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Comparison of time budgets of growing Hereford bulls in an uninsulated barn and in extensive forest paddocks

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Abstract

The housing of growing cattle in forest paddocks has recently become more common in Finland. Besides economic reasons, the practice could be justified by increased behavioural freedom of the animals. Since the behaviour of growing bulls in extensive housing has scarcely been studied, we conducted a study to investigate the behaviour of Hereford bulls in an uninsulated barn and in forest paddocks during summer. Bulls born in spring were housed from November onwards in either partly bedded pens in an uninsulated barn (two groups of five bulls, 6.4 m^2/bull) or in forest paddocks (two groups of five bulls, 1000 m^2/bull). All animals were fed a total mixed ration *ad libitum*. The following summer, the behaviour of the bulls (age 15–18 months) was observed for 24 h (00:00–00:00) in July and for 15 h (06:00–21:00) in August and September. Instantaneous sampling with a 5-min sampling interval was used. The paddock bulls performed more self-grooming and walking, and less drinking and other behaviours (e.g. idling in standing position) than the pen bulls during all or most of the observations. There were no differences between the groups in time spent on eating at the feeding trough, object manipulating, ruminating, social licking, butting or resting during any or most of the observations. Furthermore, the paddock bulls spent also some time on grazing and browsing. Stereotyped tongue-rolling or bar-biting was not found in either housing environment. The results of the present study show that the bulls readily utilise the opportunities for more diverse behaviour (e.g. foraging, locomotion) in the paddocks. In the pens, drinking behaviour was disturbed, probably due to the lower space allowance and the rather slow refilling rate of the water bowl. Otherwise also the relatively spacious, partly bedded pens in the uninsulated barn seemed to be satisfactory in regard to the bulls' welfare, because clear behavioural signs of distress, such as stereotypies or severe aggression, were not observed in the pen bulls.

Keywords: Bulls; Forest paddock; Uninsulated barn; Behaviour; Time budget; Welfare

1. Introduction

European agricultural policy reforms have resulted in great changes in the beef sector. In a high cost country such Finland, these reforms have important

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implications for the economics of the beef sector and for farmers' incentives to rear cattle (Pihamaa and Pietola, 2002). Because profitability in beef production requires large production units, many beef producers have been investing in larger production units in recent years (Jalonoja et al., 2004). Production costs can be reduced also by using simple housing solutions and, therefore, extensive housing of growing cattle has become more common in sparsely populated parts of Finland. In this practice animals are raised year-round in spacious enclosures that are built up in forested areas (Uusi-Kämppä et al., 2007).

Besides economic reasons, the housing of growing cattle in forest paddocks could also be justified by the increased behavioural freedom for the animals compared to conventional housing in tie-stalls or group pens. However, the behaviour of growing bulls in extensive conditions has been scarcely studied. Studies with cows and heifers have shown that at pasture the animals e.g. behave in a more synchronised fashion (O'Connell et al., 1989; Miller and Wood-Gush, 1991; Krohn et al., 1992), have fewer agonistic interactions (O'Connell et al., 1989) and exhibit less stereotyped tongue-rolling (Redbo, 1990) than animals housed in close confinement in cubicle houses or tie-stalls.

We hypothesise that a complex and spacious environment such as a forest paddock could have positive effects on the welfare of growing bulls, e.g. by allowing the bulls better opportunities for normal species-specific behaviour. In the present study, we aimed to compare the behaviour of Hereford bulls in an uninsulated barn and in forest paddocks during summer months. The possible welfare effects of these two housing systems are also discussed.

2. Materials and methods

2.1. Animals, environments and feeding

This study comprised 20 Hereford bulls. They were born in spring 1999 at the Tohmajärvi Suckler Cow Barn (62°20′N, 30°15′E) of MTT Agrifood Research Finland. The bulls were kept on their first summer at pasture with their dams. In autumn 1999, the bulls were weaned and transferred to the North Ostrobothnia Research Station (Ruukki, 64°44′N, 25°15′E) of MTT Agrifood Research Finland where the present experiment was conducted.

