The drinking behaviour of dairy cows in late lactation

J. G. JAGO, J. R. ROCHE, E. S. KOLVER and M. W. WOOLFORD

Dexcel Limited, Private Bag 3221, Hamilton, New Zealand

ABSTRACT

The drinking behaviour of grazing cows was investigated in two studies with the purpose of determining the suitability of using water intake as a motivator for voluntary movement of cows within a pasture-based automatic milking system (AMS). In the first study 100 mixed-age Jersey cows in late lactation were observed for 48 h. Cows drank on average 2.4 times/24 h (range: 1-6) and usually alone or with one or two other animals. Although every cow drank at least twice during the 48 h, 31% of cows recorded an interval between drinks > 24 h. Less than 1% of drinking occurred between 2000 h and 0700 h. The second study compared the drinking behaviour of Overseas (OS) and New Zealand (NZ) Holstein Friesian cows that were either grazing pasture (GRASS) or fed a Total Mixed Ration (TMR). TMR cows drank more often (5.2 times/24 h) than GRASS cows (3.5 times/24 h, $P < 0.001$). Feed type altered the distribution of drinking with 76.8 % of TMR cows drinking between 2000 h and 0700 h compared with only 24.5% for GRASS. Water intake was also higher for TMR (73.0 L/cow/day) compared with GRASS (53.7 L/cow/day) animals. The studies showed that the individual nature of drinking behaviour would be aligned with the AMS objectives of distributed rather than batch milking. However, the small number of cows drinking during darkness when grazing indicates that water intake would need to be used in combination with other motivators to ensure a continuous flow of cows to the dairy.

Keywords: drinking behaviour; grazing; dairy cows; automatic milking.

INTRODUCTION

Recently there has been interest in incorporating automated milking (AMS) into pasture-based farming systems (Ketelaar-de Lauwere & Ipema, 2000; Ketelaar-de Lauwere *et al*., 2000; Salomonsson & Sporndly, 2000; Jago *et al*., 2002, 2004; Van Dooren *et al*., 2002; Woolford & Jago, 2002). The key to establishing a voluntary milking system is ensuring that there is a steady flow of cows to the dairy and through the AMS throughout 24 h, thereby minimising queues in front of the AMS and the need to fetch cows for milking. This is particularly challenging in a grazing environment where the feeding and resting behaviour of the herd tend to be synchronized (Hancock, 1950, 1954). Drinking, along with the other essential maintenance behaviours of grazing and resting, are activities that could be targeted as drivers of cow movement when developing a farm layout for combining automated milking within pastoral farming systems

If water is to be used as a motivating factor for cow movement in a pasture-based AMS, the time of day when drinking occurs, the frequency of drinking and the interval between drinks are all important factors to be considered along with the social behaviour associated with drinking and the distance cows will voluntarily travel to water. Despite drinking being an essential maintenance behaviour for cattle, there are few published data on the drinking patterns of grazing dairy cows during lactation in the New Zealand (NZ) pasture feeding environment. International studies have shown that drinking behaviour is dependent upon feeding patterns, ambient temperature, water quality and availability (Murphy, 1992; Albright & Arave, 1997), stage of lactation (Arave & Kilgour, 1982) and that individuals develop consistent feeding and drinking patterns over time (Melin *et al*., 2005). While it has been reported that cows drink between one and six times/day (Arnold & Dodunski, 1978) and generally during daylight hours, there appear to be few published data on the distribution of drinking or the social behaviour associated with it, for grazing lactating cows.

These studies aimed to describe the drinking behaviour of dairy cows and to determine factors influencing drinking frequency and distribution. The purpose of the studies was to determine the suitability of using water intake as a motivator for voluntary movement of cows within a pasture-based automatic milking system.

