Effects of a change in the daily time of access to hay on the rate of eating and feed intake of dairy cows

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Altering the length of daily feeding time induces metabolic and behavioural adaptations in animals. When the daily time of access to feed was limited the rate of eating increased to prevent a reduction in the feed intake of cows²⁾. Similar results have been reported in rats⁶⁾ and in chickens⁴⁾. LEPKOVSKY *et al.*³⁾ have reported that chickens trained to eat their daily food in two hours adapted at the crop, enabling it to hold more food. Furthermore, changes have been reported in intermediary metabolism such as thyroid activity and body fat following the restriction of the length of daily feeding time¹⁾.

In the practical feeding of farm animals it has been generally suggested that sudden changes of feeding system are undesirable; there are, however, many points about such changes which are not clear. In order to provide a better understanding of behavioural adjustments, the time of eating, the feed intake and the rate of eating were observed successively on dairy cows in which daily time of access to feed was changed abruptly from, for example, 24 hr to 4 hr and *vice versa*.

Experimental

Cows and feeds:

Sixteen non-lactating Holstein cows, 3-10 years old and 512-708 kg live weight, were fed on mixed hay, predominantly Timothy, as a sole feed. They were tied in a cowshed during the experimental period. Salt licks and water were accessible at all times. The mean chemical composition of the hay is given in Table 1.

Table 1. Chemical composition of hay fed to each group (%)

Group	Moisture	Crude protein	Crude fat	N.F.E.	Crude fibre	Crude ash
I	11.8	9.5	2.9	40.1	26.9	8.8
II	12.9	8.5	2.3	44.2	25.3	6.8
III	11.8	9.5	2.9	40.1	26.9	8.8
IV	12.6	6.3	2.2	45.3	27.4	6.2

Recording:

Hanging mangers, strain amplifiers and a recorder described in the previous report⁵⁾ were used for recording the eating behaviour. The speed of the charts was 150 mm per hr and records were made all the time cows had access to the feed.

Experimental plan:

The animals were divided into four groups, each of four cows, and the time cows had access

to feed daily was changed for Groups I, II, III and IV from 24-hr to one meal of 4-hr, *vice versa*, from 24-hr to two meals of 2-hr and *vice versa*, respectively. In 24-hr and a 4-hr feeding hay was offered at 08.00 h, while in 2×2-hr feeding offered in two meals at 06.00 h and 16.00 h. The amount of hay offered was adjusted so that the unsaten portion was about 10% of the amount offered.

Results

Differences due to daily feeding time:

Mean daily time spent eating, mean daily intake and mean rate of eating were calculated from the values for the last 5 days of each treatment and are given in Table 2.

Table 2. Daily time spent eating, daily hay intake and mean rate of eating in the four groups (Mean with S.E.)*

	Group	Daily feeding time		Group	Daily feeding time	
		24-hr	4-hr		24-hr	2×2-hr
Time spent eating (min/day)	I	386±18.7	226± 6.2	III	494±18.0	240±0.0
	II	419±32.1	204± 6.5	IV	440±20.1	238±1.0
Daily hay intake (kg)	I	11.1± 1.05	8.6± 0.85	III	13.4± 1.00	10.8± 0.75
	II	13.1± 0.80	9.4± 0.77	IV	13.5± 0.24	12.1± 0.28
Mean rate of eating (g/5 min)	I	149±11.6	191±19.1	III	141± 3.0	229±15.9
	II	161±18.8	238±24.3	IV	153± 3.5	253± 5.7

* Means are calculated from the values of the last 5 days of each treatment

Daily time spent eating with 24-hr access was significantly longer than in a 4-hr and 2×2-hr access ($P<.05$), slightly higher values were obtained in 2×2-hr access than in a 4-hr access, but the difference was not significant. The similar trend was found on the daily intake. In one meal of 4-hr the cows consumed 3 kg (1.8–4.5 kg) less than in 24-hr access; this difference was significant ($P<.05$). The cows of Groups III and IV, having 2×2-hr access, consumed 2 kg (0.7–3.7 kg) less than those with 24-hr access ($.10>P>.05$).

Mean rate of intake was significantly faster with 4-hr than with 24-hr access ($P<.05$); with 2×2-hr access the mean rate was faster than in 4-hr access, but the difference was not significant.

Changes in eating pattern:

With 4-hr and 2×2-hr access cows ate continuously until nearly the limit of the time of access to feed; with 24-hr access the cows ate during 4–17 periods each day, the mean time for individuals was 7.7 ± 0.4 (S.E.). The values on the first day, the second day and the subsequent days after changes in daily feeding time to 24-hr access were 4.5, 5.0 and 7.3–8.5 periods in Group II, and 5.5, 6.8 and 6.0–7.5 periods in Group IV.

