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THE BEHAVIOUR AND WELFARE OF COWS IN RELATION TO CUBICLE HOUSE DESIGN

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ABSTRACT

The importance of housing design to behaviour, production, incidence of lameness and other aspects of welfare is emphasised. Characteristics of cubicle houses which can affect social and other behaviour in dairy cows include: the number and type of feeding stations; the width of the feeding passage; the width of other passageways; the number, size and design of cubicles; the ease of access to water; the uses of the building by other stock and by man; the dung disposal system; and flooring characteristics.

In a study of 46 Friesian cows housed in a 50 cubicle commercial system there were two parallel lines of cubicles and three passageways through the central cubicles allowing access to the feed passage where all cows could feed simultaneously. Activity records over 24 hours were made and the passageways to the feed passage were blocked experimentally. Feeding and resting were synchronised and individuals visited the feed passage only 5.2 times in 24 hours. Restriction of access to the feed passage caused minor local increases in congestion and rate of aggressive interactions but not throughout the system as a whole.

Many individuals demonstrated marked preferences for feeding in particular sections of the feed barrier and for occupying or walking in particular cubicle or passageway areas. Although there were no differences between groups of different social rank in either total resting or feeding time, high ranking cows showed more marked feeding section preferences whilst those of low rank spent a greater proportion of their resting time in the central cubicles. Low ranking cows also spent more time standing in cubicles and standing in passages with their head in a cubicle. These data suggest that animals of low ranks use cubicles to avoid competitive social interactions as well as for resting. Welfare problems due to social factors, are likely to be important if there are insufficient feeding or lying places for all animals, or a less stable herd. Synchrony of activity would result in competition if numbers of feeding or lying places were inadequate, and the size and number of passageways might then be of importance to welfare.

INTRODUCTION

The requirements of housed dairy cows are sometimes expressed solely in terms of the amount of space required per cow, for example Arave et al (1974) concluded that a minimum of $2.3m^2$ per cow was necessary. It is not desirable to make recommendations about space requirements, however, without taking into account details of house

design, the composition of the group of cows and management practices. Both welfare and production will depend upon individual and social responses to the conditions, so this paper deals with how these are affected by cubicle house design. The effects of house design, however, will interact with other factors, for example the age structure of the group and the frequency of movements of animals into the group. Social mixing has considerable effects on social behaviour and milk production (Arave et al 1973, Jeziersky and Podluzny 1984) so an effect of house design which might be slight in a stable group could well be considerable in a group which is subject to frequent social mixing.

The concept of individual distance (Hediger 1955) or personal space as applied to dairy cows has been discussed by Wierenga (1983). This idea of the minimum distance within which approach elicits attack or avoidance has been found to be relevant to many different animals (Broom 1981). It is clear from studies of cattle, however, that there is no general personal space which is the same at all times and for all individuals. The closeness of approach which is tolerated, is different according to the activities of the animals and is altered by the presence of barriers such as cubicle or food trough bars. The mean inter-individual distance varies according to the confidence of the animal in the social situation, hence Syme et al (1975) found that the distance was lower for high ranking Jersey cows than for lower ranking animals. This and other measures of social behaviour will be affected by factors such as the early experience of the animals, their familiarity with the housing system and the presence or absence of horns.

Besides the effects on milk production, social behaviour can also influence the incidence of lameness. Many injuries to the feet are the result of falls, slips and abrasion on concrete or slatted floors. Mechanical damage such as this will frequently result from competitive social interactions in which animals are engaged in pushing contests or when one animal moves rapidly to avoid an aggressor. Changes in housing design can have a considerable effect on the rate of such interactions, for example Metz (1983) found a dramatic increase in the frequency of chasing when the number of feeding places for a group of heifers was reduced from 1 to 0.35 per animal. Mental, as well as

physical trauma can influence lameness, for example stress will increase the susceptibility of cattle to metabolic disorders of the foot (Peterse, this volume). It must be considered therefore, that the cost of treatment of these disorders, as well as production losses, could more than compensate for any minor economic saving which might result from crowded or otherwise inadequate housing conditions. If the real costs of these losses were known, it might be possible to argue in favour of good housing conditions in economic terms. The necessity for changes in management practices would then be clear to farmers and welfare would be improved without the need to resort to arguments based on physiological, behavioural and moral grounds.