In November 1999, the bulls (age 6.8±0.5 (mean±SD) months) were divided into four groups of five animals according to their live weight and placed in two different housing environments. Two groups of five bulls (pen bulls) were placed in an uninsulated barn in two adjacent pens (4×8 m). The uninsulated barn was covered with a roof and it had solid wooden walls on all sides except the front that was left open. In the pens, the space allowance was 6.4 m^2 per bull, which was 2.4 m^2 per bull more than the minimum recommended space allowance for the cattle over 500 kg live weight (LW) in this type of housing in Finland (Ministry of Agriculture and Forestry, 1997). The rear half of the pen area was a straw bedded lying area and the fore half with a solid concrete floor was used as a feeding area. A feeding trough was situated in the front of the pen, and there was 0.8 m feeding space per bull at the feeding trough. There was one water bowl between the two pens providing water for all ten bulls.

Two groups of five bulls (paddock bulls) were placed in two adjacent forest paddocks (50×100 m) that were constructed in young forest. The vegetation of the paddock area consisted mostly of young conifers mixed with some birch (Uusi-Kämppä et al., 2007). At ground level there were twigs and grass. The two adjacent paddocks were separated with a wooden fence. The other three sides of the paddocks were enclosed with an electric fence. In the paddocks, the space allowance was 1000 m^2 per bull.

A simple, roofed, three-walled shed (8×4 m) was available for the bulls between the two paddocks. The floor of the shed was deep straw bedded. In front of the shed was a feeding area (8×4 m) with a solid concrete floor. The shed as well as the feeding area were split in two with wooden walls so that each group of paddock bulls had access to a 4×4 m shed area and a 4×4 m feeding area. A feeding trough with 1.0 m feeding space per bull was situated in front of the feeding area opposite to the shed. There was one water bowl in the feeding area providing water for all ten bulls.

All bulls were fed with a total mixed ration (TMR) *ad libitum*. The dry matter (DM) of the TMR was composed of grass silage and rolled barley, 500 g/kg DM of each. The TMR was supplemented with appropriate minerals and vitamins.

2.2. Behavioural observations

The behaviour of the bulls was observed three times during the summer in 2000. Observations were carried out during the daylight hours, i.e. in July for 24 h (00:00–00:00) and in August and September for 15 h (06:00–21:00). At the outset of the behavioural observations in July, the bulls were 15.4± 0.5 months old and weighed 665±52 kg. During all observations, the weather was dry most of the time. During observations (06:00–21:00 h) the average rainy hours were 0.7, 1.9 and 0.0, the maximum temperatures +23.7, +21.9 and +15.1 °C, the minimum temperatures +6.4, +5.6 and +4.6 °C and the mean temperatures +18.5, +15.1 and +10.9 °C in July, August and September, respectively.

The bulls were observed directly using instantaneous sampling with a 5-min sampling interval (Martin and Bateson, 1993). The posture and activity of each bull were registered according to a classification that is presented in Table 1. Each bull's location (bedded lying area, concrete floored feeding area, forest) in the pen or the paddock area was also registered.

Both groups of the pen bulls were observed simultaneously whereas the two groups of the paddock bulls were observed

Table 1
Description of postures and activities recorded during observations

Behaviour	Description
Posture	
(1) Lying	Lying in any position with trunk in contact with ground.
(2) Standing or moving	Standing with all hooves in contact with ground. Walking or running.
(3) Sitting	Sitting on hindquarters with forelimbs extended.
Activity	
(4) Eating feed	Eating and masticating feed mixture at the feeding trough.
(5) Grazing and browsing	Taking bites and masticating grass, branches, twigs, etc. in the forest.
(6) Manipulating objects	Licking, gnawing and masticating bark or structures of pen, shed or fence.
(7) Drinking	Drinking water from the bowl or a puddle. Waiting for the bowl to refill.
(8) Ruminating	Chewing cud in any position.
(9) Self-grooming	Licking own body or rubbing it against any equipment or trees.
(10) Walking	Walking without any other activity except observing or sniffing environment.
(11) Social licking	Licking another bull. Being licked by another bull.
(12) Butting	Butting or pushing another bull with forehead in playful or aggressive way. Being butted by another bull.
(13) Resting	Lying without any apparent activity in any position with trunk in contact with ground. Sleeping.
(14) Tongue-rolling	Twisting and twirling the tongue, either inside or outside the open mouth for at least 5 s.
(15) Bar-biting	Taking any equipment in the mouth and chewing it for more than 10 s.
(16) Other behaviours	All behaviours that did not fit in any other category, e.g. idling in standing position.

