ADDIS ABABA UNIVERSITY
SCHOOL OF VETERINARY MEDICINE

EVALUATION OF REPRODUCTIVE PERFORMANCE OF BEGAIT CATTLE BEFORE AND AFTER APPLICATION OF ESTRUS SYNCHRONIZATION PROTOCOLS IN NORTHERN ETHIOPIA

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LIST OF ABBREVIATIONS

AAU	Addis Ababa University
AFC	Age at First Calving
AFS	Age at First Service
AI	Artificial Insemination
ANOVA	Analysis of Variance
BC	Before Birth of Jesus Christ
BoARD	Bureau of Agriculture and Rural Development
BoNAR	Bureau of Agriculture and Natural Resources
CI	Calving Interval
CL	Corpus Luetum
CSA	Central Statistical Agency
DMY	Daily Milk Yiled
E2	Estradiol-17β
FSH	Follicle Stimulating Hormone
GnRH	Gonadotropin-releasing Hormone
IBC	Institute of Biodiversity Conservation
LH	Luteinizing Hormone
LL	Lactation Length
M.a.s.l.	Meter above sea level
MoA	Ministry of Agriculture
mRNA	Messenger Ribonucleic Acid
NMA	National Meteorological Agency
P4	Progesterone
PGF2α	Prostaglandin F2alpha
SE	Standard Error
SPSS	Statistical Packages for the Social Science
TMY	Total Milk Yield
µg	microgram

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ABSTRACT

Retrospective and prospective studies were conducted in Kafta-Humera and Wukro areas of Tigray region. A retrospective study was carried out on 12 herds consisting 2144 *Begait* cattle from pastoral and agro-pastoral areas to assess herd composition and calf-crop. To evaluate the reproductive and lactation performance, 210 and 61 cows, respectively, were selected randomly from pastoral, agro-pastoral, confinement and crop-livestock production systems. All necessary data of reproductive and lactation parameters were collected through questionnaire surveys, group discussions and follow-up observations. Another experimental study was conducted to evaluate the estrus characteristics, estrus response and reproductive performance of *Begait* cattle following estrus synchronization using $PGF_{2\alpha}$ alone and GnRH + $PGF_{2\alpha}$ treatments. Forty heifers and 47 cows were purposively selected for this study and randomly assigned in the two treatment groups. Thirty-eight cattle were treated with $PGF_{2\alpha}$ (GI) followed by mating after estrus exhibition and second $PGF_{2\alpha}$ injection was given for those that didn't exhibit estrus signs in the first injection. The rest, 49 cattle were treated with GnRH followed by $PGF_{2\alpha}$ (GII) 7 days later and observed for estrus that followed by mating. SPSS software was applied to analyze the data. The result of the present study showed that the average calf-crop of 53% and 42.4% and annual calf mortality rate of 20.8% and 9.4%, were observed for pastoral and agro-pastoral production systems, respectively. The mean AFC and CI in months were 43.9 and 12.9 in pastoral, 45.0 and 14.0 in agro-pastoral, 44.9 and 15.0 in confinement and 49.5 and 19.6 in crop-livestock production systems, respectively. Both parameters were significantly ($P<0.05$) affected by site and production system. Significantly longer AFC and CI were noticed in crop-livestock system than in the other 3 production systems. However, CI was not affected by age and parity. Likewise, the mean daily milk yield at early, middle and late lactation of *Begait* cows was significantly higher ($P<0.05$) in the agro-pastoral (4.5, 6.7 and 3.1 liters, respectively) than in pastoral (2.2, 4.0 and 1.4 liters, respectively) production system. On the other hand, lactation lengths were shorter in pastoral (150 $\pm$ 4.39 days) and crop-livestock (148.4 $\pm$ 5.48 days) than in confinement (209.7 $\pm$ 7.90 days) and agro-pastoral (189.2 $\pm$ 4.45 days) production systems. Younger and first parity animals as well as those with once milking practice per day also had significantly lower lactation performance while site did not have effect. The hormonal experiment study showed that an overall 71.3% of cows responded in both treatment groups. The most frequently observed estrus behaviors and physical changes were standing to be mounted,

restlessness, swelling and redness of vulva and vaginal discharge with the value of 100, 100, 96.7 and 90%, respectively. The mean time interval from $PGF_{2\alpha}$ injection to the onset of estrus in GI and GII was 73.8±5.26 and 67±2.42 hours, respectively. Both the estrus response and pregnancy rate in GII (83.7 and 92.7%) were significantly higher ($P<0.05$) as compared to GI (55.3 and 85.7%), respectively. The present study showed that heifers and moderate body condition cattle became more responsive ($P<0.05$) to the therapy than cows and those with poor body condition cattle. In conclusion, acceptable results of estrus responses and pregnancy rates obtained following $PGF_{2\alpha}$ and GnRH + $PGF_{2\alpha}$ treatments in the present study appear to be promising for enhancing reproductive performance in Begait cattle breed and may help as a stepping- stone for researchers and developmental agencies for further innovation, adoption and extension in the area.

Key words: *Begait cattle, production systems, reproductive performance, estrus synchronization, $PGF_{2\alpha}$, GnRH...*

1. INTRODUCTION

Agriculture is the main economic activity in Ethiopia employing about 85% of the population. Farm animals are its integral parts (IBC, 2004) of which especially cattle, play a significant role, directly or indirectly, in achieving subsistence food security for all smallholder farmers, pastoralists and agro-pastoralists and to the economy of the nation at large.

Though Ethiopia has an estimated 50.8 million (CSA, 2010) heads of cattle population, almost all of them (99.19%) are local indigenous breeds that are known to have poor reproductive and productive performance perhaps due to inadequate nutrition, poor genetic potential, inadequate animal health services, lack of appropriate breeding policy and lack of efforts to use latest and appropriate application of reproductive and productive technologies to improve their performances (Lobago *et al*., 2006; Tesfaye and Puskur, 2007; Staa *et al*., 2008 and Lemma *et al.,* 2008). In general, the little attention given to the indigenous cattle in the country has led to obligatory harvest at its lowest production level.

To up-grade the alleged low genetic makeup of the existing local cattle breeds and to respond to the dramatically increasing milk demand in the country, many European cattle breeds have been imported for milk production and improvement program of which Friesian and Jersey were considered to be the best adaptive breeds for both pure line and crossbreeding programs. In fact, importing the European cattle breeds could play a pivotal role for milk production and genetic improvement program, but there are two hidden problems that need attention with the replacement program. Firstly, the focus has been given to the 15% of the country's human population (the urban and peri-urban) leaving out the 85% rural farmers and also without regard for situations in which the exotic animals could be less fruitful with the currently existing local farm management system. Secondly, if the indiscriminate distribution of the presumed "best performing genotypes" into different parts of the country were to continue unabated at the current swiftness with negligence towards the local breeds, the indigenous farm animal genetic resources and associated traditional knowledge would then be lost in the near future before they are even fully used, utilized, understood and described.

In view of the above mentioned points, with concerted and well organized plan to help the poor farmer, save the endangered breeds and increase the economy of the nation; in parallel with the introduction of European cattle and crossbreeding programs, giving attention to the indigenous (Ethiopian) cattle breeds which have better performance is mandatory.

Although little is known on the productivity of all Ethiopian breeds of cattle, the *Begait*, *Borana*, *Fogera* and *Horro* cattle show very considerable potential for milk and meat production (MOA, 1999). The indigenous cattle breeds of Ethiopia such as *Begait* cattle have special adaptive traits for disease resistance, heat tolerance, optimum maintenance requirement, ability to utilize poor quality and quantity feed, as well as easily manageable by the poor rural farmers (Rege, 1999).

Begait cattle breed is one of the four major breeds found in Ethiopia, used primarily for milk and meat production, and is usually white with black spots or splashes (Mason, 1996). The *Begait* type cattle are the largest with well developed udder, long teats and a higher milk yield. This breed ranks first in milk and meat production of all Northern Ethiopia cattle breeds (Zerabruk *et al.*, 2007; Mekonnen, 2008 and Abereham, 2009). Owing to better production capacity, *Begait* breed are being distributed to various poverty-prone (ex-situ sites) areas by the regional government to satisfy the demand of milk, though one-third of them are being culled by the farmers due to reproduction and production failures (Mekonnen, 2008). Thus, researches aiming at assessing the performance of these cattle in the different sites and production systems are vital.

In Ethiopia, except for the initiative taken to evaluate, multiply, improve and conserve the *Fogera* and *Borana* breeds, there have been no institutionalized attempts made towards improving and conserving the other breeds such as *Begait* (Zerabruk *et al.*, 2007). Consequently, the extinction probability for most of the Ethiopian breeds is high ranging from 0.37 to 0.67, the highest (67%) being for the *Begait* breed (Zerabruk *et al.*, 2007). This indicates the need for urgent intervention in terms of breed multiplication, good management and conservation efforts to save the breed.

Almost all of the available information pertaining to the reproductive performance of *Begait* cows in Ethiopia is based on research station or institutional herds. For Example, attempts have

been made to investigate the lactation and reproductive performance of *Begait* cows on research station by many authors (Tegegne *et al.*, 1981; Rege, 1999 and Million and Tadelle, 2003). However, there is a scarcity of reliable information regarding milk yield and reproductive performance of *Begait* cows in their in-situ and ex-situ sites and in different production systems in Ethiopia, though it has paramount importance to livestock owners, extension agents, veterinarians and researchers. Moreover, such studies can assist in the development of strategies and prioritization of possible intervention options for performance improvement.

On the other hand, *Begait* cattle are mainly raised under traditional management systems and forced to experience seasonal forage problem, thermal and environmental stresses that lead to low individual and herd productive and reproductive performance. Even though a number of scopes exist for increasing reproductive efficiency by modifying in the traditional methods of breeding, feeding and management; fast improvement can be achieved through appropriate application of reproductive biotechnology such as estrus synchronization using Gonadotropin-Releasing Hormone (GnRH) and Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) as many authors (Tegegne and Franceschini 1993; Diskin *et al.*, 2002; Macmillan *et al.*, 2003; Bekana *et al.*, 2005; Meles, 2007; Silva *et al.*, 2007; Meyer *et al.*, 2007; Córdova-Izquierdo *et al.*, 2009 and Patterson *et al.*, 2010) reported satisfactory results in different cattle breeds. Estrus synchronization helps to produce uniform heifers, shorten the calving interval and to schedule the calving time with the seasonal forage availability and milk demand. Though remarkable advantages, the effect of hormonal treatment on Begait cattle for estrus synchronization has never been studied so far.

Based on the above scenario, the objectives of this study were therefore:

- To assess the reproductive and productive (lactation) performance of *Begait* cattle in in-situ and ex-situ sites and in different production systems.
- To evaluate and compare the estrus characteristics, estrus response and reproductive performance of *Begait* cattle following $PGF_{2\alpha}$ alone and GnRH + $PGF_{2\alpha}$ treatments.

2. REVIEW OF LITERATURE

2.1. *Begait* cattle

2.1.1. Origin of *Begait* cattle

The *Begait* cattle, with synonym name *Barka*, are known in the breed group name of Large East African Zebu and Subgroup of North Sudan Zebu. Zebu cattle (*Bos indicus*), with their characteristic hump and pendulous dewlap, are known to have descended from the secondary cattle domestication in the arid areas about 5000 BC (Payne and Wilson, 1999). Available archaeological records indicate that they are the most recent types of cattle to be introduced into Africa. Recent molecular genetics as well as archaeological evidences (Hanotte *et al.*, 2002) also showed that the introduction of Zebu cattle into Africa centered in East Africa rather than though the land connection between Egypt and the Near East. Zebus are known to be better than the Humpless cattle in regulating body temperature (hence lower body water requirements). Their hardened hooves and lighter bones enable them to endure long migrations. These adaptive attributes have facilitated their importation and spread by Indian and Arabian merchants across the Red Sea to drier agro-ecological regions of the Horn of Africa. The Large East African Zebu breeds of cattle, like the present-day Boran of Ethiopia, Kenya and Somalia, and the Butana and Kenana of the Sudan are very similar morphologically to the zebu breeds of Asia. Mainly pastoral communities in the Horn of Africa maintain them. The *Begait* breed descended originally from the first introductions of zebu from West Asia, but appears to have some Sanga background as appears from long legs and cervico-thoracic hump and maintained by the Barka and Beni-Amir tribes in the lowlands of western Eritrea and neighboring areas of the Sudan and Ethiopia. The breed is also currently found in the area of Northern Ethiopia (North-western Tigray). They are one of the four major breeds of cattle found in Ethiopia (Mason, 1996; Hanotte *et al.*, 2002).

2.1.2. Distinguishing characteristics

Zerabruk *et al.* (2007) reported two distinct types of *Begait* breed, namely the *Dohin* and the *Begait* types. The *Dohin*, is a tall and slender type with short ears, a straight nose, a narrow long neck and long thin legs, a long tail, a less developed dewlap and a smaller udder. Milk production is lower than the other type. Both males and females have thin and medium horns, with black or brown coat colour. The most important traits of this type are its aggressive behavior towards intruders which is an advantage in areas where cattle rustling is a big problem, and the capacity to travel long distances and graze in the vast range lands. The *Begait* type is the largest and most docile with a well developed udder, long teats and a higher milk yield. Small and stumpy horns are common in both males and females of this type. The *Begait* is very vulnerable to food shortage. Grey, brown and black and white coat colours are most common (Zerabruk *et al.*, 2007; Abraham, 2009). Fairly large, the *Begait* frequently has the hump more cervically situated than is common in East African zebu, possibly owing to cross-breeding with Sanga or humpless short-horn cattle in an earlier generation (Epstein, 1971).

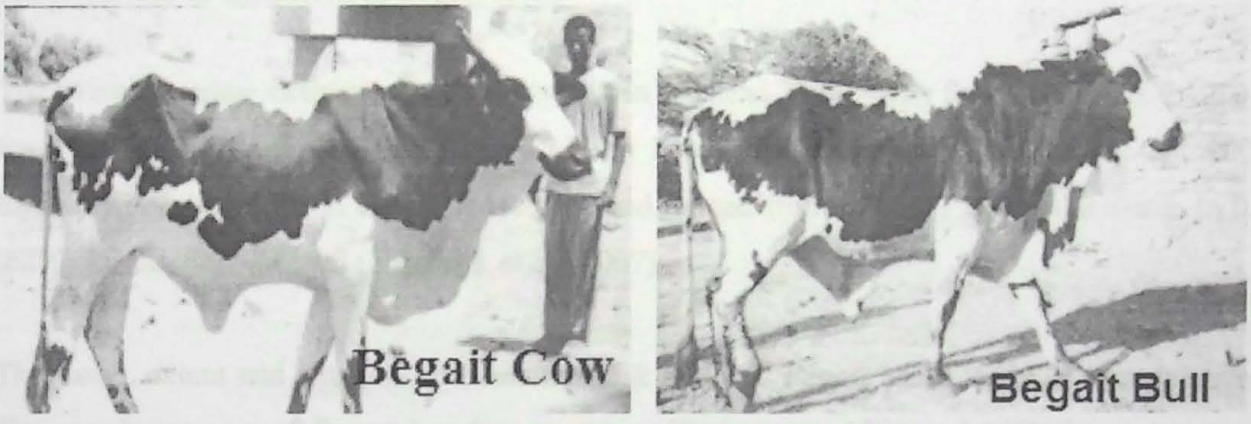


Figure-1. Picture of *Begait* cow and *Begait* bull. (Source: Zerabruk *et al.*, 2007)

2.1.3. Production and reproduction capacity of *Begait* cattle

Begait/Barka cattle are not only the main sources of milk but also meat and draft power in Northern Ethiopia (Mekonnen, 2008 and Abereham, 2009). Males and females of the *Begait* breed were heavier and taller than the other breeds in the Northern Ethiopia (Zerabruk *et al.*, 2007). And Rege (1999) reported adult live weight range 335-490 kg and 295-415 kg for males and females, respectively. The *Begait* type is the largest with well developed udder, long teats and a higher milk yield. According to the reports of (Million and Tadelle, 2003; Zerabruk *et al.*, 2007), the average daily milk production for *Begait* cattle is the highest and ranks number one of all Northern Ethiopia cattle breeds. Abereham (2009) on his discussion with the farmers of the western found that in the past when the range land was at a better condition *Begait* cattle used to calve every year. According to Oquba-Micheal (2003), daily milk yield of 6 to 8 liters was recorded from Begait cattle reared in the in-situ places of Eritrea. He also reported that they are relatively resistant to diseases and are also known for their high feed conversion rate making them good meat producers.

2.1.4. Threats of extinction of *Begait* cattle

The overall average extinction probability within the next 20-50 years for all breeds is 0.49±0.09 for 49 African breeds including some of the breeds in Ethiopia (Reist-Marti *et al.*, 2003). Extinction probabilities in Ethiopian cattle breed ranged from 0.37 (37%) for the *Arado* to 0.67 (67%) for the *Begait* breed (Zerabruk *et al.*, 2007).

The cause, extent and situation of extinction risk with the *Begait* breed are even more alarming. The population size of *Begait* has decreased by 67% between 1981 and 1999 due to two major famines in the area in 1984/1985 and 1995/1997 (BoNAR, 1999).

Currently, the populations *Begait* breeds are under extreme pressure as a result of increased demand for meat from the presence of a huge number of army personnel (concentration of army of Ethiopia, Eritrea and some extent of Sudan) in the northern part of the country since the 1998 border war between Ethiopia and Eritrea (Zerabruk *et al.*, 2007).

