Journal homepage: http://www.sasas.co.za/journals

South African Journal of Animal Science 2018, 48 (No. 5)

Invited Paper: 50th SASAS Congress 2017

Fertility in dairy cows and ways to improve it

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(Received 8 August 2018; Accepted 10 November 2018; First published online 17 November 2018)

Abstract

The fertility of dairy cows affects the genetic improvement and financial sustainability of dairy herds. Fertility is a complex trait that is affected by several factors. Genetically, fertility is difficult to improve because of low heritability. Cows that do not become pregnant are usually culled from the herd. This paper reviews results from studies conducted in South Africa that are aimed at improving the reproductive performance of dairy cows. Records from 9 046 cows in 14 Holstein herds showed that, while lactation number, calving year and calving season affected fertility traits significantly, herd management had the largest effect. Mean ± sd for calving to first service (CFS) and from calving to conception (DO) intervals were 77 ± 30 and 134 ± 74 days, respectively. The number of services per conception (SPC) was 2.55 ± 1.79. The proportion of first services within 80 days post partum and cows confirmed pregnant within 100 and 200 days post partum were 0.64 ± 0.48, 0.36 ± 0.48, and 0.71 ± 0.45, respectively. Heritability (h^2) estimates were 0.06, 0.08 and 0.07 for CFS, DO, and SPC, respectively. Albeit low h^2 estimates were consistent with literature results, the genetic correlation between CFS and DO was positive (0.56), and negative (-0.29) between CFS and pregnancy success. Crossbreeding, using a dual-purpose breed, improved fertility, similar to studies conducted overseas. Increasing the energy content of the total diet of Holstein cows on kikuyu-ryegrass pasture by feeding 7 kg versus 12 kg concentrates/cow/day, improved fertility as a higher proportion of cows were pregnant by 150 days in milk, being 0.52 versus 0.84 and 0.56 versus 0.76 for primi- and multiparous cows, respectively. Estimating breeding values for fertility traits for breeding sires would assist in improving fertility in dairy cows.

Keywords: Concentrate level, crossbreeding, days open, energy source, interval traits, genetic parameters, management-induced infertility

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Introduction

The fertility of dairy cows affects the genetic improvement and financial sustainability of a dairy herd. Cows calve down to start a new milk production phase, while producing progeny for the next generation. Milk yield in the Holstein breed has increased markedly in recent years, while fertility has declined. Butler (1998) showed that while the milk yield in Holstein cows doubled from 4 750 kg in 1951 to 9 000 kg in 1996, the conception rate of cows decreased from 68% to 40%. Silva (2003) also showed that the number of days from calving to conception (DO) increased, and the number of services per conception (SPC) also increased. In South African Holsteins, calving interval (CI) increased from 386 days in 1986 to 412 days in 2004 (Makgahlela *et al.*, 2008). The reason for the decline in fertility is probably because breeding and selection programmes in dairy herds have focused on the improvement of milk yield and conformation traits. Little emphasis has been put into the genetic improvement of dairy cow fertility. This is probably because fertility is a complex trait that is affected by a number of factors. Genetically, it is difficult to change because it of low heritability. Cows that do not become pregnant are culled involuntary because of infertility at the farm level. Poor reproduction management may result in poor fertility in dairy cows, that is, cows may come on heat, but are not inseminated owing to poor heat observation, resulting in not becoming pregnant. On the other hand,

URL: http://www.sasas.co.za
ISSN 0375-1589 (print), ISSN 2221-4062 (online)
Publisher: South African Society for Animal Science http://dx.doi.org/10.4314/sajas.v48i5.6

because of veterinary interventions such as hormonal treatments to activate the heat cycling, the probability of cows becoming pregnant increases because of timed inseminations. Therefore, poor management could induce infertility, while veterinary treatments could improve fertility. Both practices have direct and indirect cost implications for farmers and also complicate efforts to select for improved reproduction.

Traditionally, CI and SPC have been used as indicators of herd fertility. Although important, these traits are not suitable indicators of the standard of reproduction management. Calving interval is a reflection of historical events, while cows that do not calve for a second time are not included in genetic evaluations. The number of SPC is affected by cow effects, such as poor heat signs and people effects, because of poor heat detection and inferior artificial insemination (AI) techniques. The prerequisites for fertility may be defined as cows coming on heat soon after calving, as indicated by the calving to first service interval (CFS), and conceiving from a minimum number of services while maintaining pregnancy to the next calving. Binary traits could be derived from linear traits, that is, whether first service took place within 80 days post partum, first service conception rate, and pregnancy being confirmed within 100 or 200 days post partum.