separately because the larger area in the paddocks made it impossible to observe the two groups simultaneously. Observations were done mainly in sessions of 6 h on consecutive days beginning at 00:00, 06:00, 12:00 or 18:00 h. The pen bulls were observed from the top of a tank that was approximately two meters high and placed in front of the pens. The paddock bulls were observed from outside the enclosures with the aid of binoculars.

2.3. Statistics

The statistical analyses of the behavioural data were performed with SPSS for Windows 14.0 (SPSS, Inc., Chicago IL, USA). The data was analysed using a linear mixed model procedure or the non-parametric Mann–Whitney test. In the linear mixed model analyses the group of five bulls was used as an experimental unit. However, in the Mann–Whitney test, the animal was used as the experimental unit.

The differences in behaviour between the pen and the paddock bulls were analysed for a 24-h day in July. The general structure of the linear mixed model (1) was:

$$Y_{ijk} = \mu + \beta_i + \theta_{j(i)} + \varepsilon_{ijk} \quad (1)$$

where $i=1, 2$ (housing environment), $j=1, 2$ (two groups per housing environment), $k=1, 2, 3, 4, 5$ (five animals per group), Y_{ijk} is the dependent variable of the ith housing environment, the jth group and the kth animal, μ is the general mean, β_i is the effect of the ith housing environment and $\theta_{j(i)}$ is the random effect of the jth group nested in the ith housing environment. Finally ε_{ijk} is the residual error.

If the model residuals were not normally distributed, a natural logarithm $(x+1)$ transformation was performed for the variable (x). If a normal distribution of the residuals was not achieved by this transformation, the variable was tested using the Mann–Whitney test.

In the analyses of the differences in behaviour between the pen and paddock bulls in July, August and September, observations obtained between 06:00 and 21:00 h were included.

The general structure of the linear mixed model (2) was:

$$Y_{ijkl} = \mu + \beta_i + \gamma_j + \beta\gamma_{ij} + \theta_{k(i)} + \varepsilon_{ijkl} \quad (2)$$

where $i=1, 2$ (housing environment), $j=1, 2, 3$ (month), $k=1, 2$ (two groups per housing environment), $l=1, 2, 3, 4, 5$ (five animals per group). Y_{ijkl} is the dependent variable of the ith housing environment, the jth month, the kth group and the lth animal. μ is the general mean, β_i is the effect of the ith housing environment, γ_j is the effect of the jth month and $\beta\gamma_{ij}$ is the interactive effect of the ith housing environment and the jth month. Furthermore $\theta_{k(i)}$ is the random effect of the kth group nested in the ith housing environment. Finally, ε_{ijkl} is the residual error.

The covariance matrix for repeated measurements was selected using Akaike's information criteria. Compound symmetry structure, first-order autoregressive structure, Toeplitz structure or heterogeneous Toeplitz structure were used in the analyses. Pairwise comparisons between the months were carried out using Bonferroni correction of the P-values. The residuals were plotted against the predicted value to check the constancy of the residual variance and, if needed, a Box–Cox transformation (Box and Cox, 1964) or a natural logarithm $(x+1)$ transformation was performed for the variable (x).

The occurrences of different activities of the bulls in the different areas of the pen or the paddock are illustrated for a 24-h day in July. In order to simplify this illustration, some of the original behavioural classes were pooled.

