

## The Effects of the Density of Cows in Free-stall Housing on Duration of the Lying Periods

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### Abstract

The objective of this study was to examine the lying behavior of cows in free-stall housing with different density levels. The observations were made in three commercial farms that had free-stall housing. Density was 0.53 in housing A, 0.77 in housing B and 1.20 in housing C. The cows were observed throughout a 24-hour period. The position of the cows (trough, stall and alley) and behavior patterns (eating, lying and standing) were observed every 10 minutes. Daily lying time was 789 minutes/day/cow in housing A, 613 minutes/day/cow in housing B and 545 minutes/day/cow in housing C. Daily lying time was shortened according to the increase in density. The number of lying period was 9 periods/day/cow in housing A and B, and 11 periods/day/cow in housing C. The average duration of the lying period was 86 minutes in housing A, 68 minutes in housing B and 49 minutes in housing C, and was significantly ( $P < 0.05$ ) shortened according to the increase in density. In housing A and B, the duration of the lying period after the milking was the longest, and it was shortened according to the time after the milking. In housing C, the duration of the lying periods was not influenced by the time after the milking. Although the difference in duration of the lying period was large after the milking between housings, after that it became small. Therefore, it is considered that in housing C, in which the density was the highest of the three housings, cows were forced more effort to maintain their daily lying time than those in other

housings. It was found that the duration of the lying period after the milking was especially shortened according to the increase in density. Further, it was found that the cow's activity after the milking was much influenced by density.

### Introduction

Housing system of the dairy cow has been changed from stanchion housing (individual management) to free-stall housing (group management) in Japan. In free-stall housing, cows are restricted inside the housing. However, they can go around in their housing freely (feeding area, lying area and walking area). The contact of cows with each other are made frequently in free-stall housing, so competition between cows appears. When the competition between cows increases, some cows may be prevented from lying and eating. In a competitive situation, aggression may also arise from the frustration of subordinated cows that are prevented from eating or compelled to leave the feeding site<sup>4)</sup>. Thus, cows may be restricted from some behaviors by their social hierarchy.

It is considered that density of cow affects to the eating behavior and lying behavior of cow and the competition between cows in high-density housing is higher than that in low-density housing. When the competition between cows increases, some cows may be not able to lie down. Thus, by increasing the standing time of cow, leg injuries may frequently appear. Krohn and Konggaard<sup>9)</sup> showed that blood cortisol levels became more than twice as high compared with normal levels

when the lying time of cows was reduced from 667 to 167 min per 24 h. They suggested that reducing lying time affect the physiology of cows. Metz<sup>5)</sup> showed that a lack of free opportunity for lying must be considered as a factor that seriously impairs an animal well-being in experiments on lying-deprivation. Therefore, to find out about the effects of density on the lying behavior of cows is a matter of great importance.

There has been some study on the effects of density on the behavior of cows until now <sup>2,6)</sup>. In these studies, the effects of density on the behavior of cows have been examined from daily lying time and daily eating time. However, it is expected that examination including the duration of the lying period shows some special features, which could not be shown by only the examination by daily lying time, on the effects of density on the lying behavior of cows. The objective of this study was to examine the duration of the lying period of cows in free-stall housing with different density levels.

### Materials and Methods

Observations were made in three commercial farms that had free-stall housing in Hokkaido. The information of three housings is shown in Table 1. The number of rearing cows was 32 cows in housing A, 58 cows in housing B and 78 cows in housing C. The number of stalls was 60, 75 and 66, and the density was 0.53, 0.77 and 1.20, respectively. Three rows of stalls were placed in each farm's housing. Observations were carried out from July 29 to August 2, 1996. The cows were observed throughout a 24-hour period. The position of the cows (trough, stall and alley) and behavioral patterns (standing, lying and eating) were observed every 10 minutes. From recorded data, daily lying time (total time of lying down in a stall during a 24-hour period per cow), and

Table 1 Information of the three housings

	housing	A	B	C
Number of cows	cows	32	58	78
Number of stalls	stalls	60	75	66
Density of cows	cows/stalls	0.53	0.77	1.20
Row of stall	row	3	3	3

number of lying periods (total number of times lying down in a stall during a 24-hour period per cow) were determined. The duration of the lying periods was compared for each housing. Diurnal patterns of the duration of the lying period and the average time until lying down after the milking (latency period) were also compared for each housing. In this case, the average duration of lying down on each hour during the day was shown as diurnal patterns of the duration of the lying period. In addition, when the milking of all cows was finished, its time was shown as the finished time of the milking.

### Results

Daily lying time and number of lying periods are shown in Figure 1. Daily lying time was 789 minutes in housing A, 613 minutes in housing B and 545 minutes in housing C. Daily lying time was shortened according to the increase in density. Number of lying periods was 9 periods/day/cow in housing A and B, and 11 periods/day/cow in housing C, in which the density was the highest of the three housings.