The characteristics of cubicle houses which can affect behaviour and welfare are summarised below.

1. The number of feeding places at the feed barrier. Grazing behaviour is synchronised in the field (Benham 1982) and feeding is often synchronised in cubicle houses (Zeeb, this volume, and this paper). A consequence of this is that restriction of the number of feeding places can lead to a reduction in the daily feeding time by low ranking cows and a substantial increase in fighting and chasing behaviour (Metz and Mekking 1978, Metz 1983). The provision of more feeding places than there are cows has relatively little effect on behaviour (Wierenga et al 1985). The use of a single automatic feeder for many cows can cause access problems, especially for low ranking animals, and cows may avoid cubicles near the feeder (Wierenga, pers. comm.).
2. The type of feeding place at the feed barrier. The range of design of feed barriers has been reviewed by Čermák (1980) and by Zappavigna (1983). Poor design such as a high, sharp feeding rack base may lead to cows straining to avoid contact and risking falling by doing so (Blom et al 1984). The importance of adequate bars to separate cows in reducing competitive interactions is emphasised by the work of Bouissou (1970, 1981).
3. The width of the feeding passage. Access to places at the feed barrier can be difficult, especially for subordinate cows, if the space behind a row of cows already feeding is narrow.

4. The width of other passageways. Konggaard (1983) compared the behaviour of cows in passageways of width 2.0m and 1.2m. He found that the narrower passageway resulted in more frequent contact, yielding by entering cubicles, turning in the passageway, and waiting in line to enter the passageway.
5. The number of cubicles. If there are fewer cubicles than there are cows, there is a reduction in the time which cows spend in the cubicles and an increase in aggressive interactions (Kaiser and Lippitz 1974, Friend et al 1977). A detailed study by Wierenga (1983) makes it clear that the greatest effect is on low ranking animals which, when unable to lie in a cubicle often lie down in walking areas. The importance of lying to cows is also demonstrated by the fact that, after a period during which cows were deprived of lying and food they lay down for some hours before feeding (Metz and Wierenga pers. comm.).
6. The position, size and design of cubicles. The use of cubicles is affected by their position in the cubicle house, for example if the main standing area is behind the row of cubicles then low ranking cows may be unable to get out of their cubicle because another cow is standing at or near the cubicle entrance (Metz and Mekking 1984). Cubicle size, floor slope and the positioning of the various rails or walls will affect usage and the likelihood of injury (Čermák, this volume). The frequency of contusions resulting from hitting cubicle side rails when lying or standing declines with experience in such cubicles (Blom et al 1984) so new animals in a cubicle house have to adapt to physical as well as social situations.
7. The ease of access to water. Although drinking behaviour in relation to the distribution of water is much studied in field situations the effects of the positioning of water sources requires more study in cubicle houses.
8. The uses of the building by other stock and by man. Various sorts of disturbance have been found to increase the incidence of competitive interactions in groups of cattle (Bouissou 1976). The organisation of groups of cows in a building may also affect behaviour, for example in a situation where a row of cubicles or

a feed rack is head on to neighbouring cows. Human activity can have considerable effects on cows, and stockmanship is a very important factor in dairy cow management.

9. The dung disposal system. Dung accumulation makes most floors more slippery. In bad conditions animals might reduce considerably the amount of locomotion and some areas of the house may be used less if they are slippery. Dung scraping activities can force animals close together and may be disturbing to the cows.

10. The characteristics of the floor. The effects of different types of flooring and cattle preferences for flooring have been reviewed by Irps (1983 and this volume) and others. Locomotion is affected by floor characteristics (Zeeb, this volume) and locomotor difficulties are likely to have considerable effects on other behaviour and on adrenal physiology. Even if injuries do not occur, welfare may be adversely affected by flooring which the animal regards as hazardous.