3. Results

3.1. 24-h day behaviour in July

There was no difference in the percentages of observations spent in different postures (lying, standing or moving, sitting) between the pen and the paddock bulls (Table 2). With regard to the activities, there were no differences between the pen and the paddock bulls in the percentages of observations spent in eating feed, ruminating, self-grooming, social licking, butting, resting and other behaviours (e.g. idling in standing position). Drinking was more often observed in the pens than in the paddocks, whereas manipulating objects and walking were more often observed in the paddocks than in the pens. Furthermore, the paddock bulls spent time also on grazing and browsing.

3.2. 15-h day behaviour in July, August and September

There were no differences in the percentages of observations spent in eating feed, manipulating objects, ruminating, social licking, butting and resting between the pen and paddock bulls during all or most (two of three) of the observations (Tables 3 and 4). Drinking and other behaviours were observed more often in the pens than in the paddocks. On the other hand, self-grooming and walking were observed more often in the paddocks than in the pens during all or most (two of three) of the observations. The paddock bulls also spent time on grazing and browsing. Stereotyped tongue-rolling or bar-biting was not found in either housing environment.

In the pens, the time of summer had no effect on the percentages of observations spent in eating feed, manipulating objects and ruminating (Tables 3 and 4). Drinking was observed least often in September and

Table 2
Percentage of observations (mean±SD) spent in different postures and activities for a 24-h day in July for pen and paddock bulls

Variable	Housing environment		Significance
	Pen	Paddock	P [a]
Posture			
Lying (1)	60.0±4.8	58.1±5.1	NS
Standing or moving (2)	39.5±4.3	41.9±5.1	NS
Sitting (3)	0.5±0.7	0.0±0.1	NS[Q]
Activity			
Eating feed (4)	9.4±1.4	8.9±1.1	NS
Grazing and browsing (5)	–	5.7±3.5	
Manipulating objects (6)	0.1±0.3	0.6±0.3	**[Q]
Drinking (7)	5.4±1.9	1.4±0.3	***[Q]
Ruminating (8)	31.4±3.2	35.7±4.1	NS
Self-grooming (9)	0.5±0.4	2.8±1.7	NS
Walking (10) [b]	0.1±0.2	1.8±1.3	***
Social licking (11)	0.6±0.4	0.6±0.5	NS
Butting (12)	0.5±0.3	0.9±0.7	NS
Resting (13)	34.0±6.4	25.7±3.0	NS
Tongue-rolling (14)	0.0	0.0	–
Bar-biting (15)	0.0	0.0	–
Other behaviours (16)	18.2±3.6	15.8±2.8	NS

All categories are mutually exclusive within the upper categories "posture" or "activity". Note that grazing and browsing was not possible in the pens. The figures in parentheses refer to the descriptions of behavioural categories in Table 1.
**P<0.01; ***P<0.001; NS: P>0.05.
[a] Linear mixed model, except [Q]Mann–Whitney test.
[b] P-values are based on comparisons of estimated marginal means of ln(x+1) transformed variable.

Table 3
Percentage of observations (mean±SD) spent on different behaviours in July, August and September between 06:00–21:00 h in bulls housed in pens and in paddocks

Variable		Housing environment		P1
		Pen	Paddock	
Eating feed (4)	July	14.8±2.4	12.8±1.4	NS
	August	14.3±2.9	14.2±2.0	NS
	September	16.2±2.0	13.1±2.6	*
	P2	NS	NS	P3 NS
Grazing and browsing (5)[1,2]	July	–	5.3±3.9	–
	August	–	3.5±1.6	–
	September	–	6.8±4.7	–
	P2	–	NS	P3 –
Manipulating objects (6)[3]	July	0.1±0.4	0.5±0.6 [a]	NS
	August	0.4±0.5	2.0±1.1 [b]	**
	September	0.7±0.8	1.1±1.1 [ab]	NS
	P2	NS	**	P3 *
Drinking (7)[3]	July	8.0±3.0[b]	1.9±0.6[b]	**
	August	6.2±2.6[b]	2.2±1.4[b]	**
	September	3.3±1.2[a]	1.0±1.0[a]	**
	P2	***	**	P3 NS
Ruminating (8)	July	24.3±3.7	31.8±4.9[b]	***
	August	26.9±3.2	28.2±5.1[ab]	NS
	September	25.9±2.1	26.9±4.8[a]	NS
	P2	NS	*	P3 *
Self-grooming (9)[3]	July	0.5±0.5[a]	2.8±1.0[ab]	**
	August	1.6±0.8[b]	2.9±2.2[a]	NS
	September	0.4±0.6[a]	4.6±2.5[b]	**
	P2	**	*	P3 ***

