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Note

Effect of walking on roughage intake and milk yield and composition of Montbéliarde and Tarentaise dairy cows *

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Summary — Twenty-eight multiparous cows (14 Tarentaises and 14 Montbéliardes) in mid-lactation were used in a changeover design with two periods. Throughout the trial, animals received a second cut cocksfoot hay ad libitum, complemented with a fixed amount of concentrate adapted to the milk production of each animal. The first day of each of the two 8-day periods, one of the two groups (seven cows of each breed) was subjected to a single walking of 12.8 km. During the following 24 h, walking incurred a drop in the quantities of forage ingested (–1.1 kg dry matter/day, $P < 0.01$) and in milk yield, which was greater ($P < 0.05$) in the Montbéliarde (–3.3 kg/day) than in the Tarentaise (–1.7 kg/day) cows. At the same time, fat content increased similarly in both breeds (+6 g/kg, $P < 0.01$). Protein content increased only in the Montbéliarde cows (+1.1 g/kg, $P < 0.1$). In both breeds, milk cell counts rose significantly after walking (+600 000 cells/mL, $P < 0.01$), but no occurrence of clinical mastitis was observed. Walking provoked a rise in body temperature (+0.5°C, $P < 0.01$) and in non-esterified fatty acids (+1.18 mM/L, $P < 0.01$) and glucose (+0.08 g/L, $P < 0.01$) plasma contents.

dairy cow / walking / milk yield

Résumé — Effet d'une marche prolongée sur les quantités ingérées et la production de vaches laitières Montbéliardes et Tarentaises. Au total, 28 vaches multipares (14 Tarentaises et 14 Montbéliardes) en phase descendante de lactation ont été utilisées dans un essai en inversion hiérachisé. Durant tout l'essai, les animaux recevaient à volonté un foin de dactyle de deuxième coupe, complémenté avec une quantité fixe de concentré, adaptée à la production de chaque vache. Le premier jour de chacune des deux périodes de 8 jours, un des deux lots (sept vaches de chaque race) a effec-

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tué une marche prolongée unique de 12,8 km. Au cours des 24 heures qui ont suivi la marche, on a observé une diminution des quantités ingérées de fourrage (–1,1 kg MS/jour, $p < 0,01$) et de la production laitière, plus importante ($p < 0,05$) chez les vaches Montbéliardes (–3,3 kg/jour) que chez les vaches Tarentaises (–1,7 kg/jour). Parallèlement, le taux butyreux a augmenté, de manière semblable chez les deux races (+ 6 g/kg, $p < 0,01$). Le taux protéique n'a augmenté que chez les vaches Montbéliardes (+1,1 g/kg, $p < 0,1$). Au sein des deux races, la numération cellulaire du lait a fortement augmenté suite à la marche (+600 000 cellules/mL, $p < 0,01$), sans qu'aucun cas de mammite clinique ne soit détecté. La marche a entraîné une augmentation de la température corporelle (+0,5 °C, $p < 0,01$), et des teneurs plasmatiques en acides gras non estérifiés (+1,18 mM/L, $p < 0,01$) et en glucose (+0,08 g/L, $p < 0,01$).

vache laitière / aptitude à la marche / production laitière

INTRODUCTION

Depending on management conditions, dairy cows are required to walk more or less long distances. When walking is restricted (1 to 3 km/day), animal performances are generally not affected (Anderson et al, 1979; Lamb et al, 1979; Gustafson et al, 1993). However, under certain conditions (scarce or hilly pasture) the distances walked by dairy cows can be substantially greater. The repercussions of walking or work on the increase of animal requirements or on production performances have been studied in sheep (Henning, 1987) and suckling cattle (Pearson and Archibald, 1989; Lawrence and Stibbards, 1990; Matthewman et al, 1993). However, little work has been done on dairy cows (Matthewman et al, 1989). In a series of recent trials (D'Hour et al, 1994; Coulon and Garel, 1996) we showed that, in animals at pasture, the response of milk yield to a long walk can vary between breeds, but we could not separate the effect of feeding level from that of animal breed. The objective of the present trial was to complete the former works, by defining, in housed animals, the effect of a long walk on the performances of Tarentaise and Montbéliarde cows, fed in such a way that their nutritive requirements were equally satisfied.

