PRODUCTION AND REPRODUCTION PERFORMANCE OF JERSEY AND FLECKVIEH × JERSEY COWS IN A PASTURE-BASED SYSTEM

by

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DECLARATION

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Date: April 2014

Abstract

Production and reproduction performance of Jersey and Fleckvieh × Jersey cows in a pasture-based system

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Genetic selection for high milk production, type and appearance for the last 50 years has suppressed secondary traits such as reproductive performance, productive life, health and survivability in the pure milk breeds. The economic importance of these secondary traits in dairy production systems is the basis for the interest seen in crossbreeding. The problem of growth rate of heifers, cow fertility, reduced disease resistance and small body frame for beef production in Jerseys can be improved by crossing Jerseys with dual purpose breeds, such as Fleckviehs which possess a more beef potential. Against this background, this study aimed at comparing the production and reproduction of Jersey and Fleckvieh × Jersey cows in a pasture-based system.

Milk recording was done according to standard milk recording procedures. Milk production (milk, fat, and protein yield) was adjusted to 305 days of lactation and corrected for age at calving. Effects of breed, parity, month and year were estimated for milk, fat and protein yield as well as fat and protein percentage using general linear models procedure. The fixed effects identified as having significant effects on milk, fat and protein yield were breed, parity and year. F×J cows produced significantly more milk than J cows (6141 ± 102 vs. 5398 ± 95 kg milk). Protein and fat yield were significantly higher in F×J (201 ± 3 and 272 ± 4 kg, respectively) than in J cows (194 ± 2 and 246 ± 3 kg, respectively). There percentages of fat and protein differed slightly between the two breeds with the Jersey recording slightly higher percentages (4.61 ± 0.04 and 3.62 ± 0.03 %, respectively) compared to the F×J cows' percentages, which were, respectively, 4.47 ± 0.04 and 3.51 ± 0.03 %. It was concluded that F×J crossbred cows were more productive than purebred J cows probably owing to heterotic effects.

Heifers were inseminated at 13 months of age and cows 40 days post-calving. Using insemination records and pregnancy check results, fertility traits were analyzed and compared between the two breeds, using analysis of variance for continuous records. Conception age was the same for both breeds resulting in a similar age at first calving. For cows, the interval from calving to first insemination was significantly shorter (P <0.001) in crossbred cows being 76.7 ± 2.2 days compared to 82.4 ± 2.5 days for purebreds. A larger proportion (P < 0.001) of 0.70 for crossbred cows was inseminated within 80 days after calving compared to 0.54 for J cows. Although the absolute number of days between calving and conception (DO) was lower for F×J cows in comparison to J cows (104.8 ± 6.8 vs. 114.8 ± 8.1days, respectively), the difference was not significant. However, the proportion of F×J cows confirmed pregnant by 100 days in milk was 0.79, which was higher (P < 0.001) than the 0.66 for J cows. Results indicate the potential of improving reproductive performance of J cows through crossing with dual-purpose breeds.

The beef production of purebred J and Fleckvieh x Jersey (F×J) bull calves was compared, where bull calves were reared similarly for veal, i.e. carcass weight not exceeding 100 kg, or as steers for beef to 21 months of age. In both the veal and steer production systems, the mean birth weight were higher (P < 0.001) for crossbred in comparison to J calves and steers (33.5 ± 1.2 kg vs. 27.9 ± 1.2 kg for veal) and (33.4 ± 0.9 kg vs. 26.9 ± 0.9 kg for steers) respectively. The live weight at 6 months of age was 163.5 ± 3.9 kg for J bull calves, which was lower (P < 0.001) than that for F×J bull calves (180.6 ±

4.0 kg). The F×J bull calves had a significantly higher average daily gain (ADG) of 0.82 ± 0.02 kg/day compared to 0.73 ± 0.02 kg/day for J bulls. Marketing age differed ($P < 0.001$) in the veal production system with F×J and J bull calves marketed at 7.1 ± 0.1 and 6.3 ± 0.1 months, respectively. End live weight at 21 months of age was significantly higher ($P < 0.001$) in F×J bulls (441.4 ± 14.9 kg) than the 322.6 ± 13.4 kg in J bulls; while ADG differed ($P < 0.001$) between the two breeds being 0.64 ± 0.02 and 0.46 ± 0.0 kg/day in F×J and J bull calves, respectively. Crossbred steers had a significantly higher carcass of 206.5 ± 8.9 kg compared to 157.9 ± 8.6 kg for J steers. Results indicate the potential of improving beef production characteristics of the J cattle through crossbreeding.

Opsomming

Produksie en reproduksie prestasie van Jersey en Fleckvieh × Jersey koeie in 'n weidings-baseerde sisteem

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Genetiese seleksie vir hoë melkproduksie, tipe en voorkoms die afgelope 50 jaar het sekondêre eienskappe soos reproduksie, produktiewe lewe, gesondheid en oorlewing onderdruk in die suiwer melk rasse. Die ekonomiese belangrikheid van hierdie sekondêre eienskappe in melkproduksie stelsels is die basis vir kruisteling. Probleme soos groei tempo van verse, koei vrugbaarheid, verlaagde weerstandbiedenheid teen siektes en klein liggaam raam vir vleisproduksie in Jerseys kan verbeter word deur die kruising van Jerseys met ' n dubbele doel rasse, soos Fleckviehs wat beskik oor beter vleis potensiaal. Teen hierdie agtergrond, is hierdie studie daarop gemik om produksie en reproduksie van Jersey en Fleckvieh x Jersey koeie in 'n weiveld - gebaseerde stelsel te vergelyk.

Melk opname is gedoen volgens standaard melkaantekening prosedures. Melkproduksie (melk-, vet- en proteïen opbrengs) was aangepas vir 305 dae van laktasie en gekorrigeer vir kalf ouderdom. 'n Algemene lineêre model was gebruik om die effekte van ras, pariteit , maand en jaar op melk-, vet- en proteïen opbrengs sowel as vet- en proteïen persentasie te bepaal. Die vaste effekte geïdentifiseer met 'n beduidende effek op melk-, vet- en proteïen opbrengs was ras, pariteit en jaar. F × J koeie het aansienlik meer melk as J koeie (6141 ± 102 teen 5398 ± 95 kg melk) produseer . Vet opbrengs was aansienlik hoër in F × J koeie as in J koeie (272 ± 4 246 teen ± 3 kg vet). Proteïen opbrengs was ook aansienlik hoër in F × J koeie as J koeie (201 ± 3 vs 194 ± 2 kg proteïen). Vet en proteïen persentasies het geneig om effens te verskil met 'n klein effek (4.61 ± 0.04 % vet en 3.62 ± 0.03 % proteïen) vir J koeie en (4.47 ± 0.04 % vet en 3.51 ± 0.03 % proteïen) vir F × J koeie. Daar is tot die gevolgtrekking gekom dat F × J gekruisde koeie kan meer produktief wees as suiwer J koeie weens heterotiese effekte.

Verse kunsmatig geïnsemineer was op 13 maande ouderdom en koeie 40 dae na- kalwing aangehou was. Met behulp van bevrugting en swangerskap rekords, is vrugbaarheid eienskappe ontleed en vergelyk tussen die twee rasse, met behulp van ontleding van variansie vir deurlopende rekords. Ouderdom van bevrugting was dieselfde vir beide rasse wat in 'n soortgelyke ouderdomsgroep was by eerste kalwing. Vir koeie was die interval van kalf tot eerste inseminasie aansienlik korter ($P < 0.001$) vir kruisgeteelde koeie wat 76.7 ± 2.2 dae in vergelyking met 82.4 ± 2.5 dae suiwerrasse is. ‘n Groter proporsie ($P < 0.001$) van 0.70 vir gekruisteelde koeie is binne 80 dae na kalwing geïnsemineer in vergelyking met 0.54 vir J koeie. Alhoewel die absolute aantal dae tussen kalwing en opvatting (DO) laer was vir F × J koeie in vergelyking met J koeie (104.8 ± 6.8 teen 114.8 ± 8.1dae, onderskeidelik), is die verskil nie betekenisvol nie. Maar die verhouding van F × J koeie wat swanger bevestig is met 100 dae in melk was 0.79, wat hoër was ($P < 0.001$) is as die 0.66 vir J koeie. Resultate dui daarop dat daar potensiaal is reproduktiewe prestasie te verbeter van J koeie deur kruisteling met 'n dubbel- doel rasse.

Die vleisproduksie van suiwer J en Fleckvieh x Jersey (F × J) bulkalwers vergelyk. Die bul kalwers is soortgelyk grootgemaak vir kalfsvleis, d.w.s karkas gewig mag nie 100 kg oorskry as bulkalwers nie,

en as osse vir vleis tot 21 maande oud. In die kalwers- en os produksie stelsels, was die gemiddelde geboorte gewig hoër ($P < 0.001$) vir die kruise in vergelyking met J kalwers en osse (33.5 ± 1.2 kg teen 27.9 ± 1.2 kg vir kalwers) en (33.4 ± 0.9 kg vs . 26.9 ± 0.9 kg vir osse) onderskeidelik . Die lewendige gewig op 6 maande ouderdom was 163.5 ± 3.9 kg vir J bulkalwers en was hoër ($P < 0.001$) vir F × J bulkalwers 180.6 ± 4.0 kg. Die F × J bul kalwers het 'n aansienlik ‘n hoër gemiddelde daaglikse toename (GDT) van 0.82 ± 0.02 kg/dag in vergelyking met 0.73 ± 0.02 kg/dag vir J bulle. Bemarkingsouderdom verskil ($P < 0.001$) in die kalf produksie stelsel met F × J en J bulkalwers bemark op 7.1 ± 0.1 en 6.3 ± 0.1 maande , onderskeidelik. Finale lewendige gewig van 21 maande oud was aansienlik hoër 441.4 ± 14.9 kg in F × J bulle as 322.6 ± 13.4 kg in J bulle , terwyl GDT hoër was ($P < 0.001$), met 0.64 ± 0.02 kg/dag en 0.46 ± 0.0 kg/dag in F × J en J bulkalwers, onderskeidelik. Gekruisde osse het 'n aansienlik hoër karkasgewig 206.5 ± 8.9 kg in vergelyking met 157.9 ± 8.6 kg van J osse. Resultate dui daarop dat daar potensiaal is om die beesvleis produksie-eienskappe van die J beeste te verbeter d.m.v. kruisteling.

DEDICATION

This work is dedicated to my late mother **Mrs Nontobeko Eunice Goni**, for teaching me the importance of education, for loving and supporting me in all of my accomplishments. It has been a privilege having you as my mother and I will always love you mom.

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Chapter 1

GENERAL INTRODUCTION

The dairy industry in South Africa is a major provider of food in milk and meat, job opportunities and supports the agricultural mechanisation enterprise (Gertenbach, 2007). The South African dairy industry has changed in its structure and face dramatically over the last decade from a single channel marketing system to a free-market system (Maree, 2007). Commercial dairy industry is made up of total mixed ration systems (TMRS) in central provinces such as Free State, Northwest, Gauteng, Mpumalanga and Limpopo and is also characterised by pasture based systems (PBS) in coastal provinces such as KwaZulu-Natal, Eastern Cape and Western Cape (Maree, 2007). In a PBS more than 50 % of dry matter intake originates from pasture with cows kept on pastures almost throughout the year. More than 70 % of South Africa's milk is produced on pastures in the fertile coast region and more than half of dairy cattle in this area are Jersey (Swart, 2004). With the trend towards milk component pricing, the contents of solids such as fats and protein in milk has become increasingly important (Caraviello, 2004). Jersey milk has higher percent components of butterfat and protein and, producers feel the breed is more suited for today's milk market. In addition, producers feel the Jersey cow is more feed efficient on pastures and has less reproductive problems (Underwood, 2002).

There has been a decline in producer numbers that resulted in a sharp increase in the size of farm enterprises, shifts in the important production regions and huge improvements in technology that is being used in dairies (Maree, 2007). This decline is due to considerably lower prices paid by wholesalers to dairy farmers and an increase in input costs such as maize, soya, diesel and electricity (Mkhabela & Mndeme, 2010). The decline in producer numbers and improvement in technology have led to changes in management systems, cost structures, herd sizes and production per cow. According to Lacto Data (May 2012), the number of milk producers has decreased from 3899 in January 2007 to

2474 in January 2012. Cow numbers decreased by 6 % between 2003 and 2007 (Scholtz & Grobler, 2009), and during the same period the average herd size increased from 70 to 138 cows.

