A COMPARISON OF CONCEPTION RATES IN NATURALLY SERVICED AND ARTIFICIALLY INSEMINATED TULI AND AFRIKANER FEMALES AS A REPRODUCTIVE PERFORMANCE INDICATOR.

SIJABULISO DUBE

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Abstract

A study was conducted to compare conception rate between groups of 71 Tuli and 86 Afrikaner heifers and cows bred using artificial insemination technology and natural service method at Matopos Research Institute. Data on female ID number (ear tag), last calving date, parity, the breed of animal, breeding method (inseminated vs. natural mating) and pregnancy status were recorded. Binary logistic regression and cross tabulations were used for statistical analysis. Breeding method, breed, parity and last calving date were the predictors and pregnancy status was the dependent variable. The overall conception rate was 66.8%. Conception rate between Tuli and Afrikaner breeds, and between cows in different parity and calving interval groups were not significant different. However, the method of breeding animals significantly ($P< 0.05$) affected conception rate. More females became pregnant when artificial insemination (77.6%) was used compared to natural mating (56.8%). Conception rate was significantly lower in females with calving dates spanning more than one year (72.1%) compared to females with calving dates falling within 365 days (76.6 %). Heifers also showed a lower conception rate of 52.9%. The cows that had calving dates falling within 365days exhibited higher conception rate in both breeding methods. In conclusion, the study confirms that favourable conception rate can be obtained when the Tuli and Afrikaner breeds which are the common breeds in the southern part of Zimbabwe are exposed to artificial insemination technology, they exhibit comparable results to those bred with natural service method. As such, artificial insemination technology can be used as an alternative method of breeding or can be used to complement natural service in indigenous cattle of Zimbabwe.

Key words: indigenous cattle, breeding method, conception rate/pregnancy rate, smallholder farmers.

Declaration

I Sijabuliso Dube hereby declare that this thesis has been the result of my own original efforts and investigations. It has not been presented for a degree in any other University. All sources of information used have been duly acknowledged by means of references.

Student's Signature………………………………………Date ………/………/…………

Certification of thesis work

The undersigned certify that they have read and endorse that Sijabuliso Dube has submitted a research project entitled: **A COMPARISON OF CONCEPTION RATES IN NATURALLY SERVICED AND ARTIFICIALLY INSEMINATED TULI AND AFRIKANER FEMALES AS A REPRODUCTIVE PERFORMANCE INDICATOR.** The project is submitted in partial fulfilment of the requirements of the Bachelor of Science Honours degree in Animal and Wildlife Sciences under the faculty of Natural Resources Management and Agriculture. They endorse that the thesis is acceptable in form and content and that a satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on: ……………………………..

Supervisor

Signature ………………………………………Date ………/………/…………

Chairperson

Signature ………………………………………Date ………/………/…………

Dedication

To my late father (D. Dube) and most of all, my mother (Ms S Moyo)

Acknowledgements

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CHAPTER ONE

1.0 Introduction

Reproduction, in cattle production is defined as the capability of a cow to produce and raise an offspring until weaning, and it is very significant in requisites of profit prospective in beef production (Perry, 2005). There are hints of major profit losses in Zimbabwe smallholder beef production due to poor conception rates. The poor conception rates are exuberated by traditional breeding systems among other management factors (Tavirimirwa *et al.,* 2013). In the country's report of the world's animal genetic resources (Tawonezvi *et al.* 2004), it is reported that Zimbabwe is endowed with diverse breeds of all species, comprising of both the indigenous and exotic types. The exotic breeds are dominant in the commercial sector, which is the source mainly of marketed livestock products. Indigenous breeds are numerically predominant in the smallholder communal production systems where they perform multiple functions (Tawonezvi *et al.,* 2004).

Two service methods of breeding animals are common in Zimbabwe, and they include the natural mating and artificial insemination. Natural service is the traditional bull service method in which bulls detects heat and services the cows. This method can be either controlled or random. It is the widely used method in the communal areas by the smallholder farmers in Zimbabwe. Random mating is most practiced by the smallholders in Zimbabwe communal cattle production systems, and the communal cattle production systems hold over 90% of the cattle population in the country (Mavedzenge *et al.,* 2006); Nyamushamba *et al.,* 2017; Ndebele *et al.,* 2007). Chinembiri (1999) stipulated that in communal areas females run with bulls all year round without much reference as to which bull serves which cow or heifer. Natural service is the easiest service method for cattle producers that may not have the finances, time and labour to implement oestrus synchronisation and detect heat, thus implement reproductive technologies such as artificial insemination. However, with natural service there is lower genetic progress per generation, high risk of inbreeding problems; transmission of coital diseases during service, low fertility and a premium bull may not serve all the cows on heat (Chatikobo, 2017).

Reproductive efficiency of the cows in the communal areas is little known and it is generally accepted that productivity is low, with calving intervals of nearly two years while heifers produce their first calves between two and four years (Nqeno, 2008). Reproductive performance varies with breeds. Different farmers in different production systems tend to choose the service method that gives fitting concern to the best, more competent; cost as well as labour effective method of getting cows to conceive in a shortest period in their production.

Biotechnologies in farm animals have massively contributed to increased productivity, principally in the developed countries (FAO, 2010); also in some countries in Africa (Rege, 2005). In countries such as Ghana, Ethiopia, Malawi, Nigeria, Botswana, Mali , Sudan and Senegal artificial insemination has been employed, principally for the improvement indigenous stock (Rege, 2005; Mpofu 2002). Conversely, even in some of these countries, the facilitation and service delivery of the technology has gone through times of disintegration or severe collapse and have had to be revitalised or rehabilitated (Rege, 2005). Hence, it is a necessity to explore and evaluate if there exist any significant differences in conception rate of naturally serviced and inseminated cows for breeds common in communal areas in Zimbabwe.

1.1 Problem statement

Biotechnologies in farm animals have massively contributed to increased productivity, principally in the developed countries and in some countries in Africa (Rege, 2005). Azage *et al.* (1995) pointed out that the success rate in African and other developing countries is still low owing to a number of technical, system related, financial and managerial problems. In some of these few African countries which have employed artificial insemination, it has gone through periods of collapse or serious degeneration and has had to go through "rehabilitation" phases (Rege, 2005). Artificial insemination has been used effectively on exotic breeds at commercial level in the country, the technology has been poorly received by small scale farmers as the majority of communal farmers, government officials, stakeholders and some inseminators in the Zimbabwe are uncertain of its effectiveness as shown by conception rates. There has been inconsistent and inconclusive data on artificial insemination in communal areas (Ndebele *et al*., 2007). Pregnancy rate sometimes can be used interchangeably with conception rate. Smith *et al.* (2013) and Khan *et al*., (2015) defined conception rate as the proportion of the number of females which conceived divided by the figure of the animals bred at the time of pregnancy check. There are reports of very poor conception rates of inseminated indigenous breeds which are dominant in the communal production systems (Mashoko *et al.*, 2002; Kaziboni *et al*., 2004, Ndebele *et al*., 2007, Tada *et al*., 2010).

1.2 Justification

The current study aims to compare the conception rates of naturally serviced and artificially inseminated Tuli and Afrikaner females. According to Assan (2012), these are cattle breeds found in communal areas of Zimbabwe. There is need to conduct detailed studies to generate information and make farmers more aware of the potential benefits of artificial insemination in the small-scale sector through generation and capturing of adequate data to proffer solutions to question being raised by farmers.

Considering factors such as parity, breed and calving interval; this study is aimed to make a detailed account of the conception rates of indigenous cows in order to recommend the optimum breeding method with the highest conception rates. Breeding success is a complex issue; complicated by many factors such as environmental aspects including the management practices, time of year, and nutrition.

1.3 Objectives

1.3.1 Main Objective

To compare the conception rates of naturally serviced and artificially inseminated Tuli and Afrikaner cows.

1.3.2. Specific Objectives:

To determine if breed has an effect on conception rate in females bred through naturally service and artificial insemination,

To determine if parity has an effect on conception rate in Tuli and Afrikaner females bred through naturally service and artificial insemination,

To determine if a calving interval had an effect on the conception rate in naturally serviced and artificially inseminated Tuli and Afrikaner females.

1.4 Hypothesis

H_{01}: There are no significant differences between conception rates of naturally serviced and artificially inseminated Tuli and Afrikaner females.

$H_0 2$: Breed does not influence conception rate of Tuli and Afrikaner females bred with natural service or artificial insemination.

$H_0 3$: Parity does not influence conception rate of Tuli and Afrikaner females bred with natural service or artificial insemination.

$H_0 4$: Calving interval do not influence conception rate of Tuli and Afrikaner females bred with natural service or artificial insemination.

CHAPTER 2

Literature review

2.0 Introduction

Reproductive inefficiency the significant reason for the losses in livestock production, it is realized throughout the world. The inefficiency is caused by a variety of factors such as inbreeding, low conception rates, and high calving intervals. Sharifuzzaman (2015) pointed out that conception is a prerequisite for every female getting into the productive life for efficient livestock production. It determines the total profitability of a farm enterprise (Miah *et al*., 2004). Therefore, to get maximum profitability it is imperative to identify the factors affecting conception rates in any enterprise. Mokantla, (2004) declared that conception rate is an excellent pointer of the herd productiveness. Mufti *et al*, (2010) brought up that conception rates are impacted by various factors; 96% variation in conception rates reported for environmental factors and management. It is said that the other 4% variation is accredited to heredity factors; with 3% variation originating from the cow/dam itself and 1% from the sire/bull. Mokantla, (2004) likewise stipulated that calving rates of different herds tend to vary from season to season owing to genetic and non-genetic (environmental) factors. The data on the effects of parity; breed and calving interval of African beef cows on conception rates is scarce or poorly documented.

