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Effect of feeding space allowance for cows on meal length in free-stall barn

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Abstract

The objective of this experiment is to examine the effect of the feeding space allowance for cows on meal length at a commercial farm using a 3 stall-row type free-stall barn. The observation of eating behavior was conducted at three commercial dairy farms in that the feeding space allowance was differed as follow (Farm A: 0.34 meter per cow, B: 0.56 m/cow and C: 0.89 m/cow). There was no difference in the daily eating time between Farm A and B. The average meal length was shortened by the reduction of the feeding space. The frequency distribution of the individual eating time was shifted to a shorter period of time by the reduction of the feeding space allowance from the amount at Farm C to the amount at the Farm B. The percentage of quite short meals increased by the reduction of the space from Farm B to A level. The probability of meal continuation under 20 minutes at Farm B was about same as that at Farm C, and that over 20 minutes at Farm B was similar to that at Farm A. It was recommended that the feeding space should be more than 0.34 m per each rearing milking cow. This is necessary for normal eating behavior. The number of cows kept in a barn was less than 120% of the number of stalls in a three-row type housing.

Key words: space allowance for feeding, meal length, three-row type housing

For a compact design of free-stall housing, a reduction in the feeding space per cow is one of the choices being considered. Space saving of animal housing has the benefit of reducing building costs, but also the risk of reducing production because of both short and long-term reasons. On the recommendation, 0.7 m of minimum feeding space is required per each eating cow[1]. If all the cows that are reared in a housing eat simultaneously, the recommended space per each rearing cow is needed for a sufficient eating time for the less dominant cows.

The feeding space prepared is affected by diurnal patterns of eating behavior in several milking and feeding systems. It is considered that if cows have a 24-hour access to food, and some of them vary their eating times[4,6], less space per rearing cow would be required. Thus, decreasing the size of the feeding space is allowed by spreading the eating behavior throughout a day. However, cows tend to eat together shortly after morning and afternoon milking and when fresh food is offered[2], so space for all of the cattle would need to be available. Morita *et al.*[7] pointed out that in an automatic milking and feeding situation, *i.e.* in a no stimulus situation of milking and feeding, the number of cows eating simultaneously was low. They calculated that one feeding space was enough for five cows in this situation.

On rough calculation, as the width of each stall is 1.2 m, the feeding space per cow is 0.6 m in a 2 stall-row stall type housing and 0.40 m in a 3 stall-row type housing when stalls are the same number as rearing cows. In practice, the feeding space per rearing cow is related to the number of stall-rows chosen during the planning of the free-

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stall housing design at commercial farms. Friend *et al.*[3] pointed out daily eating time and the amount of intake were affected in space under 0.1 m per rearing cow in a 2 stall-row type housing. There were some reports dealing with the effects of feeding space allowance on the eating behavior of cows in 2 stall-row type housing, but few reports were made on 3 stall-row type housing.

Besides the fact that spreading the eating behavior throughout a day allows for a decrease in size of the feeding space, it is important to know how many cows could be housed in a free-stall housing in order to increase the efficiency of the housing. Increasing the population density of rearing cows affects the eating behavior by decreasing the space allowance. Sugita *et al.*[9] concluded that the effect of the population density of cows in a free-stall barn was directly shown in the length of the lying periods of the cows than the daily lying time. In heifers, Longenbach *et al.*[5] showed that the meal length was shortened with decreasing the feeding space allowance. However, there was no experiment conducted concerning the effect of the feeding space allowance in milking cows on the meal length. The objective of this experiment is to examine the effect of the space allowance for feeding on meal length at a commercial farm using a 3 stall-row type free-stall barn.

Materials and Methods

The observation of eating behavior was conducted in three commercial dairy farms that had free-stall barns. The housing conditions and feeding space information are shown in Table 1. Three rows of stalls were placed in each farm's housing. There were 66 stalls in Farm A, 75 in Farm B and 60 in Farm C. The total feeding space was 27.1 m, 32.4 m and 28.4 m, respectively. The feeding barrier was the post-rail type in all the housings. Seventy-nine cows were kept in the housing of Farm A, 58 cows in Farm B and only 32 in Farm C. All cows were milked twice daily. The feeding space per rearing cow was 0.34 m in Farm A, 0.56 m in Farm B and 0.89 m in Farm C.

The milking was conducted twice daily, once between 5:25 - 7:35 and once between 16:20 - 18:05 at Farm A, once between 5:05 - 6:10 and once between 17:15 - 18:15 at Farm B, and once between 8:40 - 9:50 and once between 20:35 - 21:45 in Farm C. At Farm A, the size of the holding area was small for keeping all cows at one time, so cows were divided into two groups every milking time. Cows were given total mixed rations twice a day (5:55 and 18:10) at Farm A, three times a day (5:35, 11:35 and 17:30) at Farm B and once a day (10:50) at Farm C.