The average duration of lying periods is shown in Figure 2. The average duration of lying periods was 86 minutes in housing A, 68 minutes in housing B and 49 minutes in housing C, and was significantly ( $P < 0.05$ ) shortened according to the increase in density.

Diurnal patterns of the duration of the lying period in the three housings is shown in Figure 3. In housing A and B, the duration of the lying period, which was the longest during the day, was

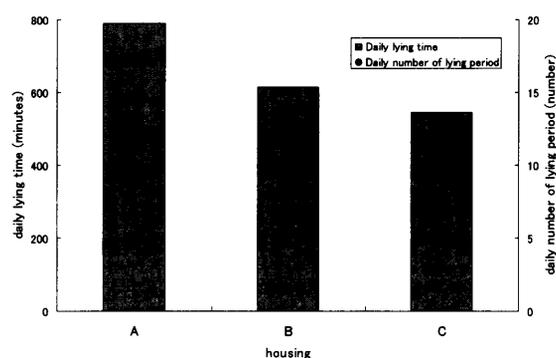
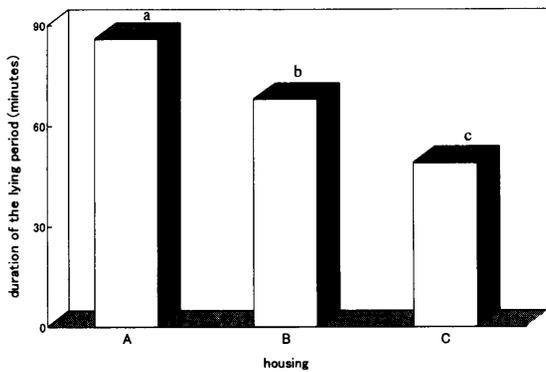
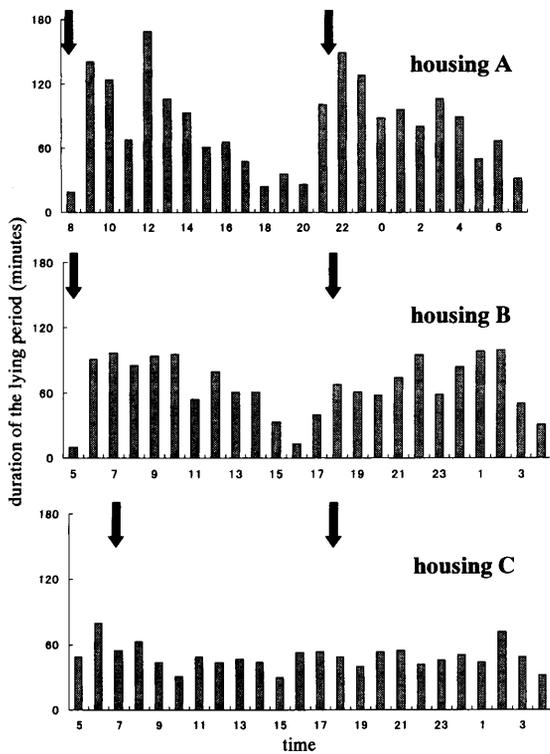


Figure 1 Daily lying time and number of lying period of the three housings.



**Figure 2** The average duration of lying periods of the three housings. a,b,c Differences between averages with a different letter are statistically significant ( $P < 0.05$ ).

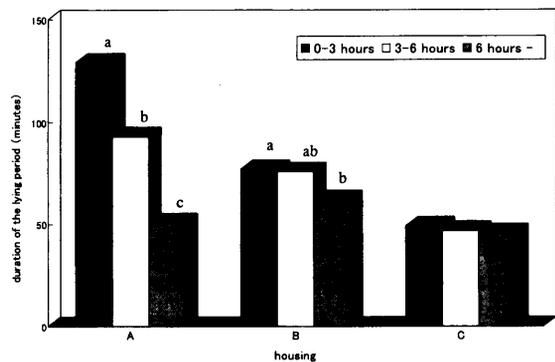


**Figure 3** Diurnal patterns of the duration of the lying period in the three housings. Two arrows (↓) show the finished time of the milking (morning and evening).

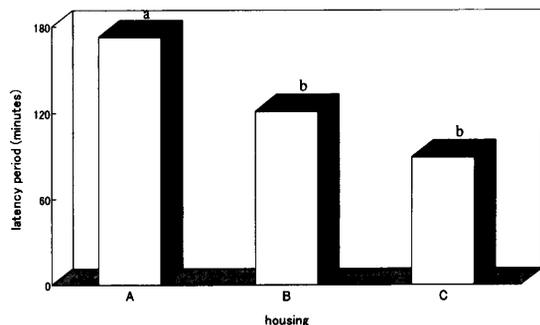
it after the milking. There was a tendency that it was shortened according to time after the milking. In housing C, there was no change for the duration of the lying period throughout the day.