2.1 The effects of parity on conception rates in beef females

The majority of the studies reviewed reported that parity has an effect on conception (Sharifuzzaman, 2011; Miah *et al.,* 2004, Balendran *et al*., 2008; Tada *et al*., 2010; Kaziboni *et al*., 2004) and there were few authors who indicated that parity of the female did not affect conception rates (Ono *et al*., 2016, Hasler 2001). In the studies reviewed, there are controversies as to whether heifers can have higher conception rates than cows. It has been recorded in some investigations that conception rates mostly have a tendency to be higher in heifers than in cows (Balendran *et al*., 2008, Potdar *et al*., 2016; Hossain *et al*., 2016), assuming that the heifers have achieved pubescence and are cycling (Smith *et al*., 2013). Woldu *et al*. (2011) and Khan (2008) indicated that conception rates of heifers can be significantly lower, contrasted with that of mature cows. Therefore it can be concluded that heifers can have lower conception rate as fertility increases with parity which subsequently decreases as age increases (Kaziboni *et al*., 2004). Heifers are at times perceived not to be fully developed and might sometimes show infertile first oestrus (Alexandra *et al*., 1999) and this can be the reason they exhibit low conception rates. Lower conception rates can be demonstrated by old bovines which are closer to the end of the productive life. Several studies reported that conception rates increased up until the third parity and diminished in the ensuing parities (Miah *et al*., 2004 and Woldu *et al*., 2011; Sharifuzzaman, 2015).

In an investigation by Ono *et al.* (2016) parity did not have an effect on conception rates, abortion, stillbirth or normal calving. Hasler (2001) also revealed that pregnancy rates after embryo transfer in bovines were not influenced by parity. Sharifuzzaman (2015) also highlighted that conception rate improved up until the third parity, and then dwindled to the seventh parity. Sharifuzzaman (2015) demonstrated that parity and breed have notable impact on pregnancy rates. To accomplish the desired conception rate farmers ought to consequently, breed females taking into consideration the breed, parity and age of the cows.

Miah *et al*. (2004) found out that conception rates increased up to the second parity and then decreased up to the fifth parity but it was also observed that the conception rate in the fifth parity (27.57%) differed significantly with the rest of all the parities. There was a steady decline in conception rates. Miah *et al.* (2004) revealed better conception rate with increasing parity from the second parity to the sixth and afterward decreased in parity seven and eight.

Thus it can be concluded that the conception rates in the first to third parities of cows are higher than that of subsequent parities and conception rate tend to decrease in the seventh parity.

Khan *et al*. (2015) found a significant increase in conception rate in both parity 2 and parity 3. In Khan *et al*. (2015) a noteworthy increment in conception rate was observed in parity 2 and parity 3cows than the nulliparous animals. Woldu *et al*. (2011) observed no significant difference in conception rates among different parity groups. However, in this study (Woldu et al., 2011) heifers exhibited lower conception rate (34.5%) compared to cows at higher parities. Cows in the third parity exhibited higher conceptions (54%) but lower performances were noted in the second parity cows (40%). In addition, Tada *et al*. (2010) also observed a significant interaction between parity and conception. Kaziboni *et al.* (2004) highlighted that conception rates differed according to parities.

2.2 Breed effect on conception rates of beef cattle

A breed is defined by Bayer *et al.* (2004) and Halimani *et al*. (2010) as homogenous grouping of animals which are phenotypically distinct from other groups or subpopulations of similar species. The Africaner and the Tuli are classified as the *Bos taurus* breeds (Mpofu, 2002) an*d Bos taurus* Africanus by some (Rewe *et al*., 2009 and (Tuli, 2017). Corah and Lusby (2012) affirmed the assertions that different breeds are significantly more productive and prolific compared to others. Certain breeds unquestionably adjust better to specific environmental conditions and topography than others and, considering this, they exhibit higher conception rates under those kinds of conditions. This enhanced rate of conception will normally relate back to the animal and its capacity to efficiently survive in the feeding regimes being given to the animals.

The Sanga cattle are the basis of several breeds through adaptation by natural selection with the passing of centuries. The Tuli breed is in the genealogy of the Sanga cattle brought into Southern Africa by relocating tribes around 700 (Tuli, 2017). The Tuli breed, which is exceptionally fertile, predominantly polled, pure indigenous breed with excellent beef qualities, was developed from extensive selection efforts. The Tuli breed performed extremely well in relative trials in the past carried out using five pure breeds under broad farming conditions in Botswana (Tuli, 2017). A calving rate of 86.6% and a mortality rate of 7.2% of calves up to two years of age have been exhibited by this breed in these investigations. This a clear sign of how well adapted the breed is in harsh environments found in Southern Africa (Tuli, 2017).

Khan *et al.* (2015) observed breed influence in conception rate. Conception was highest in indigenous cattle than in intermediates and crosses. Shamsuddin *et al.* (1997) also found the different conception rates in different breeds. Moyo *et al*. (1996) demonstrated that the indigenous Sanga breeds are impressively more prolific and productive than exotic breeds, substantiated by their high calving rates. From a few investigations looked into, the Tuli has been recognized to be highly fertile with calving rate around 70% contrasted to the least fertile Afrikaner, which is a relative of the indigenous Sanga, with a calving rate around 56%. The fertility of the Afrikaner is in concurrence with results of a few different investigations in Africa, as checked on by (Lepen, 1996; Moyo et al.1996). Lepen (1996) recorded lower conception rates in Afrikaner cows. Conception rates of 69% in the Tuli breed and of 57% in the Afrikaner wrer reported by (Moyo *et al*., 1993). The Tuli breed was classified in the year 2015-2016 as the most fertile indigenous breed in South Africa (Donkerhoektulis, 2017). Tada *et al*. (2010) observed a huge relationship between breed of cows and conception rates in investigation concerning three *Bos indicus* breeds (indigenous tropical breeds) the Tuli, Mashona, and Brahman with the Tuli breed performing considerably higher with conception rate of 54%; compared to the Mashona breed with 42% and Brahman with 39%). Therefore it can be assumed that there are variations in conception rates of different breeds.

2.3 Effects of calving interval on the conception rates of beef cattle

Calving interval has been extensively explored and detailed. It is maybe the the most excellent index of a farm animals' reproductive performance according to Dayyani *et al*. (2013). MacGregor (1997) argued that calving interval in beef cows bred during a controlled breeding season is a biased way of assessing reproductive efficiency, because of the extensive negative consequences of the previous calving date. Massawe (2011) asserted that both genetic and non genetic factors have an effect on calving interval. Non-genetic effects are more important in view of the fact that the calving interval trait has low heritability and repeatability (Mwatawala, 2006). Therefore calving interval is basically subjective to management factors. With smallholder farmers in Zimbabwe, few cows calve each year, the majority calve irregularly with calving intervals of two years or more (Tavirimirwa *et al.,* 2013; Chimonyo *et al.*, 2000). Afrikaner has a calving interval about 445 days (CGIAR 2017). Ball and Peters (2004) stipulated that even in the without particular fertility issues, it is hard to accomplish the ideal 365 day calving interval as it is likely to be a multi-factorial subject involving the genetic and the environment interaction.

Various studies reported variations in the calving interval in different breeds in different environments. Ball and Peters (2004) pointed out that in different extensive production systems in adverse climatic conditions, where there are very limited resources, cows may fail to conceive during the breeding season and then lose another year before getting pregnant. Thus, calving intervals of two years are normal, particularly in the semi-arid tropics (Nyamushamba *et al*., 2017; Chimonyo, 2000). However, Ball and Peters (2004) argued that it is advantageous to have longer intervals in some high genetic merit, high yielding cows which need much time to conceive. It is articulated that economic benefits are produced in the case of milk production where environment and nutrition permit. Further pointed out that more than 365days calving interval should be accepted or even entirely planned for; since early insemination of high producing animal are associated with problems. Wassell *et al*. (1998) demonstrated that stretching out calving intervals by three months lacked significant detrimental effects on profitability. However, this is generally applicable to the developed world; in the dairy production systems not with the smallholder beef farmer in the communal areas as long calving interval infer lesser benefits and more expenses.

Ball and Peters (2004) stated that yearly calving interval has generally been a typical go for both beef and dairy producers. Different factors contribute to the variations of the calving interval. Some of these factors depend exclusively on the genetic makeup and some, largely on the environment or interaction from both. These factors include availability of feed resources continuously during the year, genotype (breed), the routine management (health, housing conditions etc.) and climatic conditions where the animal live. To get ideal calving interval in the beef cattle in the tropics, it is important to consider among different factors, breed disparity with respect to their capacity to adjust to antagonistic climatic conditions (Arthington and Kalmbacher, 2003; Jaurez *et al.,* 2009). High temperatures and high humidity levels negatively influence beef production, in tropical farms (Jaurez *et al.,* 2009). The probable explanations behind shorter calving intervals may be the accessibility of sufficient feed resources from natural pasture, crop residues, and less inclined of a region to intermittent dry spells and suitable weather conditions. Amid the rainy and the early dry season breeding cows and heifers can benefit from improved nutritional conditions since the forage quality and quantity will be much better compared to other seasons, hence breeding females are most likely to show oestrus and conceive (Mukasa-Mugerwa, 1989; Mwatawala and Kifaro 2009).

Longer calving intervals are probably associated to ecological factors, poor sustenance, unsatisfactory bull service and artificial insemination services, poor housing, reproductive management and poor health. Herd nutrition is important for fertility, especially for heifers under one year of age and for females up to 150 days in lactation as it has a bearing on reproduction. Long dry periods reduce the standard yearly production of the production females by broadening the calving interval past the ideal 13-14 month interval, causing a decline in the overall lifetime production. Consequently, the calving interval ought to be shortened for improved reproductive performances and profitable exhibitions (Zereu and Lijalem, 2016).