Other factors that contribute to extinction threats of indigenous cattle are very high temperature, human population growth, uncontrolled breeding, conflict (war), natural calamities, privatization, commercialization and market liberalization that are being introduced without concurrent adjustment in policy, institutions and legal frameworks.

In Ethiopia, except for the initiative taken to evaluate, improve and conserve the *Fogera* breed at the Metekel and Andasa cattle breeding ranches and the Borana breed improvement and multiplication centre for *Boran* cattle in Oromia Region, there are no institutionalized attempts towards improving and/or conserving the other breeds such as *Begait* (Zerabruk *et al.*, 2007).

The high overall extinction probability for most of the breeds, especially the *Begait* breed cattle, calls for immediate action to save the breed or indicates the need for urgent intervention in terms of breed multiplication, good management and conservation efforts. Biotechnology offers tools that achieve rapid increases in reproductivity and productivity (Mukassa-Mugerewa *et al.*, 1991).

2.2. Reproductive performance in female cattle

Reproductive performance is a vital factor in determining the efficiency of animal production (Peters and Ball, 1995). Low reproductive efficiency hinders genetic improvement efforts and causes direct economic loss in the tropical regions (Mukassa-Mugerwa *et al.*, 1991). The main indicators of reproductive efficiency in the female animal are age at first service, age at first calving, calving interval and number of services per-conception (Bekana *et al.*, 1996; Bekana, 1997and Kassa and Tegegne, 1998).

2.2.1. Age at first service

Age at first service (AFS) is the age at which heifers attain body condition and sexual maturity for accepting service for the first time. AFS signals the beginning of the heifer's reproduction and production and influences both the productive and reproductive life of the female through its effect on her life time calf crop. It occurs when the gonads begin to secrete sufficient steroids to

accelerate the growth of the genital organs and the development of secondary sexual characteristics (*Mukasa-Mugerwa et al.*, 1989). Heifers, especially *Bos taurine* can reach puberty and breed at one year old. However, *Bos indicus* reach puberty late. In general, the time taken zebu cattle to attain sexual maturity and puberty are highly influenced by environmental factors including feed quantity and quality (Mukasa-Mugerwa *et al.*, 1989).

2.2.2. Age at first calving

First calving marks the beginning of a cow's productive life. Age at first calving is closely related to generation interval. The average age at first calving in *Bos indicus* cattle is about 44 months, compared with about 34 months in *Bos taurus* and *Bos indicus* x *Bos taurus* crosses in the tropics (Mukasa-Mugerwa , 1989). Age at first calving is the age at which heifers calve for the first time (Gidey, 2001). It is closely related to the rearing intensity, and in a breeding program has impact on generation interval and response to selection. Different works of various authors had shown values of age at first calving estimated for different cattle genotypes in Ethiopia.

Table-1. Some estimates of age at first calving in *Bos indicus* cattle

Breed	Location	months	Source
Kenana	Sudan	23-58	Alim (1960)
Gobra	Senegal	31-40	Dennis and Thiongane (1978)
Boran	Kenya	34	Reinhardt (1978)
Boran	Ethiopia	45.2	Haile-Mariam *et al.* (1993)
East African Zebu	Ethiopia	35.1	Alberro (1983)
Red Sindhi	India	35.6	Basu *et al.* (1979)
East African Zebu	Uganda	43	Galukande *et al.* (1962)
Highland zebu	Ethiopia	53	Mukasa-Mugerwa *et al.* (1989)
Horro	Ethiopia	35	Tegegne *et al.* (1981)
Barka	Ethiopia	30.3	Goshu (1981)
Fogera	Ethiopia	53.8	Asheber, (1992)
Arsi	Ethiopia	32.8	Negussie *et al.* (1998)

2.2.3. Calving interval

Calving interval refers to the period between two consecutive calving. Calving interval can be divided into three periods: gestation, postpartum anoestrus (from calving to first oestrus) and the service period (first postpartum oestrus to conception) (figure-2).

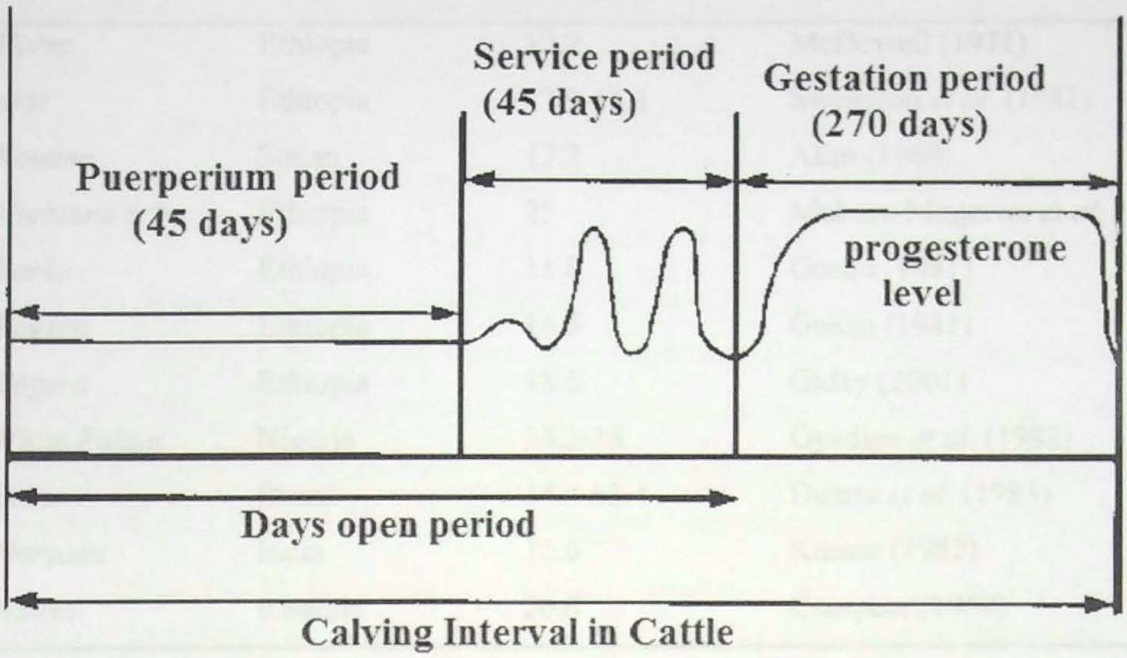


Figure-2. Schematic representation of the main components of calving interval and its relationship with progesterone level (Mukassa-Mugrewa, 1989)

Calving interval is probably the best indicator of a cow's reproductive efficiency. Estimates of calving interval in zebu cattle range from 12.2 to 26.6 months (Mukassa-Mugrewa, 1989). Most Zebu cows do not commence postpartum ovarian cyclic activity until weaning their calves at 8 months of age (Mukassa-Mugrewa, 1989; Tegegne *et al.*, 1992). Nutritional conditions that vary seasonally and yearly have major effects on body condition as well as calving interval (Oyedipe, 1982 and Meneghetti and Vasconcelos, 2008). Calving interval is also influenced by parity, suckling and lactation intensity. In zebu cattle, calving interval is longest in first calf heifers and older cows and shortest in cows of intermediate age (6-9 years) (Mukassa-Mugrewa, (1989). Abereham (2009) also reported that the average calving interval of *Begait* cattle ranged between

24 months in Kola-Tembein, 14 months in Adwa in the ex-situ and 13.96 months in their in-situ (Western zone of Tigray).

Table-2. Some estimates of calving interval in zebu cattle

Breed	Location	Months	Source
Horro	Ethiopia	12.2	McDowell (1971)
Arsi	Ethiopia	12.9-15.1	Swensson *et al.* (1981)
Kenana	Sudan	13.2	Alim (1960)
Highland zebu	Ethiopia	25	Mukasa-Mugerwa *et al.* (1989)
Barka	Ethiopia	11.8	Goshu (1981)
Fogera	Ethiopia	14.5	Goshu (1981)
Fogera	Ethiopia	18.6	Gidey (2001)
White Fulani	Nigeria	14.2-18	Oyedipe *et al.* (1982)
Zebu	Brazil	14.4 ±3.4	Duarte *et al.* (1983)
Haryana	India	15.6	Kumar (1982)
Native	Rwanda	26.6	Compere (1960)

2.2.4. Pregnancy rate

Pregnancy rate refers to the number of cows pregnant as a proportion of those in the herd that were mated. Many authors have shown that fertility, measured in terms of percentage of animals becoming pregnant to a single service. Generally pregnancy diagnoses are rarely conducted in rural areas as there is scarcity of veterinarians and also farmers do not consider it as an important practise, and thus, pregnancy rates are largely unknown. Matiko *et al.* (2008) observed a pregnancy rate of 44% in Tanzania, which is low. In commercial beef herds, pregnancy rates should be in excess of 70% (Peters, 1984 and Kanuya, *et al.*, 2006). There is evidence that poor nutrition and management, harsh climatic conditions, genetic and seasonal effects affect fertility of Zebu cattle (Tegegne *et al.*, 1981; Haile-Mariam *et al.*, 1993 and Kassa and Tegegne, 1998).

2.3. Lactation performance of cattle

Milk production systems in Ethiopia may be classified into two broad categories viz: commercial system which produces milk mainly for market; and subsistence systems which produce milk mainly to meet household needs for milk products. The milk production potential of indigenous breeds of cattle is very low (table-3). Therefore, to up-grade, the production of the local cattle, crossbreeding of the indigenous breeds with temperate exotic breeds has been practiced in the country, since the establishment of the Institute of Agricultural Research, with the aim of making use of the high genetic potential for milk production of exotic breeds and the adaptability to the local environment of indigenous breeds. Improvements in daily milk yield of cows could be considered as one of the strategies to increase the overall milk production in the areas i.e. assuming that persistency and lactation length is improved. This could be achieved through nutritional management interventions during the most critical periods of the lactation period and life cycle. Improvements in nutritional management during the later quarter of pregnancy and during early lactation period could increase peak milk yield, improve persistency and increase lactation length (Tegegne *et al.*, 2003; Belete, 2006 and Adebabay, 2009).

Table-3. On-station milk production performance of indigenous cattle in Ethiopia

Indigenous breed	Lactation		Source
	Milk yield (kg)	Length	
Boran	494	155	Beyene and Galal (1982)
Horro	559	285	Beyene and Galal (1982)
Arsi	809	272	Kiwuwa *et al.* (1983)
Barka/Begait	552[a]	128[a]	Goshu (1981)
Barka/Begait	675	---	Tegegn *et al.* (1981)
Fogera	613[a]	353[a]	Goshu (1981)

a=first lactation

2.4. Reproductive physiological basis for estrus induction/synchronization in cattle

2.4.1. The estrous cycle

The estrus cycle of dairy cattle averages 20 days in heifers and 21 days in cows, with normal cycles ranging from 18 to 24 days with ovulation occurring 10 to 12 hours after cessation of estrus. Ovulation of the dominant follicle, therefore, occurs about 30 hours after the time of initiation of behavioral estrus (Senger, 2003). The estrous cycle consists of the follicular and luteal phases, throughout which gonadotropins influence ovarian folliculogenesis, ovulation, and subsequent CL function. There are transient changes in concentrations of many reproductive hormones in blood during the estrous cycle. These changes regulate reproduction and behavior during estrous cycles as hormone secretions assist in communication among various tissues during specific periods of the estrous cycle. As a consequence of these communications, regulation of hormonal secretions occurs by feedback loops when the respective hormone concentrations exceed their threshold amounts in blood. The hormonal changes occurring during the estrous cycle regulate changes in the morphology and function of ovarian structures (follicles and corpora lutea) and also the tubular genitalia (oviduct, uterine horns, cervix and vagina). The hormonal changes that occur during the estrous cycle also are normally divided into four stages or periods. These four stages or periods are: (1) estrus (period of receptivity to the male); (2) metestrus (period from cessation of estrus to early development of the corpus luteum); (3) diestrus (period when the corpus luteum is fully functional); and (4) proestrus (period from the time of regression of the corpus luteum to onset of estrus) (Hopper *et al.*, 1993; Senger, 2003 and Baruselli *et al.*, 2004).

Estrus: Estrus is defined as the period of sexual receptivity in the female (Senger, 2003) and is characterized by behavioral expression of estrus. The mean duration of estrus in Zebu cattle is around 10 hours, but with a range of 1.3 to 20.0 hours (Mukasa-Mugerwa, 1989). The steroid hormone estradiol-17β (E_2) secreted by growing follicles on the ovary is the primary hormone responsible for expression of estrus. In addition, E_2 prepares the uterine and vaginal environments for mating and initiates the preovulatory surge of LH (Rhodes *et al.*, 1995). Frequent and high amplitude pulses of E_2 originating from the preovulatory follicle result in

attainment of threshold concentrations of E2 (Walters and Schallenberger, 1984). This triggers a positive feedback effect on the hypothalamus, resulting in increased secretion of GnRH that culminates in a GnRH surge, and resulting release of the preovulatory LH surge from the anterior pituitary (Walters and Schallenberger, 1984). The preovulatory LH surge is necessary for final maturation and ovulation of the oocyte (Ginther *et al.*, 2000).

Metestrus: The preovulatory surge of LH induces ovulation of the dominant follicle, and LH concentrations subsequently decline (Walters and Schallenberger, 1984 and Cupp *et al.*, 1995). Ovulation occurs about 30 hours after the onset of estrus (Senger, 2003). The ovulated follicle undergoes luteinization, or structural and cellular remodeling, resulting in the formation of a CL which produces the hormone progesterone (Garverick *et al.*, 1992). Luteinizing hormone assists in transforming the follicular theca and granulosa cells into small and large luteal cells, respectively (Garverick *et al.*, 1992). The majority of P4 produced by the CL originates from large luteal cells (Niswender *et al.*, 2007).

Diestrus: Prior to ovulation, the primary ovarian structures are follicles comprised of theca and granulosa cells that secrete E_2. Following ovulation, however, these follicular cells differentiate to form a CL, a transient endocrine gland which secretes the steroid hormone P4 (Garverick *et al.*, 1992 and Niswender, 2002). Progesterone is an important regulator of the bovine estrous cycle. Progesterone functions by suppressing the secretion of other hormones, inhibiting expression of behavioral estrus, and maintaining pregnancy (Garverick *et al.*, 1992 and Driancourt, 2001). Progesterone concentrations begin to increase by day 4 of the estrous cycle, reach maximal concentrations by day 7 to 12, and remain elevated until day 18 or 19 when luteolysis occurs. Concentrations of P4 decline after luteolysis and remain low throughout the subsequent follicular phase. Together, metestrus and diestrus comprise the luteal phase of the bovine estrous cycle (Garverick *et al.*, 1992 and Driancourt, 2001).

Proestrus: During the luteal phase of the estrous cycle, P4 blocks the ability of E2 to enhance expression of uterine endometrial oxytocin receptors. However, P4 eventually down-regulates its own receptor toward the end of the luteal phase, removing the inhibitory effect of P4. This allows E2 to induce the formation of endometrial oxytocin receptors and stimulate the release of

oxytocin from the pituitary, which in turn stimulates the uterus to release low levels of prostaglandin F2α ($PGF_{2\alpha}$). These low levels of $PGF_{2\alpha}$ then cause release of luteal oxytocin, which amplifies the release of $PGF_{2\alpha}$ from the uterus (McCracken *et al.*, 1999). In cattle, $PGF_{2\alpha}$ of uterine origin exerts its effect on the CL by means of vascular countercurrent exchange (Senger, 2003). Luteolysis, or regression of the CL, occurs at the end of the luteal phase around day 18 of the estrous cycle. Regression of the CL causes a significant decrease in P4 concentrations that end the negative feedback of P4 on the preovulatory surge center of the hypothalamus (Savio *et al.,* 1990). High frequency pulses of GnRH are then secreted from the hypothalamus, which signal the anterior pituitary to release the gonadotropins LH and FSH. Three days following the decrease in P4, E2 reaches peak threshold concentrations. Secretion of E2 and the gonadotropins promote continued growth and development of preovulatory follicles. Together, proestrus and estrus comprise the follicular phase of the bovine estrus cycle (Savio *et al.,* 1990; Garverick *et al.,* 1992 and Cupp *et al.*, 1995).

Table-4. Characteristics of the bovine estrous cycle

Stage	**Day of the estrous cycle**	**Characteristics**
Estrus	0	Behavioral estrus (heat)
Metestrus	1 to 4	Ovulation and CL formation
Diestrus	5 to 16	CL growth and maintenance, progesterone secretion
Proestrus	17 to 21	Luteolysis and rapid follicular growth

Source: Nicole, R. (2007).

2.4.2. Postpartum anestrous in cows

The postpartum anestrous in cattle has been identified as one of the major problem affecting the efficiency of reproduction and thus overall production in rural areas. At the end of pregnancy, the hypothalamic-pituitary axis responds to a negative feedback effect of placental and ovarian

steroids by suppressing FSH release and accumulating this hormone in the anterior pituitary and depleting LH stores (Yavas and Walton, 2000). Following parturition, there is a dramatic increase in FSH that is followed by the emergence of the first follicular wave (2–7 days postpartum, (reviewed by Wiltbank *et al.*, 2002). Data indicate that it is LH, and not FSH, that is the limiting hormone for the onset of postpartum ovarian activity. After LH stores are re-established between 15 and 30 days postpartum (Yavas and Walton, 2000); nutritional status and suckling may be the most important factors that inhibit postpartum ovulation in cows. Poor nutrition is a recognized cause of reduced fertility in cattle grazing in subtropical/tropical areas (Bó *et al.*, 2003).