P1: significance between housing environments, P2: significance within housing environments between months, P3: significance of interactive effect of housing environment and month. Note that grazing and browsing was not possible in the pens. The figures in parentheses refer to the descriptions of behavioural categories in Table 1.
*P<0.05; **P<0.01; ***P<0.001; NS: P>0.05. Linear mixed model. [1]The effect of the housing environment was excluded from the model. [2]P-values are based on comparisons of estimated marginal means of Box–Cox transformed variable. [3]P-values are based on comparisons of estimated marginal means of ln(x+1) transformed variable. [a,b]Figures without a common letter within the behavioural category are statistically different (P<0.05) within the housing environment.

Table 4
Percentage of observations (mean±SD) spent on different behaviours in July, August and September between 06:00–21:00 h in bulls housed in pens and in paddocks

Variable		Housing environment		P1
		Pen	Paddock	
Walking (10)[1]	July	0.1±0.2[a]	2.0±1.6	***
	August	0.6±0.6[ab]	2.1±1.6	**
	September	0.7±0.5[b]	2.8±1.1	***
	P2	*	NS	P3 NS
Social licking (11)	July	0.7±0.6[a]	0.5±0.4	NS
	August	1.7±1.3[b]	0.7±0.8	NS
	September	0.4±0.6[a]	0.9±0.9	NS
	P2	**	NS	P3 **
Butting (12)	July	0.7±0.6[b]	0.5±0.3[a]	NS
	August	0.1±0.2[a]	0.4±0.6[a]	NS
	September	1.6±0.9[c]	1.2±0.6[b]	NS
	P2	***	*	P3 NS
Resting (13)	July	30.4±7.2[b]	27.0±3.0	NS
	August	19.1±4.8[a]	27.6±6.5	**
	September	23.4±4.0[a]	22.5±6.3	NS
	P2	***	NS	P3 **
Tongue-rolling (14)	July	0.0	0.0	–
	August	0.0	0.0	–
	September	0.0	0.0	–
	P2	–	–	P3 –
Bar-biting (15)	July	0.0	0.0	–
	August	0.0	0.0	–
	September	0.0	0.0	–
	P2	–	–	P3 –
Other behaviours (16)	July	20.5±5.6[a]	14.9±4.2	*
	August	29.2±4.7[b]	16.2±5.0	***
	September	27.4±4.5[b]	19.2±4.2	***
	P2	***	NS	P3 **

P1: significance between housing environments, P2: significance within housing environments between months, P3: significance of interactive effect of housing environment and month. The figures in parentheses refer to the descriptions of behavioural categories in Table 1.
*$P<0.05$; **$P<0.01$; ***$P<0.001$; NS: $P>0.05$. Linear mixed model. [1]P-values are based on comparisons of estimated marginal means of $\ln(x+1)$ transformed variable. [a,b,c]Figures without a common letter within the behavioural category are statistically different ($P<0.05$) within the housing environment.

self-grooming most often in August. Furthermore, walking was observed least often in July and most often in September, social licking most often in August, butting least often in August and most often in September, resting most often in July and other behaviours least often in July.

In the paddocks, the time of summer had no effect on the percentages of observations spent in eating feed, grazing and browsing, walking, social licking, resting and performing other behaviours (Tables 3 and 4). Manipulating objects was observed least often in July and most often in August, drinking least often in September and ruminating most often in July and least often in September. Self-grooming was observed least often in August and most often in September and butting most often in September.

