Production responses of Jersey cows on three different feeding systems of pasture, concentrate and a total mixed ration

C.J.C. Muller# & J.A. Botha
Directorate Animal Sciences, Department of Agriculture Western Cape,
Private Bag X1, Elsenburg 7607, South Africa

Abstract

In this study the production performance of 26 multiparous Jersey cows in three production systems was compared over standard lactation periods in a year-round calving pattern. The production systems were: (1) pasture plus 3kg concentrate/cow/day (AG), (2) pasture plus 4 kg oat hay/cow/day and 6 kg concentrate/cow/day (LG) and (3) total mixed ration (TMR) fed *ad libitum* (ZG). Pasture intake of cows in systems 1 and 2 was estimated with a falling plate disc meter by using pre-and post-grazing regression equations of pasture dry matter (DM) regressed on disc meter height. Pasture intake of Jersey cows was 10.7 and 4.7 kg DM/d for the AG- and LG-systems respectively. The estimated total daily feed intake of cows in the AG-, LG- and ZG-system was 14.2, 14.7 and 15.1 kg DM respectively. Production parameters did not differ between production systems with the exception of protein percentage while protein and milk yield tended to differ. Cows in the ZG system tended to have a higher condition score at conception than cows in the other treatments. Cows in the AG and LG systems lost more live weight during the first two months of the lactation than cows in the ZG system, i.e. -21 and 16 kg *vs*. -3 kg/cow. Results indicate that the production performance of Jersey cows on pasture-based production systems with appropriate buffer feeding could be similar to cows being fed a TMR.

Keywords: Body condition score, live weight, milk yield parameters, production system
#Corresponding author: carelm@elsenburg.com

Introduction

Milk production systems in South Africa range from feedlot style zero-grazing systems using conserved roughages and high concentrate levels to pasture-based systems supplemented with varying amounts of concentrates and roughages. The general perception is that the milk yield of cows is higher in a zero-grazing system. This is related to a higher concentrate feeding level and a more constant feed intake. In the past the effect of production system on the performance of cows is often based on surveys leading to generalizations and simplifications. The differences in management level, macro- and micro-climatic conditions, and attitude of farmers regarding the genetic merit of their herds and the level of concentrates being fed are not always considered. Scott (1981) compared four production systems generally in use in the USA, Israel, parts of Europe and New Zealand. Results from this study based on average results from official surveys indicate that the cost of milk production is lower on grazed pasture in temperate climates in comparison to areas where milk is produced from crops and crop products. However, this study further showed that a pasture-based milk production system is 3 to 4 times more efficient than systems using conserved feeds even though the milk yield of cows is substantially lower. Although the pasture-based production system had a lower operating cost, the return on investment was lower.

Because the Jersey breed is growing in popularity, producers are keen to know the affect of production system on milk performance. The general perception is that Jerseys, being smaller, would be more suitable for pasture-based production systems. Studies comparing production systems have been conducted with Holstein cows usually over a relatively short period during the lactation. In such studies the effect of the production system on the reproductive performance of cows is not determined. In South Africa the effect of different concentrate feeding levels on the performance of Jerseys on pastures has been determined (Muller, 1988 and Meeske *et al*., 2006). The aim of the study was to compare the production and reproduction performance of Jersey cows in two pasture-based dairying systems to a feedlot style zero-grazing system.

Materials and Methods

Twenty six multiparous Jersey cows (mean ± SD live weight, 378 ± 38 kg; milk yield in previous lactation, 5080 ± 979 kg; parity, 1.7 ± 0.9) were used in the study. The experimental period was over a 300-day lactation period. Cows were selected from the Jersey herd at the Elsenburg Research Station of the Western Cape Department of Agriculture. Elsenburg is situated in the winter rainfall region of South Africa approximately 50 km east of Cape Town at an altitude of 177 m, longitude 18° 50' and latitude 33° 51'. The average annual rainfall in this area is 650 mm of which 70% occurs during winter from May to August. During summer very little rainfall occurs and all cultivated pastures need to be irrigated with a permanently installed irrigation system. Before the start of the experiment, cows received the same treatment in terms of feeding and housing. Primiparous cows were fed a TMR in a feedlot, while multiparous cows were on a kikuyu and grass-clover pasture supplemented with oat hay and a concentrate mixture. At the start of the experiment, Jersey cows calving down after 1 December 1991 were stratified into groups of three according to lactation number and milk yield during the previous lactation. Cows within groups were randomly allocated to one of three dietary treatments: (1) pasture plus a limited amount of concentrates/cow/day (AG), (2) pasture plus oat hay and a higher level of concentrates/cow/day (LG) and (3) a total mixed ration (TMR) fed *ad libitum* and a limited amount of oat hay/cow/day (ZG).