The sequential periods making up calving interval include the gestation, postpartum anoestrus (from calving to the first oestrus) and the service period (first postpartum oestrus to conception) (Dayyani *et al*., 2013). The gestation period is normally an average of 280 ±5 days in cattle and can be manipulated to some degree through simulated initiation of parturition (Ball and Peters 2004).Enhanced herd management can shorten postpartum anoestrous and days open (Mukasa-Mugerwa, 1989). The postpartum period is the key determinant of calving interval, and as a result it is usually is manipulated (Ball and Peters, 2004). Manipulating the postpartum period is inhibited by uterine involution, a period necessary for repair of the reproductive tract so that the animal can be able to be pregnant again (Funston, 2014). Uterine involution usually takes place after parturition within 30 days (Ball and Peters, 2004). However, poor nutrition and health, and calving difficulties will hinder normal involution to take place (Funston, 2014); as a result the calving interval will be longer. According to Ball and Peters, (2004) and Mukasa-Mugerwa, (1989) days open in beef cattle must not go beyond 80–85 days if an ideal 365 days calving interval is to be accomplished.

Fetrow *et al.* (2007) and Kranjec. (2015) postulated that calving interval involves return to cyclicity and conception.Parturition is trailed by a stage of ovarian inactivity and sexual quiescence before reproductive cycles recommence again (Ball and Peters 2004). This is a characteristic system for minimising chances of conceiving before the recently born calf is weaned (Ball and Peters 2004). The length of this phase is variable and it is influenced by factors as nutritional status, milk yield, heritability, season and suckling (Corah and Lusby 2012; Diskin and Kenny, 2014; Ball and Peters 2004). In some studies, the incidence of cyclicity is inhibited by many factors including malnutrition and body condition, the breed and age of the cow, days postpartum, uterine involution, reproductive infections and/diseases, the strength of the bond between the dam and her calf (Stevenson *et al*., 2003; Corah and Lusby 2012; Diskin and Kenny, 2014; Ball and Peters 2004). Nutrition is often the biggest limiting factor in delayed rebreeding in commercial beef cow herds raised on pasture (Corah and Lusby 2012; Diskin and Kenny, 2014).

Ball and Peters (2004) emphasized on oestrus detection in order to detect any oestrus and attain the target calving interval of 365 days. They asserted that in practice, it is not easy to identify the likely reasons of longer calving intervals. For example, if the period from calving to first service is longer than expected it might be due to the fact that oestrus was not detected owing to the failure of a cow to show signs of heat or failure to notice oestrus (in case of A.I). In the case that cow did not show signs of oestrus, the reason might be the lack of ovarian activity, irregular ovarian activity or silent ovulation. Corah and Lusby (2012) postulated that long post-partum intervals affect conception rates or might have them reduced slightly.

2.4 The conception rates of the Tuli and Afrikaner females

French (2001) accentuated that it is generally acknowledged that among the common unimproved herds in Africa, including inferior crossbred types, calving rates are exceptionally low and calf mortality is high. The normal birth rates of African smallholders' beef cattle rarely exceed 50%, it is regularly in the vicinity of 30 and 40% and calf mortality at 20-25%. In South Africa calving rates of beef cattle in communal farming systems were approximated at 41 % and 14.9 % in investigations using structured interview techniques (Nthakheni, 1993; Bembridge and Tapson, 1993). A review in Botswana which combined structured questionnaire technique with rectal palpation pregnancy diagnosis and monthly recording of calving approximated the calving rate at 36–50 % for cows on communal farms (Mokantla, 2004). Radostis *et al.* (1994) affirmed that the best possible level of performance ought to give a calving percentage of 95–99 % in the commercial sector and the goal must be 98 % respectively.

Undoubtedly, low calving rates and high calf mortality are clear after-effects of poor nutrition and management as well as reproductive diseases. Diseases extensively affect and reduce fertility and impact pregnancy rates particularly in the communal areas (Mokantla. 2004). Seasonal effects as well have a significant impact on the conception, depending partially on when cows are bred as well as on their age when they are mated. Mokantla, (2004) pointed out that annual calving records within herds can differ significantly. As a result, it is hard to confer in general the breed averages for calving rates because of seasonal nutrition and management effects. Yet, from scattered information in the literature, some breeds do have a reputation for high fertility (Corah and Lusby 2012).

Hamudikuwanda (1999) reported that Tulis could conceive when bred at of 15 months after attaining a body weight of 330kgs. Heifers when bred at two years can exhibit higher conception rates (Mhlanga *et al*., 1999). Holness (1992) reported conception rates of 70% and 58% re-conception rates in this breed. Du Plessis *et al*. (2006) recorded significantly lower pregnancy rates in the Afrikaner cows, young heifers and herd compared to those of other beef breeds (Simmentaler cross, Bonsmara cross and Nguni cows). In that study poor cow efficiency was also observed in the Afrikaner cows, young heifers and herd compared to other breeds. The low pregnancy rate observed for the Afrikaner herd, although it is a satisfactory breed in terms of fertility and is thought doubtlessly an innate characteristic of the breed.

2.5 Other factors affecting conception rates in beef cattle

2.5.1 Nutrition

Numerous studies have detailed in cattle the connection between nutritional status and reproductive performance. Lamb and Dahlen, (2014) accentuated that a good enough condition is required by beef cows to recommence oestrous cycles following parturition. It is also required to overcome general infertility, to reduce the post partum anoestrus period, maintain oestrous cycles, and for the involution of the uterus in order to maintain a yearly calving interval (; Corah and Lusby, 2012). The nutrition and reproduction interaction entail quite a lot of complex associations (Lamb, 2012). These include relationships linking nutritional components and physiological signals (Ball and Peters, 2004). However, the interaction is largely responsible for the feeding of cows adequately in order for them to conceive and keep the pregnancy to term without consuming excess resources (Lamb, 2012). Inadequate levels of nutrients have all been related to sub-optimal performance in terms of reproduction (Lamb and Dahlen, 2014).

Funston, (2007) asserted that body condition score (BCS) is linked with some reproductive measures for example the calving interval, postpartum period, services per conception, calving difficulty, milk production, weaning weight, and calf survival which considerably have a bearing on the returns of cow/calf production. Wettemann *et al*. (2003) articulated that body energy reserves at calving primarily influence pregnancy rate in beef cattle. Body condition at parturition determines when they will begin cycling again after calving. It also has an impact on the response to postpartum nutrient intake (Funston, 2007). Lamb and Dahlen, (2014) accentuated that body condition scoring is a reliable technique to measure the nutritional status of a herd and is generally a reflection of nutritional management. Conversely, parasitism and diseases cause lower body condition scores even though nutrient requirements are met (Funston, 2007). A visual body condition scoring system for beef cattle was developed by Whitman, (1975) and it uses a scale from 1to 9.

2.5.1.1 Pre-partum nutrition

Corah and Lusby (2012) proposed that poor nutrition prior to parturition, leads emaciation at calving which is a setback to the resumption of oestrual activity after calving. Postponement of the onset of cycling activity will have an impact on the number of cows available for breeding in the breeding season, hence lowering the overall rates of conception (Corah and Lusby, 2012). Lamb, (2012) observed that, cows sustained with adequate nutrition before parturition have a shorter postpartum period to first ovulation generally, compared to cows on a decreasing nutrition. The quantity of energy in the feed will determine the number of cows that cycle, and more significantly affect first service (Corah and Lusby, 2012). Consequentially, prolonged postpartum anoestrus, low body condition scores at parturition and low overall conception rates in the breeding season will result (Corah and Lusby, 2012; Lamb 2012; Ball and Peters 2004). In spite of the benefits accrued by the BCS, few cattle man utilise it to monitor the status of their cattle. According to Lamb and Dahlen, (2014) appreciating the reproduction cycle of the cow and knowing how to manipulate the nutrition will enhance reproductive performance, might possibly minimize costs of feed inputs and enhance profitability.

2.5.1.2 Postpartum Nutrition

Postpartum is a phase of maximum nutritional requirement, for this reason it is expected of farmers to try and make sure that this period falls in the first to the third month after the first effective rains. Ideal body condition scores can be realized by calculated feeding which is achievable through appreciating the production cycle of the cow (Lamb and Dahlen, 2014). Lamb, (2012) asserted that the greatest nutritional requirement period comes about soon after calving; this is the stage when a cow is expected to produce milk for the calf, regain the weight lost prior and post calving, perform uterine involution and be pregnant within three months after calving. Several studies reported that in beef cows increasing nutritional levels after calving increased conception rates (Lamb 2012; Corah and Lusby 2012). Lalman *et al*. (1997) pointed out that increasing the dietetic energy concentration enhances the body condition score and weight of the cow, in the process diminishing the postpartum period to first oestrus and indirectly impacting conception rates.

2.5.2 Specific Nutrients and Reproduction

Suboptimal reproductive performance is likely to be attributable to inadequate intake of nutrients such as vitamins, protein, energy, and macro-and micro minerals (Lamb and Dahlen, 2014). Energy balance is presumably the absolute most imperative factor associated with inefficient reproduction (Lamb and Dahlen, 2014, Corah and Lusby, 2012; Funston, 2007). Funston, (2007) postulated that cows are incapable of consuming sufficient dry matter to supply adequate nutrients to support maintenance requirements, lactation, and reproductive processes. According to Short and Adams (1988) the metabolic utilization of accessible energy in ruminant animals was positioned in each physiological state and arranged sequentially by significance, as: 1) basal metabolism; 2) activity; 3) growth; 4) energy reserves; 5) pregnancy; 6) lactation; 7) additional energy reserves; 8) oestrous cycles and initiation of pregnancy and 9) excess energy reserves.