Twenty-four hours observation of the eating behavior was started at the morning milking. The identification of each eating cow and its location were recorded in every 10 minutes. Based on the results in Morita *et al.*[7], the minimum length of pre-meal intervals (meal criterion) was set at 20 minutes in this study. Then, non-access to the feeding space in one observation between two accesses was considered for the duration within a meal. The daily eating time was the total time of meals. From these data, daily accessing time to the feeding spaces was determined individually.

For comparison of the average, the Wilcoxon-Mann-Whitney two-sample test[8] was used. The Kolmogorov-Smirnov two-sample test[8] was used for the comparison between the distributions of

Table 1. Housing condition of three commercial farms

Farm		A	B	C
Number of stalls		66	75	60
Number of rows of stalls		3	3	3
Number of cows		79	58	32
Ratio of cows to stalls		1.20	0.77	0.53
Feeding space width	m	27.1	32.4	28.4
Feeding space per cow	m/cow	0.34	0.56	0.89

Table 2. Daily eating time, number of meals and average meal length

Farm		A	B	C
Daily eating time	hours/day/cow	3.39[a]	3.24[a]	4.81[b]
Number of meals	meals/day/cow	8.30[a]	5.81[b]	6.59[b]
Average meal length	minutes/meal	24[a]	37[b]	44[c]

a,b,c: Means with different superscripts in same row differ significantly ($P<0.05$).

daily eating time and the meal length. The Kolmogorov-Smirnov one-sample test[8] was used for examining to fit with the distribution of meal length and its random distribution.

Results and Discussion

Table 2 shows the daily eating time, the number of meals and the average meal length. The daily eating time was longest at Farm C, and there was a significant ($P<0.05$) difference. There was no difference in the daily eating time between Farm A and B. Although Farms A and B had about the same daily eating time, the number of meals and the average meal length significantly ($P<0.05$) differed. The number of meals in Farm A was significantly ($P<0.05$) larger than that in the other farms. There was no difference in the number of meals between Farm B and C. The average meal length was significantly ($P<0.05$) shortened by decreasing the feeding space. Longenbach *et al.*[5] demonstrated that the average meal length was shortened by decreasing the feed bunk length for heifers. Our result for milking cows was similar to their result.

Sugita *et al.*[9] concluded that the effect of the population density of cows in free-stall barns was directly shown on the length of the lying periods of cows rather than the daily lying time. In the present study, the effect of the space allowance on eating occurred in the meal length rather than the daily eating time. This result is the same with the lying behavior reported by Sugita *et al.*[9]

Figure 1 shows the frequency distribution of the individual eating times at three farms. At Farms A and B, there were a high frequency of 200-250 and 150-200 minute eating times. At Farm C, there was a high frequency of 250-300 and 300-350 minute eating times. The frequency distribution of the individual eating time was significantly ($P<0.05$) different in Farm C than that of the other farms. The Frequency rate of the cows that ate for 150-250 minutes daily was about 55% at Farm A, 60% at Farm B, and less than 20% at Farm C. The frequency distribution of the individual eating time was shifted to a shorter period of time by the reduction of the feeding space (the change from the Farm C level to the Farm B level). However, the space change from the Farm B to Farm A level did not have an affect on the distribution of the individual eating times.

There are differences in the distribution changes of the individual eating times between

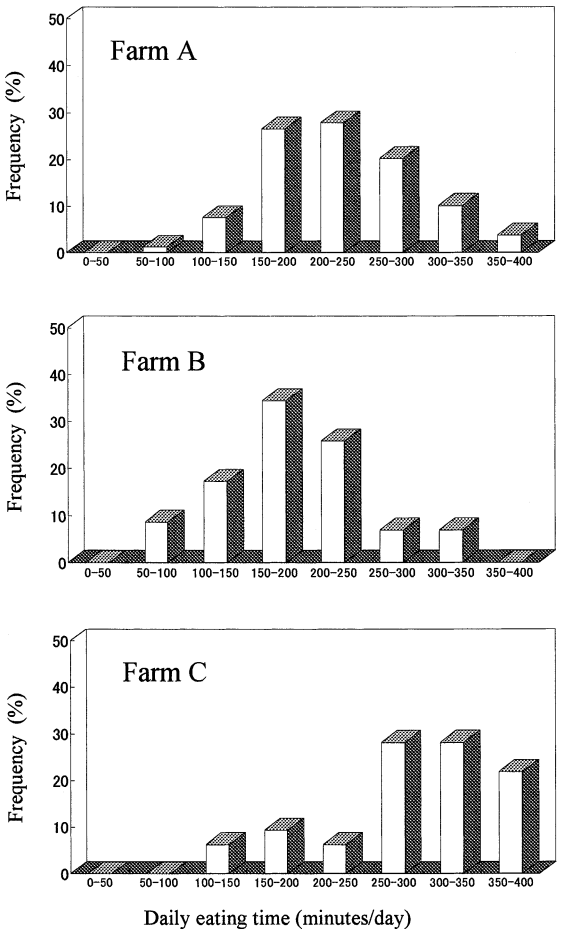

Fig. 1 Frequently distribution of individual daily eating time in three farms.