An Australian survey (Morton, 2004) used reproduction records from almost 30 000 cows in 168 herds to develop norms and standards to indicate the level of reproduction management and to identify top performing and problem herds. The InCalf project used four traits to indicate the standard of reproduction management. Traits were 100-day-in-calf rate (the percentage of cows confirmed pregnant within 100 days of calving), and 200-day-not-in-calf rate (the percentage of cows not pregnant within 200 days of calving). The drivers of these in-calf rates are the 80-day submission rate (the percentage of cows that have been inseminated by 80 days of calving) and the conception rate (the inverse of the number of services per conception).

The aim of this paper is to review results from studies conducted in South Africa that were aimed at ways to improve the reproductive performance of Holstein cows. Using farmers' AI records, standards and norms were established to determine the level of reproduction management. Genetic parameters for fertility traits based on service records were estimated. Two studies were conducted to quantify the effect of crossbreeding using a dual-purpose breed. A study to determine the effect of concentrate feeding level and concentrate energy source on the fertility of Holsteins was also conducted. Each approach is discussed separately, followed by a general conclusion and recommendation.

Discussion

Establish norms and standards for reproduction management

Dairy farmers in South Africa mostly use CI, SPC and age at first calving of heifers as indicators of cow fertility and reproduction management. Although important, these indicators are not well suited to establish the level of reproduction management in a dairy herd. There is no information on CI for cows that fail to calve down for a second or third time. The number of SPC depends on heat observation and technical skill of the inseminators, while age at first calving of heifers is affected by the feeding programme. In Australia the reproductive performance of lactating dairy cows was studied in a prospective observational study of 29 462 cows in 168 commercial herds in nine regions (Morton, 2004). There were substantial variations in all reproductive performance measures between herds, suggesting that improvements in reproductive management would be possible.

In a first attempt to establish norms and standard for South African dairy herds, insemination records were used of about 9 000 Holstein cows in 14 herds in zero-grazing and pasture-based production systems from 1991 to 2007 (Muller *et al*., 2014). Calving down and AI dates of individual cows were used to estimate fertility parameters. The outcome of each AI event was known. Pregnancy diagnosis was based on rectal palpation by a veterinarian, usually on a monthly farm visit. Descriptive statistics for fertility traits are shown in Table 1. The level of reproduction management is also compared with the Australian InCalf survey guidelines (Little, 2003) to establish the level of reproduction management.

Although cows became pregnant in 85% of lactations, and average values for some traits were acceptable from a management point of view, large variations were observed, as indicated by high coefficients of variation, that is 39% and 70% for CFS and SPC, respectively. This indicates the complex interplay among elements such as the decision policy of the dairy farmer with regard to the voluntary waiting period (VWP), post-calving treatment of cows, nutritional management, environmental factors and the genetic merit of cows for fertility (Potgieter, 2012).

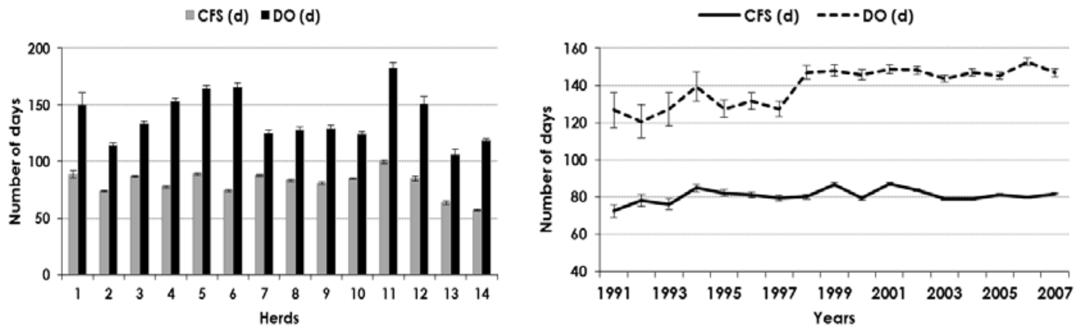
Table 1 Mean, standard deviation and coefficient of variation of fertility traits (Muller *et al*., 2014) in comparison with InCalf guidelines (Little, 2003)

Traits	Mean ± SD	CV (%)	InCalf guidelines	
			Good managers	Seek advice
Calving to first service (days)	77 ± 30	39	-	-
First service within 80 DIM (%)	64 ± 48	75	73	<61
Services per conception	2.55 ± 1.79	70	1.96	>2.32
Days open (days)	134 ± 74	55	-	-
Cows pregnant within 100 DIM (%)	36 ± 48	133	58	<43
Cows pregnant within 200 DIM (%)	71 ± 45	63	87	<81

DIM: Days in milk

Although the mean interval for CFS was 77 days, only 64% of first services occurred within 80 days of calving. The Australian survey indicated that good managers achieved first services within 80 days of calving in 73% of cases. The DO interval was high and variable at 134 ± 74 days. Only in 36% and 71% of all lactations were cows confirmed pregnant within 100 and 200 days post partum, respectively. These values are lower than the level at which InCalf guidelines suggest farmers seek advice. Overall data indicate that reproduction management in the sample herds was relatively poor and required management intervention.

