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Individual differences in behaviour and in adrenocortical activity in beef-suckler cows

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Abstract

The aims of this study were to investigate the existence of individual behavioural strategies in beef-suckler cows in a stable herd, whether these strategies are related to basic activities and to adrenocortical activity, and whether they are consistent in a situation of social competition.

Social interactions of 19 beef-suckler cows were recorded over a period of 3 months for 208 h. The animals were classified into three groups of different social strategies by factor and cluster analysis: agonistic dominant (AD), non agonistic (NA) and agonistic challenging (AC). Basic activities (lying, standing, feeding, walking) and the concentration of faecal cortisol metabolites were compared between groups. Consistency of social strategies was tested in a situation characterised by increased social competition (reduced number of feeding places).

In the undisturbed social situation, AD-animals initiated most agonistic interactions, whereas AC-animals received most and showed least *social licking*. NA-animals initiated less agonistic interactions and performed more *social licking* than AC-animals and most *head play*. The dominance values were highest in AD-animals, but did not differ between NA- and AC-animals. AC-animals had the highest frequency of walking, standing, feeding and drinking, and they kept lying shortest. Concentrations of faecal cortisol metabolites were higher in NA-animals than in AC. Identified social strategies were confirmed in a social competition test.

Our results revealed that the cows showed different behavioural social strategies consistent across situations of low and high social competition. The three strategies differed in social behaviour, basic activities and adrenocortical activity. Thus, NA- and AC-animals seemed to adopt two different strategies to cope with a subdominant status.

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1. Introduction

The environment for cattle housed in a barn differs substantially from the natural habitat of the species with respect to the limitation of space and resources like lying or feeding places, as well as in composition and size of the herd. As a consequence, the individual animal is forced to deal with increased social strife (e.g. [Wierenga, 1984a](#)). In addition, some animals may restrict the behaviour of others, which can lead to a decrease in productivity, health and welfare ([Zayan and Dantzer, 1990](#)).

The social status of an animal is one important factor influencing the amount of constraints an individual encounters. For instance, low ranking dairy cows might be negatively affected by reduced time lying and increased time standing in crowded situations ([Wierenga, 1983, 1984b](#)), and subsequently may be more prone to develop lameness ([Galindo and Broom, 1993](#)).

However, focusing on rank-related effects can often mean that important information on individual animals is neglected. Animals may show individual variation in behaviour and physiology irrespective of their social status. In recent years, such individual differences in behaviour and physiology have been explained by underlying personality traits, styles or strategies ([Erhard and Schouten, 2001](#)). These concepts should help to understand individual behavioural differences and to predict the behaviour of animals. Strategy can be defined as a behaviour or collection of behaviour patterns, which an individual uses to achieve a goal ([Davies, 1982; Mendl and Deag, 1995](#)). According to [Erhard et al. \(1999\)](#) strategies are a reflection of different categories within a personality trait. Therefore, personality presumably represent an important and underlying factor for each behavioural strategy. Studies in several species suggest that the strategy by which an animal responds to its social environment is more important for its physiological state and health than its social rank ([Mendl et al., 1992; Mendl and Deag, 1995](#)). Animals often show large individual differences in social behaviour ([Manteca and Deag, 1993](#)) and in physiological reactions to social situations ([Raab et al., 1986](#)), which cannot be explained by means of social status. Also, individuals of quite different social rank may do similarly well in terms of their welfare and reproduction. In male tree shrews, [von Holst et al. \(1983\)](#) described two different responses in behaviour and physiology of individuals forced to stay together with a dominant male. Similar behaviour towards dominant individuals was reported by [Benus \(1988\)](#) in mice. [Mendl et al. \(1992\)](#) defined three groups of pigs according to their social interactions: “high success”, “low success” and “no success”. These groups differed not only in their ability to displace others but also in basal levels of salivary cortisol and in reactions to stimulation by adrenocorticotrophic hormones.

There are some indications found in dairy cows that three groups of social strategies exist also in cattle ([Knierim and Sattler, 1998; Waiblinger et al., 2000](#)). However, published reports on behavioural strategies of beef-suckler cows are lacking. In contrast to dairy herds, the social structure and dynamics in beef-suckler herds are closer to a natural situation. Herds of beef-suckler cows are more stable and the cows live together with their calves.

Adrenocortical activity is widely used as an indicator of social stress and therefore as an indicator of animal welfare. Differences in adrenocortical activity, however, might express basic differences in physiology rather than stress level ([Koolhaas et al., 1999](#)). For interpreting differences in adrenocortical activity we should know, among other things, how

adrenocortical activity is related to behavioural strategies. Since now no studies in cattle have been published about this relationship. The concentration of glucocorticoids in plasma is often used to evaluate adrenocortical activity, yet there are two methodological problems: (1) blood sampling itself causes an increase in glucocorticoid concentrations (Hopster et al., 1999) and (2) frequent sampling is necessary due to considerable fluctuations during the day and even within minutes. These problems can be overcome by measuring faecal cortisol metabolites (Palme and Möstl, 1997). This method has been successfully evaluated in ruminants: faecal cortisol metabolites reflected cortisol production and fluctuations are evened out (Palme et al., 1999; Palme et al., 2000).