After re-establishment of LH stores in the anterior pituitary, maternal-offspring bond increases postpartum anestrous due to the negative effect on LH release, which, in turn, affect the final maturation and ovulation of the dominant follicle. As the postpartum period proceeds, the negative effect of suckling becomes less intense and cows eventually ovulate and begin to cycle. Restricted suckling or calf removal increases LH pulse frequency and stimulates follicular growth and ovulation in cows >30 days postpartum (Yavas and Walton, 2000 and Baruselli *et al.*, 2004). Henao *et al.* (2000) observed that duration of postpartum anestrous in suckled Brahman cows is longer than that in non-suckling cows. During anestrus, ovulation does not occur despite ovarian follicular development, because growing follicles do not mature. Although many factors affect postpartum anestrus, nutrition and suckling are the major factors influencing the resumption of postpartum ovarian cycles, as they affect hypothalamic, pituitary and ovarian activity and thus inhibit follicular development (Montiel and Ahuja, 2005). Besides to the hormonal disturbance, prolonged interval to first ovulation, retained fetal membranes and uterine infections and low level of progesterone are the main factors that impair post-partum reproductive performance (Bekana *et al.*, 1996; Bekana, 1997 and Belachew and Regassa, 2010).

2.5. Principles of induction and synchronization of estrous cycle in cattle

The ultimate goal of estrous synchronization is to synchronize estrus and ovulation effectively, so that the animals can be inseminated at a predetermined time without estrous detection and

reduction in fertility. Several commercial programs have been developed in an attempt to meet these aims.

According to Diskin and Sreenan (1994), there are two main basic approaches that can be used to synchronize or control estrus in cattle. The first is to treat with exogenous progesterone or synthetic progestins (through the use of controlled release drug delivery systems developed for either subcutaneous or intravaginal administration) to prevent estrus and ovulation for a sufficient period to allow spontaneous regression of the corpora lutea during the period of treatment. Theoretically, all animals will come into estrus and ovulate after withdrawal of the exogenous progesterone or synthetic progestins. The second method is to induce regression of the corpora lutea of all animals with injections of $PGF_{2\alpha}$ or its analogs, and after 2–4 days the animals will come into estrus and ovulate.

The hormones used to pharmacologically control the estrous cycle are identical to (or analogs of) the reproductive hormones found within the hypothalamus (GnRH), ovary (estradiol and progesterone), and uterus ($PGF_{2\alpha}$) of cattle. The biological activity of exogenous hormones recapitulates the biological activity of endogenous hormones in the normal cow. The earliest estrous synchronization method was blocked ovulation by administering exogenous progestogens. Although the method provided acceptable synchrony, conception rates were depressed. The subsequent discovery of $PGF_{2\alpha}$ as the uterine luteolysin led to the development of new synchronization methods in the 1970s. Exogenous progestogens and $PGF_{2\alpha}$ were later combined to improve the outcomes of both methods (Kojima *et al.*, 2004; Schafer *et al.*, 2006; Nicole, 2007).

Despite considerable improvement when progestogens and $PGF_{2\alpha}$ were combined, depressed conception rates, especially following prolonged exogenous progestogen treatment, impeded the full implementation of the system. A greater understanding of follicular dynamics in the 1990s revealed that the persistent dominant follicle was the causative agent for depressed fertility. Programs that control follicle development, the length of the luteal phase, and the time of ovulation were then developed.

2.6. Prostaglandin and its analogues treatment in postpartum dairy cattle

2.6.1. Prostaglandin in synchronization of estrus in cows.

Prostaglandin ($PGF_{2\alpha}$) is a naturally occurring hormone. During the normal estrous cycle of a non-pregnant animal, $PGF_{2\alpha}$ is released from the uterus 16 to 18 days after the animal was in heat. Prostaglandin is a luteolytic hormone that regulates the life-span of the CL. A major limitation of using $PGF_{2\alpha}$ is that animals will only respond if they have a functional CL present at the time of treatment and is therefore not suitable for use in pre-pubertal heifers and cows in the early post-partum period (Tenhagen *et al.*, 2000 and Bekana *et al.*, 2005). Wenzel (1991) has noted normal or above normal fertility following synchronization of estrus with $PGF_{2\alpha}$ in cows. Reproductive performance in dairy cattle was also improved following double 14 days- $PGF_{2\alpha}$ treatment without assessing ovarian status when compared to a single dose based on detecting a CL by rectal palpation or by milk progesterone enzyme immunoassay (Bekana, 1997; Bekana *et al.*, 1996 and Bekana *et al.*, 2005). Tenhagen *et al.* (2000) observed that timed insemination following double 14 day-prostaglandin treatment reduced the number of days open in lactating dairy cows when compared to AI performed at observed estrus.

Subsequent research efforts then attempted to improve the reproductive efficiency of dairy cattle by inducing estrus with $PGF_{2\alpha}$ (Macmillan *et al.*, 2003). Several studies demonstrated the capacity of $PGF_{2\alpha}$ and its synthetic analogues, alfaprostol (Randel *et al.*, 1996), cloprostenol (Cooper, 1974), fenprostalene (Martinez and Thibier, 1984) to trigger the regression of a mature CL in the ovary, thus provoking and synchronizing estrus (Stevenson and Pursley, 1994). When $PGF_{2\alpha}$ was administered to cows with a functionally mature CL, 85 to 95% reached estrus within 7 days of treatment (Folman *et al.*, 1990); 70 to 90% showing signs of estrus 3 to 5 days after treatment (Ferguson and Galligan, 1993).

Table-5. Summary of alternative methods to use prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) to control estrus onset in cyclic cattle

Method	Suitable for use in	Timing of insemination (AI)	Comments
Two injections of $PGF_{2\alpha}$ 11 days apart	Cyclic heifers	Detected estrus or double AI at 72 and 96 h or single AI at 72 h and heat check for 2–4 days	Cost effective, efficient, small number of animal handling events, good estrus response, one period of heat detection, fixed time AI possible
Single $PGF_{2\alpha}$, breed at detected estrus and re-inject those non bred on day 11	Cyclic heifers, dairy cows	Detected estrus	Decreased drug costs, two periods of heat detection required, good estrus response in cyclic animals, not suitable for fixed time AI
$PGF_{2\alpha}$ given after known estrus date or following confirmation of CL	Cyclic heifers, dairy cows, beef cows	Detected estrus	Reduced drug usage offset by cost of determining presence of CL, good estrus response, not suitable for fixed time AI

Source: (Bekana *et al.*, 2005 and Lane *et al.*, 2008).

2.6.2. Response of prostaglandin at different Stage of estrous cycle of cows

For $PGF_{2\alpha}$ treatment to achieve its luteolytic effects, the cows must be in the diestrus stage of the estrous cycle (Day 5 to 17). Prostaglandin treatment in the early stage of estrous cycle (first 5 days) was found to be ineffective in causing a luteolytic response in cattle (figure-3).

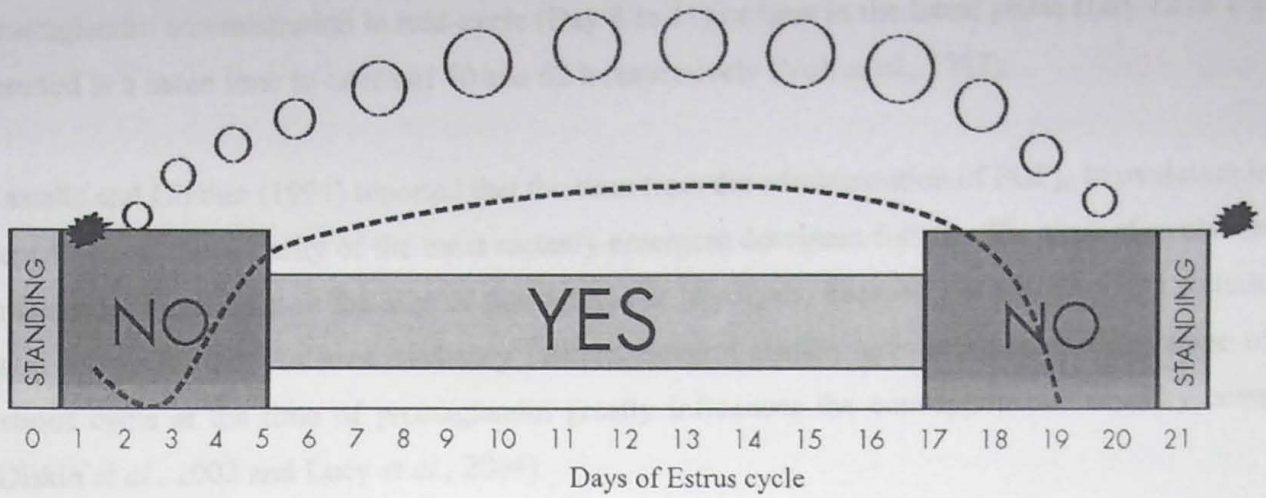


Figure-3. Diagram of ovary response for injection of $PGF_{2\alpha}$. Normal growth and regression of the CL (dotted circles) during the estrous cycle along with the changes in concentration of progesterone (dotted line) that occur. From day 0 to 5 and from 17 to 21 (indicated with the NO) the CL will not respond to an injection of $PGF_{2\alpha}$. From day 5 to 17 (YES) the CL will regress following an injection of $PGF_{2\alpha}$. (Salverson and George, 2005).

Consequently, a double protocol in which $PGF_{2\alpha}$ injection at 7, 11 or 14 days interval was developed, so that cows at a stage in the estrous cycle other than diestrus would have a functional CL when they received the second $PGF_{2\alpha}$. Kristula *et al.* (1992) reported that weekly doses of $PGF_{2\alpha}$ allowed AI to be performed earlier, because cows not in the diestrus stage when subjected to the first $PGF_{2\alpha}$ injection were found to have a functional CL when the second $PGF_{2\alpha}$ injection was given 7 days later. However, several authors report the improved reproductive efficiency of cows detected to be in estrus after the second $PGF_{2\alpha}$ dose using the double regime in which $PGF_{2\alpha}$ doses are given 11 or 14 days apart (Folman *et al.*, 1990; Ferguson and Galligan, 1993 and Lane *et al.*, 2008).

Since, induction of estrus was brought about by the luteolytic effect of $PGF_{2\alpha}$ on the mature CL; the success of $PGF_{2\alpha}$ primarily depends on the presence of a mature functional CL in the ovary (Kristula *et al.*, 1992). The stage of follicular wave development at the time of $PGF_{2\alpha}$ treatment appears to be the factor determining the time of estrus onset (Ferguson and Galligan, 1993). Thus, the time elapsed between $PGF_{2\alpha}$ treatment and the onset of estrus depends on the stage of the estrous cycle at the time of $PGF_{2\alpha}$ treatment. $PGF_{2\alpha}$ was administered on estrous cycle Day 5 or Day 8 in dairy cows. The mean interval to estrus was 48 to 72 hours following $PGF_{2\alpha}$ injection.

Prostaglandin administration in mid-cycle (Day 8 to 11) or later in the luteal phase (Day 12 to 15) resulted in a mean time to estrus of 70 and 62 h respectively (Voh *et al.*, 1987).

Kastelic and Ginther (1991) reported that the time from the administration of $PGF_{2\alpha}$ to ovulation is dependent on the maturity of the most recently emergent dominant follicle. The time of ovulation is therefore dependent on the size of this follicle at luteolysis, because a small dominant follicle takes longer to grow into an ovulatory follicle. Several studies have reported that the stage of estrous cycle at the time of prostaglandin greatly influences the conception rate in dairy cows (Diskin *et al.*, 2002 and Lucy *et al.*, 2004).

2.7. GnRH treatment in estrus synchronization protocol in cows

2.7.1. Effect of GnRH on follicular dynamics

The injection of GnRH causes all estrogen dominant follicles to ovulate, recruits new follicles, and luteinizes 'old' follicles. In cycling cows, administration of GnRH or a derivative induces a gonadotropin surge (Evans and Rawlings, 1994) and alters the pattern of follicle growth (Wolfenson *et al.*, 1994). Administration of GnRH induces a LH surge with similar maximum LH concentrations (20.6 ± 2.8 ng/ml) (McDougall *et al.*, 1995) but with approximately half the duration (Chenault *et al.*, 1990), when compared to the endogenous LH release during the normal estrous cycle at the time of ovulation. A single injection of GnRH or an agonist is sufficient to induce ovulation or atresia of a dominant follicle (Twagiramungu *et al.*, 1995). Pursley *et al.* (1995) reported that growing follicles greater than 10 mm in diameter ovulate after GnRH injection.

In cattle, administration of GnRH during the early or mid luteal phase causes an alteration of follicular distribution in the ovary by increasing the number of medium sized follicle and decreasing the number of large follicles by inducing luteinization or atresia (Guilbault *et al.*, 1990). Wolfenson *et al.* (1994) studied the dynamics of follicular development by ultrasonography in cows following administration of a single dose of GnRH in the mid luteal phase (Day 12) of the

estrous cycle. They reported the preovulatory follicles in cows following the injection of GnRH during the luteal phase were more homogeneous, more estrogen-active, probably due to preovulatory follicles being recruited and selected close to the time of estrus, and more dominant. GnRH induced ovulation or atresia of dominant follicle is followed by a new wave emergence within 3 to 4 days of treatment at any stage of estrous cycle (Twagiramungu *et al.*, 1995).

2.7.2. Response of GnRH at different stage of estrous cycle in cows

Response of ovaries to GnRH is dependent on the stage of follicular growth that GnRH is administered (Geary *et al.*, 2000). A high percentage of cows during the later stages of their estrous cycle (day 15 to 17) failed to ovulate a follicle after administration of GnRH and exhibited estrus prior to an injection of $PGF_{2\alpha}$ (Geary *et al.*, 2000). During an estrous cycle with three follicular waves, there are three time periods when a dominant follicle is present and can be induced to ovulate with an injection of GnRH. When a follicular wave is developing and a dominant follicle is not present an injection of GnRH will have no effect (figure-4). Following the induced ovulation of a dominant follicle by an injection of GnRH, a CL will form and a new follicular wave will be initiated. Generally, the administration of GnRH or a derivative induces a gonadotrophin surge, alters the pattern of follicular growth and may induce ovulation of a dominant follicle.

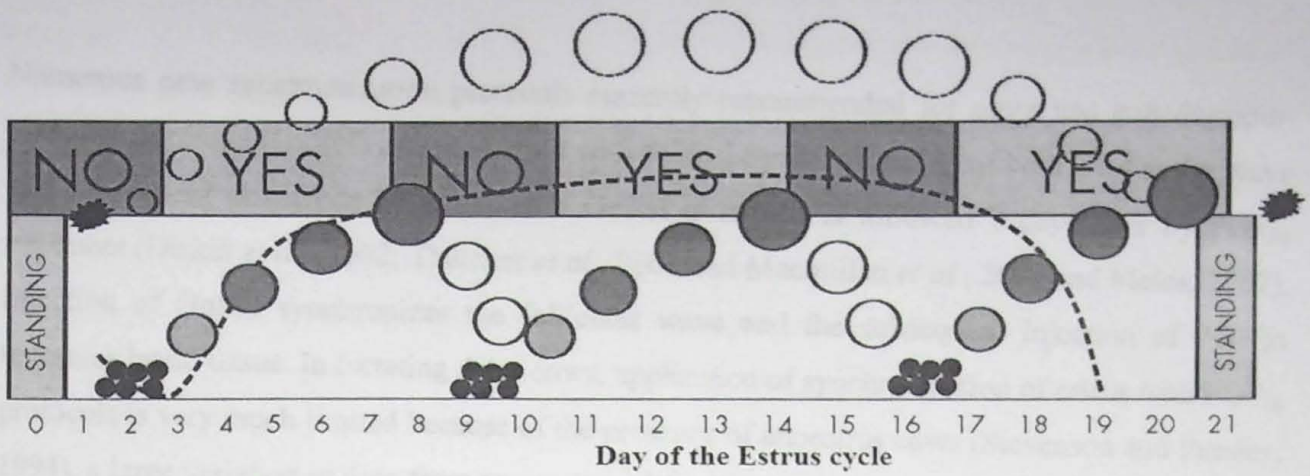


Figure-4. Diagram of ovarian response to GnRH injection. Three follicular waves (indicated by the groups of small, medium, and large circles) occurring during the estrous cycle along with the growth and regression of the CL (dotted circles) and the changes in concentration of progesterone (dotted line). When a dominant follicle is present, an injection of GnRH is capable of inducing ovulation and initiating a new follicular wave (indicated with a YES). When a follicular wave is developing and a dominant follicle is not present, an injection of GnRH will have no effect (NO). (Salverson and George, 2005).