MATERIALS AND METHODS

Animals and treatments

Two groups of seven multiparous cows (mean lactation rank: 4.8) of each of the two breeds, Tarentaise and Montbéliarde, in mid-lactation (mean lactation stage at the beginning of the trial: 169 days) were used in a changeover design experiment carried out between 6 May and 2 June 1995. They were housed in individual stalls. At the beginning of the trial, milk yield was 16.8 and 12.4 kg/day for the Montbéliarde and Tarentaise cows, respectively (table I). Throughout the trial, all animals were fed a diet composed of a second cut of cocksfoot hay (0.81 UFL, 77 g PDIN and 85 g PDIE per kg dry matter [DM]), provided ad libitum, and of a production-type concentrate (1.05 UFL, 127 g PDIN and 127 g PDIE per kg DM), the quantities of which were fixed for the duration of the trial according to the milk yield observed during the 2 weeks preceding the beginning of the trial (ie, 0, 1, 2, 3 and 4 kg/day for milk yields of 14, 16, 18, 20 and 22 kg/day of fat-corrected milk). On average, Montbéliarde cows received 2.1 kg DM/day of concentrate and Tarentaise cows 0.7 kg DM/day. Additionally, all animals received 100 g/day of mineral supplement (6P-14Ca). Hay was fed in two daily meals and concentrate in one meal, unless quantities exceeded 3 kg/day, which were fed in a second meal. In a first 10-day period (P0), all animals were managed in the same way. On the first day of a second 8-day period (P1), one group walked 12.8 km (3.2 km circuit, with a total elevation variation of 80 m, covered four times), after the morning milking, according to the procedures defined by

Table I. Milk production, food intake, blood parameters and behaviour data.

	Tarentaise		*Montbéliarde*		*RSD* [1]	*Significance*	
	Rest	*Walking*	*Rest*	*Walking*		*TR*	*TR × BR*
Week before walking							
Live weight (kg)	593	595	637	637			
Milk yield (kg/day)	12.5	12.2	16.8	16.7			
Energy balance (UFL/day)	1.1	1.2	1.4	2.0			
Walking day[2]							
Hay intake (kg DM/day)	12.4	11.3	14.7	13.6	1.5	**	NS
Milk yield (kg/day)	12.0	10.3	17.1	13.8	1.2	**	*
Fat concentration (g/kg)	37.7	43.2	38.0	44.6	4.2	**	NS
Protein concentration (g/kg)	33.1	32.9	33.1	34.2	1.2	NS	+
Fat yield (g/day)	446	439	645	605	60	NS	NS
Protein yield (g/day)	398	337	563	469	44	**	NS
Somatic cell count (log/mL)	5.29	5.78	5.19	5.80	0.28	**	NS
Energy supply (UFL/day)	10.8	9.9	14.0	13.1	1.2	**	NS
Estimated energy balance (UFL/day)	0.8	0.2	1.5	1.4	1.3	NS	NS
Estimated nitrogen balance (g PDI/day)	105	60	186	198	129	NS	NS
Time spent lying[3] (min)	172	150	157	154	29	NS	NS
Time spent eating[3] (min)	180	123	200	129	25	**	NS
Time spent lying[4] (min)	143	150	132	154	24	*	NS
Time spent eating[4] (min)	113	123	114	129	21	*	NS
Body temperature (°C)	38.3	38.8	38.3	38,9	0.3	**	NS
Glucose (g/L)	0.63	0.66	0.60	0,72	0.07	**	*
NEFA (μM/L)	100	1370	70	1150	250	**	NS
Days 2 to 5 after walking							
Hay intake (kg DM/day)	12.7	12.6	14.6	14.1	1.0	NS	NS
Milk yield (kg/day)	12.1	12.0	16.6	16.5	0.6	NS	NS
Fat concentration (g/kg)	35.8	37.9	37.1	38.4	3.5	+	NS
Protein concentration (g/kg)	32.3	32.5	33.0	33.1	0.5	NS	NS
Somatic cell count (log/mL)	5.26	5.41	5.21	5.41	0.23	*	NS

[1] Residual standard deviation; [2] performances during the 24 h after walking; [3] Between the end of the morning milking and the beginning of the evening milking; [4] between the end of walking and the beginning of the evening milking. TR: treatment; BR: breed; NEFA: non-esterified fatty acids. + $P < 0.1$; * $P < 0.05$; ** $P < 0.01$; NS: not significant.

