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The effect of non-genetic factors on milk yield and composition of Red Dane cattle in Zimbabwe

G B Nyamushamba, D Chikwanda*, G H M Matondi, T Marandure, J Mamutse, B Tavirimirwa, N Y D Banana*** and M Dhliwayo******

Faculty of Agriculture, Women's University in Africa, P.O Box, MP 1222, Mt Pleasant, Harare, Zimbabwe
gnyamus@gmail.com
** Faculty of Science and Agriculture, University of Fort Hare, P. Bag X1314, Alice, 5700, South Africa*
*** Department of Research and Specialist Services, Matopos Research Institute P Bag k5137, Bulawayo, Zimbabwe*
**** Faculty of Agriculture and Natural Resources Management, Midlands State University, Gweru, Zimbabwe*
***** Department of Animal and Wildlife Management, Bindura University of Science Education, Zimbabwe*

Abstract

A study was carried out to establish non genetic factors affecting milk, butterfat and protein yields in Zimbabwean Red Dane cattle. A total of 1325 unedited 305-day lactation records were obtained from Zimbabwe Livestock Identification Trust herd, with cows calving in the period 2002–2006. The Henderson Type III sum of squares in Genstat edition 14 program was used.

Parity, days in milk, year of calving and age of calving had significant effects (P< 0.05) on milk, fat and protein yield; milk yield; protein and fat yield; and milk and protein yield respectively. An increase in parity resulted in an increase in milk yield and composition up to parity 4 and started declining in parity 5. An increase in days in milk also resulted in an increase in milk yield whereby the milk yield increased at a declining rate as from 350 days to 550 days. Milk yield and composition declined in 2005 and there was a decline in protein yield from 2006 to 2009. Lastly, milk and protein yield resulted in a gradual increase up to 58 months followed by a declining trend up to 103 months. Month of calving and days dry did not have significant effects (P> 0.05) on milk yield and composition of Red Dane cattle in Zimbabwe. The study showed that non-genetic factors have a significant effect on milk yield and composition of Red Dane cattle in Zimbabwe.

Keywords: *non-genetic factors, herd, season, calving interval, Red Dane cattle*

Introduction

Dairy farming is an important source of income to many agricultural labourers in the form of wages and salaries. Since most agricultural activities are seasonal, dairy farming offers year round opportunities for many people (Lintas 2007). In Zimbabwe, milk production has declined due to a rapid decline in the number of dairy farmers as well as the size of the dairy herd (Nyamushamba et al 2013). Most newly resettled farmers do not have the management and financial capacity to propel the dairy sector to previously recorded levels. They particularly fail to meet the adequate nutritional and environmental requirements of the highly selected dairy breeds. To resuscitate milk production in the dairy sector, FAO (2010) suggested that making small holder dairy farming more competitive could be a powerful tool. Organizations such as Agricultural Rural and Development Association - Dairy Development Programme (ARDA-DDP) have supported dairy production in the smallholder sector in Zimbabwe to a larger extent (Gambiza and Nyama 2000). However Owen, Segall and Lisowki (2005) feel there is need for concerted effort to raise levels of production if the market requirements are to be met. There is need for providing a solution to the problem attributed to the effects of non genetic factors (Nyamushamba et al 2013). Many pure exotic breeds are poorly adapted to the Zimbabwean climate. Encouraging the adoption of a breed with the genetic potential that can match the available resources and environment in the different sectors can be the best alternative.

The Red Dane is a Danish breed which has achieved popularity amongst a large number of smallholder dairy farmers in Zimbabwe. It is similar in size to the Aryshire (500 kg), red in colour, hardy and like the Dexter, notable for longevity. It produces an average of 5500 kg per lactation and 4.2% butterfat (Imbayarwo-Chikosi 2009; Masunda 2009). It is a breed that is highly preferred in the tropical countries because it is tolerant to diseases, adaptable to grazing and can utilize poor quality crude fibers. It is also docile and easy to handle. The breed is also not prone to mastitis and pink eye. It has outstanding easy calving in combination with a low incidence of still- born calves. It also has substantially lower somatic cell counts compared to Holstein and very low incidence of mastitis which is a good ground for the good economy of the herd. Mastitis and high cell counts are causing big economic losses in high producing dairies. The Red Dane breed also has high fertility and cows that get pregnant and calve every year are considered essential to the herd (Nyamushamba 2012). It is also described as a breed that is excellent in producing dairy and cream products.

