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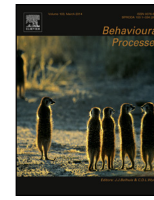

Temperament, age and weather predict social interaction in the sheep flock

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ABSTRACT

The aim of the current study was to investigate the social relationships between individual sheep, and factors that influence this, through the novel application of the statistical multiple membership multiple classification (MMMC) model. In study one 49 ewes (ranging between 1 and 8 years old) were fitted with data loggers, which recorded when pairs of sheep were within 4 m or less of each other, within a social group, for a total of 6 days. In study two proximity data were collected from 45 ewes over 17 days, as were measures of ewe temperament, weight and weather. In study 1 age difference significantly influenced daily contact time, with sheep of the same age spending an average of 20 min 43 s together per day, whereas pairs with the greatest difference in age spent 16 min 33 s together. Maximum daily temperature also significantly affected contact time, being longer on hotter days (34 min 40 s hottest day vs. 18 min 17 s coolest day), as did precipitation (29 min 33 s wettest day vs. 10 min 32 s no rain). Vocalisation in isolation, as a measure of temperament, also affected contacts, with sheep with the same frequency of vocalisations spending more time together (27 min 16 s) than those with the greatest difference in vocalisations (19 min 36 s). Sheep behaviour in the isolation box test (IBT) was also correlated over time, but vocalisations and movement were not correlated. Influences of age, temperature and rain on social contact are all well-established and so indicate that MMMC modelling is a useful way to analyse social structures of the flock. While it has been demonstrated that personality factors affect social relationships in non-human animals, the finding that vocalisation in isolation influences pair social contact in sheep is a novel one.

1. Introduction

Sheep are highly social and have evolved to live in large groups within a home range (Lawrence and Woodgush, 1988). A variety of factors affect the sociability of the sheep within the flock including hierarchy, food availability, defence strategy and behavioural ontogeny (Le Pendu et al., 1996). In a production setting the complexity and size of the paddock influences group formation, with sheep clustering together in smaller paddocks, but preferring to spread out when space is available (Dwyer and Lawrence, 1999). Group activity, age difference and breed differences also contribute to group dynamics; with sheep dispersing when grazing and staying closer together when resting (Michelena et al., 2009), and sheep of similar ages associate together and spend time apart from those different in age (Lawrence, 1990).

Since spatial proximity is highly correlated with social affinity, proximity can be used to understand social relationships in the flock (Le Pendu et al., 1996). Visually observable 'nearest neighbour distance' is one way social dynamics can be identified (Dwyer and Lawrence, 1999; Shank, 1982; Festa-Bianchet, 1991). This is an effective way to assess flock dynamics because it records both social relationships and motivations without interference (Sibbald et al., 2005); however, it can be time consuming and often limited by visibility of the individual animals. More recently, proximity loggers, a remote sensing technology, have been used to quantify social dynamics within a group of animals. To date, proximity loggers have been used in sheep to identify ewe-lamb interactions (Broster et al., 2010), stocking rates (Broster et al., 2012a) and feed availability (Freire et al., 2012), but they have not been used to identify individual social interactions within a stable adult flock.

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The aim of the current research was to intensively study the social relationships between individual sheep, and factors that influence this, through the use of a multiple membership multiple classification (MMMC) model (Browne et al., 2001). The MMMC model allows the variation of an individual parameter on an individual or group response to be assessed (Tranmer et al., 2014), and thus allows parameters influencing variability between individual pairs in a social group to be analysed, and importantly, predictions on how modifications may affect social behaviour can be made. While this method has been used in some examples of human social network research (Tranmer et al., 2014), this is the first time it has been applied to animals. This aim was fulfilled in two studies; the first investigated the effect of age on social interactions, and the second study investigated the effects of sheep temperament and weather conditions.

The isolation box test (IBT) was used to measure temperament in study two. Published studies commonly use an automated measure of agitation, which pools both movements and vocalisation (Plush et al., 2011). As we were using a manual observation of this, we investigated relationships between these behavioural indicators as well in an effort to maintain consistency with published data.

2. Materials and methods

Both studies were conducted in Wagga Wagga, New South Wales, Australia (35°3′S, 147°20′E). Two different flocks of sheep were used for study one and two. For both studies sheep were kept in their respective mobs for one month before the commencement of the data collection period. This was done to ensure a relatively stable flock social structure. Both studies were approved by the Charles Sturt University animal ethics committee.