The aim of the present study was to investigate if different behavioural strategies to deal with the social environment could be found in beef-suckler cows in a stable undisturbed herd and whether such strategies would be consistent in a social stress situation. Moreover, basic activities and adrenocortical activity were studied to elucidate differences between types of strategy.

2. Animals, material and methods

2.1. *Animals and housing*

The study was carried out on the Teaching and Research Estate of the University of Veterinary Medicine from December 1999 until March 2000 with 19 beef-suckler cows—17 Pinzgauer and two cross-bred Pinzgauer–Limousin, aged between 1.5 and 7.9 years (average 4.5 years). The animals were housed with their calves and five heifers in a loose housing with cubicles and with outdoor feeding. The pen offered the animals 26 cubicles and 27 feeding places. The calves had their own lying area with deep litter between the two cubicle rows and a separated feeding area. In summer, cows had free access to pasture. Into the herd existing since 2 years, five animals were introduced in March 1999 and two younger animals in November 1999. There were two permanent herds-men. The animals were provided silage three times a day (7.00, 11.00 and 15.30) for ad libitum consumption. In addition, they received hay and concentrates (1–2 kg per animal) at midday. One watering device for two animals drinking at the same time were installed. To identify the cows, they were marked individually by bleaching or dyeing the hair.

2.2. *Social behaviour in the undisturbed herd situation (low level of competition)*

The social behaviour in the herd was observed during January to March 2000 for a total of 208 h. Observations were carried out for 6 h per day during feeding time, when a lot of social activity occurred (7.00–9.00, 11.00–13.00 and 15.00–17.00). Agonistic as well as non-agonistic social interactions were recorded continuously by behaviour sampling (Martin and Bateson, 1993) using a portable microcomputer (Husky[®] FC-PX5) with the software The Observer[®], Noldus, NL. The following behavioural parameters were observed for the actor cow (A) as well as the receiver cow (R) and recorded:

2.2.1. Agonistic behaviour

- *Push away*: A pushes the receiver with her head resulting R moving away from A or changing the position;
- *Chase away*: A pushes away R and chases R for more than 2 m;
- *Threat*: A presents the typical threat-posture (presenting the forehead with inclined head) without touching R, and R moves away or changes the position;
- *Chase up*: A butts a lying R and R stands up;
- *Threat without success*: A presents the typical threat-posture—but R does not leave the place or change position;
- *Butting*: A butts R with her head—but R remains;
- *Avoid*: A avoids R, although R does not threaten A visibly directly before.

2.2.2. Non agonistic social behaviour

- *Social licking*: A licks R (except anogenital-area);
- *Licking invitation*: A presents body areas to R in a typical position (head and neck hold down in a stretched position)—but R does not lick A;
- *Head play*: A touches the forehead of R or the side of the head or neck of R with her forehead and both animals rub or gently push each other;
- *Sniff*: A sniffs R;
- *Head rubbing*: A rubs the head on R (except head play);
- *Head leaning*: A leans with the forehead against any body region of R except the head and neck, most often at the back of R.

For further analysis, the agonistic behaviours leading to displacement (moving away or changing the position) of R by A were grouped together:

displacement = push away + chase away + threat + chase up

The ‘displacement’ interactions were used to rate the dominance relationship of each pair of individuals. A dominance relationship was classified as “known”, if one cow displaced another cow at least twice as frequent as the other way around (Samraus, 1975). The dominance value of each animal was calculated following Samraus (1975) by dividing the number of animals that a cow dominated by the number of all “known” dominance relationships of this cow within the herd.

$$DV = \frac{\text{Number of animals cow A dominates}}{\text{Number of animals cow A dominates} + \text{number of animals dominating cow A}}$$

2.3. Basic activities

The herd was videotaped with eight video cameras and the basic activities (frequencies and duration of walking, standing, lying, feeding, drinking) of each animal were recorded from the videotape for a period of 4×24 h distributed over the period from December until February continuously by focal animal sampling using the software The Observer Video Pro[®], Support Package for Video Analysis (Noldus, NL).

2.4. Adrenocortical activity

Faecal samples from each cow were collected (unborn faeces from the rectum) in the morning (6.00–7.00 h) on 5 days between December 1999 until March 2000 in order to evaluate adrenocortical activity by measuring 11,17-dioxoandrostanes (11,17-DOA), a group of cortisol metabolites. As faecal metabolites are excreted with a delay of about 10–12 h in ruminants it has to be taken into account that measured concentrations reflect glucocorticoid production 10–12 h earlier (Palme et al., 1999). Thus the cortisol production of the evening before was reflected. During that time period, the animals were undisturbed by human interference. Thus, this time seems to be suitable to measure the cortisol levels. Two animals, which were more than 18 weeks into gestation, were excluded from the analysis, as the placenta produces large amounts of steroids, which potentially cross-react with the antibody used (Möstl et al., 2002).

Samples were stored at -20°C immediately after collection until analysis. After a simple extraction procedure (0.5 g faeces with 5 ml of 80% methanol) the concentration of 11,17-DOA was measured by an 11-oxoetiocholanolone enzymimmuneassay (EIA) as described by Palme and Möstl (1997).