Vasconcelos *et al.* (1999) recorded low ovulation rate (23%) when cows are treated with GnRH during the early part of estrous cycle. Low ovulation rate following GnRH injection given at the early stage of estrous cycle have been related to the fact that protein (Bodensteiner *et al.*, 1996) or mRNA (Bao *et al.*, 1997) for LH receptor are not expressed in the granulose cells of growing follicles during first 2 days of the follicular wave. After the follicular deviation (Day 4 to 5 of estrous cycle) and prior to loss of follicular dominance, the dominant follicle has been found to express LH receptor (Bao *et al.*, 1997) and all the follicles have ovulatory capacity leading to higher ovulation rate (96%), when GnRH administered during 5 to 9 days of estrous cycle (Vasconcelos *et al.*, 1999). They also observed low ovulation rate (54%) when GnRH is injected near mid-cycle and during this period, the ovulation rate following GnRH injection depends on the presence or loss of functional dominance in the largest follicle of the first follicular wave. During near mid cycle, there is loss the functional dominance in the most of the largest follicles of the first follicular wave, increased serum FSH concentrations, and emergence of a new follicular wave (Ginther *et al.*, 1996).

2.8. GnRH – $PGF_{2\alpha}$ protocol in dairy cattle

Numerous new synchronization protocols currently recommended for cows use gonadotropin-releasing hormone (GnRH) in conjunction with $PGF_{2\alpha}$. Synchronization of both a follicular wave and subsequent estrus can be achieved if GnRH treatment is followed 7 days later by $PGF_{2\alpha}$ treatment (Diskin *et al.*, 2002; Thatcher *et al.*, 2002 and Macmillan *et al.*, 2003 and Meles, 2007). Injection of GnRH synchronizes the follicular wave and the subsequent injection of $PGF_{2\alpha}$ regresses luteal tissue. In lactating dairy cows, application of synchronization of estrus with $PGF_{2\alpha}$ protocols is very much limited because of the presence of anoestrus cows (Stevenson and Pursley, 1994), a large variation in time from regression of the CL to expression of estrus. This variation in time to estrus is due to differences in the developmental stage of the preovulatory follicle at the time of $PGF_{2\alpha}$ injection and is related to the rate of progesterone decrease to basal level. To improve the estrus synchrony exogenous GnRH, which controls the developmental stage of the preovulatory follicle has been included with prostaglandin for synchronization of estrus in dairy cows (Stevenson and Pursley, 1994). The random administration of GnRH during the estrous cycle results in LH release (Chenault *et al.*, 1990), causes ovulation or luteinization of large follicles present in the ovary, synchronizes the recruitment of a new follicular wave. Subsequent administration of $PGF_{2\alpha}$ induces the regression of an original or GnRH-induced CL, and allows final maturation of the synchronized dominant follicle (Martinez *et al.*, 2000).

Amaya *et al.* (2007) conclude that 7-day GnRH-$PGF_{2\alpha}$ synchronization protocol can effectively induce dairy cows to ovulate as early as 21 days postpartum, regardless of ovarian status. Sakase *et al.* (2007) have successfully synchronized the oestrous cycle just before luteolysis in beef cattle. The beef cattle were treated with one protocol i.e GnRH day 0 + $PGF_{2\alpha}$ on day 7. This protocol synchronizes both follicular wave development and regression of the corpus luteum. A timed artificial insemination protocol (Ovsynch) based on the use of GnRH and prostaglandin to synchronize ovulation was developed for use in dairy cows (Pursley *et al.*, 1995). This program, extensively used at farm level and gave a satisfactory results for improving reproductvity. This procedure includes a GnRH treatment given at a random stage in the estrous cycle followed 7 days later by an injection of $PGF_{2\alpha}$, 30-36 hours later, a second dose of GnRH is administered and cows are inseminated 16 to 20 hours late.

Advantages of the GnRH- $PGF_{2\alpha}$ system include simplicity of administration and short duration of treatment. The major disadvantage of the GnRH- $PGF_{2\alpha}$ protocol is the percentage of cows that exhibit estrus after GnRH and before $PGF_{2\alpha}$, which in some cases may be as high as 15% of the total number of cows treated (Kojima *et al.*, 2000). Amaya-Montoya *et al.* (2007) have effectively induced ovulation dairy cows by the treatment with gonadotropin releasing hormone (GnRH) followed by prostaglandin F2α ($PGF_{2\alpha}$) during the early postpartum period and described their ovarian and hormonal responses according to ovarian status. Ahuja *et al.* (2005) have conducted their research on anestrous and lactating Bos taurus by Bos indicus crossbred cows with minimum body condition to determine the efficacy of GnRH + $PGF_{2\alpha}$ combinations for induction of estrus and ovulation and they have observed satisfactory results.

Table-6. Some research works so far done on estrus synchronization in cattle in Ethiopia.

Reference	Breed	Parity (Cow or Heifer)	Protocol	Estrus Response	Synchronized Conception Rate	Synchronized Pregnancy rate
Akafete and Bekana, 2008	Zebu (Boran)	heifers	$PGF_{2\alpha}$	78.57%	73%	57.1%
Ephrem, S. 2007	Jersey		$PGF_{2\alpha}$	75%	-	66.7%
	Jersey X Zebu crossbred		$PGF_{2\alpha}$	71%	-	60%
Meles, H. 2007	Zebu		GnRH + $PGF_{2\alpha}$	80%	75.0	60%
	Zebu		$PGF_{2\alpha}$	60%	66.6	40%
	Friesian X Zebu crossbred		GnRH + $PGF_{2\alpha}$	80%	75.0	60%
	Friesian X Zebu crossbred		$PGF_{2\alpha}$	80%	75.0	60%
Bekana *et al.*, 2005	Zebu (Fogera)	heifers	$PGF_{2\alpha}$	80%	83%	-
Heinonen *et al.*, 1996	Ethiopian highland zebu cattle	cows	$PGF_{2\alpha}$	61.5%	66.6%	-
Sisay *et al.*, 1998	Zebu (Boran)	heifer	$PGF_{2\alpha}$	65.2	67.4%	-
		cows	$PGF_{2\alpha}$	29.4	35.3%	-
Tegegne *et al.*, 1989	Zebu (Boran)	cows	$PGF_{2\alpha}$	62.5%	-	50%
		heifers	$PGF_{2\alpha}$	85.7%	-	60.7%
Mukasa-Mugerwa and Tafesse, 1988	Zebu (Arsi)		$PGF_{2\alpha}$		-	44%

2.9. Definitions and descriptions of terms/phrases used in this paper

Calf crop: the group of calves born to a herd of cows during one breeding season.

Calf crop percentage: the percentage of calves born to the cows bred or exposed to breeding bulls.

Estrous response: The number of females that exhibit estrus during a synchronized period.

Synchronized period: The period of time during which estrus is expressed after treatment

Synchronized pregnancy rate: The proportion of females that become pregnant of those exhibiting estrus and inseminated or mated during the synchronized period.

Duration of estrus: the time from onset of physical and behavioral signs of estrus to the end of estrus (Roberts, 1986; Patterson *et al.*, 2003; Bekana *et al.*, 2005 and Patterson *et al.*, 2010)

2.10. Especial need of estrus synchronization of cattle in Ethiopia

In Ethiopia, there is seasonal feed and forage availability. In most parts of the country, feed of animals is scarce/low from the month of January to June, whereas, surplus feed availability is seen during the month of July to December. Therefore, estrus synchronization will give an opportunity to schedule the calving or production time with the feed availability. Secondly, good detection of estrus is critically important in dairy husbandry. Incorrect detection of estrus is related to loss of profit due to extended calving intervals, milk loss, veterinary costs, etc. Detection of estrus remains a major problem despites enormous progress in the knowledge of reproductive physiology of the cow and in development of estrus detection aids. To achieve good estrus detection, many factors have to be taken into account. On one hand, a cow has to express estrus and on the other hand, the farmer has to detect it. However, in Ethiopia there is lack of awareness of farmers and even low or medium level professionals on estrus detection, therefore, estrus synchronization can reduce the estrus detection problems.

Thirdly, the shortage of balanced feed and environmental influences (very high temperature) in the country may reduce the reproductive performance of the cattle by disturbing the hormonal profiles and metabolic disorders that leads to late first calving, prolong calving interval and delay

puberty. Therefore, administration of exogenous hormone can improve the reproductive performance.

Fourthly, the efficiency, effectiveness and accessibility of AI service in the country, particularly in the rural area where AI service cannot reach on day to day basis, is under pressure with a number of constraints (Desalegn, 2008). Therefore, estrus synchronization technology helps to enhance the usefulness of AI by inseminating many cows at the same season and at right time.

Fifthly, the relatively low productive cattle (*Arado* breed) are increasing in number but the higher productive cattle (*Begait* breed) are decreasing in number (Zerabruk *et al.*, 2007). Hence, estrus synchronization is more advantageous to produce the desirable breeds in large number with in short period of time to be distributed to the rural farmers.

Finally, in Ethiopia, especially in those areas where by more Orthodox Christian religion believers are concentrated; the people do not consume milk, meat and their products in some specific weeks and even months. Especially, the fasting days of locally called '*Hodadi or Abbiy Tsom'* stays for around two months (Aymro and Joachim, 1970). This makes the milk demand to be seasonal, that at one time people need more milk but not in the other time. Therefore, through estrus synchronization technology, it is possible to schedule the milk yield availability with the consumption demand in those areas where Orthodox Christian believers are more concentrated such as the Northern Ethiopia.

This review or scenario clearly shows the possibility of enhancing the reproductive performance of Ethiopian dairy cattle such as *Begait* breed by different estrus synchronization protocols.

Therefore, in the present study, a) the reproductive and lactation performance of the Begait cattle in-situ and ex-situ condition as well as in different production systems were studied. And b) the estrus characteristics and reproductive performance of these cattle after application of estrus synchronization protocols with $PGF_{2\alpha}$ alone and GnRH $\pm$ $PGF_{2\alpha}$ and was evaluated and compared.

3. MATERIALS AND METHODS

3.1. Description of study area

The study was conducted in Kafta-Humera, the Western Zone (the place considered as the in-situ site for Begait cattle) and Wukro and its environs, the Eastern Zone (the place considered as the ex-situ site) of Tigray region, Northern Ethiopia.

Kafta-Humera

Kafta-Humera woreda is located in Western Zone of Tigray region, North-west Ethiopia (Figure-5). Kafta-Humera is bordered on the south by Tsegede, on the west by Sudan, then by the Tekeze River which separates Kafta-Humera from Eritrea on the North and Tahtay-Adiyabo on the East, and on the Southeast by Wolqayt. Its administrative center is Humera town. Geographically, it's Northern and Southern boundaries are located at 13^0 42' and 14^0 28'N Latitude; while its Eastern and Western boundaries coincide with 36^0 23'E and $37^0$31'E Longitude, respectively (BOANRDT, 2003). The woreda is located at about 650kms far from Mekelle, the capital city of Tigray, which is 783kms far from Addis Ababa. Throughout the zone, being more pastoralists and ago-pastoralists, human survival is strongly linked to livestock production. It is a transit point for cross-border to Ethiopia, Eritrea and Sudan and high traffic for exporting live-animal to Sudan and Egypt.

The area has a Kola and Weina-Dega agro-climate conditions with its elevation ranging from 560 to 1849 meter above sea level. The mean maximum temperature varies from 42.4^{O}C in March to 33.5^{O}C in August, while the mean minimum temperature varies from 25.1^{O}C in May to 18.5^{O}C in January (NMA, 2009). There is a phenomenon whereby mean annual rainfall increases from North to South (ranging from 448.8 mm at the Northern part to 1102.5 mm at the Southern part per annum). It has unimodal rainfall pattern 80 to 85% of the rain falling in the summer (wet season). The rainy season is from June to September (NMA, 2009). The relative humidity is highest during the rainy months and lowest at the end of the dry season in April. Main cattle breeds raised in Kafta-Humera Wereda are the local *Arado* and *Begait* cattle. The later is believed to be the dominant breed.

Wukro and its environs

The study was also carried out in Wukro district (in and around Wukro), located in Eastern zone of Tigray region. The district is situated in the Northern Ethiopian highlands, an area with a long agricultural history and the prevailing agricultural system is one of integrated annual crop and livestock production in which oxen provide the draught power for ploughing smallholders' fields. The district's main town of Wukro town is located at about 45 km north of Mekelle, the regional capital city. The altitude of this Woreda ranges from 1850 to 2560 meter above sea level. The average mean rainfall is 400 mm and the mean annual temperature is 20^{O}C (BoANRDT, 2003).

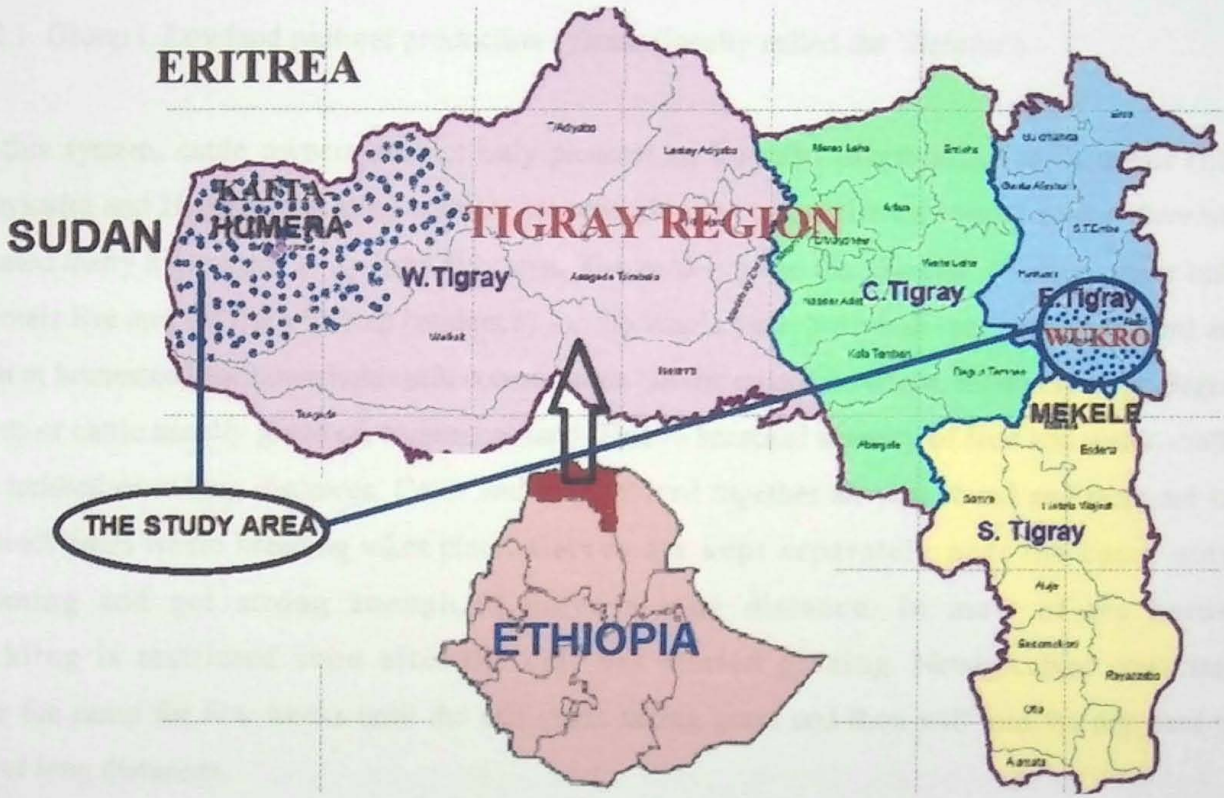


Figure-5: The study areas in Tigray region. (Source: BoANRDT, 2003)

3.2. Study animals and their production system

Currently, the study animals (the *Begait* cattle) are found in four major systems of cattle production in Tigray region, Ethiopia. These are: pastoral and agro-pastoral production systems (in-situ); rural highland small-holder (crop-livestock production, mostly distributed by the regional government to up-grade the genetic potential of the low producing *Arado* breed cattle) and urban and peri-urban small scale dairy production system (confinement system) (ex-situ). It is known that, it is vital to determine whether the different management systems lead to differences in productive and reproductive efficiencies of the cows. Therefore, for the present study, the *Begait* cattle were selected from the four types of production systems and designated as group I - IV.

3.2.1. Group I. Lowland pastoral production system (locally called the '*Bereha*')

In this system, cattle owners are not only pastoralists but also investors living in towns (like Maykadra and Humera) but their animals are tended in the pastoral area, locally called '*Bereha*', located many kilometers away from the town. The herd stays in the '*Bereha*' (a place where only animals live and far from human residence) for the whole year, but small number of wet herd are kept at homestead for household milk consumption. In the pastoral system, relatively large *Begait* herds of cattle usually graze on communal land. Due to seasonal scarcity of feed and water, cattle are trekked over long distances. Cows and bulls moved together all year round and there are no distinct times where breeding takes place. Calves are kept separately near the camp until weaning and get strong enough to move a long distance. In most of the herds, suckling is restricted soon after the calf has started grazing. Newly calved cows stay near the camp for few weeks until the calf starts taking grass and then will join the dry herd to travel long distances.

3.2.2. Group II. Lowland Agro-pastoral production system

Agro-pastoralists owned sizable pieces of land in and around Maykadra town, Kafta-Humera Woreda, and practice integrated cop-livestock production. Animals in this group have permanent

residence with their owners. They spend the night in kraals and travel to field for grazing. Only the newly calved and the late pregnant cows are kept around the homesteads. In this system, man-made water availability and crop residues are utilized when feed is scarce but nutritional inadequacies remained unsolved because these animals depend on limited grazing area near the towns, where there is lack of grazing area due to over-cultivation of crops. Calves remain at home during the day and stay at night together with their dams because suckling is not restricted until the cow becomes pregnant. AI service is completely absent. Milking practice was usually once (for household consumption only, because of traditional taboo of not selling the milk) but sometimes twice (for household consumption and sale).