MATERIALS AND METHODS

Study One: The drinking behaviour of lactating dairy cows grazing pasture

Animals: One hundred mixed-age, late lactation Jersey dairy cows, located at Dexcel Scott Farm, were observed during two consecutive 24-h periods. Observations began when cows returned from the morning milking on Wednesday 7 February 2001. The cows were identified by ear-tags and large numbers painted on their sides. The herd grazed a new 1 ha paddock after each morning milking. Estimated pre-grazing herbage mass was 4200 and 3900 kgDM/ha, and post-grazing herbage mass was 3150 and 3000

kgDM/ha for paddocks on days one and two, respectively. Water was available *ad libitum* from a single round water trough (capacity = 585 L) positioned beneath the fence line at one end of the paddock. The herd was milked twice daily at around 0645 h and 1430 h. No water was available at the dairy.

Behaviour observations and data collection: The drinking behaviour of individual cows was observed throughout the 48 h. Observers were positioned in an adjacent paddock in a small caravan approximately 20 m from the water trough and used binoculars to determine drinking. To ensure that the presence of the caravan did not influence the cows' behaviour the caravan was parked in a paddock adjacent to the herd for two days prior to the observations to allow a period of habituation. All occurrences of drinking (defined as a cow dipping her muzzle in the water and swallowing) were recorded using continuous behaviour sampling. To determine the social behaviour associated with drinking, a 2 m area was marked out from the perimeter of the water trough and all occurrences of agonistic behaviour (threats, bunts and fights as described in Jago *et al*., 1997) recorded. When a cow left this zone then returned and drank again this was considered a separate drinking event. The number of cows standing within the 2 m zone was recorded at 2-minute intervals. The time spent within this zone during a drinking event was recorded for approximately every fifth cow to visit the water trough. Maximum and average daily air temperature, relative humidity and rainfall data were obtained from the Ruakura meteorological records. Water intake was recorded for the herd using in-line volumetric water meters.

Study Two: Effects of feed type and genotype on drinking behaviour

Animals: Behavioural observations were conducted in March 2001 at the Dexcel No 1 Dairy, Hamilton, in the third year of a four-year genotype comparison trial (described by Kolver *et al.,* 2002). Overseas (OS) and NZ Holstein-Friesian (HF) cows in late lactation (mean days in milk = 228 ± 22) were fed either a TMR diet or grazed pasture (GRASS) according to a 2 x 2 factorial design. The four treatment groups were NZ TMR (n = 14), OS TMR (n = 14), NZ GRASS (n = 14), and OS GRASS (n = 13). Each group consisted of primiparous and multiparous cows and had an equivalent age structure (4.7 ± 1.1 years; mean ± SD).

Feeding and management of the treatment groups have been described previously by Kolver *et al.* (2002) and further in Thorne *et al*. (2003). During the observation period the TMR herds were held on a 0.25 ha loafing paddock with the two genotypes separated by an electric fence, while the two pasture-fed herds were grazed in the same 1 ha paddock but separated by an electric fence. All herds were offered water *ad libitum*. The TMR herds drank from the same water trough (550 L capacity) that was accessible from both loafing areas. Similarly the pasture herds shared a water trough positioned beneath the electric fence dividing the paddock in two. Pasture-fed herds were fed *ad libitum*. During the observation period pre-grazing herbage mass was 2900 ± 450 kg DM/ha, post-grazing herbage mass was 2150 ± 450 kgDM/ha, and pasture allowance was 103 ± 17 kgDM/cow/day. The TMR herds were also fed *ad libitum*. Feed was offered once between 0800 h and 1000 h, and again between 1500 h and 1700 h. Fresh pasture breaks were offered to the GRASS herds following morning and afternoon milking. Dry matter content of the grass and TMR during the observation period was 16.5% and 49.2%, respectively. The herds were grouped together twice daily for milking at approximately 0730 h and 1530 h. No water was available at the dairy.