Producers in the coastal areas with higher rainfall and moderate temperatures are predominantly on PBS. The PBS is generally regarded by consumers of dairy products as "more natural" by virtue of their inherent holistic perspectives which include protection of the environment, welfare of the cows and the economic well-being of the communities that they sustain (Verkerk, 2003), but may produce more greenhouse gases (Conner & Rozeboom, 2009). Pasture-based dairying makes up to 49% of South Africa's commercial dairy producers producing about 74% of the total milk yield (Lacto data, 2012). The PBS is increasingly gaining attention due to better profit margins and, the increase in demand and price of cereals that raises production costs in TMR systems (Gertenbach, 2007). In addition to reduced feed costs, PBS can have lower capital costs for machinery, manure systems and facilities (White, 2000). Grazed forage from fresh pastures can replace much of the stored forages in the ration and, cows are on pastures almost throughout the year with supplementary roughage fed for a short period, particularly during drier months.

Genetic selection for high milk production has resulted in concerns regarding fertility, calving ease, health, and survival in the purebred milk breeds, due to the limited genetic ability of cows for coping with intensive genetic selection (Oltenacu & Broom, 2010). Inbreeding levels are increasing rapidly in all of the major dairy breeds, and crossbreeding may be an effective option for reducing the impact of inbreeding depression on commercial dairy farms (McAllister, 2002). Du Toit *et al*. (2012) reported significant negative effects of inbreeding on functional herd life in the first and second lactation of Jersey cows. Maiwashe *et al*. (2006) also reported an increase of inbreeding at a slightly higher rate in the Jersey population than the other dairy breeds. Another challenge with the Jersey is that little income is generated by rearing bull calves for beef, and the sale of cull cows for beef does not contribute significantly to herd income (Muller & Botha, 2008).

Crossbreeding is one way of improving milk composition, health, fertility, and survival because differences between breeds are much greater than differences within breed and extra benefits can be achieved from heterosis (Caraviello, 2004). However, crossbreeding which was once unpracticed in dairy circles is becoming a more popular concept in an industry dominated by purebred herds of Jerseys, Holsteins, Ayrshire and other purebreds. There is little information in South Africa on the effect of crossbreeding in dairy cows. Most research trials on dairy crossbreeding in other countries have been conducted with Holsteins, while Jerseys have received little attention, being a breed with relatively small numbers. Crossbreds of Jersey × Holstein were reported to have a 23 days advantage for days open (DO) than pure milk breeds (Heins *et al*., 2008). Calving ease, fertility, longevity and calf vitality are some of the importance attributed to crossbreds (Caraviello, 2004).

The problem of growth rate of heifers, cow fertility, reduced disease resistance and small body frame for beef production in Jerseys can be improved by crossing Jerseys with dual purpose breeds, such as Fleckviehs which possess a more beef potential. The Fleckvieh breed, a Simmental derived breed from Bavaria in Germany, promises to increase the beef production of a Jersey herd while not affecting the milk yield of crossbred females negatively. Purebred Fleckviehs also produce milk with high concentrations of fat and protein and should, therefore, not reduce the fat and protein yields of crossbred cows (Muller & Botha, 2008).

1.1 Justification

Genetic selection for high milk production, type and appearance for the last 50 years has suppressed secondary traits such as reproductive performance, productive life, health and survivability in the pure milk breeds. The economic importance of these secondary traits in dairy production systems is the basis for the interest in crossbreeding (McAllister, 2002). Indeed, no breed out-produces Holsteins and no breed has milk component levels higher than those of Jerseys. However, there have been concerns about a marked decline in fitness traits in traditional dairy breeds attributed to inbreeding.

Increased inbreeding in a population tends to concentrate undesirable recessive genes and that depresses performance accordingly. Inbreeding also denies dairy producers of income by increasing stillbirths, hampering growth rates of heifers, reducing cow fertility, and reducing disease resistance (Heins *et al*., 2008). Crossbreeding seeks to take advantage of hybrid vigour (also known as heterosis) and as two breeds become more and more inbred; the heterosis benefit from crossing members of each in a crossbreeding programme becomes greater (Williams, 2007). Historically, the strength of breed associations and personal preferences of purebred breeders are factors that have limited the acceptance of crossbreeding in many dairy populations (Weigel & Barlass, 2003). Crossbreeding improves fitness traits, reproduction and lifetime profits.

1.2 Study objectives

The broad purpose of the study was to compare the production and reproduction performance of Jersey and Fleckvieh × Jersey cows in a pasture-based system.

The specific objectives were to compare:

1. milk production of Jersey and Fleckvieh × Jersey cows in a pasture-based system;
2. reproductive performance of Jersey and Fleckvieh × Jersey cows and heifers in a pasture-based system; and
3. beef production of Jersey and Fleckvieh × Jersey steers and veal calves in a pasture-based system.

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Chapter 2

LITERATURE REVIEW

Secondary traits such as reproductive performance, productive life, health and survivability in pure milk breeds have been suppressed by genetic selection for high milk production. This literature review discusses the concept of crossbreeding in dairy production systems and the use of dual purpose breeds to improve productive life of pure milk breeds in dairy systems. Pasture-based dairy systems in South Africa are briefly reflected. Finally, a historic background is provided for the Fleckvieh breed and the attributes of this breed are briefly discussed.

2.1 Overview of crossbreeding in dairy production systems

Interest in crossbreeding of dairy cattle has become a topic of great interest in the last five years and has developed in response to concerns of dairy producers about fertility, calving difficulty, and stillbirths in today's genetically improved Holstein cows (Heins, 2007). Crossbreeding provides a simple method to increase the health and efficiency of many animals by introducing favourable genes from other breeds, by removing inbreeding depression, and by maintaining the gene interactions that cause heterosis (VanRaden & Sanders, 2003). Most research trials on dairy crossbreeding in other countries have been conducted with Holsteins, while Jerseys have received little attention because of their relatively small numbers (Muller & Botha, 2008).

There are several reasons behind the interest in crossbreeding in dairy production systems. Firstly, inbreeding levels within the major dairy breeds are rapidly increasing (Weigel, 2001), and crossbreeding may be an essential tool to cope with this trend in dairy populations under selection and to reduce the impact of the phenomenon of inbreeding depression (Weigel & Barlass, 2003). Secondly, direct payments for protein and fat in many milk pricing systems have encouraged some producers of the Holstein breed to consider crossbreeding as a tool to improve milk nutrient content (Penasa, 2009). This enhances the ability of other breeds and crossbreds to compete with Holstein strains on an economic basis, particularly in countries where cheese industry is gaining importance. Thirdly, easy access to genetic material from all over the world, strong competition among pure milk breeds and standardisation of sire evaluations are making crossbreeding viable. Lastly, breeding criteria have changed in recent years, animals are now selected on the basis of economic indices that do not only include milk yield, but also consider functional traits such as fitness, reproductive performance, calving ease, and longevity (Thompson, 2000; Caraviello, 2004; Oltenacu & Broom, 2010). In short, crossbreeding takes advantage of breed complementarity, non-additive effects and capturing hybrid vigour (Spangler, 2007). The economic importance of these traits is valuable in dairy production systems, even if they are still secondary to milk yield (McAllister, 2002). Crossbred animals are more robust and economically efficient compared with the parental breeds (Sørensen *et al*., 2008).

There is very little information in South Africa on the effect of crossbreeding dairy cows. Much of our experience on dairy crossbreeding comes from countries such as New Zealand, where more than 20 % of milk-recorded animals come from crosses between the Holstein and Jersey breeds (Caraviello, 2004). Vance & Ferris (2011) reported clear evidence of earlier resumption of cyclicity and improved fertility in the Jersey × Holstein Friesian (J × HF) crossbreed. Their study compared the performance of Holstein-Friesian (HF) and J × HF dairy cows when managed on one of three grassland-based systems of milk production. Commencement of luteal activity and days to first observed heat occurred 3.4 and 8.8 days earlier, respectively (Vance & Ferris, 2011). In addition, conception rate to first service, conception rate to first and second services and pregnancy rate at the end of the breeding season were 23, 29 and 16 percentage points higher with the J × HF cows, compared to the HF cows. Hybrid vigour is likely to have been a significant contributor to the improved fertility observed in the crossbred cows.

Udder traits are also important for functional milk production. Heins *et al*. (2008) reported that Jersey × Holstein had significantly less udder clearance from the ground to the bottom of the udder than pure Holsteins (47.7 vs. 54.6 cm), and greater distance between front teats (15.8 vs. 14.0 cm) than pure

Holsteins during first lactation. In a study by Vance & Ferris (2011), HF cows produced on average 625 kg more milk than J × HF cows, while milk fat and protein concentrates were 5.8 and 2.9 g/kg higher in the J × HF.

2.1.1 Heterosis

Heterosis is the difference in performance of crossbred animals from the average merit of the two parent breeds for each trait (Cassell & McAllister, 2009). It is specific for the two breeds involved in the cross. Cattle of different breeds receive credit for heterosis but cattle of the same breed do not. For example, if a purebred Holstein sire and purebred Jersey sire are compared as potential mates for a Holstein cow, the progeny of the Jersey sire will receive half of the breed difference plus heterosis. Additionally, if the same two sires are compared as potential mates for a Jersey cow, the progeny of the Holstein sire will receive the heterosis but the progeny of the Jersey sire will not. Heterosis is also expected to increase over time as relationships increase within breeds but not across breeds (VanRaden & Sanders, 2003).

An example of productive performance of straight bred and crossbred dairy herds under different scenarios of heterosis is provided in Table 2.1. This example illustrates that production per ha of milk, fat and protein for crossbred herds differed by +51 *l*, -3 kg and -1 kg from the average of the straight herds when heterosis was ignored in scenario I. In addition, heterosis effects for production traits (scenario II) caused the crossbred herds to rank higher than the Holstein Friesian for fat yield per cow, whilst heterosis for longevity (scenario III) reduced replacement rate.

According to McAllister (2002), New Zealand field data showed significant heterotic effects of New Zealand Holstein Friesian × Jersey for milk, fat, and protein yields. Heterosis also affected body weight, reduced days to first mating, positive calving rate from successful artificial insemination, and survival from first to fifth lactations (McAllister, 2002).

Table 2.1 Productive performance of straight bred and crossbred dairy herds[A] under different scenarios for heterosis[B] (Lopez-Villalobos & Garrick, 2002)

			Scenario I		Scenario II		Scenario III	
	F	**J**	**F_1 F×J**	**Rt F×J**	**F_1 F×J**	**Rt F×J**	**F_1 F×J**	**Rt F×J**
Live weight, kg	447	353	400	400	407	405	410	406
Production per cow								
Milk, *l*/year	3,770	2,768	3,269	3,269	3,396	3,354	3,427	3,370
Fat, kg/year	165	160	162	162	169	167	171	168
Protein, kg/year	131	112	122	122	126	125	127	125
DM requirements, kg/year	5,006	4,209	4,607	4,607	4,728	4,688	4,568	4,591
Stocking rate, cow/ha	2.40	2.86	2.61	2.61	2.54	2.56	2.63	2.61
Production per hectare								
Milk, *l*/year	9,036	7,890	8,514	8,514	8,620	8,586	9,002	8,808
Fat, kg/year	395	455	422	422	430	428	449	439
Protein, kg/year	313	321	316	316	321	319	334	327
Replacement rate, %	22.0	22.0	22.0	22.0	22.0	22.0	17.8	19.6
Average herd age, years	4.48	4.48	4.48	4.48	4.48	4.48	5.09	4.89

[A] F= Friesian, J = Jersey, F_1 F×J = first cross, and Rt F×J = rotational cross.
[B] Scenario I: ignoring heterosis; scenario II: heterosis for production; and scenario III: heterosis for production and longevity

2.2 Pasture-based dairy systems in South Africa

Feed is the largest cost in producing milk, with PBS providing the majority of the cows' feed. In addition to reduced feed costs, PBS can have lower capital costs for machinery, manure systems, and facilities (White *et al*., 2002). Grazing systems can have lower input costs causing farmers to look towards management of intensive rotational grazing to help increase profitability (White, 2000).

Pasture-based dairying makes up to 49 % of South Africa's commercial dairy producers, producing about 74 % of the total milk yield (*Lacto data*, 2012). Producers in the coastal areas such as

KwaZulu-Natal and Eastern Cape, with more moderate temperatures and higher rainfall, are predominantly on PBS, except for the Western Cape where they are on TMR production systems (Maree, 2007). The PBS is generally regarded by consumers of dairy products as “more natural” by virtue of their inherent holistic perspectives which include protection of the environment, welfare of the animals and the economic well-being of the communities that they sustain (Verkerk, 2003). They may however, produce more greenhouse gases (Conner & Rozeboom, 2009). More than 50 % of dry matter intake is from pastures with roughages in the form of ryegrass, clover mixes and or other pasture species (Maree, 2007).