2.5. Social competition test

In February and March 2000, on 5 non-consecutive days, the number of feeding places was reduced during two feeding sessions (in the morning and midday) each for 1 h. On the first day, feeding places were reduced from 27 to 12. Because competition still seemed to be relatively low, feeding places were reduced to six on the other 4 days and social interactions were recorded by direct observation as described above.

In order to investigate the access to the feeding resources, the activities of the cows were videotaped. From the last 2 days the position of each animal (in the feeding rack or elsewhere) was analysed by scan sampling. An interval of every three minutes was chosen because we suspected it sufficient enough to observe most of the changes of places.

One animal was excluded from the test situation because of lameness.

2.6. Statistical analysis

All statistical analyses were carried out with the software Package SPSS[®], Version 9.0.

Before classification of the cows into social strategy groups, the behavioural parameters recorded in the undisturbed herd situation (interactions from the cows with the five heifers were included) were reduced using a principal component analysis (PCA, Bortz, 1993). Only those behavioural parameters were included that had occurred sufficiently often during observation and which led to the highest explained total variance, best interpretation of the factors, a distinct knee in the Screeplot, Kaiser–Meyer–Olkins factor >0.6 and eigenvalues >1 . Accordingly, PCA with Varimax rotation was carried out on the following nine behaviour parameters: A pushing away, A threat, A avoid, A head play, A social licking, R pushing away, R threat, R butting, R head play. Three factors were extracted. For interpretation of the factor only loadings from 0.7 on were taken into account. The factor scores of each individual animal were used for subsequent cluster analysis (Pearson's correlation

coefficient; average linkage within group), which was performed in order to group the animals.

Following the classification of animals into groups, the group characteristics were evaluated: social behaviour parameters in the undisturbed herd situation were tested for group differences using non-parametric tests as most of the parameters were not normally distributed (Bortz, 1993; Siegel, 1997). These comparisons were done to detect all differences in social behaviour between groups and therefore characterise them in a better way than just by factor scores used in the cluster analysis.

Having identified and characterised the groups on basis of the social behaviour in the undisturbed herd situation, the three groups were then tested for differences in the remaining parameters (basic activities, concentration of faecal cortisol metabolites, social behaviour in the competition test). The Kruskal–Wallis test was performed to test for group differences and in the case of significant differences, the Mann-Whitney test was used to test which groups differed. For a better interpretation of group characteristics, it was also tested whether groups differ in the direction of their social interactions (regarding rank and membership of the other strategy group).

Affinities between cows were calculated by means of Chi-square-tests using the frequency of social licking. It was calculated, whether some of the possible licking partners (all other 18 cows) were licked “preferred”. For this, the real occurrence of the behaviour was compared by Chi-square test with the confidence interval of a frequency that would be expected by chance. If the real frequency of licking a cow was significantly higher, this cow was a “preferred” licking partner and it was told a one-sided affinity. If the preferred licking was mutual, i.e. both cows preferred each other as licking partner, it was told a mutual affinity.

To better evaluate a possible influence of dominance value on the classification of the strategy groups and on adrenocortical activity, Spearman’s correlation coefficients were calculated.

The results are visualised as boxplots or described in tables with median and ranges. For the statistical analysis of the concentration of cortisol metabolites, the median of the five samples (as values were not normally distributed) was used for each animal.

3. Results

3.1. *Social behaviour in the undisturbed herd situation*

A total of 11,390 displacements were recorded in 208 h (i.e. median: 1.33, range: 0.23–9.38 displacements per hour and animal). The 19 animals performed 1856 bouts of *social licking* (median: 0.43, range: 0.0005–1.59 h⁻¹ and animal). Only few *butting* and *threat without success* were observed. Of all the possible dominance relationships of the 19 cows (171 pairs of cows), only two relationships were unknown (1.17% of the possible pairs).

3.2. *Social strategies and possible determinants*

Three factors were extracted, explaining 83.4% of the variance. The parameters load high on these factors (Table 1). The first factor was characterised by reacting/receiving

Table 1
Factor loadings for each behaviour on the three factors

Parameter	Factor		
	1	2	3
A pushing away	−0.415	−0.207	0.776
A threat	−0.135	−0.004	0.933
A avoiding	0.837	−0.009	−0.361
A head play	−0.377	0.775	−0.193
A social licking	−0.327	0.716	0.446
R pushing away	0.912	−0.009	−0.194
R butting	0.446	0.620	−0.384
R threat	0.933	−0.008	−0.13
R head play	0.007	0.918	−0.01
Explained variance (%)	33.84	26.74	22.80

Method of extraction: principal component analysis. Method of rotation: varimax with Kaiser-Normalization.

agonistic behaviour (explained variance: 33.84%), the second by initiating and receiving non agonistic social behaviour (explained variance: 26.74%) and the third factor by active agonistic behaviour leading to displacement, i.e. successful aggressive behaviour (explained variance: 22.8%).