Behaviour observations and data collection: The four herds were observed continuously for 48 h commencing after the morning milking on 6 March, 2001. Cows were identified by ear-tags, collars and large numbers painted on their sides. Observers were situated in a caravan or van in a paddock adjacent to the herds. The following data were recorded: all occurrences of drinking; water intake for Period 2 using volumetric water meters fitted in-line for the combined GRASS herds and the combined TMR herds; rainfall, sunlight hours, maximum and average air temperature were obtained from the Ruakura meteorological records; milk solids production (MS/cow/day) and yield. The grazing, lying and standing behaviour of individual cows was also recorded at 10 minute intervals and has been reported elsewhere (Thorne *et al*., 2003).

Data analyses

Descriptive statistics were used to describe the distribution and frequency of drinking for both studies. For Study 2 data were analysed using ANOVA (GenStat, Version 6.1) to determine genotype and feeding effects on drinking frequency.

RESULTS

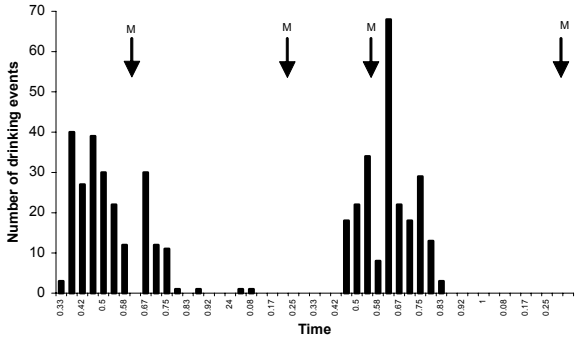
Study One

Cows drank on average 2.3 times/24 h (SD ± 1.04, range = 1-6) and 2.4 times/24 h (± 0.92, range = 1-5) times in the two 24-h periods, respectively. Figure 1 shows the distribution of drinks for the 48 h. Less than 1% of drinking occurred between 2000 h and 0700 h. There were noticeably higher incidences of drinking after the afternoon milking during both periods compared with before milking. On average cows spent 1 minute 57 seconds (± 1 minute 27seconds, range = 8

seconds to 10 minutes) in the 2 m area around the trough during a drinking event. The average number of cows standing within this zone when a cow was drinking was 1.7 and the maximum six cows.

The time interval between drinks varied widely both within and between cows. The distribution was bimodal with cows generally having one long between-drink interval and one or more shorter intervals between drinks. On average the longest drinking interval was 22:19 h (± 3:42, range = 10:33 - 30:40 h) and the mean of all other drinking intervals was 3:14 h (± 1:07, range = 0:22 - 6:01 h). Thirty-two cows recorded a maximum between-drink interval greater than 24 h. There were 30 instances of cows with a drinking interval < 1 hour, of which 16 were < 15 minutes. On these 16 occasions agonistic behaviour from other cows interrupted their drinking. Less than 5% of attempts to drink were unsuccessful due to agonistic behaviour. Mean water intake was 27 L/cow/24 h and 26 L/cow/24 h for Periods 1 and 2, respectively.

FIGURE 1: Frequency distribution of drinking events for 100 lactating dairy cows during 48 h (M = milking)



There was light rain during the afternoon of the first 24 h period of observations and heavier rain during that night. Period two was fine and sunny. Maximum air temperature was 18.1°C and 24.0°C and average air temperature was 15.0°C and 16.0°C for Periods 1 and 2, respectively. Total rainfall was 6.2 mm and 3.0 mm for Periods 1 and 2, respectively. Relative humidity was 96.9% and 97.0%, for Periods 1 and 2, respectively.

Study Two

Feed type but not genotype affected drinking behaviour with TMR cows drinking more frequently than GRASS cows (TMR = 5.2 drinks/24 h, GRASS = 3.5 drinks/24 h, SED = 0.276, $p < 0.001$). The frequency of drinking for TMR herds was consistent from Period 1 to Period 2, however GRASS cows drank less often in Period 2, compared with Period 1 (Table 1). All GRASS cows drank at least once and all TMR cows at least twice in each 24 h.