Cows had fewer periods of eating on the first and the second day in Group II ($P<.05$) and on the first day in Group IV (non-significant) than on the subsequent days.

No consistent trend in the response of eating pattern to adaptation to 24-hr access was found, except in the first eating period. The first eating period began when hay was offered; intakes during this period in 24-hr access in Groups II and IV are shown in Fig. 1. On the

Feed intake of dairy cows

first day, and occasionally on the second day, after the change in treatment the length of the first eating period was significantly longer than those on the subsequent days. On three out of eight cows it decreased on the second day to the level of the subsequent days.

Fig. 1. Intake during the first eating period and the length of the period
(— Group II, --- Group IV)

changes in eating time:

Daily time spent eating in the four groups is given in Figs. 2 and 3. On the day when daily feeding time changed to a 4-hr access (Group I) daily time spent eating was less than on the second day or subsequently; mean daily time spent eating was about a half that observed on the subsequent days. In Group III no such difference was observed in three cows out of four, although one cow spent less time (180 min) eating on the first day than subsequently. The trend observed in Group I was not shown in Groups II and IV, changed from restricted to 24-hr access to feed.

The cows receiving two meals of 2-hr daily ate almost throughout the time they had access to feed, but those receiving one meal of 4-hr daily spent less time in eating than those receiving two meals.

Fig. 2. Mean time spent eating, mean hay intake and mean rate of eating in Groups I and III
(— Group I, --- Group III)

Fig. 3. Mean time spent eating, mean hay intake and mean rate of eating in Groups II and IV
(— Group II, --- Group IV)

Changes in daily intake and mean rate of eating:

Changes in the mean daily intakes and mean rate of eating in the four groups are also given in Figs. 2 and 3. Intake on the first day after changing daily feeding time was less in Groups I and III ($P < .005$ for Group I, $.20 > P > .10$ for Group III), and more in Groups II and IV than on the subsequent days ($P < .025$).

Quicker mean rates of eating were shown with restricted access than with 24-hr access. Mean rates with 24-hr and a 4-hr access (Groups I and II) were 155 and 215 g/5 min, while those with 24-hr and 2×2 -hr access (Groups III and IV) were 147 and 241 g/5 min, respectively. The cows ate faster with two 2-hr periods than in one 4-hr period. Mean rates of intake on the first day after changing daily feeding time in Groups I, II and III, and on the first and the second day in Group IV were slower in Groups I and III, and faster in Groups II and IV than on the subsequent days.

Although the difference between the mean rates of eating on the first day and on the subsequent days was less in Group III than in Group I, the mean rate during the first meal after changing daily feeding time to 2×2 -hr was close to that on the first day in Group I, as shown in Table 3. A similar trend was observed in the amount of food consumed.

Table 3. Mean rate of eating and the amount of intake in each meal in Group III

Before or after changing daily feeding time	Rate of eating (g/5 min)		Amount of intake (kg)	
	Morning	Evening	Morning	Evening
Before	141 $\pm$ 5.9		13.4 $\pm$ 1.00	
1st day	155	256	3.3	6.2
2nd day	211	261	5.1	6.3
3rd day	224	250	5.4	6.0
4th day	218	245	5.2	5.9
5th day	204	256	4.9	6.2
6th day	212	237	5.1	5.7
7th day	225	221	5.4	5.3
S. E. of a day, mean	17.8	15.7	0.47	0.38

Discussion

Effect of daily feeding time:

Daily time spent eating with 24-hr access was 361 to 513 min, approximately twice as long as with 4-hr access daily (189 to 222 min). Although the rate of eating increased markedly when access was restricted to 4-hr, the increase was insufficient to prevent a reduction in feed intake. This observation is in agreement with that of FREER *et al.*²⁾ on the rate of eating, when daily time cows had access to hay was reduced from 24 hr to 4½ hr.

In spite of eating time being similar to that observed with 4-hr access, two meals of 2-hr each permitted cows to consume larger amounts of hay and to eat more quickly than one meal of 4-hr. Reduction of the amount of digesta in the reticulo-rumen and the progress in metabolic turnover during the period of 8 hr between the meals may have been implicated in this increased intake.

Eating behaviour in the course of adaptation:

On the day daily feeding time changed from 24-hr to 4-hr, the eating pattern of the cows during the 4 hr of access was the same as it had been with 24-hr access; this resulted in a similar rate of eating, shorter eating time and lower intake. On the second or the third day, however, those values settled down to the levels for the subsequent days (Groups I and III in Fig. 2). These facts suggest that most cows had learned to expect the limited time of access to feed by the early part of the second day and had by then adapted their eating behaviour to the new system of feeding.

