ATTEMPTS TO INTEGRATE DIFFERENT PARAMETERS INTO AN OVERALL PICTURE OF ANIMAL WELFARE USING INVESTIGATIONS IN DAIRY LOOSE HOUSES AS AN EXAMPLE

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Abstract *Animal Welfare 2003,* ***12***: 557-563

The aim of this study was to illustrate the integration of different parameters into an overall assessment of animal welfare on the basis of studies with dairy cows. Behavioural observations were carried out on 36 farms with cubicle houses. Summed variables of resting behaviour were constructed by summing the results for three to nine behaviours. These summed variables showed higher correlations with cubicle features than did single behaviours. Individual animals may react differently to the same causes (cubicle features), and adding up may compensate for these different reactions of individuals to the same causes. Most recorded behaviours correlated with one another; this could be interpreted as evidence for identical causes. A cubicle sum variable was constructed, giving scores for cubicle features. The cubicle sum variable showed higher correlations with resting behaviours than did single cubicle features. This suggests that certain behaviours are affected by several cubicle features (additive effects). This hypothesis was confirmed by multivariate analysis.

Keywords: *animal welfare, dairy cow, index construction, loose housing, parameter integration*

Introduction

In most studies concerning animal welfare, more than one parameter is used in order to define the overall welfare state of an animal or a group of animals (eg Appleby & Hughes 1997). This particularly applies at the farm level, where many parameters are recorded, often including housing and management characteristics (eg Sørensen & Sandøe 2001). An important question is how different parameters could be integrated into an overall picture of animal welfare.

The weighing-up of the results of different animal parameters in the discussion sections of scientific papers can be regarded as a form of qualitative integration. However, a quantitative integration has additional advantages. An overall score is easier to communicate than just a listing of single findings, for example in a certification process (eg Bartussek *et al* 2000). By integrating animal-related parameters, it is possible to compensate for different reactions of individuals to a certain influencing factor. Furthermore, it may be possible to identify a key symptom for the overall welfare situation which represents several parameters. Integration of housing parameters may allow for compensation between single housing features. In epidemiological studies, multivariate analysis is often used (eg for a risk analysis) which also includes integrative aspects.

The purpose of integration is to combine different, usually related, observations to provide some overall index of welfare and thereby strengthen the association between provision and outcome — for example, between housing and comfort. Quantitative integration in welfare science may include adding up of parameters — either of animal parameters or of housing parameters. A welfare index can be constructed in different ways. A score for one parameter and one body part (eg lameness or body condition scoring) is not yet an index. Indices can be built out of one parameter and several body parts (eg cleanliness or injuries index) or can include several findings relating to one body part (eg claw index) (see examples in Sørensen & Sandøe 2001). Furthermore, several animal and several housing management parameters can be combined with scores into an index system. Capdeville and Veissier (2001) constructed a system for dairy cows mainly focussing on animal-related parameters. Bock (1990) and Platz *et al* (1999) used systems which included animal and housing criteria to a similar extent. The Animal Needs Index (TGI) (Bartussek *et al* 2000) is mainly based on housing criteria. Finally, indices have been used which include only housing features, such as the cubicle sum variable used by Menke (1996), or the composite variables 'floor', 'alley', and 'social' defined by Winckler and Willen (2001).

While the above-mentioned indices including animal-related parameters mainly focus on clinical findings, different behaviours can also be integrated. Some authors have summated resting behaviours of dairy cows. Kohli and Kämmer (1985) and Kohli (1987) defined for dairy cows a 'sum of negative experiences' while lying down in stanchion barns, summing the relative frequencies of 13 behaviours. Wechsler *et al* (2000) summed each of three behaviours to derive a 'difficulty rate' of lying down and standing up.

Methods

Farms and subjects

The investigations were carried out in 36 dairy cubicle houses. Nine farms were organic. Six farms had an additional exercise yard. Herd size ranged from 15 to 140 cows with a mean of 52.6 cows (standard deviation = 26.7). Twenty-six farms kept Holstein–Friesians and ten farms Simmental cows. Horned cows were present at six farms.

Behavioural observations

Direct observations of resting behaviour took place once per farm for approximately 6 h after the morning milking to include the main resting period around noon. Thirteen behaviours out of the three behaviour groups of lying down, standing up and lying were recorded. As described in Wechsler *et al* (2000), at least 20 lying down and standing up events were recorded per farm. Behaviours while lying (maximally synchronous lying cows, leg stretching, ruminating) were recorded for 30 min intervals (scan sampling).