In view of this rundown of metabolic priorities for energy, pregnancy initiation of least priority in the partitioning of nutrients. It is crucial to note that emaciated cows commonly do not rebreed (Funston, 2007). Lamb (2012) affirmed that reproductive purposes are often disturbed in a period of negative energy balance on the grounds that accessible energy is channelled towards meeting minimum energy reserves and lactation. In general, it is hard to meet the cows' entire energy requirements, some of the requirements will come from fat or body reserves. Funston (2007) pointed out that cows in good condition are capable of meeting the energy requirement, are better able to lactate, and have energy for involution of the uterus, tend to rebreed earlier compared to a cow in a poor body condition.

Availability of feed resources is a key limiting factor in the small holder communal production systems. Smallholder farmers generally lack supplementary supplies of feed and they need to be advised on which animals to feed, when and the amount required for feeding them. Extensive grazing on natural rangelands is an ordinary tradition by the poor farmers who lack resources; for feed; animals completely depend on rangelands or natural pastures and crop residues (Tada *et al*., 2013a; Tada *et al*., 2013b; Masikati *et al*., 2004). Seasonal changes in terms of the quantity and quality of feed especially in the late the dry season is a significant limitation of livestock production particularly in the smallholder farmers (Mapiye *et al*., 2009, Masikati, 2011). Katiyatiya *et al*. (2014) and Mapfumo and Muchenje, (2015) accentuated that the quality and quantity of natural pastures are greatly variable, with crude protein tumbling to less than 5% during the dry season in the tropics. Inappropriate grazing practices, natural fires and poor management of natural pastures are all factors which contribute to the unavailability of forages in the smallholder areas (Andersen *et al.,* 2005). Poor nutrition leads to poor body condition which inhibits breeding success in livestock production as animals have to use the nutrients for maintenance and basic life processes.

Assan (2012) emphasized that water shortages in small-scale production systems affect livestock production. Water contributes considerably to macro and micro nutrients intake and in a way may enhance or become detrimental to production and reproduction (Funston 2007). Assan (2012) highlighted that intermittent dry spells have been a constant obstacle to the continuous development of the beef industry and have affected conception and calving rates in the last decade, with an estimate of fertility levels stationed beneath 50%.

2.5.2 The environment as a factor that affects conception rates

Dash *et al.* (2016) postulated that global warming greatly affects the reproductive processes of cows. The Intergovernmental Panel on Climate Change demonstrated that developing countries are more at risk to outrageous climatic conditions, due to their reliance on agriculture and forestry, which are climate sensitive sectors. FAO, (2006) pointed out that agriculture and livestock contribute 18% of total greenhouse gas emissions. Dash *et al.* (2016) articulated global warming and climate change are likely to affect livestock production and reduce production and reproduction performances.

Hahn *et al*. (2003) demonstrated that solar radiation, relative humidity, temperature, wind speed, and rainfall are the main physical environmental aspects affecting livestock. Hahn *et al*. (2003) highlighted that when these environmental factors are combined they form what is known as heat stress on animals. Dash *et al.,* (2016) defined heat stress as any integration involving the environmental variables to form an environment which is above the animal's thermo neutral zone. Dash *et al*. (2016) asserted that when there are high temperatures and high humidity in the environment, then it is going to be hard for the animal to regulate internal heat and then the animal will experience heat stress. The negative impact of heat stress on reproduction of livestock can be measured by the temperature humidity index (THI) (Sinha *et al.,* 2017). According to Sinha *et al.* (2017) THI is one of the regularly used indexes to estimate the extent of heat stress impacting performance, production, growth, and reproduction traits in livestock. At a temperature humidity index of 72 cows begin to experience heat stress (Sinha *et al.,* 2017; Dash *et al*., 2016; Bilby *et al*., 2008; Hansen 2015). According to Armstrong, (1994) the Livestock Conservation Institute characterized THI values into mild, moderate and severe stress levels for cattle.

According to Annex to the EFSA Journal (2009); Hansen, (2009); Ball and Peters, (2004) both heat stress and too cold temperatures; greatly reduce conception rate. Von Borell *et al.* (2007) pointed out that anoestrus and silent ovulations are more frequent during summer and it is often difficult to detect heat (Hansen, 2009). Therefore, it is imperative to adjust breeding seasons accordingly.

Sprott *et al*. (2001) and West, (2002) pointed out that high temperatures and high humidity reduce fertility and impair reproductive performance. West, (2002) and (Lucy 2002) articulated that high body temperatures; affect expression of oestrus, cause ovarian malfunction, failure to ovulate, lack of implantation, impaired embryonic development, embryo disintegration, and premature foetal abortion. Wolfenson *et al*. (1995) stipulated that elevated temperatures modify follicular waves, bringing about abridged oocyte quality. Al-Katanani *et al*. (2001) and Cartmill *et al*. (2001) asserted that 42 days prior to and 40 days after breeding heat stress can affect conception rates.

Dzama, (2016) accentuated that heat stress in beef cattle reduces foraging time, feed intake, growth performance and carcass quality. Reproductive performance is also compromised; conception rates will decrease, calving interval will increase and spermatogenesis and sperm quality will be impaired. Hence, it is noteworthy that effects heat stress is found also in bulls. Bilby *et al.* (2008) attributed the effects of heat stress as extensively affecting natural mating bulls. Bilby *et al.* (2008) postulated that it affects spermatogenesis and decreases sex drive. The scholar continued to say that semen quality is affected on a chance that bulls are persistently exposed to temperatures of 36°C for five weeks or 37.8°C for two weeks, regardless of no obvious impact on libido.

Malik *et al.* (2012) exhibited that sperm concentration, sperm motility, abnormal acrosome reaction, proximal droplets are diminished and the level of morphologically abnormal sperms in an ejaculate is increased due to heat stress (Bilby *et al.,* 2008). Bilby *et al.* (2008) asserted that the quality of semen does not return to normal instantly, but there is a carryover effect of heat stress on reproduction; it takes about two months due to the duration of the spermatogenic cycle (Bilby *et al.*, 2008).

2.5.2.1 Primary strategies for reducing negative effects of heat stress

Beef cattle can be affected by heat stress, particularly in feedlot situations (Dzama, 2016). However, several factors moderate the severe after-effects of heat stress on the reproduction of beef cattle. The factors that raze the impact of heat stress on beef cattle consist of the existence of genetically resistant breeds (Gaughan *et al*., 2010), breeding seasons that ensure that cows are bred in the late rainy season and in the early dry season and not in hot summer. Dzama, (2016) pointed out that in Southern Africa, many countries have limited climate change frameworks for the livestock sector. Dzama continued to say that quite a number of commercial and smallholder farmers are now shifting from the exotic breeds towards the indigenous Sanga breeds which are heat and drought tolerant in response to climate change. Monda, (2017) and Nyamushamba *et al.* (2017) articulated that indigenous cattle breeds have important adaptive traits ranging from drought tolerance, heat tolerance and resistance to ticks and tick-borne diseases.

Minimising the effects of heat stress on reproduction is difficult. Bilby *et al.* (2008) projected a number of approaches to possibly help reduce the unconstructive effects of heat stress on reproduction in both dairy and beef cows. These involve genetic manipulation, use of timed artificial insemination protocols and embryo transfer in cows on intensive production systems or on pasture, injection at oestrus for example the GNRH analogue, and use feed additives which can dissipate increased heat hence moderately easing heat stress. Hansen (2015) pointed out that shade structures have been used to reduce heat stress in many dairies in hot areas in different parts of the world. Shades are thought to minimise the heat load from the sun and they increase the heat loss the animals by reducing the ambient temperatures or by increasing directly the evaporative heat loss from animals.

2.6 Conception rates of beef cattle using artificial insemination and natural service

Mufti *et al*., (2010) articulated that 96% of the differences in conception rates arise from management and environmental factors. The outstanding 4% is attributable to genetic factors. Diskin and Kenny, (2014) accentuated that, conception rates of about 60-70% are attainable in beef cattle when using either AI or natural service except when there are issues with the quality of the semen, artificial insemination procedure or fertility of the bull. Lima *et al*. (2009) asserted that excellent pregnancy rates can be obtained in both natural service and artificial insemination programs when there is proper management of reproduction. Kaziboni *et al.* (2004) evaluated the performance of artificial insemination using the Red Dane and Friesian semen in smallholder dairies of Nharira-Lancashire in Zimbabwe and realized an average of 59% conception rate. Woldu *et al*., (2011) in Ethiopia observed overall conception of 48.3%, and Mukasa-Mugerwa, *et al*. (1991) reported 47% conception rate, also in Ethiopia. Tada *et al*. (2010) reported lower conception rates, averaging 43% in the communal area of Zimbabwe.

Risco *et al*. (1998) contended that numerous dairy farmers practice natural service, in view of the acuity that it brings about higher conception rates because of efficiency and accuracy of oestrus detection. Risco *et al*. (1998) expressed that the traditional bull breeding method circumvent human errors in detecting oestrus. Risco *et al.* (1998) efficient reproductive management is essential in natural service and bulls ought to be carefully selected for their intended most important duty, which is to impregnate cows. Malik *et al*. (2012) highlighted that the bull's capability to execute this task is reliant upon libido, semen quality, mating ability and social ranking. Therefore, it is prescribed that NS bulls go through a breeding soundness examination, as suggested by the American Society for Theriogenology and this should be rehashed on a yearly basis (Chenoweth, 1992). Chinembiri *et al.* (1999) articulated that in some communities Zimbabwe, young bulls have to pass a "community approval test" for the animal to join the breeding herd as a superior bull. Risco *et al.* (1998) accentuated that it is important to precisely observe the performance of a natural service bull so as to make accurate and timely decision to replace sub-fertile bulls as bull infertility possibly have incredibly grim economic consequences. Risco *et al.* (1998) also postulated that natural service to be effective, the selection, management, and evaluation of bulls ought to be imperative tasks of any beef enterprise.