In context, genetically, the Red Dane breed has a recorded potential to improve both the yield and composition of milk produced in Zimbabwe. However, its production continues to be limited by factors that are non-genetic especially in the small holder sector where management systems are very poor (Nyamushamba 2012). There is also scarce information on performance of the breed compared to other breeds in Zimbabwe. Not much research has been carried out on the Red Dane, unlike other breeds such as the Holstein and Jersey breeds (Makuza et al 1999; Dzomba 2000; Nyamushamba et al 2013). As a result, very few farmers utilize this breed. Currently, only one commercial farm, Red Dane farm in Beatrice is making use of the breed. Breed differences reflect differences in management conditions. Each breed has to be provided with suitable conditions for full expression of its phenotype. Therefore, there is need for determining the non-genetic factors that affect the performance of Red Dane so as to ameliorate the dairy production in Zimbabwe (Masama et al 2006; Ngongoni et al 2006).

Although genetically, the Red Dane breed has a recorded potential to improve both the yield and composition of milk produced in Zimbabwe, production continues to be suppressed by other factors that are non-genetic as observed in the smallholder sector where production constraints have been noticed. For the smallholder farmers to succeed in dairy production there is need to provide effective technical support to reduce cost. It is therefore critical to provide information on both the genetic and non genetic factors that influence milk production. A study on the non-genetic-factors affecting milk production in Red Dane cattle is therefore justifiable. The results can be used as a management tool, to improve selection criteria by accounting for non-genetic factors. The objective of this study was to determine the effect of non genetic factors on milk yield and milk composition of Red Dane cattle in Zimbabwe.

Materials and Methods

Environment

Zimbabwe is located in Southern Africa in the tropical savannah region. The total land is 390,759 km^2 and it is divided into five agro ecological regions. Rainfall patterns and crop production progressively deteriorate from ecological regions 1 to 5. However, livestock production including dairying is practiced in all the ecological regions (Gambiza and Nyama 2000). In the regions with low rainfall, dairying is assisted by production of drought-resistant fodder crops (Chinogaramombe et al 2008; Jingura 2000; Nyamushamba et al 2013). Most dairy farms are located within 40 km of the major cities and towns (United States Department of Agriculture (USDA 2009).

Data

The standard 305-day milk production records of pure bred Red Dane were obtained from Zimbabwe Livestock Identification Trust herd. It was unedited with the period of calving starting from 2004-2009. The data consisted of animal ID, days in milk, days dry, parity, age at calving, milk yield, protein content, fat content, somatic cell counts, year and month of calving, month of birth and year of birth. Animals were grouped by year of birth born from 2001 to 2007. Records were of individual cow milk yield, butterfat and protein contents.

Statistical analysis

The data were analysed using the General Linear Model of Henderson Type III sum of squares in Genstat edition 14 program. All duplicate records were deleted to remove bias from the data. The model used was:

$$Y_{ijkl} = \mu + P_i + DD_j + YOC_k + (b_1AOC + b_2AOC)_l + e_{ijkl}$$

Where:-

Y_{ijkl} is the observed value of all milk traits (305-day milk yield, fat and protein yields)
μ is the overall mean common to all observations
P_i is the fixed effect of parity
DD_j is the significant effect of dry period
YOC_k is the significant effect year of calving
$(b_1 \text{ and } b_2)_n$ are the linear and quadratic regression coefficients respectively of months effect on age at calving $(AC)_l$.
e_{ijkl} is the random residual error

Results and Discussion

Parity had a significant effect (P<0.05) on milk yield, fat yield and protein yield in the Red Dane herd. The milk yield increased gradually from parity 1 up to parity 4 and there was a slight decline in parity 5 with no significant difference in the milk yield in parity 1 and 2. In parity 7 there was an increase in the milk yield and was the highest milk yield compared to parity 1, 2, 3, 4, 5 and 6 followed by parity 4. Milk yield was highest in parity 4 and the lowest in parity 5. This was illustrated in Figure 1.