Feed type also influenced the distribution of water intake with drinking events for TMR cows more evenly distributed over the 24 h compared with the GRASS cows (Figure 2). A higher proportion of TMR cows (76.8%) drank between 2000 h and 0700 h compared with GRASS (24.5%) cows. On average TMR cows had a shorter maximum interval between drinks (10:34 h ± 0:17) than GRASS cows (15:19 h ± 0:17). All cows had a maximum between-drink interval less than 24 h. Water intake for the second period was 70.0 L/cow/24 h (21.7 L/drinking event) and 53.7 L/cow/24 h (14.9 L/drinking event) for the TMR and GRASS herds, respectively. Maximum air temperature was 24.9°C and 21.6°C, and average air temperature 19.0°C and 17.2°C for Periods 1 and 2, respectively. Relative humidity was 86.2% and 93.3% for Periods 1 and 2, respectively. There was no rainfall during either period.

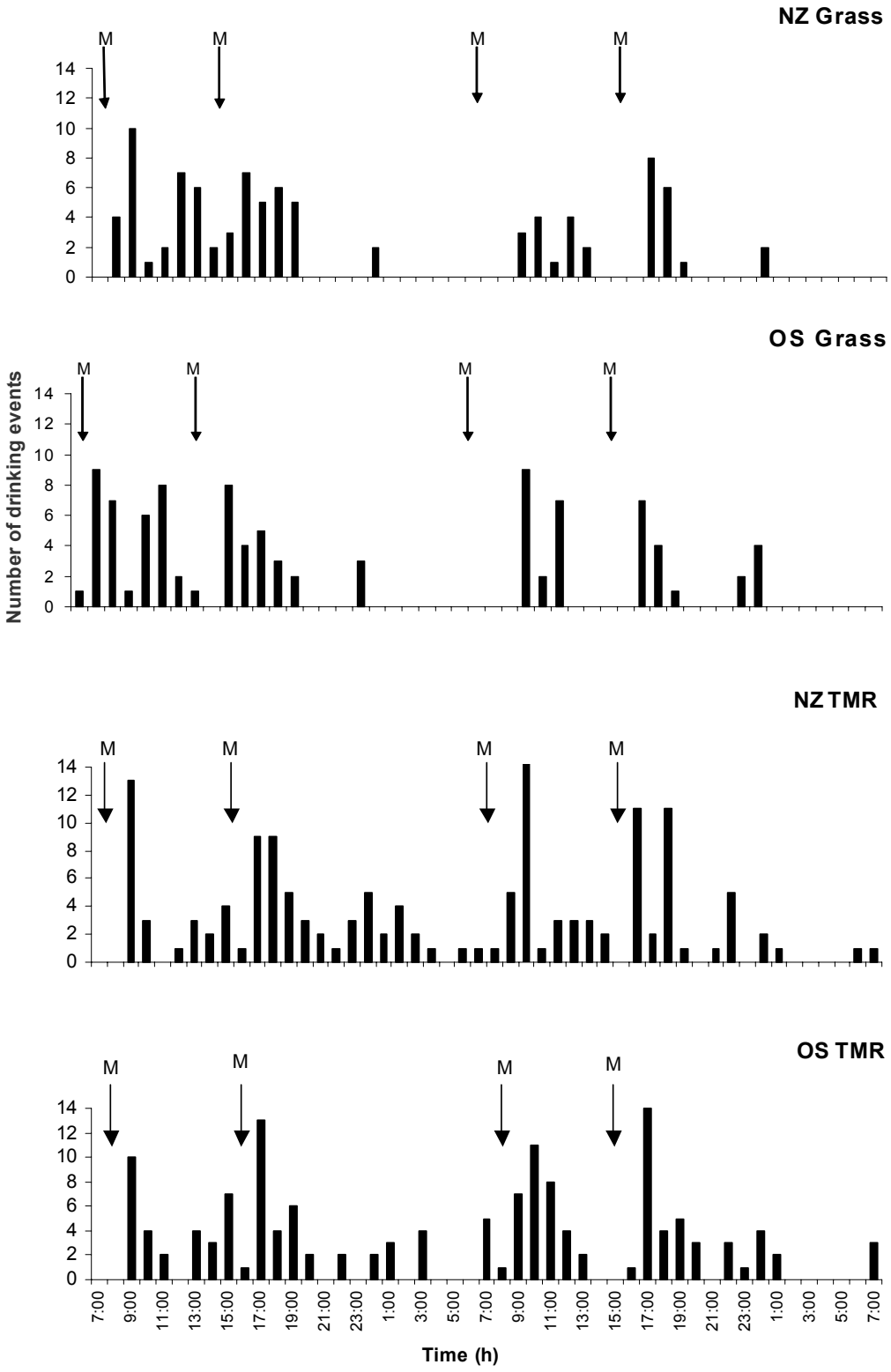
Average milk production was as follows: NZGRASS 14, NZTMR 19.8, OSGRASS 15.8 and OSTMR 30.6 kg/cow/day and milk solids production: NZGRASS 1.23, NZTMR 1.69, OSGRASS 1.24 and OSTMR 2.19 kg/cow/day.