Additional benefits of PBS include conjugated linoleic acid (CLA) identified as the only known fatty acid to potentially inhibit cancer in experimental animals (Ip *et al*., 1999). The CLA content of milk from pastured cows is 2 to 5 times higher than that found in milk from dairy cows raised in confinement operations (Kelly *et al*., 1998; Dhiman *et al*., 1999; Khanal *et al*., 2005). Conjugated linoleic acid has also been linked to enhancing lean body mass (Conner & Rozeboom, 2009). The potentially positive health benefit of CLA offers the dairy industry an exciting opportunity to increase the consumption of dairy products. Conjugated linoleic acid has been associated with enhanced immune function, cardiovascular health, and reduced cancer, diabetes, and obesity risks in cell and animal models. However, these benefits have not yet been consistently observed in controlled human trials (Butler *et al*., 2009). Many factors have been identified as increasing CLA levels in milk fat; and these include forage to concentrate ratio, intake of dietary fatty acids, and pasture intake (Conner & Rozeboom, 2009). Conversely, it is not known if all common pasture species are likely to have similar effects on CLA levels.

It is however imperative to note that PBS has challenges that impede production. The low-cost pasture-based dairying in Sub Saharan Africa often cannot support the high nutritional requirements needed by large framed, high producing *Bos taurus* dairy breeds currently dominant in the region’s commercial dairy herd (Svinurai, 2010). Cattle on full pasture travel long distances around pastures and to the milking parlour, and spend most of their time grazing in a heat stressful environment

(Nehring *et al*., 2007; Dodzi, 2010). Considering such situations, the large framed exotic dairy breeds produce less milk than normal, particularly in summer due to excessive heat stress (West *et al.,* 2003; Dodzi, 2010). Notably, heat stress and harsher environments have implications on the reproductive performance of the cows (Nehring *et al*., 2007).

2.3 Historic background of Fleckvieh dual purpose breeds

The Fleckvieh breed, a Simmental-derived breed from Bavaria in Germany is one of Europe's oldest breeds. There are approximately 4 million Fleckvieh in the regions of Germany, Austria and Czech Republic, and are estimated to be at 41 million worldwide, making Fleckvieh the second largest breed in the world (CRV, 2013). They were developed to be highly productive on mostly grass-based diets and yet produce high amounts of fat and protein for cheese making. In addition, they are durable, hardy and easy handling to work within a small farm. They also have excellent feet and legs to handle the mountainous regions they were developed to graze. Selection and breeding programmes in the Fleckvieh breed have been aimed at increasing milk yield and milk composition of cows while maintaining the beef quality of cows and steers (Fleckvieh, 2008).

2.3.1 Attributes of the Fleckvieh breed

The average mature cow is approximately 1.5 m tall and has excellent strength and body development. A mature cow weighs approximately 700 kg with an average milk fat percentage of 4.2 and 3.45 % of protein. Fleckvieh are hardy and adaptable to different geographical and climatic conditions. They have excellent female fertility with the national 90 day non-return to service rate of 61.8 % and a calving interval of 12.9 months. They have very good calving ease traits and a stillbirth average of only 5.6 %. The national average age of the cows is 5.5 years or a little over 4 lactations with many cows living to be 10 years or older. Very good conformation of udders and feet and legs, together with the medium body size of animals is ideal with respect to longevity and feed efficiency (Bouška *et al*., 2006).

2.3.2 Crossbreeding trials in dairy using dual purpose sire breeds and beef breeds

Many dairy producers are fighting health problems in their herds and recognise that, given falling returns from milk, a supplementary income in the form of dairy beef production is required to keep their operations profitable. Crossbreeding of pure dairy cows with dual purpose breed bulls may provide more suitable progeny for beef production, in which case selection of the breed of beef bull to be used becomes important. Different beef breeds have been used for crossbreeding in dairy production to increase export volumes of beef through dairy-bred cattle that are males and surplus females or culls (Keane, 2011).

In countries such as New Zealand, the dairy industry is seen as an important source of beef-producing animals. In the past, beef producers have not farmed Jersey cattle because of their slower growth rates, lighter carcasses, inferior carcass grades, and renowned yellow fat caused by high concentrations of carotene in the fat (Burke *et al*., 1998). Conversely, research has also highlighted that the disadvantages of pure Jersey cattle are greatly reduced by crossbreeding with beef breeds (Barton *et al*., 1994). In the study by Purchas *et al*. (1992), Simmental × Jersey grew generally faster than the other groups (Murray Grey × Jersey, Limousin × Jersey). Carcasses from steers sired by Simmental and Limousin bulls were longer, had less fat, and yielded heavier meat cuts at the same carcass weight. Meat cuts from Limousin-cross carcasses were heavier than those from Simmental-cross carcasses of the same weight (Purchas *et al*., 1992).

The growth performance of Jersey (J) and Fleckvieh × Jersey (F×J) veal calves and steers is presented in Table 2.2, which shows the higher birth weights of F×J than those of pure J bull calves. The results also illustrate the 50 % higher average daily gain of F×J than that of J calves, resulting in a higher live weight (LW) at marketing at 21 months of age (Muller *et al*., 2010). Age at marketing for F×J veal calves was earlier than that of J veal calves, i.e., 6.3 vs. 7.1 months of age.

Table 2.2 The growth performance of Jersey (J) and Fleckvieh × Jersey (F×J) veal calves and steers reared at Elsenburg (Muller *et al*., 2010)

Production systems	**Parameters**	**J**	**FxJ**	**Ratio (F×J/J)**
Veal	Number of animals	16	22	-
	Birth weight (kg)	26.8±1.5	31.3±1.3	1.17*
	End BW (kg)	192.9±2.7	195.7±1.3	1.01
	ADG (kg/day)	0.765±0.017	0.859±0.015	1.12*
	Carcass weight (kg)	92.2±2.3	99.6±1.0	1.08*
	Dressing (%)	0.48±0.008	0.51±0.004	1.06*
	Marketing age (m)	7.2±0.1	6.3±0.1	0.88*
Beef	Number of animals	11	7	-
	Birth weight (kg)	27.7±1.3	33.0±1.6	1.19*
	LW at 21months of age (kg)	334.9±15.3	475.5±22.4	1.42*
	Cold carcass weight (kg)	159.6±9.4	238.0±10.0	1.49*
	Dressing (%)	0.49±0.02	0.51±0.01	1.04*
	ADG (kg/day)	0.475±0.027	0.681±0.040	1.43*

ADG = average daily gain; BW = body weight; * breeds differ significantly at P<0.05

Muller *et al*. (2010) reported higher milk yield of F×J than that of J cows at first lactation (Table 2.3), and milk yield of J and F×J cows varied from 4277 to 5747 and from 4481 to 6353 kg, respectively, with the respective coefficients of variance of 10 and 13 %.

Table 2.3 The mean (±se) 305-d milk yield and milk composition of first lactation Jersey (J) and Fleckvieh × Jersey (F×J) cows utilising kikuyu pasture and limited concentrates (Muller *et al*., 2010)

Parameters	**J**	**F×J**	**Ratio (F×J/J)**
Number of animals	13	7	-
Milk yield (kg)	5023±160	5422±218	1.08
Fat (%)	4.59±0.09	4.45±0.11	0.97
Fat yield (kg)	230±6	240±8	1.04
Protein (%)	3.47±0.02	3.43±0.06	0.99
Protein yield (kg)	175±5	186±7	1.06
Lactose (%)	4.73±0.03	4.76±	1.01
Persistency (%)	96±5	84±3	0.88

Without directly comparing the two findings, Meeske *et al*. (2009) also found F×J cows to have 7% higher milk yields at first lactation than pure J cows on a kikuyu/ryegrass pasture production system. In addition, Jerseys × Fleckvieh cows produced 6.7 % more fat corrected milk per cow than Jerseys, but were 24.2 % heavier (Table 2.4), and milk protein content of Jerseys was higher than that of crossbreds.

Table 2.4 Milk production, milk composition of Jersey and Jersey × Fleckvieh primiparous cows grazing on kikuyu/ryegrass pasture farmlets under irrigation (Meeske *et al*., 2009)

Parameter	Jersey	Jersey × Fleckvieh	LSD
Birth weight (kg)	24.2[b]	33.8[a]	2.36
ADG g/day birth to calving	0.428[b]	0.537[a]	0.025
BW before calving (kg)	302[b]	377[a]	16.8
BW end of lactation (kg)	330[b]	408[a]	23.9
BCS before calving (1-5)	2.4[b]	2.8[a]	0.23
Shoulder height before calving (cm)	119[b]	123[a]	1.95
Shoulder height at end of lactation (cm)	122[b]	128[a]	1.7
Milk production (kg/day)	11.6[b]	12.7[a]	0.86
Fat corrected milk production (kg/lactation)	3702[b]	3959[a]	262
Milk protein %	3.69[a]	3.46[b]	0.102

ADG = average daily gain; BW = birth weight; BSC = body condition score; [ab] values with different superscripts in each row are different.

2.4 Summary of literature review

The review highlighted different investigations that have been conducted here in South Africa and throughout the world with regards to dual purpose and beef breeds and their capacity in improving dairy production when used in crossbreeding. The importance of breed diversity as a potential solution to enhance productivity and fertility in dairy production; thus efficiently optimizing productivity, has been emphasized. Very little research has been conducted on crossbreeding using dual purpose breeds or beef breeds in dairy production systems in South Africa. The study was conducted to evaluate the contribution made by crossbreeding using dual-purpose breeds to dairy production.

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Chapter 3

MILK PRODUCTION OF JERSEY AND FLECKVIEH × JERSEY COWS IN A PASTURE-BASED SYSTEM

3.1 Abstract

Milk production parameters of purebred Jersey (J) cows and Fleckvieh x Jersey (F×J) cows in a pasture-based feeding system were compared, with milk recording done according to standard milk recording procedures. Milk production (milk, fat, and protein yield) was adjusted to 305 days of lactation and corrected for age at calving. Effects of breed, parity, month and year were estimated for milk, fat and protein yield as well as fat and protein percentage, using general linear models procedure. The fixed effects identified as significantly affecting milk, fat and protein yield were breed, parity and year. F×J cows produced significantly more milk than J cows (6141 ± 102 vs. 5398 ± 95 kg milk). Fat and protein yields were significantly higher in F×J (272 ± 4 and 201 ± 3 kg, respectively) than in J cows (246 ± 3 and 194 ± 2 kg, respectively). Fat and protein percentages only differed slightly with 4.61 ± 0.04 % fat in the J compared to 4.47 ± 0.04 % fat in the F×J, while the protein was 3.62 ± 0.03 % in the J and 3.51 ± 0.03 % in the F×J cows. It was concluded that F×J crossbred cows could be more productive than purebred Jersey cows owing to heterotic effects.

Key words: fat, protein, purebred, crossbred, significant

3.2 Introduction

For dairy farmers to remain financially viable, they should increase milk production either by increasing production per cow or by increasing the number of cows, without compromising the health status of the cows. Cow production efficiency and feed utilization efficiency are important measures in dairy production and are already synonymous with some breeding guides. With the increase in the demand and price of cereals, which increases production costs in total mixed ration systems (Gertenbach, 2007), the cost of feed may be reduced by utilizing pasture-based systems through cheaper machinery, manure systems and facilities (White, 2000). Stall-feeding with stored fodder is often replaced by grazing forage from fresh pastures almost throughout the year, with supplementary roughage fed during the drier months. Supplementation is done to improve milk yield and composition, upon which South African milk pricing is based.

The current trend in dairying is towards milk component pricing, such that the volume of milk solids, such as, protein and fat, has become increasingly important; thus milk prices are heavily influenced by milk composition (Caraviello, 2004). Milk producers consider the Jersey breed as being more suited for today's milk market and has milk with higher components of butterfat and proteins (Underwood, 2002). In addition, producers view the Jersey cow as being more efficient in utilizing pastures, with less reproductive problems (Underwood, 2002). Milk production is conventionally improved through genetic selection, which may however, not be optimal due to the increased levels of inbreeding observed in most dairy breeds. Crossbreeding may therefore be an effective option for reducing the impact of inbreeding depression on commercial dairy farms (McAllister, 2002). Well-designed crossbreeding programs may lead the farmer to exploit desirable characteristics of breeds involved, and to take advantage of heterosis for traits of economic relevance (López-Villalobos, 1998).

Milk production in Jerseys can be improved by crossing with dual purpose breeds, such as, the Fleckvieh. Purebred Fleckvieh produce milk high in butterfat and protein content, and therefore may not be expected to compromise the total fat and protein yields of crossbred cows (Muller & Botha, 2008). Most dairy crossbreeding is practiced in countries like New Zealand on the Holsteins, while Jerseys have received little attention. In South Africa, little attention has been paid to crossbreeding in dairy cattle and no crossbreeding studies have been conducted. Against this background, the primary objective of the study was to compare the milk production of pure Jersey and Fleckvieh × Jersey cows in pasture-based systems.

3.3 Materials and methods

3.3.1 Site description

The study was conducted at the Elsenburg Research Farm of the Western Cape Department of Agriculture. Elsenburg Research Farm is situated approximately 50km east of Cape Town at an altitude of 177m, longitude 18° 50' and latitude 33° 51' and is in the winter rainfall region of South Africa. The area is characterised by cool wet winters and long warm dry summers with an average annual rainfall of 650mm.