The effect of herd and calving year on the interval traits CFS and DO is presented in Figure 1 (Muller *et al*., 2014). Large differences were found between herds. That is, minimum and maximum intervals were 75 and 142 days for CFS and 115 and 185 days for DO, respectively



(a) (b)

Figure 1 Effect of (a) herd and (b) calving year on interval traits for calving date to first service date and days open . CFS: Calving to first service

Over years, the largest increase (3.5 days) in CFS occurred from 1991 to 1994. From 1995 the interval CFS did not change over time, probably indicating that herd managers were not able to improve this trait or had accepted this level of reproductive performance. The interval DO increased from 127 days in 1991 to 153 days in 2006, with the largest increase occurring from 1991 to 1998 at 2.1 days per year. These results suggest that farmers have adopted a strategy for VWP and insemination protocols to maintain a DO interval of about 147 days.

Subsequently, another dataset was compiled using a commercial (DIMSSA) reproduction management programme (Muller *et al*., 2016). Reproduction records of 45 560 lactations from 15 770 Holstein cows were obtained from 27 dairy herds. Data included cow identification number, calving dates, and all service dates of heifers and cows. Pregnancy diagnosis was by rectal palpation by a herd veterinarian. Heifer fertility traits included age at first service and age at first calving. The proportion of age at first service and age at first calving at specific target ages was also established. Similar cow fertility traits to the first survey were derived. Top and bottom herds were identified with a ranking system for each trait, 1 being best and 27 poorest. Table 2 shows the mean reproduction management performance for all Holstein herds and the top and bottom 10% of herds.

Table 2 Mean reproduction management performance for 27 herds and top and bottom 10% performing Holstein herds (Muller *et al*., 2016)

Animals	Parameters	Mean All herds	Herd performance	
			Top 10%	Bottom 10%
Heifers	Age at first service (months)	17.7	14.5	23.8
	First service before 15 m of age (%)	30	68	0
	First service before 18 m of age (%)	61	89	7
	Age at first calving (AFC) (months)	27.8	24.6	33.4
	AFC before 24 m of age (%)	21	60	1
	AFC before 27 m of age (%)	50	84	8
Cows	Interval calving to first insemination (days)	92	89	104
	First service before 80 days-in-milk (%)	51	62	44
	Number of services per conception	2.16	1.62	2.35
	Interval calving to conception (days)	140	112	164
	Pregnant before 100 days-in-milk (%)	40	57	31
	Pregnant before 200 days-in-milk (%)	81	90	72

Age at first calving (AFC) is mostly used to indicate the reproductive performance of heifers in dairy herds. Reducing AFC is the most effective way to lower the rearing cost of heifers. For AFC to be around 24 months old, heifers should be pregnant by 15 months old. Although 68% of heifers were inseminated before 15 months old in the top 10% herds, conception seemed to be later as only 60% of heifers calved down before 24 months old. It seems to be difficult to achieve an average AFC of 24 months, as even in the top 10% herds only 84% of first calving dates is below 27 months old.

Reproduction management indicators for top herds compared with bottom herds showed an earlier first service, lower SPC and lower DO being 89 versus 104 days, 1.62 versus 2.35, and 112 versus 164 days, respectively. As expected, the proportions of first services before 80 days-in-milk, cows pregnant before 100 and 200 days-in-milk were better for top herds compared with bottom herds. The bottom 10% herds in this survey showed poor performances compared with the InCalf guidelines.

The extended intervals from calving to first service could be ascribed to reproductive management of cows after calving, for example not having uterine infections or reproductive problems such as cystic ovaries that were not detected early. Uterine infections could be caused by the calving environment, that is, wet and dirty conditions, the birth weight of calves (poor sire selection), presentation (position) of calves during the calving process, retained placentas because of nutritional imbalances, and a host of other potential causes.