D'Hour et al (1994). The other group remained in the stable with free access to hay. Eight days later (P2), the treatments were inversed. Each walking lasted about 3 h.

Measurements

Milk yield was individually weighed at each milking. Milk chemical composition (fat and protein contents) and cell counts were analysed at each milking, each day throughout periods P1 and P2 and for the 7 last days of period P0. The quantities of feed ingested were measured individually each day. On walking days, refusals were measured twice daily (16.00 and 07.00 hours), to assess the quantities of feed taken during the first hours following the return of the animals to the stable (10.30 hours). DM content of the foods was determined every day for hay and once a week for concentrate. The chemical composition of the hay was determined once in the course of the trial. The DM and organic matter digestibilities of the hay were determined using six wether sheep during a 1-week measurement period after a 2-week adaptation period. Their nutritional value was computed according to the Inra equations as established by Andrieu and Demarquilly (1987). The quantities of water consumed were measured, per group, every day and every 2 h on walking days. Also on walking days, as soon as the animals returned to the stable, body temperature was measured and a blood sample was taken from all cows. Two tubes of plasma were prepared and frozen for analysis of glucose (Bergmeyer et al, 1974) and non-esterified fatty acid (NEFA) contents (Chilliard et al, 1984). On these same days, the behaviour of the animals (eating, standing or lying) was observed visually every 5 min, between the two milkings for the rest group and between their return to the stable (10.30 hours) and the evening milking (16.00 hours) for the walking group.

Data analysis

The immediate effect of walking was assessed by considering, on the one hand, animal performances during the 24 h after walking (ie, corresponding to the two milkings following walking) and, on the other hand, over the following 4 days (days 2 to 5 after walking). These data were treated by analysis of variance (GLM procedure, SAS, 1987). Fixed effects included in the model were treatment, breed, treatment × breed interaction, period, period × breed interaction and cow (nested within breed). Milk cell count was expressed as a logarithm. The values presented in figure 1 are arithmetic means. For behaviour variables, times spent eating, ruminating, lying or standing, were calculated either over the time separating the two milkings of walking days, or over the time between the return to the stable of walking animals and the evening

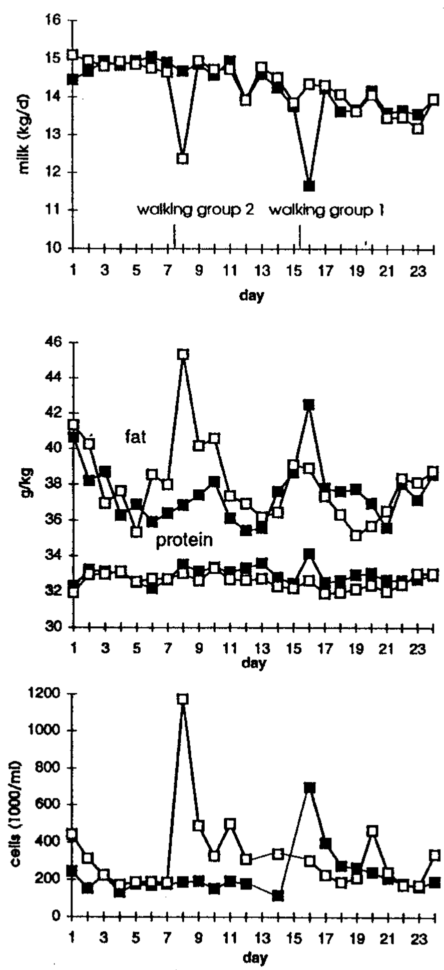

Fig 1. Milk production and composition pattern during the trial.(■: group 1; □: group 2).

milking. For these data, as for body temperature and blood parameters, the treatment model was the same as that described earlier.