the space allowance levels. The number of cows in Farm C (cows filled about half of the stalls) was quite low and the feeding space was enough for simultaneously eating of all cows. Although the number of cows was smaller than the number of stalls and the feeding space was large in Farm B, the distribution of individual eating time was similar with the small-space farm (Farm A). Normally, in a two stall-row type housing, feeding space is sufficient for simultaneously eating of all cows. In a three stall-row type housing, like the present experiment, feeding space allowance is insufficient when cows eat simultaneously even though the number of cows is equal to the number of stalls. The less dominant cows changed the timing of their visits to feeding areas with the cows of higher dominance[4,6]. So, *ad libitum* feeding is needed in three stall-row type housing, even though the number of cows is equal to the number of stalls.

A frequency distribution of meal length at the three farms is shown in Figure 2. The frequency distribution of the meal length was significantly ($P<0.05$) different in Farm A than that of Farm B and C, and also that of Farm B was significantly ($P<0.05$) different than that of the other farms. At Farm A, 50% of the meals were stopped within 10 minutes, on the other hand, at Farm B and C, less than 20% of the meals were stopped within 10 minutes. The percentage of meals that were equal to and longer than 60 minutes was 3.2% at Farm A, 8.0% at Farm B, and 20.9% at Farm C. The percentage of quite short meals (less than 10 minutes) increased because of the reduction of feeding space from Farm B to A level, and the longer meals decreased because of the decreasing of the space from Farm C to B.

Figure 3 shows the log-survivor function of the

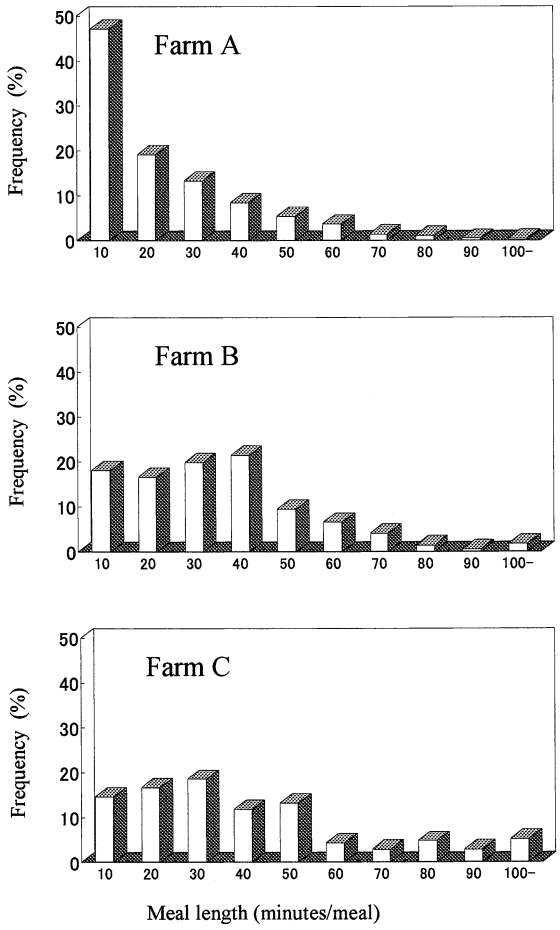

Fig. 2 Frequently distribution of meal length in three farms.