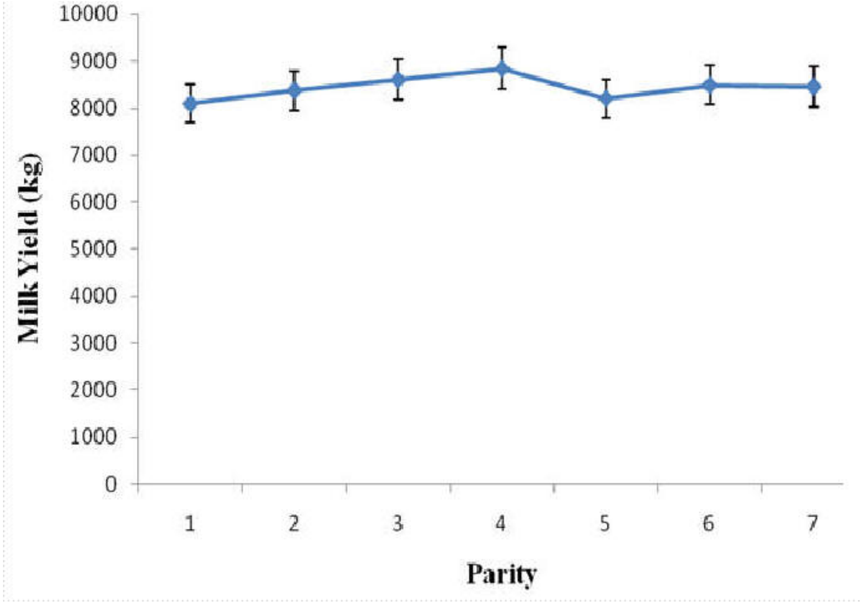

Figure 1: Effect of parity on milk yield for Red Dane cattle

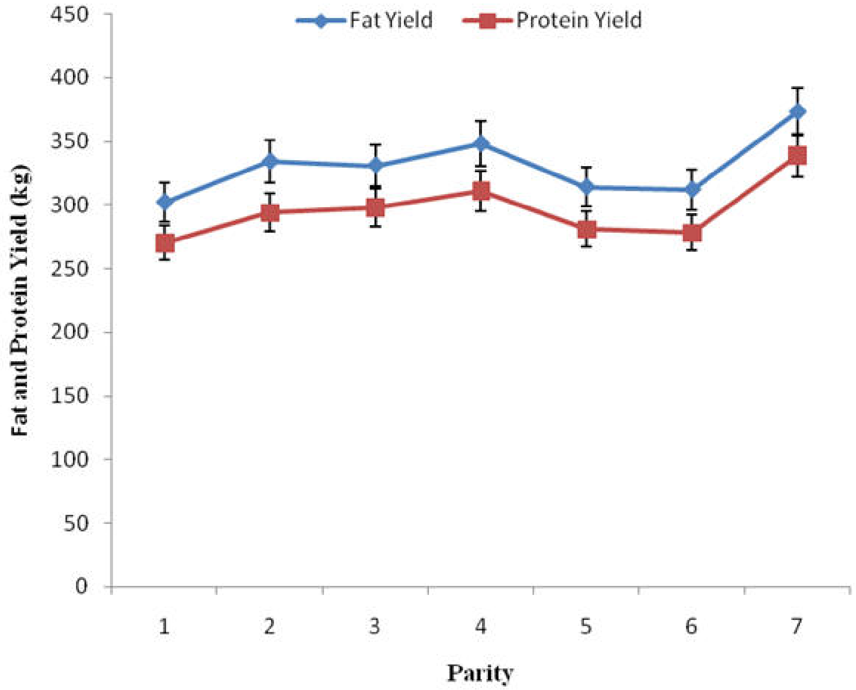

Figure 2: Effect of parity on fat and protein yield for Red Dane cows

The fat yield slightly increased in parity 2 and maintained more of the same yield up to parity 4, for there was no significant difference between the yields of parity 2, 3 and 4 (Figure 2). There was then a slight decrease in parity 5 and 6 then increased in parity 7. Protein yield was the highest in parity 7 and lowest in parity 1, 5 and 6 as in fat yield. There was also no significant difference in the protein yield in parity 2, 3 and 4.