3.2.3. Group III. Rural highland small-holder dairy production (crop-livestock production)

Around Wukro: the traditional, the most common animal husbandry in most parts of Tigray, in which all the feed requirement is derived from native or home-near pastures, grasses (sub grazing) and crop residues and are utilized in this mode of production system. In the highland areas agricultural production system was predominantly smallholder mixed crop-livestock farming practiced within the same management unit. Calves stay the whole day together with the cows because of lack of separate grazing area. Usually calves are separated during the night. Suckling is not restricted during the day until the cow refuses to suckle. Mating by bull is the most common practice. Milk is usually used for household consumption and milking practice is usually once and sometimes twice.

3.2.4. Group IV. Urban and peri-urban small scale dairy farming at Wukro town

Cows in the farm are managed under confinement. The main feed resources are agro-industrial by-products and purchased roughage including hay and crop residues. The system comprises small and medium sized dairy farms that own Holstein-Friesian crossbreed dairy cows. The primary objective of this system is milk production for generating cash income. The breeding practice is done by using both natural mating and by artificial insemination and completely dependent on heat detection by the animal attendants or owners. Milking is practiced twice a day. Calves are kept separately until weaning. During

early period calves are mainly fed with milk and gradually, are introduced to bucket concentrate feed mixed with milk. The first 10-30 days calves are provided with three liters of milk per day. When the calves reach 1 to 2 months of age, they are provided with only two liters of milk. At 2 to 3 months of age calves are made to feed on concentrate to which only one liter of milk is added.

From the above four cattle management systems and sites the following cattle were selected;

- For evaluation of herd fertility, composition and calf-crop percentage; 12 herds (6 each from Group I and Group II) composing 2144 heads of cattle were selected purposively based on convenience or accessibility, knowledge of the owner and/or herder about productive and reproductive performance of the individual animal and the herd.
- To study the reproductive performance of *Begait* cattle, using the formula recommended by Arsham (2007); $N=0.25/SE^2$ where SE= Standard Error, with the assumption of 3.5% standard error, a total number of 210 cattle (90 each from group I and group II; and 15 each from group III and group IV) were obtained with simple random sampling procedure. Effort was made to proportionate the number of cattle between group I and II and between group III and IV.
- For lactation performance, a total of 61 *Begait* cattle were selected from Groups I (24), II (17), III (11) and IV (9). The selection was based on the lactation status, convenience of the herd and milking practice of the owner.
- A total of 120 *Begait* cattle were selected for estrus synchronization purposively based on the behavior of the individual cow (docile cattle were preferred), the willingness of the owner, the time of previous calving and the productive and reproductive status of the cow, though 33 of them were discarded from the study later on due to lost and abortion post-treatment.

3.3. Study protocol and experimental design

3.3.1. Assessment of reproductive and lactation performance of Begait cattle in-situ and ex-situ

Evaluation of the reproductive performance is a good starting point in any program aiming to improve productivity in cattle farming. Therefore, the aim of this phase of the study was to evaluate reproductive and lactation performance of *Begai*t cattle in-situ and ex-situ as well as in different types of production system in Northern Ethiopia.

The retrospective and follow-up studies were conducted by multi-stage sampling method; using cluster (for in-situ and ex-situ grouping), purposive (for selecting the different production system and herds) and simple random (for individual animals within herds) sampling methods.

Suitable and convenient tables and formats (Annex-2) were prepared to collect observational study and retrospective data on the performance of *Begait* cattle. Before starting the research work, the questionnaire format and the previously prepared data collecting tables and formats were pre-tested and modified by the professionals and some farmers of the study area to include some main cattle productive and reproductive problems of the area related to the research work to make a problem solving research to the study area.

A total of 12 herds (containing 2144 cattle) were selected from pastoral and agro-pastoral areas. Herd composition, annual calf-crop production, calf-crop percentage and annual calf mortality were recorded to evaluate the reproductive performance of the herds. A total of 210 *Begait* cows (from different management systems and sites) were randomly selected to study individual and herd reproductive efficiency. Retrospective and prospective data were used to calculate some of the reproductive parameters; such as age at first service (AFS), age at first calving (AFC), previous calving (PC), Recent calving (RC) and calving interval (CI). Individual cow traits such as age, parity, and body condition score (BCS) were recorded. The body condition scoring was done according to Richard (1993). The detailed description of criteria considered in body condition scoring is presented in Annex-3.

A total of 61 cows were selected and subjected for prospective data collection on lactation performance. Milk production traits considered and recorded were daily milk yield at different lactation period (early [1st month], middle [3rd month] and late [5th month] of lactation), lactation length and total milk yield per lactation (Annex-2.2). The daily milk yield was taken from the average of three consecutive milking days. Effort was made to minimize the factors that can affect the daily milk yield such as heat period, feed change and any health abnormalities.

With pre-structured questionnaire format (Annex-1); multiple visits were made to interview animal owners, herders, and veterinarians and extension workers to generate data on the general herd and particular individual cows' productive and reproductive performance. The study was supported by follow-up observations and group discussions during the study period.

In the group discussion, three group discussions, 12 members each (animal owners, herders and professionals [veterinarians and extension workers]) were included. Animal owners in the selected places were invited to a central point by the local extension workers in each area.

3.2.2. Evaluation of the estrus characteristics and reproductive performance of Begait cattle after application of different estrus synchronization protocols

A total of 120 non pregnant *Begait* cattle, 60 heifers and 60 cows with 3 months and more postpartum anestrous interval and clinically or apparently healthy were purposively selected for the study in the agro-pastoral area. Animals with (BCS) body condition score of 2, 3, and 4 (scoring scale of 0-5) were selected (Annex-3). During convenient cases and times, per-rectal pregnancy diagnosis (Roberts, 1986) was conducted before starting the experiment to minimize the risk of abortion by the exogenous hormones. The animals were diagnosed for reproductive abnormalities and were randomly assigned to two treatment groups. However, a total of 33 cattle (due to: 31 disappeared after treatment and 2 abortion cases) were eliminated from the study. The remaining 87 cows and heifers finished the study as follows.

Group I ($PGF_{2\alpha}$ group)

A total of 38 *Begait* cattle (19 heifers and 19 cows) were registered for this group. Animals were given one intramuscular injection of 500 µg or 2 ml of Estrumate® (the prostaglandin analogue). Prostaglandin F2α was injected on Day 0 and checked for estrus and only cows that came in estrus during the first injection were mated following estrus detection (Figure-6). Second prostaglandin injection was given on day 14 to all females those not previously bred by the first injection. Thereafter, animals were closely and continuously observed for onset, characteristics and duration of estrus for five days following the injection of $PGF_{2\alpha}$ (Patterson *et al.*, 2010).

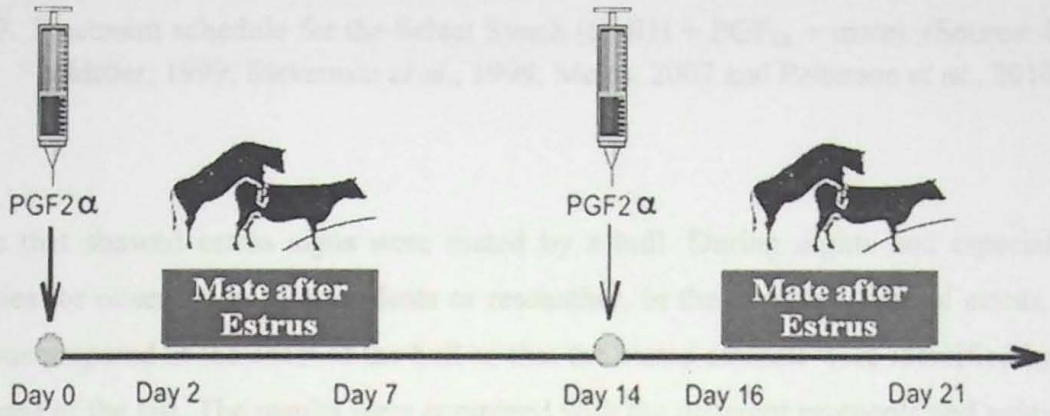


Figure-6. Treatment schedule for synchronizing estrus using $PGF_{2\alpha}$ alone.
(*Source:* Córdova-Izquierdo *et al.*, 2009 and Patterson *et al.*, 2010)

Group II (Select Synch: GnRH- $PGF_{2\alpha}$-Estrus and mating)

The Gonadotropin-releasing hormone GnRH used for synchronization of estrus was Receptal ® Vet. Intervet. India Pvt. Ltd. A total of 49 *Begait* cattle (21 heifers and 28 cows) were included in this protocol. Injection of 10 µg or 2.5 ml of Receptal of the GnRH analogue Buserelin acetate, according to the manufacturer's instructions, was given intramuscularly on day 0, followed by prostaglandin on day 7. All animals were continuously observed visually for signs of estrus day and night for 5 days following injection of $PGF_{2\alpha}$ as described by previous authors (Whittier *et al.*, 2002; Meles, 2007 and Patterson *et al.*, 2010).

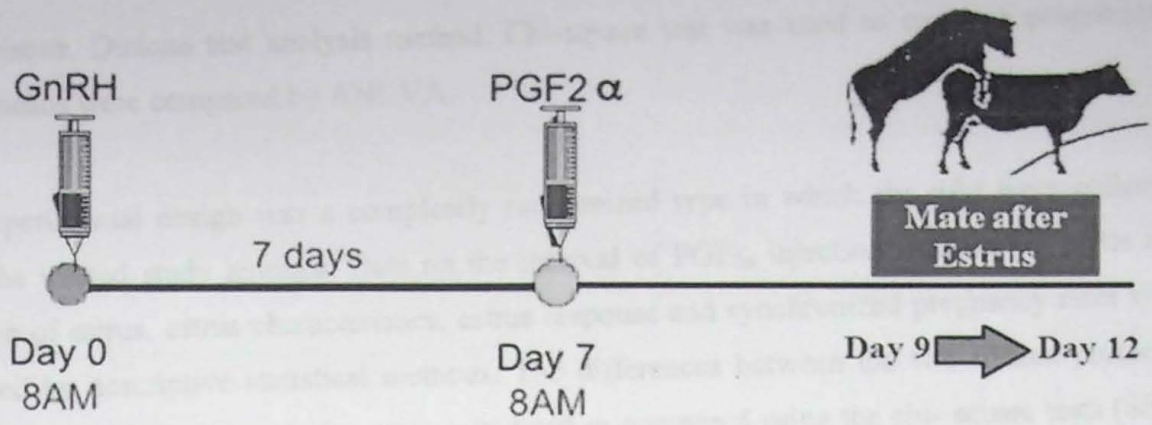


Figure-7. Treatment schedule for the Select Synch (GnRH + $PGF_{2\alpha}$ + mate). (Source: Geary and whittier, 1999; Stevenson *et al.*, 1999; Meles, 2007 and Patterson *et al.*, 2010).

Animals that showed estrus signs were mated by a bull. During nights and especially during difficulties for observation by attendants or researcher, in the expected time of estrus, '*Raddled paint*' was prepared in the chest of the bull so that the mated animals were identified by the paint on the base of the tail. The results were compared with the different protocols and animal groups. The efficacy of therapeutic protocols was expressed and recorded in terms of number of animals exhibited estrus (Estrus response), non-return rate, synchronized pregnancy rates, characteristics, onset and duration of estrus; and were compared with each group. The effect of some factors such as BCS, age and parity to the treatment was considered and evaluated. The mated cows were observed on day 18-24 for return to estrus and followed by per-rectal palpation to know the pregnancy status 3 months later according to Roberts (1986).

3.4. Statistical analysis

The computer software excel was used for data managing and most of the data were analyzed with the SPSS 15.0; 2005. The effects of the site and production systems on reproductive and lactation performance parameters (like calving interval, age at first service and age at first calving, daily milk yield and lactation length) were analyzed using post Hoc multiple

comparisons, Duncan test analysis method. Chi-square test was used to compare proportions, while means were compared by ANOVA.

The experimental design was a completely randomized type in which the data were collected from the treated study animals. Data on the interval of $PGF_{2\alpha}$ injection to onset of estrus and duration of estrus, estrus characteristics, estrus response and synchronized pregnancy rates were analyzed by descriptive statistical methods. The differences between the two treated protocols and among the different variables were calculated or compared using the chi- square tests (SPSS 15.0; 2005). The level of significance was observed at the 5% level.

4. RESULTS

4.1. Assessment of reproductive and lactation performance of *Begait* cattle in in-situ and ex-situ sites and in different production systems

The reproductive and lactation performance of the *Begait* cattle were recorded in their natural habitats without pharmacological intervention.

4.1.1. Reproductive performance of *Begait* cattle prior to estrus synchronization

Reproductive performance of *Begait* cattle prior to estrus synchronization was recorded in terms of herd composition, calf-crop production, annual calf mortality, calving interval, Age at first service and age at first calving under different sites and production systems in the present study.

I. Cattle herd composition, annual calf-crop production and annual calf mortality

Of a total number of cattle (n=2144) included in this study, 49.7% (n=1067) were cows, 4.7% were bulls (older than 3 years) and the rest were young heifers and males. The retrospective data collected from the study herds for the previous year (September, 2009 - August, 2010) showed that the calf-crop percentage of pastoral area was higher than the agro-pastoral, ranging from 50.1 to 55.6% and 39.3 to 44.4%, with an average of 53% and 42.4%, respectively (Table-7). In the same year, the percent of annual calf mortality was higher (20.8%) in pastoral production system compared to agro-pastoral production system (9.4 %).

Table-7. Herd composition, calf crop production and calf mortality of some selected herds in pastoral and agro-pastoral areas of Kafta-Humera woreda from September, 2009 - August, 2010

Herds	Total No. of cattle	Herd composition							Calf crop production from (September ,2009-August, 2010)			Calf crop %	Annual Calf morta-lity (%)
		Total No. Cows	*Heifer*			*Males*							
			total	*<3 yr*	*≥3 yr*	*total*	*<3 yr*	*≥3 yr*	*Total*	*alive*	*Dead*		
Agro-pastoral													
A	36	*16*	*11*	7	4	*9*	6	3	*7*	6	1	43.7	14.2
B	45	*25*	*12*	9	3	*8*	5	4	*11*	11	0	44.0	00.0
C	59	*28*	*20*	15	5	*11*	8	3	*11*	10	1	39.3	09.1
D	62	*27*	*22*	16	6	*13*	8	5	*10*	10	0	44.4	00.0
E	87	*41*	*29*	22	7	*17*	12	5	*17*	14	3	41.5	17.6
F	97	*46*	*31*	25	6	*20*	16	4	*19*	16	3	41.3	15.8
Sub-Total												**42.4**	**09.4**
Pastoral													
G	143	*69*	*48*	36	12	*26*	18	8	*35*	29	6	50.1	17.0
H	175	*91*	*58*	47	11	*26*	20	6	*50*	39	11	54.9	22.0
I	223	*116*	*74*	54	20	*33*	25	8	*59*	45	14	50.9	23.7
J	295	*153*	*93*	69	24	*49*	38	11	*83*	64	19	54.2	22.3
K	409	*194*	*147*	119	28	*68*	45	23	*101*	78	23	52.1	22.2
L	513	*261*	*173*	131	42	*79*	58	21	*145*	111	34	55.6	23.4
Sub-Total												**53.0**	**20.9**
Total	***2144***	***1067***	***718***	***550***	***168***	***359***	***259***	***101***	***548***	***433***	***115***	***51.4***	***20.8***

According to the interviewees taken from the 12 herds included in the study, a total of 115 calves died in a year which accounted 20.9 % with higher mortality rates an overall of (62.3%) during the months of April, May and June with the value of 19, 25 and 18.3%, respectively (Figure-8), while, the highest monthly temperature and the lowest rainfall were recorded in these months. On the other hand, the lowest proportion of calf death, the lowest temperature and the highest rainfall recorded were in the month of July, August, September and October (Figure-8).

