SOCIAL BEHAVIOUR AND INJURIES OF HORNED COWS IN LOOSE HOUSING SYSTEMS

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The relationship between social behaviour and skin injuries (caused by horns) of loose housed horned cows was investigated on 35 dairy farms. While the frequencies of two agonistic behaviour elements (push and chase away) were positively correlated with the occurrence of skin injuries, the frequencies of butting and horning were not. Butting appears to have an ambivalent motivation, in that its occurrence is correlated positively both with agonistic behaviour and with social licking. Horning showed a positive correlation with social licking only. Four groups of husbandry conditions that may be associated with the occurrence of social behaviour and of injuries were distinguished: i) herd management, with variables including problem solving management by the farmer, integration of new cows, and dealing with periparturient and oestrus cows; ii) human-animal relationship, with variables including ability to identify individual cows, frequency of brushing the cows, number of milkers, and frequency of personnel changes; iii) animal characteristics, with the variable of herd size; and iv) stable characteristics, with the variable of space per cow (m^2). The relevance of the husbandry variables investigated here had been confirmed in a previous stepwise regression analysis (Menke 1996). The variables for herd management and human-animal relationship conditions correlated in a consistent way with the occurrence of agonistic behaviour and/or of injuries, while most of them also correlated in the opposite direction with the occurrence of social licking. Herd size correlated positively with agonistic behaviour, but negatively with social licking. Space per cow correlated negatively with agonistic behaviour and injuries. In more than 70 per cent of the herds investigated, the levels of agonistic behaviour and of skin injuries were low, implying that horned dairy cows can be kept with less risk than is often assumed. We argue that such risks strongly depend on management factors that can be improved.

Keywords: *animal welfare, horned dairy cows, human-animal relationship, injuries, loose housing, management, social behaviour*

Introduction

Dairy cows in loose housing systems are usually dehorned. One reason for this painful treatment (Taschke 1995; Taschke & Fölsch 1995; Graf *et al* 1996) is the general opinion that horned dairy cows are a danger to herd members. Oester (1977) found a higher level of avoidance behaviour among horned dairy cows than among dehorned ones and inferred from this, that cows should be dehorned. Graf (1974) reported that the frequency of chasing and pushing away among horned cows was lower than among dehorned ones, which he attributed to the cows' lack of respect for one other in the latter group. Meischke *et al* (1974) and Shaw *et al* (1976) investigated the contribution of horns in fattening cattle to carcase bruising and showed that the frequency of injuries in dehorned groups was lower than in groups of horned cattle; and they argued stongly for dehorning. Ernst (1977) and Kretzmann *et al* (1985) also stressed the advantages of dehorning in relation to transport problems among cattle. Individual distances, as defined by Fraser and Broom (1990), were reduced by dehorning cows (Graf 1974); and dehorning also has a great effect on social rank order (Graf 1974; Kimstedt 1974; Oester 1977).

This paper focuses on the quantitative aspects of social behaviour of horned dairy cows in loose housing systems as related to the occurrence of skin lesions in these cows. We also investigated how far injurious social behaviour of dairy cows might depend on existing management factors which could be improved. These management factors should be reviewed and described as completely as possible. The resulting welfare improvements could reopen discussion about the practice of dehorning as a general and necessary rule in modern dairy cattle farming.

Animals and methods

Thirty-five herds of horned dairy cows kept in loose housing systems were selected from a list of more than 80 Swiss and German farms (Table 1). The first criterion of this selection was that the proportion of dehorned cows present in any study herd should not exceed 25 per cent. In fact, most (63%) of the 35 herds investigated had no dehorned cows at all, and only in six herds (Herd numbers 1,4,6,7,12,14) was the proportion higher than 10 per cent. We also required that three types of loose housing systems should be represented: i) cubicle housing (n = 16); ii) straw bedding pens (n = 15); and iii) straw flow pens (with inclined resting areas allowing straw to slide down into the dung passage) (n = 4). Finally, each herd should consist preferably of one breed and both small and large herds should be included (herd size ranged from 8–92 cows herd^{-1}). The breeds investigated were mainly Brown Swiss, Pied Cattle, Black Pied, Red Pied and German Red. The space per cow could vary widely (from 5–22 m^2 cow^{-1}). In a pilot experiment, various parameters of social behaviour and injuries caused by horns were determined, as well as the best daytime observation period. Investigations were conducted during the winter (December–March 1991/1992). Table 1 presents some additional characteristics of the herds.