There were interactive effects of the housing environment and the time of summer in the percentages of observations spent in manipulating objects, ruminating, self-grooming, social licking, resting and performing other behaviours.

3.3. Use of different areas of the pens and paddocks during the 24-h day in July

The pen bulls spent 74.9±4.0% of their time in the bedded lying area and 25.1±4.0% in the concrete floored feeding area (Fig. 1). Correspondingly, the paddock bulls spent 27.9±5.3% of their time in the bedded lying area inside the shelter, 14.8±4.4% in the concrete floored feeding area and 57.3±4.8% in the forest area.

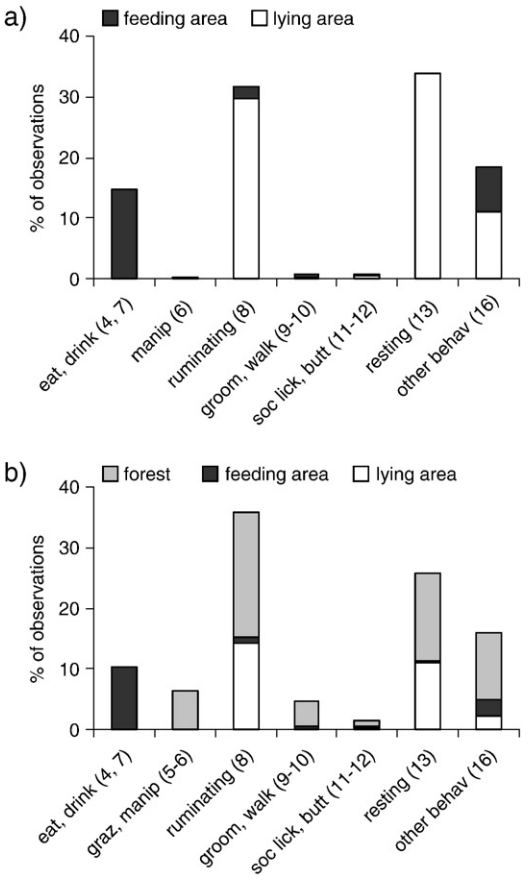

Fig. 1. Occurrence of different activities in the pen (a) and paddock (b) bulls in the feeding area, straw bedded lying area and forest for a 24-h day in July. The figures in parentheses refer to the descriptions of behavioural categories in Table 1.

The pen bulls performed all their resting and most of their ruminating, social licking and butting and other behaviours in the bedded lying area (Fig. 1). Eating feed and drinking, manipulating objects and most of grooming and walking were performed in the feeding area of the pens. In the paddocks, the bulls performed eating and drinking exclusively in the feeding area. The paddock bulls performed most of grazing, browsing and manipulating objects, ruminating, grooming and walking, social licking and butting, resting and other behaviours in the forest. Furthermore, a lot of ruminating and resting was observed in the bedded lying area.

4. Discussion

In our study we compared the behaviour of the bulls in extensive forest paddocks and in the uninsulated barn with the spacious pens. In the pens, the space allowance per bull was 37.5% higher than the current minimum recommended space allowance for the cattle over 500 kg LW in this type of housing in Finland (Ministry of Agriculture and Forestry, 1997). This relatively high space allowance was chosen because the bulls in our study were very heavy in accordance with the general trend in Finland. The average carcass weight of bulls has increased from 270 kg to 333 kg (prognosis) in eight years (1999–2007) in Finland (Information Centre of the Ministry of Agriculture and Forestry, 2007) resulting final LW of the bulls approximately 650 kg. However, the current Finnish legislation (Ministry of Agriculture and Forestry, 1997) does not recognize so heavy animals and in the space allowance recommendations the final weight class is "bulls more than 500 kg LW". Obviously, a bull with 650 kg LW needs more space than a bull with 500 kg LW, and there is a need to update the current national legislation. Furthermore, very crowded conditions were wished to avoid in our study due to their well known harmful effects on the welfare of growing cattle (e.g. Ruis-Heutinck et al., 2000).