TABLE 1: Mean (range: min-max) drinks per cow for 2 consecutive 24-hour periods[1] for cows of two genotypes (OS, NZ) fed either TMR or GRASS

	NZ		OS			P		
	Grass	**TMR**	**Grass**	**TMR**	**SED**	**Genotype**	**Diet**	**G x D**
Period 1	4.3 (2-7)	5.4 (2-9)	4.5 (2-6)	5.1 (3-7)	0.38	0.936	0.029	0.536
Period 2	2.2 (1-3)	4.9 (3-8)	2.8 (2-5)	5.2 (4-9)	0.32	0.147	<0.001	0.653
Mean	3.25	5.14	3.65	5.18	0.27	0.374	<0.001	0.503

[1] Excluding 2 hours per day for a.m. and p.m. milkings

FIGURE 2: Frequency distribution of drinking events over two 24-h periods for OS and NZ Friesians either grazing (GRASS) or fed a TMR (TMR), M = milking



DISCUSSION

As farm management systems evolve to take account of increasing herd sizes and new technologies such as automatic milking it is important to have an understanding of the behavioural and physiological needs of dairy cows. Drinking is an essential maintenance behaviour that has consequences for milk production and animal health. Utilising the strong motivation of cows to seek water is one approach when designing a cow traffic system for pasture-based AMS (Artmann, 1992; Prescott, 1995). Data from these observations have shown that one attraction of using drinking behaviour is that cows will not all try to attend the water trough at the same time, rather they space their drinking out. Both Artmann (1992) and Prescott (1995) have considered making water available when cows attended the AMS, although they did not consider the option of utilising water as an incentive to visit a pre-selection unit some distance from the robot as described by Jago *et al*. (2004), which has the advantage of greater accessibility while grazing.

As reported previously, drinking was shown to be mainly a diurnal activity for grazing cows and in these studies appears to be strongly influenced by the routine of milking and availability of fresh pasture. In contrast, drinking was not strictly a diurnal activity among cows fed a TMR with a large proportion of these cows drinking during darkness as well as daylight hours. Feeding a TMR also resulted in a higher frequency of drinking than pasture-fed cows. Observations also showed that the ingestive behaviour differed between the two feed types with TMR fed herds distributing their eating more evenly throughout the 24 h. TMR had a much higher dry matter content (49.2%) than grass (16.5%) which is likely to be the cause of the increased drinking frequency and is reflected in the higher water intake (Sekine *et al*., 1989).

