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Real-Time Locating System to study the persistence of sociality in large-mammal group dynamics

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Abstract

Many animals live in highly structured groups. Individual differences in the number and identity of social contacts define the social network structure. Most domesticated animals belong to such species. The composition of groups can be disturbed by grouping animals according to age or production stage, which can in turn induce stress. We investigated whether the preference of two animals to stay together depends on their sociality or on the composition of the group. We observed 158 dairy cows in six pens during 17 weeks. The precise positions of the cows were monitored with positional loggers 24/7 in stable groups and during the formation of new groups. In stable groups, the sociality of a cow was maintained over the entire observation period. When introducing foreign individuals into well-established social groups, the sociality of individual cows was maintained independently of the group; this sociality was therefore not necessarily defined by the time spent in the group. During the formation of new groups, newly introduced cows dynamically interacted with resident ones, forming a few strong short-lasting contacts between newcomers and resident cows. However, most long-lasting interactions occurred between resident group members. Our study reveals that in a species that spontaneously lives in large social groups, such as cattle, each animal has its own sociality independent of group. However, when it comes to establishing strong relationships between newcomers and resident animals, more than 2 weeks is needed.

Keywords: Precision Livestock Farming, RTLS, animal behaviour, social network, cattle

Introduction

Many animals are gregarious. Within a group, animals vary in their readiness to interact with others and their affinities to specific partners. Such a complexity can be represented by social networks where the individuals and the whole group can be

characterized by a number of statistics (Krause et al., 2007; Wey et al., 2008). For instance an individual can be characterized by the number of its immediate neighbors, the strength of its relations with these neighbors, the number of individuals its neighbors are connected to (clustering coefficient), and so on. Such statistics can also be calculated at group level to characterize the network as such. The structure of social networks is likely to have high impact on fitness, both impacting on cooperation between animals, information transfer, reproductive success of specific individuals, and also disease transmission (Krause et al., 2007; Wey et al., 2008).

Domesticated animals mostly belong to gregarious species that spontaneously live in structured groups. Cattle represent a common type of large domesticated animals with a high sociality. Groups of cows are formed thanks to dominance/subordination relationships and to preferential relationships (Reinhardt & Reinhardt, 1981; Bouissou et al., 2001; Stoye et al., 2012). When two cows are mixed together for the first time, they exchange aggressive interactions (fights, butts), but once the dominance/subordination relationship is established (i.e. only one gives butts to the other, but not vice-versa) then the frequency of aggressions declines dramatically and the hierarchy remains stable (Bouissou et al., 2001). Preferential relationships are also observed, whereby animals stay close to each other, synchronize their activities (e.g. eating, walking, resting), and exchange mild interactions such as sniffing and allo-grooming (Gibbons et al., 2010).

Under farm conditions, the groups are shaped by humans and animals can be moved from one group to another according to their sex, age or production stage (e.g. cows in milk vs. dry cows), no matter their social preferences. Previous studies showed that mixing animals can be stressful, inducing an dysregulation of the corticotropic axis and a decrease in growth or milk production (Hasegawa et al., 1997; Mounier et al., 2005). This is likely to be due to aggressive interactions between animals that do not know each other. In addition, the social buffering properties of the group – by which animal stress is reduced by the presence of group mates – is diminished (Mounier et al., 2006). We suspect that such effects of mixing animals result from the whole social network being disturbed.

We used a Real Time Locating System (**RTLS**) to record the position of each individual cow housed in a free stall at every second 24/7 for 17 weeks. The underlying assumption is that cows spending time together interact socially. Using these high-resolution data, we were able to build dynamic interacting networks between cows. We analyzed the sociality of cows in stable group then we followed the introduction and removal of individuals between groups. We focus our study on two levels of sociality persistence: in an individual moving from one social group to another, and in a group experiencing the introduction of many newcomers.

Material and methods

The observations were performed at the INRA Herbipole farm (UE1414, France). There were on average 158 cows in the barn per week, 75% Holstein and 25% Montbeliard cows. They were housed in six pens with a maximum of 28 cows per pen. Each pen consists of a feeding area on one side and 2 rows of 14 cubicles (1.25 m x 2.53 m) on the other side (Fig. 1).