Reproduction norms and standards are not available for South African dairy herds, although a number of advisors are active in this field. Although a larger dataset would have provided more robust guidelines, the present results could be used by farmers to determine their own level of reproduction management. A national database is required, which would enable the estimation of genetic parameters for fertility traits towards the development of a fertility index to reflect the national selection objective.

Genetic and environmental parameters for fertility traits in South African dairy cattle

The estimation of genetic parameters is usually preceded by the establishment of an operational model that accounts for the systematic sources of variation that affects traits. Failure to account for these sources of variation results in biased estimates of genetic (co)variance components and ratios. In a first attempt to estimate genetic parameters for fertility traits in South African dairy herds, insemination records (n = 69 181) from 24 646 lactations of 9 046 Holstein cows in 14 Holstein herds from 1991 to 2007 were used (Potgieter, 2012). Against this background, the effects of herd, calving year, calving season and lactation number on fertility traits of Holstein cows are presented in Table 3, as based on the paper by Muller *et al*. (2014).

Table 3 Estimated least square means of the effect of herd, calving year, calving season and lactation number on fertility traits in South African Holstein (Muller *et al*., 2014)

Traits	Fixed effects			
	Herd	Calving Year	Calving Season	Lactation Number
Interval calf to first AI date (days)	2598201**	118646**	25816**	75173**
Days open (days)	1259070**	2273999**	21501[1]	331422**
Services per conception	1473.7**	1059.9**	27.9[1]	34.1[1]
First service < 80days-in-milk	487.6**	41.4**	6.1**	11.8**
Pregnant < 100 days-in-milk	119.7**	25.4**	9.2**	14.7**
Pregnant < 200 days-in-milk	196.9**	37.3**	7.5**	32.3**

**P <0.01; *P <0.05; [1]Not significant

With the exception of DO, herd (management effect) had the largest effect on the variation for all the fertility traits (underlined values in Table 3). This result is probably a function of management factors such as the calving down process (dystocia, disinfection of the uterus or a clean calving down area), applied voluntary waiting period, heat detection rate and inseminator proficiency.

Generally, two types of traits are used in fertility evaluation of dairy cows, namely binary (discrete) responses on the binomial scale, and continuous or interval traits. These traits may have to be treated differently when appraised statistically. For instance, one could implement the restricted maximum likelihood (REML) linear mixed models (LMM) procedure for continuous traits, and the generalized linear mixed model (GLMM) procedure for binomial traits via a LOGIT link back transformation. Alternatively, a Bayesian approach using Monte Carlo Markov Chain (MCMC) methods employing Gibbs sampling may be employed when threshold traits are analysed with continuous traits in a genetic analysis.

Because this review is based on the genetics of reproduction of South African dairy cows, recent reports based on local herds are emphasized. The genetics of those reproduction traits in Tables 3 and 4 of Holstein cattle in South Africa were studied by Muller *et al*. (2010) and Potgieter (2012). These studies all implemented MCMC methods based on the BLUPF90 suite of programmes as described by Misztal *et al*. (2002) and Misztal (2008). A synthesis of genetic parameters from these studies is reported in Table 4.

Table 4 Range of (co)variance ratios for the reproduction traits interval calving to first service; days open; number of services per conception; whether first service was within 80 days of calving (FS80d); whether cows became pregnant within 100 days after calving; whether cows became pregnant within 200 days of calving as derived from South African studies

Trait	CFS	DO	SPC	FS80d	PD100d	PD200d
CFS	**0.06 to 0.09**					
DO	0.55 to 0.56	**0.05 to 0.08**				
SPC	-0.01 to -0.10	0.72 to 0.81	**0.05 to 0.07**			
FS80d	0.03	-0.50 to -0.51	-0.88	**0.04 to 0.10**		
PD100d	-0.64	-0.99	-0.88	0.54	**0.07 to 0.08**	
PD200d	-0.29 to -0.36	-0.79 to -0.98	-0.85 to -0.90	0.36 to 0.60	0.95 to 0.96	**0.06 to 0.08**

Heritability estimates are in bold on the diagonal; genetic correlations below the diagonal
CFS: Calving to first service; FS: first service; DO: days open