Cows on the AG and LG treatments were on pasture in two separate paddocks of 3 and 1 ha, respectively. The pasture in both paddocks was a mixture of white clover (*cv*. Haifa and *cv*. Tamar), red clover (*cv*. Kenland), ryegrass (*cv*. Nui) and cocksfoot (*cv*. Hera). Pasture was fertilized five times during the spring and summer at a rate of 50 kg N/ha. An irrigation system with sprinklers 15 x 15 m apart was installed permanently beforehand on each pasture to provide supplemental irrigation during summer at approximately 10 mm/hour. Pastures in both paddocks were irrigated at least twice a week for two to three hours at a time to supplement the natural rainfall. Pasture allocation in both AG and LG systems was managed daily with moveable electric fences. Pre-grazing pasture mass was used to determine the size of the grazing area. At least three times the expected pasture intake of cows was provided before grazing within each production system. This amounted to 30 and 15 kg DM per day for the AG and LG production system respectively. A fresh strip of pasture was provided after each milking, while a second poli-wire fence was used as a back-fence to prevent cows grazing pasture regrowth. When pasture growth slowed down in autumn and winter, a larger grazing area was provided to ensure that the targeted minimum amount of pasture mass was available before grazing. At the maximum rotation length (*ca* 48 days), additional oat hay was fed to cows in both the AG and LG systems as a buffer feed. During the spring flush and summer a smaller area was provided to avoid pasture wastage. A number of lactating cows was used in each paddock to maintain the prescribed stocking rate of 2 and 6 cows per ha for the AG and LG systems respectively.

Cows in the AG and LG pasture production systems received their concentrate allowances before each milking according to the guidelines recommended for farmers in South Africa by Stewart *et al*. (1995). During the first 10 weeks of the lactation period each cow in the AG system received 3.6 kg/day of a 12% CP concentrate mixture as well as 0.8 kg/day of a high-protein (38% CP) concentrate mixture. From week 11 to week 26, week 27 to week 34 and week 35 to week 43 of the lactation, each cow in the AG system received 4.0, 3.0 and 2.0 kg/day of the 12% CP concentrate mixture respectively. Cows in the LG system received during the first 10 weeks of the lactation 7.2 kg/day of a 15% CP concentrate mixture as well as 1.6 kg/day of a high-protein (38% CP) concentrate mixture. From week 11 to week 26, week 27 to week 34 and week 35 to week 43 of the lactation, each cow in the LG system received 8.0, 6.0 and 4.0 kg/day of the 15% CP concentrate mixture respectively. The total amount of concentrates that each cow in the AG and LG systems received was 1050 and 2100 kg respectively. Cows in the LG received an additional 4 kg of oat hay per cow per day throughout the lactation period. The amount of hay was increased during winter (June to August) when the pasture intake was deemed to be less than the expected pasture intake, approximately 5 kg DM/day.

A falling plate disc meter (Bransby & Tainton, 1977) was used to estimate pre- and post-grazing pasture mass. This device uses the relationship between compressed pasture height readings and pasture mass underneath the disc meter plate. The difference between the amount of pasture available before grazing and the residual material after grazing was used to determine pasture intake of cows. Once a month at least 40 disc meter height readings were taken before and after grazing on a specific 24-hour grazing strip in both the AG and LG paddocks. At each occasion and in each paddock, pasture was cut at ground level at 10 disc meter height readings after which plant material was collected, weighed and then dried at 55 ºC. From the amount of DM produced on the area covered by the plate of the disc meter and the disc meter height readings, pre- and post-grazing regression equations were obtained for each paddock. The monthly average pre- and post-grazing height readings and grazing area were used to determine the amount of available pasture before grazing and residual grazing after grazing. The pasture intake of cows was estimated for the AG and LG systems by using the difference between the amount of pasture available before grazing and residual pasture after grazing divided by the number of cows in the paddock on the day.

Cows in the ZG system were kept in a feedlot consisting of an open camp with a surface area of about 100 m² per cow and a fence-line feeding trough providing feeding space of 600 mm/cow. Manure collecting at the feed trough was removed once a year during summer. No protection was provided against solar radiation, wind and rain. A TMR consisting of lucerne and oat hay, ground wheat and maize, wheat bran, fishmeal, cottonseed oil-cake-meal, feed lime and salt providing 15.5% crude protein (CP) and 11.0 MJ ME/kg DM was provided *ad libitum* twice a day in feed troughs, while the cows were in the milking parlour. An additional 2 kg of oat hay/cow/day was also provided in the feed trough together with the TMR.

The intake of oat hay, concentrates and TMR was determined on the same day by providing weighed amounts of feeds and collecting and weighing feed refusals the next day. Samples of the feeds were collected and dried to determine the DM content. From this the daily group DM intake of cows was determined.

Samples of feeds were also collected once a month and oven-dried at 55 °C for 72 h, after which they were ground through a 1mm screen of a Wiley mill. Samples were then subjected to chemical analyses. Crude protein (CP) and crude fibre (CF) contents were analysed according to the methods of the AOAC (1984). The *in vitro* organic matter digestibility (IVOMD) was determined according to the method of Engels & Van der Merwe (1967). The methods of Van Soest (1983) and Van Soest & Wine (1967) were used to determine the acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents of the crude fibre fraction.