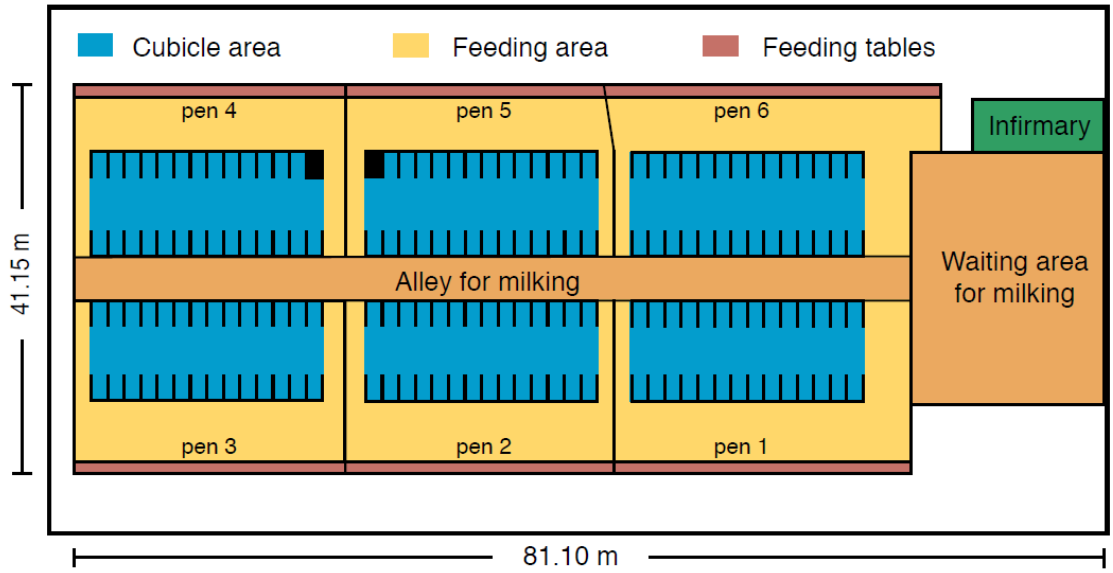

Figure 1: Barn composed of 6 pens, each with a capacity of accommodating 28 cows.

All observations were done under the routine management of the farm. We first observed the dynamics of two stable groups of cows in Pen 4 (18 cows) and Pen 5 (17 cows). The cows knew each other for at least one year, except five heifers in each pen that had been introduced one month before the observations. Both groups remained stable throughout the 17 weeks of observation, except that a cow was introduced in Pen 4 on Week 13 and another removed on Week 15. Then we observed unstable groups, with cows moved from Pens 2 or 3 to Pen 1. Finally, we analysed how the social network changes in a specific Pen 2 when, after a period of three weeks of stability, nine cows were removed and eight cows (from different pens) were moved in. This pen was observed from one week before to two weeks after this reshuffling.

We recorded the position of the cows with the CowView system (GEA, Germany). Each cow was equipped with a tag on its neck collar. Every second, the tag emits radio waves within the ultra-wideband area, which are detected by antennas within the barn. The accuracy of the position is on average 50 cm in the whole barn. We applied a rolling median filter of three consecutive positions to remove outliers and minimize the noise. Because of missing data, due e.g. to physical blockage of the signal from time to time, we focused on cows that were detected for at least 2/3 of a day (i.e., 16 h) for at least 2/3 of the total time (i.e., 80 days). This resulted in the collection of data for 158 cows out of the 188 that stayed in the barn.

We considered that two cows were in contact with each other when the distance between their tags was 1.25 m or less for at least 10 min of a day when they were outside the cubicle area. We defined the sociality of a cow during a given day as the number of other cows she was in contact with. We also calculated the average sociality of a cow over a week. To study social networks, we looked at all dyadic contacts of cows within a pen, measuring the total time two cows have been close to each other; in this case we used a threshold of 25 min to consider that cows were in contact with each other.

Results

The sociality of cows varies within a group. In Pens 4 and 5 that were stable along the observations, some cows contacted up to 14 other cows during a single day whereas other cows contacted one or even no partner. This characteristic seems stable across days. We divided artificially cows from each pen in three equal groups according to their sociality across the 17 weeks of observations: high vs. moderate vs. low sociality. In each pen, the three groups were statistically different along the 17 weeks: respectively for high, moderate, and low sociality cows, 5.89 ± 0.44, 4.35 ± 0.34 and 1.85 ± 0.60 contacts per day in Pen 4 ($F = 127.1$, $P < 0.0001$) and 3.67 ± 0.34, 2.94 ± 0.23, and 2.19 ± 0.44 contacts in Pen 5 ($F = 25.14$, $P < 0.0001$), with binary differences between groups also significant ($P < 0.01$).

Five cows were introduced in Pen 1 on Day 18, one from Pen 2 and four from Pen 3. These cows remained in the same sociality class (relative to the pen) from before to after introduction in Pen 1, suggesting that sociality is a trait that depends essentially on the individual and not the group.