RESULTS

The walk caused a considerable decrease in milk yield over the two subsequent milkings (2.5 kg, $P < 0.01$). This drop was significantly greater in Montbéliarde than in Tarentaise cows (3.3 vs 1.7 kg, $P < 0.05$) (table I). It was equally spread over the two milkings following walking (respectively −1.2 and −1.3 kg in the two subsequent milkings) but, regardless of breeds, did not persist beyond the first day (fig 1). Within breed, the depression of yield was neither linked to the production level of animals nor to their live weight (fig 2). Fat content increased similarly in both breeds (+6 g/kg, $P < 0.01$). Protein content did not vary in Tarentaises cows and slightly increased in Montbéliarde cows (+1.1 g/kg, $P < 0.1$). Consequently, fat yields were not affected by walking, contrary to those of protein (−78 g/day, $P < 0.01$). Whatever the breed, milk yield and hay intake were similar in the two groups during days 2 to 5 after walking (table I). However, fat concentration remained slightly higher ($P < 0.1$) in cows having walked, compared to those at rest.

In both breeds, milk cell counts increased considerably in the two milkings subsequent to walking (nearly 600 000 cell/mL in arithmetic mean, $P < 0.01$), but no occurrence of clinical mastitis was observed. This increase concerned all animals, but varied widely in amplitude: in nine cows it was below 200 000 cells/mL, and in six cows it exceeded 1 000 000 cells/mL. This increase was linked neither to the initial level of cells in milk, nor to the extent of the decrease in milk yield. It was, on average, more significant in the first period than in the second, probably due to harsher weather conditions in the first period (mean temperature 5.1°C vs 11.9°C in the second period). The cell counts of animals having walked remained above those of control animals for 4 days (+100 000 cells/mL during days 2 to 5 after walking, $P < 0.05$), especially in the first period (fig 1).

On the day of walking, the quantities of forage ingested until the evening milking were reduced by 2.4 kg DM. Part of this difference was made up for during the night, so that by the next morning the remaining difference between the two groups was only 1.1 kg DM ($P < 0.01$), whatever the breed, which incurred a decline in energy supply of 0.9 UFL (table I). The quantities of water drunk, respectively equal to 80 and 92 L/cow/day in Tarentaise and Montbéliarde

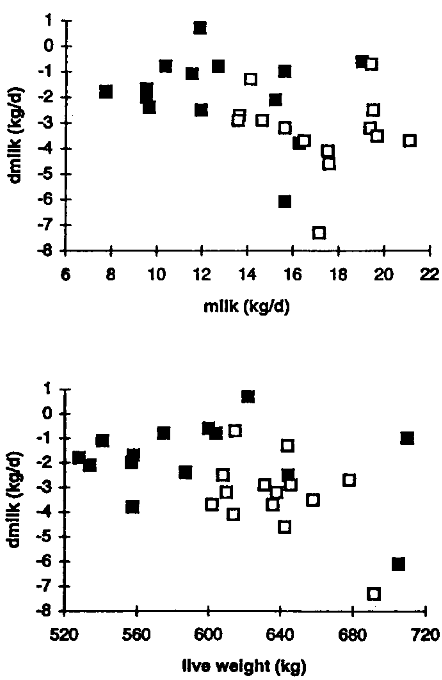

Fig 2. Relationship between the effect of walking on milk yield (dmilk), once corrected for period effect (upper graph), and milk yield and live weight at the beginning of the trial (lower graph). (■: Tarentaise cows; □: Montbéliarde cows).

cows on the days preceding the walk, remained unchanged on walking days.

On walking days, cows having walked spent, once in the stable, 13 min longer feeding than those having remained in the stable ($P < 0.05$). Between the two milkings, the latter spent 61 min more taking feed than those having walked ($P < 0.01$). The forage intake rate was not modified by walking (respectively, 45 and 48 g DM/min for cows at rest and those having walked). Between the two milkings, time spent lying did not differ between treatments.

Walking incurred a significant rise in body temperature (+0.5°C, $P < 0.01$), as well as an increase in NEFA (+1.18 mM/L, $P < 0.01$) and glucose (+0.08 g/L, $P < 0.01$) plasma contents. The increase in glucose content was more marked ($P < 0.05$) in Montbéliarde (+0.12 g/L) than in Tarentaise cows (+0.03 g/L) (table I).

