to a pneumonia case lambs were heavier than unaffected lambs and then lost weight after a case

I am a veterinarian with a keen interest in epidemiology and food safety topics. Currently I am at the final year of my PhD at the University of Nottingham, which focuses on application of quantitative methods to identify husbandry factors leading to a healthy and efficient production of lamb meat.