The cluster analysis using these factor scores led to three groups of animals. According to the group differences in social behaviour (Table 2), they were labelled “agonistic dominant” (AD, $n = 4$), “non agonistic” (NA, $n = 8$) and “agonistic challenging” (AC, $n = 7$). The two cross-breeds both belonged to the NA-group. The animals introduced into the herd in the year 1999 were in the NA-group (4 animals) and AC-group (3 animals).

Table 2
Social behaviour in the undisturbed herd situation

Parameter	AD	NA	AC	Kruskal–Wallis P -value
A displacing	1393 (862–1951) a	213 (47–755) b	276 (154–985) b	0.007
A avoiding	14.5 (2–32) a	58.8 (0–95) b	65 (53–116) b	0.018
A butting	12 (3–27)	14.8 (1–33)	11 (2–20)	0.918
A head play	10 (4–15) ab	20 (9–50) a	7 (4–11) b	0.008
A social licking	144 (93–330) a	115 (2–306) a	13 (1–105) b	0.025
A licking invitation	9 (4–13)	27 (2–42)	9 (2–17)	0.118
A head leaning	4 (0–11)	1 (0–3)	4 (0–27)	0.273
R displacing	197 (64–377) a	445 (7–760) a	795 (509–881) b	0.004
R avoiding	198 (33–395) a	10 (3–40) b	13 (3–117) ab	0.025
R butting	5.5 (4–15)	15 (2–26)	10 (2–22)	0.741
R sniffing	20 (18–26)	18 (12–26)	14 (9–28)	0.099
R head play	9 (4–24) a	20 (7–34) b	6 (3–10) a	0.046
R social licking	60 (50–154)	90 (−201)	50 (17–81)	0.208
R licking invitation	17 (16–30)	14 (8–77)	10 (4–18)	0.079

Median (and range) of the frequencies of active (A) and received (R) social behaviour in AD-, NA- and AC-animals in 208 h of observation and P -values of the Kruskal–Wallis test. Values in a line with different letters differ significantly ($P < 0.05$). $N = 19$.

Post hoc comparison with Mann–Whitney U Test were performed. AD-animals *displaced* more cows than NA-animals ($U = 0, N1 = 4, N2 = 8, P < 0.01$) and AC-animals ($U = 1, N1 = 4, N2 = 7, P < 0.01$). They *avoided* less frequently other animals than NA-animals ($U = 4, N1 = 4, N2 = 8, P < 0.05$) and AC-animals ($U = 0, N1 = 4, N2 = 7, P < 0.01$), but they were *avoided* by the others more often than NA-animals ($U = 2, N1 = 4, N2 = 8, P < 0.05$) and AC-animals ($U = 4, N1 = 4, N2 = 7, P < 0.1$, tendency: $P < 0.1$). AD-animals performed and received more *social licking* than AC-animals ($U = 1, N1 = 4, N2 = 7, P < 0.01$).

NA-animals less often *displaced* other cows than AD-animals. They received less agonistic interactions neither from higher ranking animals nor from AD-animals than AC-animals ($U = 6, N1 = 8, N2 = 7, P < 0.01$; $U = 0, N1 = 8, N2 = 7, P < 0.01$). NA-animals showed more *social licking* than AC-animals ($U = 11, N1 = 8, N2 = 7, P < 0.05$). They also showed more *head play* in total than AC ($U = 2.5, N1 = 8, N2 = 7, P < 0.01$) and AD ($U = 5, N1 = 4, N2 = 4, P < 0.1$, tendency: $P < 0.1$) and more *head play* with AD-animals than AC-animals ($U = 10; N1 = 8; N2 = 7, P < 0.05$).

AC-animals were most *displaced* by other cows compared with AD-animals ($U = 0, N1 = 7, N2 = 4, P < 0.01$) and NA-animals ($U = 5, N1 = 7, N2 = 8, P < 0.01$) and they showed the lowest amount of social licking.

Thirty-five one-sided affinities were found: AD animals preferred to lick four AD, seven NA and one AC cow; NA animals preferred as licking partners two AD, eight NA and seven AC-cows and AC animals preferred to lick one AD, one NA and four AC animals. AC-cows had less one-sided affinities than AD- ($U = 3.5, N1 = 4, N2 = 7, P < 0.05$) and NA-cows ($U = 10, N1 = 8, N2 = 7, P < 0.05$). AD-animals showed more one-sided affinities to NA-animals than did AC-animals ($U = 1; N1 = 4, N2 = 7, P < 0.01$).

Six pairs of mutual affinities between cows were found: two NA–NA, two AD–NA, one AD–AD and one AC–AC pair.

Group values of possible determinants (dominance values, age and weight) of frequencies of social behaviour are presented in Table 3. Dominance values of AD-animals were higher than in NA- ($U = 4.5, N1 = 4, N2 = 8, P < 0.05$) and AC-animals ($U = 0, N1 = 4, N2 = 7, P < 0.01$). The age of AD-animals, too, was higher than in NA- ($U = 4, N1 = 4, N2 = 8, P < 0.05$) and AC-animals ($U = 0, N1 = 4, N2 = 7, P < 0.01$). No differences in dominance values and age were found between NA and AC cows. The three groups did not differ in weight.