The heritability estimates of most fertility traits were low, ranging from 4% to 10% depending on the definition of the trait and the methodology used for its analysis. Dematawewa & Berger (1998) using a linear model, found heritability to be 0.04 for DO in Holsteins. Similarly, Van Raden *et al*. (2004) and Oseni *et al*. (2004) found heritability estimates for DO of 0.037 and 0.03-0.06, respectively, for US Holsteins, indicating a strong management effect. However, there is consensus that there is sufficient genetic variability that can be exploited to improve reproductive performance (Averill *et al*., 2004). Moreover, the level of variation associated with animal permanent environmental effects was similar to the heritability estimates reported for these traits. This means that selection for improved reproduction based on the traits would result in some current herd gains. Genetic correlations suggested that cows with a longer CFS would have higher values for DO and would be less likely to be pregnant within 100 days of calving. Higher values for DO would be associated with more SPC and lower levels for FS80d, PD100d, and PD200d. Cows with higher levels for SPC would be less likely to be inseminated before 80 days after calving and less likely to be pregnant 100 and 200 days after calving. Cow with early first services would be more likely to be pregnant after 100 and 200 days. PD100d and PD200d were similar traits on the genetic level, which could be expected. Additionally, Potgieter (2012) did not report any significant genetic correlations of the traits considered in this review with qualitative and quantitative milk traits.

From the results reviewed here, it is evident that the traits considered should be included with age at first calving and CI, as used by Mostert *et al*. (2010) for dairy cattle in South Africa. However, for this to be implemented, a national database is required to enable the estimation of genetic parameters for fertility traits. Further objectives could include the development of a fertility index to be included in a national selection index.

Managerial interventions: To quantify the effect of crossbreeding

Because of increasingly poor reproductive performance in dairy herds, commercial farmers are considering crossbreeding to overcome this, reasoning that fertility traits of low heritability should benefit from heterosis. Traditional crossbreeding uses Jersey (J) sires on Holstein (H) cows and vice versa. In New Zealand 35% of all cows are crossbred J x H (Montgomerie, 2002). However, some local dairy farmers have started crossbreeding programmes using a dual-purpose breed. Because such ad hoc inseminations resulted in only a small number of records in varying production systems, farmers requested a formal study to determine the effect of crossbreeding on production and reproduction performance using Fleckvieh (F) sires on H and J cows. The Fleckvieh (a Simmental-derived dual-purpose breed from Germany) is one of the major breeds in worldwide milk production (Edell *et al*., 2011). The Montbéliarde breed (a similar Simmental-derived breed from France) has been used in crossbreeding studies in the USA (Heins *et al*., 2012) and Ireland (Walsh *et al*., 2008).

Two studies were conducted at Elsenburg Research Farm over six years from 2008, as described by Goni *et al*. (2014) and Metaxas (2015). For the first study, J cows were inseminated with J or F sires to create a purebred J herd and a crossbred F x J herd. Jersey and F x J cows were compared in a pasture-based system consisting of kikuyu pasture supplemented with a standard commercial concentrate mixture fed twice a day after milking at 7 kg/cow/day. A pasture-replacement mixture consisting of oats and lucerne hay and a high protein source such as cottonseed meal was provided as additional roughage during winter when pasture availability was low. For the second study, 48 five-day-old H and F x H heifers were sourced from a commercial dairy herd. Heifers were transported to Elsenburg Research Farm and reared to first calving with the standard herd management programme. After calving, cows were put in an open camp system and fed a total mixed ration on an ad libitum basis in fence-line feeding troughs. Fresh drinking water was freely available at all times.

Cows in both production systems were machine-milked twice a day in a milking parlour about 500 m from the open camps. The milk yield of cows at the evening milking and that of and following morning, was recorded approximately every 35 days during the lactation period. Milk samples were collected at both milking sessions and combined for analysis for fat, protein and lactose content at the milk testing laboratory of the National Milk Recording Scheme. Milk, fat and protein production were adjusted to 305 days per lactation. Cows in both trials were inseminated from 60 days after calving and the reproductive performance of each cow was recorded. Heifers were put in a service group from 13 months old and inseminated when observed to be in heat. Insemination dates of all heifers and cows were recorded as is usual for a dairy herd. From these dates, a number of fertility parameters was derived. The production performance of all crossbred cows (+50% Fleckvieh) were grouped together and compared with purebred J and H cows in each production system. Cows in both studies were evaluated over parities 1 to 5. Milk production and reproduction data were analysed using suitable statistical software.

The milk, fat and protein yields of F x J cows were higher (P <0.05) than those of J cows in the pasture-based system. Fat and protein percentages did not differ (P >0.05) between breeds, although they were lower in absolute terms in F x J cows (Goni *et al*., 2014). In the zero-grazing system milk, fat and protein yields of H and F x H cows did not differ (P >0.05), while fat and protein percentages were higher (P <0.05) in F x H milk (Metaxas *et al*., 2014; Metaxas, 2015).