2.7 Reproductive challenges in communal cattle production systems

In sub-Saharan Africa livestock production in communal areas is held back by a wide range of factors. Amongst them are high mortality rates; over dependence on natural service; lack of finances and resources; high incidence of diseases and parasites and poor management (Mashoko *et al*., 2007; Mavedzenge *et al*., 2006).

Lack of resources is one of the major setbacks in the smallholder sector. The majority of farmers do not have bulls (Mashoko *et al.,* 2007). There is lack financial input to buy superior bulls which are in many cases costly. This result in some smallholder farmers relying on community bulls (Chinogaramombe *et al*., 2008) instance a bull can service a cow on heat for a fee, which is usually charged by the bull owner (Chinembiri *et al.,* 1999). The fact that a few own bulls implies that bulls might be used to mate close relatives, potentially increasing the inbreeding levels in the communal areas (Chinogaramombe *et al*., 2008). The indiscriminate mating in communally grazed cattle spread coital diseases (Tada 2010). The existing bulls may not necessarily be genetically superior ones and this is exacerbated by the fact that some farmers are complacent about the "quality" or the superiority of the bulls they use (Temba, 2011).

In the small holder sector mating is generally random (Chinembiri *et al.,* 1999). The random mating system lead to very low bulling ratios as one bull services quite a number of cows even when the bull is old and has low fertility. Some farmers keep bulls for more than ten years due to financial costs associated with buying bulls and maintaining them.

Diseases and parasites are a major constraint in communal areas; which result in high mortalities and reduce fertility due to nutrition induced stress, (Chimonyo *et al.,* 2000). High prevalence of reproductive diseases caused by uncontrolled breeding systems coupled by the fact that, the government is failing to supply veterinary health services to poor resource farmers (Peeling and Holden, 2004) are major constraints of the small holder farmer. Poor management in conjunction with lack of resources; the high costs drugs (Ndebele *et al*., 2007) to mitigate the health challenges further aggravates the situation.

Feed shortages together with high incidence of disease and mortalities lead to low livestock productivity (Masikati, 2010), as evidenced by high calving intervals of more than two years (Chimonyo, 2000; Muchenje, 2007) and low conception rates, are the major causes of poor reproductive performance and unprofitability to cattle producers in Zimbabwe. Rooyen and Homann-Kee Tui (2009) have shown that the main sources of high mortality of livestock are poor animal husbandry and poor animal health. Nkomboni *et al*. (2014) also pointed out that high mortality and low fertility mainly due to feeding and health factors results in low cattle productivity in semi-arid Zimbabwe.

2. 8 Potential technologies for redressing communal reproductive challenges

Dube *et al*. (2015) pointed an urgent need to improve productivity of local cattle genetic resources through reproductive technologies, conservation or maintaining of local breeds integrity, while at the same time considering biological and socioeconomic aspects of the existing production system. Dube *et al.* (2015) continue to say appropriate description of breeding goal, establishing the selection criteria, keeping records of performance and carrying out assessment to design optimal mating systems that take cognizance of the challenges of the target communities should be taken into account. In the Recent years there have been the rapid development of technologies used to increase reproductive efficiency and these technologies are alternatives to the bull dependent natural service. These modern reproductive biotechnologies include artificial insemination, embryo transfer, cloning, nano technology to mention a few (Verma *et al.*, 2012). However, many cattle producers in Zimbabwe, especially in small holder farmers, have little or no knowledge of these new technologies. Smith *et al*. (2006) pointed out that the overall conclusions are that these technologies can come up with considerable enhancement in terms of genetic gain, with tolerable rates of inbreeding, also reduce high mortalities and reproductive diseases disseminated through natural service.

2.8.1 Multiple ovulation and embryo transfer

Multiple ovulation and embryo transfer (MOET) is a technique of producing numerous progeny from a hereditarily superior dam (Rege, 2005; Ball and Peters, 2004) than would be possible by natural breeding. Embryo transfer gives an opportunity to make the most out of the genetic contribution of both the sire and the dam simultaneously. Embryo transfers make possible the genetic progress, it has successively used for increasing rapidly the population of superior and elite breeds of livestock. Meanwhile, multiple ovulation and embryo transfer is not an extensive tool for genetic improvement due to a variety of explanations including its overhead expenses, technological demands, and unpredictable and variable effectiveness (Hafez, 2015).

2.8.2 Artificial Insemination

Despite the fact that AI is an extensively used technology; used not as much in developing countries, in contrast to developed countries. It has been restricted mainly to "investigative" uses generally by the research organizations and institutes (Rege, 2005). Most developing countries which have taken the technology into the field still face setbacks or the programme in a way have in different stages disintegrated. High rate of conception is achievable provided the cow is inseminated at the correct time by a highly competent technician using viable semen. Medhin *et al.,* (2009) outlined that A.I is not flourishing in Ethiopia. It is deduced; consequently, that artificial insemination program in Ethiopia is not a success and consequently requires critical remedial measures. Artificial insemination in Ethiopia has been given almost no accentuation at centrally and at local level in the past years despite the fact that it is a broadly practiced animal biotechnology everywhere throughout the world (Medhin *et al*., 2009). The most critical imperatives related with artificial insemination service in Ethiopia incorporate less auxiliary linkage between artificial insemination centres and service giving units. There is nonattendance of joint efforts and consistent correspondences between National Artificial Insemination Center (NAIC), and partners.

The chief limitations that obstruct the success of artificial insemination include: heat detection issue, unawareness', managerial and health issues, no clear breeding policy; herd recording systems and insufficient resources in terms of inputs and facilities (Ashebir *et al*., 2016; Medhin *et al.,* 2009). The absence of motivation and rewards to inspire the artificial insemination technicians and cattle owners coupled by the low experience of the artificial insemination technicians are also some of the obstacles that affect the success of A.I (Ashebir *et al*., 2016; Medhin *et al*., 2009).

Artificial Insemination involves the deposition of the semen of superior bulls of exotic or indigenous breeds into the ovulating females' reproductive tract (FAO. 2010) and it offers a selection of bulls with known genetic potential measured by estimated breeding values (EBVS). It is used primarily for genetic improvement of livestock since there is faster genetic progress in livestock hence, enhanced herd productivity and performance (Jere and Gordon, 2003; Nimbkar *et al*., 2009; Ruane and Sonnino, 2011). Jere and Gordon, (2003) pointed out that artificial insemination is the most valuable technique to control a variety of reproductive infections and diseases spread through the bull during natural mating. It also deals with the indiscriminate, continuous mating as there can be efficient use of oestrous synchronization which can move the breeding season to an earlier time of year, thereby improving the uniformity of a calf crop (Nimbkar *et al*., 2009).

With artificial insemination, there are no shipping costs for live bulls and expensive shipping. Nimbkar *et al*., (2009) pointed out that A.I allows practical use of sexed semen. However, adoption of artificial insemination by communal farmers in Zimbabwe has been poor owing to some overhead expenses incurred when practicing this system, although these can often be recovered from the decreased costs of keeping bulls.

Azage *et al,* (1995) accentuated that there is overwhelming evidence of the suitability of artificial insemination as a technology for reproductive improvement in Zimbabwe, there has been relatively poor adoption of the technology in smallholder and communal farming systems due to the farmer’s incapability to perceive heat; the unsystematic mating in communally grazed livestock in addition to the high costs associated with setting up inputs and infrastructure in support of an effectual artificial insemination program (Kaziboni *et al.,* 2004). Woldu *et al.* (2011) pointed out that artificial insemination technology has been poorly adopted not in Zimbabwe only but in Africa in general. Lack of locally generated information, failure to engage communal stakeholders when trials are conducted are some of the factors hindering the adoption of the technology.

CHAPTER 3

3.0 Methodology and Materials

3.1 Study Site

The study was carried out in Matopos Research Institute, Lucydale section. Matopos Research Station (20° 23'S, 31° 30'E) is situated 30 km South West of Bulawayo in Zimbabwe on an altitude of 800 m and experiences low erratic rainfall (<450) per annum (Homann et al., 2007). It is in agro-ecological zone IV. The region is characterised by high summer temperatures, maximum and minimum mean temperatures of hottest months are 21.6° C and 11.4° C respectively, frequent droughts (Hagreveas *et al.*, 2004).

3.2 Study Animals and Selection Criteria

157 Tuli and Afrikaner cows and heifers were selected from the Matopos Research stud herd and used in this investigation, 76 were subjected to artificial insemination and 81 were on natural service. Heifers and cows with body condition score of three and 3.5 in a scale of 1-5 as articulated by Whitman (1975) were selected for the experiment. The cows were in different parities, it ranged from the first to the fifth parity. Cows with obvious reproductive disorders such as cysts excluded from the trial. All females and bulls used in this trial were vaccinated thirty days prior to breeding them; against reproductive diseases such as contagious abortion, vibriosis and leptospirosis using Brucella S19 and Vibrio Leptoferm 5 respectively. They were also confined in a feedlot for thirty days where they were fed at ad lib with commercial feed. Pregnancy diagnosis by rectal palpation was conducted three months after the end of the breeding season to give the number of females that conceived following the procedure described by Noakes (1991).