4.1. Behaviour in pens vs. forest paddocks

The proportion of lying in the bulls' time budgets was very similar to those recorded for bulls in feedlots (Gonyou and Stricklin, 1984) or in individual stalls (Houpt and Wollney, 1989). In the present study, sitting had a very low incidence in both environments. Lidfors (1992) found that sitting is associated with abnormal getting up via a sitting position among pen-reared bulls. In the present study, the relatively low space allowance in the bedded lying area (3.2 m^2/bull) probably led occasionally to abnormal getting up movements (see e.g. Ruis-Heutinck et al., 2000) and sitting behaviour in both pen and pasture bulls. Furthermore, the heavy body weights of the bulls may have contributed to the sitting behaviour, because sitting has also been observed in cattle at pasture and especially in heavier types of animals, e.g. in beef cattle (Ewbank, 1964).

There were no large differences in the time the pen and paddock bulls spent eating feed. The TMR diet was planned to meet the nutritional needs of the bulls and the feed was offered *ad libitum*. The paddock bulls grazed and browsed in addition to consuming the TMR. It is likely that eating merely the TMR did not fully satisfy the bulls' motivation to forage and, therefore, the paddock bulls readily utilised the opportunity for species-specific grazing behaviour. Grazing and browsing had only a minimal effect on the nutrient supply of the paddock bulls, because the bulls were able to ingest only some bushes, leaves and twigs. However, by grazing the paddock bulls could fulfil their foraging-related behavioural needs and this may have had positive effects on their welfare. On the other hand, stereotyped tongue-rolling or bar-biting were not observed in either the pen or the paddock bulls. Stereotyped behaviour in cattle is often associated with long-lasting frustrating situations such as restricted roughage feeding (Redbo and Nordblad, 1997) or tethering (Redbo, 1992). Accordingly, the present results suggest that in our study the pen and pasture bulls were not subjected to strong long-lasting frustration.

In the paddocks, oral manipulative activity (manipulating objects) was directed mostly to the bark of growing or fallen trees in the forest area. In the pens, this activity was limited to the hard timber that was used in the pen structures. Biting and gnawing at wooden fittings and swallowing wooden matter have been considered abnormal behaviour in fattening bulls, and is possibly caused by lack of roughage (see Wiepkema et al., 1983). In the paddocks, oral manipulative activity had only little or no stereotyped features, and the bulls were observed actually to masticate and ingest bark which made this behaviour presumably rewarding for the bulls. Therefore, it seems that gnawing at bark is mostly normal exploratory or foraging behaviour in bulls housed in forest paddocks.

In the present study, the water bowls were simple prototypes of a heated model with a rather slow refilling rate, and the bowls enabled only one animal in the pen groups and in the paddock groups to drink at a time. Even though the pen and the paddock bulls had identical water bowls, the pen bulls spent more time on drinking than the paddock bulls. Although not

measured, it seemed that the two pen bull groups (i.e. two groups of five animals) acted together more synchronously than the two paddock bull groups. The two pen bull groups were observed often to come to drink simultaneously, which occasionally caused crowding at the water bowl. More synchronised drinking behaviour together with the rather slow refilling rate of the water bowl probably increased the drinking (including drinking and waiting for the bowl to refill) time of the pen bulls compared to the paddock bulls. It is also possible that to some extent the drinking bowl acted as enrichment for the pen bulls, allowing the bulls play at and splash water with their tongues. However, the increased drinking time obviously indicates that the capacity of the water bowl was insufficient for the number of animals in the pens. Nonetheless, it seemed that the pen bulls were still able to satisfy their water need since there were no differences in feed intake and growth rates (Huuskonen et al., 2002) between the pen and the paddock bulls.