It is clear from the studies on the effects of cubicle house characteristics on cattle that the various factors interact with one another. The effects of two inadequacies of design or management may be much greater than would be predicted from studies of the effects of either inadequacy alone. Another general finding is that many of these factors have much more effect on some animals in the group than on others. In certain situations the welfare of animals of a low social rank may be very much worse than that of others in the group and situations where such poor welfare exists could sometimes be avoided by changes in design or management.

The aim of the study reported in this paper was to investigate the responses of dairy cows to aspects of cubicle house design and to examine the effects of restricting access from the cubicle to the feeding area.

METHODS

The study concentrated on a 50 cubicle commercial system which housed a section of a Friesian dairy herd. Cubicles were arranged in two parallel lines, one of which extended along the side of the house and faced head to head with a separate section of the herd. The other

cubicles, which faced the feed passage, were separated from the first line by a passage 2.15 m wide, and were divided into two sections by a central passageway connecting the cubicle passage with the feed passage. Two further connecting passageways located at either end of the house each contained a water trough. The central passageway was 2.38 m wide, and those at either end 2.95 m. The feed passage was 3.18 m wide and contained a feed barrier which extended the length of the house (32.3 m). Access to food was through 0.34 m gaps between vertical bars, 84 of which allowed cows to feed, usually with at least one vacant gap between adjacent animals. The layout of the system is shown in Fig. 1.

The study group consisted of 46 cows from the low milk yielding section of the herd, and were all either dry or nearing the end of lactation. Most were approaching calving, the remainder being infertile and awaiting market. The age range of the group was from 2+ years to 12+ years (mean 5.75 years). Although the group was together for five weeks before the start of observations, cows were continually being removed when due to calve, and replaced by others nearing the end of lactation. The group composition was therefore changing at a rate of 2.5 animals per week. Since the complete herd had grazed together throughout the preceding summer, all entrants to the group were familiar with existing group members. Although a changing group composition was not ideal from an experimental viewpoint, there were compensating benefits in that it represented a situation more typical of a working farm than many other studies of cattle behaviour.

All animals passed through the milking parlour twice daily at 07.00 and 15.30. Although there was always some food left in the trough, it was always replenished with silage after both milkings. All cows also received a fixed ration of concentrate in the milking parlour as well as hay from racks positioned above the feed barrier which were filled each evening. All cows were individually marked with numbered plastic collars.

Behaviour records were made live and using video. At a tape speed of one frame s^{-1}, 24 hour records of activity in selected parts of the system were made. To obtain records of variation in activity over 24 h, 15 minute point samples of the numbers of cows feeding, lying in cubicles, and standing and walking in passageways were taken

from the video tapes. Other video records were used to count the number of cows moving through the passageways which connected the feed passage with the cubicle passage.

All other behaviour was observed in the post a.m. milking period, commencing when cows were first allowed access to the fresh feed and continuing for $3\frac{1}{2}$ h. At 15 minute intervals throughout this time an observer on a tower noted the floor positions and behaviour of all cows not in cubicles. At 30 minute intervals, cubicle use was measured by recording the identity and behaviour of each cow in a cubicle. For the remainder of the time (30 min. h^{-1}) detailed records of all observable social interactions were made.

Behaviour records as described, were made for three different conditions of access between cubicles and feed passage. In the control condition, cows had all three connecting passageways open. In experiment 1, the passageways at either end of the house were blocked, thus restricting access to the feed passage to a single central passageway. In experiment 2, the single passageway remaining open was one at the far end of the house. These manipulations of the system were designed to (i) increase the traffic flow through connecting passageways and other walking areas, and (ii) to increase the distance which cows had to walk when moving between cubicles and feed passage. Cows were permitted three days to adjust to an experimental manipulation before recordings were made for a further seven days.