Typically the behaviour of grazing cows is highly synchronized with the entire herd participating in several grazing bouts throughout 24 h (Hancock, 1954; Arnold & Dodunski, 1978). In contrast the small number of cows visiting the trough at any one time and the fact that drinking was spread fairly evenly through the day, albeit with peaks following afternoon milking, showed that cows do not all drink at the same time. The observations from these studies indicate that drinking among dairy cows appears to be something that cows do either alone or in small groups rather than as a herd. Cows would stop grazing and walk deliberately to the water trough while almost all of the rest of the herd continued to graze or rest. This pattern of behaviour is in contrast to cattle grazing large rangeland areas, which tend to drink as a group at sunset (Albright & Arave, 1997).

There was considerable variability in the drinking frequency for individual cows in both studies but this was consistent with the range of one to six drinks/day previously reported for grazing cattle (Arnold & Dudzinki, 1978). This is likely a result of a combination of herd size, position in the herd social hierarchy, milk yield and water intake. Arnold and Dudzinki (1978) reported that water intake is greater for small herds and when water availability increases. The reduction in drinking frequency in Study 2, from Period 1 to Period 2 for GRASS cows is difficult to explain as feed and environmental conditions remained similar for both days. One possibility is the increasing distance from the fresh grass to the trough as cows strip grazed the paddock. During Period 1 cows were grazing very close to the water trough (maximum distance approximately 50 m) while in Period 2 the maximum distance to the water trough doubled. Despite this increase, the distances involved were small so it seems unlikely that the reduction in drinking frequency would be due to increasing distance.

Environmental conditions will influence cows' motivation to drink. In the first study the numbers of cows visiting the trough was relatively evenly spread throughout daylight hours after morning milking (except from 0800 h to 1100 h in Period 2). The lack of drinking between 0800 h and 1100 h in Period 2 is likely to be due to the rainfall the previous night and therefore the high water content of the pasture the following morning. A sample of pasture showed that the dry matter percentage was 15.45%, indicating a high water content. Clearly, changing the type of feed for dairy cows changes their drinking patterns.

The current studies were carried out in late lactation and it would be expected that the water demands of cows early in lactation would be higher (Arave & Kilgour, 1982). It is unknown whether cows drink more frequently or simply have a higher intake per drinking event when they require more water. In this study the cows fed TMR drank more often than grass-fed cows but their water intake was less per drinking event than grass-fed cows (14.9 vs 21.7 L/drink) suggesting that the frequency of drinking is increased rather than the intake per drink.

The results have implications for the increasing number of large herds on NZ dairy farms. Flow rates must be sufficient to cope with the high demand for water after milking, particularly if walking distances are long. The relatively low frequency of drinking for exclusively grass-fed cows and the seemingly adaptable nature of water intake behaviour among cattle, raises the question of where water is provided on dairy farms. Alternative methods of watering dairy cows such as a large watering point available at the dairy post milking or along raceways, should be considered.

In conclusion, the studies showed that the daily frequency and individual nature of drinking behaviour would be aligned with the AMS objectives of distributed rather than batch milking. However the small number of cows drinking during darkness, particularly when grazing, and the significant number of cows with drinking intervals greater than 24 h indicates that water intake would need to be used in combination with other motivators to ensure a continuous flow of cows to the dairy.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the contribution of Peter Copeman, Michael de Veth, Renee Railton, and Robert Wieliczko in undertaking the behaviour obsevations for these studies and Paul Taylor and Alan Napper for animal management. This research was funded by the Agricultural Marketing and Research Development Trust and the New Zealand Dairy Board Global Research Fund.