At the first meal, after a change in daily feeding time from 24-hr to 2×2-hr, cows ate as slowly as with 24-hr access, but intakes and the rates of eating at the second meal had attained the levels of the subsequent meals. These facts seem to show that adaptive behaviour to the change of the daily time of access to feed will occur as early as in the second meal, although the adaptation of cows has certain limitation in the rate of eating, and consequently in the daily intake.

The cows of Groups II and IV consumed more hay on the day the time of access to feed was changed from 4-hr to 24-hr than on the subsequent days, whereas daily time of eating showed no distinct difference. Mean rates of eating during the first 2 hr after offering hay for 4-hr, on the first day of 24-hr access and on subsequent days were 256, 298 and 216 g/5 min, respectively, but the differences were not significant. The fact that most cows ate faster on the first day of 24-hr access than on the other days suggests that the offer of a larger amount of hay probably stimulates temporarily the rate of eating.

Though there was no appreciable difference in the daily time spent in eating, by Groups II and IV, between the first day and subsequent days of 24-hr access, the characteristic patterns of eating behaviour were shown on several days after changing to 24-hr access. As shown in Fig. 1, the intake during the first eating period of a day and the length of the period were higher on the first day. In some of the cows it decreased for 2-4 days and attained the levels of the subsequent days. It is reasonable to assume that several days should be allowed for adaptation of eating pattern to the change of time of access to feed.

Summary

Time of eating and feed intake were recorded successively on 16 non-lactating dairy cows fed on mixed hay. The length of daily feeding time was changed from 24-hr to 4-hr and *vice versa* and observations were made on the behaviour of the cows.

When daily feeding time was restricted to 4-hr the cows ate nearly all the time they had access to feed with a rapid rate of eating, but they could not prevent a reduction in feed intake compared to those with 24-hr access. In two meals of 2-hr the cows consumed more hay, with a quicker rate of eating, than in one meal of 4-hr.

On the day access time changed from 24-hr to 4-hr intake was significantly less, and after changing from 4-hr to 24-hr it was longer than on subsequent days; this was because the rate of eating did not change immediately. At the second meal, however, intake and the rate of eating nearly attained the levels at the subsequent meals. It was suggested that cows adapt in feeding behaviour to the change of daily feeding time in a short period; one or two days.

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給飼時間の変更が乳牛の乾草摂食速度と摂食量におよぼす影響

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1日の給飼時間の変更に対して、乳牛がどのように対応するかを知るため、16頭のホルスタイン種乾乳牛を4頭ずつ4群に分け、乾草単飼で20日間の摂食行動を連続記録し、10日目に給飼時間を変更、その前後の摂食量・時間・速度を比較検討した。

各群の前・後半の給飼時間は、それぞれ、第Ⅰ群不断給飼と4時間1回給飼、第Ⅱ群4時間1回給飼と不断給飼、第Ⅲ群不断給飼と2時間2回給飼、第Ⅳ群2時間2回給飼と不断給飼とした。乾草は少なくとも約10%を食べ残す程度の量を、2時間2回給与期には午前6時と午後4時、他の期には午前8時に実験用飼槽に入れて与え、飲料水および固型塩を別に常備した。摂食行動の記録は、飼槽内の給与乾草の重量変化を歪計・打点式記録計にとらえる方法により、記録紙速度は1時間150mmとした。結果は次のとおりであった。

(1) 1日4時間給飼の時は、ほとんど給飼時間1杯、速い速度で摂食したが、1日の摂食量は不断給飼時

に及ばなかった。4時間1回給飼よりも2時間2回給飼の方が、やや速く、より多く摂食した。

(2) 不断給飼から4時間給飼に切り替えた日には、摂食速度は不断給飼期と変わらず、1日の摂食量は極度に減少した。2時間2回給飼に切り替えた群では、朝の給飼時には同様の現象が見られたが、夕刻の給飼時には既に摂食速度が大きくなり、摂食量は朝の2倍にも達した。

(3) 1日4時間給飼から、不断給飼に切り替えた日には、朝の摂食速度は4時間給飼期に近く、1日の総摂食時間は不断給飼期と変わりなかったが、摂食量は著しく多かった。

(4) 給飼時間切替日のこれらの著明な傾向は、2-3日目から、それぞれ4時間給飼・不断給飼時の摂食速度・時間・量にほぼ安定し、乳牛の給飼時間変更に対する順応はきわめて速いことが観察された。