The reproductive performance of J and H cows compared with Fleckvieh crossbreds is presented in Table 5. Goni *et al*. (2015) found that the CFS interval was shorter for F x J cows compared with J cows, that is, 76.7±2.2 days versus 82.4 ± 2.5 days. A larger proportion of F x J cows were inseminated within 80 days post calving compared with J cows (0.70 and 0.54, respectively). Similarly, the proportion of cows confirmed pregnant by 100 days in milk was higher for F x J cows *vs*. J cows, being 0.79 and 0.66, respectively.

The interval from calving to first service was shorter (P <0.01) for F x H cows compared with H cows, being 86 and 105 days, respectively (Metaxas *et al*., 2014; Metaxas, 2015). This resulted in a shorter (P = 0.07) interval from calving to conception (days open), being 153 and 135 days for H and F x H cows, respectively. A larger (P = 0.08) proportion of F x H cows were inseminated within 80 days post partum while a larger proportion of F x H cows were confirmed pregnant within 100 days of calving compared with H cows.

Table 5 Mean ± se (standard error) reproductive performance of Jersey (J) and Fleckvieh x Jersey (F x J) cows in a pasture-based system and Holstein (H) and Fleckvieh x Holstein (F x H) cows in a zero-grazing system

Traits	Pasture-based		Traits	Zero-grazing	
	J	F x J		H	F x H
Number of records	155	190	Number of records	158	142
Conception rate	$0.66^{a} \pm 0.03$	$0.79^{b} \pm 0.03$			
Interval CFS (days)	$82.4^{a} \pm 2.5$	$76.7^{b} \pm 2.2$	Interval CFS (days)	$104.7^{a} \pm 5.0$	$86.2^{b} \pm 5.3$
Proportion FS <80d	$0.54^{a} \pm 0.05$	$0.70^{b} \pm 0.05$	Proportion FS <80DIM	0.45 ± 0.04	0.51 ± 0.04
Interval DO (days)	$114.8^{a} \pm 8.1$	$104.8^{b} \pm 6.8$	Interval DO (days)	$153.1^{a} \pm 6.8$	$135.3^{b} \pm 7.1$
Services/conception	$1.7^{a} \pm 0.1$	$1.6^{b} \pm 0.1$	Services/conception	2.24 ± 0.14	2.30 ± 0.15
			Pregnant <100DIM	$37^{a} \pm 6$	$48^{b} \pm 6$
			Pregnant <200DIM	76 ± 4	81 ± 4

[a,b] Values with different superscripts within heifer and cow groups differ at P <0.10

CFS: calving to first service; FS: first service; DO: days open; DIM: days in milk

Although not compared directly, inseminator proficiency seemed to differ between production systems and breeds, being about 0.61 for J and F x J cows in the pasture-based system and 0.44 for H and FxH cows in the zero-grazing system. Haile-Mariam *et al*. (2004) reported services per conception of 1.84 for Holstein cows in Australia, which converts to an insemination efficiency of 0.54.

Managerial interventions: To verify the effect of concentrate level and energy source

It has been suggested that the nutrient requirements for the early resumption of ovarian activity, follicle development and embryo development differ. For this reason, a high non-structural carbohydrate (starch) diet is suggested until oestrus, followed by a diet that did not promote insulin secretion (fat) until the end of the breeding season. It is postulated that feeding fat as an energy source would improve the quality and survival of the ovum after 60 DIM. A British study has shown that feeding starch early in the lactation period reduced the number of days from calving to first service and increased the proportion of cows ovulating by 50 DIM and a greater pregnancy rate at 120 DIM (Van Knegsel *et al*., 2007a; 2007b; Garnsworthy *et al*., 2008) and enhanced ovarian activity (Gong *et al*., 2002). In a South African study (Useni, 2017), two groups of Holstein cows on kikuyu-ryegrass pasture were fed two levels of starch-containing concentrates at 7.0 (Control*)* versus 12.6 kg/cow/day (high starch-low fat; HSLF) from calving to 154 days after calving. In addition, a third group of cows was fed the same HSLF concentrate to 60 days after calving followed by a lipogenic (low starch-high fat (LSHF)) concentrate from 61 to 154 days after calving. Drinking water was provided ad libitum. Cows were milked twice a day and concentrates were fed in equal amounts after each milking. Milk production, live weight and reproduction performance of primi- and multiparous cows were recorded..

The effects of various concentrate levels and energy source on fertility traits in primi- and multiparous Holstein cows are presented in Table 6.