REFERENCES

Albright, J.L.; Arave, C.W. 1997: The Behaviour of Cattle. United Kingdom, CAB International, 306 pp

Arave, C.W.; Kilgour, R. 1982: Differences in grazing and milking behaviour in high and low breeding index cows. *Proceedings of the New Zealand Society of Animal Production, 42:* 65-67

Arnold, G.W.; Dudzinki, M.L. 1978: Ethology of Free Ranging Domestic Animals. Amsterdam, Elsevier Scientific Publishing Company, 198 pp

Artmann, R. 1992: Status, results and further development of an auomatic milking system. *In*: Ipema, A.H., Lippus, A.C., Metz, J.H.M. and Rossing, W. *ed.* Prospects for automatic milking. *Proceedings of the internatioanl symposium on prospects for automatic milking*. Wageningen, Netherlands, Pudoc Scientific Publishers, pp 23-32

Hancock, J. 1950: Grazing habits of dairy cows in New Zealand. *Empire journal of experimental agriculture 18:* 249-263

Hancock, J. 1954: Uniformity trials: grazing behaviour. In: *Studies in Monozygotic Cattle Twins*. New Zealand Department of Agriculture Animal Research Division Publication Number 63. Hamilton, pp.85-122

Jago, J.G.; Bass, J. J.; Matthews, L. R. 1997: The effect of pre-pubertal immunization against gonadotrophin-releasing hormone on the development of sexual and social behaviour in bulls. *Journal of animal science 75:* 2609-2619

Jago, J.; Copeman, P.; Bright, K.; McLean, D.; Ohnstad, I.; Woolford, M. 2002: An innovative farm system combining automated milking with grazing. *Proceedings of the New Zealand Society of Animal Production 62:* 115-119

Jago, J.G., Bright, Copeman, P, Davis, K., Jackson, A. K., Ohnstad, I.; Wieliczko, R.; Woolford, M. 2004: Remote automatic selection of cows for milking in a pasture-based automatic milking system. *Proceedings of the New Zealand Society of Animal Production 64:* 241-245

Ketelaar-de Lauwere, C.C.; Ipema, A.H. 2000: Cow behaviour and welfare if grazing is combined with voluntary automatic milking. *Proceedings of the International Symposium on Robotic Milking*, The Netherlands, 17-19 August, pp 289-296

Ketelaar-de Lauwere, C.C.; Ipema, A.H.; Lokhorst, C.; Metz, J.H.M.; Noordhuizen, J.P.T.M.; Schouten, W.G.P.; Smits, A.C. 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

Kolver, E.S.; Roche, J.R.; de Veth, M.J.; Thorne, P.L.; Napper, A.R. 2002: Total mixed rations versus pasture diets: Evidence foe a genotype x diet interaction in dairy cow performance. *Proceedings of the New Zealand Society of Animal Production 62:* 246-251

Melin, M.; Wiktorsson, H.; Norell, L. 2005: Analysis of feeding patterns of dairy cows in two cow traffic situations in automatic milking systems. *Journal of dairy science 88:* 71-85

Murphy, M.R. 1992: Water metabolism of dairy cattle. *Journal of dairy science 75:* 326-333

Prescott, N.B. 1996: Dairy cow behaviour and automatic milking. Ph.D. thesis. Bristol University, UK

Salomonsson, M.; Sporndly, E. 2000: Cow behaviour at pasture with or without supplementary roughage in automatic milking systems. *In. Proceedings of the International Symposium on Robotic Milking*, Lelystad, The Netherlands, 17-19 August. pp 192-193

Sekine, J.; Morita, Z.; Oura, R.; Asahida, Y. 1989: Water drinking frequency and quantity of water drunk by steers fed hay or fresh forage. *Animal feed, science and technology 25:* 207-211

Thorne, P.; Jago, J.; Kolver, E.S.; Roche, J.R. 2003: Diet and genotype affect feeding behaviour of Holstein-Friesian dairy cows during late lactation. *Proceedings of the New Zealand Society of Animal Production 63:* 124-127

Van Dooren, H. J.; Sporndly, E.; Wiktorsson, H. 2002: Automatic milking and grazing, applied grazing strategies, EU report, www.automaticmilking.nl

Woolford, M.; Jago, J. 2002: The use of robotic milking machines in pastoral dairy systems. *Proceedings of the Massey Dairy Farmers Conference*, pp 109-11