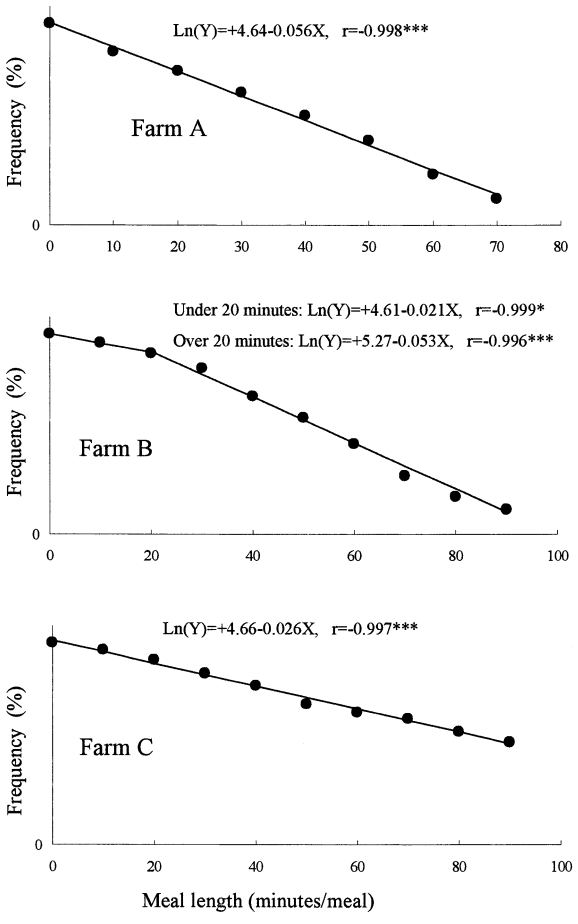

Fig. 3 Log survivor function of the distribution of meal length in three farms.

frequency distribution of meal length. The log-survivor curves of Farm A and C were fitted with a straight line, but that of Farm B was not fitted with a straight line, which meant there was random distribution. This demonstrated that the frequency distribution of meal length at Farm B was divided by its length, and the probability of meal continuation was different with shorter and longer meals. Twenty minutes was chosen for the criterion of two types of meals at Farm B. Under 20 minutes in Farm B, regression coefficient was similar with that in Farm C, and over 20 minutes, it was similar with that in Farm A.

From the data of the frequency distribution of meal lengths, the probabilities of meal continuation were calculated and shown in Table 3. The probability of meal continuation under 20 minutes at Farm B was about same as that of Farm C, and that over 20 minutes in Farm B was similar to that of Farm A. It became clear that there were behavioral changes in eating when the feeding space allowance was low. There was a decrease in the continuation of long meals (more than 20 minutes) at Farm B compared to cows at Farm C which had enough space for the cow to eat simultaneously, but there was a same continuation of short meals (under 20 minutes) at Farm B. All cows could not eat simultaneously in 0.56 m feeding space at Farm B. The cow in Farm B change eating behavior only in the meal pattern over 20 minutes. They keep meal pattern under 20 minutes. Then they have another way that changes the meal pattern less than 20 minutes. The cows in Farm A decreased the continuation of both (long and short) meals compared to the cows in Farm C because of small feeding space condition. There may be no other ways for maintaining their eating time in the situation of a small feeding space like at Farm A.

Friend *et al.*[3] recommended that upper limit of the ratio of cows to the number of stalls was 130%. In a three stall-row type housing, feeding allowance was quite short and the eating behavior was changed even though the ratio of cows to the number of stalls was 120%, like Farm A in the present experiment. When only daily eating time data was considered, as in Friend's report[3], it was concluded that there was no problem in a small-space system like in Farm A. However, from the aspect of meal length, the cows in a small-space system had to exert more effort to maintain their intake. This data showed that feeding space of 0.34 m per milking cow was too small to maintain normal eating behavior. So, it was recommended that the feeding space be more than 0.34 m per milking cow, which is necessary for normal eating behavior. It was also recommended that the ratio of cows kept to the number of stalls be less than 120% in a three-row type housing.

Table 3. The probability of meal cntinuing under and over 20 minutes of length

Farm	A	B	C
Meal length		%	
under 20 minutes	59.2	77.1	79.7
over 20 minutes	51.5	61.2	76.7

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要　　約

フリーストール牛舎での施設や飼養管理技術を検討する際には，そこで飼育されている牛の行動を知る必要がある。本研究では，フリーストール牛舎における飼槽幅が乳牛の採食行動に及ぼす影響を，採食期持続時間に着目し検討した。乳牛１頭当たりの飼槽幅の異なる３戸の酪農家（A牛舎 0.34，B牛舎 0.56，C牛舎 0.89 m/頭）を対象に 24 時間の採食行動調査を実施し，10 分間隔で採食している乳牛を個体識別して記録した。各牛舎での平均採食時間は，A牛舎で約 3.4 時間/日，B牛舎で約 3.2 時間/日，C牛舎で約 4.8 時間/日となった。平均採食期持続時間は，飼槽幅が短くなるに伴い短縮した。個体ごとの採食時間分布は，１頭あたりの飼槽幅の長いC牛舎で，他の２つの牛舎と異なったが，AとB牛舎との間に差は認められなかった。A牛舎での持続時間の短い採食期の割合は，B牛舎およびC牛舎に比べ高かった。B牛舎において持続時間が 20 分以下の採食期での採食を継続する確率はC牛舎とほぼ等しく，20 分を超える採食期の継続する確率はA牛舎での値とほぼ等しかった。これらのことから，１日当たりの採食時間だけでなく採食期の持続時間にも着目すれば，１頭当たりの飼槽幅は 0.34 m より広くすることが必要であり，飼槽列に対する牛床配列が３列である牛舎では飼養される乳牛頭数を牛床数に対し 120％未満にする必要のあることが示された。