Social behaviour

On 2 successive days, each herd was observed in the evening for one, 4h period, starting 1h after opening the feeding rack following milking. The cows were active during this period, yet they were subject to fewer variable influences at this time than during the day. Each occurrence of the following behavioural elements was recorded:

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Table 1 **Selected characteristics of all 35 herds ranked according to the three housing systems, as in Figures 1 and 2.**

Herd no	Herd size (individuals)	Space per cow (m^2)	Breed	No of different milkers	Personnel changes per year (see Table 2)
1	14	8.10	Brown Swiss	1	≤1per 2 years
4	18	6.96	Brown Swiss	2	≤1per 2 years
5	39	7.09	Pied Cattle	>2	≤1 per year but >1 per 2 years
6	80	5.1	Mixed breeds	1	≤1per 2 years
8	39	9.64	Black Pied	>2	>1 per year
10	24	10.34	Mixed breeds	1	≤1 per 2 years
12	61	8.73	Black Pied	>2	≤1 per year but >1 per 2 years
17	33	7.27	Black Pied	>2	≤1 per year but >1 per 2 years
22	54	5.48	Red Pied	2	≤1per 2 years
24	34	8	Brown Swiss	>2	≤1 per year but >1 per 2 years
25	63	5.32	Pied Cattle	>2	>1 per year
26	30	6.59	Pied Cattle	1	≤1per 2 years
28	19	11.71	Brown Swiss	1	≤1per 2 years
30	20	4.95	Pied Cattle	2	≤1per 2 years
33	32	8.39	Pied Cattle	2	≤1per 2 years
35	92	9.31	Pied Cattle	2	≤1per 2 years
3	16	16.77	Pied Cattle	2	≤1 per year but >1 per 2 years
7	32	11.84	German Red	>2	≤1 per year but >1 per 2 years
9	39	21.08	Mixed breeds	>2	≤1 per year but >1 per 2 years
11	32	13.36	German Red	>2	≤1 per year but >1 per 2 years
13	28	21.96	Black Pied	1	≤1 per year but >1 per 2 years
14	11	10.43	Black Pied	2	≤1per 2 years
15	46	9.22	Red Pied	2	>1 per year
16	56	7.99	Red Pied	>2	≤1 per year but >1 per 2 years
18	8	22.13	Jersey	1	≤1per 2 years
19	24	10.85	German Yellow	>2	≤1per 2 years
20	39	10.91	Black Pied	>2	≤1 per year but >1 per 2 years
21	56	8.21	Mixed breeds	2	≤1 per year but >1 per 2 years
23	38	9.67	German Red	2	≤1 per year but >1 per 2 years
31	20	6.2	Pied Cattle	2	≤1 per year but >1 per 2 years
34	50	8.14	Brown Swiss	>2	>1 per year
2	9	18.22	Brown Swiss	1	≤1per 2 years
27	17	6.48	Brown Swiss	1	≤1per 2 years
29	12	6.47	Red Pied (Vorderwälder)	1	≤1 per year but >1 per 2 years
32	24	8.19	Pied Cattle	2	≤1per 2 years
Mean (± SEM)	34.54 (3.37)	10.03 (0.79)	-	-	-

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Push away: one cow pushing another one in such a way, that the latter moves away from the attacking cow.
Chase away: running after another cow that flees; chase away was mostly preceded by push away. Since both variables are closely associated they were classed together as the grouped variable 'chase/push away'. The value of this grouped variable was calculated by regressing the two variables on injuries caused by horns (coefficient for push away = 1, for chase away = 1.3278 and the constant = 0.0413).
Butting: one cow butting another one; both remain in the same place.
Horning: mutually touching horns, in a playful manner or with distinct agonistic components (the horns touch the head and neck of the opponent).
Social licking: mutual licking, with the exception of licking at the anal region.

Only active behavioural patterns, in which the individual involved took the initiative, were recorded. The mean frequency values from the two evening observation periods were calculated for each behaviour and expressed as the mean frequency variable^{-1} 4h^{-1} per cow and per herd.

Injuries
Injuries caused by horns were characterized by their vertical orientation and somewhat variable position; a typical location of these injuries was the lower part of the abdomen and shoulder. Most injuries caused by stable equipment had a horizontal orientation and a more or less identical position among all animals in a given stall. Such injuries were disregarded in this investigation and only the injuries caused by horns were investigated. Horning injuries were recorded on the days when the behavioural observations were made. Injuries caused by horns were expressed as the mean frequency per cow and per herd. Such injuries are visible for a relatively short period of time (1–2 months). In contrast, injuries to the vulva are visible for much longer periods of time (often more a year). As this made them not comparable to the vertical skin-injuries, we also disregarded all vulval injuries.

Husbandry conditions
Any husbandry conditions that might influence the behaviour of a herd, and consequently the occurrence of skin lesions, were recorded and quantified by a questionnaire and by direct registration. Recorded variables within each condition included: elements of herd management, of the human-animal relationship, animal characteristics and housing (stable characteristics). Only those variables that, according to regression analysis (see below), contributed in a relevant way to the observed variance are presented. These variables were classified into four categories corresponding to the husbandry conditions (Table 2).

