

SOCIAL RELATIONSHIP AND SPATIAL DISTRIBUTION IN A SMALL HERD OF JAPANESE BLACK CATTLE IN A DRY-LOT

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Summary

Behaviour of 7 horned Japanese Black Cattle (3-9 years old) kept in a 450 m² dry-lot under loose housing condition was observed in the daytime (0930-1730 h) during 3 consecutive days. Eating and lying behaviour of cattle and the positions of all animals when lying together were recorded at 10-min intervals. Agonistic encounters and social licking interactions in the herd were also recorded. The cattle established a social hierarchy which was near linear. An irregularity in the diurnal rhythm of lying behaviour was found on the 3rd day, which appeared to be caused by oestrus behaviour of a herdmate. Eating frequency showed greater variation among individuals than lying frequency, and the most dominant animal ate most frequently in the herd. The spatial pattern of the herd when lying indicated a relatively loose dispersion in the lot. Higher ranking cattle tended to lie down more frequently near the hay rack in the lot, so that lower ranking animals had more difficult access to feed. Cattle with more social licking interactions had a tendency to lie down near each other irrespective of proximity of social order, therefore it was suggested that social preference among particular individuals occurred in the herd.

(Key Words : Japanese Black Cattle, Lying Behaviour, Agonistic Behaviour, Social Licking Interaction, Spatial Distribution, Social Preference)

Introduction

Understanding cattle behaviour leads to better environmental management including social environment in animal agriculture from the animal's point of view (Curtis, 1983). Behavioural aspects, i.e. maintenance, social and spacing behaviour of cattle kept in a limited space under loose housing condition provide useful information not only on determination of space allowance and population density adequate for animals, but also on proper arrangement of feed trough, watering place or salt rack in paddock. The majority of the studies on "socio-spatial patterns of behaviour" (Stricklin and Kautz-Scanavy, 1984) have been performed with dairy cattle under semi-confined conditions, indicating that social order of the animals was closely associated with their spacing patterns in a yard (Beilharz and Mylrea, 1963;

Syme et al., 1975), in a loose housing barn (Mimura, 1971; Kondo et al., 1980), and in a free stall area (Friend and Polan, 1974). Compared with dairy cattle, less attention is directed to the relationship between social dominance and spacing pattern of beef cattle, especially beef heifers and cows.

In attempt to obtain basic information which would improve management procedures of beef cattle herd in dry-lot feeding systems, daytime activity of a small herd of Japanese Black Cattle in a dry-lot was observed to investigate the relationship between social structure and spatial distribution.

Materials and Methods

Animals and management

A herd of 7 horned Japanese Black Cattle kept in a dry-lot at the Kuju Agricultural Research Center of Kyushu University, located in Oita (alt. 950 m) was used for this study. The herd consisted of 6 cows and a heifer ranging in age from 3 to 9 years. The animals were kept daylong in an outdoor lot of 15 × 30 m (figure 1). The lot was enclosed by iron fences and the

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Received March 11, 1991

Accepted January 9, 1992

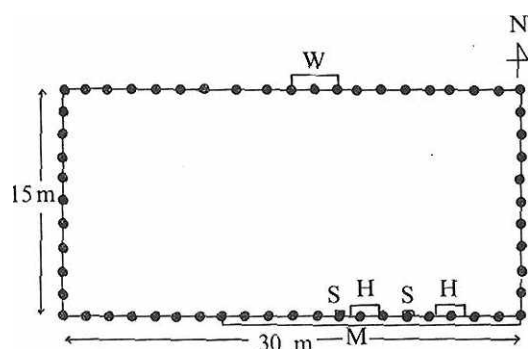


Figure 1. Schematic diagram of experimental dry-lot.

W, Water; H, Hay rack; M, Manger with stanchion; S, Salt; •, Colored pole.

floor was concreted. During the observation period, 2.5 kg/head of alfalfa hay cubes per day was offered in the manger with stanchion at 09:00 h and the cattle were allowed free access to rice straw at hay racks in the lot. Water and salt were given *ad libitum*.