3.3.2 Study cows

Data were collected over the period of five years between 2008 and 2012. A total of 58 pure Jersey (J) cows and 64 Fleckvieh × Jersey (F×J) cows were used as experimental animals. The animals were grouped randomly in two treatments based on age and estimated breeding value for milk yield. Both breeds were repeated with a parity ranging from 1 to 5. Cows were inseminated from 60 days in milk and the reproductive performance of each cow was recorded. Hormonal treatment to get cows pregnant was applied when cows that are 150 days in milk were not confirmed pregnant.

3.3.3 Grazing and feeding management

When heifers for both Jerseys and Fleckvieh × Jersey were confirmed pregnant, they were put on kikuyu pastures until calving. They were also supplemented with a growth meal containing 150 g crude protein (CP)/kg at 3 kg per heifer per day. The Jersey and Fleckvieh × Jersey cows were then placed on open cultivated pastures after calving. Oat hay was provided as additional roughage during winter when pasture availability was low. As the CP content of oat hay is lower than that of kikuyu pasture, oat hay was then supplemented with a high protein source such as cotton seed oil cake meal. Lactating cows received a commercial concentrate meal in a post-parlour feeding facility and received 7 kg per cow on a daily basis.

3.3.4 Data collection

Milk recording was done according to the standard milk recording procedures. Milk was then tested for fat and protein percentage at 35-day intervals, such that on average, ten samples were tested for each cow. Milk production (milk, fat, and protein yield) was adjusted to 305 days of lactation and corrected for age at calving.

3.3.5 Statistical analysis

The data were analysed using the PROC GLM procedures of the SAS (2009). The effects of breed, month, year and parity on milk yield, fat yield, protein yield, fat percentage and protein percentage were analysed using ANOVA. Least square means were calculated for each effect, where they were separated using the PDIFF STDERR of SAS (2009).

The model used was:

$Y_{ijkl} = \mu + B_i + M_j + Y_k + P_l + e_{ijkl}$

where:

Y_{ijkl} = milk yield, fat yield, protein yield, fat%, protein%

μ = population mean

B_i = fixed effect of breed (i=Jerseys, Fleckvieh × Jersey)

M_j = fixed effect of month (j=1, 2, 3….12)

Y_k = fixed effect of year (k=2008, 2009….2012)

P_l = fixed effect of parity (l=1, 2, 3….5)

e_{ijkl} = random error

3.4 Results and Discussion

The analysis of variance revealed that breed, year and parity affected ($P < 0.0001$) milk yield, fat yield, protein yield, fat percentage and protein percentage. Month only had an effect ($P < 0.05$) effect on protein yield and percentages.

3.4.1 Effect of breed on milk production

The least square means and standard errors of the breed effect on milk production parameters are depicted in Table 3.1. Breed had an effect ($P < 0.0001$) on milk, fat and protein yield, and fat and protein percentages.

Table 3.1 Least square means (±s.e.) for Jersey cows and Fleckvieh x Jersey cows on indicated milk parameters (305 d)

Parameters	**Jersey (J)**	**Fleckvieh x Jersey (FxJ)**
Number of records	58	64
Milk (kg)	$5398^{a} \pm 95$	$6141^{b} \pm 10$
Protein (kg)	$194^{a} \pm 2.0$	$20^{b} \pm 3.0$
Fat (kg)	$246^{a} \pm 3.0$	$272^{b} \pm 4.0$
Protein %	$3.62^{b} \pm 0.03$	$3.51^{a} \pm 0.03$
Fat %	$4.61^{b} \pm 0.04$	$4.47^{a} \pm 0.04$

Means within the same row with different superscripts are significantly different ($P < 0.05$).

Milk, protein and fat yield of F×J cows were higher (P < 0. 0001) than J cows. The findings were consistent with other studies by Meeske *et al*. (2009) on the study on milk production of Jersey and Jersey/Fleckvieh crosses on kikuyu, and Muller *et al*. (2010) on the study on crossbreeding Jerseys with Fleckvieh sires. However, fat and protein percentages of J cows were higher (P < 0. 0001) than F×J cows, supporting studies by Meeske *et al*. (2009) and Muller *et al*. (2010). The differences in the productivity levels of J cows and F×J cows may be attributed to hybrid vigour, which is the advantage crossbred animals, have over the average of their parents' breeds (McAllister, 2002). In addition, previous studies on crosses between Holsteins and European Black and White cattle populations may be indicating that the percentage of heterosis is higher under pasture-based systems than under more intensive conditions (Penasa, 2009). Without directly comparing the two studies, a study under New Zealand conditions involving Jersey × Holstein crosses found significant heterosis for milk, fat and protein yield (Caraviello, 2004); hence heterosis was presumed to have had significant contribution to increased milk production of F×J cows.

3.4.2 Effect of year on milk production in J and F × J cows

Year had an effect ($P < 0.0001$) on milk production of both J cows and F×J cows. The least square means and standard errors of the year effect on milk production parameters are illustrated in Table 3.2. Year-wise means indicated that milk, fat and protein yields increased from 2008 to 2012. Both breeds tended to have significantly the highest milk, and fat yields during the year 2012. The variation in milk yield from one year to other could be attributed to changes in herd size, age of animals and good management practices introduced from year to another. The effect of cows' ages on milk production has been reported in literature (Atil *et al*., 2001; Mostert *et al*., 2001; Thakur & Singh, 2005; Dhara *et al*., 2006; Habib *et al*., 2010; M'hamdi *et al*., 2012). Increase in age at first calving from 30 to 42 months of age was associated with significant increase in milk yield 316 kg (Atil *et al*., 2001); thus the significant increases in milk yield of cows calving at older ages.

Table 3.2 Least square means (±s.e.) depicting effect of year on milk production (305 d) of Jersey and Fleckvieh × Jersey cows

Parameters	Breed	Year				
		2008	2009	2010	2011	2012
Milk (kg)	J	$4779^{a} \pm 256$	$5168^{a} \pm 168$	$4978^{a} \pm 142$	$5278^{a} \pm 123$	$5740^{b} \pm 135$
	F×J	$6295^{a} \pm 535$	$5546^{ab} \pm 232$	$6145^{ac} \pm 186$	$6383^{ac} \pm 170$	$7065^{a} \pm 142$
Fat (kg)	J	$228^{a} \pm 10$	$239^{ab} \pm 7$	$225^{ac} \pm 6$	$242^{a} \pm 5$	$256^{b} \pm 5$
	F×J	$285^{a} \pm 22$	$252^{ab} \pm 9$	$270^{ab} \pm 7$	$285^{a} \pm 7$	$300^{a} \pm 5$
Protein (kg)	J	$183^{a} \pm 9$	$181^{ab} \pm 5$	$179^{a} \pm 5$	$196^{a} \pm 4$	$195^{a} \pm 4$
	F×J	$216^{a} \pm 15$	$193^{ab} \pm 6$	$219^{ac} \pm 5$	$222^{a} \pm 5$	$232^{a} \pm 4$
Fat %	J	$4.77^{a} \pm 0.13$	$4.68^{a} \pm 0.09$	$4.55^{a} \pm 0.07$	$4.61^{a} \pm 0.06$	$4.48^{a} \pm 0.07$
	F×J	$4.57^{a} \pm 0.19$	$4.56^{ab} \pm 0.08$	$4.45^{ab} \pm 0.07$	$4.49^{ab} \pm 0.06$	$4.28^{a} \pm 0.05$
Protein %	J	$3.82^{a} \pm 0.11$	$3.53^{b} \pm 0.07$	$3.62^{ab} \pm 0.06$	$3.72^{a} \pm 0.05$	$3.41^{b} \pm 0.06$
	F×J	$3.42^{a} \pm 0.11$	$3.50^{ab} \pm 0.05$	$3.61^{ac} \pm 0.04$	$3.51^{ab} \pm 0.04$	$3.32^{a} \pm 0.03$

Means within the same row with different superscripts are significantly different (P < 0.05).

3.4.3 Effect of parity on milk production in J and F × J cows

There was an effect (P < 0.001) of parity on milk production in both J cows and F×J cows. Lactation curves illustrating the effect of parity on milk yield, fat yield, protein yield, fat percentage and protein percentage for both J and F×J cows are represented in Figures 3.1, 3.2, 3.3, 3.4 and 3.5. Peak milk yield (5674 ± 133 and 6342 ± 207 kg, respectively), fat yield (262 ± 5 and 288 ± 8 kg, respectively) and protein yield (209 ± 4 and 218 ± 6, respectively) were reached in the third lactation for the two breeds. While milk, protein and fat yields of J cows showed a sharp decline on 4^{th} to 5^{th} lactations (Fig 3.1, 3.2 and 3.3), and these traits showed persistency in F×J cows, which may be attributed to the effect of heterosis. Crossbred F×J cows generally reached higher (P < 0.001) levels of milk, fat and protein yields compared to pure J breed, which is consistent with earlier findings (Lopez-Villalobos, 1998; Lopez-Villalobos *et al*., 2000; Bryant *et al*., 2007; Heins, 2007; Muller & Botha, 2008; Meeske *et al*., 2009).

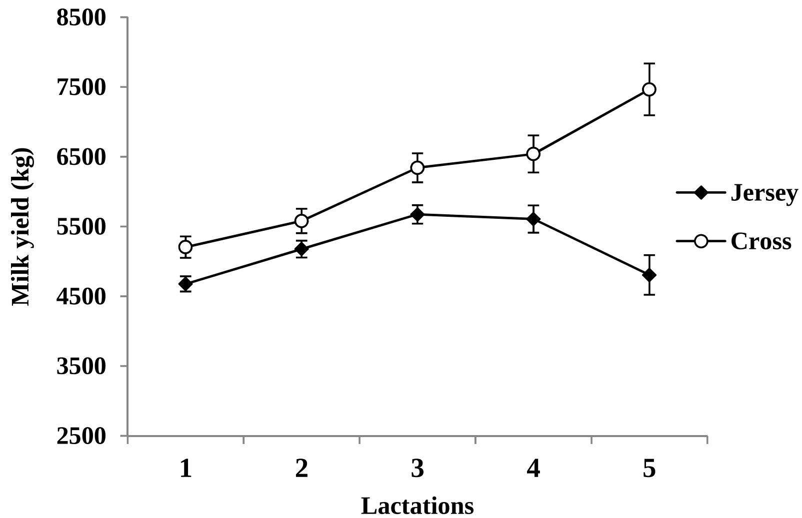

Figure 3.1 Milk yield as affected by lactation number (305d). Vertical bars around the observed means signify standard errors

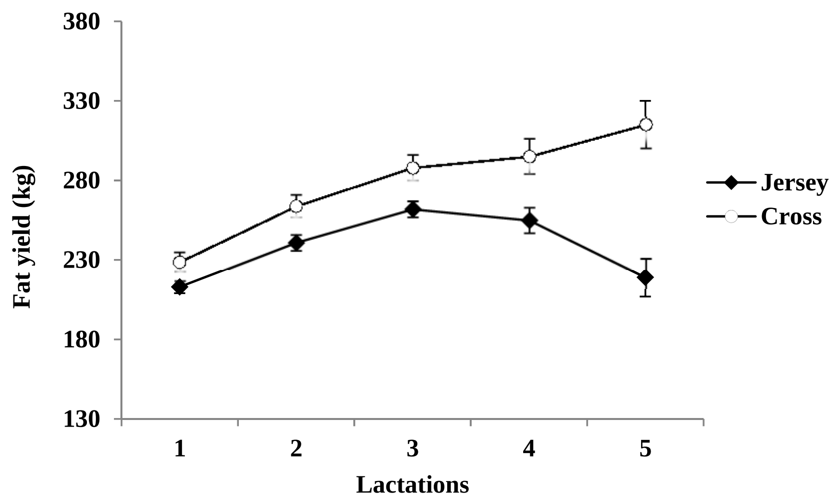

Figure 3.2 Fat yield as affected by lactation number (305d). Vertical bars around the observed means signify standard errors

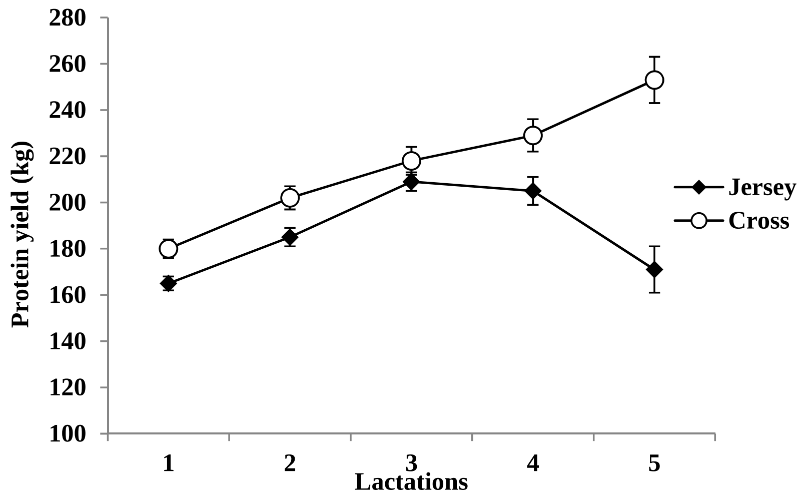

Figure 3.3 Protein yield as affected by lactation number (305d). Vertical bars around the observed means signify standard errors

