SMALL FLOCK NETWORKS: HOW MANY FRIENDS DOES A SHEEP HAVE?

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Introduction

The aim of this project is to develop understanding of the dynamics of the transmission of infectious diseases such as foot-and-mouth disease (FMD) within a herd of animals by establishing contact networks for a small flock of sheep. Mechanical transfer of the virus is considered to be the most common form of transmission between infected and susceptible animals so species that interact frequently and in close proximity to each other would be at greater risk. In the aftermath of the 2001 FMD outbreak in the UK several epidemiological models were developed to control the spread of disease from farm-to-farm by establishing contact networks for the sheep industry (Kiss *et al* 2006; Webb 2005). By using a similar approach the objective here is to build-up networks detailing the direct and indirect contact that occurs in a flock of sheep in order to further our knowledge of spread of disease within a herd using social network analysis.

Methods

A small flock of conventionally farmed Dorset sheep were observed. There was a total of 11 ewes and 19 lambs that were grazed rotationally in three small paddocks. The stocking density averaged about 1.3 LSU per hectare. The ewes had lambed late November and were placed in the paddocks with their lambs within one week of lambing. The ewes ranged between 18-36 months and parity numbers 1-4. Each sheep was clearly numbered so they could be easily identified from one and other.

Pilot Study

A pilot study was conducted to establish all the different types of direct and indirect contact that occurred between individuals. Contacts were categorised as follows:

- **Close proximity :** *Within 1m and within 2m*
- **Physical Contacts** *Sniffing, Suckling, Suckling attempts, Head butting, Kicking, Standing, Pawing, Mounting, Rubbing and Resting*.

With the exception of resting the majority of these contacts were of short duration lasting less than 30 seconds.
Interactions with objects such as the water trough, feed cakes, molasses tub and hurdles that were in the paddock were also recorded.

Field Trials

Two 15 day trials were undertaken. The first one took place in December when the lambs were approximately two weeks old. The second one began at the end of January when the lambs were older and close to weaning age.
Each sheep was individually observed for 10 minutes periods once each day with interactions with all other sheep and objects being recorded. The physical contacts were recorded for frequency and the proximity measures only being recorded if they were present or not. The order in which the sheep were observed was randomised so that no sheep was occupied the same time slot on any given day. The observations took place between 8am and 4pm everyday.

Results

Physical Contacts.
Networks have been constructed for each of the different types of contact.

Figure 1: Sniffing Network

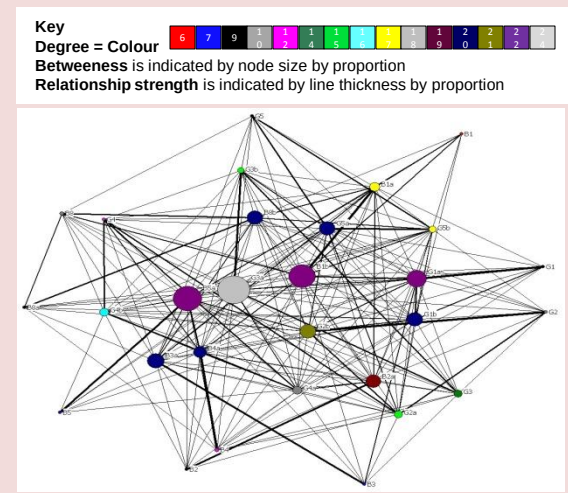


Figure 2a: Resting Network

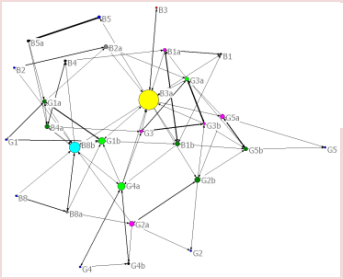
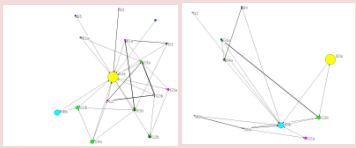


Figure 2b: Resting ego network for B3a and B8b



Proximity Measures.
The networks for the proximity measures are far more connected than the ones for physical contact suggesting that each sheep was observed within 1m and 2m of every other sheep at some point during both trials. The mean relationship strength for within 1m was 0.821 and for within 2m it was 0.933. The table below summarises centrality measures for those networks.

	Within 1m		Within 2m	
	Degree	Between	Degree	Between
Highest	28	0.499	28	0.037
Lowest	24	0.075	27	0

All analysis was carried out in UCInet (Borgatti *et al* 2002).

Discussion

The majority of physical contacts are lamb-to-lamb or lamb-to-ewe, also the lambs tend to have higher degree centrality and betweeness centrality than the ewes suggesting that a flock is more connected when there are lambs present. The networks displayed do not include interactions with objects or the herdsman as the farm staff were observed checking the sheep only on four days during the entire 30 day trial. If this is typical of most farmers this would suggest interactions with people and associated equipment are not important as a means of indirect transmission between individuals when sheep are grazing out at pasture. If the sheep had been observed during lambing or shearing times then this would no doubt be different. The analysis for this project is far from complete the centrality measures used above only reflect an individuals role in the network. Further analysis into the overall structure of the networks and intermediate measures that indicate the presence of sub-groups is required. It will also be interesting to compare networks from trial one with trial two to see if there is any difference in the behaviour of the lambs as they get older. All this will need to be statistically analysed too. During the course of the trials extreme weather conditions were noted so it may be possible to see if this altered the closeness and interactions of the flock. Ultimately the analysis will reveal how closely connected a small flock of conventionally farmed sheep actually is and subsequently further insight into within-herd transmission of FMD.

References
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Webb, C.R. (2005) Farm animal networks: unravelling the contact structure of the British sheep population. *Preventative Veterinary Medicine* **68,** 1, 3-17.