Observations

Cattle were numbered with decolorizer on their sides so that they could be individually identified. Herd behaviour was observed between 09:30 and 17:30 h during 3 consecutive days. During the observation periods, eating and lying (rest and rumination) behaviour was recorded for each animal at 10-min intervals. Agonistic behaviour (fighting, butting, threatening and avoiding) and social licking interactions were also recorded whenever they occurred. Dominance order in the herd was determined by direct observation of wins and losses of agonistic encounters in the lot. The positions of all cattle that were lying in the corral (which was marked with colored poles; 1.5 m intervals) were recorded at 10-min intervals. The position of each animal was determined by observing animals on the lot floor with grid mark (10 × 20 squares), and plotted onto the recording sheet which also had grid mark. From the records of the lying positions, the distances between individuals in the herd (individual distance) were calculated.

Analysis of data

Behavioural data obtained in this study were analysed by non-parametric statistical procedures described by Siegel (1956). In addition, the degree

of aggregation or dispersion in spatial pattern of the herd was estimated by the ratio of the mean distance to the nearest neighbour (\bar{r}_A) to the expected distance to the nearest neighbour in random distribution (\bar{r}_E) which was equal to $1/(2\sqrt{\rho})$ (ρ : the number of individuals per unit of area) according to the method proposed by Clark and Evans (1954).

Results and Discussion

Diurnal variation of eating and lying patterns of the herd

Eating and lying patterns of the cattle are shown in figure 2. The diurnal rhythms of eating and lying of the herd were similar for Days 1 and 2. The highest frequency of lying was between 10:30–12:30 and 13:30–15:30 h. On Day 3, there was a peak of lying around noon, but not afterward. Decrease in lying of the herd from 12:30–17:30 h on the 3rd day may be due to the oestrus behaviour of a herdmate. There is some evidence that under both grazing and housing conditions a decrease in lying time of the cattle herd was observed on the day of oestrus of a herdmate and oestrus was a factor which could reduce the time spent lying for a short period (Samraus, 1971; Pollock and Hurnik, 1979; Phillips and Schofield, 1990).

In this study, therefore, the results and discussion are described, exclusive of data on the afternoon of Day 3 (13:00–17:30 h).

Relationships between eating and lying behaviour and dominance order

Table 1 shows the percentage of time spent eating and lying and dominance order of each animal during the observation period. Eating frequency showed considerable variation amongst individuals (χ^2 -test, $p < 0.01$), and animal 7 had the highest frequency in the herd. Comparing eating frequency, variation in lying frequency was relatively small (χ^2 -test, $p < 0.10$). From dominance-subordination relationships amongst the cattle in the herd, it was shown that since animal 23 was dominated by only animal 14, which was a lower ranking animal, a linear order was not always observed in this herd. However, it is likely that the pattern of social dominance is a linear-tending hierarchy as described by Hafez and Bouissou (1975). Correlations of eating and lying

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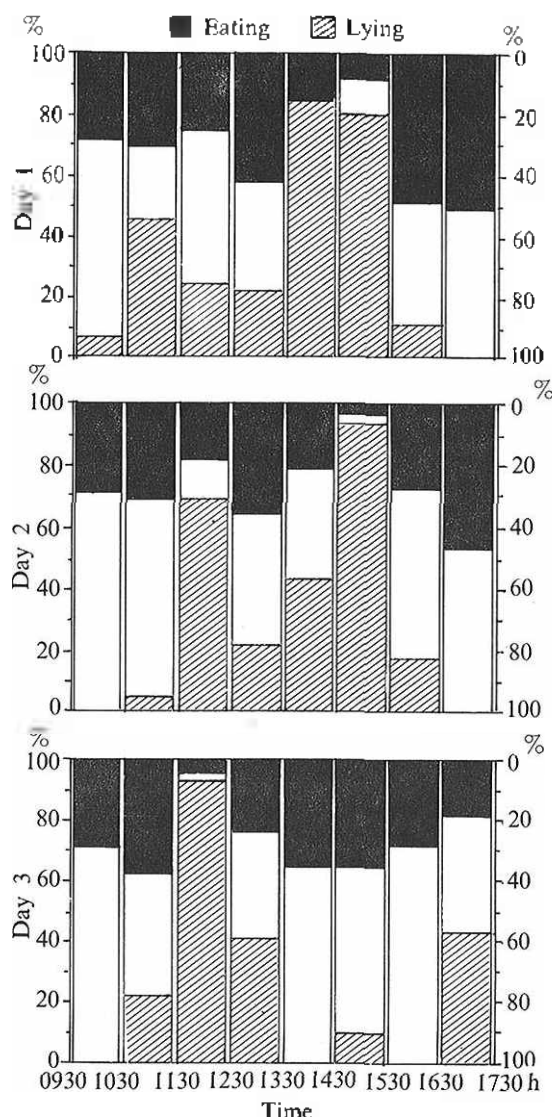