Cows were milked twice a day in a milking parlour. The milk production and milk composition of cows in the three production systems were recorded according to standard milk recording procedures. The total daily milk yield of each cow that was at least five days in milk was recorded every five weeks. Milk samples of each cow were collected at the evening and following morning's milking, composited and analysed for fat, protein and lactose concentrations with a MilkoScan Infrared Analyser in the central laboratory of the South African Milk Recording Scheme (De Waal & Heydenrych, 2001).

Cows were weighed and condition scored within seven days after calving and then once a month during the lactation period. Condition scoring was by the tail-head method as described by Mulvany (1977). Cows were observed daily for signs of heat. Artificial insemination started 60 days into the lactation period. Cows not conceiving after three inseminations were put with a bull when observed on heat. Pregnancy diagnosis was by rectal palpation by a veterinarian about six weeks after last insemination. Reproduction parameters such as the number of days from calving date to first insemination date, the number of days from calving date to conception date and the number of inseminations (including services by a bull) per conception were recorded for each cow in the three production systems. Body weight and condition score of cows at conception were determined by linear interpolation from monthly recordings of live weight and condition score.

Animals were treated as replicates in the analyses of all data (Wilkins *et al*., 1995). It was judged that cows in all systems had *ad libitum* access to feeds with no unusual competition for feed. Milk yield parameters were adjusted by analysis of co-variance for yield and composition measured over a previously completed lactation. Other parameters were analysed according to one-way analysis of variance by the Statgraphics statistical programme (1993).

Results and discussion

This study reports on the production performance of Jersey cows in different production systems which included pasture based systems. Similar to Fisher *et al*. (1996) treatments were not replicated. This is mainly due to the expense and logistical problems of pasture based experiments. Results of pasture characteristics should therefore be treated with caution. The mean chemical composition of the TMR, oat hay and pasture available to cows in the AG and LG systems is presented in Table 1. Pasture quality in both pasture paddocks was comparable although higher values for CP, ME and IVOMD were observed for pasture in the LG system. Values for CF, ADF and NDF were, however, lower. While relatively high CP concentrations and IVOMD were found, CP levels were lower than those obtained by Meeske *et al*. (2006) in the Southern Cape region of South Africa on ryegrass-clover pasture (*ca* 19.0% *vs* 22.6%). This is probably because of different fertilization programmes and pasture types. Other parameters such as ME, ADF and NDF were similar. Oat hay typically has lower CP and ME values in comparison to most cultivated pastures. Feeding additional oat hay in the LG system would therefore have a diluting effect on the pasture component of the diet requiring a higher concentrate level with a higher protein and energy content than for the AG system.

Table 1 The average (±SD) chemical composition of the total mixed ration (TMR), oat hay and pasture offered before grazing in the *ad libitum* (AG) and limited grazing (LG) paddocks. (Values in the table are on a DM basis).

Parameters	TMR	Oat hay	Pasture AG	Pasture LG
DM at sampling (%)	91.6±1.3	92.8±1.5	20.9±3.4	17.7±4.0
Crude protein (%)	15.3±1.1	6.6±3.5	18.7±3.1	19.5±4.8
Metabolisable energy (MJ/kg DM)	11.4±0.9	8.6±1.3	11.0±0.8	11.6±1.0
Organic matter digestibility (%)	75.5±6.0	56.9±9.0	72.9±5.5	76.7±6.6
Crude fibre (%)	18.1±2.4	35.1±6.4	22.8±3.5	21.5±3.8
Acid detergent fibre (%)	25.8±5.3	48.6±1.4	31.0±3.9	28.0±4.3
Neutral detergent fibre (%)	35.6±7.2	66.3±5.6	49.1±9.0	43.9±8.3
Calcium (%)	0.57±0.09	0.19±0.06	0.76±0.23	0.83±0.19
Phosphorus (%)	0.38±0.06	0.17±0.05	0.37±0.06	0.40±0.07

Regression equations of pasture DM production on disc meter height readings for pre- and post-grazing pasture for the AG and LG paddocks were as follows:

1. AG: Pre-grazing: $y = 1925 + (174±21)x$; $R^2=0.76$ and post-grazing: $y = 1401 + (173±49)x$; $R^2=0.41$
2. LG: Pre-grazing: $y = 1322 + (217±19)x$; $R^2=0.86$ and post-grazing: $y = 1408 + (155±26)x$; $R^2=0.71$ where y = pasture mass (kg DM/ha) and x = falling plate disc meter height (cm).