RESULTS AND DISCUSSION

24 hour activity

The most prominent feature of all the 24 h video records was the high degree of synchrony in moving, feeding and in occupying cubicles. Cows in this particular system therefore show patterns of activity comparable to those shown by cows at pasture. There are two essential features of this system that permit this. The first is the design of the feed barrier and feed passage, which allows all cows to feed simultaneously. The width of the passage (3.18 m) was also just adequate to allow two cows to pass each other while others were feeding, so there were no major problems in finding a vacant feed space. The second feature important to synchrony of activity is that there were sufficient cubicles for all cows to rest together. This

was demonstrated by the 24 h records of cubicle use which showed a high proportion of cubicles to be occupied in the midnight to early morning period. In the experimental periods, when access to the feed passage was restricted to a single passageway, records of all cows moving through the passage showed that the mean number of visits to the feed area per day was between 4.8 and 5.5 per cow. This demonstrates that when resting and feeding places can accommodate the herd, the total amount of cattle movement can be very low. This is thought to be the most important feature of this system from a welfare aspect, since it affects all other features of the system. For example, synchrony of activity results in a tendency towards a one way flow of cows through passageways, hence fewer head to head confrontations. Competitive interactions must also be much lower when a resource (feeding or lying places) is not limited.

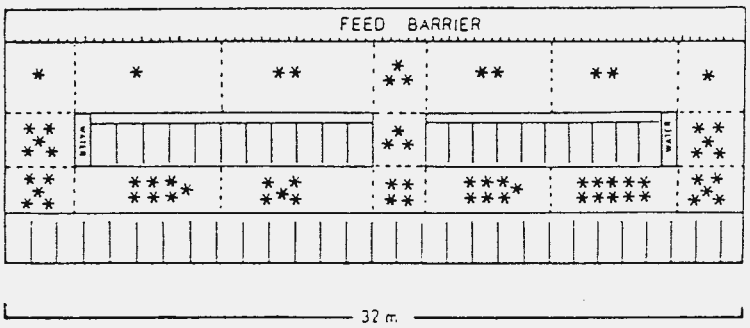

Fig. 1. Relative frequency of use (m^{-2}) of different floor areas. Broken lines show limits of the 17 floor areas used in recording behaviour.

Connecting passageways

The data on rate of movement through the three connecting passageways show that the central one was used more frequently when cows had a choice from the three. Apart from times when the herd was first allowed access to feed, when all the cows might pass through in less than 5 minutes, the peak rates of traffic flow were comparatively low (37 cows h^{-1}). The increase in the use of a passageway when it was the only one open (maximum rate 45 cows h^{-1}) was lower than

expected. This might indicate a slight inhibition in moving freely around the house, or it might be accounted for by cows using the passageways to escape from other aggressive animals more frequently when all passageways were open. A comparison of passageways' use also shows that there was seldom any significant congestion in these passageways, and this was not increased when two passageways were shut. The values for relative use of floor space for walking and standing (Fig. 1) further support the conclusion that congestion is not a problem in these areas. The data on the rates of competitive interactions in different parts of the system (Fig. 2) show that, when all gates are open, rates are not higher in these passageways than in the remainder of the house. With only one passageway open, this rate was increased only when the open passageway was the central one (Fig. 3) although the overall rate of competitive interactions throughout the system remained constant. (Table 1).

TABLE 1 Rate (no. $min.^{-1}$) of all competitive social interactions in the cubicle house.

	Displacements from food	All other aggressive interactions
All gates open	0.23 (N = 190)	0.52 (N = 404)
Centre gate only open	0.19 (N = 100)	0.55 (N = 285)
End gate only open	0.19 (N = 98)	0.55 (N = 290)

Use of other floor areas

The dimensions of various parts of cubicle systems have been shown to dramatically influence the freedom of movement of cows (Konggaard 1983). This study demonstrated that in this system there are no areas subject to particularly high or low use. There was, however, a strong tendency for animals not feeding or occupying a cubicle to stand in the cubicle passage rather than the feed passage (Fig.1). The width of this passage (2.15 m) was also considered adequate for this system and the amount of use it was subject to. The data on rates of competitive interactions throughout the system showed

that a forced increase in use of the feed and cubicle passages did not raise rates of aggression in these areas. The exceptions to this were the floor sections adjacent to the central passageway during the period when this was the only one open (Fig.3). This might be due to