The ordinal scales in Table 2 were ranked by considering the amount of time, financial input or work that had to be invested or perfomed for each measurement. High scores indicated that stockpeople/farmers spent more time or went to greater expense in regard to herd management, stable equipment and human-animal relationships. High scores were also awarded when there were a low number of different milkers herd^{-1} or the frequency of personnel changes was low.

Statistical analysis
Given the use of different data scales (ordinal and cardinal), Spearman rank correlation coefficients were calculated (Martin & Bateson 1993). In addition, a (backward) stepwise

Table 2 **Descriptions, rankings and scales for selected variables of the four husbandry conditions.**

Conditions *and variables*	Description /ranking	Scale[1]
Herd management (hm)		
Problem solving management by the farmer	Farmer recognizes and avoids critical situations and negative points in husbandry to solve or avoid problems with the social behaviour of the cows (eg immediately repairs a defective feeding rack; develops solutions to problems from single aggressive cows in the herd). 0: no problem solving management; 1: partly; 2: good problem solving management (subjective ratings).	Ordinal
Integration of new cows into the herd	0: single integration, directly without any acclimatization measures; 1: integration of a group of animals (> 2) or integration of a single animal with measures to acclimate; 2: group integration with acclimatization measures.	Ordinal
Separation of dry/calving cows from the herd	Separation time of dry/calving cows from the herd 0: > 14 days; 1: 4–14 days; 2: < 4 days	Ordinal
Measures for nervous oestrus cows	0: no measures; 1: tying nervous cows in a safe place in the herd, or a bull in the herd; 2: removing the cow for a short time from the herd	Ordinal
Human animal relationship (har)		
Ability of the stockperson to identify individual cows	0: < 95% cows of the herd; 1: 95–99%; 2: 100%	Ordinal
Frequency of personnel changes (of stockperson or milker)	Frequency of changes of standard personnel 0: >1 per year; 1: ≤ 1 per year but >1 per 2 years; 2: ≤ 1 per 2 years.	Ordinal
Frequency of brushing the cows	0: 0–1 per year; 1: < 1 per month but >1 per year; 2: ≥ 1 per month.	Ordinal
Number of different milkers	Number of regular milking persons 0: > 2 milkers; 1: 2 milkers; 2: 1 milker.	Ordinal
Animal characteristics (an)		
Herd size	Number of animals per herd during observations (range 8–92).	Cardinal
Stable characteristics (st)		
Space per cow	Total space available (m^2) to the animals, ie resting, feeding, moving area , (range 5–22 m^2 cow^{-1}).	Cardinal

[1] All ordinal scales range from 0–2.

regression analysis was carried out (Menke 1996) to confirm the relevance of the correlations. The evaluation takes into consideration that the variables selected were not entirely independent. Due to the large number of recorded variables, only the results of correlations of variables which were confirmed by the regression analysis are presented.

Results

The frequencies of push away, chase away and of injuries caused by horns differed considerably between the 35 herds and farms (Figure 1). The mean frequency of pushing away (0.92 instances $4h^{-1}$ cow^{-1}) was about 10 times higher than that of chasing away (0.09 instances $4h^{-1}$ cow^{-1}). (Standard errors of the means are not presented as the data were not normally distributed.) Means of between 1 and 63.5 injuries cow^{-1} $herd^{-1}$ were caused by horns. Over all the herds, there was a mean frequency of 13.6 injuries cow^{-1}. Injuries caused by horns consisted mainly (92.6%) of superficial grazes to the hair.