When Pen 2 was reshuffled, the average duration of contacts between resident cows did not change significantly (from 106 ± 29.8 s on the week before the reshuffling, to 94.5 ± 28.4 s one week later and 74.5 ± 29.3 s the week after, $P > 0.05$). However, these contacts were not necessarily between the same cows (no correlation between dyadic contacts before and two weeks after the reshuffling). After their introduction, the new cows had strong contacts with the resident cows; however, with whom the contacts were established changed from one day to another. As a consequence, when averaged over a week, the dyadic contacts between resident and newcomer cows were scarce still two weeks after the replacement (Figure 2). At the same time the strength of the social network within the pen deceased: on average 2400 s of contacts between pairs of cows before the reshuffling to 2080 s during the first week after reshuffling and 1750 s the week after.

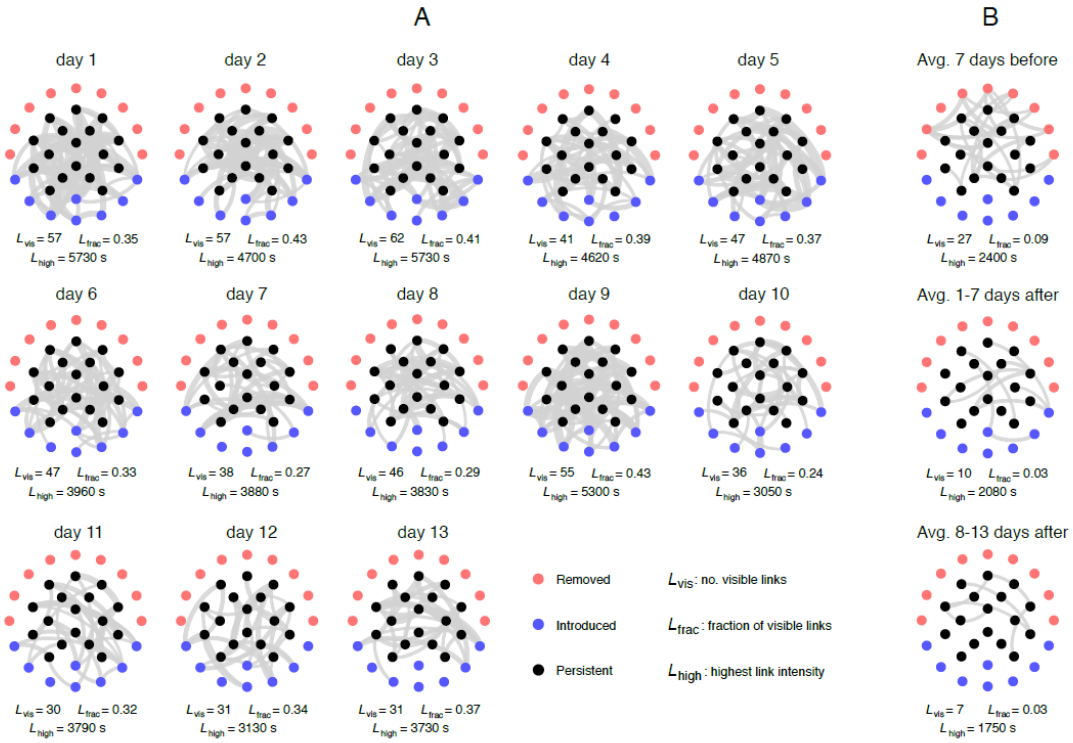

Figure 2: Network within Pen 2 before and after the replacement of 9 resident cows by 8 newcomers. L_{vis}, contacts between animals that lasted 25 min/d or more; L_{frac}, proportion of L_{vis} over all contacts whatever their duration; L_{high}, the longest duration of contact between two cows.

Conclusion

With a simple RTLS device we were able to characterise cows according to their sociality, that is their readiness to get close to – and probably interact with – other cows from their group. This characteristic seems stable over time, at least for the 17 weeks of observation of our study, and to depend more on the individual than the group it is in.

Groups of cows also seem to form a whole entity characterised by a network defined by dyadic connections between cows. This network is disturbed when cows are replaced by newcomer cows: not only does it take more than two weeks for the newcomers to mix with the resident cows, but also the network between the former resident cows is weakened.

RTLS can be used to study the social behaviour of cattle. It can also be used to monitor disturbances due to mixing, such mixings occurring frequently in farming. The cohesion of social groups is essential to encourage cooperation between animals and reduce stress (see introduction). RTLS could be used by farmers to ensure the proper functioning of groups of animals, identifying animals which have difficulties to get in contact with

others and whose welfare is likely at risk or identifying groups where the social cohesion is poor. It could thus help the management of social groups by farmers.

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