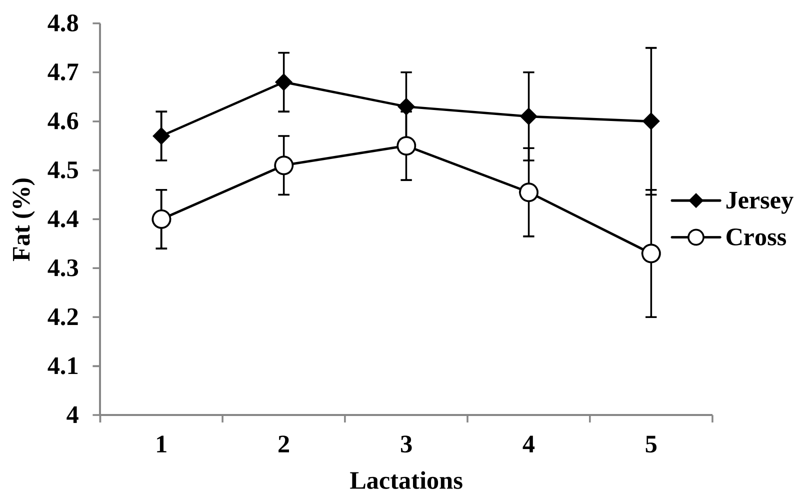

Figure 3.4 Fat percentage as affected by lactation number (305d). Vertical bars around the observed means signify standard errors

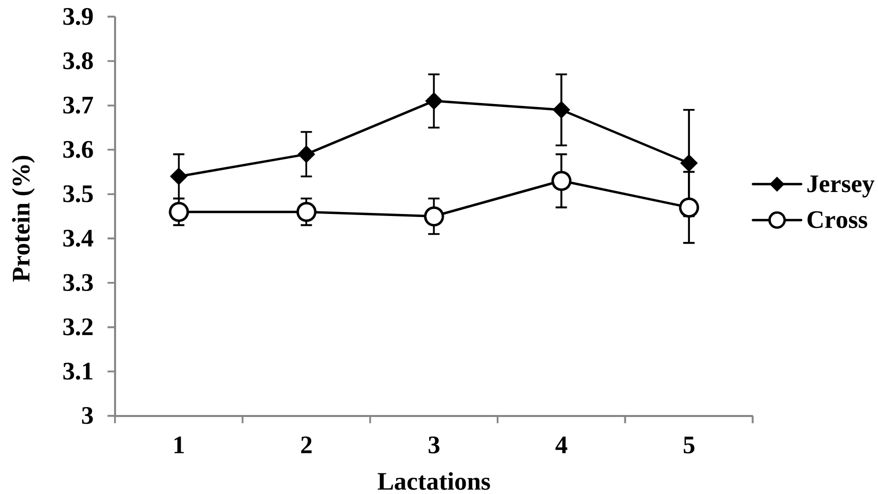

Figure 3.5 Protein percentage as affected by lactation number (305d). Vertical bars around the observed means signify standard errors

Bryant *et al*. (2007) reported highest heterosis for Holstein-New Zealand Jersey crossbreds for milk, fat, and protein production which ranged from 5.0 to 9.5 %, and concluded that crossbreds of Jersey and Holstein had higher fat and protein production than that of pure Holsteins, due to the expression of heterosis. Both fat and protein percentage were lowest in early lactation, but increased steadily as lactation progressed (Prendiville *et al*., 2011); with milk solids higher for J than F×J cows. Production of high milk solids by J cows compared to other breeds has been well established (Lopez-Villalobos, 1998; Lopez-Villalobos *et al*., 2000; Heins, 2007; Muller & Botha, 2008; Lateef *et al*., 2008; Meeske *et al*., 2009; Prendiville *et al*., 2009; Prendiville *et al*., 2010; Prendiville *et al*., 2011a; Prendiville *et al*., 2011b).

3.4.4 Effect of month on milk production in J and F×J cows

The effect of month on milk yield, fat yield, protein yield, fat percentage and protein percentage for both J cows and F×J cows are illustrated in Figures 3.6, 3.7, 3.8, 3.9 and 3.10. Month only affected ($P < 0.05$) protein yield and percentage for both J cows and F×J cows. Milk yield, fat yield and percentage were not affected ($P > 0.05$). This is contrary to findings by Mostert *et al*. (2001) in a study on the effect of calving season and age at calving on production traits of South African dairy breeds, where cows calving in the cooler months (August-October) produced highest daily milk yields. Adequate feed supplementation of cows during drier months could have cancelled out the effect of month differences on milk yield, fat yield and fat percentages of both J cows and F×J cows. Protein yield was significantly lower in June, July and December (4898 ± 267, 4864 ± 220 and 4991 ± 386, respectively) for J cows compared to that for F×J cows (5921 ± 300, 6055 ± 233 and 5703 ± 334, respectively). Milk, fat and protein yields dropped for F×J cows during the month of November while in J cows tended to increase equalling F×J cows.

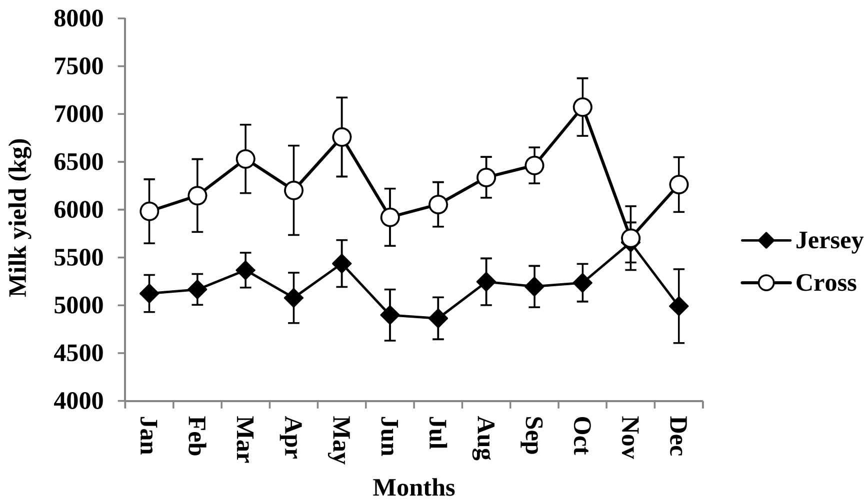

Figure 3.6 Milk yield as affected by month (305d). Vertical bars around the observed means signify standard errors

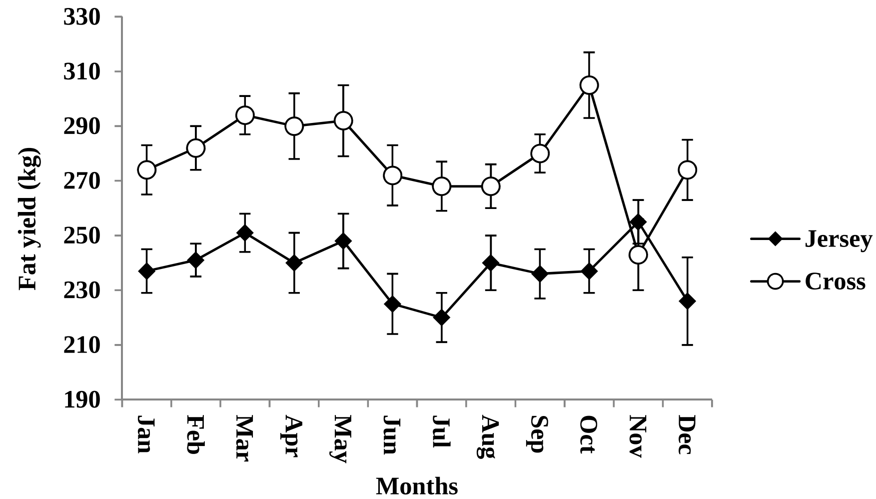

Figure 3.7 Fat yield as affected by month (305d). Vertical bars around the observed means signify standard errors

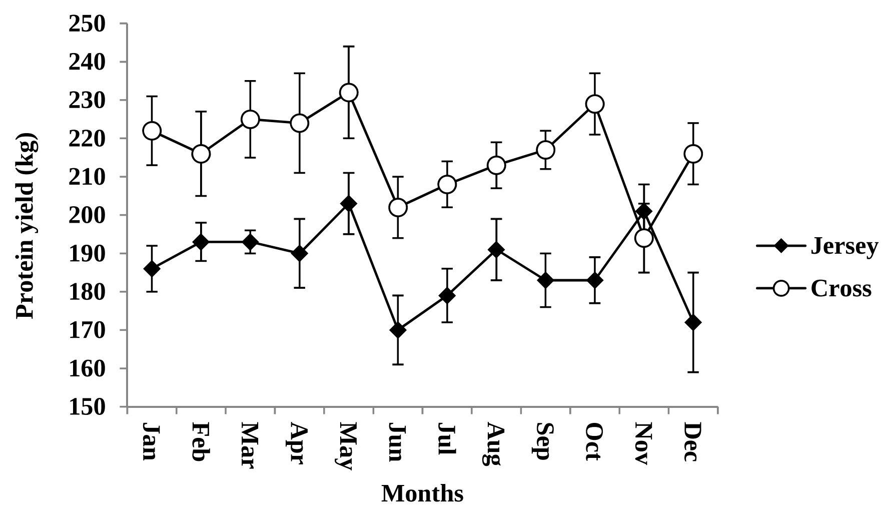

Figure 3.8 Protein yield as affected by month (305d). Vertical bars around the observed means signify standard errors

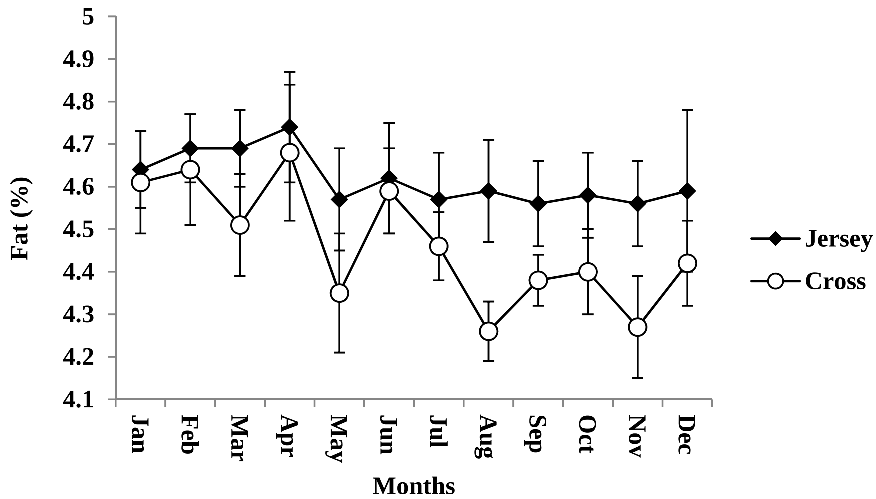

Figure 3.9 Fat percentage as affected by month (305d). Vertical bars around the observed means signify standard errors

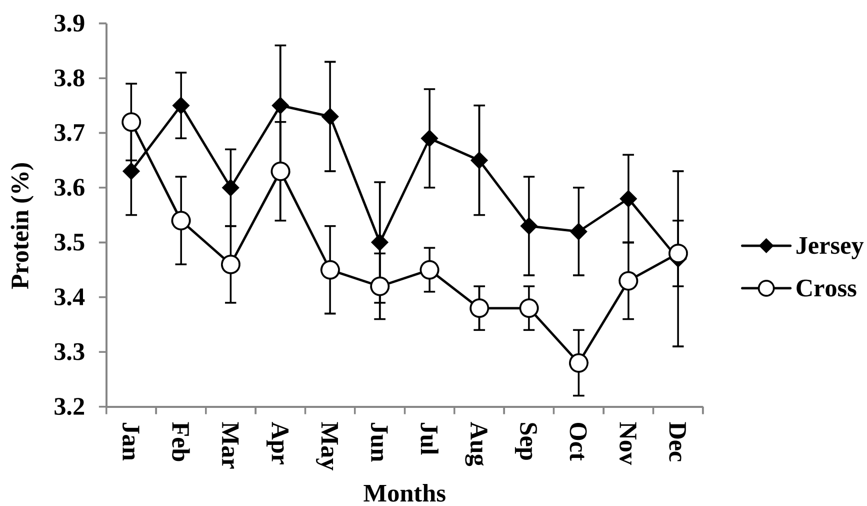

Figure 3.10 Protein percentage as affected by month (305d). Vertical bars around the observed means signify standard errors

3.5 Conclusions

Milk production for both breeds was affected by breed, year and parity, with month only affecting milk protein for both breeds. The lack of significant effect of month on milk and fat yields could be attributed to adequate feed supplementation of both breeds during drier months. Milk production levels tended to be significantly high during the fifth year (2012) owing to the effect of age of cows in lactation. Parity effect followed the expected trend where cows produced less milk during the first lactation and increased in third to fourth lactation. In addition, milk, fat and protein yields showed persistent increase from first to fifth lactation for crosses, with such trend possibly attributable to the effect of heterosis on crossbreds. Fat and protein were lower in the crossbred than in purebreds. Crossbred animals generally produced significantly higher milk, fat and protein yields compared to pure breed. Crossbred cows could be more productive than purebred and production can be improved by crossbreeding, which has advantages of breed complementarity and heterosis. Considering the importance of reproductive performance of dairy cows in a dairy enterprise, it is therefore essential to determine the reproduction of these breeds.

