the characteristics of pasture, their feeding value and livestock production. Appropriate fundamental criteria for effective management related to the animal production and to the value of the pastures need to be developed.

Classical criteria of management considered

Animal liveweight change is the principal parameter usually used to evaluate the effectiveness of various strategies. However, because the consequences of changes in nutrient intake on live weight are usually not evident for at least some weeks, there is usually limited opportunity to progressively correct the grazing management. An alternative is to base the management on the ingestive behaviour of the animals, since this strongly influences the intake of metabolisable energy and thus animal production. The most important components of ingestive behaviour appear to be the intake rate and the bite mass since these appear to be most closely correlated with voluntary intake (Goncalves *et al.*, 2009; Boval *et al.*, 2007). However, bite mass is difficult to measure on commercial farms, and also gives only a short-term evaluation. Management may be based on herbage characteristics such as the height, biomass, chemical composition or leaf content. Any specific nutrient deficiencies of the forage such as of nitrogen, phosphorus or sodium, which are not uncommon, will also be expected to determine voluntary intake of pasture. However knowledge is generally lacking of the selection of the components of tropical pastures by grazing animals, and how selection is influenced by pasture growth and defoliation, and other attributes of the pasture. The digestibility of pasture is often used as a basis for management, but it appears to have a lesser effect on voluntary intake, and therefore metabolisable energy intake, of tropical pastures than of temperate pastures (Fanchone *et al.*, 2010). Because of the heterogeneity of tropical pasture swards, the selectivity of grazing animals and the methodological and experimental difficulties we have a poor understanding of the nutrient intake of ruminants grazing tropical pastures. Based on present knowledge it is difficult to develop general rules between the various herbage characteristics and appropriate management in tropical pastures. Although some criteria such as those described above have the potential to guide management, they are often still not appropriate and easily measured. The best criteria would clearly be knowledge of the amounts of the various pasture components selected by the animal and thus nutrient intake in the short and long term.

Recent methodological progress

This has improved capacity within practical constraints to measure intake of various nutrients by grazing ruminants. Several remote sensing technologies have enhanced evaluation and utilization of pastures. Progress in methods to evaluate the diet selected and nutrient intake include alkanes, faecal NIRS and improved nutritional models to evaluate the grazing ruminant (CSIRO, 2007). NIRS analysis of faeces is an attractive technology (Dixon and Coates, 2009) since it provides reasonably precise, fast and low cost analyses a number of diet attributes (digestibility, ingestion, botanical composition, methane emission) where appropriate calibrations have been developed. The challenge is to develop the co-operation between the researchers of various geographical sectors, to gather databases for the development of robust and applicable calibrations in contrasting situations, in order to have suitable management criteria and to reinforce effective strategies of the management of the pastures.

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doi:10.1017/S2040470010000567

Management of intensive grazing: when grazing behavior and milk yield are modified by an alternative paddock system

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Introduction

Pasture-based animal production has, in the last decade, assumed outstanding importance worldwide (Mannetje, 2007). This fact is mostly related to economic advantages, animal welfare, and ecological issues (Murphy *et al.*, 1996). The viability of small family farms, through

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pasture-based ecological dairying, has been highlighted as a way to revitalize rural communities and avoid urban social problems in South America (Rizzoli and Schmitt, 2007). Management methods determine synchronized grazing behaviour responses (Taweel *et al*., 2006). Dairy cows can be expected to anticipate being moved to a fresh paddock after milking and synchronize their behaviour to this prediction. This results in reduction of grazing time and intake, especially around reward time (Arriaga-Jordan and Holmes, 1986). This experiment tested the effect of paddock management in reshaping behavioural patterns of cows to improve use of the pasture resource.

Material and Methods

A herd of lactating, rotationally grazed, Holstein cows was the subject of this grazing trial at a commercial dairy farm near Hinesburg, Vermont USA. The host farmer participated in the University of Vermont Pasture Management Outreach Program. Two control groups of cows were under typical half-day paddock management. Two treatment groups were moved to paddocks with distinct internal design. Half-day paddocks were fenced into two areas: main (85% of area) and remainder (15% of area). The main area was made available to cows when they arrived in a paddock. The remaining area of fresh forage was integrated to the main area during the waiting period few hours before milking (12 PM/afternoon and 10 PM/evening). Evaluations of behavioural budgets were done by analyzing 24-hour periods, main periods (AM/PM AND PM/AM) and sub-periods (MORNING, AFTERNOON, EVENING and DAWN). Daily milk yield (kg day^{-1}) was assessed during a week in each monthly experimental period. Pasture daily dry matter requirement provided per animal was about 2.5% of bodyweight. Cows grazed each paddock when a target pre-grazing mass reached 2700 kg DM/ha. During the experiments, an average of 32 days of plant regrowth was required to reach target pre-grazing mass. Cows were supplemented individually after every milking. Supplements were intended to complement pasture forage nutritional value in meeting cows' requirements. Behavioural and production differences between treatment and control were tested using ANOVA. The magnitude of the difference was evaluated through Tukey-Kramer HSD.

Results

Total grazing time during 24-hour periods was 71 min ($P < 0.01$) longer for treatment cows than controls. Total grazing time was 498 min (SD = 47) for treatment, compared to 427 min (SD = 49 $P < 0.01$) for control. These behavioural adjustments happened only in afternoon and evening periods, when the fenced off pasture strip was released to the treatment group. Rumination and leisure time was affected negatively by alternative paddock management. Treatment paddock management had a positive effect on milk yield during the entire experiment. Treatment cows had an average daily milk yield of 1 kg higher than control cows. Treatment cows produced 20 kg cow^{-1} (SD = 4), while control cows had a milk yield of 19 kg cow^{-1} (SD = 4, $P < 0.01$). This overall better performance of treatment cows resulted in greater milk yield in both June and August experimental trials. The June trial was characterized by an average daily milk yield of 20.4 kg cow^{-1} (SD = 4.1), with a significant difference between control and treatment cows. Treatment cows produced 1.1 kg more than control cows during this trial ($P < 0.01$). Treatment cows had an average daily yield of 20.9 kg cow^{-1} (SD = 4.4), compared to 19.8 cow^{-1} (SD = 3.8) for control cows. With an average daily milk yield of 18.5 kg cow^{-1} (SD = 4.4), the August trial had a similar pattern. Treatment cows had an average daily milk yield 0.9 kg cow^{-1} higher than control cows ($P < 0.05$). Treatment cows produced 18.9 kg cow^{-1} (SD = 4.4), while control cows produced 18.0 kg cow^{-1} (SD = 4.4).

Conclusion

The alternative paddock management discussed here was used to recondition feeding behaviour of cows by different moving schedules to distinct parts of paddocks. It motivated the herd to graze more, especially in the last hours of paddock occupation, thereby increasing total daily grazing, even under constant moving schedules. The higher performance of dairy cows under treatment management was a consequence of several behaviour adjustments to different environmental stimuli related to alternative paddock management. A simple management practice such as this can greatly reshape cow grazing behaviour, improve overall productivity, and may affect farm profitability.

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https://doi.org/10.1017/S2040470010000567 Published online by Cambridge University Press