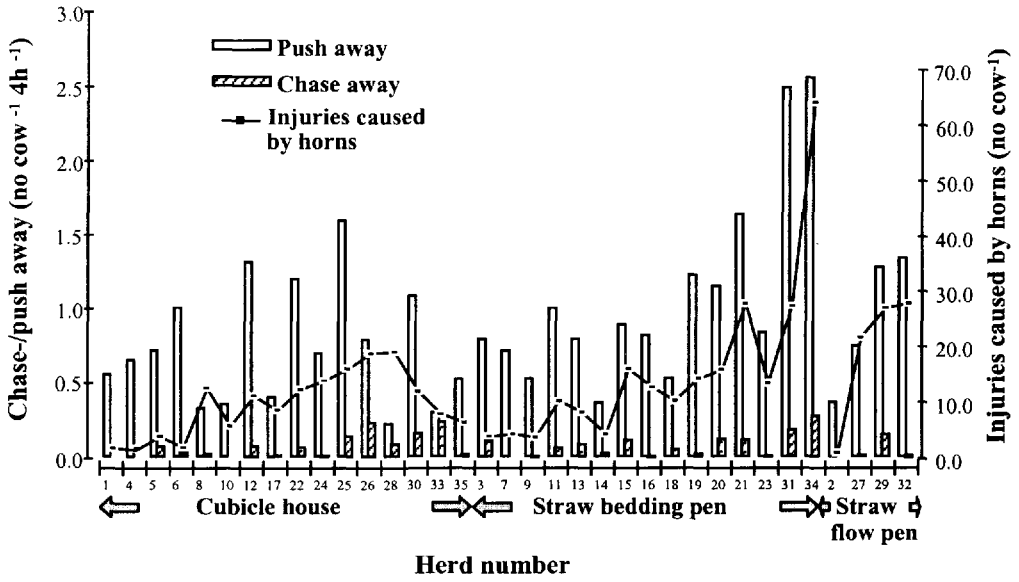

Figure 1 **Frequency of chase away and push away behaviour, and injuries caused by horns, among the 35 herds.**

Figure 1 also indicates that large differences existed between the three types of housing system in the frequencies of push away, chase away and injuries caused by horns among the herds. Some farms seemed to have serious problems in keeping horned dairy cows (eg Herd numbers 25, 31 and 34). The mean frequencies of butting (0.23 instances $4h^{-1}$ cow^{-1}), of horning (0.11 instances $4h^{-1}$ cow^{-1}) and of social licking (0.24 instances $4h^{-1}$ cow^{-1}) also differed substantially between herds (Figure 2).

The Spearman rank correlation coefficients between all the parameters shown in Figures 1 and 2 are given in Table 3. These data not only show a significant positive correlation between both agonistic behaviours (push away and chase away), but also a strong positive one between these agonistic elements and the occurrence of injuries caused by horns. Finally, Table 3 demonstrates a weak (but significant) positive correlation between butting and push away; whereas social licking is correlated significantly only with butting and horning.

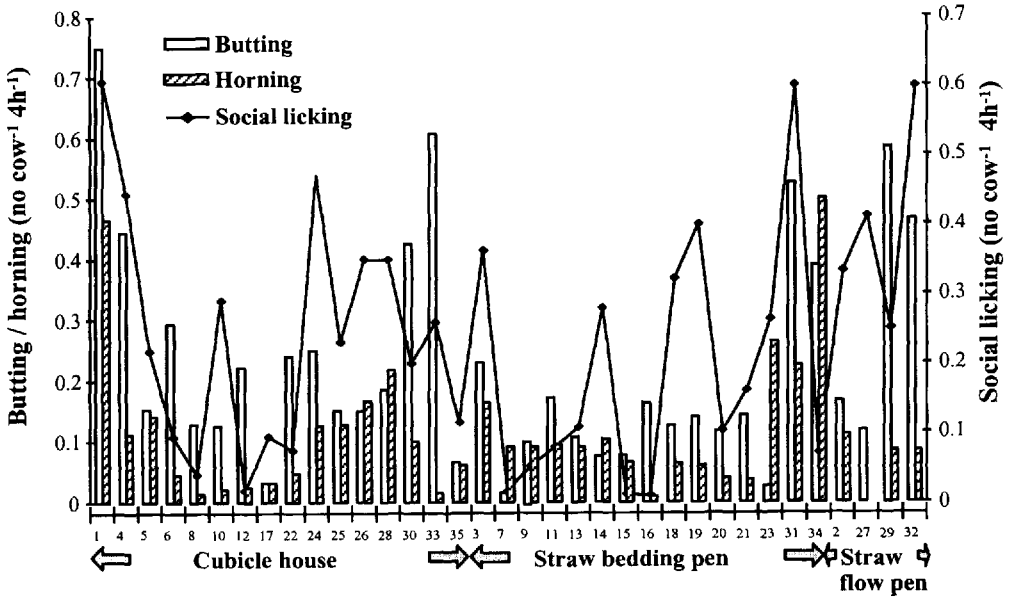

Figure 2 **Frequency of butting, horning and social licking among the 35 herds.**

Table 3 **Spearman rank correlation coefficients between the frequencies of various social behaviours and injuries caused by horns among dairy cows (n = 34). *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.**

Parameter	Chase away	Push away	Butting	Horning	Social licking	Injuries
Chase away	1.000					
Push away	0.452**	1.000				
Butting	0.257	0.290*	1.000			
Horning	0.140	0.106	0.238	1.000		
Social licking	-0.117	-0.107	0.376*	0.404*	1.000	
Injuries	0.526***	0.608***	0.172	-0.033	0.042	1.000

Table 4 shows the Spearman rank correlation coefficients between the occurrences of agonistic behaviour (push away and chase away have been classed together as chase/push away, as described earlier), injuries and social licking, and the 10 selected husbandry variables (see Table 2). The frequencies of chase/push away and of injuries show a basically similar relationship with all 10 husbandry variables; whereas the frequency of social licking demonstrates the opposite trend.