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Chapter 4

REPRODUCTIVE PERFORMANCE OF JERSEY AND FLECKVIEH × JERSEY COWS AND HEIFERS IN A PASTURE-BASED SYSTEM

4.1 Abstract

Poor reproduction in dairy herds reduces farm income as cows are culled earlier, reducing their productive lives and increasing replacement costs. Crossbreeding is regarded as a way to improve the reproductive performance of dairy cows. Reproductive performance of purebred Jersey (J) cows and heifers were compared to Fleckvieh × Jersey (F×J) crossbreds. These animals were kept on a pasture-based system, where heifers were inseminated at 13 months of age and cows 40 days post-calving. Using insemination records and pregnancy check results, fertility traits were analyzed and compared between the two breeds, using analysis of variance for continuous records. Conception age was the same for both breeds resulting in a similar age at first calving. For cows, the interval from calving to first insemination was significantly shorter ($P < 0.001$) for crossbred cows, being 76.7 ± 2.2 days compared to 82.4 ± 2.5 days for purebreds. A larger proportion ($P < 0.001$) of 0.70 for crossbred cows was inseminated within 80 days after calving compared to 0.54 for J cows. Although the absolute number of days between calving and conception (DO) was lower for F×J cows in comparison to J cows (104.8 ± 6.8 vs. 114.8± 8.1days, respectively), the difference was not significant. However, the proportion of F×J cows confirmed pregnant by 100 days in milk was 0.79, which was higher ($P < 0.001$) than the 0.66 for J cows. These results indicate the potential of improving reproductive performance of J cows through crossing with a dual-purpose breed.

Key words: cow fertility, calving, conception and pregnancy, artificial insemination, days open, crossbreeding.

4.2 Introduction

The productive life of a dairy cow is influenced by her reproductive performance depicted by her age at first calving, calving intervals, length of each lactation, and survival to the next lactation. Financial viability of the dairy industry depends on the increase in milk production and efficient reproductive performance of dairy cows without compromising the health status of the cows. It is becoming increasingly evident that fertility is declining with rising milk yields for some dairy breeds (Makgahlela *et al*., 2008). However, there is no clear consensus regarding the mechanism of the effect of yield on fertility (Pryce *et al*., 2004). Genetic selection for high milk production has resulted in concerns regarding female fertility, calving ease, health, and survival in the purebred milk breeds, due to the limited genetic ability of animals for coping (Oltenacu & Broom, 2010). This may be partly attributed to rising levels of inbreeding which characterizes most modern dairy breeds (McAllister, 2002).

Maiwashe *et al*. (2006) reported an accumulation of inbreeding at a slightly higher rate in the Jersey population than the other dairy purebreds. Du Toit *et al*. (2012) also reported significant negative effects of inbreeding on functional herd life in the first and second lactation of Jersey cows. Smith *et al*. (1998) observed that inbreeding decreased the mature equivalent production of milk, fat and protein during first lactation by 27, 0.9, and 0.8 kg, respectively, while the lifetime production of milk, fat and protein was reduced by 177, 6.0, and 5.5 kg per 1 % increase in inbreeding respectively. Decreased survival rate of Jerseys has been observed as the level of inbreeding increased and was likely to have a greater negative impact on the financial health of the dairy enterprise than production losses (Thompson *et al*., 2000).

Crossbreeding is one way of mitigating inbreeding by improving health, fertility and survival. The reason for this is because differences between breeds are much greater than the differences within breed and extra benefits can be achieved from heterosis (Caraviello, 2004). Crossbreeding which has not been considered in some dairy circles, is becoming a more popular concept in an industry now dominated by purebred herds. With the exception of countries using purely pasture-based dairying systems, Jerseys have received little attention in dairy crossbreeding, being a breed with relatively small numbers. Most of research trials conducted on dairy crossbreeding in the USA have used Holsteins. In South Africa, little information is available on the effect of crossbreeding in dairy cows. Heins *et al*. (2008b) found in a study comparing the production and reproduction of Jersey × Holstein and pure Holstein cows that crossbred animals had a 23 days advantage for days open (DO) than pure dairy breeds. Compared to pure Holsteins, Fleckvieh × Holstein cows required fewer inseminations per conception (1.93 vs. 2.79) and had shorter intervals from calving to first insemination (89 vs. 97 days) and from calving to conception (132 vs. 172 days) (Muller, 2011). Calving ease, fertility, longevity and calf vitality are some of the important attributes of crossbreds (Caraviello, 2004).

Little attention has been given towards using dual-purpose breeds in dairy crossbreeding programs. Dual-purpose breeds provide the opportunity to maintain higher milk yield of cows while improving fertility, longevity and beef production. Against this background, the objective of the current study was to compare the reproductive performance of pure Jersey and Fleckvieh × Jersey cows in pasture-based systems.

4.3 Materials and methods

4.3.1 Site description

The study was conducted at the Elsenburg Research Farm of the Western Cape Department of Agriculture. Elsenburg Research Farm is situated approximately 50 km east of Cape Town at an altitude of 177 m, longitude 18° 50' and latitude 33° 51' and is in the winter rainfall region of South Africa. The area has a typical Mediterranean climate with short, cold, wet winters and long, dry summers with an average annual rainfall of 650mm.

4.3.2 Study cows

Data was collected over six years between 2008 and 2013. A total of 155 pure Jersey (J) cows and 190 Fleckvieh × Jersey (F×J) cows were used as experimental animals for cow reproduction analysis. Fifty-nine J and 80 F×J heifers were included in the analysis of reproductive performance. Heifers were inseminated at 13 months of age and cows 40 days post-calving. Hormonal treatment to get cows pregnant was applied when cows that were 150 days in milk were not confirmed pregnant.

4.3.3 Feeding management

When heifers and cows for both J and F×J were confirmed pregnant, they were put on kikuyu pastures until calving. They were also supplemented with a growth meal containing 15 % crude protein (CP) at 3 kg per heifer per day. The J and F×J cows were then placed on open cultivated pastures after calving. Oat hay was provided as additional roughage during winter when pasture availability was low. As the CP content of oat hay is lower than that of kikuyu pasture, oat hay was then supplemented with a high protein source, such as, cotton seed oil cake meal. Lactating cows received a commercial concentrate meal in a post-parlour feeding facility and all received 7 kg per cow on a daily basis.

4.3.4 Data collection

The age at first conception for the animals was recorded, while calving ease was recorded for both breeds. Calving to first service (CFS), pregnancy rate (CR), conception age (CA), expected age at first calving (ExpAFC), number of inseminations per conception (SPC) and days open (DO) were recorded.

4.3.5 Statistical analysis

Data were analysed using the GLM procedures of the SAS (2009) to estimate the effects of breed, calving age, year of service and parity on fertility traits. Least square means were calculated for each effect, where they were separated using the PDIFF STDERR of SAS (2009).

The following model was adopted for the traits in each of the two breeds for reproductive performance:

$Y_{ijkl} = u + B_i + CA_j + Y_k + S_l + e_{ijkl}$

where:

Y_{ijkl} = an observation of each trait

μ = population mean

B_i = breed (i=Jerseys, Fleckvieh × Jersey)

CA_j = calving age

Y_k = year of birth, service and calving (k=2008, 2009…….2013)

S_l = season of birth, service and calving (l=summer, winter)

e_{ijkl} = random error

4.4 Results and Discussion

The results showed that breed had an effect ($P < 0.05$) on the reproductive performance of the J and F×J cows. There were no differences in the reproductive performance of J and F×J heifers. Birth year only had a significant effect on age at first insemination of heifers in both breeds. There was an interaction between the calving year and calving season on CFS for both J and F×J cows. Therefore, CFS in a particular season was not consistent over the years during the study.

4.4.1 Effect of breed on reproductive performance.

The least square means and standard errors depicting the effect of breed on reproductive performance of J and F×J cows and heifers are illustrated in Tables 4.1 and 4.2. The pregnancy rate of J and F×J cows reared on a pasture-based system differed ($P < 0.001$), with crossbreds achieving a 13 % higher pregnancy rate compared to J cows. Without direct comparison, Anderson *et al.* (2007) also reported a pregnancy rate of 6 percentage units greater for Jersey × Holsteins than pure Holsteins. The CFS was significantly longer in pure J cows (82.4 ± 2.5 days) compared to the crossbred cows (76.7 ± 2.2 days). This leads to long calving interval for J cows translating to fewer calves born during the reproductive lifetime of these cows and therefore loss of potential income. The percentage of cows inseminated for the first time within the first 80 days after calving was 16 % higher ($P < 0.01$) for crosses in comparison to pure J cows. This could be because F×J cows experienced an easier calving down process resulting in a quicker recovery of the reproductive system.

Comparing crossbred cows to the purebreds on a small data set, Muller (2011) reported that crossbreds required 2.5 inseminations per conception compared to 2.9 for J cows, and needed 72 days from calving to first insemination compared to 91 days for J, while the J and F×J cows took 131 and 168 days, respectively from calving to conception. The crossbreds of Normande/Holsteins and Montbéliarde/Holsteins were reported to have significantly higher first-service conception rates compared to pure Holsteins (Heins *et al*., 2006). While the number of days between calving and conception (DO) were 10.3 days less for crosses in comparison to J cows (104.5 ± 6.8 vs. 114.8 ± 8.1 days, respectively), the difference between the breeds was not significant. Heins *et al.* (2008) found Jersey-Holstein (J×H) cows to have significantly fewer days open (DO) than pure Holsteins and a significantly greater proportion of J×H were pregnant at 150 and 180 days postpartum than pure Holsteins. Dechow *et al*. (2007) also reported DO to be significantly less for crosses of Brown Swiss/Holsteins than pure Holsteins. This difference is probably related to a large variation in uterine involution in the different breeds.

Table 4.1 Least square means (±s.e.) depicting breed effect on reproductive performance of Jersey (J) and Fleckvieh × Jersey (F×J) cows

Parameters	**Jersey (J)**	**Fleckvieh × Jersey (F×J)**
Number of records	155	190
Pregnancy %	$0.66^{a} \pm 0.03$	$0.79^{b} \pm 0.03$
CFS (d)	$82.4^{b} \pm 2.5$	$76.7^{a} \pm 2.2$
% First AI <80 dim	$0.54^{a} \pm 0.05$	$0.70^{b} \pm 0.05$
Days Open (DO)	$114.8^{a} \pm 8.1$	$104.8^{a} \pm 6.8$
NSC	$1.7^{a} \pm 0.1$	$1.6^{a} \pm 0.1$

[a,b]Means within the same row with different superscripts are significantly different (P < 0.05). (AI = artificial insemination, CFS = calving to first service, NSC = number of services per conception).

Table 4.2 Least square means (±s.e.) depicting breed effect on reproductive performance of Jersey (J) and Fleckvieh × Jersey (F×J) heifers

Parameters	**Jersey (J)**	**Fleckvieh × Jersey (F×J)**
Number of records	59	80
Pregnancy %	$0.87^{a} \pm 0.04$	$0.94^{a} \pm 0.03$
Age at first AI (m)	$15.4^{a} \pm 0.2$	$15.1^{a} \pm 0.2$
Conception age (m)	$16.5^{a} \pm 0.4$	$16.7^{a} \pm 0.4$
ExpAFC (m)	$26.0^{a} \pm 0.4$	$26.2^{a} \pm 0.3$
NSC	$1.7^{a} \pm 0.2$	$1.9^{a} \pm 0.1$

[a,b]Means within the same row with different superscripts are significantly different (P < 0.05). (AI = artificial insemination, ExpAFC = expected age at first calving, NSC = number of services per conception).