Table 2 Average (±SD) parameters concerning pasture intake and pasture utilization of Jersey cows in the *ad libtum* (AG) and limited grazing (LG) systems

Pasture parameters	Pasture system AG	Pasture system LG
Pre-grazing falling plate height (cm)	5.9±2.3	6.3±2.0
Post-grazing falling plate height (cm)	3.4±0.9	3.6±1.0
Grazing area/day (m²/cow)	115±47	52±27
Estimate pasture available (kg DM/cow/day)	30.4±10.6	14.8±8.0
Estimated residual pasture (kg DM/cow/day)	19.7±8.4	10.1±6.1
Estimated pasture intake (kg DM/cow/day)	10.7±3.1	4.7±2.6
Pasture utilization (%)	37.4±7.5	30.8±6.1

Equations in both paddocks were similar with the post-grazing equations showing larger variations because of uneven utilization of pasture by cows. Pre- and post-grazing disc meter height readings were similar in both grazing paddocks (Table 2). A larger grazing area was provided in the AG-paddock because of the expected higher pasture intake of cows in this system in comparison to the pasture intake of cows in the

LG-paddock. The utilization of pasture seems to be low, i.e. 35.2 and 31.8% for AG and LG respectively. This is probably related to the way regression equations were established. All pasture material under the disc meter plate was removed to ground level. In more recent studies, pasture material is cut at about 5 cm leave height. It is well known that cows do not graze pasture lower than about 5 cm.

Different ways of measuring pasture height have been used in past studies making it difficult to compare pasture height readings. Compressed pasture height readings would be lower than pasture height readings based on a rising plate meter or a pasture stick. Similar to other studies (e.g. Meijs & Hoekstra, 1984), there was a strong positive relationship (P <0.01) between the amount of pasture available before grazing and pasture intake of cows in both paddocks. Pyraud *et al*. (1996) also found that pasture organic matter intake increased quadratically (R^2 = 0.60) with daily pasture allowance. Fisher *et al*. (1996) showed that sward type significantly (P <0.05) affected herbage intake of Holstein-Friesian cows being 14.5 and 11.6 kg DM/day on high and low tiller density perennial ryegrass pasture, respectively. Peyraud *et al*. (1996) found in a study with Holstein cows that herbage organic matter intake and fat corrected milk yield tended to increase when the daily herbage allowance increased from low to medium levels. Herbage organic matter intake increased in a quadratic manner for low, medium and high daily herbage allowance. Similarly, Spörndly & Burstedt (1996) found that herbage intake increased by 0.8 kg organic matter per cm increase in sward height. Herbage intake was lower at pasture heights below 9 cm. The daily herbage organic matter intake of cows weighing 546 kg on average was 12.8, 12.3 and 10.2 kg OM/cow. Stockdale (1997) showed that feeding supplements such as maize silage and cottonseed meal to Friesian cows grazing white clover pasture reduces pasture intake and therefore pasture utilization. In the present study the expected pasture intake of Jersey cows was lower because of supplemental feeds such as oat hay and a higher level of concentrate feeding. Holmes (1987) noted that daily herbage allowances of 26 and 22 kg DM/cow affected some degree of intake restriction on cows.

In Tasmania, Michell & Fulkerson (1987) found that Friesian cows in two farmlets removed only 20 to 30% of the green herbage available before grazing. Cows on a high grazing intensity (stocking rates of 3.4 milking cows/ha) removed a higher proportion of available green leaf material than cows on a low grazing intensity (stocking rate of 1.9 milking cows/ha). In that study the total daily herbage intake of cows was 12.2 and 11.3 kg herbage DM/cow at low and high grazing intensity during spring. During summer total daily herbage intake was 7.4 and 9.1 kg herbage DM/cow at low and high grazing intensity respectively. In the present study the stocking rate was about 2 and 6 Jersey cows/ha on the AG and LG systems respectively. These results also confirm that cows are not able to graze pasture below a minimum plate height. Meijs & Hoekstra (1984) found that Holstein cows, consume only small amounts of pasture in the 4.5 to 7 cm leaf height layer of pasture. On a short growing pasture, sufficient amounts of pasture can only be provided by enlarging the grazing area. In the present study the amount of pasture available before grazing in both paddocks was at least three times the amount of estimated pasture intake. This is in contrast to general recommendations such as Combellas & Hodgson (1979) that double the expected pasture intake should be provided before grazing. The reason for the difference in the amount of pasture available was because regression equations were based on pasture harvested to ground level. In other studies pasture is cut at a 5 cm stubble height (Reeves *et al*., 1996). Wilkins *et al*. (1995) showed that the daily milk yield of New Zealand-Friesian cows was reduced more rapidly under a compressed sward height of 4.5 cm in comparison to a 6 cm sward height. This trend would appear to be the result of a reduction in the quantity rather than the quality of herbage consumed. Le Du *et al*. (1981) also suggested that a reduction in sward height would reduce the cow's daily pasture intake.

Animals used in the study were from the same research herd managed by the same workers. Production systems were managed as separate groups. No management biases should favour a specific production system over another. It was, however, unexpected that production parameters, with the exception of protein percentage, did not differ (P >0.05) between production systems. The milk yield of cows on the pasture-based systems tended (P = 0.11) to be higher than the milk yield of cows receiving a TMR. This in contrast to other studies showing higher milk yields for cows on a TMR vs pasture-based systems. Bargo *et al*. (2002) found that Holsteins on a TMR produced 33% and 19% more milk (P <0.05) than similar cows on a pasture plus concentrate diet and pasture plus TMR diet, respectively. The pasture consisted of 50% smooth bromegrass (*Bromus inermis*), 33% orchardgrass (*Dactylis glomerata*) and 7% Kentucky bluegrass (*Poa pratensis*) and 10% weeds and dead material. White (2000) similarly found that the milk yield of Holstein and Jersey cows in a TMR-based feeding system was 7.9% and 12.9% respectively higher than cows in a pasture-based system. No information is provided on the pasture management in the study.