Dominance values were correlated with factor scores of factor 1 ($r_S = -0.75; P < 0.01; n = 19$) and with factor scores of factor 3 ($r_S = 0.52; P < 0.05; n = 19$), but did not

Table 3
Possible determinants for social strategies

Parameter	AD	NA	AC	Kruskal–Wallis P -value
Dominance value	0.87 (0.74–0.96) a	0.57 (0.14–1.0) b	0.52 (0.36–0.61) b	0.036
Age (month)	76 (59–101) a	48 (23–100) b	49 (34–55) b	0.033
Weight (kg)	776 (737–821) a	763 (545–1025) a	695 (583–852) a	0.219

Median (and range) of dominance value, age (months) and weight (kg) of AD, NA and AC animals and P -values of the Kruskal–Wallis test. Values in a line with different letters differ significantly ($P < 0.05$). $N = 19$.

Table 4
Basic activities in the beef-suckler cows

Basic activities	AD	NA	AC	Kruskal–Wallis <i>P</i> -value
Frequency walking	185 (142–194) a	198 (142–227) a	245 (163–268) b	0.024
Frequency standing	173 (136–181) a	189 (134–222) a	232(160–245) b	0.028
Frequency lying	6 (5–7)	9 (4–13)	7 (5–11)	0.081
Frequency feeding	44 (32–52) a	39 (29–61) a	61 (46–72) b	0.020
Frequency drinking	6 (4–7) a	6 (5–9) a	9 (7–11) b	0.011
Duration walking (h)	0.6 (0.4–0.7)	0.5 (0.4–0.7)	0.6 (0.4–0.8)	0.298
Duration standing (h)	12.8 (11.7–13.5) a	12.3 (10.2–13.6) a	13.9 (12.5–14.3) b	0.027
Duration lying (h)	10.6 (9.9–11.9) a	11.2 (9.9–13.4) a	9.5 (8.9–11.0) b	0.035
Duration feeding (h)	5.5 (4.6–6.6)	5.2 (3.4–6.6)	6.0 (5.4–6.6)	0.221
Duration drinking (h)	0.2 (0.2–0.3)	0.2 (0.1–0.4)	0.3 (0.2–0.4)	0.176

Frequencies and duration of basic activities (median and range) in AD-, NA- and AC-animals and *P*-values of the Kruskal–Wallis test. Values in a line with different letters differ significantly ($P < 0.05$). $N = 19$.

correlate with factor scores of factor 2 ($r_S = -0.06$; $P = 0.81$; $n = 19$). Thus, dominance value might explain a quite high proportion of variance in the factor 1, but relatively few (around one-quarter; assessed by the Pearson's correlation coefficient which was quite the same) in factor 3 and nothing in factor 2.

3.3. Basic activities

On average the cows were standing for 12.8 (standard deviation ± 1.02) h, walking for 0.6 (± 0.13) h, lying for 10.6 (± 1.09) h and feeding for 5.6 (± 0.81) h per day (24 h).

The three groups differed significantly in their basic activities (Table 4). AC-animals were significantly more active: they had higher frequencies of basic activities than AD-animals (walking and standing: $U = 3$, $N_1 = 7$, $N_2 = 4$, $P < 0.05$; feeding: $U = 2$, $N_1 = 7$, $N_2 = 4$, $P < 0.05$; drinking: $U = 1.5$, $N_1 = 7$, $N_2 = 4$, $P < 0.01$) and NA-animals (walking: $U = 8$, $N_1 = 7$, $N_2 = 8$, $P < 0.05$; standing: $U = 9$, $N_1 = 7$, $N_2 = 8$, $P < 0.05$; feeding: $U = 7$, $N_1 = 7$, $N_2 = 8$, $P < 0.01$; drinking: $U = 5.5$, $N_1 = 7$, $N_2 = 8$, $P < 0.01$). The total duration of lying was shorter in AC-animals than in AD ($U = 5$, $N_1 = 7$, $N_2 = 4$, tendency: $P < 0.1$) or NA ($U = 7$, $N_1 = 7$, $N_2 = 8$, $P < 0.01$), whereas the total duration of standing was higher than in AD ($U = 5$, $N_1 = 7$, $N_2 = 4$, tendency: $P < 0.1$) and NA ($U = 6$, $N_1 = 7$, $N_2 = 8$, $P < 0.01$) (Table 5).

No differences between AD- and NA-animals in their basic activities were found except that NA-animals lay down more often than AD-animals ($U = 5$, $N_1 = 8$, $N_2 = 4$, tendency: $P < 0.1$).