DISCUSSION

This trial confirmed that a long walk incurs a considerable decrease in milk yield, but of very short duration (two milkings). However, animals were fed above their requirements (the energy balance during the 4 days before walking was, indeed, largely positive: +1.4 UFL/day on average) and therefore, in all probability, were less sensitive to extreme variations in nutritive supply. The concomitant variations in fat content were linked to the concentration of the fat yielded, as often observed upon extreme fluctuations in feed supply (Stobbs and Brett, 1974). The animal mobilizes its body reserves to synthesize milk fats which are concentrated in a smaller volume. The drop in milk yield far exceeded that which we observed previously at pasture, for animals of the same breed submitted to the same physical effort (D'Hour et al, 1994). This difference could be partly due to the fact that, in the present study, animals were not trained for walking (before the beginning of the trial, the only exercise taken by cows was the walk between their stall and the milking parlour, ie, around 200 m per day). The increase in energy requirements linked to walking can be assessed, according to the data of Ribiero et al (1977) and considering the nature of the circuit, at around 4 500 kcal of metabolizable energy, ie, 1.6 UFL (if we assume an efficiency of metabolizable energy utilization for lactation of 0.6). As observed by Matthewman et al (1993), this increase in energy requirements was not compensated for by an increase in forage intake. On the contrary, cows having walked ingested less forage than cows at rest, due to the reduced access time, compensated for neither by an increased rate of intake nor by a sufficiently raised nocturnal intake. Fatigue engendered by the walk may be responsible for this difference: Metz (1984) demonstrated that dairy cows required a minimum amount of rest during the day. Overall, the effect of walking resulted in a difference of 2.5 UFL between cows at rest and those having walked (1.6 UFL due to the increase of energy requirements (see earlier) plus 0.9 UFL due to lower energy supply (table I)). This would correspond to 5.7 kg of milk with a 4% fat content if we consider a maximal marginal efficiency of 2.3 kg/UFL. However, cows responded far less than this theoretical value because of their ability to rapidly and strongly mobilize their body reserves, as indicated by the extremely high increase in NEFA plasma content just after walking (Matthewman et al, 1989; Pearson and Archibald, 1989; D'Hour et al, 1994; Animut and Chandler, 1996).

As observed earlier (D'Hour et al, 1994; Coulon and Garel, 1996), the response of milk yield to walking differed between breeds. Contrary to those trials, however, we cannot propose a difference in energy balance (during the days preceding walking, Montbéliarde and Tarentaise cows all had a positive energy balance: respectively, +1.5 and +1.0 UFL/day). This disparity could be due to morphological differences which allow Tarentaise cows to expend less energy when walking; their weight is slightly below that of Montbéliarde cows (–40 kg), but it does not seem that live weight per se was responsible for the variation of milk yield response to walking (fig 2). It is also possible that Tarentaise cows are able to better counteract an important energy shock. The greater increase in glucose content in Montbéliarde cows immediately after the physical effort supports this argument. Indeed, as was observed previously in cows (D'Hour et al, 1994) and ewes (Animut and Chandler, 1996), glucose content was raised just after walking, in all likelihood due to increased muscular requirements (Pearson and Archibald, 1989).

This trial emphasized a considerable increase in milk cell counts subsequent to walking. Due to the lack of information surrounding the characteristics of the cells excreted and the possible presence of pathogenic germs in the milk, this result is difficult to interpret. Substantial increases in cell counts have occasionally been observed in the absence of mammary infection, consecutive to thermal or drug treatment stress (Wegner et al, 1976). These results are, however, disputed (Paape et al, 1973). The indirect effect of concentration linked to the depressed milk yield can only explain a small part of this result, all the more so that we observed no inter-individual relationship between the decrease in milk yield and the increase in cell counts. It is more probable that a long walk undergone without prior training resulted in physical mammary traumas, which were responsible for the raised milk cell counts. These traumas could have been accentuated by weather conditions, as would indicate the wide difference in response between the two periods.

The practical consequences of these results (drop in milk yield varying according to breed, effect on cell count) can be considerable, particularly in cows managed, during pasture, in an extensive system. These initial observations must, however, be clarified by trials in which walking is repeated over a long time span.

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