Vaughan *et al*. (1993), in a short term study of 98 days, found that Holstein cows grazing lucerne pasture and cows grazing a mixed lucerne-red clover-orchard grass-smooth brome grass pasture performed similarly to cows in a confinement feeding system with lucerne silage fed *ad libitum* as forage source. Only milk fat percentages for multiparous cows in the confinement group differed between treatments. Kabiligi *et al*. (1996) also found that lactating Holstein cows receiving maize silage and concentrates in a dry-lot system tended (P <0.10) to gain more weight during some seasons, but did not consistently produce more actual milk and 3.5% fat corrected milk than cows grazing fescue pastures. Vilela *et al*. (1995) found in a study in Brazil that cows in a free-stall housing system that were fed a complete diet consisting of maize silage and concentrates *ad libitum* produced more (P <0.10) 4% fat corrected milk (21.4 vs 18.6 kg/day) over a 294 day period to cows grazing only lucerne. Polan *et al*. (1986) found that the milk production of Holstein cows consuming pasture and 7 to 8 kg of a concentrate mixture was similar to cows receiving a TMR. The milk yield of high producing cows was reduced when the diet was changed from TMR to pasture; however, the difference was not significant.

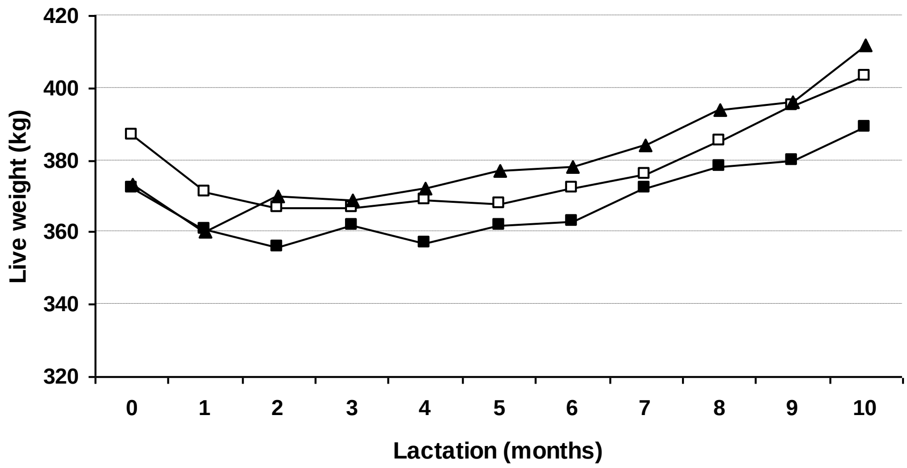
Table 3 The average (±SE) production parameters of Jersey cows in the *ad libitum* grazing (AG), limited grazing (LG) and feedlot (ZG) production systems (*P*: Significance level; SEM: Standard error of mean)

Production parameters	Production system			SEM	*P*
	AG	LG	ZG		
Number of cows	10	8	8	-	-
Lactation number	2.8±0.3	3.0±0.3	2.3±0.3	0.2	0.25
Milk yield (kg/cow)	5634±125	5963±142	5537±139	77	0.11
Fat yield (kg/cow)	236±6	240±6	230±6	4	0.56
Fat (%)	4.19±0.07	4.06±0.08	4.14±0.08	0.05	0.54
Protein yield (kg/cow)	195±4	210±4	198±4	2	0.06
Protein (%)	3.44±0.04	3.55±0.04	3.59±0.04	0.02	0.05

The milk yield of cows in different production systems at farm level depends on a number of factors, i.e. the genetic potential of cows and quality of feed. In this study the number of cows used in the study was small while cows in the ZG system were, in absolute terms, younger (although at P >0.05) than cows in the other groups. The small difference in production level could probably further be explained by comparing the estimated daily feed intake of cows in the three production systems (Table 4). From this it appears that the total daily feed and ME intakes was very similar, i.e. 14.3 to 15.1 kg DM/cow/day while the CP intake of cows in the ZG system was lower than for cows in the pasture-based systems. This could have resulted in a reduced milk yield for the ZG cows. The total DM intake of cows in all the treatments was approximately 3.4 to 3.6% of live weight. This is in accordance with NRC (1989) requirements as the expected daily feed intake of cows weighing 400 kg and producing 20 kg milk/day at 4% fat should be 14.4 kg DM/day. Muller & Botha (1998) found, however, that Jersey cows consumed 14.1 kg DM per day of a TMR which is equivalent to 4.0% of live weight.