Index construction

For the previously mentioned behaviour groups, 'difficulty rates' were calculated by adding up those single behaviours which were similar in average values and standard deviation. The 'difficulty rate lying down' included preparation time before lying down (from sniffing of the floor until bending of the first carpal joint), lying down duration (from bending the first carpal joint until completely lying) and percentage of lying down attempts (standing up again after one carpal joint has contacted the floor). The 'difficulty rate standing up' included percentage of standing up attempts (interruption after lunging head forward), percentage of standing up horse-like (with forelegs first) and standing up duration. The 'difficulty rate lying' included percentage of maximally synchronous lying cows (the highest of 30 min scans), percentage of cows ruminating while lying and percentage of cows lying with stretched hindlegs. The 'sum of negative behaviours' included the behaviours of the difficulty rates of lying down and standing up and, in addition, the number of steps with the forelegs before lying down ('tripping') and the percentages of hitting against partitions and of the head lunging sideways while standing up. A 'cubicle index' was developed, scoring one to four points in ascending order for the following five cubicle features: cubicle length (≤2.3, ≤2.4, ≤2.5, >2.6 m), cubicle width (≤1.1, ≤1.15, ≤1.2, >1.2 m), distance of the neck rail (≤1.45, ≤1.55, ≤1.65, >1.65 m), height of the straw (0.8–2.5, 2.9–4.3, 7.2–9.7, 10.1–12.7 cm) and type of divider (Newton Rigg, mushroom, Super Dutch comfort, flexible).

Statistical analyses

Correlations between variables were calculated using Spearman's Rho test. To test the influences of cubicle features on resting behaviours, a general linear model (GLM) was used. The GLM includes both regression and variance analysis so that categorical and continuous variables can be used in combination. The categorical variables 'cubicle dividers' and 'straw amount class' were included in the model as fixed factors and the continuous variables 'cubicle length', 'cubicle width' and 'neck rail distance' as covariates. Data were evaluated using the statistical package SPSS Version 10.0.

Results

The summing of resting behaviours into difficulty rates enhanced the correlations with single cubicle features compared with single behaviours in most cases (Table 1). The correlation coefficient and/or the significance level increased. A further increase was found with the sum of negative behaviours, which included more behaviours.

Table 1 Correlations between cubicle features and resting behaviours and respective sum variables.

Cubicle features	Width	Length	Area	Straw amount	Divider	Index
Tripping before lying down	–0.51**	–0.42**	–0.50**	–0.45**	–0.52***	–0.60***
Lying down attempts	–0.49**	–0.66***	–0.65***	–0.64***	–0.76***	–0.69***
Lying down preparation time	–0.42*	–0.45**	–0.49**	–0.25	–0.50**	–0.48**
Lying down duration	–0.38*	–0.51***	–0.50**	–0.67***	–0.63***	–0.62***
Head lunging sideways	–0.57***	–0.56***	–0.61**	–0.47**	–0.42**	–0.60**
Standing up horse-like	–0.58***	–0.61***	–0.66***	–0.56***	–0.65***	–0.67***
Standing up attempts	–0.49**	–0.56***	–0.60***	–0.53***	–0.58***	–0.62***
Standing up duration	–0.22	–0.37*	–0.34*	–0.47**	–0.44**	–0,45**
Hitting against partitions	–0.37*	–0.63***	–0.60***	–0.44**	–0.67***	–0.57***
Stretched forelegs	0.39*	0.32*	0.40*	0.53***	0.57***	0.53**
Stretched hindlegs	0.40*	0.35*	0.41*	0.42**	0.60***	0.49**
Lying fully stretched	0.25	0.42*	0.37*	0.42*	0.75***	0.50**
Ruminating while lying	0.46**	0.44**	0.50**	0.40*	0.54***	0.48**
Max. synchronous lying	0.41*	0.38*	0.43**	0.56***	0.38*	0.51**
Difficulty rate lying	0.51**	0.48**	0.54***	0.60***	0.67**	0.64***
Difficulty rate lying down	–0.56***	–0.62***	–0.66***	–0.68***	–0.79***	–0.79***
Difficulty rate standing up	–0.53***	–0.63***	–0.65***	0.59***	–0.65**	–0.73***
Sum negative behaviours	–0.62***	–0.75***	–0.77***	–0.69***	–0.74***	–0.82***

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Correlations between cubicle area (length × width), cubicle index and single resting behaviours were higher than using single cubicle features (Table 1). The highest correlations were found between the sum variables from the animal and housing parameters groups (Table 1).

Most of the resting behaviours were significantly correlated (Table 2). Behaviours where an increase is regarded as negative for welfare (eg longer duration or more deviations of standing up or lying down) correlated with each other positively and negatively with those behaviours where an increase is regarded as positive (eg synchronous lying, leg stretching, ruminating).

Table 2 Correlations between resting behaviours.

	Tripping before lying down	Lying down attempts	Preparation lying down duration	Lying down duration	Standing up duration	Standing up attempts	Standing up head lunging sideways	Standing up horse-like	Lying with stretched forelegs	Lying with stretched hindlegs	Lying in a fully stretched position	Ruminating while lying
Lying down attempts	0.61***	–										
Preparation lying down duration	0.38**	0.30°	–									
Lying down duration	0.61***	0.73***	0.15	–								
Standing up duration	0.37*	0.47**	0.08	0.81***	–							
Standing up attempts	0.55**	0.75***	0.33°	0.61***	0.47**	–						
Standing up head lunging sideways	0.32°	0.41*	0.39*	0.14	0.10	0.57***	–					
Standing up horse-like	0.78***	0.80***	0.34*	0.70***	0.51**	0.81***	0.48**	–				
Lying with stretched forelegs	–0.55**	–0.62***	–0.22	–0.69***	–0.52**	–0.65***	–0.37*	–0.63***	–			
Lying with stretched hindlegs	–0.59***	–0.60***	–0.33*	–0.41*	–0.20	–0.44**	–0.38*	–0.56***	0.69***	–		
Lying in a fully stretched position	–0.38*	–0.61***	–0.31°	–0.58***	–0.37*	–0.49***	–0.20	–0.48**	0.57***	0.52***	–	
Ruminating while lying	–0.58***	–0.52***	–0.41*	–0.37*	–0.09	–0.38*	–0.32°	–0.56***	0.48**	0.54**	0.46**	–
Max. synchronous lying	–0.47**	–0.51***	–0.04	–0.65***	–0.51**	–0.61***	–0.30°	–0.62***	0.60***	0.22	0.44**	0.35*