3.4. Adrenocortical activity

Median faecal cortisol metabolite values (11, 17 DOA) were 77.2 (range: 66.4–94.6) nmol/kg, 103.4 (65.9–507.7) nmol/kg and 58.6 (48.1–98.1) nmol/kg for AD-, NA- and AC-animals respectively. The two animals, which were excluded from the analysis because of their high stadium of pregnancy, belonged both to the NA-group. One of them

Table 5
Social behaviour and access to feeding resources in the social competition situation

Parameter	AD	NA	AC	Kruskal–Wallis <i>P</i> -value
A displacing	118.5 (43–155) a	25 (1–63) b	58 (13–141) ab	0.048
A avoiding	2.5 (0–4)	3 (0–9)	5 (3–9)	0.102
A butting	1.5 (0–5)	2 (0–8)	2 (0–7)	0.460
A head play	0 (0–1)	0 (0–5)	0 (0–2)	0.707
A social licking	4.5 (3–14) a	1 (0–26) a	0 (0–1) b	0.005
A licking invitation	0 (0–1) a	2 (0–7) b	0 (0–5) ab	0.038
A head leaning	0.5 (0–3)	0 (0)	1 (0–6)	0.073
R displacing	24 (12–43) a	47 (1–79) a	68 (51–122) b	0.005
R avoiding	13 (1–34)	1 (0–2)	2 (0–8)	0.115
R butting	1.5 (0–3)	3 (0–9)	1 (0–3)	0.415
R head play	0 (0–1)	1 (0–4)	0 (0–1)	0.144
R social licking	1.5 (0–8)	4 (0–9)	0 (0–7)	0.644
R licking invitation	2 (0–5)	0 (0–10)	1 (0–2)	0.449
R head leaning	1 (0–6)	1 (0–2)	0 (0–1)	0.232
R sniffing	0 (0–1) ab	1 (0–2) a	0 (0) b	0.020
frequency standing in the feeding rack	60 (22–73)	15 (0–62)	14 (0–24)	0.038

Median (and range) of the frequencies of active (A) and received (R) social behaviour in AD-, NA- and AC-animals in 10 h of observation and *P*-values of the Kruskal–Wallis test. Values in a line with different letters differ significantly ($P < 0.05$). $N = 19$.

was a cross-breed. The age and the dominance value of the cows did not correlate with their cortisol levels ($r_s = -0.13$; $P = 0.63$; $n = 17$; $r_s = -0.04$; $P = 0.89$; $n = 17$). NA-animals showed the highest level of cortisol metabolites in the faeces (Fig. 1). However, they differed significantly only from AC-animals ($U = 5$, $N_1 = 6$, $N_2 = 7$, $P < 0.05$).

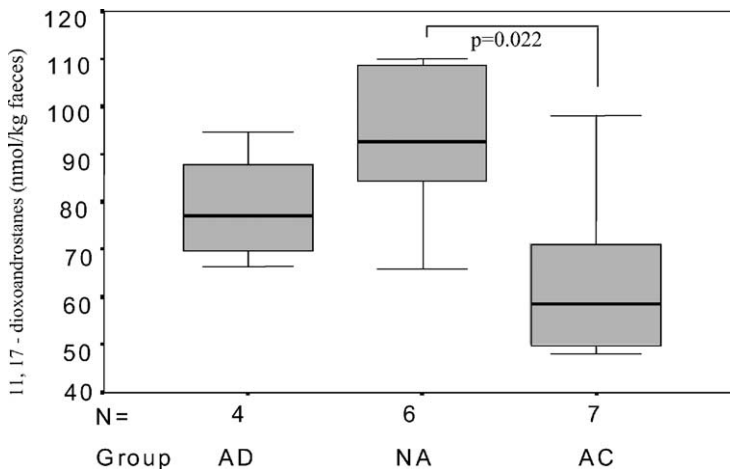


Fig. 1. Boxplots of the concentrations of cortisol metabolites (11,17-dioxoandrostanes; nmol/kg) in faeces of AD-, NA- and AC-animals $N = 17$. Boxplots show the median, the first and third quartile (25 and 75%) and the lowest and the highest value.

3.5. Social competition test

As expected, more displacements were performed in the social competition test than in the undisturbed social situation. In total, the frequency of displacements was more than three times higher per animal and hour (undisturbed situation: median: 1.33, range: 0.23–9.38 h⁻¹ per cow; social competition test: 4.9, range: 0.1–15.5 h⁻¹ per cow). During the test situation, AD-animals initiated 1.8 times as many agonistic interactions as in the undisturbed social herd situation, NA-animals 2.5 times as many and AC-animals 4.4 times as many. The excluded cow belonged to the NA-group.

Group differences in behaviour during the social competition test are presented in Table 5. The AD-animals performed more *displacements* than NA-animals ($U = 2$, $N1 = 4$, $N2 = 7$, $P < 0.05$). During the social competition situation, AC-animals no longer differed significantly in the number of displacements initiated from AD-animals, as was the case in the undisturbed herd situation. AC-animals again were more *displaced* by others and performed less *social licking* than AD (for both behaviours: $U = 0$, $N1 = 7$, $N2 = 4$, $P < 0.01$) and NA (for both behaviours: $U = 5$, $N1 = 7$, $N2 = 7$, $P < 0.01$) animals. NA-animals more often performed a *licking invitation* than AD-animals ($U = 2.5$, $N1 = 7$, $N2 = 4$, $P < 0.05$) and AC-animals ($U = 10$, $N1 = 7$, $N2 = 7$, tendency: $P < 0.1$) and they were more often *sniffed* by other animals than AC ($U = 7$, $N1 = 7$, $N2 = 7$, $P < 0.05$). They received less agonistic interactions from higher ranking animals than AC-animals ($U = 5$, $N1 = 7$, $N2 = 7$, $P < 0.01$).