The change in live weight and condition score of cows in the different production systems is presented in Figure 1. As expected, cows lost weight after calving with cows on the pasture based feeding programmes losing more live weight (P <0.05) during the first two months of the lactation than cows receiving a TMR in the ZG system, i.e. -21 and -16 vs -3 kg/cow. Cows in the ZG system showed little change in condition score after calving and an increase in condition score after 5 months in milk. Cows in the pasture based systems lost more condition after calving and recovered only some of their body reserves towards the end of the lactation. While the live weight of cows in the different feeding programmes did not differ at conception (P >0.05), condition score of cows in the ZG system was higher (P <0.05) than that of cows in the AG and LG feeding systems, i.e. condition scores of 2.9, 2.2 and 2.1 respectively.

(a)



(b)

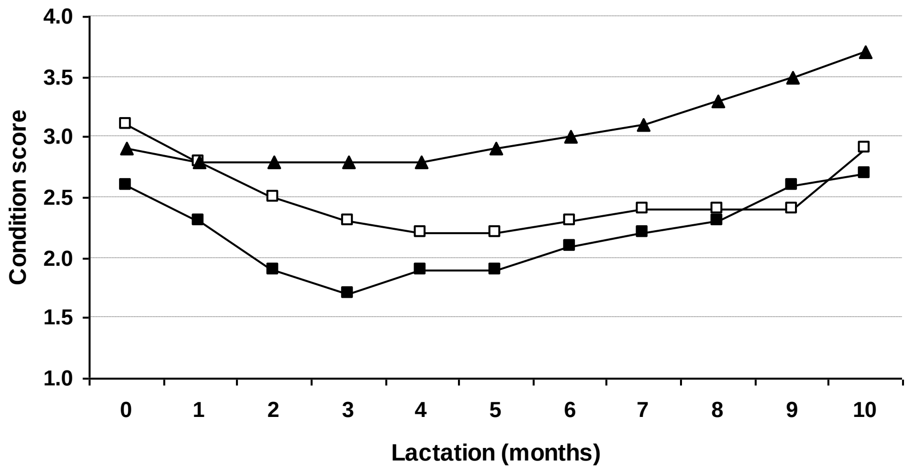


Figure 1 The change in (a) live weight and (b) condition score over a lactation period starting one week post calving of Jersey cows receiving different diets, i.e. *ad libitum* grazing plus 3 kg concentrates/cow/day (□), *ad libitum* grazing plus 4 kg oat hay/cow/day and 6 kg concentrates /cow/day (■) and total mixed ration fed *ad libitum* daily (▲)

Reproduction parameters (Table 5) did not differ (P >0.05) between production systems with the exception of the interval from calving to first heat that tended to differ (P = 0.08). Washburn *et al*. (2002) also found no significant differences in reproductive parameters for Jersey cows in confinement or pasture based systems. In that study first service conception was 60% for confinement and 59% for pasture based Jersey cows. In the present trial first service conception varied from 20% to 25%. While 63% of cows in the TMR

Table 4 The estimated daily feed intake of Jersey cows in three production systems, i.e. *ad libitum* grazing plus 3 kg concentrates/cow/day (AG), *ad libtum* grazing plus 4 kg oat hay/cow/day and 6 kg concentrates/cow/day (LG) and a total mixed ration fed *ad libitum* daily (ZG)

	Production system (kg DM/cow/day)		
Feeds	AG	LG	ZG
Pasture	10.7	4.7	-
Oat hay	0.4	3.7	1.4
Concentrate 12% CP	3.03	-	-
Concentrate 15% CP	-	6..06	-
High protein concentrate (38% CP)	0.18	0.36	-
Total mixed ration	-	-	13.7
Total daily feed intake	14.3	14.8	15.1
Crude protein intake (kg/cow/day)	2.494	2.290	2.188
Metabolisable energy (MJ/cow/day)	148.5	158.0	159.7

based production system conceived within 75 days after calving, the number of days from calving toconception (days open) for cows in this production system was similar to days open for cows in the other production systems. The small number of cows in the three systems probably affected reproduction results. The percentage of cows conceiving within 100 days after calving ranged from 50% to 63% for cows in the pasture and TMR based production systems. Polan *et al*. (1986) found that although the milk yield of Holstein cows receiving a TMR in comparison to pasture and a concentrate mixture was similar, cows on the TMR were heavier with a higher condition score than pasture based cows. The increases in body weight of cows in the different production systems were similar.

Table 5 The average (± SE) reproduction parameters, live weight and condition score of Jersey cows receiving different diets, i.e. *ad libitum* grazing plus 3 kg concentrates/cow/day (AG), *ad libitum* grazing plus 4 kg oat hay/cow/day and 6 kg concentrates/cow/day (LG) and total mixed ration fed *ad libitum* daily (ZG). (*P*: Significance level; SEM: Standard error of mean; [a,b]Values with different superscripts differ at $P < 0.05$).