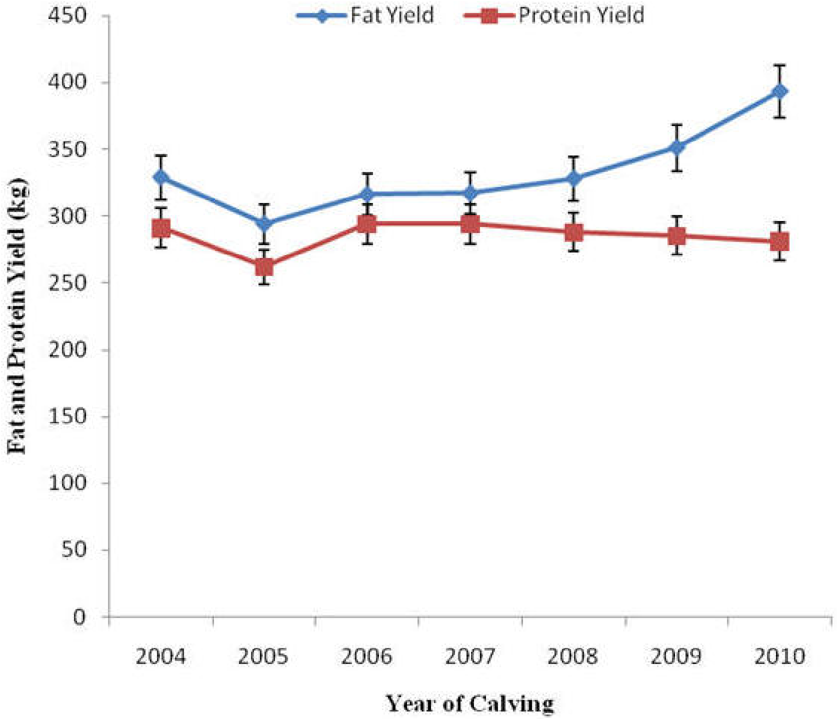

Figure 3: Effect of year of calving on fat and protein yield for Red Dane cattle

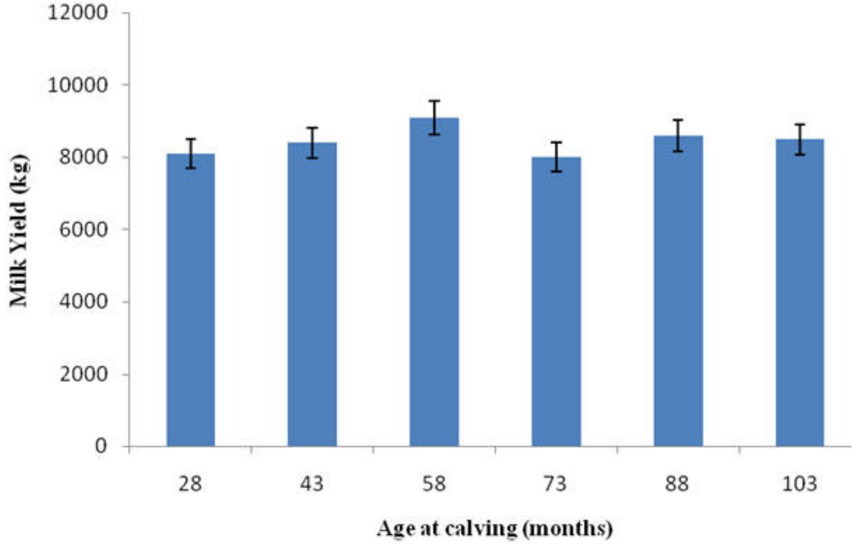

Figure 4: Effect of age at calving on milk yield for Red Dane cattle

Year of calving had a significant effect (P<0.05) on fat and protein yield and had no significant effect (P>0.05) on milk yield as shown in Figure 3 above. The fat yield slightly declined in 2005 and there was a gradual increase in the years 2006, 2007, 2008 and 2009 when the fat yield was the highest. There was, however, no significant difference in fat yield in 2006, 2007 and 2008 as it was recovering from a decline in 2005. In protein yield, there was a decline in 2005 followed by an increase in 2006. Unlike in fat yield, there was a declining trend from 2006 to 2009 as shown in Figure 3 above.

Age at calving had a significant effect (P<0.05) on milk yield and protein yield. However, age at calving had no significant effect (P>0.05) on fat yield. There was a gradual increase in milk yield from 28 up to 58 months which is when the peak yield was observed. After the peak, there was a declining trend with the lowest milk yield in 73 months. This was illustrated in Figure 4 above and Figure 5 below respectively.

