Dairy cows with access to both indoor and outdoor environments - experiences from automatically milked cows on pasture in temperate regions

E. Spörndly, Swedish University of Agricultural Sciences, Department of Animal Nutrition and Management, Kungsängen Research Centre, SE-753 23 Uppsala, Sweden
E-mail: Eva.Spondly@huv.slu.se

Abstract
Pasture-based milk production offers many advantages, such as high quality feed at a low cost and the opportunity for the cows to exercise, graze and move more freely in an outdoor paddock. However, large variations in herbage mass and quality can lead to an uneven nutrient supply and high temperatures or other stressful environmental conditions can negatively impact the animals. A model that combines grazing with indoor feeding has, in some cases, proved to be advantageous.
Experiments have shown that automatic milking (AM) can be successfully combined with grazing. On AM farms that practice grazing, cows are offered a choice between indoor and outdoor environments during the hours that pasture is available. Various factors affect that choice, thus farmers with AM face the new management challenge of stimulating their cows to move regularly between barn and pasture throughout the grazing season. Grazing experiments have been performed to study how factors such as distance between barn and pasture, location of drinking water and supplementary feeding levels in the barn affect cow traffic and milk yield. Results have in some cases differed substantially depending on conditions, thus illustrating the importance of a detailed analysis of the indoor and outdoor environments actually offered to the cows in each situation.

Introduction

There are many advantages for the dairy farmer in temperate climates to practice grazing. Pasture is a low-cost feed because there are no harvest, storage or feeding costs when the cows collect their own herbage out in the field (T' Mannetje, 2000). It has also been shown that grazing is beneficial for animal health. In a large study where 15 151 cows from 39 Danish herds were included, Thomsen (2005) found that herds with no grazing had a higher proportion of "loser cows" (i.e. cows with health problems and higher veterinary costs) compared with herds that practiced grazing. Finally, grazing is often mentioned as an important factor that promotes various aspects of animal welfare (Redbo, 1990; Krohn et al., 1992).

The general public appreciates grazing (Mathijs, 2000) since it is beneficial for animal welfare and it preserves the grassland landscape, with its scenic beauty and biodiversity values. Recently, there has been an increased interest in the health qualities of milk from cows on pasture as it contains a higher proportion unsaturated/saturated fat with more poly-unsaturated fatty acids and conjugated linoleic acid compared with milk from silage-fed cows (Elgersma et al., 2006).

On the other hand, there are several disadvantages to grazing for the dairy farmer. One of these disadvantages is the large variation in pasture supply and quality due to season, management and weather (Parsons, 1988). These variations make it difficult to achieve an even herbage allowance throughout the season and a high herbage intake for all animals at all times. Bargo et al. (2003) mention low herbage intake as one of the major constraints that can lead to lower milk yields during the grazing season. Finally, if herbage allowance is sufficient

to obtain a high herbage intake, grazing generally leads to lower herbage utilization compared with cutting (Mayne et al., 2000). It has been shown that a reduction in the area of rejected patches can be obtained with a higher grazing pressure, but this reduction is achieved at the cost of a lower milk yield (McBride et al., 2000).

The choice of the dairy farmer, "to graze or not to graze", is a product of farmer interest, farm conditions, and regional standards/legislation. In addition, the choice is influenced to a certain extent by prevalent attitudes and tradition. This can be seen in the large differences between countries reported from a survey of farms in 4 countries in the same region (north-western Europe) where the external conditions for grazing are fairly comparable: Belgium (B), The Netherlands (NL), Germany (D), and Denmark (DK) (Mathijs, 2004). The results of the survey showed to what extent the farmers practiced grazing before and after the introduction of automatic milking (AM) on their farm. Before the introduction of AM, the percentage of farmers that chose to have their cows indoors with summer feeding or with zero-grazing in the four countries was: B 7.7%, NL 16.3%, D 21.7% and DK 35.7%. Corresponding values for the farms after the introduction of AM were B 23.1%, NL 50.9%, D 62.5% and DK 53.9%. These results show that there can be large variations between countries in the same region with regard to interest in grazing management and that automatic milking led to a dramatic increase in the proportion of farms that did not practice grazing. Thus, modern dairy farming systems, such as AM, often lead to a decrease in grazing. The decrease in farms that practice grazing is especially obvious when studying larger farms where the logistic problems with long walking distances to the most distant paddocks can lead to a desire to cease grazing or to substantially decrease grazing hours and pasture areas for the dairy herd.