3.3 Bulling Groups and Insemination Management

All insemination females were synchronized at the onset of the program using a prostaglandin analogue, the PGF2α (Estrumate). Merk, (2006) the manufacturer of Estrumate articulated that it can be incorporated into a controlled breeding program by the following methods, the single or double injection program (Merk, 2006). In this study, the double injection method was used. There are usually two synchronized groups, cows injected have 11 days apart (Merk 2006), this means that the second injection is given 11 days after the first injection. This drug does not work on anoestrous cows. A cow comes on heat 2-5 days after injection (Paul *et al.* 2015, Merk 2006) but only on condition that she has a corpus luteum and is already cycling. Cows without a corpus luteum in the first Prostaglandin injection should respond to the second injection, as they will be past the follicular phase (Paul *et al.* 2015). Females were inseminated between January and February 2016 using sexed semen from a single bull. For the duration of the experiment, all inseminated females were herded and penned. One technician inseminated all the cows to cater for variations in inseminator efficiency. Three fertile bulls (selected for this task basing on the records-libido, having sired before, and the scrotal circumference) serviced the females at a ratio of 20 cows per bull for a three-month period (January-March 2016) in the paddocks.

3.4 Limitations of the study

The numbers of animals used in the study were limiting as breeding studies requires large quantities of data and also the time frame in which the study was conducted was short.

3.5 Data Collection

Animal ID number (ear tag), age, parity, breed of animals and the last calving date were recorded (the secondary data). Records for last calving dates were used as a determinant of calving interval. Calving interval is an essential parameter in gauging the reproductive efficiency of cattle production enterprise and is a function of previous calving date (MacGregor and Case 2000). Breeding method to which the females were subjected to (inseminated and natural mating) was recorded. Pregnancy diagnosis by rectal palpation gave the number of females that conceived and this was recorded as pregnancy status of the females.

3.6 Data Analysis

A binary logistic regression analysis and cross-tabulations were conducted in SPSS to predict pregnancy status of 157 females using breeding method, parity, breed and calving interval as predictors.

CHAPTER 4

4.1 Results

A logistic regression was performed to ascertain the effects of breed, parity, calving interval and breeding method on the likelihood that the females conceive. The logistic regression model was statistically significant $\chi^2 = 15.472$, p= 0.009. Binary logistic regression indicated that breeding method is a significant predictor of pregnancy status. The other three predictors' parity, breed and calving interval were not significant. All the four predictors "explained" 13% (Nagelkerke R^2) of the variability of pregnancy status. Breeding method was significant at the 5% level [breeding method Wald=5.949, p=0.015 (<0.05)]. The odds ratio (OR) for breeding method was 2.528 (95% CI 1.200 – 5.327) and for parity, breed and calving interval the corresponding figures were 0.549 (95% CI: .194 – 1.555); 0.544 (95% CI: .258 – 1.148) and .625 (95% CI: .244 – 1.602). The model correctly predicted 25.0% of cases where there was no conception and 90.5% of cases where there was conception, giving an overall conception rate of 66.8%. The Log odds of the outcome also known as the co-efficient constant/B is modelled as a linear combination of the predictor variables. It gives the change in the log odd of the outcome for one unit of increase in the predictor variable. A negative log odds explains a reduction per one unit of increase. The odds ratio of the individual co-efficient known as Ex (B) in the table is the exponentiation co-efficient. Odd ratio greater than one explain that the event is more likely to occur as predictors increases; and a negative one means that an event is less likely to happen as predictors increase. The overall results of the study are shown in Table 4.1 below.

Table 4.1: Showing significance level of different predictors, the intercept and likelihood of change.

Parameter	Log odds	Standard Error	Odds ratio	P-value
Artificial insemination	.927	.380	2.528	.015
Heifers	-.470	.480	.328	.512
<365 days CI	-.470	.480	.625	.328
>365days CI	.018	.461	1.018	.968
Parity (1)	.599	.531	.549	.259
Tuli	-.609	.381	.544	.110

High conception rates were observed in females bred with artificial insemination (77.6%) compared to that of naturally serviced females with 56.8%. Females bred by artificial insemination were 2.528 times likely to exhibit pregnancy than those in natural service. The conception rate of females exposed to A.I and N.S is shown in Fig 4.1 below.

Breed was not a significant predictor of pregnancy. However, it was observed that a greater proportion of the Tuli (73.2%) were pregnant compared to the Afrikaner breed (61.6%). Conception rate was low in females with low parities (parity 1 with 64% and parity 2 with 78%) and higher in females with higher parities.

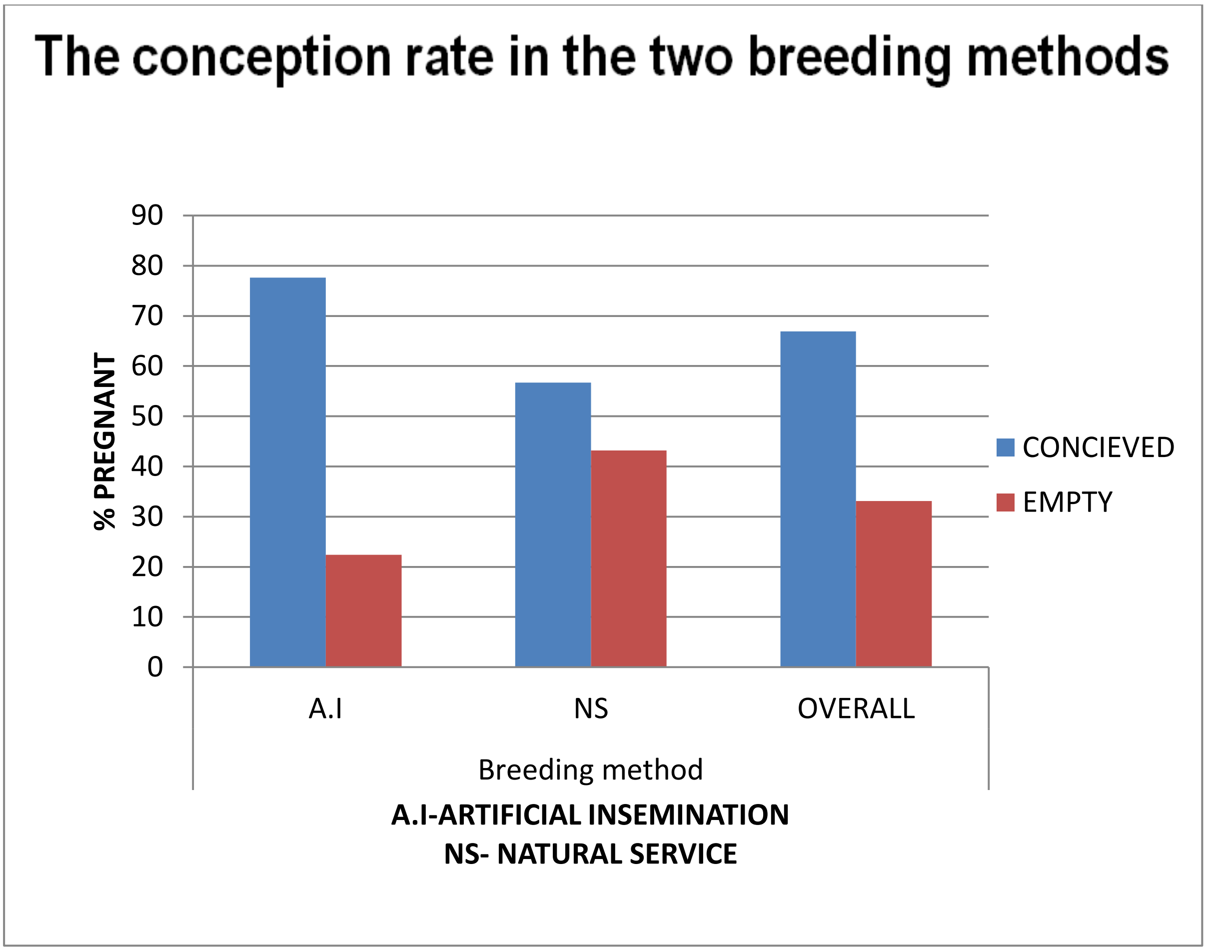

Fig 4.1: Conception rates of females in A.I and N.S respectively

Conception rate was low in cows with the last calving date of greater than one year. Heifers also exhibited significantly lower conception rates of 52.9%. Cows whose records indicated last calving dates of less than one year exhibited greatest pregnancy rate of 76.6 % compared to cows whose calving records indicate last calving date of greater than one year (72.1%). The cows that calved down consistently (every year) exhibited higher conception rates in both breeding methods. Cows with calving interval of one year were less likely to conceive than those with more than one year calving interval. It was also observed that heifers performed poorly in artificial insemination (15.3%) compared to natural service (37%). Performance in terms of conception rate of heifers and cows with different calving intervals within the two breeding methods is shown below in Fig 4.2.