There were no significant differences on all other reproductive performance traits that were measured for J and F×J heifers. These heifers were serviced for the first time and could have had equal chances on reproductive performance with similar management practices also contributing to the outcomes of these results. Inseminator proficiency is also an important aspect of reproduction management in dairy herds which could mask the genetic effect of crossbreeding. Most of the work reviewed reported largely on Holsteins and their crossbreds, being a breed that has received more attention than Jersey in dairy crossbreeding.

4.4.2 Effect of birth year, calving year and service year on reproductive performance

The least square means and standard errors of the effect of birth year, calving year and service year on reproductive performance of J and F×J cows and heifers are illustrated in Table 4.3. Birth year only affected ($P < 0.05$) age at first artificial insemination of both J and F×J heifers. The age at first artificial insemination was older ($P < 0.05$) during 2011 and, was 2 to 3 months older compared to the other years. The heifers reached oestrus earlier and were therefore inseminated earlier at 14.8 ± 0.4 and 15.2 ± 0.3 months of age in 2009 and 2010, respectively. This could have been due to management errors, late detection of oestrus signs, chronological date of inseminations of cows and low pasture availability leading to slow reproductive age during the year of 2011.

Table 4.3 The least square means (±s.e.) depicting year effect on reproductive performance of Jersey (J) and Fleckvieh × Jersey (F×J) cows and heifers

Variables	Class	Year				
		2008	**2009**	**2010**	**2011**	**2012**
Pregnancy %	[1]Cows	0.70[a] ± 0.08	0.91[a] ± 0.05	0.85[a] ± 0.04	0.87[a] ± .04	0.79[a] ± 0.04
	[2]Heifers	1.02[a] ± 0.06	1.01[a] ± 0.06	0.97[a] ± 0.05	0.88[a] ± 0.06	0.84[a] ± 0.06
NSC	[1]Cows	1.67[a] ± 0.29	2.01[a] ± 0.18	1.60[a] ± 0.18	1.67[a] ± 0.16	1.61[a] ± 0.17
	[2]Heifers	1.46[a] ± 0.22	1.65[a] ± 0.25	2.10[a] ± 0.18	1.80[a] ± 0.25	2.45[a] ± 0.24
CFS (d)	[1]Cows	84.94[a] ± 5.1	74.21[a] ± 3.4	84.81[a] ± 3.1	76.08[a] ± 2.9	75.50[a] ± 2.9
% First AI <80 dim	[1]Cows	0.57[a] ± 0.10	0.73[a] ± 0.07	0.49[a] ± 0.07	0.68[a] ± 0.06	0.64[a] ± 0.06
Days Open (DO)	[1]Cows	116.7[a] ± 15.3	121.5[a] ± 8.7	122.3[a] ± 7.5	114.2[a] ± 7.2	106.6[a] ± 7.2
Age at first AI (m)	[3]Heifers	15.4[a] ± 0.38	14.8[ab] ± 0.40	15.2[ab] ± 0.36	17.1[ac] ± 0.42	15.1[a] ± 0.70
Age at conception (m)	[3]Heifers	17.1[a] ± 0.53	16.5[a] ± 0.60	17.3[a] ± 0.56	18.2[a] ± 0.62	15.2[a] ± 1.23
ExpAFC (m)	[2]Heifers	24.6[a] ± 0.57	25.4[a] ± 0.63	26.6[a] ± 0.46	25.7[a] ± 0.66	27.2[a] ± 0.63

[a,b]Means within the same row with different superscripts are significantly different ($P < 0.01$). (AI = artificial insemination, CFS = calving to first service, ExpAFC, expected age at first calving, NSC = number of services per conception).

[1]effect of calving year

[2]effect of year of service

[3]effect of birth year

4.4.2 Effect of season on reproductive performance

The effect of birth season, service season and calving season on both cows and heifers had no significance ($P > 0.05$) on all reproductive traits, and the interactions between season and year did not reach significant levels in both breeds. Despite the negative effects of thermal stress during summer, fertility in this study was not depressed on both breeds. Pregnancy rates were more consistent over seasons when timed artificial insemination programmes were used compared with artificial insemination after detected oestrus. The negative effects of heat stress on cow reproductive performance were observed previously (Jordan, 2003). Contrary to these observations, there is a widely observed decrease in the fertility of postpartum dairy cows inseminated in the summer compered to cows inseminated in winter, and the precise mechanism of this effect has not been conclusively identified (De Rensis & Scaramuzzi, 2003). Heat stress has been reported to reduce the duration and intensity of oestrus in dairy cows leading to a reduction in the number of mounts in hot weather compared to cold weather; hence poor detection of oestrus (Pennington *et al*., 1985).

4.5 Conclusions

Breed comparison for reproductive performance of J and F×J cows raised under the production system generally used by dairy farmers, was conducted. Crossbred cows had shorter calving to first service intervals compared to purebreds, with a larger percentage of crossbreds having their reproductive systems recovering earlier than the purebreds. Thus, a higher percentage of crossbred cows was confirmed pregnant than purebreds. There were no breed differences on all the reproductive performance traits that were measured on heifers, suggesting that heifers have equal chances of reproductive performance at young age. The poorer reproductive performance of pure J cows can be mitigated and improved by crossing this breed with the dual-purpose Fleckvieh. Maintaining a high level of reproductive efficiency is required if dairy producers want to maximize the herd profitability. Beef production potential of dairy herds is not always exploited fully hence it is important to ascertain beef production potential of crossbreeding dairy cows.

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Chapter 5

BEEF PRODUCTION OF JERSEY AND FLECKVIEH × JERSEY VEAL CALVES AND STEERS IN A PASTURE-BASED SYSTEM

5.1 Abstract

While Jersey (J) bulls produce high quality beef, the growth rate of J bull calves for veal and beef is low in comparison to other dairy breeds. This could be improved by crossbreeding with beef breeds. In the current study, beef production of purebred J and Fleckvieh x Jersey (F×J) bull calves was compared. The bull calves were reared similarly for veal, i.e. a carcass weight not exceeding 100 kg, or as steers for beef to 21 months of age. In both veal and steer production systems, the mean birth weight were higher (P < 0.001) for crossbred in comparison to J calves and steers (33.5 ± 1.2 kg vs. 27.9 ± 1.2 kg for veal) and (33.4 ± 0.9 kg vs. 26.9 ± 0.9 kg for steers), respectively. The body weight at 6 months of age was 163.5 ± 3.9 kg for J bull calves and was higher (P < 0.001) for F×J bull calves 180.6 ± 4.0 kg. The F×J bull calves had a significantly higher average daily gain (ADG) of 0.82 ± 0.02 kg/day compared to 0.73 ± 0.02 kg/day for J bulls. Marketing age differed (P < 0.001) in the veal production system with F×J and J bull calves marketed at 7.1 ± 0.1 and 6.3 ± 0.1 months, respectively. End live weight at 21 months of age was significantly higher in F×J (441.4 ± 14.9 kg) bulls than the 322.6 ± 13.4 kg in J bulls; while ADG was higher (P < 0.001) being 0.64 ± 0.02 and 0.46 ± 0.0 kg/day in F×J and J bull calves, respectively. Crossbred steers had a significantly higher carcass weight (206.5 ± 8.9 kg) compared to 157.9 ± 8.6 kg of J steers. These results indicate the potential of improving beef production characteristics of the Jersey cattle through crossbreeding.

Key words: Birth weight, body weight, carcass weight, slaughter age, average daily gain, dressing percentage, crosses, significant.

5.2 Introduction

In South Africa, the beef production potential of dairy herds is not fully exploited. As most dairy farmers are not bull breeders, bull calves could be reared for veal or beef production. However, Jersey (J) bull calves are regarded as unwanted animals and are sold at low prices. Even though the tenderness and meat:bone ratio of J steers is high (Purchas *et al*. 2002), their growth rate is low in comparison to other dairy breeds (Morgan *et al*., 1969; McIvor, 2004). Specialization of farming systems has resulted in most dairy herds becoming purely milk production enterprises in contrast to past systems. In the 1980's, a major portion of the beef animals in the United Kingdom were born in dairy herds and were reared for beef production.

Breeding and selection programs towards increased milk yields have resulted in cows showing more dairy character or "sharpness" (Hansen, 2003), with cows having a lower beef potential in comparison to the earlier British Friesian type dairy cows. Kempster *et al*. (1988) reported that Canadian Holsteins slaughtered either at 16 or 24 months of age, had a lower carcass weight and conformation score in comparison to British Friesian steers. The growth in the Jersey breed replacing Friesian or Holstein herds has further reduced the beef potential of the dairy industry. Culling of cows not becoming pregnant to maintain a strict seasonal calving system have in some countries such as Ireland resulted in fertile cows requiring low replacement rates to maintain herd sizes. This provides the opportunity to inseminate a considerable portion of the herd with beef semen to increase the beef potential of dairy herds. In South Africa this practice may not always possible as the internal herd growth of most dairy herds is questionable because of high culling rates of cows and poor success rate of heifer rearing.

Crossbreeding has become a system to overcome some breeding problems like fertility and longevity in some dairy breeds (Funk, 2006). Little attention has been given towards using dual-purpose breeds in crossbreeding programmes which provides the opportunity to maintain the milk yield of cows while increasing the beef production of crossbred animals. One such breed to consider is the Fleckvieh (F), a Simmental-derived breed from Germany. This is a dual-purpose breed with medium to high (in comparison to Holstein cows) milk yield levels and milk components while also having a high beef production potential. The objective of the study is to compare beef production of Jersey and Fleckvieh × Jersey (F×J) bull calves reared intensively for veal and for beef in a partly pasture-based feeding system.

5.3 Materials and methods

5.3.1 Site description

The study was conducted at the Elsenburg Research Farm of the Western Cape Department of Agriculture. Elsenburg Research Farm is situated approximately 50km east of Cape Town at an altitude of 177m, longitude 18° 50' and latitude 33° 51' and is in the winter rainfall region of South Africa. The area has a typical Mediterranean climate with short, cold, wet winters and long, dry summers with an average annual rainfall of 650mm.

5.3.2 Study animals

Data were collected over four years between 2007 and 2010. A total of 22 pure Jersey (J) bull calves and 39 Fleckvieh x Jersey (F×J) bull calves were used as experimental animals for veal production. For steer production, 22 J steers and 23 F×J steers were used as experimental animals. Crossbred and pure Jersey bull calves were reared equally and marketed as veal at approximately 6 months of age and as beef at 21 months of age. Bull calves reared for beef were castrated at three months of age with a *Burdizzo* and steer calves were dehorned at two months of age.

5.3.3 Feeding management

For the veal production system, calves were fed intensively using a commercial calf starter meal to 2 months of age and a calf growth meal to marketing, viz. a carcass weight not exceeding 100 kg. For the beef production system, J and F×J bull calves were reared similarly as the veal production system to 3 months of age, after which they were put on kikuyu pasture supplemented with about 2 kg of a calf growth meal to 6 months of age. After 6 months, they were kept on natural pasture, i.e. pasture was rain-fed and no fertilizers were used. During summer droughts, pasture was supplemented with oats hay. Fresh drinking water was freely available at all times.

5.3.4 Data collection

Birth weights were recorded when bull calves were removed from their dams to be put into individual crates at two days of age. Thereafter, calves were weighed once a month. On reaching a live weight of about 180 kg, the calves reared for veal, and were weighed once a week on a Thursday. When a body weight of approximately 195 kg was reached, these bull calves were marketed the following Tuesday. The calves were weighed before leaving to the abattoir (end body weight) and hot and cold carcass weights were recorded after slaughter. Bull calves reared for beef were grouped according to calving date which had to be within 7 days of each other for both breeds. This was to ensure that animals from both breeds were exposed to similar environmental conditions over the 21-month growing-out period. Similarly, bull calves were weighed at birth and thereafter, once a month until marketing at 21 months of age when they were transported to the abattoir.

5.3.5 Statistical analysis

The data were analysed using the PROC GLM procedures of the SAS (2009). The effects of breed, season and year on birth weight (BW), end body weight (EBW), average daily gain (ADG), carcass weight (CW), dressing percentage and market age, were analysed using ANOVA. Least square means were calculated for each factor, where they were separated using the PDIFF STDERR of SAS (2009).

The following models were adopted for the traits in each of the two breeds for veal and steer production:

$$Y_{ijk} = \mu + B_i + S_j + J_k + e_{ijk}$$

where:

Y_{ijk} = birth weight of the ijk'th calves and steers (kg)

μ = population mean

B_i = fixed effect of breed (i=Jerseys, Fleckvieh × Jersey)

S_j = fixed effect of season (j=1, 2)

J_k = fixed effect of year (k=2007, 2008….2010)

e_{ijk} = random error

NB: birth weight (BW) & slaughter age were fitted as covariates for end body weight, carcass weight and dressing percentage

5.4 Results and Discussion

The analysis of variance showed breed to have an effect (P < 0.001) on the growth performance of the J and F×J veal calves and steers. Year and season had no effect on the growth performance of these calves. The interactions between season and year did not reach significance and only main effect means were thus presented.