Additionally, groups tended (Kruskal–Wallis, $P < 0.1$) to differ in the frequency of *leaning the head* against other animals (NA-animals lowest) and actively *avoiding* others (AD-animals lowest).

AD-animals spent more time standing in the feeding places than NA ($U = 3$, $N1 = 4$, $N2 = 7$, $P < 0.05$) or AC ($U = 1$, $N1 = 4$, $N2 = 7$, $P < 0.01$) cows, while NA and AC cows did not differ.

4. Discussion

4.1. Behavioural strategies in the social context

On the basis of data of the social behaviour in the undisturbed herd situation, beef-suckler cows were divided into three groups by means of factor analysis and subsequent cluster analysis. This finding of three different groups of social behavioural strategies show a good consensus with previous studies in dairy cows (Knierim and Sattler, 1998; Waiblinger et al., 2000), sheep (Cook et al., 1996) and pigs (Mendl et al., 1992).

The agonistic dominant group (AD), *displaced* most often other animals and performed much *social licking*. This group also had the highest dominance values and age compared with the other two groups (although the highest ranking cow with a dominance value of 1.00 belonged to the non-agonistic group).

The high dominance values of AD-animals may be a result of the higher age of these cows (Sambraus et al., 1979). Due to our results, it is not absolutely clear, whether the social rank influences the social strategy or the opposite. It could be possible that the social

status obscures the strategy of an animal at least in part. The calculation of dominance values and identification of social strategy groups partly are based on the same behaviours and thus are not independent. However, the two subdominant groups differed distinctly in frequency of social interactions but not in social status, suggesting that the grouping into social strategies was rarely related to dominance value in these groups. To further investigate the possible confounding effect of dominance value (DV), we tried to take into account the DV by dividing the frequencies of social interactions by the DV for each individual cow, and subsequently performing factor analysis and cluster analysis with these new, dominance-corrected values. However, this analysis did not lead to substantial changes. Furthermore, although we found a relationship between factor score 1 and 3 and dominance value (DV), factor score 2—as expected—was not correlated with DV. Also, the size of the correlation coefficient of factor score 3 with DV points at other influences being more important. The grouping of the cows into strategy groups by Cluster analysis was based on all three factor scores and thus, the influence of social status on this grouping is only limited. It is more likely, that the social strategy of an animal influences its social status. Studies in pigs suggest that the strategies of individuals predispose them to different levels of aggressiveness in groups and that a low rank is probably a result of low aggressiveness rather than its cause (Hessing et al., 1994a; Mendl et al., 1992; Erhard and Mendl, 1997; Erhard and Schouten, 2001). However, social status, age or weight did not differ between NA- and AC-cows. These groups point to two different strategies to deal with a subdominant status. It seems that the strategy of NA-animals was to avoid agonistic encounters and to appease higher ranking animals through positive social interactions: They were less often displaced from AD-animals as were the AC-animals, but had more affiliative interactions with the AD-animals (initiated more head play to AD). Sembraus (1969) described *social licking* as a behaviour to reduce aggression. Recent results also suggest a function of social licking in conflict resolution to reduce social tension (Waiblinger et al., 2002). Head play is found often in direct association with social licking, it correlates with social licking and classifies also as an affiliative behaviour (Menke, 1996; Menke et al., 1999). As both NA-cows and AC-cows arrived later in the herd, no difference with respect to familiarity of these animals to AD-cows and thus affinities or tolerance of AD-cows to them can be expected. Both subdominant groups had the same chance for developing affinities to AD-animals. Obviously, it is easier for NA-animals, which are characterized by their affiliative behaviour, to build up affinities and social bonds—but these are a result of their appeasing, affiliative social strategy. Contrary to NA-animals, the AC-animals built up less affinities than NA- or AD-animals and faced agonistic encounters with increased frequency.

The results of the social competition test emphasise the interpretation of the social strategies. They were confirmed and, additionally, the differences between the two subdominant strategy groups—NA- and AC-animals—got even more distinct. Here, the ratio of feeding places to animals was decreased to 1:3. This is known to lead to an increase of agonistic behaviour (Corkum et al., 1994; Stumpf et al., 2000). Interestingly, the increase of agonistic interactions in the social competition test compared to the undisturbed herd situation differed distinctly between the groups with the highest increase (4.4 times) in AC-animals. Hence, AC-animals no longer differed from the AD-animals with respect to displacing others, while NA-animals still were the least aggressive ones. NA-animals once again got less displacements from higher ranking animals than AC-animals. Furthermore, in contrast

to NA- and AD-animals, AC-animals hardly ever showed *social licking* (median 0, range 0–1). It is important that with respect to the frequency of staying in the feeding rack, both subdominant groups were similarly successful.

These results are consistent with previous studies, which found similar strategies to cope with a subdominant status: trying to avoid attacks, thus showing low involvement in *agonistic* (and sometimes also *non-agonistic*) *interactions*, or staying aggressive and competitive (in rats: Fokkema, 1985; in mice: Benus, 1988; in pigs: Mendl et al., 1992; in cows: Knierim and Sattler, 1998).