Social behaviour (social licking and butting) was very similar in the pens and in the paddocks. Decreasing the space allowance has been reported to increase agonistic interactions in female cattle and steers (Kondo et al., 1989). Accordingly, in cows agonistic interactions are more common inside cubicle houses than at pasture (O'Connell et al., 1989; Miller and Wood-Gush, 1991). In the present study, the lower space allowance in the pens did not result in more butting behaviour than in the more spacious conditions in the paddocks. The butting behaviour seemed also to be fairly harmless in both groups and often resembled mock fighting that is a common play behaviour seen in cattle (see Reinhardt and Reinhardt, 1982). In addition, young bulls are socially more active than the older ones (Kilgour and Campin, 1973) and male calves are socially more active than female calves (Reinhardt et al., 1978). Therefore, in the present study the young bulls' keenness for social contact may also explain the similar proportions of butting found in the pen and pasture bulls. It should also be noted that due to the relatively high space allowance in the pens the pen bulls may have encountered agonistic behaviour less than could have been observed in more crowded conditions.

The higher proportion of walking in the paddock bulls compared to the barn bulls was probably a natural consequence of the larger living area in the forest paddocks. Walking during grazing and browsing was not taken into account in our study, and therefore the paddock bulls were actually moving even more than the current results indicate. Daily exercise promotes health in tethered cows (Gustafson, 1993), and it is reasonable to assume that exercise has positive effects also on the health of bulls. In addition, the non-slippery, solid ground could promote leg health of bulls kept in paddocks, since in previous studies severe lameness was found to be associated largely with slatted floors (e.g. Murphy et al., 1987).

The time the bulls spent on resting was fairly consistent between the groups. During daytime (06:00–21:00 h), the pen bulls spent more time performing other behaviours (e.g. idling in standing position) than the paddock bulls. In the paddocks, the high space allowance and diverse environment gave the bulls good opportunities for more diverse activities, e.g. self-grooming, walking and grazing and browsing. In contrast, the low space allowance and less stimulating environment in the pens were probably at least partially responsible for the considerable proportion of time the pen bulls spent on performing other behaviours, i.e. idling in standing position.

4.2. Use of different areas of the pens and paddocks

The pen bulls were observed to lie exclusively in the bedded lying area as has previously been found in a similar housing system (Lidfors 1992). This result is consistent with preference studies which have shown that cattle have a strong preference for lying on deep bedding over slatted floors or slatted floors covered with rubber mats (Irps, 1987; Lowe et al., 2001).

Since the paddock bulls spent most of their time in the forest area, it seems that the forest offered the bulls comfortable ground for standing and lying as well as stimulation for many activities, e.g. foraging, grooming and exploration. The paddock bulls spent a considerable amount of time lying and ruminating also in the bedded lying area. This may have been convenient for the animals, because in this way the bulls were near the feeding trough. In the present study, the weather was mostly dry during the observations and therefore its effect on shelter seeking behaviour was not further considered. It has been found that at pasture, high air temperatures during daylight hours as well as rain increase the time the bulls spend under the shelter (Vandenheede et al., 1995).

In the forest area, the activities of the bulls, mainly grazing, browsing, gnawing at bark and walking, caused considerable damage to the vegetation and soil. It was noted that the bulls spent some time in all parts of the enclosure, but the areas nearest to the shelter and the feeding place were most worn and damaged. In the present study, it seems that the animal density in the paddocks was too high considering environmental

protection issues. On farms, outdoor enclosures are usually much more extensive than in the present study, leading to less severe damage to soil and vegetation.

5. Conclusion

The present study showed some differences in the time budgets of the growing bulls housed in the pens in the uninsulated barn and those in the forest paddocks. The results indicate that the bulls readily utilise the opportunities for more diverse behaviour (e.g. foraging, locomotion) in the paddocks. In the pens, drinking behaviour was disturbed, probably due to the lower space allowance and the rather slow refilling rate of the bowl. Otherwise also the relatively spacious pens in the uninsulated barn seemed to be satisfactory in regard to the bulls' welfare, since clear behavioural signs of distress, such as stereotypies or severe aggression, were not observed.

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