The duration of the lying periods separated for every 3-hours from immediately after the milking of the three housings is shown in Figure 4. In housing A, the duration of the lying period of “0-3 hours” was the longest ( $P < 0.05$ ), and it was shortened according to the lapse of time after the milking. In housing C, the duration of the lying period was not influenced by time after the milking. Although the difference for the duration of the lying period was large for “0-3 hours” between housings, after that it became small.

The latency period is shown in Figure 5. The latency period was 173 minutes in housing A, 121 minutes in housing B and 89 minutes in housing C. The latency period was shortened according to the increase in density. The latency period in



**Figure 4** The duration of the lying periods separated for every three hours from immediately after the milking of three housings. a,b,c Differences between averages with a different letter are statistically significant ( $P < 0.05$ ).



**Figure 5** Average time until lying down after the milking in the three housings (latency period). a,b,c Differences between averages with a different letter are statistically significant ( $P < 0.05$ ).

housing A was significantly ( $P < 0.05$ ) longer than that in other housings.

### Discussion

The density of each housings are 0.53 in housing A, 0.77 in housing B and 1.20 in housing C. The reduction of daily lying time was shown that it didn't correspond to increase in density. However, a reduction of the duration of the lying period was well corresponding to an increase in density. It is considered that there was no need for increasing the number of lying periods for cows in housings where the number of cows is equal or less than the number of stalls (density  $\leq 1.0$ ) as in housing A and B. However, there is a need for increasing the number of lying periods for cows in housing where the number of cows is more than the number of stalls (density  $> 1.0$ ) as in housing C. It is described that a cow's need for lying depends on the circumstances<sup>6)</sup>. The cows in housing C may try to fulfil their required daily lying time by increasing the number of lying periods and be forced more effort to maintain their daily lying time. Social hierarchy affects the lying behavior of cows due to that some cows appear to evict stall occupants, subsequently occupying the space themselves in free-stall housing<sup>2)</sup>. The effect of social hierarchy might be large according to the increase in density. It is considered that social hierarchy was an important factor reducing the duration of lying periods according to the increase in density.

From results, a special feature appeared in the duration of the lying period after the milking. It was shown that large meals were consumed after milking and the allocation of fresh feed<sup>1)</sup>. Cows were forced to stand for a long time from waiting in the holding-area. It was concluded that several hours of forced standing impose a relatively high need for lying in cows<sup>5)</sup>. It is considered that the need for lying increased after the milking. However, some cows spent time for a meal before lying. Generally, cows in free-stall housing may be divided into an eating group (cows which started eating in trough immediately after the milking) and a lying group (cows which started lying in stalls immediately after the milking).

Cows change in place with a lapse of time after the milking in free-stall housing. The change in high-density housing may be more intense than that in low-density housing. Therefore, it is considered that the duration of the lying period after the milking was shortened by the change in place of cows in housing C. It was found that a cow's activity immediately after the milking is much influenced by a difference in density.

Effect of density of cows was shown on duration of the lying period after the milking. The special feature, which has not been able to be understood by only analysis by daily lying time, was shown in this study. However, the special feature shown in this study may be greatly changed by the difference in management styles of the dairy cow. For example, for management using an automatic milking system, there is not a common time of the milking for a herd so that a cow can freely enter the automatic milking system. Thus, to analyze of the lying behavior of dairy cow are required in various management style.

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### 要 約

収容率の異なるフリーストール牛舎における乳牛の横臥行動について検討した。観察は3軒の牧場のフリーストール牛舎において24時間連続して行った。収容率はA牛舎で0.53, B牛舎で0.77およびC牛舎で1.20であった。牛の滞在位置(飼槽, ストールおよび通路)および行動形(採食, 横臥および佇立)を10分間隔で記録した。1日の横臥時間はA牛舎で789分, B牛舎で613分およびC牛舎で545分となり, 収容率の上昇に伴い1日の横臥時間は短く

なった。1日の横臥回数はAおよびB牛舎で9回および3軒のうち収容率の最も高かったC牛舎で11回となった。横臥持続時間はA牛舎で86分, B牛舎で68分およびC牛舎で49分となり, 収容率の上昇に伴い有意に( $P < 0.05$ )短くなった。AおよびB牛舎では, 搾乳後数時間の横臥持続時間が最も長くなる傾向にあり, 搾乳後時間の経過に伴い短くなった。これに対し, C牛舎では搾乳後の経過時間によらずほぼ一定の横臥持続時間であった。搾乳直後の横臥持続時間は, 牛舎間で差が大きかったものの, その後小さくなった。以上のことから, 収容率の増加は, 特に搾乳後の横臥持続時間を短くすることがわかった。また, 搾乳直後の牛の活動が収容率による影響を大きく受けることがわかった。