Figure 2. Diurnal pattern of eating and lying behaviour of the herd.

frequency with dominance order were low, though the most dominant animal (animal 7) had the highest eating frequency.

Spatial pattern of the herd

Table 2 shows the mean distance to the nearest neighbour (\bar{r}_A), the expected distance to the nearest neighbour (\bar{r}_E) of lying cattle and the ratio of \bar{r}_A to \bar{r}_E expressed as R . The \bar{r}_A ranged from 3.65 to 5.98 m during the observation period, and R values were closer to 1.0 (random spacing) or \bar{r}_A was significantly different from \bar{r}_E ($p <$

0.05), indicating that the spatial pattern of the herd was not aggregate for the 3 days. The R values obtained in this study were more than 0.91, and much higher than the value of 0.54 presented by Kondo et al. (1989) who studied spatial pattern of beef cattle kept in a dry-lot in which animals had 15.4 m²/head. The present study suggests a relatively loose dispersion of the herd in the lot, though space allowance for the cattle was relatively large (approximately 64 m²/head).

Relationship between spatial distribution and social structure

By dividing the lot floor into a 2 × 2 grid (each 7.5 × 15 m) in figure 1, the relationship between lying frequency of each animal in the area with the hay rack and dominance order was studied. A relatively high correlation was found between lying frequency in the vicinity of the hay rack and dominance order ($r_s = 0.694$, $p < 0.10$), so that animals higher in dominance order (animals 23 and 7) tended to lie down more frequently near the hay rack in the lot than those lower in the social order (table 3). The lying of the dominant animals near the hay rack may be due to their preference for comfortable floor surface conditions (straw bedding) in front of the hay rack. In a higher density lot, it may be expected that the lying close to the trough will affect feeding frequency of subordinate animals. Similar results in that higher ranking cattle were inclined to occupy any place at their desire were reported by Mimura (1971) and Kondo et al. (1980) using dairy cattle in loose housing barn.

In this study, social licking interactions in the herd were observed for 8 combinations during the observation periods. Individual distances of lying cattle, and the number of social lickings for each combination are shown in table 4. Though only a social licking interaction was observed for animals 1-10 combination, with smaller individual distance, the number of social lickings was negatively correlated to the individual distance ($r_s = -0.634$, $p < 0.10$), and cattle with more close social licking interactions showed a tendency to lie down close to each other. When individual distances of lying cattle were pooled for 4 and 13 combinations with 1 and 0 social licking interaction respectively, those values were 13.4 and 12.8 m. Considering the pooled values,

TABLE 1. PERCENTAGE OF TIME SPENT EATING AND LYING IN DIURNAL ACTIVITY FOR EACH ANIMAL AND DOMINANCE ORDER

Item	Cattle No.						
	1	7	10	14	17	22	23
Eating behaviour (%) ¹	16.1	44.1	31.4	26.3	25.4	28.0	27.1
Lying behaviour (%) ¹	47.5	25.4	34.7	33.9	27.1	34.7	37.3
Dominance order ²	4	1	3	5	5	7	1

¹ Expressed as percentage of total number of observations during 3 days (except 13:00-17:30 h on the 3rd day).