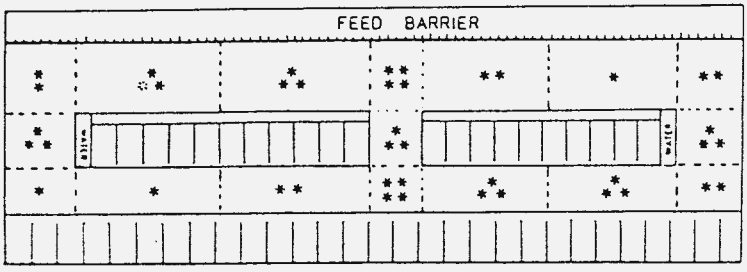

Fig.2. Comparison of rates of competitive social interactions in different areas of the cubicle house.
All three connecting passageways open.

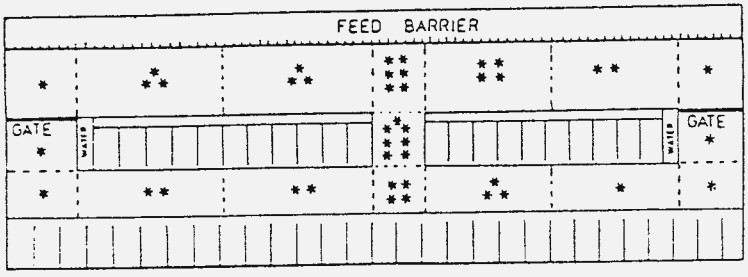

Fig.3. Comparison of rates of competitive social interactions in different areas of the cubicle house.
Central connecting passageway only open

the fact that a central passageway will be approached by animals coming from four directions compared with two directions for one sited at one end of the house. This suggests that if access is restricted to a single passageway, it might be better positioned at one end, rather than in the middle of the house. Although the widths of the feed and cubicle passages have been described as adequate, it is important to note that this only applies to this particular system.

The reason for this is that two potentially competitive animals approaching each other in these passages always had the opportunity to avoid confrontation by moving into a vacant feed space or cubicle.

The comparison of use of floor areas by individual cows showed a trend towards higher ranks using all areas of the house more freely than lower ranks. This was not a dramatic difference, and there was no evidence that low ranks were constrained to limited parts of the house. This was supported by the data on total time that low ranks spent away from cubicles but not feeding; there was a slight but non significant reduction compared to higher ranks.

Feeding

The data on individual feeding times showed that low ranking cows spent a slight but not significantly lower proportion of time feeding in the post a.m. feed period. This may not necessarily reflect a lower feed intake and there was no evidence to suggest that they were feeding later than higher ranking cows. If there are rank related problems in feeding in this system it would appear that they are slight.

The actual position at the feed barrier where individuals chose to feed showed that many high ranking animals demonstrated a strong preference for a particular section. These preferred sections were often at the far ends of the house (Fig. 4). This might suggest a mutual repulsion of the most dominant animals. It would be possible to test for this by combining spatial and temporal data on individual movements; this has yet to be done. It is also possible, however, that all cows might have a preferred feeding area, but higher ranks are better able to maintain their position. Whatever the cause of this effect, it suggests that a long feed barrier can better accommodate this behavioural trait.

A final, but important point on the feeding data was the observation by the herdsman, Mr T. Brown, that there was an overall reduced feed intake for the herd during the 9 days on which the only passageway open was at one end of the house. This might be the result of some inhibition in cows moving to the feed barrier, although this was not reflected in the records of competitive interactions. It might also be the result of the greater effort in moving the increased

distance from cubicles to food. It would be worthwhile repeating this manipulation a number of times, with measures of feed intake, to examine this further.