It is often argued that unless weather conditions are excessively hot, it is beneficial for dairy cows to be put out onto pasture summertime, at least for part of the day. However, if given the choice, do dairy cows prefer the indoor or outdoor environment? The objective of this paper is to present the results of some experiments that have been performed with automatically milked dairy cows with access to both indoor and outdoor environments and to discuss both the performance and the preference of the cows in relation to the choices they have been offered.

The challenge: Automatic milking and grazing

Only one cow can be milked at a time in an AM unit. Therefore, milking in an AM barn takes place at all times with only short interruptions for cleaning the system. The aim of management is to obtain a continuous, steady flow of cows coming and leaving the milking unit throughout the day and night. Grazing combined with AM is an extra challenge for the farmer. During the pasture season, cows often want to synchronize their visits to both the barn and pasture (Ketelaar-de Lauwere et al., 1999). Therefore, it is difficult to obtain an even flow of animals to the milking unit. During some parts of the day, cows often arrive to the milking unit in large groups, meaning they have to wait several hours before being milked. At other times, it is not unusual for all cows to be out in the field, leaving the milking unit empty (Ketelaar-de Lauwere et al., 2000). Therefore, farmers who wish to combine AM with grazing must actively motivate their cows to move regularly between the barn and the field several times daily, individually or in smaller groups. Some important factors to consider have been studied experimentally and the results are presented below.

Distance to pasture and supplemental feeding – how do they influence cow traffic?
The distance between barn and pasture and its effect on cow traffic has been studied in several experiments. Ketelaar-de Lauwere et al. (2000) studied the behaviour of 24 automatically milked cows with access to the pasture 15 hours /day. The distance between the barn and pasture varied between 146 m and 360 m and the cows strip-grazed at different distances during 4 experimental periods, each lasting 5 days. In this experiment the distance between barn and pasture had no effect on the number of visits to the barn or to the milking unit. The behaviour observations showed that when the cows had a choice between the indoor and outdoor environments, they spent most of their resting time outdoors (96%), most of their foraging time grazing (85.9-91.2%) and most of their total time outdoors (79.5-86.0%).

In another experiment from The Netherlands, the effects of distance between barn and pasture and the effect of supplemental feeding supply were studied in a 2-factor experiment with approximately 64 cows during the 2002 and 2003 grazing seasons (van Dooren et al., 2004). They studied 2 different distances between barn and pasture (less than 150 m versus more than 500 m) and 2 different supplemental feeding regimes in the barn (6 versus 10 kg DM maize silage), giving a total of 4 treatment combinations. The treatments were applied after each other in time throughout the summer period with 4-day adaptation periods followed by 4-day registration periods. A selection gate was open for the cows to go to the pasture 9.5 hours during daytime and the animals that had not returned in the evening after 13.5 hours were fetched. In 2002, the cows could only reach the exit door to the pasture and the feeding table with roughage by passing the AM unit (forced cow traffic) whereas in 2003 cow traffic was free. In the results of their experiment, van Dooren et al. (2004) found no effect of distance between barn and pasture or the level of maize silage on milking interval, milk yield or number of fetched animals in 2002 and 2003 (Figure 1).