	Production system				
Parameters	AG	LG	ZG	SEM	*P*
Number of cows	10	8	8	-	
Interval calving to first heat (days)	35±6	56±6	44±6	4	0.08
Interval calving to conception (days)	118±25	144±28	121±28	16	0.77
Number of insemination per conception	3.00±0.56	3.12±0.63	2.50±0.63	0.35	0.76
Live weight at conception (kg)	366±13	367±15	375±15	8	0.89
Condition score at conception	2.20±0.23	2.12±0.26	2.87±0.26	0.14	0.10
Live weight one week post-calving (kg)	387±12	372±14	373±14	8	0.65
Live weight change calving to 2 months in milk (kg)	-21±3[a]	-16±4[a]	-3±4[b]	2	0.01
Condition score one week post-calving	3.10±0.17	2.62±0.19	2.91±0.19	0.11	0.19
Condition score calving to 2 months in milk	-0.65±0.17	-0.72±0.20	-0.16±0.20	0.11	0.10

In the present study Jersey cows performed similarly in two pasture based and a zero-grazing production system. Washburn *et al*. (2002) reported similar results for Jerseys in a pasture based system in comparison to a confinement system. According to Bargo *et al*. (2002) energy is the primary limiting nutrient for high producing dairy cows on pasture. Kolver & Muller (1998) showed that Holstein cows produce less milk from cultivated pasture alone than from a nutritionally balanced TMR, i.e. 29.6 *vs* 44.1 kg/d. This was mainly due to a lower energy intake because of a lower DM intake (19.0 vs 23.4 kg/d). Further studies have shown that supplementing pasture with 8 to 9 kg/d of corn-based concentrates increases total DM intake while sustaining a milk yield of about 30 kg/d (Bargo *et al*., 2002; Soriano *et al*., 2000). In the present study the estimated daily DM and energy intake of cows in the different production system were similar.

Conclusions

Production parameters, with the exception of protein percentage, did not differ between production systems. This is probably related to the small number of cows in the study. Although the estimated daily feed intake of cows in the different production systems was similar, cows in both pasture-based systems lost more weight and had lower condition scores at two months after calving than cows receiving a TMR. However, the CP intake of cows in the ZG system was lower. This could have affected the milk yield of these cows. Cows on the TMR diet showed a substantial increase in condition score towards the end of the lactation period. Although the absolute number of days from calving to first insemination was higher and the interval from calving to conception was longer for cows in the LG feeding system, differences in reproduction parameters did not differ between treatments. The utilization of pasture in the AG and LG systems was low, i.e. 37 and 31%, respectively. This is in accordance with other research results and is probably related to the way available and residual pasture material pre- and post-grazing was determined. Results indicate that the production performance of Jersey cows on pasture-based production systems with appropriate buffer feeding could be similar to cows being fed a TMR.

Acknowledgement

The help of Mr A. Shipman and his staff in the caring, milking and managing of the experimental animals is greatly appreciated.

References

AOAC. 1984. Official methods of analysis (14th ed.). Association of Official Analytical Chemists. Washington DC, USA.

Bargo, F., Muller, L.D., Delahoy, J.E. & Cassidy, T.W., 2002. Performance of high producing dairy cows with three different feeding systems combining pasture and total mixed rations. J. Dairy Sci. 85, 2948-2963.

Bransby, D.J. & Tainton, N.M., 1977. The disc pasture meter: possible applications in grazing management.Proc. Grassl. Soc. Southern Africa. 12, 115-118.

Combellas, J. & Hodgson, J., 1979. Herbage intake and milk production by grazing dairy cows. 1. The effects of variation in herbage mass and daily herbage allowance in a short-term trial. Grass & Forage Sci. 34, 209-214.

De Waal, H. & Heydenrych, H.J., 2001. The effect of sampling frequency on the accuracy of estimates of milk-fat yields of dairy cows. S.Afr. J. Anim.Sci. 31, 9-11.

Engels, E.A.N. & Van der Merwe, F.J., 1967. Application of an *in vitro* technique to South African forages, with special references to the effect of certain factors to the results. S. Afr. J. Agric. Res. 10, 983-995.

Fisher, G.E., Dowdeswell, A.M. & Perrott, G., 1996. The effects of sward characteristics and supplement type on the herbage intake and milk production of summer-calving cows. Grass & For. Sci. 51, 121-130.

Holmes, C.W., 1987. Pastures for dairy cows. In: Nichol, A.M. (ed.) Livestock feeding on pasture. pp. 133-143. Occasional publication No. 10, New Zealand Society of Animal Production.

Kabiligi, J.F., Moss, B.R., Bransby, D.I., Holliman, J.L. & Lin, J.C., 1996. AU Triumph, Johnstone and Kentucky 31 tall fescue pastures versus maize silage in diets for lactating dairy cattle. Afr. J. Range & For. Sci. 13, 9-14.

Kolver, E. S. & Muller, L.D., 1998. Performance and nutrient intake of high producing Holstein cows consuming pasture or a total mixed ration. J. Dairy Sci. 81,1403-1411.

Le Du, Y.L.P., Baker, R.D. & Newberry, R.D., 1981. Herbage intake and milk production by grazing dairy cows. 3. The effect of grazing severity under continuous stocking rate. Grass & For. Sci. 36, 307-318.

Meeske, R., Rothauge, A., Van der Merwe, G.D. & Greyling, J.F., 2006. The effect of concentrate supplementation on the productivity of Jersey cows on a pasture based system. S.A. J. Anim. Sci. 36, 105-110.