Within the herd management category (hm), the variable 'problem solving management by the farmer' had the most distinct (negative) correlation both with agonistic behaviour and with injuries caused by horns. On farms ranking high in problem solving management, ie with farmers who efficiently prevented or corrected critical husbandry points, the frequency of agonistic social behaviour and of injuries was low. The variable 'integration of new cows

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into the herd' had only a suggestive negative relationship with the occurrence of chase/push away – but a distinct one with injuries caused by horns. In herds where the farmer habituated new cows gradually to the herd (eg initially keeping the new cows separate with older and higher ranked cows of the herd) and paid adequate attention to the social behaviour of his cows during integration, the frequency of injuries was lower than in herds where the new cows were integrated without any additional measures.

Table 4 **Spearman rank correlation coefficients between the frequencies of social behaviours (chase/push away, social licking) and injuries caused by horns and the occurrence of 10 selected husbandry variables (from four husbandry conditions; hm, har, an, st). See Table 2 for full description of abbreviations, conditions and variables. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.**

Condition	Possible influencing variables	Chase / push away	Injuries	Social licking
hm	Problem solving management by the farmer	-0.538***	-0.513***	0.248
hm	Integration of new cows into the herd	-0.255	-0.454**	0.211
hm	Separation of dry/calving cows from the herd	-0.101	-0.195	0.554***
hm	Measures for nervous oestrus cows	-0.483**	-0.274	0.252
har	Ability of the stockperson to identify individual cows	-0.291*	-0.285	0.523***
har	Frequency of personnel changes	-0.349*	-0.255	0.526***
har	Frequency of brushing the cows	-0.164	-0.185	0.305*
har	Number of different milkers	-0.154	-0.014	0.471**
an	Herd size	0.295*	0.221	-0.681***
st	Space per cow	-0.366*	-0.407 **	-0.101

The variable 'separation of dry/calving cows from the herd' correlated well with the frequency of social licking. In herds with a long separation time, the frequency of social licking was lower than in herds with a short separation interval. The significant negative correlation between the 'measures for nervous oestrus cows' variable and frequency of agonistic behaviour implies, that in herds where the farmers tie these animals in a secure place in the stable or remove them from the stable for a short time, the frequency of chase/push away was lower than in the other herds.

With respect to the human-animal relationship category (har), the following findings are relevant. Both the variable 'ability of the stockperson to identify individual cows' and the variable 'frequency of personnel changes' correlated negatively with the occurrence of agonistic behaviour and positively with that of social licking. This implies that in farms where the farmer/stockperson knew fewer than 95 per cent of his/her cows by name or number, or where the frequency of personnel changes was high, the herd showed a relatively high frequency of agonistic behaviour and a low frequency of social licking. Both the 'frequency of brushing the cows' variable and the 'number of different milkers' variable correlated positively with occurrence of social licking. A low frequency of brushing and a relatively high number of different milkers was typical of those herds in which social licking was relatively rare.

In the animal characteristics category (an), the variable 'herd size' correlated just significantly (but positively) with the occurrence of agonistic behaviour, and highly negatively with occurrence of social licking. This indicates that in large, as compared with

small, herds agonistic behaviour occurs at relatively high frequencies and social licking at relatively low ones.

In the stable characteristics category (st), the variable 'space per cow' correlated negatively both with the occurrence of agonistic behaviour and of injuries. This suggests that greater space per cow reduces the frequency of agonistic behaviour and the associated occurrence of injuries.

Figure 1 shows that in all three housing systems the levels of agonistic behaviour and of injuries caused by horns differed markedly. Although some models of the stepwise regression analysis (Menke 1996) have indicated a significant influence of the variable 'housing system', these models showed a high degree of instability caused by this variable. This could have indicated multi-collinearity (ie a high correlation between predictive variables in the regression model) and, therefore, that the effect of housing system could not be assessed reliably. The same holds true for the variable 'breed'.

Discussion

Social behaviour patterns

The present findings show a complicated pattern of social behaviour (Figure 3) in herds of dairy cows during the evening hours after milking and feeding. Two elements of this behaviour – push away and chase away – are performed in competitive situations between two or more individuals and result in an increased distance between the participants. Since these same two elements are closely associated with the occurrence of skin injuries (Table 3), we consider push and chase away to be the most typical agonistic behaviour elements observed among our study herds.

In addition to this agonistic behaviour, distance-reducing or social bonding behaviour also occurred. The most typical expression of this type of behaviour in cows is social licking (Sato & Maeda 1991; Sato *et al* 1991; 1993). The occurrence of social licking was neither positively nor negatively correlated with the performance of push and chase away behaviours, suggesting that independent factors underlie both types of behaviour. The intermediate position of butting (Figure 3) indicates the ambivalent motivation for this behaviour. However, the position of horning (Figure 3), often performed in a playful manner, suggests a motivation to improve positive social relationships between specific members of the herd. This picture fits with ideas formerly advanced by Schloeth (1961), Reinhardt (1973) and Clutton-Brock *et al* (1976).