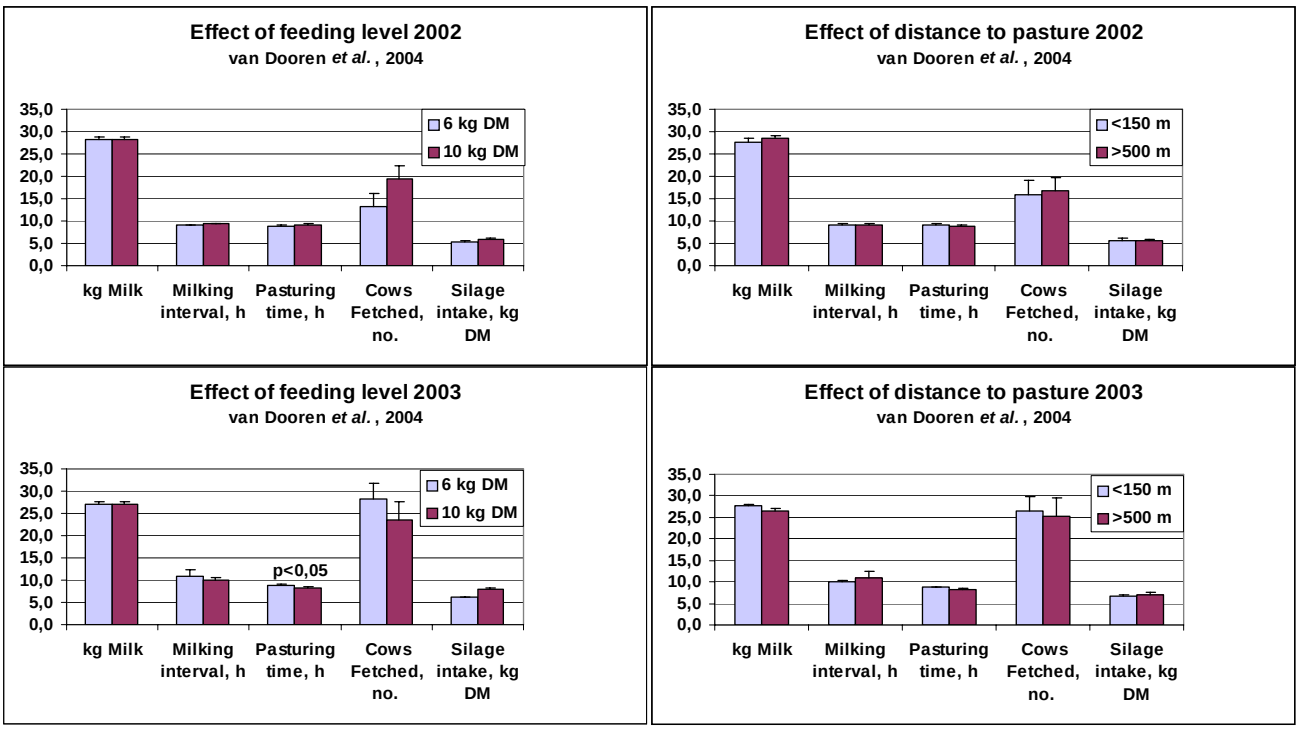

Figure 1. The effect of supplementary roughage and distance to pasture on milk yield, milking interval, pasturing time, cows fetched and on intake of silage.

During 2003, feeding level appeared to have a significant effect on pasture time. A tendency was also observed in 2002. However, feeding level had an opposite effect in those years: in 2002, less pasturing time was observed with the low supplementation level, whereas in 2003 the lesser time was observed with the high supplementation level.

In a field study on 25 farms with AM and grazing, van Dooren et al. (2002) observed that there was great variation in net profit between farms during the pasture season. No clear relationship could be seen between net profit and distance to the field; however, the average number of milkings/day decreased from 2.9 in the indoor season to 2.7 in the pasture season. There was also great variation between farms in the percentage of cows fetched for milking (from 0 to more than 90%). A separate analysis of the effect of distance was performed including only farms with no fetching of cows for milking. van Dooren et al. (2002) found that the milking frequency decreased by 0.18/km increase in distance between barn and field.

The effects of distance between barn and pasture and level of supplementary roughage were studied in yet another experiment with 45 automatically milked cows on pasture (Spörndly and Wredle, 2004). The animals had access to the pasture 24 hours/day and stayed in the same treatment groups throughout the grazing season. Three treatments were compared: pasture "near" with 3 kg DM grass silage/day supplement in the barn, pasture "far away" with the same supplement (3 kg DM grass silage/day), and pasture "far away" with access to *ad libitum* grass silage in the barn. Cows on the near pasture had to walk 50 m to reach the pasture and the most distant part of the field was 330 m from the barn door. Corresponding distances for cows on the far pasture were 260 and 850 m, respectively. During the first half of the grazing season, Spörndly and Wredle (2004) observed that cows grazing near the barn spent much more time outdoors compared with cows that grazed far away, 68 and 44% of their time, respectively (Figure 2). They observed a similar difference during the second part of the grazing season (August). The animals grazing near the barn had a significantly higher milk yield (29.1 vs. 26.4 kg milk) and a higher milking frequency (2.5 vs. 2.3 milkings/day) compared with the animals grazing far away during June-July (Figure 2). Regardless, no significant differences between groups in grazing time were observed (both ~20%). In August, the animals on the distant pasture became even more reluctant to walk out to the field and their grazing time decreased to ~10%, whereas the group with pasture near the barn continued to spend ~20% of their time grazing.