5.4.1 Effect of breed on beef production

The least square means and standard errors of the effect of breed on beef production of J and F×J veal calves and steers are shown in Tables 5.1 and 5.2. The birth weight (BW) of J and F×J bull calves reared for veal differed. Crossbred bull calves had higher (P < 0.001) ADG compared to purebred calves. Crossbred bull calves reached the required live weight for veal averaging 32 days earlier (P < 0.001) than J bull calves. Differences between bull calves are in agreement with Muller (2006) and Muller & Botha (2008) although studies were at the preliminary stages. The birth weight of J was lower than that for F×J bull calves. Crossbred bull calves had a 37 % higher (P < 0.001) end live weight at 21 months marketing age than J steers. Naude & Armstrong (1967) also found low growth rates and efficiency of gain for purebred J steers in comparison to beef-Jersey crossbred steers, and the weight gain of J bulls was improved by 39 % from crossbreeding with Simmental bulls.

Table 5.1 Effects of breed on growth performance of Jersey (J) and Fleckvieh × Jersey (F×J) veal calves

Variables	**Jersey (J)**	**Fleckvieh x Jersey (F×J)**
Number of records	22	39
Birth weight (kg)	$27.9^{a} \pm 1.2$	$33.5^{b} \pm 1.2$
BW at 6m of age (kg)	$163.5^{a} \pm 3.9$	$180.6^{b} \pm 4.0$
ADG (kg/d)	$0.73^{a} \pm 0.02$	$0.82^{b} \pm 0.02$
Hot carcass weight (kg)	$89.0^{a} \pm 1.9$	$94.2^{a} \pm 1.7$
Cold carcass weight (kg)	$86.2^{a} \pm 1.9$	$89.5^{a} \pm 1.7$
Dressing (%)	$0.47^{a} \pm 0.01$	$0.50^{b} \pm 0.01$
Market age (m)	$7.1^{b} \pm 0.1$	$6.3^{a} \pm 0.1$

^{a,b}Means within the same row with different superscripts are significantly different ($P < 0.01$). (BW = body weight, ADG = average daily gain).

Table 5.2 Effects of breed on growth performance of Jersey (J) and Fleckvieh × Jersey (F×J) steers

Variables	**Jersey (J)**	**Fleckvieh x Jersey (F×J)**
Number of records	22	23
Birth weight (kg)	$26.9^{a} \pm 0.9$	$33.4^{b} \pm 0.9$
LW at 21m of age (kg)	$322.6^{a} \pm 13.4$	$441.4^{b} \pm 14.9$
ADG (kg/d)	$0.46^{a} \pm 0.02$	$0.64^{b} \pm 0.02$
Hot carcass weight (kg)	$162.5^{a} \pm 8.7$	$212.1^{b} \pm 9.1$
Cold carcass weight (kg)	$157.9^{a} \pm 8.6$	$206.5^{b} \pm 8.9$
Dressing (%)	$0.49^{a} \pm 0.01$	$0.47^{a} \pm 0.01$

^{a,b}Means within the same row with different superscripts are significantly different ($P < 0.01$). (BW = body weight, ADG = average daily gain).

The body weight of bull calves reared as veal and steers reared as beef is illustrated in Figures 5.1 and 5.2 demonstrating the earlier marketing age of the F×J calves, as well as the higher live weight of F×J steers at the same marketing age in comparison to J calves and steers, respectively.

Jersey steers grew slowly and when slaughtered at 22-23 months of age, their carcass were too light (Barton *et al*., 1994). In the beef production system, crossbred bull calves had a higher ($P < 0.001$) ADG than J steers. Carcass weight of beef crosses was significantly higher (206.5 ± 8.9 kg) compared to 157.9 ± 8.6 kg of J steers, consistent with the study by Muller *et al*. (2004) who found carcass weight of J to be lower than that of crossbreds on beef production of Belgian-Blue/Jersey, Limousin/Jersey and Jersey cattle in a pasture-based system. Beef breeds × Holstein-Friesians have been reported to have superior carcass weight and conformation compared to pure Holstein-Frisians dairy breed (Everitt *et al*., 1980; Keane & Allen, 2002; Keane, 2003; Keane, 2011). Crossbred calves of J cows sired with Belgian-Blue and Limousin bulls were also reported to be heavier at birth than J calves, i.e. 32 and 31 vs. 24 kg, respectively (Muller *et al*., 2004). Purchas *et al.* (1992) and Barton *et al*. (1994) also found that the disadvantages of purebred J cattle in beef production were greatly reduced by crossbreeding with beef breeds. Breed cross effect became more evident and the live weight advantage continued through to slaughter with crosses being significantly heavier at birth, weaning and at the final weighing prior to slaughter (Burke *et al*., 1998).

5.4.2 Effect of season on beef production

The interactions between season and year did not reach significance between breeds. The effect of season on both veal and steer production systems for J and F×J calves did not have an effect ($P > 0.05$) on all growth traits. Veal calves were not subjected to pasture grazing and hence there were no season effects. Calves reared for steers to 21 months of age were adequately supplemented with oat hay during summer droughts; thus negating the effect of season. Most of the related studies that were reviewed made no reference on the effect of season on veal and steer production.

5.4.3 Effect of year on beef production

The least square means and standard errors of the effect of year on beef production of J and F×J veal calves are shown in Tables 5.3. The effect of year on steer production system did not yield any significance for both breeds. The effect of year affected ($P < 0.05$) birth weight, end body weight, ADG and carcass weight of only F×J calves for veal production system. The traits measured were significantly lower during the first two earlier years of the trail. This could have been due to feed management errors as the project was still on the initial phase. The J bull calves for veal production were not affected by year. Most of the work reviewed made no mention or report the effect of year on veal and/or steer production.

Table 5.3 The least square means (±s.e.) depicting year effect on growth performance of Jersey (J) and Fleckvieh × Jersey (F×J) veal calves

Variables	**Breed**	**Year**			
		2007	**2008**	**2009**	**2010**
Birth weight (kg)	Jersey	$27.8^a \pm 4.3$	$26.4^a \pm 1.9$	$26.9^a \pm 2.5$	$29.5^a \pm 2.6$
	F×J	$34.9^b \pm 3.2$	$37.8^b \pm 2.3$	$30.9^a \pm 1.1$	$34.8^b \pm 1.6$
End BW (kg)	Jersey	$155.5^a \pm 7.3$	$168.5^a \pm 3.4$	$166.0^a \pm 4.3$	$159.9^a \pm 4.5$
	F×J	$152.4^a \pm 12.8$	$175.3^a \pm 10.0$	$191.2^b \pm 4.6$	$191.9^b \pm 6.5$
ADG (kg/d)	Jersey	$0.70^a \pm 0.04$	$0.77^a \pm 0.01$	$0.76^a \pm 0.02$	$0.71^a \pm 0.02$
	F×J	$0.66^a \pm 0.06$	$0.79^b \pm 0.05$	$0.87^b \pm 0.02$	$0.88^b \pm 0.03$
Hot carcass weight (kg)	Jersey	$78.3^a \pm 5.9$	$94.6^a \pm 2.6$	$94.0^a \pm 3.3$	$95.0^a \pm 3.6$
	F×J	$75.7^a \pm 4.8$	$99.3^b \pm 3.5$	$99.0^b \pm 1.7$	$99.3^b \pm 2.4$
Cold carcass weight (kg)	Jersey	$70.0^a \pm 4.9$	$93.9^b \pm 2.1$	$90.8^b \pm 2.7$	$93.0^b \pm 2.9$
	F×J	$68.8^a \pm 5.0$	$97.1^b \pm 3.7$	$95.7^b \pm 1.8$	$95.3^b \pm 2.5$
Dressing percentage	Jersey	$0.45^a \pm 0.2$	$0.48^a \pm 0.01$	$0.48^a \pm 0.01$	$0.49^a \pm 0.01$
	F×J	$0.48^a \pm 0.01$	$0.50^a \pm 0.01$	$0.51^a \pm 0.01$	$0.51^a \pm 0.01$

[a,b]Means within the same row with different superscripts are significantly different ($P < 0.01$). (BW = body weight, ADG = average daily gain).

5.5 Conclusions

Breed comparison was conducted using production systems generally used by dairy farmers. Higher growth rates for F×J in comparison to purebred J bull calves reared for either veal or beef production under similar feeding conditions were observed. Crossbred bull calves reached the required body weight for veal, on average 32 days earlier than J bull calves. The end body weight of the F×J steers reared as beef in a partially pasture-based system was 37 % higher than that of J steers. Although a higher beef production is realized from crossbreeding using a dual-purpose breed, the improvement in milk yield, milk composition and fitness traits would determine the economic value of crossbreeding. Further studies should be conducted to determine the effect of including better quality pasture into the diet of steers reared for beef as only poor quality pasture was available in the present study. This should include the effect of using supplementary feeds to increase the performance of crossbred steers, as steers finished on grass could result in very lean carcasses.

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Chapter 6

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Jersey cattle have traditionally been selected for milk production. To fully utilize the genetic resources in a dairy operation, all components of production should be considered and improved. Better reproductive performance, which is the main driver of dairy enterprises, was observed in crossbred cows than in pure Jersey cows. Crossbred cows had shorter CFS and their reproductive tract recovered quicker than the purebreds, while the number of days between calving and conception were not different. The percentage of cows confirmed pregnant was also higher for crossbreds than J cows. After parturition, crossbred cows also exhibited superior milk production compared to the purebred Jersey cows. Milk production was affected by year and parity, probably due to an increased number of older cows, which produced more milk, as the years progressed. The crossbred cows were more persistent having consistently increasing milk production in the later parities. The lack of season effect on milk production may be attributed to the similar nutrition environment provided by the pastures and supplementary feeding. Although milk is the main product in dairy enterprises, the meat production potential of the by-products (bull calves and cull cows) can be enhanced to improve enterprise income.

Crossing the Jersey with the Fleckvieh also presented an opportunity of producing meat from a dairy establishment, where the male calves are sold for veal or beef, and generally do not have the desirable meat production characteristics. Higher growth rates were observed in crossbred bull calves than in the purebred Jersey bull calves, which were reared for either veal or beef production under similar feeding conditions. Thus, crossbred bull calves reached the required live weight for veal earlier than the Jersey bull calves. The end live weight and ADG of crossbred steers reared as beef in a partially pasture-based system were also higher than those of Jersey steers. Therefore, if the beef production potential of a Jersey dairy enterprise is to be improved without compromising milk production, crossbreeding may be done by using a dual-purpose breed, such as, the Fleckvieh. This improvement in reproductive performance, milk production, and beef and veal production observed after crossbreeding may be attributed to breed complementarity and heterosis.

This study showed the superiority of crossbred animals over the purebred Jersey in reproductive performance, milk production, and beef and veal production. Although this superior performance can be attributed to heterosis, this could not be established in the current study. Calculation of heterosis requires records for both parent breeds to be available, which was not the case in this study. Data were only available for one parent breed, the Jersey. The performance of the crossbred animals could also not be compared to that of the Fleckvieh, like what was done with the Jersey. With inbreeding coefficients increasing by 2 to 3 %, heterosis for yield could increase by 0.6 to 0.9 % per decade, making crossbreeding more attractive over time (VanRaden & Sanders, 2003).

Proper evaluation of the production could only be made if an economic analysis of the enterprise was performed. The production figures should be compared with the inputs of the enterprise, especially the feed and health status, which form part of the production costs. It needs to be established if the fast-growing crossbred animals are high-maintenance or not. Using current South African prices (R3.60/l) for raw milk (*Lacto data*, 2013), crossbred cows that produced milk yields of 6141 ± 102 kg would have generated R22 107.60 compared to R19 432.80 from 5398 ± 95 kg milk of pure J per milking season. With the South African weaner prices (R16.15/kg) (*Agri Trends*, 2013), crossbred calves that reached 180.6 ± 4.0 kg would have generated R2916.69 per calf, compared to R2640.25 of pure J bull calves reaching 163.5 ± 3.9 kg at 6 months. Crossbred steers weighing 441.4 ± 14.9 kg would have generated R3439.26 at R28.95/kg more than pure J steers weighing 322.6 ± 13.4 kg at market age. A study by VanRaden & Sanders (2003) on economic merit of crossbred and purebred US dairy cattle, reported that F1 crosses of Brown Swiss or Jerseys with Holsteins were more profitable than purebred Holsteins. Lopez-Villalobos *et al*. (2000) also found that Holsteins × Jerseys herds had the highest net income per hectare compared to Holsteins and Ayrshire herds. Crossbreeding can, therefore be recommended if it produces fast-growing animals using almost similar production inputs. This entails computing the costs of all possible variable costs, and income obtained from the sale of milk, bull calves, cull cows, replacement costs and the sale of heifer calves.

6.1 References

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