Social interactions

These have already been considered in relation to floor areas, there are however, some important general points. The overall rate during the post a.m. feed period was considered to be very low, the

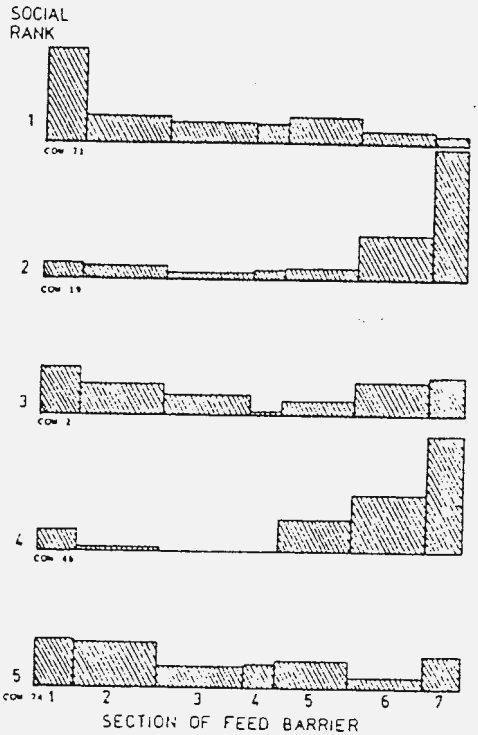

Fig. 4. Relative use of different sections of the feed barrier for the 5 cows of highest social rank.

mean rate of involvements per cow per hour being 2.1 h^{-1}, and only 11.6% of these being classed as particularly aggressive (i.e. a potential cause of injury from slipping etc.). Although figures from other systems frequently produce values much higher than this, they are difficult to compare for reasons stated in the introduction. This rate was for the peak activity period over a 24 h cycle, therefore it too would represent the peak rate of interactions. It should be

remembered that the herd was a low yield group, all of which had grazed together before being put into the system. The herd also had a reputation for being 'quiet', probably the result of good management. It would be interesting to study another herd in an identical system, particularly since a few aggressive individuals can trigger off chains of aggressive acts. A less placid or more disruptive herd might show considerably higher levels of aggression in a similar system.

TABLE 2 Number of aggressive social interactions h^{-1} during the 3½ h post a.m. feed period (N = 2,109)

	Time from a.m. feed (h)					
	½ - 1	1 - 1½	1½ - 2	2 - 2½	2½ - 3	3 - 3½
Aggressive encounters - walking areas	35	39	33	29	32	25
Displacements from feed	17	13	11	11	11	12
Displacements from cubicles	4	4	5	4	3	2

Of particular interest was the comparatively constant rate of competitive interactions over the 3½ h post a.m. feed period (Table 2). Cubicle displacements were as high or higher when more than 80% were unoccupied than when most were filled. Displacements from the feed barrier were also quite constant, in spite of a drop in animals feeding over the period. It is possible that herds have a base rate of competitive interactions, perhaps due to being confined into close contact, and these will be manifested whatever the housing system. The housing design, however, should not add to these.

One important feature of the data was that low ranking cows, although by definition losing a greater proportion of the competitive interactions in which they were involved, were not the subject of bullying by the rest of the herd, and were not considered to be suffering under this system.

Cubicle occupation

There was a clear preference for the central cubicle blocks (Fig. 5). This was interesting in that it was the low rank cows that were occupying them significantly more than other ranks (Fig. 7). Other

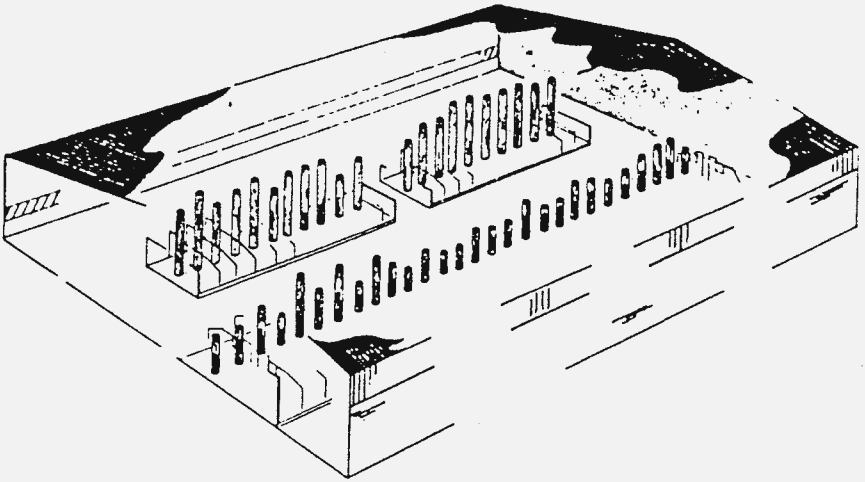

Fig. 5. Relative incidence of occupancy of cubicles during the 3½ h post a.m. feed period.
All 3 passageways open.