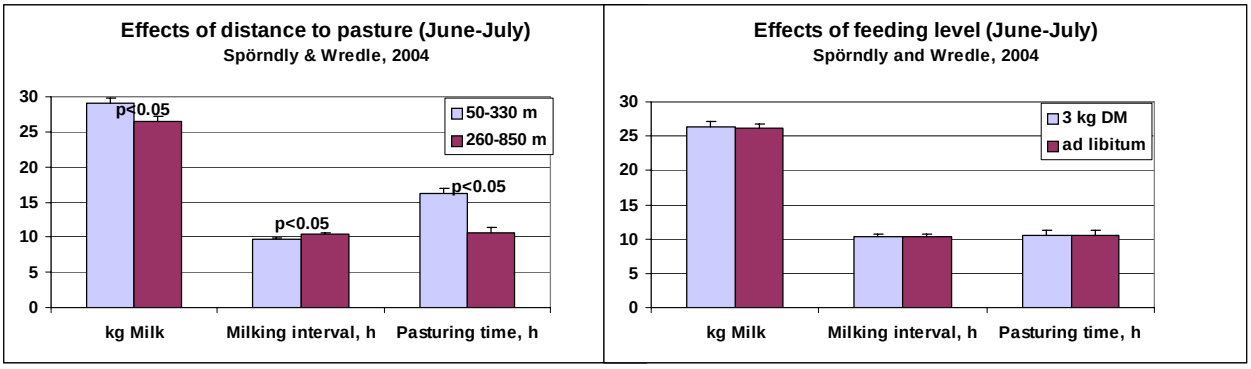

Figure 2. Effect of level of supplementary feeding (3 kg DM/day vs. ad libitum) and distance between barn and pasture (50-330 m vs. 260-850m) on milk yield, milking interval and pasturing time of automatically milked cows.

The higher level of supplementary roughage (*ad libitum*) had no significant effect on milk yield or time spent outdoors, grazing, or lying down in the field and did not increase milking

frequency compared with the lower level of supplementation (3 kg DM/day) at the same pasture distance (Figure 2).

During the first part of the grazing season (June-July), there was also a large difference in time spent lying in the pasture, which was 35 and 13% for the groups grazing on the near and distant pastures, respectively (Figure 3).

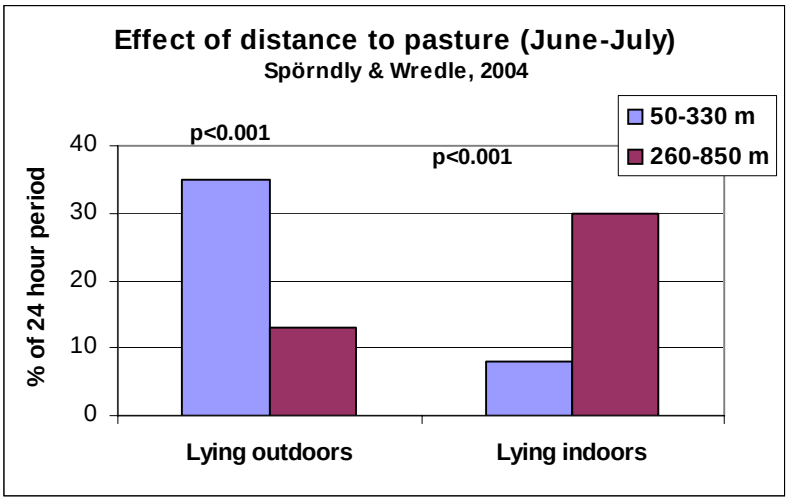

Figure 3. Effect of distance to pasture (50-330 m vs. 260-850 m) on the lying behaviour of cows.