The occurrence of agonistic behaviour

The frequency of agonistic behaviour (push and chase away) was estimated by consistently using the same observation method in all 35 herds. Agonistic behaviour was recorded at a time of day when there was a high probability of its occurrence. Yet how do these frequencies relate to those reported in the literature? To enable a meaningful comparison with agonistic behaviour in (de)horned herds, we will express our own data as the sum of push away and chase away behaviours per hour and per cow. The mean combined frequency of push and chase away, reported above, thus becomes 0.25 instances h^{-1} cow^{-1}. Over all 35 herds this value ranges from 0.0 to 0.7 instances h^{-1} cow^{-1}. Using comparable methods, Menke (1986) found a frequency of 0.67 instances h^{-1} cow^{-1} in a herd of 80 dehorned cows in a cubicle housing system. Andreae *et al* (1985) reported a frequency of 0.33 instances h^{-1} cow^{-1} in a dehorned herd with a space allowance of $28m^2$ cow^{-1}. However, their data were derived from observations over the entire day. Graf (1974) found that horned cows on

pasture pushed away from one other at a frequency of 0.67 pushes h^{-1} cow^{-1}, whereas dehorned cows did so at a rate of 2.64 pushes h^{-1} cow^{-1}. Jonasen (1991) investigated dehorned dairy cows in a loose housing system with a yard and free access to pasture and also established a value for pushing away of 2.39 instances h^{-1} cow^{-1}. Collis *et al* (1979) reported push away frequencies of 1.5–4.6 instances h^{-1} cow^{-1} among dehorned dairy cows.

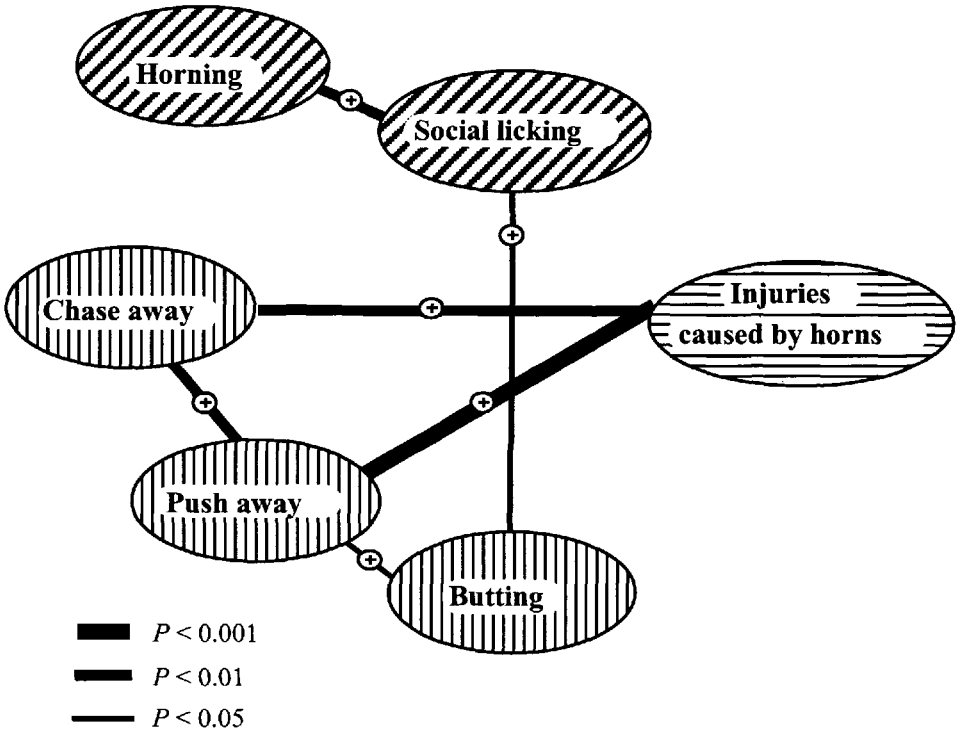

Figure 3 **Significant rank correlation cofficients between the frequencies of specified social behaviours among dairy cows and the frequency of injuries caused by horns.**

These data support two conclusions. i) The variation in agonistic levels (expressed as frequencies per hour and per cow) in herds of (de)horned dairy cows is high and probably due, in part, to variability in the time of day at which the original observations were made; and to large differences in management aspects of the herds involved. ii) Despite this variation, dehorned cow herds appear to have higher levels of agonistic behaviour than horned ones. Without doubt, this difference is related to the fact that the presentation of horns not only determines and supports the rank position of individual cows (Espmark 1964; Geist 1966; Walther 1966; Bouissou 1972), but also reduces the frequency of agonistic behaviour (Graf 1974; Fries 1978). This is an important aspect of older animals which, due to their large horns and in spite of reduced physical strength, remain able to contribute to a stable herd structure.