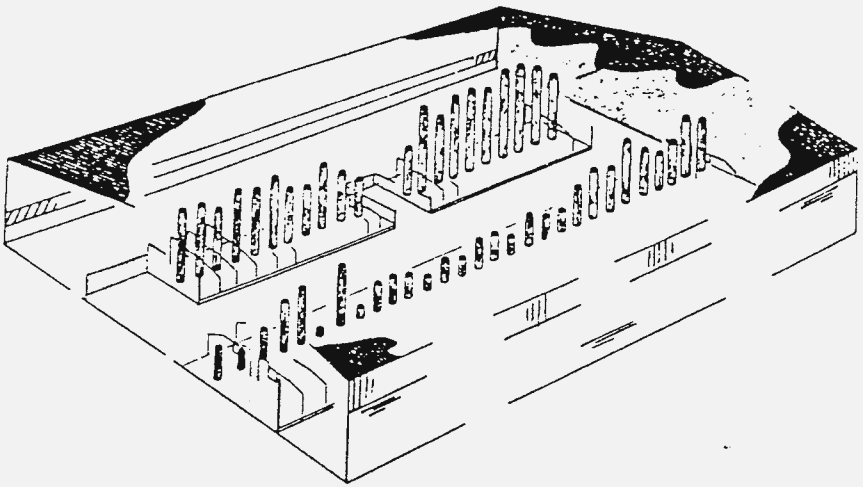

Fig. 6. Relative incidence of occupancy of cubicles during the 3½ h post a.m. feed period.
End passageway only open.

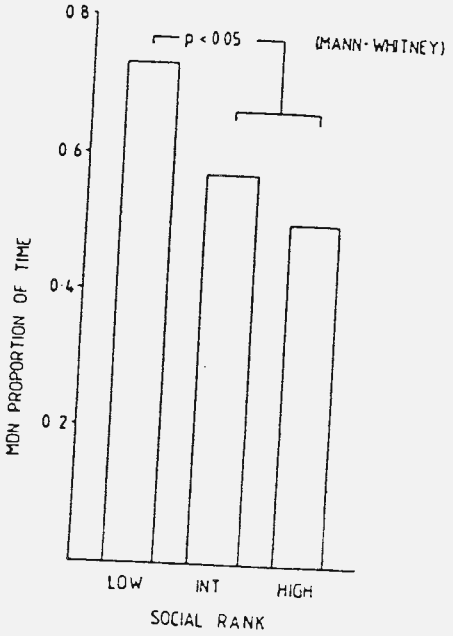

Fig.7. Proportion of cubicle time spent in the central cubicles for cows of different social rank in the 3½ h post a.m. feed period.

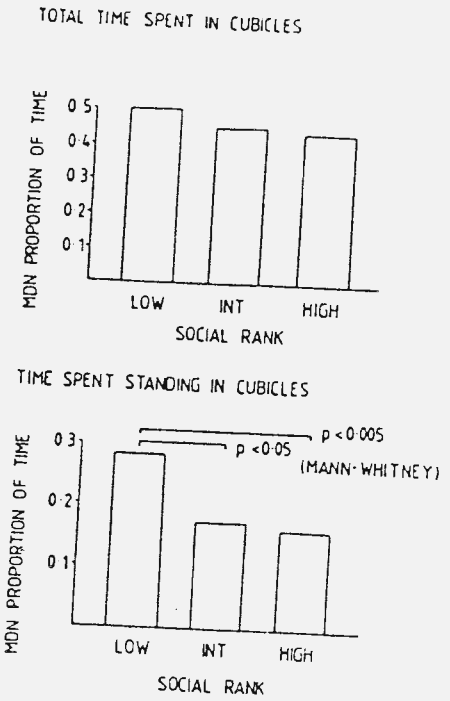

Fig. 8. Cubicle use by cows of different social rank in the 3½ h post a.m. feed period.