The results from these 3 experiments are contradictory. In the experiment Ketelaar-de Lauwere et al. (2000), distance to pasture had no significant effect on behaviour and in the experiment of van Dooren et al. (2004) no effects on behaviour or production were observed. However, in the van Dooren et al. (2002) field study and in the Spörndly and Wredle (2004) experiment, distance did have an effect. In the Spröndly and Wredle (2004) experiment, the far away grazing area was situated so that the animals could not see the field from the area just outside the barn exit. It was suspected that this situation made it more difficult for the cows to see whether there were other cows in the far away grazing area or not, making the cows more reluctant to leave the area around the barn. Thus, it seems that in some cases distance may have an important effect and that the location of the grazing area in relation to the barn may be of fundamental importance in obtaining smooth cow traffic between barn and pasture.

When the amount of high quality pasture was sufficient, high levels of supplementary feeding in the barn did not have any significant effect on cow traffic or performance (van Dooren et al., 2004; Spörndly and Wredle, 2004). However, van Dooren et al. (2002) observed that feeding supplementary roughages at fixed times served as a stimulus to bring cows voluntarily from the field back to the barn.

Grazing hours

Many farms choose to give their animals access to pasture during only part of the 24-hour period (Mathijs, 2004). There are several reasons for this, such as a limited pasture near the barn, farmer concerns over low milking frequencies, or a desire by the farmer to obtain better control of feed intake in the herd. In the survey of 25 farms from The Netherlands, approximately half the farms allowed the animals to graze more than 15 hours /day, 5 farms had 11-15 hours grazing and 7 farms let the cows graze 5-10 hours /day (van Dooren et al.,

2002). In a barn with AM, Ketelaar-de Lauwere et al. (1999) compared zero grazing with 12 and 24-hour grazing periods. Milking frequency was significantly lower for cows with 24-hour access to pasture (2.3 milkings/day) compared with the other 2 treatments (2.5-2.8 milkings/day). In experiments with cows in conventional milking systems with *ad libitum* feeding of silage indoors, higher milk yields were obtained in the group with 12-hour night time grazing compared the group kept indoors throughout the 24-hour period (Virkajärvi et al., 2004). These results indicate that part time grazing also may be a good solution for cows in barns with AM.

Drinking water location and sward height in the field

On some farms, drinking water is supplied only in the barn with the objective of motivating cows to return to the barn (and the milking unit) regularly during the grazing season. In an experiment this question was studied with 2 groups of automatically milked cows (Spörndly and Wredle, 2005). Both groups had drinking water in the barn, but while the first group also had access to drinking water in the grazing area outdoors, the second group did not. During that experiment, the walking distance to the pasture varied between 50 m to 330 m during different sub-periods. No significant differences between groups in milking frequency, milk yield, milk composition or total water intake were observed on an overall level. Even though there were no differences in total water intake, the group of cows with drinking water in the field consumed a large proportion of their drinking water out on pasture (28%, 55% and 67% during the 3 registration periods).

Sward height can in some cases be used as a tool to assess pasture supply. In an AM barn with a rotational grazing system, Ketelaar-de Lauwere et al. (2000) observed that when the average sward height decreased over the days that cows were in a paddock, the number of milkings increased: from 2.6 to 3.0 milkings/cow/day from the first to the last day in the same paddock.

Summertime management of automatically milked cows

What general conclusions can be drawn with regard to management? The reported beneficial effects of grazing on animal health (Thomsen, 2005) indicate that grazing, or at least daily exercises (Gustafson, 1993), should be recommended. The low milking frequencies that have been observed with 24-hour grazing compared with shorter grazing hours (Ketelaar et al., 1999) lead to the conclusion that it may be beneficial to apply limited grazing hours. However, this conclusion is based on only 1 experiment and there is a need for further research in this area. A better understanding of cow preference may lead to the development of management strategies for longer grazing hours with maintained high milking frequencies. Supplying the animals with drinking water in the field at grazing distances up to 330 m from the barn did not decrease milking frequency or milk yield and had no effect on milk composition on an overall level and is therefore recommended in most cases.