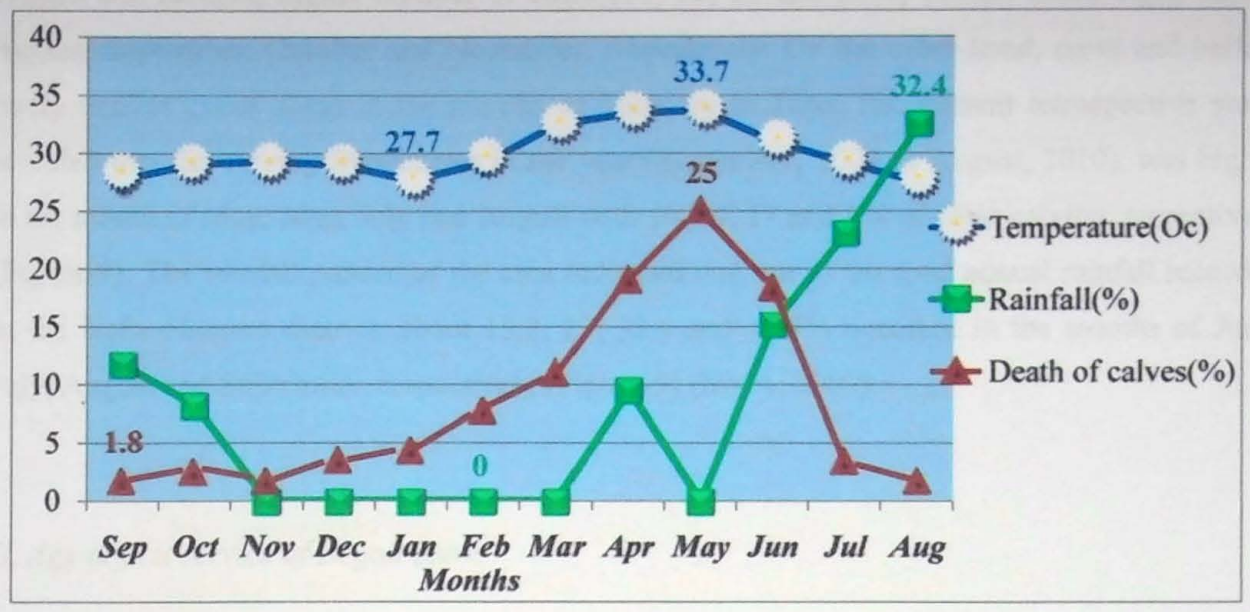


Figure-8. Season-wise distribution of calf mortality in relation to the rain fall and temperature in some selected herds in the study area from September 2009 to August 2010: (the temperature and rain fall of the study area was taken from the average of minimum and maximum values in every month recorded from 2008 and 2009; NMA, 2009).

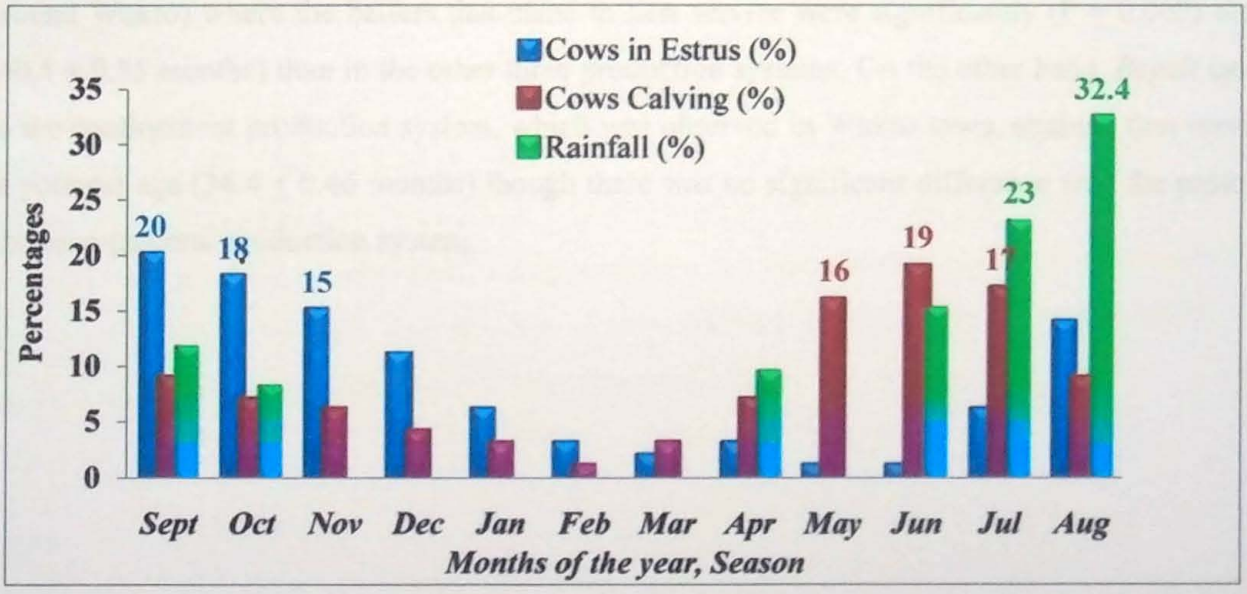


Figure-9. Season-wise pattern of occurrence of estrus and calving frequencies from September 2009 to August 2010 in relation to rainfall in *Begait* cattle in the study area: (the rainfall of the study area was taken the average of minimum and maximum values in every month recorded from 2008 and 2009; NMA, 2009).

According to the results calculated from the interview data and group discussion made with the owners and herders, higher number of cows (14, 20, 18 and 15%) exhibit estrus signs during August, September, October and November, respectively. On the other hand, cows and heifers rarely exhibit estrus signs in the months of February to June. The present retrospective study revealed that the calving frequencies in the year (September, 2009 to August, 2010), was higher in the month of May, June, July and August with 16, 19, 17 and 9% of cows calving, respectively (Figure-9). The rainfall pattern of the area indicated that out of the total annual rainfall recorded in the Kafta-Humera district, about 15.2, 23, 32.4 and 11.7% occurred in the months of June, July, August and September, respectively (Figure-9) (NMA, 2009).

II. Age at first service of Begait cattle

The average age at first service for *Begait* cattle was significantly ($P < 0.05$) shorter in in-situ sites (35.0 ± 0.21 months) than the ex-situ sites (37.7 ± 0.7 months), ranging from 30 to 41 and 32 to 47 months, respectively. The present study also showed that the age at first service was almost similar in all types of production systems except in the crop-livestock system (taken from around Wukro) where the heifers that came to first service were significantly ($P = 0.002$) older (40.5 ± 0.85 months) than in the other three production systems. On the other hand, *Begait* cattle in the confinement production system, which was observed in Wukro town, attained first service at younger age (34.4 ± 0.46 months) though there was no significant difference with the pastoral and agro-pastoral production system.

Table-8. Mean age at first service of *Begait* cattle in different sites and production systems.

Factors	Groups	No. of animals	Mean ±SE (Months)
	Overall	210	35.6 + 0.21
Sites	In-situ	180	35.0 ± 0.21
	Ex-situ	30	37.7 ± 0.70
	P-value		0.01
Production system	Agro-pastoral area	90	35.9 ± 0.30[a]
	Pastoral area ('*Bereha*')	90	34.9 ± 0.27[a]
	Wukro (confinement)	15	34.4 ± 0.46[a]
	Around Wukro (crop-livestock)	15	40.5 ± 0.85[b]
	P-value		0.002

[abc...] Values with the same letter superscript are not significant difference: SE=Standard Error

III. Age at first calving of Begait cattle

The mean age at first calving in *Begait* cattle in in-situ (44.5 ± 0.21 months) was slightly younger than in ex-situ site (46.8 ± 0.68 months). Moreover, age at first calving differed significantly differed ($P < 0.05$) among the production systems, where higher age at first calving (49.5 ± 0.85 months) was recorded in crop-livestock system than the other 3 production systems (Table-9). The present study showed that the age at first calving in the pastoral, agro-pastoral and confinement production system had no significant difference.

Table-9. Mean age at first calving of *Begait* cattle in different sites and production systems

Factors	*Groups*	*No. of animals*	*Mean ±SE (Months)*
	Overall	*210*	44.8± 0.21
Sites	In-situ	180	44.5±0.21
	Ex-situ	30	46.8± 0.68
	P-value		0.03
Production system	Agro-pastoral area	90	45.0 ± 0.31^{b}
	Pastoral area (Bereha)	90	43.9 ± 0.27^{b}
	Wukro (confinement)	15	44.9 ± 0.43^{b}
	Around Wukro (crop-livestock)	15	49.5 ± 0.85^{a}
	P-value		0.001

[abc...] Values connected by the same letter have not significant difference: SE=Standard Error

IV. Calving interval of Begait cattle

The effect of age, parity, site, production system and status of calf on the calving interval are presented in Table-10. The results showed that the age and parity had no significant effect on calving interval, whereas the calving interval of *Begait* cattle was significantly ($P < 0.05$) affected by production system, site and early calf mortality. Calving interval was significantly ($P < 0.05$) shorter in pastoral production system (12.9 ± 0.13 months) followed by agro-pastoral (14.1 ± 0.13 months) while, it was found to be significantly ($P < 0.05$) longer in crop-livestock production system (19.6 ± 0.75 months). The present study revealed that *Begait* cows in the urban and peri-urban confinement production system had longer calving interval (15 ± 0.31 months) than those in the pastoral and agro-pastoral, but shorter than in the crop-livestock production system.

The mean values for CI was significantly ($P < 0.05$) lower in the in-situ site (13.49± 0.10) months than the ex-situ (17.30± 0.59) months. The study also reported that the length of calving interval

was significantly (P= 0.007) reduced by the early calf mortality (12.31 ± 0.19 months) when compared to cows with their calves alive (14.25± 0.17 months).

Table-10. Results of one-way ANOVA to assess the effect of variables on calving interval of *Begait* cows

Variables	Groups	No. of animals	Mean ± SE Months
	Overall	*210*	*14.03 + 0.15*
Age	5years	91	14.61± 0.33
	6years	69	13.85± 0.12
	≥7years	50	14.48±0.34
	P-value		0.08
Parity	<3	106	14.31± 0.23
	≥3	104	13.35± 0.17
	P-value		0.06
Site	in-situ	180	13.49± 0.10
	ex-situ	30	17.30± 0.59
	P-value		0.001
Production system	Agro-pastoral area	90	14.0 ± 0.13^{a}
	Pastorla (Bereha)	90	12.9 ± 0.13^{b}
	Wukro (confinement)	15	15.0 ± 0.31^{a}
	Around Wukro (crop- livestock)	15	19.6 ± 0.75^{c}
	P-value		0.000
Status of calf	Early calf death	28	12.31± 0.19
	Alive calf	182	14.25± 0.17
	P-value		0.007

[abc...] Values connected by different letter showed significant difference: SE=Standard Error

4.1.2. Lactation performance of *Begait* cattle in-situ and ex-situ sites and in different production systems

Lactation performance was recorded in terms of daily milk yield (DMY), lactation length (LL) and total milk yield (TMY) under different sites and production systems. The means of daily milk yield at the early, middle and late lactation; the lactation length and total milk yield are shown in Table-11. The overall means of daily milk yield at early, middle and late lactation of *Begait* cows were higher in the confinement production system with 5.7, 8.1 and 3.9 lts, respectively, when compared with crop-livestock production system (around Wukro town) of which 2.1, 3.2 and 0.9 lts , respectively.

The mean daily milk yield recorded from the pastoral production was recorded to be lower (2.5 ± 0.18 lts) than the agro-pastoral production (4.8 ± 0.26 lts) with statistical significant difference ($P < 0.05$). The ranges of lactation length and total milk yield of Begait cattle were 148.4 to 209.7 days and 314.2 to 1281.0 lts, respectively, under different sites and production systems in the present study.

Table-11. Means of daily milk yield of *Begait* cattle in different production systems at early, middle and late lactation stages

Site	production system	No. of animals sampled	Daily milk yield (liters)			
			Stage of lactation			Average
			Early	Middle	Late	
In-situ	Agro-pastoral area (Maykadra)	24	4.5	6.7	3.1	4.8±0.26
	Pastoral area ('*Bereha*')	17	2.2	4	1.4	2.5±0.18
Ex-situ	Confinement (in Wukro town)	11	5.7	8.1	3.9	6.0± 0.35
	Crop-livestock (around Wukro)	9	2.1	3.2	0.9	2.1±0.17
Total Average		***61***	***3.7±0.21***	***5.7±0.17***	***2.5±0.25***	***4.1±0.23***

Table-12. Effect of production system on lactation performance of *Begait* cows

Production System	Nº. of Cattle	Daily Milk Yield (liter) (Mean + SE)	Lactation Length (days) (Mean + SE)	Total Milk Yield (liter) (Mean + SE)
Maykadra (Agro-pastoral)	24	4.8 ± 0.26^{a}	189.2 ± 4.45^{a}	924.1 ± 70.44^{a}
Bereha (Pastoral)	17	2.5 ± 0.18^{b}	150 ± 4.39^{b}	391.0 ± 37.64^{b}
Wukro (Confinement)	11	6.0 ± 0.35^{c}	209.7 ± 7.90^{c}	1280.9 ± 111.9^{c}
Around Wukro (crop-livestock)	9	2.1 ± 0.17^{b}	148.4 ± 5.48^{b}	314.2 ± 35.24^{b}
Overall	***61***	***4.1± 0.23***	***176 ± 4.05***	***749.9 ± 58.02***
P-value		***0.000***	***0.000***	***0.000***

[abc...] Values connected by the same letter in the same column have not significant difference: SE=Standard Error

Significantly higher ($P < 0.05$) daily milk yield (6.0 ± 0.35 lts) was recorded in confinement followed by agro-pastoral production (4.8 ± 0.26 lts) against longer lactation lengths of 209.7 ± 7.90 and 189.2 ± 4.45, respectively, while the daily milk yield was as low as 2.5 and 2.1 lts and their respective lactation lengths were also shorter (150 and 148.4 days) for pastoral and crop-livestock production systems, respectively.

In the present study, age and parity significantly affected lactation performance (Table-13). the results showed that the cows aged 6 to 7 and >7 years had higher daily milk yield, longer lactation length and higher total milk yield than the cows aged 4 to 5 years. Likewise, there was no significant difference in milk yield, lactation length and total milk yield in cows that had 2 to 3 and > 3 parities, but the cows with first parity gave significantly lower daily and total milk yield. The production sites (in-situ and ex-situ) had no significant influence on production performance of *Begait* cattle.

Table-13. Mean (SE) Daily Milk Yield (DMY), Lactation Length (LL) and Total Milk Yield (TMY) Vs. age, parity and site.

Factors	Groups	No. of animals	DMY Lts	LL Days	TMY Lts
	Overall	***61***	***4.1 ±0.23***	***176 ± 4.06***	***749.9 ± 58.02***
Age	4-5years	22	3.1 ± 0.39[a]	159.9 ± 6.55[a]	541.5 ± 96.20[a]
	6-7years	20	4.5 ±0.38[b]	183.5 ± 7.20[b]	866.4 ± 96.59[b]
	>7years	19	4.5 ±0.34[b]	186.6 ± 5.83[b]	868.5 ± 93.73[b]
	P-value		***0.011***	***0.009***	***0.023***
Parity	1	17	2.7±0.38[c]	154.3± 6.84[c]	452.8± 96.37[c]
	2	21	4.3± 0.41[d]	182.4± 7.65[d]	839.5± 105.02[d]
	3	11	5.2± 0.48[d]	186.0± 6.95[d]	995.7± 132.63[d]
	>3	12	4.2± 0.29[d]	186.1± 6.97[d]	788.6± 81.45[d]
	P-value		***0.008***	***0.009***	***0.001***
Site	In-situ	41	3.8± 0.2457	172.9± 4.38	703.1± 60.24
	Ex-situ	20	4.2± 0.4895	182.1± 8.53	845.9± 126.63
	P-value		***0.439***	***0.291***	***0.251***

[abc...] Values followed by the same letter in the same column do not differ significantly: SE=Standard Error

The mean daily milk yield and total milk yield for *Begait* cattle that were milked twice a day were 4.9 ± 0.32 and 982.5 lts; and once a day 3 ± 0.22 lts and 509.6 ± 48.79 lts, respectively. The effect of milking frequency on milk yield showed a high significance difference ($P < 0.05$), in that more milk was recorded in twice milking practice. The current study revealed that the effect of milking frequency had not shown any difference on the lactation length ($P > 0.05$) though some numerical differences were recognized. In the present study, *Begait* cattle have shown the capacity of producing a maximum of 13 lts of milk per day per cow during twice milking though the traditional taboo not to sell milk in the Western Tigray discourages milk production in the area.

Table-14. Effect of milking frequency on lactation performance of *Begait* cattle

Lactation parameters	Frequency of milking per day	No. of animals	Mean (SE)	P-value
Daily milk yield	Once	30	3.0±0.22	0.001
	Twice	31	4.9± 0.32	
	Total	***61***	***4.1 ± 0.23***	
Lactation length	Once	30	169.6± 4.21	0.07
	Twice	31	191.8 ± 5.58	
	Total	***61***	***175.9 ± 4.05***	
Total milk yield	Once	30	509.6 ± 48.79	0.001
	Twice	31	982.5± 85.76	
	Total	***61***	***749.9 ± 58.02***	

SE: Standard Error; P-value < 0.05: differed significantly

4.2. Evaluation of the estrus characteristics and reproductive performance of *Begait* cattle after estrus synchronization

The characteristics of synchronized estrus, conception and pregnancy rates with two different synchronization protocols ($PGF_{2\alpha}$ alone and GnRH + $PGF_{2\alpha}$) were evaluated and compared.

4.2.1. Characterizing estrus signs following estrus synchronization

Out of 87 cattle included in the experiment, 62 (71.3%) cattle responded to treatments, of which 30 (15 from experiment I and 15 from experiment II) of them were given special attention and very close observation day and night to evaluate the onset, characteristics and duration of estrus. Table-15 shows the number of cows and heifers showing physical behavioral changes following injection of $PGF_{2\alpha}$ in both treatment groups. The most frequent and consistently appreciated estrus behaviors and physical changes were standing to be mounted, vaginal discharge; bellowing, restlessness and swelling and redness of vulva (Table-15 and Annex-4.2). Besides, rising and twitching of tail, mounting and sniffing of the genitalia of other cows were also recognized during the characterizing of the estrus signs.