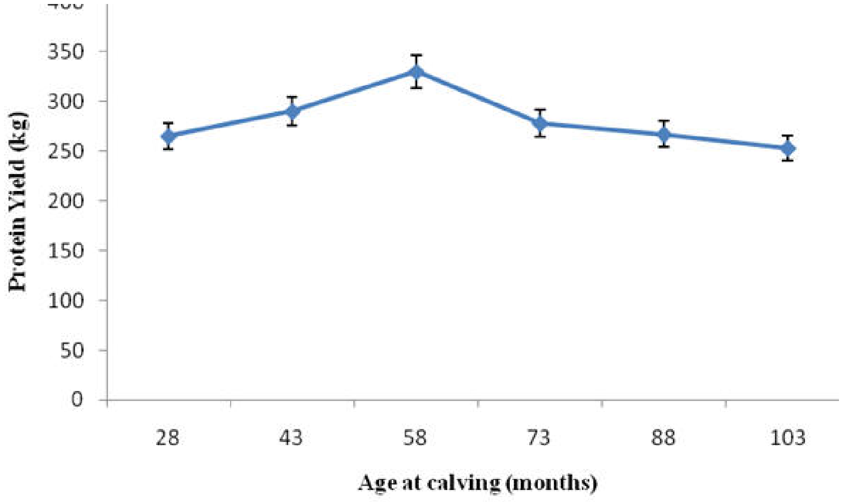

Figure 5: Effect of age at calving on protein yield for Red Dane cattle

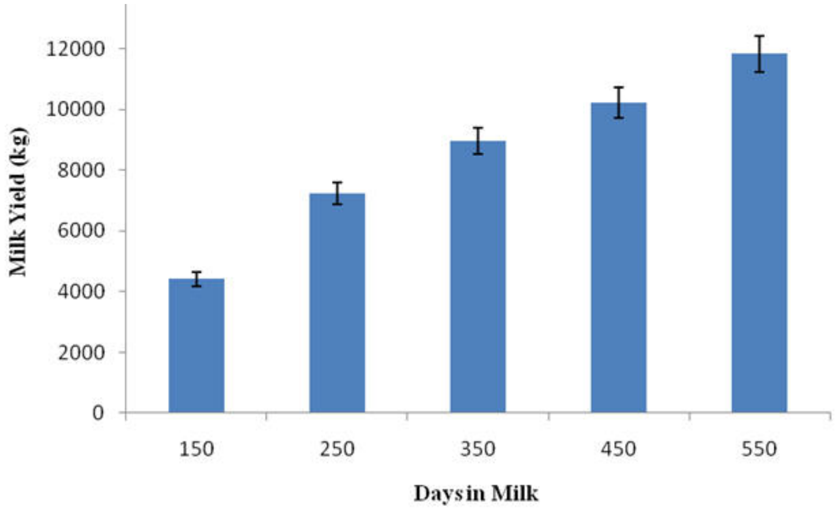

Figure 6: Effect of days in milk on milk yield for Red Dane cattle

The same trend was also observed in protein yield, where the peak was in 58 months, and was significantly different from the yields that were observed in 28, 88 and 103 age at calving (months). This is shown in Figure 5 above. The lowest protein yields for Red Dane cattle were recorded in 28 and 103 months respectively.

Days in milk had a significant effect ($P<0.05$) on milk yield of Red Dane cattle. However, it was not significant ($P>0.05$) on fat and protein yields. There was a sharp increase in milk yield as from 150 to 350 days in milk with a declining rate of increase from 350 to 550 days in milk.