Even though a long distance between barn and pasture (approximately 400-500 m) had, in most cases, no effect on milk production or milking frequency (Ketelaar et al., 1999; van Dooren et al., 2004), the results of Spörndly and Wredle (2004) indicate that distances as little as 260 m may, in some cases, have a negative effect on milk production and milking frequency. Therefore, it is an advantage if the pasture area is situated near the barn.

Are indoor or outdoor environments preferred by dairy cows?

It is tempting to try and answer this question by studying the results from experiments with AM and grazing in which cows can choose between the indoor and outdoor environment. However, the results of some of the experiments above do not seem to point in same

direction. This is exemplified by the different results obtained with regard to total time spent outdoors and time spent lying outdoors. Early behaviour studies with AM and grazing clearly showed that during the period that they could choose between indoor and outdoor environments, cows chose to spend approximately 85 % of their time outdoors on a fresh pasture, then around 70% of their time outdoors on the fourth day on the same pasture. In the experiment with different distances, the corresponding figure was approximately 80-85% (Ketelaar et al., 2000). This was in line with the results of Krohn et al., (1992) who found that cows with a choice of indoor and outdoor environments spent more than 70% of their time outdoors in the summertime. However, in the experiment of Spörndly and Wredle (2004), cows on the distant pasture spent only 44 and 47% of their time outdoors in June-July and in August, respectively. In a similar manner, the cows in most experiments seem to prefer to lie outdoors, but in some cases they choose to lie mainly indoors, as was observed for cows on a distant pasture (Figure 3).

Obviously, each situation differs with regard to the cows' preference. In the question above on whether cows prefer to lie down outdoors or indoors, the answer will differ depending on how attractive the outdoor compared to the indoor environment is to the cow. Factors such as pasture quantity, pasture quality, and access to shade, shelter and water are just a few important factors that can differ in the outdoor environment. The behaviour and choice of the cows can also depend on the amount of time they have access to the outdoor environment, the position of the barn exit compared with the facilities in the barn and the outdoor area, the distance to the pasture and how visible it is for the cows from the barn exit, etc.

Thus, the answer to what the effects of a certain management decision are, cannot easily be generalized. The construction and lay-out of AM barns can vary and management differs with regard to cow traffic, feeding routines, feed quality, one-way gates and various computer regulated facilities (minimum time between milkings and concentrate meals). Therefore, caution must be taken in interpretation of research results in AM barns so that all these factors are taken into consideration when the results from single experiments are viewed.

Conclusion

The above experiments indicate that in temperate summer climates, there are many advantages to combine AM with grazing so long as the cows are offered high quality pasture in sufficient quantities. It is possible that it is more beneficial with part-time grazing compared with 24-hour grazing in many cases, but more research and experience is needed to fully explore this question.

Cows with a choice between indoor and outdoor environments will often spend the main part of their time outdoors if there is enough high quality pasture available at a distance not too far from the barn (400-500 m). It seems that the cow's choice is also influenced by the possibility to synchronize outdoor activities with other their herd-mates; so, limited visibility of herd-mates can therefore affect the choice between indoor and outdoor environments.

Finally, it can be concluded that the AM barn is a highly interesting environment to study cow preferences and behaviour. However, caution must be taken not to generalize from single experiments, but instead to deepen the analysis of behaviour observations and to critically evaluate the effects of multitudinous other factors that may influence the obtained results.

References

Bargo, F., L. D. Muller, E. S. Kolver, and J. E. Delahoy. 2003. Invited Review: Production and digestion of supplemented dairy cows on pasture. J. D. Sci. 86:11-42.

Elgersma, A., Wever, A. C., and Nalęcz-Tarwacka, T. 2006. Grazing versus indoor feeding: effects on milk quality. In: Grassland Science in Europe (European Grassland Federation) Vol 11, pp. 419-427.

Gustafson, G. M. 1993. Effects of daily exercise on the health of tied dairy cows. Prev. Vet. Med. 17:209-223.

Ketelaar-de Lauwere, C. C., A.H. Ipema, E. N. J. van Ouwerkerk, M. M. W. B. Hendriks, J. H. M. Metz, J. P. T. M. Noordhuizen, and W. G. P. Schouten. 1999. Voluntary automatic milking in combination with grazing dairy cows. Milking frequency and effects on behaviour. Appl. Anim. Behav. Sci. 64:91-109.