ystems have shown that the perimeters are the favoured areas Stricklin et al 1979). It was considered that the side cubicles ight be avoided due to their head to head contact with an adjacent it separate group of animals. The data did not support this however. ie low ranks also spent a greater proportion of their cubicle time anding (Fig. 8), and this, coupled with the results that show they

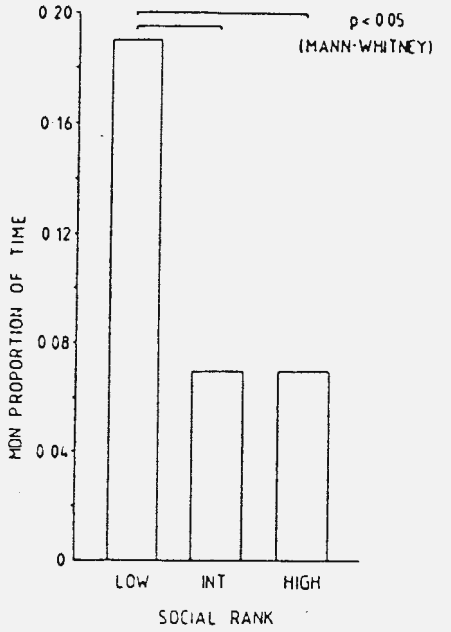

Fig. 9. Comparison of time spent standing in the cubicle passage with the head in a cubicle by cows of different social rank in the $3\frac{1}{2}$ h post a.m. feed period.

feed and idle slightly less, leads to the conclusion that the central cubicles are being used as safe standing areas. This points to a dual function for cubicles, (i) as a lying place, (ii) as a zone where the effective personal distance is increased by the bars of a cubicle. This is reinforced by the finding that low ranks spent almost three times as much time standing in the cubicle passage with head and front legs in a cubicle than other ranks (Fig. 9). If space in a housing system were limited therefore, it might be beneficial to increase the number of cubicles at the expense of floor space to provide these safety zones for low ranks.

Individuals showed little signs of preference for particular cubicle areas, although the data has not been examined for a preference for a few specific cubicles.

The manipulations of passageway access did not change overall time spent in cubicles although the distribution of favoured cubicles was influenced (Fig. 6).

CONCLUSIONS

This study has demonstrated that by careful and considerate design, many problems associated with the responses of cows to loose housing systems may be minimised or removed. In the cubicle house investigated, differences between social rank groups, although detectable, can be accommodated and therefore do not appear to be significant in terms of welfare. Most important in the design, is the provision of sufficient feed space and cubicles to allow synchrony in feeding and resting. Many studies have demonstrated that this is the most persistent and least readily disrupted behavioural characteristic shown by a herd of cows; low ranking cows generally suffering whenever synchrony of activity is prevented. By removing the need to compete for either of these resources, the aggressive social interactions must largely relate to competition for personal space, or in maintaining a social order within the herd. The results show that the physical barriers within the house are used more frequently by low ranking cows to increase their effective personal distance from potential aggressors. This demonstrates the importance of these barriers to the cows and the inadequacies of expressing housing requirements in space needed per cow. Many studies of the behaviour of cattle in cubicle houses concentrate on differences between high and low ranking animals. It is possible, however, that there might be competition between individuals close in social rank. The data on the use of the feed barrier suggests that high ranking cows might be actively avoiding each other by feeding at opposite ends of the house. If this were the case, restricted feed space might lead to social problems for both high and low ranking cows.

Since changes in the layout of cubicle houses have been shown to have such a profound effect on behaviour, the importance to both production and welfare of considering all the details of housing design cannot be over-emphasised.

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