The frequency of agonistic behaviour among the horned herds in the present study was, on average, low but probably typical of that which can be observed in horned herds.

Nevertheless, the highest levels on some of our farms approached those reported for agonistic behaviour in dehorned herds.

Skin injuries

The mean number of skin injuries caused by horns differed very much between farms in our study, ranging between 1 and 63.5 injuries cow^{-1} $herd^{-1}$. Most of these injuries were, however, superficial. The large variation between farms was also found within each of the three housing systems. This indicates that the differences between the three systems cannot explain the different levels of skin injuries observed. Oester (1977) reported the occurrence of such serious injuries in a group of horned dairy cows (whose housing changed from a tying stable to a loose housing system), that two of the animals had to be slaughtered. However, 1 year later, he did not find any fresh injuries in this group.

Changing from a tie stall to loose housing always means stress for the cows involved; and some animals are unable to cope with the new environment. This applies especially to old and somewhat defective animals, if the environmental factors are suboptimal. Under these conditions – and particularly if the cows are horned – serious injuries may result, as described by Oester (1977).

Husbandry, agonistic and bonding behaviour, and skin injuries

We now focus on those husbandry conditions that either influenced agonistic behaviour of horned dairy cows and the consequent occurrence of skin injuries, or influenced social bonding behaviour among the same cows and the consequent stability of the herds involved. This latter stability may modulate the frequency of agonistic behaviour and of resulting skin injuries.

Herd managment

The first husbandry condition, or from the point of view of the cows involved, the first environmental condition we considered, was herd management (hm). The most important variable in this category appeared to be 'problem solving management by the farmer'. This variable correlated strongly both with agonistic behaviour and the occurrence of skin injuries. The implication is that farmers/stockpeople who remark and prevent situations that facilitate competition among cows, prevent its negative effects among their herds. For example, on several farms we noticed that faulty feeding racks were only repaired after a long delay – sometimes more than 2 years. Since a highly competitive situation exists at feeding places, cows may receive serious injuries at faulty feeding racks (as pointed out years ago by Woodbury [1941]).

The second herd management variable 'integration of new cows into the herd' showed a strong correlation with skin injuries only, and not with agonistic behaviour. A possible reason for this divergence, is that the procedure of integrating a new cow takes place at intervals, while its effect on agonistic behaviour will be restricted to the period of integration itself. Injuries, however, remain visible for a longer period, since healing of fresh skin injuries may take 1–2 months. Our method of recording (observations on 2 successive evenings per farm) favoured detecting a relationship between method of integration and skin injuries more than between the same variable and the occurrence of agonistic behaviour.

The variable 'separation of dry/calving cows from the herd' did not show any relationship with agonistic behaviour or the occurrence of skin injuries. However, it was related significantly to the occurrence of social licking. This implied, that in herds where cows were

removed for periods of 2 or more weeks for specific reasons, the frequency of social licking was relatively low. Since this licking is an indication of a social bond between individual cows (Clutton-Brock *et al* 1976; Reinhardt *et al* 1978) long separation times obviously interfere with bonding mechanisms. Under such circumstances, individual cows would have only a reduced opportunity to build up individual bonds (Reinhardt 1979). This aspect of herd management needs to be investigated in more detail, since it may have an influence on the stability of the entire herd.

The last herd management variable 'measures for nervous oestrus cows', strongly influenced the occurrence of agonistic behaviour. Oestrus cows are characterized by their restless behaviour; they direct horning and mounting at other herd members and do not avoid higher-ranking cows. On those farms where the farmer removed oestrus cows temporarily from the herd, agonistic behaviour was much lower than on farms where the farmer took no measures with respect to such cows.

In conclusion, adequate herd management may significantly reduce agonistic behaviour and, by this, also the occurrence of skin injuries in herds of horned cows.

Human-animal relationship

The environmental variables typifying the human-animal relationship (har) aspects of the husbandry conditions yielded interesting results. They were all more or less strongly correlated with the occurrence of social licking and thus with bonding mechanisms within the herd. In brief, a good human-animal relationship promotes bonding behaviour within the herd.

This bonding behaviour was high for two of the variables, whereas agonistic behaviour was relative low (Table 4). Both the 'ability of the stockperson to identify individual cows' and a low 'frequency of personnel changes' (per year) were associated with high levels of social licking and relatively low levels of agonistic behaviour. In fact, both variables reflect the caretakers' ability not only to identify each cow individually, but to recognize individual problems as a consequence of this. Overlooking such problems, whether because of some form of unawareness or nonchalance, may seriously disturb the herds and even reduce their milk production (Rieck 1961; Schlichting 1974).