4.2. *Basic activities*

The three strategy groups differed significantly in frequency and duration of their basic activities. AC-animals were the most active ones. Since they were most often displaced by other animals, it could be that they were frequently forced by others to change places, stop drinking bouts and stop feeding bouts. However, being very active, i.e. walking around and changing places very often, also leads to a higher probability of encounters and thus a higher possibility of being displaced by dominant animals. This last hypothesis is in accordance with the finding that AC-animals initiated more agonistic interactions than NA-animals, which were less often displaced.

This is further supported by the fact that there is no obvious reason for the shortest lying times of AC-animals: 24 animals (the 19 investigated animals and five heifers) had 26 cubicles with large dimensions available, and displacing an animal from the cubicles was observed extremely rarely (in total only 10 times during the 208 h of observations), so that every cow was able to rest peacefully. Therefore, it seems more likely that the behavioural differences in the AC-animals are characteristics of their behavioural strategy. This is supported by former studies. Hopster et al. (2000) found distinct, consistent differences in the lying behaviour of dairy cows and concluded that lying behaviour (duration and frequency) is characteristic for the individual cow. Schrader (2001) also described distinct and consistent differences in the undisturbed behaviour of dairy cows in motor activity (assessed as locomotion/standing in the walking area), in the duration of lying periods (as an indicator of behavioural persistence) and in the regularity of their behaviour. The animals with the longest duration of lying periods also exhibited the greatest regularity in their behaviour and the lowest motor activity. Further, they were the most successful in agonistic interactions. The author concluded that locomotion reflected behavioural restlessness opposed to behavioural routines, which he assumes to be reflected by the regularity and duration of lying periods (Schrader, 2001). Those results agree with the present ones: here, animals with the lowest amount of total duration of lying also showed the highest amount of motor activity and received agonistic interactions most often. Thus the greater behavioural restlessness seems to be a fundamental characteristic of the AC-animals influencing their behavioural strategy.

4.3. *Adrenocortical activity*

In the present study, differences in the adrenocortical activity between groups were found. The measured concentrations of cortisol metabolites were within the range of basal values of

those previously reported (Palme et al., 1999; Palme et al., 2000), suggesting the measured concentrations in our study reflect the basal adrenocortical activity. This also supports the suggestion that the stress level for the cows in the present study were kept very low. Furthermore, the concentration of cortisol metabolites was not related to dominance values or age of the cows. The social status of an animal is often suggested as a major determinant of the animal's neuroendocrine response to social stress (Zayan and Dantzer, 1990), with low social status animals showing an increased activity of the adrenocortical axis (Zayan and Dantzer, 1990; Mendl et al., 1992). But in our study, the dominant group showed intermediate values between the two subdominant groups, which however differed significantly from each other: AC-animals showed lower cortisol metabolites' concentration than NA-animals. In the study of Mendl et al. (1992) in pigs, however those animals which experienced the highest level of attack and aggression from other animals also had the highest basal levels of cortisol. The fact that we found opposite results, supports again the suggestion that the stress level for the cows in the present study were kept very low: being frequently displaced by others probably did not represent a stressful situation for AC-animals in our study. On the one hand, the generous space allowance (11.5 m² per GVE) in our study enabled the animals to easily escape from aggressive behaviour. On the other hand, the high stability of the herd may have contributed to keeping the level of social stress relatively low. In contrast, in the study of Mendl et al. (1992), group composition changed every 4–6 weeks and the cortisol levels were measured in the fifth week after introduction. Thus, whether or not social interactions are experienced as stressful may also depend on the stability of the group under scrutiny. Our findings suggest that at least in a stable herd situation with low competition like in the beef-suckler cows investigated, social rank is not related to cortisol production, which is in accordance with earlier studies (Gabr et al., 1975; Adeyemo and Heath, 1982).

Overall, it seems that the basal adrenocortical activity rather is a fundamental characteristic of the animals related to the behavioural strategy. Other studies also demonstrated individual basal cortisol levels and adrenocortical reactivity to be related to behavioural reactions to stressors, to aggression or disposition to learn and innovate (Korte et al., 1992; Hessing et al., 1994b; Koolhaas et al., 1999; Ruis et al., 2000; Pfeffer et al., 2002). In greylag geese, these differences in levels of corticosterone appeared already in the second week of life (Pfeffer et al., 2002). Further studies are necessary to get more information about the adrenocortical activity in cows and its relation to behaviour and welfare of the animals.

4.4. Conclusion

Our study revealed that cows used different behavioural strategies to cope with their social environment. The behavioural strategies in the more natural undisturbed social environment of a beef-suckler herd were comparable to those found in more intensive systems and in other species. Furthermore, the strategies were consistent and even more explicit during increased social competition. Adrenocortical activity and behavioural restlessness seem to be fundamental characteristics of the animal related to its strategy. Further studies are necessary to follow the development and consistency of such strategies and adrenocortical activity for long periods of time and in variant social contexts. As health and welfare of an animal is the consequence of the interactions between its individuality and the environment,

more knowledge about individual differences might help to increase the animals' welfare via a better understanding and predictability of farm animals' behaviour.

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