Ketelaar-de Lauwere, C. C., A. H. Ipema, C. Lokhorst, J. H. M. Metz, J. P. T. M. Noordhuizen, W. G. P. Schouten, and A. C. Smits. 2000. Effect of sward height and distance between pasture and barn on cows' visits to an automatic milking system and other behaviour. Livestock Production Science 65:131-142.

Krohn, C. C., L. Munksgaard, and B. Jonasen. 1992. Behaviour of dairy cows kept in extensive (loose housing/pasture) or intensive (tie stall) environments. I. Experimental procedure, facilities, time budgets – diurnal and seasonal conditions. Appl. Anim. Behav. Sci., 34:37-47.

McBride, J, Baker, L. J. and Fisher, G. E. J. 2000. The effect of manipulating the stocking density of dairy cows to increase the grazing pressure in the mid season on the morphology and utilisation of rejected patches within a sward. In: Grazing management. Eds: A.J. Rook and P.D. Penning. Occasional symposium, British Grassland Society (BGS), No. 34, pp. 33-38.

T' Mannetje, L. 2000. The importance of grazing in temperate grasslands. In: Grazing management. Eds: A. J. Rook and P. D. Penning. Occasional symposium, British Grassland Society (BGS), No. 34, pp. 3-13.

Mathijs, E. 2000. Public acceptance of robot milking. Pages 243-247 in Robotic Milking, Proc. Int. Symp. H. Hogeveen and A. Meijering, eds. August 17-19 2000, Lelystad, The Netherlands.

Mathijs, E. 2004. Socio-ecomomic aspects of automatic milking. In: Automatic milking – a better understanding. Eds. A. Meijering, H. Hogeveen and C. J. A. M. de Koning. Proceedings of the symposium on automatic milking in Lelystad, March 24-26, 2004.

Mayne, C. S., Steen, R. W. J. and Vipond, J. E. 2000. Grazing management for profit. In: Grazing management. Eds: A. J. Rook and P. D. Penning. Occasional symposium, British Grassland Society (BGS), No. 34, pp. 201-210.

Parsons 1988 – NOT COMPLETE –

Redbo, I. 1990. Changes in duration and frequency of stereotypes and their adjoining behaviours in heifers, before, during and after the grazing period. Appl. Anim. Beh. Sci. 26, 57-67.

Spörndly, E. and E. Wredle. 2004. Automatic milking and grazing – Effects of distance to pasture and level of supplements on milk yield and cow behavior. J. Dairy Sci. 87:1702-1712.

Spörndly, E. and E. Wredle. 2005. Automatic milking and grazing – Effects of location of drinking water on water intake, milk yield and cow behavior. J. Dairy Sci. 88:1711-1722.

Thomsen, P. T. 2005. Loser cows in Danish dairy herds with loose-housing systems: Definition, prevelance, consequences and risk factors. PhD thesis, The Royal Vet. And Agric. Univ, Dept. of large anim. Sci. and Danish Institute of Agric. Sci. Dept. of Anim. Health, welfare and Nutr., Copenhagen., 133 p.

van Dooren, H. J. C., E. Spörndly, and H. Wiktorsson. 2002. Automatic milking and grazing. Applied grazing strategies. Deliverable D25, EU project "Implications of the introduction of automatic milking on dairy farms" (QLK5-2000-31006), 28pp, http://www.automaticmilking.nl Accessed Sept. 10, 2006.

van Dooren, H. J. C., Heutnick, L., Biewenga, B., Krohn, C., Munksgaard, L., Wiktorsson, H., Wredle, E., and Spörndly, E. 2004. Grazing strategies and their effect on animal welfare and system performance. Deliverable D27 within the EU project Implications of the introduction of automatic milking on dairy farms (QLK5 – 2000 – 31006), 55 pp. Available at http://www.automaticmilking.nl Accessed Sept. 10, 2006.

Virkajärvi, P., Hakosalo, J., Sairanen, A., Halonen, R., Mononen, J., Ahola, L., Kauppinen, R., Lindeberg, H. and Khalili, H. 2004. Comparison of the effect of night-time grazing versus silage feeding on milk production and animal welfare. Grassland Science in Europe (European Grassland Federation), Vol. 9, pp. 659-661.