The overall average milk yield that was observed in the study (8401 kg) was higher than that of the same breed under small holder sectors (1967 kg) (Ngongoni et al 2003). Therefore, Red Dane cows are not expressing their genetic potential in small holder sectors. This is due to non- genetic factors. In the study of the effect of non-genetic factors on the milk yield and composition of Red Dane cattle in Zimbabwe showed that parity, year of calving, days in milk and age of calving had significant effects. This could have been due to good feed supplementation. According to Smith (2004), the effect of season or months has become less significant because of better feeding and management of the dairy cows. However, in small holder sectors where the provision of energy in the cow's diet is usually suboptimal, the animals' performance is lower than optimal as was observed by Masama (2003). This was confirmed by the findings that the peak of calving in Lancashire occurred between August and November, as this would have been the result of mating occurring between November and February, a time that coincides with a period of abundant feed. This may have induced ovulation in a phenomenon equivalent to flushing. In commercial farms, the cows are provided with regular supplementary feed in the dry season, whereas cows reared in the smallholder-sector primarily depend on grazing (Masama et al 2003). Therefore, it can be suggested that if cows are provided with adequate feed supply, there will be no significant variation in milk produced all year round. Therefore cows can calve in any month of the year with no compromised effect on milk yield and composition. This leads to higher milk yields produced per year compared to milk yield produced in controlled breeding (breeding confined to specific months) (NIIR Board 2007).

There was a gradual increase in milk yield from parity 1 to 4. This suggests that milk yield increases as parity proceeds because large cows produce more milk than small cows due to large body size and increased udder development that comes with repeated pregnancies as well as full development of tissues of the udder. Also, multiparous cows reach their peak earlier in the lactation than first parity cows and consume more feed, eat larger meals and drink more water therefore their persistency will be longer than that of the first calvers leading to less milk yield produced by first calvers. The milk yield was also lower in early parities because the feed that was provided to the heifers was also channeled to their growth as they were still growing. As the parities proceeded, milk yield increased because the feed requirements for growth were declining (Keown et al 1986).

Milk yield declined in parity 5 and 6, however there was no significant difference between the milk yield in parity 1, 5 and 6. The results were in line with literature from the study of Aysrhire and Holstein breed (Wakhungu et al 2007). The decline is due to decline in body condition and degeneration of the body system over the recurring pregnancies. It will depend on whether the cow is able to maintain the condition to a subsist level. Therefore, it can be concluded that the productive period of Red Dane cows is as long as that of other predominant exotic breeds (Wakhungu et al 2007). They can sustain the dairy enterprise for it is possible for them to provide the farm with acceptable levels of milk yield and composition from parity 1 up to parity 6 or 7, just as other exotic breeds. Also, the cows can be bred up to parity 7 before they are culled, being a desirable trait.

The results of this study were similar to findings in other studies made in the Tropics with Holstein and Ayrshire breeds (Wakhungu et al 2007) where the peak was obtained in parity 4. The rate of culling in Red Dane and other exotic breeds, relative to parity, is comparable. This can be supported by results that were obtained by (Amimo et al 2007) where the Holstein cows were culled in parity 6 when milk yield had dropped, leading to a sudden increase in parity 7. These results disclose that that the effect of parity on Red Dane and other predominant breeds in the large scale sector is comparable. Basing on the effect of parity, performance of Red Dane is similar to that of the other predominant breeds in the large sector therefore can also be adopted at a larger scale as the other exotic breeds. However, the culling rate is very high in small holder sectors due to poor feeding and general management (Masama et al 2003).

In fat and protein yield, there was also a gradual increase from parity 1 up to parity 4, as in milk yield. There was a decline in parity 5 and 6, then a sudden increase in parity 7. The increase was also due to increase in body weight combined with advancing age at full development of secretory tissues of the udder. The decline was because of physiological activities of all body systems and secretory tissues of mammary gland. The results of this study were contrary to findings in other studies, Kabunga and Kwaku (2004) where it was reported that the variation of the chemical composition of forage and concentrate mix explained for variation in Friesian milk yield and quality. In this study, year of calving had significant effect ($p<0.05$) on milk quality only (protein and fat yield). Changes in management, feeding regime and other environmental factors are usually responsible for the variation of milk production through years (Makuza et al 1999). The 2005 economic problems such as inflation caused financial problems in the dairy enterprise. As a result, feed supply was inadequate, leading to variation in the concentrate and forage mix reported to have effect on the milk quality (Kabunga and Kwaku 2004). That is the reason why there was a decline in protein and fat yield in 2005. Also intermittent drought periods in 2005 would also have led to adverse decline in the fat and protein yield in the sense that there were also inadequate natural pastures coupled with increase in the cost of concentrates and feeds.