Table-15. Characteristics of estrus signs of PGF2α and GnRH + PGF2α treated Begait cattle

Estrus signs observed	Protocols		Total
	$PGF_{2\alpha}$ No. (%)	GnRH + $PGF_{2\alpha}$ No. (%)	No. (%)
Standing to be mounted by others	15/15 (100)	15/15 (100)	30/30 (100)
Clear vaginal discharge	13/15 (86.7)	14/15 (93.3)	27/30 (90.0)
Bellowing	10/15(66.7)	11/15(73.3)	21/30(70.0)
Restlessness	15/15 (100.0)	15/15 (100.0)	30/30 (100.0)
Swelling and redness of vulva	14/15 (93.3)	15/15 (100.0)	29/30 (96.7)
Rising and twitching of tail	12/15 (80.0)	12/15 (80.0)	24/30 (80.0)
Mounting and sniffing of the genitalia of other cows	8/15 (53.3)	7/15 (46.7)	15/30 (50.0)

Standing to be mounted and restlessness were found to be the most common estrus characteristics of all cattle observed in synchronized estrus in the study. Of the total 30 cattle observed in estrus behavior; 3 (10%), 9 (30%), 1(3%), and 6 (20%) animals didn't show the vaginal discharge, bellowing, swelling and redness of vulva, and rising and twitching of tail, respectively. Mounting and sniffing to other cows' genitalia; and frequent urination were among the estrus signs which were recorded less frequently in the present study with 50 and 46.7%, respectively. No treatment-related variation was recorded between groups on the characteristics of estrus manifestations.

Table-16. Effect of synchronization protocol on onset and duration of estrus in estrus synchronized *Begait* cattle

Protocols	No. of cattle Treated	Time interval from $PGF_{2\alpha}$ to onset of estrus (hours) Mean ± SE	Duration of estrus (hours) Mean ± SE
$PGF_{2\alpha}$	15	73.8 ± 5.26	5.69 ± 0.45
GnRH- $PGF_{2\alpha}$	15	67.0 ± 2.42	5.97 ± 0.44
P-Value		0.07	0.1
Total	**30**	**68.82 ± 3.16**	**5.89 ± 0.38**

The study showed that there was no statistical significant different in time taken for exhibition of estrus after $PGF_{2\alpha}$ injection and duration of estrus between the $PGF_{2\alpha}$ and GnRH + $PGF_{2\alpha}$ protocols used in the synchronization though some numerical differences were appreciated between them.

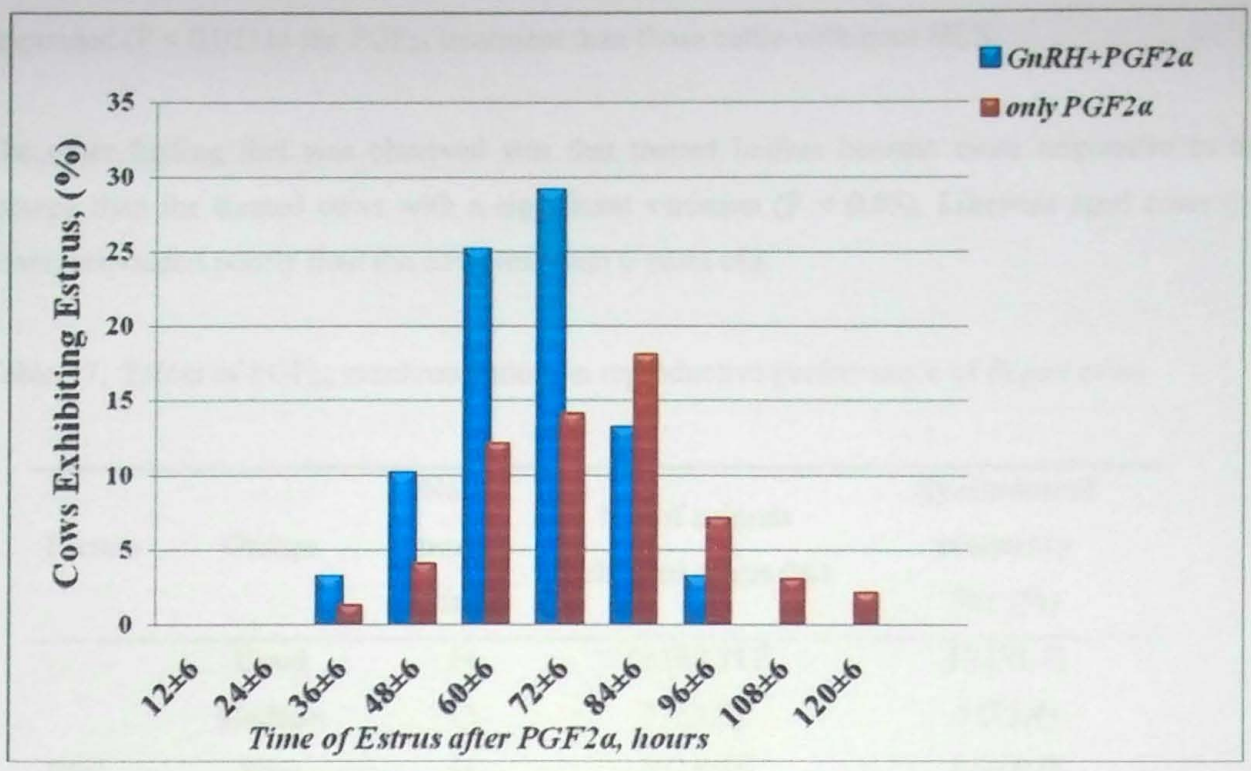


Figure-10. Percentage of estrus response in both treatment groups and time taken for onset of estrus after injection of $PGF_{2\alpha}$ (*Note*: 60 ± 6 = (54 hours - to- 66 hours)

The distribution of onset of estrus time in $PGF_{2\alpha}$ alone and GnRH + $PGF_{2\alpha}$ treated cows had no statistical significant difference, but numerically, cows treated with GnRH + $PGF_{2\alpha}$ concentrated (slightly tightened) from 48 to 72 hours and those cows treated with $PGF_{2\alpha}$ alone were exhibited estrus from 48 to 84 hours (slightly scattered) after $PGF_{2\alpha}$ injection. Major benefits of the GnRH + $PGF_{2\alpha}$ system were simplicity and tighter synchrony of estrus and most animals displayed standing estrus 2 to 4 days after the $PGF_{2\alpha}$ injection (figure-10).

4.2.2. Reproductive performance of *Begait* cattle after estrus synchronization

Number of cattle responded for the synchronization treatment and pregnancy rates in synchronized cattle as well as variables affecting reproductive performance of cows in each of the two treatment groups were summarized in Table-17 and Table-18.

The reproductive performance of cattle synchronized with $PGF_{2\alpha}$ was presented in the Table-17. The results revealed that cattle with medium and good body condition score were significantly responded ($P < 0.05$) to the $PGF_{2\alpha}$ treatment than those cattle with poor BCS.

The other finding that was observed was that treated heifers became more responsive to the therapy than the treated cows with a significant variation ($P < 0.05$). Likewise aged cows (>6 years) responded poorly than the cows less than 6 years old.

Table-17. Effect of $PGF_{2\alpha}$ synchronization on reproductive performance of *Begait* cows

Factors	Groups	No. of treated animals	No. of animals exhibited estrus (%)	Synchronized pregnancy No. (%)
BSC	Good	14	12 (85.71)[a]	11 (91.7)
	Medium	13	7 (53.8)[a]	5 (71.4)
	Poor	11	2 (18.2)[b]	2 (100.0)
	χ^2		12.39	5.343
	P-value		0.002	0.08
Parity	Heifer	19	14 (73.8)	13 (92.9)
	Cow	19	7 (36.8)	5 (71.4)
	χ^2		5.21	6.755
	P-value		0.022	0.06
Age	3-4 years	12	10 (83.3)[c]	9 (90.0)
	4.1-5.9 years	13	8 (61.5)[c]	7 (87.5)
	≥6 years	13	3 (23.1)[d]	2 (66.7)
	χ^2		9.47	5.12
	P-value		0.007	0.09
Total		**38**	**21 (55.3%)**	**18 (85.7%)**

[abc...] Values connected by the same letter in the same column have not significant difference

The effect of GnRH + $PGF_{2\alpha}$ in terms of BCS, parity and age of cattle were studied. Like in $PGF_{2\alpha}$, the results showed that the cattle with good and medium BCS significantly responded than those cattle with poor BCS. Moreover, all the heifers (100%) included in this group had responded to the treatment with statistically significant ($P < 0.05$) when compared to cows responded (71.4 %). However, age had not affected the response to GnRH + $PGF_{2\alpha}$ protocol, but numerically higher percent of young cattle responded to the treatment.

Table-18. Effect of GnRH + $PGF_{2\alpha}$ protocol on reproductive performance of Begait cattle

Factors	Groups	No. of treated cattle	No. of cattle exhibited estrus (%)	Synchronized pregnancy No. (%)
BCS*	Good	21	20 (95.2)[a]	19 (95.0)[a]
	Medium	20	18 (90)[a]	17 (94.4)[a]
	Poor	8	3 (37.5)[b]	2 (66.7)[b]
	χ^2		15.127	9.455
	P-value		0.001	0.01
Parity	Heifer	21	21 (100)	19 (90.5)
	Cow	28	20 (71.4)	19 (95.0)
	χ^2		7.171	6.31
	P-value		0.007	0.1
Age	3-4 years	16	16 (100)	16 (100)
	4<X<6 years	18	14 (77.8)	13 (92.9)
	≥6 years	15	11 (73.3)	9 (81.8)
	χ^2		4.754	5.20
	P-value		0.093	0.085
	Total	**49**	**41(83.7%)**	**38(92.7%)**

[abc....]: Values connected by the same letter in the same column have not significant difference

BCS*: Good= BCS (body condition scoring) -4; Medium= BCS-3; Poor= BCS-2: (in 0-emaciated to 5 fat scale; Annex-3)

Table-19 summarized the comparison and associations between the two treatment groups with the respective reproductive parameters such as estrus response, duration of estrus, non-return rate, synchronized pregnancy rates and synchronized conception rate

Table-19. Summary of reproductive performance in synchronized Begait cattle

Item	Treatments		*Total*
	$PGF_{2\alpha}$	$GnRH+PGF_{2\alpha}$	
	No.	No.	
No. of animals treated	38	49	*87*
No. of animals exhibited estrus (%)	21/38 (55.3)	41/49 (83.7)	*62/87 (71.3)*
$\chi 2$		8.436	
P-value		0.004	
Odds Ratio	1	4.149	
Time taken(hours) for induction of Estrus after $PGF_{2\alpha}$ injection (Mean ± S.E)	73.8 ± 5.26	67 ± 2.42	*68.8 ± 2.16*
Duration of estrus (hours) (Mean ± S.E)	5.3 ± 0.45	5.7 ± 0.44	*5.5 ± 0.38*
Non-return rate on day 18-24 (%)	20/21(95.2)	38/41(85.4)	*58/62(93.5)*
$\chi 2$	2.131		
P-value	0.2		
Synchronized pregnancy rates (%)	18/21(85.7)	38/41(92.7)	*56/62 (90.3)*
$\chi 2$	2.01		
P-value	0.3		

The $PGF_{2\alpha}$ protocol was compared to the GnRH + $PGF_{2\alpha}$ protocol in cows. The results from this study are shown in Table-19. Of the 87 *Begait* cattle included in the treatment, 21/38 (55.3%) and 41/49 (83.7%) responded for the estrus synchronization treatment with $PGF_{2\alpha}$ alone and GnRH+$PGF_{2\alpha}$ protocols, respectively. The estrus response recorded in the GnRH + $PGF_{2\alpha}$ protocol showed significantly higher than the $PGF_{2\alpha}$ protocol with ($P < 0.05$). The GnRH + $PGF_{2\alpha}$ treatment induced estrus 4 times (Odds Ratio = 4.15) higher than that of $PGF_{2\alpha}$ alone. Likewise, higher synchronized pregnancy rate was maintained in the former protocol (92.7%) than the second one 85.7%, respectively. However, the present study indicated that there was no significant difference between the two protocols on the duration of estrus, time taken for onset of estrus after $PGF_{2\alpha}$ injection and non-return rate.

5. DISCUSSION

Efficient reproductive performance is of vital importance for high productivity, in terms of production and reproduction; and economic efficiency in cattle production. Assessing the reproductive efficiency of herds of cattle helps to bring the overall picture of herd fertility to focus and enabling to design and plan the possible intervention options for performance improvement.

One remarkable and continuing problem with Ethiopian *Begait* cattle is the lack of sufficient information on their basic reproductive physiology and performance. This leads to obligatory use of the knowledge generated from the temperate breeds and some few Zebu breed cattle to manage, manipulate and discuss on reproductive performance of *Begait* cattle in the study area.

In the present study, during the assessment of herd composition and herd fertility, it was found that half of the population (49.7%) are cows. This is in-line with the result of Gashaw *et al.* (1991) who reported the dominance of cows (51.8%). However, the present finding was slightly higher than (38.7 to 44.7%) reported by Kelay (2002). The variation might be due to breed, environment and management differences. On the other hand, the calf-crop percentage of *Begait* herds in the pastoral (53.0%) is relatively high compared to the agro-pastoral (42.4%) production system. The markedly more cows than young cattle, coupled with the relatively high calf-crop production rate in the study area indicate high calf mortality. Moreover, the results obtained from the interviews and group discussions had strengthened the impression of high calf mortality in the area. These findings are in-concurrence with that reported by Musa *et al.* (2006) findings. The high value in cow to young (heifer) ratio could be due to high seasonal calf mortality (during the dry period), and lack of appropriate cow and calf management after calving. Moreover, female cattle taking long time being unproductive in dry season due to scarcity of fodder and insufficient number of bulls in the herd coupled with non-existent artificial insemination services could also contributed for the low number of young animals than cows in the selected herds. The higher number of calving in the months of May, June and July than the other months of the year is in-line with the findings of Dessalegn (2009) from *Arado* and Abereham (2009) from *Begait* cattle in the same study area is due to the feed availability in the months of September,and October.

The majority of *Begait* cows exhibited estrus signs in the months of September, October and November. This indicated that there is natural synchronization of estrus (breeding season) due to the reason that animals attain good body condition in the late rainy season. Thus, exhibition of estrus signs in the study area possibly be manipulated by the seasonal feed and fodder availability. This is in-agreement with the report of Abereham (2009). This seasonal and natural synchronized mating pattern in the late rainy season in-turn leads to large number of calving in the late dry season. The increased number of calf mortality observed in the months of April, May and June was therefore, due to the increased number of claves born, coupled with the very hot and dry environmental stressful conditions which are aggravated by the shortage of feed availability for the cows in those months.

The age at first service observed in the present study was slightly earlier (35.0 $\pm$ 0.21 months) in in-situ site than the ex-situ (37.7 $\pm$ 0.7 months). This might be due to the fact that the heifers in the in-situ site had ample opportunity to get sufficient feed (during the wet season) and accessibility of bulls in the herd led to uncontrolled breeding. On the other hand, in the ex-situ, undetected estrus (in confinement production); and lack of sufficient feed as well as lack of bulls in the herd (in crop-livestock production, castrated oxen are more common) might be the reasons to extend the age at first service. Mukasa-Mugerwa *et al.* (1989) emphasized that the time taken to attain sexual maturity and puberty are highly influenced by environmental factors including feed quantity and quality in Zebu cattle. The present study is in-line with the reports of Abereham (2009). However, the average age at first service of *Begait* cattle in this study is earlier than the Fogera heifers (44$\pm$8 months) at Andassa Livestock Research Centre as reported by Gidey (2001) and longer than the Ethiopian Zebu cattle (which is about 22.6 months) reported by Alberro (1983) which might be due to breed and management differences.

The age at first calving observed in ex-situ was longer than in the in-situ site in the present study. This is in-agreement with the report of Abereham (2009). This might be due to the lack of adaptation to the environmental stresses and lack of sufficient nutrition in the crop-livestock production; and due to undetected estrus signs coupled with artificial insemination failure in the confinement production system.

The other finding that was observed in this study was that the differences between the age at first service and the age at first calving in pastoral, agro-pastoral and crop-livestock production systems were only 9 months (equivalent with the gestation length); whereas, it was found to be 10.5 months (longer than gestation length) in the confinement production system. This might be due to the uncontrolled breeding practice in the three production systems in which the bulls usually mate the heifers at the onset of first estrus sign and conception rate by natural service is usually high. However, in the confinement production system, controlled breeding practice is common and voluntary missing of the first estrus sign (so that heifers get stronger) as well as involuntary failure of artificial insemination extended the age at first calving.

The age at first calving in the present study (43.9 to 49.5 months) is in-alignment with the previous reports for *Bos indicus* (Mukasa-Mugerwa, 1989), Boran (Haile-Mariam *et al.*, 1993) and East African Zebu (Galukande *et al.*, 1962). However, the present results were higher than the reports (35 months) for Horro cattle (Tegegne *et al.*, 1989); (32.8 months) for Arsi (Negussie *et al.*, 1998) and (30.3 months) for *Barka/Begait* cattle (Goshu, 1981). This might be due to the differences in the study design and study area. The present study was carried out on field level while the previous studies were done on-station level, which were subjected to different production systems and environmental variations. On the other hand, the current results were lower than the findings of Mukasa-Mugerwa *et al.* (1989) (53 months) for Ethiopian Highland Zebu and Asheber (1992) (53.8 months) for *Fogera* cattle. This variation might be again due to the breed, management and environment difference.