² Determined by win-loss ratio in agonistic encounters during the observation period (except 13:00-17:30 h on the 3rd day).

Spearman's rank correlation coefficients of eating and lying behaviour with dominance order were 0.400 and 0.037, respectively.

TABLE 2. MEAN DISTANCE TO THE NEAREST NEIGHBOUR (\bar{r}_A), THE EXPECTED DISTANCE TO THE NEAREST NEIGHBOUR (\bar{r}_E) OF LYING CATTLE AND THE RATIO OF \bar{r}_A AND \bar{r}_E (R)

Item	Observation day		
	1st	2nd	3rd ¹
\bar{r}_A (m)	3.65	5.98	4.23
\bar{r}_E (m) ²	4.01	4.01	4.01
R	0.91	1.49*	1.05

¹ Data except 13:00-17:30 h.

² $1/(2\sqrt{\text{the number of individuals per unit of area}})$.

* $p < 0.05$.

higher correlation was obtained between individual distance and social licking ($r_s = -0.714$, $p < 0.10$). Thus, as an overall tendency it is suggested that the more the social licking interactions, the closer the individual distance. Additionally, the largest value of social licking interactions (19 times) was observed between the most dominant (animal 23) and the most subordinate animals (animal 22) (6 rank positions apart in social order, as shown in table 1), unlike the results obtained by Fraser (1980) and Arave and Albright (1981) who stated that social licking interactions occurred among closely ranked animals (commonly within 3 rank positions apart on social scale). Therefore, the present results indicate that social

TABLE 3. LYING FREQUENCY OF EACH CATTLE IN THE AREA¹ WITH HAY RACK IN THE LOT AND DOMINANCE ORDER

Item	Cattle No.						
	1	7	10	14	17	22	23
Lying frequency ²	0	14	10	4	0	8	14
Dominance order ³	4	1	3	5	5	7	1

¹ Determined by dividing the lot floor into a 2×2 grid (each 7.5×15 m) in figure 1.

² Data from 3 observation days (except 13:00-17:30 h on the 3rd day).

³ Determined by win-loss ratio in agonistic encounters during observation period (except 13:00-17:30 h on the 3rd day).

Spearman's rank correlation coefficient between lying frequency and dominance order was 0.694 ($p < 0.10$).

licking pattern was not necessarily dependent on proximity of social order and that mutual preference among particular animals, i.e. "social preference" occurred in the herd regardless of social order, which support the findings of Hafez

and Bouissou (1975). The occurrence of mutual repulsion or preference among individuals in a herd has been discussed with special reference to spatial proximity (Beilharz and Mylrea, 1963; Friend and Polan 1974; Syem et al., 1975).

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TABLE 4. INDIVIDUAL DISTANCE OF LYING CATTLE AND THE NUMBER OF SOCIAL LICKINGS FOR EACH COMBINATION WHICH SOCIAL LICKING INTERACTIONS WERE OBSERVED

Combination	Individual distance (m) ¹	Social licking (no.) ²
22-23	7.3	19
10-17	5.3	17
1-17	3.3	16
14-17	11.1	5
1-22	18.1	1
10-22	16.1	1
14-23	13.0	1
1-10	6.3	1

¹ Mean of 3 days (except 13:00-17:30 h on the 3rd day).

² Total of 3 days (except 13:00-17:30 h on the 3rd day).

Spearman's rank correlation coefficient between individual distance and social licking interactions was -0.634 ($p < 0.10$).

However, since social licking is considered to be one of affiliative behaviour resulting in amicable relationships in cattle herds (Hart, 1985), social preference should be studied in relation to social licking interactions as well as to spatial proximity.

In conclusion, the results of the present study showed that in a small herd of horned Japanese Black Cattle kept in a dry lot under loose housing condition, the most dominant animal had a great precedence in eating over others and higher ranking animals tended to lie down more frequently near the hay rack than lower ranking animals, so that the subordinates had more difficult access to feed, though space allowance for animal was relatively large (approximately 64 m²/head). Further and more detailed research concerning feeding strategy, e.g. optimum number and position of feed rack for cattle, is required to give subordinates ready access to feed as Lamb (1976) suggested that accessibility is more important than amount of feed.