Table 6 Least square means (± SEM) of fertility traits of primi- and multiparous Holstein cows in a pasture-based system supplemented with concentrates differing in levels and types of energy sources

Parameters	Primiparous cows			Multiparous cows		
	Control	HSLF	HSLF-LSHF	Control	HSLF	HSLF-LSHF
Concentrate (kg/day)	7.0	11.6	11.6	7.0	12.6	12.6
Number of cows	30	20	19	77	38	38
Interval CFS (d)	90 ± 6	81 ± 5	83 ± 7	104 ± 6	98 ± 5	101 ± 6
Proportion FS <80 days	0.37 ± 0.12	0.47 ± 0.12	0.56 ± 0.12	0.25 ± 0.05	0.32 ± 0.08	0.38 ± 0.08
FS conception rate	0.28 ± 0.11	0.37 ± 0.12	0.38 ± 0.13	0.39 ± 0.06	0.44 ± 0.09	0.48 ± 0.08
Services per conception	2.55 ± 0.33	2.38 ± 0.36	2.31 ± 0.37	2.13 ± 0.16	2.22 ± 0.27	2.00 ± 0.22
Interval days open (days)	139 ± 14	137 ± 16	127 ± 16	140 ± 7	139 ± 10	128 ± 13
Pregnancy rate <100 DIM	0.22 ± 0.08	0.38 ± 0.11	0.35 ± 0.13	0.26 ± 0.05	0.29 ± 0.08	0.33 ± 0.08
Pregnancy rate <150 DIM	0.52^{a} ± 0.12	0.84^{b} ± 0.09	0.81^{b} ± 0.10	0.56^{a} ± 0.06	0.76^{b} ± 0.07	0.81^{b} ± 0.12

^{a,b} Means within rows with different superscripts differ at *P* <0.05
CFS: Calving to first service; FS: first service; DIM: days in milk
HSLF: high starch-low fat, LSHF: low starch-high fat

While the pregnancy rate at 150 days in milk was higher (*P* <0.05) for cows that received a higher concentrate level for both primi- and multiparous cows, other fertility traits did not differ, although they showed higher absolute values. Large variation in traits and a small number of experimental animals may have contributed to this. Gilmore *et al.* (2011) did not find improved fertility rates in dairy cows following different nutritional strategies. Garnsworthy *et al*. (2009) found that pregnancy at first insemination was improved when a high starch-based diet was fed, followed by a high fat-based diet. Fulkerson *et al*. (2001) and Gong *et al*. (2002) showed that higher levels of dietary starch-based concentrate led to an earlier resumption of ovulation, earlier oestrous detection, thus advancing the timing of first ovulation.

The proportion of pregnant primi- and multiparous cows relative to days after calving is presented in Figure 2. Feeding higher levels of HSLF and HSLF-LSHF concentrates to cows improved (*P* <0.05) the pregnancy rate at 150 DIM compared with the control. Gilmore *et al.* (2011) found that high energy diets, containing starch and fat, had similar effects on conception rate. Consistent with the HSLF treatment versus the control in this study, Gong *et al*. (2002) found that an insulinogenic (starch) diet containing 260 g/kg DM of starch improved the conception rate compared with the control at 100 g/kg of starch.

In accordance with the HSLF-LSHF treatment versus the control in this study, Garnsworthy *et al*. (2009) reported that a high-starch/high-fat combination treatment in which an insulinogenic diet was offered in early lactation for the first 50 DIM to encourage heat cycling, followed by a lipogenic diet to promote embryo development – resulted in improvement of reproductive performance at 120 DIM. However, the same treatment in another study did not yield positive results on the conception rate of dairy cows compared with other isoenergetic diets (Gilmore *et al.*, 2011). Further studies on this topic are required.

Conclusion and Recommendations

This review demonstrated possible interventions to improve the fertility of dairy cows. It showed the possibility of estimating genetic parameters for fertility traits using farmers' service records that are generally used in herd reproduction management. A larger dataset than the present study would improve the robustness of the results. A number of automatic recording systems are used by dairy farmers for herd management. Access to records from these herds would make it possible to establish a national database. However, it is important that similar fertility traits to those in other major dairying countries are used. This would enable South African results to be compared with international standards. Studies also showed that managerial interventions through crossbreeding and nutritional changes could affect the reproductive performance of dairy cows. Further work on these topics is required. A standard of reproduction management of dairy farmers should be established, as this could have a major impact on the fertility of dairy cows. It is accepted that poor reproduction management may give the impression of infertility in otherwise fertile cows.