In 2006, the yields increased, with fat yield increasing up to 2009. Protein yield started declining in 2007 up to 2009. This was due to abundant grain and forages as well as inadequate and high costs of protein feed sources in the years. Soya bean were even imported from other countries. Therefore there were inadequate protein feeds for the cows leading to the decline in protein yields. Abundant forages and grains (sources for fat milk production) were responsible for the increase in fat yields in these years. According to the results, it shows that Red Dane breeds can adapt to different environmental conditions for the variation in the fat and protein yield were very low as compared to other exotic breeds (Holstein) (Kabunga and Kwaku 2004). Milk yield also was not even affected unlike in other exotic breeds. However, the milk yield of the same breed was affected, and was very low in small holder sectors. This was because fodder size was limited by size of land and only groundnut tops were used as the source of protein. Feed resources were very poor. As a result, milk production was highly affected (Ngongoni et al 2006).

Age at calving had significant effect ($p<0.05$) on milk yield and protein yield, with no significant effect ($p>0.05$) on fat yield. The results were consistent with the report in the literature. The age increase in 305 day production was essentially linear up to 58 months, when maximum production was reached.

Thus it was possible to use the linear regression of production on age up to an average of 58 months as a basis for comparing the influence of age at various levels of production. The significance of age on dam on milk production shown in this study suggests that farmers have to provide cows with adequate feed so that by the time they reach 58 months of age, they have good body conditions so that the milk yield is not compromised. This is because increase in milk yield is due in part to an increase in body weight which increases with age (Kume and Tahuri 2007). The declining trend in 73 months (quadratic regression) was due to decline in physiological activities of body systems as well as degeneration of secretory tissues of mammary glands. The yield was however insignificantly different from the yield produced in earlier months (average of 28 months). This suggests that the Red Dane can be kept up to an average of 103 months and still maintain desirable milk yield in the herd. This was consistent with results that were obtained on the effect of parity, where cows were recommended to be culled in parity 6. Their productive life period can sustain a dairy enterprise for an average of about 100 months.

First calving was in 20 months whereas in smallholder sector, first calving was in 37-58 months (Masama et al 2003). This suggests that attainment of puberty by heifers reared in the smallholder dairy sector is delayed. Under nutrition of heifers has been found to delay the onset of puberty in dairy cattle. This supports literature that suggests the Red Dane cows in small holder sectors to have shorter productive period in small holder sectors than in commercial sectors (Masama et al 2003).

For the protein yield, there is a gradual increase up to 58 months then a declining trend. The lowest milk yield was obtained in average of 103 months although it was not significantly different from yield that was produced in 28 months. This suggests that farmers keeping the Red Dane cows for milk protein production can keep the cows in the breeding herd up to an average of 103 months. Therefore, in relation to protein yield production, the cows have almost the same productive periods as with Friesians. As in the milk yield, the peak of protein yield is lower and the declining rate is significantly higher in small holder sectors. This is also due to poor body condition (Masama et al 2003; Gambiza and Nyama 2000).

Days in milk did not have effect on milk composition of Red Dane cattle but the on the milk yield. The milk yield increased as the days in milk increased. This can be supported by literature (Boulle et al 2012). There was rapid increase from the average of 150 days up to 350 days. The milk yield increase from 350 to 550 days was at a declining rate. Therefore the recommended lactation length is 300-305 days (Bajwa et al 2004). A period beyond that will negatively affect the lifetime production of the cows. However, to obtain the expected milk yield within 305 days, good management and feeding systems have to be used. Due to the lack of these practices in many small holder sectors, the milk yield produced in 305 days in Red Dane cows compare more favorably with the 442 day length observed in small holder sector with the same breed (Masama et al 2003).

Conclusion

- Parity, year of calving, days in milk and age of calving affect yield and composition of milk of Red Dane cows in Zimbabwe.
- Farmers are encouraged to manipulate the environment of the Red Dane cows in such a way that the genetic potential of the cows can be expressed.
- If the environmental requirements of the breed are met, milk yield and composition in the dairy sector may be improved because genetically, Red Dane cows have the potential to improve the production as was shown by the results (average milk yield in the commercial sector is 8401 kg/ lactation).
- Commercial farmers are advised and recommended to adopt the breed at a larger scale for the breed is comparable to the performance of other predominant breeds in the commercial sector under the Tropical climate here in Zimbabwe.

- Farmers who produce milk specifically for milk products processing such as cheese are encouraged to adopt the Red Dane breed on their farms because it produces milk that is high in fat and protein levels.

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