° $P < 0.1$, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

The multivariate analysis with the GLM procedure revealed that any of the resting behaviours was significantly influenced by more than one cubicle feature (Table 3). For behaviours while lying, type of cubicle divider and cubicle width were the most numerous influences. Cubicle divider type, straw amount, and the interaction between these variables were important for lying down behaviours. Again, these two variables influenced standing up behaviours, in addition to the neck rail distance.

Discussion

Summing of animal parameters such as resting behaviours may enhance the relationships with housing features because individual animals may react to the same causes with different behaviours. For example, 10% of cows may react to a cubicle that is too short with horse-like

Table 3 **Multivariate analysis (GLM) of cubicle features as influences on resting behaviours; significance level (only influences with at least a tendency toward statistical significance are shown).**

	Cubicle divider	Straw amount	Straw amount × cubicle divider	Cubicle length	Cubicle width	Neck rail distance
Tripping before lying down	0.000	0.046		0.009	0.036	
Lying down attempts	0.001		0.009			
Lying down preparation time			0.046			0.132
Lying down duration		0.046		0.124		
Lying stretched forelegs	0.085			0.075	0.086	–*
Lying stretched hindlegs	0.022		0.118	0.048	0.027	–*
Lying fully stretched	0.002					–*
Ruminating while lying	0.138				0.078	–*
Max. synchronous lying		0.125				–*
Standing up horse-like	0.000	0.027				0.110
Head lunging sideways			0.005		0.136	
Standing up attempts	0.028	0.059				0.106
Standing up duration		0.027				

* not included because no influence on lying behaviours

standing up, 10% with head lunging into the neighbouring cubicle, 10% with standing attempts, and a further 10% with a longer standing up duration. Altogether, 40% of cows will have some problems. The overall problem is therefore more grave than the results of single behaviours would suggest. Kohli and Kämmer (1985) and Kohli (1987) stated that their summed variables reflect the complexity of lying down which could be composed differently for individual animals, and that they describe the quality of the lying area as a whole.

The correlations between resting behaviours could be an indicator that the same causes are responsible for the behavioural deviations. For example, a cubicle that is too short will hinder all standing up behaviours. Bock (1990) and Platz *et al* (1999) found that the same cubicle features affected behavioural deviations and injuries in dairy cows.

Adding up of housing variables such as cubicle features may demonstrate additive effects. In the present study, small cubicles often had hard floors and restrictive side partitions. On the other hand, some compensation may occur if positive and negative effects are summed up. For example, a cubicle that is too short may hinder lunging of the head forward while standing up, but would be compensated for by a spacious cubicle divider so that the cow could lunge sideways with the head in the neighbouring cubicle. However, compensation will be possible only up to a certain degree, so minimum requirements are necessary. In addition, not all animals may use such compensation possibilities in the same way.

A multivariate analysis will confirm possible multiple cause-and-effect relationships. For instance, one resting behaviour can be influenced by several different cubicle features or one cubicle feature can affect more than one resting behaviour. The cubicle features which were found to be most important for the three resting behaviour groups are in good concordance with the normal resting behaviour of the cow (Schnitzer 1971). For example, cows prefer a soft floor to avoid pain in the carpal joints while lying down. Cubicle dividers which allow the cows to avoid contact and subsequent pain while lying down are important because in the last phase of the lying-down process the hindquarters fall sideways uncontrollably. The requirements for comfortable lying are a soft floor and enough space with respect to non-hindering dividers so that cows can stretch their legs sideways. The cubicle divider type influences the possibility of lunging with the head sideways while standing up. A large amount of straw will offer a non-slippery floor for standing up. The neck rail distance should not hinder the rising movements.

Animal welfare implications

Using more than one parameter is reasonable in assessing animal welfare at farm level. Integration of the results into an overall assessment is easier to communicate. If the results of only single behaviours are listed, the problem as a whole may be underestimated because individual animals may react differently to the same causes. Correlating of behaviours could be evidence for identical causes (eg housing features). If housing features are to be included in the assessment, integration would be useful because some compensation between housing features is often possible. It is important to take into account many influencing housing factors because some animal-related parameters may be influenced by many factors, or one factor may have effects on several animal-related parameters. A multivariate analysis can highlight such multiple cause-and-effect relationships. Similar attempts to integrate different parameters into an overall assessment of animal welfare might be useful for other studies.

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