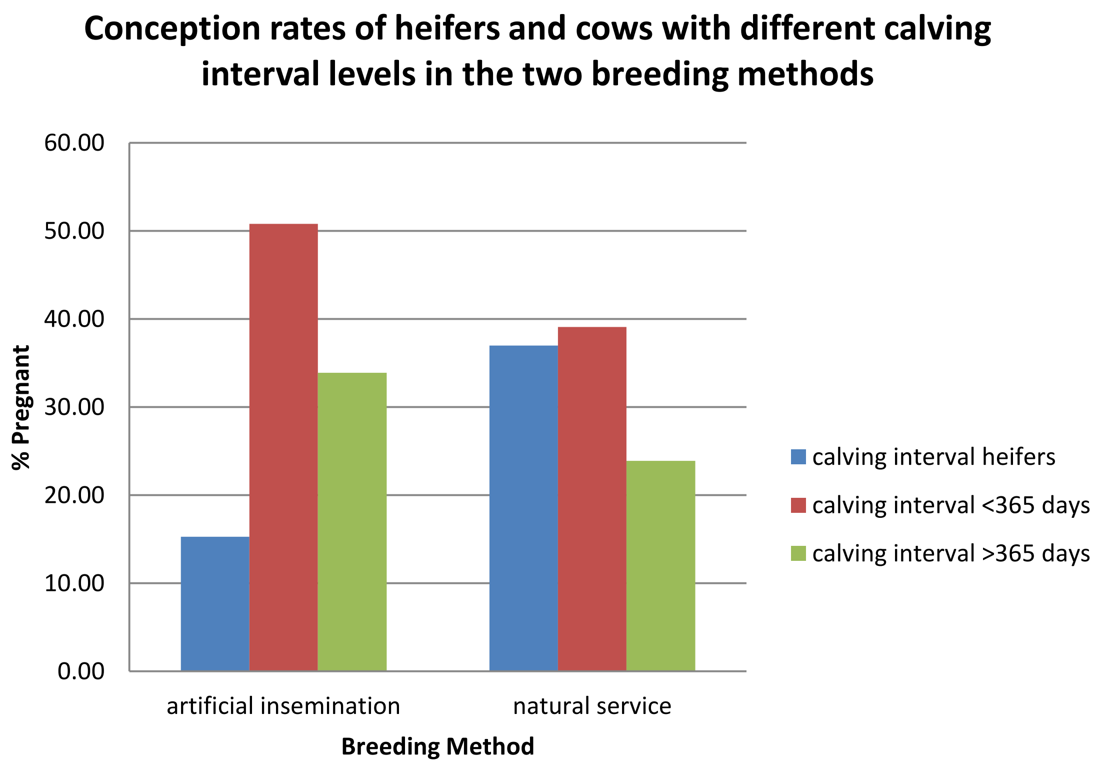

Fig 4.2: Performance in terms of conception rates of the heifers, cows with less or greater than 365 days calving interval in the two breeding methods

CHAPTER 5

5.1 Discussion

High conception rate observed in artificially inseminated animals compared to natural mating do not agree with the conclusions drawn by Lamester *et al.* (2001), who concluded that A.I programs in tropical cattle have low conception rate, which seldom exceed 30%. As such artificial insemination techniques can be adopted and effectively used in breeding with pregnancy rates similar to those from naturally serviced females with the added advantage of rapid genetic progress derived from use of semen from performance tested bulls (Nimbkar *et al*., 2009). The high conception rate of indigenous cows observed in this study particularly in artificial insemination differs from the observation of several authors who have reported low conception rate in artificial insemination programs involving indigenous cattle in communal areas. Woldu *et al*., (2011) in Ethiopia; Tada *et al*., (2010), and Mukasa-Mugerwa *et al*., (1991) in Zimbabwe reported conception rates of 32.8; 43% and 47% in indigenous cattle respectively. Kaziboni, *et al*. (2004) however reported relatively comparable conception rates of 59% in anartificial insemination study done in the smallholder dairy scheme of Nharira-Lancashire in Zimbabwe. These studies are highlighted in the table 5.1 to follow.

Table 5.1: Studies reporting different conception rate in artificial insemination programs involving indigenous cattle in communal areas.

Source	Country	Breed	Conception rates
Woldu, *et al*. (2011)	Ethiopia	Arsi breed	48.30%
Tada, *et al.* (2010)	Zimbabwe	Mashona, Brahman and Tuli	43%
Mukasa-Mugerwa, *et al*. (1991)	Ethiopia	Zebu	47%
Kaziboni, *et al*. (2004)	Zimbabwe	Sanga types	59%

The possible reasons for the high conception rate observed in the current trial is because the study was undertaken at a research institute where among other factors required for successful pregnancy, highly trained artificial insemination technicians working on the station, took due attention on oestrus observations. It has been noted that lower conceptions in artificially inseminated indigenous cows are related to the difficulty of detecting oestrus signs in tropical breeds (Ashebir *et al*., 2016; Medhin *et al*., 2009). Cows that originated in the sub-tropical regions tend to exhibit subdued oestrus signs, often for a shorter period compared to exotic breeds (Kaziboni *et al*., 2004) making oestrus detection more difficult than in *Bos taurus* females.

The present study show that high level of education of artificial insemination technicians has a direct bearing on pregnancy rates as was reported in other studies (Toleng *et al.,* 2001; Fu and Zhou 2002). Xu *et al*. (2007) observed marked conception rate increase of between 60-70% in artificially inseminated cows following refresher training of inseminators and on farm instructions to farmers in small-scale farming communities of China. Low conceptions reported in communal areas are apt to be due to management characteristics and poor inseminator efficiency rather than existing breeds. Tada *et al*. (2010) highlighted that inseminator efficiency and proper heat detection account for almost 20% of the variability of conception rate in artificial insemination program. Accordingly, government supported further technical training on artificial insemination and reproductive physiology to improve heat detection efficiency, artificial insemination timing, record keeping, semen handling procedures is therefore important to attain high conception rate in artificial insemination programmes being carried out in communal areas of Zimbabwe.

Non-significant differences observed on the conception rates of Tuli and Afrikaner breeds implies that breed had no effect on conception in the two indigenous breeds studied regardless of method of breeding. The observations in this study that a greater proportion of Tuli (73.2%) females were pregnant compared to Afrikaner females (61.6%) is in line with findings by Moyo *et al.* (1993) who highlighted that the Tuli are relatively more fertile compared to Afrikaner breed with average conception rates of 69% and 57% respectively.

In the present study, it was observed that conception rate was lower in heifers and cows within the first parity compared to older cows. The findings are in line with those of Kaziboni *et al*. (2004). Fertility increases with parity which then decline with increasing age. The differences in conception rates are probably because the majority of heifers and cows in first lactation would still be undergoing skeletal and soft tissue growth. Hence, there will be increased competition of nutrients for growth and development of the animal itself over reproduction as tropical breeds mature late compared to exotic breeds. It was also observed that heifers performed better in natural service compared to artificial insemination. These findings are not new, Ashebir *et al.* (2016) noted that farmers prefer to inseminate cows artificially but for their heifers prefer natural service. This might be due to the reason that the inseminator could not manoeuvre through the reproductive tract of the heifers and deposited the semen somewhere else not in the target uterine body or the cervical junction. Chatikobo, (2017) pointed out that heifers must have reproductive tract score (RTS) of 4 and above at the time A.I. Most heifers left to grow on natural pastures are under developed for their age and may not be cycling at the beginning of the breeding season. To circumvent such, a reproductive tract examination should be carried out (Chatikobo, 2017). A reproductive tract score (RTS) is a measurement of the sexual maturity of a heifer that is normally performed by a veterinarian approximately 4 to 6 weeks before the breeding season (Andersen *et al.*, 1991). The score is based on the degree of uterine development and ovarian status (size of dominant follicle and presence or absence of a corpus luteum). Each heifer is assigned a score of 1 to 5 (1 = immature; 5 = presence of a corpus luteum) with a RTS of 1 referring to a prepubertal heifer, 2 or 3 referring to a peripubertal heifer (transitional stage), and 4 or 5 referring to a pubertal (cycling) heifer (Andersen *et al.*, 1991). In the current study the RTS was not carried out, but the heifers had attained 60-70% of their mature weight. Live weight is the best predictor of puberty in heifers (Chatikobo, 2017).

The current study established that conception rate tended to be low when breeding cows with last calving dates exceeding one year for both artificial insemination and natural service. This phenomenon might be due to reproductive problems in cows whose last calving dates exceeded one year which may include abnormally long post-partum anoestrous, uterine pathology, and brucellosis among other reproductive infections. This may help explain the low conception rate reported in artificial insemination programs in communal areas, farmers tend to put forward problematic females and repeat breeders for artificial insemination due to misconceptions that artificial insemination is a remedy to cows with fertility problems (Chatikobo, 2017). This phenomenon is highlighted in Chimonyo *et al*. (2000) who reported calving intervals of greater than twenty four months while Homann *et al.* (2007) reporting calving rates of 22-30% in smallholder farming cattle production systems in Zimbabwe. This indicates reproductive inefficiency. Infections of the reproductive tract, many of which are spread by the indiscriminate mating in communally grazed cattle (Tada, 2010); increase the period from calving date to conception as these conditions negatively affect the conception ability of the affected females. Many authors have attributed favourable mean calving intervals to non-genetic factors which include optimum herd management, absence of brucellosis and stringent culling of infertile cows (Xu and Burton, 2003). This suggests that if artificial insemination is performed in well managed herds with good nutritional and health status, high conception rate will be attained as short calving interval has been associated with such herds. It is recommended that artificial insemination is adopted through participatory generation of data to demystify the misconceptions on the technology.

CHAPTER 6

Conclusions and recommendations

6.1 Conclusion

The study confirms that conception rate favourable or similar to when cattle are exposed to natural service can be obtained through artificial insemination technology in Tuli and Afrikaner breeds, common in the southern part of Zimbabwe. The high artificial insemination conception rate attained in this study is encouraging. Besides demystifying the misconception that artificial insemination is unsuitable for local breeds, the results provide critical insights that if proper insemination procedure is followed, and A.I is highly effective as an alternative breeding tool in indigenous breeds of Zimbabwe. This study concludes that parameters such as breeds of females, parity and calving interval do not affect conception status of the female.