2.1. Proximity loggers

Proximity loggers (SirTrack Ltd., Havelock North, New Zealand) were used to record social interactions between pairs of sheep within the flock. Each logger was fixed to a leather collar and attached to the ewes (total weight 425 g). The proximity loggers use an ultra-high frequency (UHF) transceiver that transmits a code unique to each logger. They receive and log signals from all other proximity loggers within a predetermined distance. For this study the proximity loggers were set to record all contacts within a maximum range of approximately 4 m between ewes as this distance has been previously validated (Broster et al., 2012a). This distance of 4 m cannot be determined exactly as the radio waves can be reflected, refracted and/or absorbed by a number of naturally occurring objects (Mullen et al., 2004). The distance at which contact is recorded is affected by both antenna height and the orientation of the animals, with the animal's body reducing the distance at which contact is recorded, ie. two animals facing each other will record contact at a distance greater than one animal facing another which is turned away from it and this will be further than two animals facing away from each other.

The output from each proximity logger provides a record of the date and time of the start of every contact with any of the other proximity loggers, each of which has its own individual identification number, and the duration of each contact. Loggers had to be separated, i.e. further than 4 m apart, for longer than 20 s before this was recorded as a new contact. Proximity loggers can capture multiple interactions at the same time, and so it is possible for total daily contact times to exceed 24 h (e.g. if one sheep had 5 h of contact with six different sheep the daily contact time would be 30 h). The ewes were observed for 10 min each time the collars were attached to confirm they were not displaying signs of discomfort from the collars.

2.2. Study details

In study one 49 pregnant adult Merino ewes (ranging between 1 and 8 years old, approximately 1–2 months pregnant) were kept in a 3.04 ha paddock. The paddock contained several shade trees and a water trough, and pasture was the only feed source available. A total of six days of data were collected, separated into three groups of two consecutive days between November and December, 2012. Due to collar malfunction no data were recorded by two collars in the first two day group and by one collar for each of the second and third groups of two days.

In study two 45 pregnant Merino x Border Leicester ewes (4 years old, approximately 2–4 months pregnant) were kept in a 3.9 ha paddock. The paddock contained several shade trees and a dam providing water, and pasture was the only feed source available. A total of 17 days of data, separated into seven two consecutive day groups and one with three consecutive days, were collected between January and March, 2014. For a total of 6 days one collar did not transmit or record data. During the course of the second experiment, maximum and minimum daily temperature were taken for each day using temperature loggers (Hastings Data Loggers, Port Macquarie, NSW, Australia) and the total daily rainfall for each day over the study period was taken from the Australian Bureau of Meteorology (Bureau of Meterology, 2014). Pasture quality and volume was assessed weekly in the second experiment, but no differences were noted throughout the data collection period, and so these data are not included.

Before the start of study two the ewes were weighed, and again 62 days later. The temperaments of the ewes were also tested in an IBT, before the start of the study and again 79 days later. For both IBTs, ewes were individually drafted into the isolation box (105 cm × 75 cm × 42 cm) and their behaviours scored for 1 min. Their vocalisations were scored manually and their movements were recorded with cameras (Paynter Security, Lavington NSW) for later analysis. The following movements were recorded: steps with the front right hoof ('steps'), 180° turns, single leg contact with the walls of the IBT ('pawing') and 'jumps' (lifting both front feet from the ground at the same time).

2.3. Statistical analyses

For each possible animal pairing in the flock data for the number and length of contacts per day were collected from each animal's collar and the mean used for analyses. For one deployment in 2012 the memory of three collars were full before removal; these collars were still useful as they continued to transmit their unique identification number and this information formed part of a contact recorded on any other collars that formed part of a paired contact enabling the reciprocal data to be used in analyses (Swain and Bishop-Hurley 2007; Broster et al., 2012b). When both collars in a pair recorded data for the full day (24 h) the mean for both collars was determined and this used for the analyses. When only one collar of a pair recorded a full day's data then only that collar was used for analysis and when neither collar from a pair recorded a full day's data then that pair of animals was excluded from the analysis for that day. From these data the total daily contact time with all sheep (h), the average duration of contact (min), the total number of daily contacts and the average number of daily contacts were calculated.

A multiple membership multiple classification (MMMC) model was used to identify predictive factors that influence the interactions between individual pairs of sheep (Browne et al., 2001). The MMMC model had the repeated daily measurements of individual pair interactions (measured in seconds) nested within pairings of sheep, which themselves are nested in a multiple membership of two sheep each of which might influence the length of interaction. The data were analysed in the statistical program MLwiN (Rasbash