The 'frequency of brushing the cows' and the 'number of different milkers' variables were associated with social licking only. Brushing implies a close contact between the farmer/stockperson and his cows. A close contact, as well as a low number of milkers, also enhances the ability to recognize individual cows' problems. In this context, it is interesting that Seabrook (1984) reported that such contact may enhance milk production of the cows involved.

Several authors have pointed out the benefits of consistent handling of individual cows; frequent changes will counteract such handling (Fordyce *et al* 1985; Menke 1986; Boissy & Bouissou 1988; Hargreaves & Hutson 1990; Boivin *et al* 1994; Waiblinger *et al* 1995). Thus, the quality of the human-animal relationship appears to have a distinct influence on the social behaviour of horned dairy cows. A close contact between the farmer and his animals, and a stable personnel situation contribute positively to adequate social behaviour in a herd.

Animal characteristics

In the animal characteristics category (an), the relationship between the variable 'herd size' and the occurrence of social behaviour clearly shows that in large, as compared with small, herds bonding behaviour is relatively infrequent, whereas agonistic behaviour is more

common. Arave *et al* (1984) ascribed this difference to two main factors. First, mutual recognition is difficult in large herds and this reduces the effectiveness of an existing rank order. However, Zeeb & Zimmermann-Müller (1971) showed that in large herds where cows form subgroups, space per cow is often so low that the rate of meeting of individual cows is high. Therefore, rank positions have to be tested frequently, reducing the effectiveness of existing subgroups. Second, in large herds, the frequent integration of new cows, partly resulting from the short service life of dairy cows (Frey & Berchtold 1983), also counteracts any existing rank order and reduces the development of lasting social bonds.

In large herds, the frequency of contact between the farmer and individual cows is often relatively low, because of the higher degree of technology and automation (Seabrook 1986; Chupin & Le Neindre 1990). This reduced contact may also influence handling in a negative way (Boivin *et al* 1994). In large herds there is an increased probability of frequent personnel changes and/or a higher number of different milkers, as compared with small herds; this may also contribute, as previously stated, to unwanted changes in agonistic and social bonding behaviour.

Herd size is, therefore, an important aspect of dairy cow farm conditions. It strongly influences the effects of herd management and human animal relationship conditions. Its effect can be interpreted as a reduced stability of a herd resulting from a decreased controllability of its own social environment by each cow. Such a loss of controllability implies a welfare problem if it persists for long periods of time (Wiepkema & Koolhaas 1993).

While it is obvious that small herds (for instance, 10–20 horned cows) can be controlled relatively easily with respect to preventing skin injuries caused by horns, the question remains: what is the maximum size of such a herd if it is to be controlled adequately in order to prevent the same injuries? We cannot answer this question in any definite way, and in any event, this size will strongly depend on the skilfulness of the farmer. It is, however, interesting to note that on the largest farm in our study (Herd 35, with 92 horned cows,) the observed social behaviour of the cows was well balanced and the frequency of skin injuries was low.

Stable characteristics

In the stable characteristics category (st), the variable 'space per cow' showed a distinct relationship with both the occurrence of agonistic behaviour and of skin injuries. This confirms the findings of earlier investigations, in which reduced space per cow resulted in a higher frequency of agonistic behaviour (Lippitz *et al* 1973; Czako 1978; Collis *et al* 1980; Metz & Wierenga 1984; Andreae *et al* 1985; Zeeb 1987). Obviously, providing adequate space per cow is a prerequisite for reducing the occurrence of skin injuries to a low and acceptable level. However, it is also interesting that in the herd with the lowest value of 'space per cow' (Herd 30, see Table 1) the frequency of chase and push away behaviours fell within the middle third of all recorded values.

Dangers

One frequently mentioned argument against keeping horned dairy cows in loose housing systems, is that the farmer may be too easily hurt by his cows (Hermentin 1990). However, in the farms we surveyed, no farmer nor any of his apprentices were ever hurt seriously by any of the horned cows in loose housing. Some of the herds involved had existed for more

than 20 years without such problems. Our information about injuries caused by horns, indicates that they all occurred among tethered animals or with bulls.

Animal welfare implications

Dehorning is a most painful experience for cows and calves (Taschke & Fölsch 1995). The results of the present study show that keeping horned dairy cows in loose housing systems is possible without unacceptable risks for cows and humans. However, it is absolutely necessary to optimize herd management conditions and to build up a close human-animal relationship. This might even enable horned dairy cows to be kept in relatively large herds and within the usual space allowances per cow found in present day loose housing systems. Such measures would also significantly enhance cow welfare. The results of this study show that there are no reasons to take dehorning for granted. Mutilating measures in animal husbandry should always be discussed, criticized and, if possible, prevented.

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