Meijs, J.A.C. & Hoekstra, J.A., 1984. Concentrate supplementation of grazing dairy cows. 1. Effect of concentrate intake and herbage allowance on herbage intake. Grass & For. Sci. 39, 59-66.

Michell, P. & Fulkerson, W.J., 1987. Effect of grazing intensity in spring on pasture growth, composition and digestibility and on milk production by dairy cows. Austr. J. Exp. Agric. 27, 35-40.

Muller, C.J.C., 1988. Die invloed van verskillende kragvoerpeile op die melkproduksie, melksamestelling en winsgewendheid van Jerseykoeie in die George-omgewing. Els. J. 1, 10-13.

Muller, C.J.C. & Botha, J.A., 1998. The comparative performance of primiparous Holstein Friesland and Jersey cows on complete diets during summer in a temperate climate. S.A. J. Anim. Sci. 28, 161-166.

Mulvaney, P., 1977. Dairy cow condition scoring. NIRD Paper no. 4468. National Institute in Dairying. Shinfield. Reading UK.

National Research Council, 1989. Nutrient requirements of dairy cattle. National Academy Press, Washington DC, USA.

Peyraud, J.L., Comeron, E.A., Wade, M.H. & Lemaire, G., 1996. The effect of daily herbage allowance, herbage mass and animal factors upon herbage intake by grazing dairy cows. (Abstr.) Nutr. Abstr. and Rev. (Series B). 66 (9), 599.

Polan, C.E., Blaser, R.E., Miller, C.N. & Wolf, D.D., 1986. Utilization of pasture by lactating cows. J. Dairy Sci. 69, 1604-1612.

Reeves, M., Fulkerson, W.J., Kellaway, R.C. & Dove, H., 1966. A comparison of three techniques to determine the herbage intake of dairy cows grazing kikuyu (*Pennisetum clandestinum*) pasture. Aust. J. Exp.Agric. 36, 23-30.

Scott, J.D.J., 1981. Efficiency of dairying under contrasting feeding and management systems in North America, Israel, Europe and New Zealand. Proc. XIV Intern. Grassl. Con. Kentucky, USA. Ed. By J.A. Smith & V.W. Hays. Westview Press, Boulder. Colorado. pp: 843-846.

Soriano, F.D., Polan, C.E. & Miller, C.N., 2000. Milk production and composition, rumen fermentation parameters, and grazing behavior of dairy cows supplemented with different forms and amounts of corn grain. J. Dairy Sci. 83, 1520-1529.

Spörndly, E. & Burstedt, E., 1996. Effects of sward height and season on herbage intake of strip-grazed dairy cows. Nutr. Abstr. & Rev. (Series B) 66 (9), 599.

Statgraphics, 1993. Statistical Graphics System. Statistical Graphics Corporation Incl. 2115 East Jefferson Street, Rockville, MD 20852, USA.

Stewart, P.G., Jones, R.I. & Dugmore, T.J., 1995. Practical feeding of the dairy cow. Chap. 5.4 from Dairying in Kwazulu-Natal. Department of Agriculture: Kwazulu-Natal, Pietermaritzburg, South Africa.

Stockdale, C.R., 1997. Influence of energy and protein supplements on the productivity of dairy cows grazing white clover swards in spring. Austr. J. Exp. Agric. 37, 151-157.

Van Soest, P.J., 1983. The use of detergents in the analysis of fibrous feeds. II. A rapid method of the determination of fibre and lignin. J. Assoc. Off. Anal. Chem. 46, 82-85.

Van Soest, P.J. & Wine, R.H., 1967. Use of detergents in the analysis of plant cell wall constituents. J. Assoc. Official. Anal. Chem. 50, 50-55.

Vaughan, K.K., Combs, D.K. & Albrecht, K.A., 1993. Production and milk composition of cows on an intensive rotational grazing system versus a confinement stored forage system. [Abstr.] Dairy Sci. Abstr. 55(6), 399.

Vilela, D., Cóser, A.A., Pires, M. de F.A., Malonado, H.V., de Campos, O.F., Liziere, R.S., Resende, J.C. & Matins, C.E., 1995. Comparison of a system of rotational grazing of alfalfa (*Medicago sativa*) with a system of total confinement of dairy cattle. Dairy Sci. Abstr. 57, 935.

Washburn, S.P., White, S.L., Green, J.T. (Jr) & Benson, G.A., 2002. Reproduction, mastitis, and body condition of seasonally calved Holstein and Jersey cows in confinement or pasture systems. J. Dairy Sci. 85, 105-111.

White, S. L., 2000. Investigation of pasture and confinement dairy feeding systems using Jersey and Holstein cattle. M.Sc-thesis. Graduate Faculty of North Carolina State University. Raleigh, NC 27695. USA.

Wilkins, R.J., Gibb, M.J. & Huckle, C.A., 1995. Lactation performance of spring-calving dairy cows grazing mixed perennial ryegrass/white clover swards of differing composition and height. Grass & Forage Sci. 50, 199-208.