6.2 Recommendations

Bearing in mind that bulls of high genetic merit are very costly and are not the type of investment that an average smallholder farmer is prepared to agree to regardless of the herd size, A.I is a feasible and realistic option of breeding animals for smallholder farmers as indicated by the high conception rate in this study. The field studies on artificial insemination are recommended and these should highlight the relation between conception rate versus transportation, storage, handling of semen; health aspects as well as animal nutrition in communal areas.

As shown in this examination appropriate training of A.I technicians can accomplish equivalent or much higher conception rates contrasted with those of natural service. Technicians ought to be exceptionally trained, they have to practice continually, if they are not experienced enough the low conception rate may be very low and discouraging. This will help control expansion of unregulated A.I technicians who might be adding to poor conception prompting negative artificial insemination publicity revealed in collective regions in the country through poor inseminator proficiency.

Furthermore, the use of clean up bulls to cows which could have failed to conceive in artificial insemination is recommended, taking note of the satisfactory conception rates exhibited when using natural service. The noteworthy conception exhibited by the Tuli breed as it is a highly prolific breed, compared to the Afrikaner necessitates its intensive use in the smallholder production systems. However, it is recommended that young animals such as heifers be bred using natural service, as appeared in this study that heifers tend to perform better in natural service compared to artificial insemination, unless if they are mature in terms of body weight, condition and reproductive tract size or score. There is need to carry out research studies on the ideal method of breeding for heifers, on the characteristics of heifers required for a successful A.I.

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Appendix

Binary logistic regression output

```
GET FILE='C:\Users\sja\Desktop\analysis by sjabuliso\resultss.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
LOGISTIC REGRESSION VARIABLES P.D
  /METHOD=ENTER BREED PARITY CALVINGINT BREEDINGMETHOD
  /CONTRAST (BREED) =Indicator
  /CONTRAST (CALVINGINT) =Indicator
  /CONTRAST (BREEDINGMETHOD) =Indicator
  /CONTRAST (PARITY) =Indicator
  /SAVE=PRED
  /CLASSPLOT
  /PRINT=GOODFIT CI (95)
  /CRITERIA=PIN (0.05) POUT (0.10) ITERATE (20) CUT (0.5).
```

Logistic Regression

Case Processing Summary

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	157	100.0
	Missing Cases	0	.0
	Total	157	100.0
Unselected Cases		0	.0
Total		157	100.0

a. If weight is in effect, see classification table for the total number of cases.

Dependent Variable Encoding

Original Value	Internal Value
empty	0
pregnant	1

Categorical Variables Codings

		Frequency	Parameter coding	
			(1)	(2)
Calving Interval	heifers and empty cows	50	1.000	.000
	< 365 CI	64	.000	1.000
	> 365 CI	43	.000	.000
Breeding Method	A.I	76	1.000	
	NS	81	.000	
Parity	heifers, 1 and 2 calvings	125	1.000	
	2;4 and 5 calvings	32	.000	
Breed	Afrikaner	86	1.000	
	Tuli	71	.000	

Block 0: Beginning Block

Classification Table[a,b]

	Observed		Predicted		
			Pregnancy Status		Percentage Correct
			empty	pregnant	
Step 0	Pregnancy Status	empty	0	52	.0
		pregnant	0	105	100.0
	Overall Percentage				66.9

a. Constant is included in the model.
b. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	.703	.170	17.173	1	.000	2.019

Variables not in the Equation

			Score	df	Sig.
Step 0	Variables	BREED(1)	2.367	1	.124
		PARITY(1)	2.295	1	.130
		CALVINGINT	7.430	2	.024
		CALVINGINT(1)	7.332	1	.007
		CALVINGINT(2)	3.217	1	.073
		BREEDINGMETHOD(1)	7.689	1	.006
	Overall Statistics		14.995	5	.010

Block 1: Method = Enter

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	15.472	5	.009
	Block	15.472	5	.009
	Model	15.472	5	.009

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	183.928[a]	.094	.130

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	4.596	7	.709

Classification Table[a]

Observed			Predicted		
			Pregnancy Status		Percentage Correct
			empty	pregnant	
Step 1	Pregnancy Status	empty	13	39	25.0
		pregnant	10	95	90.5
	Overall Percentage				68.8

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.
Step 1[a]	BREED(1)	-.609	.381	2.552	1	.110
	PARITY(1)	-.599	.531	1.273	1	.259
	CALVINGINT			1.341	2	.512
	CALVINGINT(1)	-.470	.480	.958	1	.328
	CALVINGINT(2)	.018	.461	.002	1	.968
	BREEDINGMETHOD(1)	.927	.380	5.949	1	.015
	Constant	1.284	.618	4.316	1	.038

Variables in the Equation

		Exp(B)	95% C.I.for EXP(B)	
			Lower	Upper
Step 1[a]	BREED(1)	.544	.258	1.148
	PARITY(1)	.549	.194	1.555
	CALVING INT			
	CALVING INT(1)	.625	.244	1.602
	CALVING INT(2)	1.018	.412	2.515
	BREEDINGMETHOD (1)	2.528	1.200	5.327
	Constant	3.612		

a. Variable(s) entered on step 1: BREED, PARITY, CALVING INT, and BREEDING METHOD.

Crosstabs

Breeding Method * Pregnancy Status Crosstab

			Pregnancy Status		Total
			empty	pregnant	
Breeding Method	A.I	Count	17	59	76
		Expected Count	25.2	50.8	76.0
		% within Breeding Method	22.4%	77.6%	100.0%
		% within Pregnancy Status	32.7%	56.2%	48.4%
		% of Total	10.8%	37.6%	48.4%
	NS	Count	35	46	81
		Expected Count	26.8	54.2	81.0
		% within Breeding Method	43.2%	56.8%	100.0%
		% within Pregnancy Status	67.3%	43.8%	51.6%
		% of Total	22.3%	29.3%	51.6%
Total		Count	52	105	157
		Expected Count	52.0	105.0	157.0
		% within Breeding Method	33.1%	66.9%	100.0%
		% within Pregnancy Status	100.0%	100.0%	100.0%
		% of Total	33.1%	66.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.689[a]	1	.006		
Continuity Correction[b]	6.777	1	.009		
Likelihood Ratio	7.816	1	.005		
Fisher's Exact Test				.007	.004
Linear-by-Linear Association	7.640	1	.006		
N of Valid Cases	157				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 25.17.

b. Computed only for a 2x2 table

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	-.221	.077	-2.825	.005[c]
Ordinal by Ordinal	Spearman Correlation	-.221	.077	-2.825	.005[c]
N of Valid Cases		157			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

Parity * Pregnancy Status Crosstab

			Pregnancy Status		Total
			empty	pregnant	
Parity	heifers, 1 and 2 calvings	Count	45	80	125
		Expected Count	41.4	83.6	125.0
		% within Parity	36.0%	64.0%	100.0%
		% within Pregnancy Status	86.5%	76.2%	79.6%
		% of Total	28.7%	51.0%	79.6%
	2;4 and 5 calvings	Count	7	25	32
		Expected Count	10.6	21.4	32.0
		% within Parity	21.9%	78.1%	100.0%
		% within Pregnancy Status	13.5%	23.8%	20.4%
		% of Total	4.5%	15.9%	20.4%
Total		Count	52	105	157
		Expected Count	52.0	105.0	157.0
		% within Parity	33.1%	66.9%	100.0%
		% within Pregnancy Status	100.0%	100.0%	100.0%
		% of Total	33.1%	66.9%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.295[a]	1	.130		
Continuity Correction[b]	1.701	1	.192		
Likelihood Ratio	2.425	1	.119		
Fisher's Exact Test				.146	.094
Linear-by-Linear Association	2.280	1	.131		
N of Valid Cases	157				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.60.

b. Computed only for a 2x2 table

Pregnancy Status * Calving Interval * Breeding Method Crosstabulation

Breeding Method				Calving Interval: heifers and empty cows	Calving Interval: < 365 CI	Calving Interval: > 365 CI	Total
A.I	Pregnancy Status	empty	Count	6	7	4	17
			% within Pregnancy Status	35.3%	41.2%	23.5%	100.0%
			% within Calving Interval	40.0%	18.9%	16.7%	22.4%
		pregnant	Count	9	30	20	59
			% within Pregnancy Status	15.3%	50.8%	33.9%	100.0%
			% within Calving Interval	60.0%	81.1%	83.3%	77.6%
	Total		Count	15	37	24	76
			% within Pregnancy Status	19.7%	48.7%	31.6%	100.0%

			% within Calving Interval	100.0%	100.0%	100.0%	100.0%
NS	Pregnancy Status	empty	Count	18	9	8	35
			% within Pregnancy Status	51.4%	25.7%	22.9%	100.0%
			% within Calving Interval	51.4%	33.3%	42.1%	43.2%
		pregnant	Count	17	18	11	46
			% within Pregnancy Status	37.0%	39.1%	23.9%	100.0%
			% within Calving Interval	48.6%	66.7%	57.9%	56.8%
	Total		Count	35	27	19	81
			% within Pregnancy Status	43.2%	33.3%	23.5%	100.0%
			% within Calving Interval	100.0%	100.0%	100.0%	100.0%
Total	Pregnancy	empty	Count	24	16	12	52

Status		% within Pregnancy Status	46.2%	30.8%	23.1%	100.0%
		% within Calving Interval	48.0%	25.0%	27.9%	33.1%
	pregnant	Count	26	48	31	105
		% within Pregnancy Status	24.8%	45.7%	29.5%	100.0%
		% within Calving Interval	52.0%	75.0%	72.1%	66.9%
Total		Count	50	64	43	157
		% within Pregnancy Status	31.8%	40.8%	27.4%	100.0%
		% within Calving Interval	100.0%	100.0%	100.0%	100.0%