Acknowledgements

The authors are grateful to Mr. T. Etoh of Kuju Agricultural Research Center, Kyushu

University and Mr. T. Shiraishi for care of experimental animals and their skilled technical assistance in this study. Special thanks are due to Dr. T. Yanagawa, Associate Professor at the Laboratory of Mathematical Statistics, Faculty of Science, Kyushu University for his instructive advice in analysing the data by non-parametric statistical procedures; to Drs. N. Fujihara and Y. Masuda, Associate Professors at the Department of Animal Science, Faculty of Agriculture, Kyushu University for their extensive and valuable discussions on this manuscript; to Dr. G. W. Arnold, Division of Wildlife and Ecology, CSIRO for his kind reviewing of the manuscript.

Literature Cited

- Arave, C. W. and J. L. Albright. 1981. Cattle behavior. *J. Dairy Sci.* 64:1318-1329.
- Beilharz, R. G. and P. J. Mylrea. 1963. Social position and behaviour of dairy heifers in yards. *Anim. Behav.* 11:522-527.
- Clark, P. J. and F. C. Evans. 1954. Distance to nearest neighbor as a measure of spatial relationships in populations. *Ecology* 35:445-453.
- Curtis, S. E. 1983. *Environmental Management in Animal Agriculture*. Iowa State Univ. Press, Ames, Iowa. pp. 171-223.
- Fraser, A. F. 1980. *Farm Animal Behaviour*. 2nd ed., Baillière Tindall, London. pp. 160-170.
- Friend, T. H. and C. E. Polan. 1974. Social rank, feeding behavior, and free stall utilization by dairy cattle. *J. Dairy Sci.* 57:1214-1220.
- Hafez, E. S. E. and M. F. Bouissou. 1975. The behaviour of cattle. in: *The Behaviour of Domestic Animals*. E. S. E. Hafez. Ed. Bailliere Tindall, London. pp. 203-245.
- Hart, B. L. 1985. *The Behavior of Domestic Animals*. W. H. Freeman & Company, New York. pp 15-81.
- Kondo, S., T. Momono, M. Yanagi and S. Nishino. 1980. The spatial distribution of cattle in a loose housing barn. *Jap. J. Livest. Management*. 16: 56-64.
- Kondo, S., M. Saito, H. Miyashita, S. Nishino and Y. Asahida. 1989. Spatial and social behavior of a beef-cattle group on grazing pasture and in dry-lot. *Res. Bull. Livestock Farm, Fac. Agric., Hokkaido Univ.* 14:99-105.
- Lamb, R. C. 1976. Relationship between cow behavior patterns and management systems to reduce stress. *J. Dairy Sci.* 59:1630-1636.
- Mimura, K. 1971. The loose housing free barn system for intensive dairy production in Japan. *Jap. J. Zootech. Sci.* 42:451-462.
- Phillips, C. J. C. and S. A. Schofield. 1990. The effect of environment and stage of the oestrous cycle

- on the behaviour of dairy cows. *Appl. Anim. Behav. Sci.* 27:21-31.
- Pollock, W. E. and J. F. Hurnik. 1979. Effect of two confinement systems on estrous and diestrous behavior in dairy cows. *Can. J. Anim. Sci.* 59: 799-803.
- Sambras, H. H. 1971. Zum Liegeverhalten der Wiederkäuer. *Züchtungskunde* 43:187-198.
- Siegel, S. 1956. *Nonparametric Statistics for the Behavioral Sciences*. McGraw-Hill Book Co., Inc., New York.
- Stricklin, W. R. and C. C. Kautz-Scanavy. 1984. The role of behavior in cattle production: a review of research. *Appl. Anim. Ethol.* 11:359-390.
- Syme, L. A., G. J. Syme, T. G. Waite and A. J. Pearson. 1975. Spatial distribution and social status in a small herd of dairy cows. *Anim. Behav.* 23: 609-614.