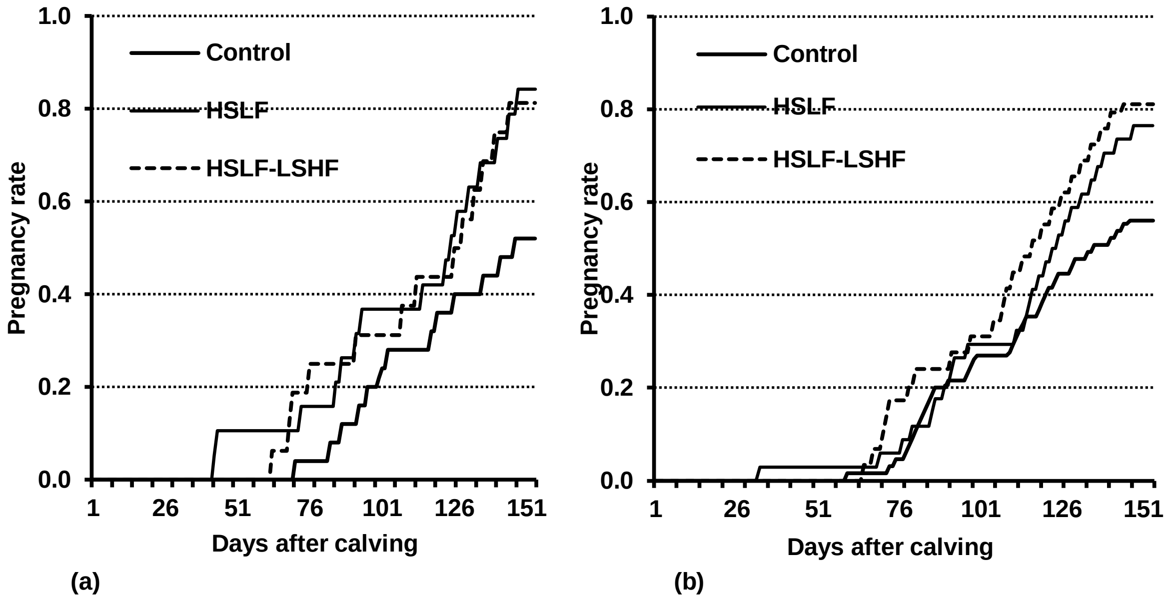


Figure 2 Pregnancy rate of (a) primiparous and (b) multiparous cows on pastures supplemented with concentrates differing in levels and types of energy sources
HSLF: high starch-low fat; LSHF: low starch-high fat

It is also important to acknowledge the effect of poor reproduction on the profit margins of a dairy herd. A longer DO interval extends the lactation period and CI. A longer lactation period results in a higher milk yield per lactation, although at lower average daily milk yield. This is because the extension of the lactation occurs when daily milk yield is naturally lower. Extending the CI from 365 to 425 days would result in a milk yield reduction of almost 2 kg/day, amounting to a loss of more than R4 500 per cow. Reproduction management in dairy herds is influenced by the herd veterinarian, who makes culling decisions based on 'infertility', and by the application of hormonal treatments. In many cases, dairy farmers do not manage these decisions. Establishing the standard of reproduction management on a regular basis would reduce dependence on veterinary input, thus reducing the production cost of milk. Potential problems for the local industry include consultants using different norms and standards, and the veterinary input at farm level, which is significant.

Research has shown that the production-reproduction antagonism may not be so prevalent as commonly believed. Herds with above average milk yield levels show better conception rates, mainly because of improved reproduction management. Two key questions remain: Has the fertility of dairy cows deteriorated genetically? Or has the ceiling been reached in management capacity for large high-producing dairy herds? Crossbreeding to improve fertility may not be required in the breeding sector, as it is possible to make genetic progress in purebred herds. However, suitable fertility traits have to be used in a selection index, which should include fertility and production parameters. On the other hand, crossbreeding may be an option in commercial herds (where records to ensure genetic improvement are not always kept) by providing a quick and easy means of ensuring pregnancy in later lactations. This viewpoint is based on the suggestion that crossbred cows tended to outperform purebred cows under pasture and total mixed ration. Crossbreeding decisions, however, will need to be based on the results of larger studies than those reviewed here and include dairy breeds other than the Fleckvieh.

Other ways to improve fertility in dairy herds depend on i) a short-term husbandry strategy such as providing a clean, dry and sunny calving down area, monitoring cows post calving for early detection of uterine infections, checking heat cycling performance of cows within the first 80 days of calving; ii) a medium-term managerial strategy such as an action plan for cows more than 150 days in milk not being confirmed pregnant, putting a heat detection programme in place, ongoing checking of AI techniques (or performance) of inseminators, checking semen quality; and iii) a long-term genetic strategy using sires for AI with breeding information, such as daughter pregnancy rates and productive life estimated breeding values.

Conflict of Interest Declaration

None

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