The calving interval recorded in this study (12.9, 14.1, 15.2 and 19.6 months from the pastoral, agro-pastoral, confinement and crop-livestock production systems, respectively) was similar with the reports of Mukassa-Mugrewa (1989) who estimated calving interval in Zebu cattle ranging from 12.2 to 26.6 months. The differences in the length of calving interval between the pastoral (12.9 months) and agro-pastoral (14 months) areas reported in the present study might be due to the suckling restriction (herders usually separate the calves from the herd) and absence of milking practice in the former production system. The suckling stimulus of a calf alters the level and release of hormones necessary for re-initiation of estrous activity in nursing cows. Calf removal for either a short period of time or permanently will often hasten resumption of estrous activity

(Tegegne *et al.*, 1992 and Sprott, 2003). Sprott (2003) also recognized that calving interval was significantly longer in those cows that suckled their calves than in cows that did not.

The extended calving interval (19.6 months) observed in the crop-livestock production system (around Wukro) might be due to the social and environmental stresses as well as lack of sufficient nutrition. The early calf death also observed to shorten the CI may be due to the suckling restriction effect.

The shorter CI in agro-pastoral (Kafta-Humera), in-situ, (14.1 months) than crop-livestock (around Wukro), ex-situ, (19.6 months) in the present study was in-agreement with the findings of Abereham (2009) who reported 13.96 months in Western zone of Tigray, for in-situ and 24 months in Kola-Tembein, ex-situ sites. The present result is also in-agreement with the reports of Swensson *et al.* (1981) for Arsi breed (12.9 months) and Gidey (2001) for Fogera breed (18.6 months). However, it was much higher than that reported by McDowell (1971) for Horro breed (12.2 months); and Goshu (1981) for Barka breed (11.8 months). This could be a reflection of differences in breed performance, management and environmental conditions as those lower intervals were recorded on-station.

The overall means of daily milk yield at early, middle and late lactation of *Begait* cows were higher in the confinement production system with 5.7, 8.1, and 3.9 lts, respectively, as compared with crop-livestock production system (around Wukro) of which 2.1, 3.2, and 0.9 lts, respectively. This might be due to the management given to the dairy type *Begait* cows such as provision of supplementary concentrates and balanced feed leading to high milk yield in the confinement production system. But in case of the crop-livestock production system, the cattle were only dependent on the marginal seasonal grazing pasture and crop residues in which animals were with deficiency of balanced feed for maintenance and production requirements in most of the dry season.

The higher average milk yield per cow found from the agro-pastoral area than the pastoral area (locally called '*Bereha*') was due to the fact that the herders in the later practice incomplete milking only a few cows leaving the other wet cows without milking due to lack of consumers.

This lack of milking experiences in the cows might have led to decreased milk production and increased the probability of exhibiting estrus signs and mating earlier postpartum which in-turn shortens the lactation length. In the present study, the maximum milk yield per day of Begait cow was 13 lts. This was in-line with the 12 lts reported by Mekonnen (2008). However, the people in Kafta-Humera have a traditional taboo not to sell milk produced from the indigenous cows.

The short lactation length observed in both pastoral ('*Bereha*') and crop-livestock production (around Wukro) were due to the separation of calves from the herd (restriction of suckling and calf-maternal bond influences the milk let-down and yield in Zebu cattle) coupled with the stressful long journey in search of feed in the former and due to insufficient feed availability in the later.

The lower milk yield recorded in the first parity in the present study might be due to the high nutritional requirement for body growth and maintenance that affect the milk production than the cows with parity number greater than one. Cows in higher parities produce more milk, and do not lose much body condition than the first calving cows (Musa *et al.*, 2006). The higher daily milk yield and total milk yield observed in twice milking per day than in once a day group was due to the fact that milking frequency increases the milk production in cattle (Gilmour, 1999).

The daily milk yield recorded from the agro-pastoral area in the present study was similar with the report (4.68 $\pm$ 0.22 lts) of Abereham (2009). However, the result obtained from pastoral area (2.5 $\pm$ 0.18 lts) in the present study was lower which might be due to differences in management and production system. The higher milk yield of *Begait* breed than other Northern Ethiopian Zebu cattle was also reported by Zerabruk *et al.* (2007).

The lactation length of *Begait* cattle in the present study was in-agreement with the report of Abereham (2009) although in this study lower values were obtained for the pastoral and crop-livestock production systems. These variations could be due to management and feed availability differences. The total milk yield reported (675 lts) by Tegegne *et al.* (1981) and (552 lts) by Goshu (1981) from the same breed; (809 lts) by Kiwuwa *et al.* (1983) from Arsi breed and (494 lts) by Beyene and Galal (1982) from Boran breed were higher than the pastoral (391 lts) and

crop-livestock (314 lts) production system but lower than the agro-pastoral (924.7 lts) and confinement (1281 lts) production system in the present study. This variation might be due to the environmental and management differences in which the previous studies were done on-station and the present study was done on field level.

The present finding supported the hypothesis that the $PGF_{2\alpha}$ alone and GnRH + $PGF_{2\alpha}$ treatments can improve the reproductive performance of *Begait* cattle. These results are in-agreement with the previous findings in *Bos indicus* (Mukasa- Mugerwa *et al.*, 1989; Tegegne *et al.*, 1989; Sisay *et al.*, 1998; Bekana *et al.*, 2005 and Meles, 2007) and *Bos taurus* cattle (Ferguson and Galligan, 1993; Geary and Whittier, 1999; Stevenson *et al.*, 2000; Tenhagen *et al.*, 2005; Córdova-Izquierdo *et al.*, 2009 and Patterson *et al.*, 2010).

The application of estrus synchronization in cattle using $PGF_{2\alpha}$ alone and GnRH+ $PGF_{2\alpha}$ seemed to have considerable importance and practically applicable in Ethiopia, particularly, in the study area, where the herd and individual cattle reproductive performance is usually influenced by the seasonal forage availability. Moreover, the lack of sufficient awareness of heat detection and the seasonal milk demand in those areas where-by more Orthodox Christian religion believers are concentrated; attracts the use of the estrus synchronization technology in the country.

Almost all of the physical and behavioral signs of estrus recorded in this study were identical in type and sequence as reported by Tsiligianni *et al.* (2001) and Roelofs *et al.* (2010) during naturally occurring estrus, suggesting that the exogenous administration of GnRH and $PGF_{2\alpha}$ injection does not alter the essential events occurring in estrus activity.

The present study showed that the proportion of cows observed in estrus was higher in the GnRH + $PGF_{2\alpha}$ (83.7%) than the $PGF_{2\alpha}$ alone (55.3%) treatments. This might be due to the multi-role of GnRH on reproductive process (Nagaraja and Devaraj, 2006) such as luteinizing 'old' follicles, causing dominant follicles to ovulate and initiating the emergence of new ovulatory follicles (Pursley *et al.*, 1995). The present finding was in-agreement with the observations of Stevenson *et al.* (1999); Diskin *et al.* (2002); Thatcher *et al.* (2002); Macmillan *et al.* (2003); Meles, (2007) and Patterson *et al.* (2010). The result of the present study showed that the total number of cattle

failed to exhibit estrus signs after the treatment was higher in the $PGF_{2\alpha}$ alone protocol (44.7%) than the GnRH + $PGF_{2\alpha}$ (16.3%). This could be due to the fact that more non-cycling heifers and cows were included in the treatment. In addition, the seasonal shortage of forage might increase the number of anestrous or acyclical cows in the study area. $PGF_{2\alpha}$ has no effect on non-cycling cows due to the fact that the success of $PGF_{2\alpha}$ primarily depends on the presence of a mature functional CL in the ovary (Kristula *et al.*, 1992). On the other hand, GnRH influences reproductive processes, mainly by regulating pituitary gonadotropin synthesis and release, which in turn modulate steroidogenesis and gametogenesis (Millar, 2005). The episodic release of GnRH during the female reproductive cycle is seen as a prerequisite for fertility (Pawson and McNeilly, 2005).

The mean duration of estrus periods (5.89 ± 0.38) in this study was included in the range 1.3-20 hours as cited by Mukasa-Mugerwa (1989) for Zebu cattle; 2.53 - 7.36 hours reported by Mattoni *et al.* (1988) for Small East African Zebu. However, it was higher than the reports of Albero (1983) 4.5 ± 2.2 hours in Ethiopian zebu, but lower than Ralambofilinga (1978) who found 8 to 9 hours in N'Dama cattle. The variations might be due to the breed, environment and management differences. The probable cause of short estrus duration was also shortage of estrogen secreted by the animals during the estrus time. Mukasa-Mugerwa (1989) reported that, shortage of estrogen may lead to failure or reduced intensity, duration and type of estrus symptoms.

The estrus response rate observed in this study following the use of $PGF_{2\alpha}$ alone was somewhat in agreement with the findings of Tegegne *et al.* (1989) (62.5%) and Sisay *et al.* (1998) (65.2%) in the Boran and Meles, (2007) (60%) in Ethiopian Zebu cattle. However, it was lower than the previous reports by Bekana *et al.* (2005) (80%); Akafite and Bekana, (2008) (78.57%); Rosenberg *et al.* (1990) (85 to 95%); (Ferguson and Galligan, (1993) (70 to 90%). This variation might be due to the methodology, breed and environmental differences. The present study was conducted by injection of the $PGF_{2\alpha}$ without checking the presence or absence of CL in the ovary; whereas, in the previous studies injection was given after confirmation of CL. Moreover, though it is known that the conventional protocol is to use the double dose (11 or 14 days interval) of the $PGF_{2\alpha}$ to bring all female cattle in to heat period, the single dose $PGF_{2\alpha}$ treatment schedule was conducted for ease application and cost considerations in the present study.

The higher pregnancy rate (92.7%) in synchronized cows observed in this study than (60%) reported by Meles (2007) following treatment of GnRH + $PGF_{2\alpha}$ was probably due to the use of natural service (bull) in the former and artificial insemination in the latter studies. The mean interval to estrus following $PGF_{2\alpha}$ injection in the present study was 48 to 72 hours in the GnRH + $PGF_{2\alpha}$ protocol. This was in-agreement with the reports of Voh *et al.* (1987), 48 to 72 hours and Stevenson *et al.* (1984), 60 to 70 hours after $PGF_{2\alpha}$ injection who used the same protocol.

The present study indicated that there was scattered/ extended estrus response in the $PGF_{2\alpha}$ treatment group than the concentrated or tighter estrus exhibition observed in the GnRH + $PGF_{2\alpha}$. This is due to the fact that the time of ovulation depends on the stage of dominant follicle at the time of prostaglandin-induced luteolysis. If $PGF_{2\alpha}$ is given when the dominant follicle of a wave is in the late growing or early phase, ovulation will occur within 3-4 days. But if the $PGF_{2\alpha}$ is given when the dominant follicle is in mid-late static phase, it will result in ovulation of the dominant follicle from the next follicular wave 5-7 days later (Bo *et al.*, 2003; Diskin *et al.*, 2002 and Lucy *et al.*, 2004). On the other hand, an injection of GnRH causes a release of Luteinizing Hormone (LH) from the pituitary gland in the brain. This LH "surge" results in ovulation or luteinization of most large dominant follicles. A new "synchronized" follicular wave is initiated in these animals 2 to 3 days later leading to synchronized estrus and ovulations. Because GnRH stimulates development of luteal tissue in place of the dominant follicle, a higher percentage of cows will possess sufficient luteal tissue to respond to $PGF_{2\alpha}$ 7 days later. Injecting cows with $PGF_{2\alpha}$ 7 days after a GnRH injection synchronizes luteal regression in animals with previously synchronized follicular development. This resulted to a higher estrus response rate and much tighter synchrony of estrus when compared to $PGF_{2\alpha}$ alone (Pursley *et al.*, 1995; Diskin *et al.*, 2002 and Macmillan *et al.*, 2003).

In the present study, estrus response in both the treatment groups was higher in animals with moderate body condition (BCS 3 and 4) than in those with poor body condition (scoring-2) cattle. These results were in-agreement with the previous report by Sisay *et al.* (1998). Santos *et al.* (2004) and Meneghetti and Vasconcelos, (2008) also reported that cows show reduced fertility and loss of body condition when the nutrient requirement for maintenance and lactation exceed intake.

6. CONCLUSION AND RECOMMENDATIONS

The present study showed that the reproductive and lactation performance of *Begait* cattle is satisfactory though variations among site and production systems are recognized. Shorter age at first calving and calving interval was observed in this study in the pastoral and confinement than in the agro-pastoral and crop-livestock production systems. Likewise, the higher milk yield recorded in the confinement and agro-pastoral than the pastoral and crop-livestock production systems shows the influences of management, milking frequency and environment on lactation performance. Based on the present study, the most frequent and consistently observed characteristics of estrus in the treated *Begait* cows and heifers were standing to be mounted, restlessness, clear vaginal discharge and swelling and redness of vulva. The remarkable estrus response and synchronized pregnancy rates observed during the synchronization period indicate the possibility of enhancing the reproductive performance of *Begait* cattle through hormonal treatment. The GnRH + $PGF_{2\alpha}$ protocol showed more effective than the $PGF_{2\alpha}$ alone protocol in inducing estrus. The acceptable results of the hormonal treatments in the this study can help in solving the longer age at first calving and calving interval problems observed in the ex-situ sites. Based on the present findings and conclusion, the following recommendations are forwarded:

- To achieve the optimal reproductive and productive performance of Begait cattle, the concerned bodies should improve the owners' awareness on good husbandry practice of cattle and to minimize the traditional taboo of 'not selling of milk' in the study areas.
- Professionals, policy makers, developmental agencies and animal owners should cooperate to make the country benefited from the huge number of cattle within it.
- To reduce the reproductive wastage and the high seasonal calf mortality rate in the study areas; to schedule the calving time with the forage availability and milk demand; as well as for rapid and massive multiplication, either traditional modification or pharmacological intervention (like estrus synchronization technology) of controlling estrus cycle of the best performer breed like Begait cattle should be introduced and implemented.
- Use of either single $PGF_{2\alpha}$ after conformation of CL or combination of GnRH + $PGF_{2\alpha}$ should be preferred for better estrus response than blindly injection of $PGF_{2\alpha}$ alone.
- Researches should be encouraged for further innovation, adoption and extension of the reproductive enhancing techniques to improve the productivity of local cattle breeds.

7. REFERENCES

Abereham, H. (2009). Phenotypic characterization of *Begait* cattle breed and their traditional production systems in Western Zone of Tigray, Northern Ethiopia, MSc. Thesis, School of Graduate Studies, Mekelle University, Mekelle, Ethiopia.

Adebabay, K. (2009). Characterization of Milk Production Systems, Marketing and On Farm Evaluation of the Effect of Feed Supplementation on Milk Yield and Milk Composition of Cows at Bure District, Ethiopia. MSc. Thesis, Bahir-Dar University, Bahir Dar, Ethiopia.

Ahuja, C., Montiel, F., Canseco, R., Silva, E. and Mapes, G. (2005). Pregnancy rate following GnRH + $PGf_{2\alpha}$ treatment of low body condition, anestrous *Bos taurus* by *Bos indicus* crossbred cows during the summer months in a tropical environment. *Anim. Repro. Sci.* **87**: 203-13.

Akafete, H. and Bekana, M. (2008). Oestrus characterization in Borana and Holstein-Friesian X Borana (F1 crossbred) heifers treated with Prostaglandin F 2α. *Ethiop. Vet. J.* **12**:145-159.

Alberro, M. (1983). Comparative performance of F_1 Friesian x zebu heifers in Ethiopia. *Anim.Produ.* **37:** 247-252.

Alim, A. (1960). Reproductive rates and milk yield of Kenana cattle in Sudan. *J. Agri. Sci.* **55**: 183-188.

Amaya-Montoya, C., Matsui, M., Kawashima, C., Hayashi, K.G., Matsuda, G., Kaneko, E., Kida, K., Miyamoto, A., and Miyake, Y. (2007). Induction of ovulation with GnRH and $PGF_{2\alpha}$ at two different stages during the early postpartum period in dairy cows. Ovarian response and changes in hormone concentrations. *J. Repro. Dev.* **53(4):** 867.

Arsham, H. (2007). Questionnaire Design and Surveys Sampling. http://www.mirrorservice.org/sites/home.ubalt.edu/ntsbarsh/Business-stat.

Asheber, S. (1992). Evaluation of the reproductive and preweaning growth performance of Fogera cattle and their F1 Friesian crosses at Abernassa Cattle Breeding Station, Ethiopia. MSc. Thesis, Alemaya University, Ethiopia.

Aymro, W. and Joachim, M. (1970). The Ethiopia Orthodox Church. The Ethiopia Orthodox Mission, 1st ed. Addis Ababa. Ethiopia.

Bao, B., Garverick, A., Smith, W., Smith, F., Salfen, E. and Youngquist, S. (1997). Changes in messenger ribonucleic acid encoding luteinizing hormone receptor, cytochrome P450-side chain cleavage, and aromatase are associated with recruitment and selection of bovine ovarian follicles. *Biol. Reprod.* **56**: 1158-1168.

Baruselli, P., Reis, E., Marques, M., . Nasser, L. and Bó, G. (2004). The use of hormonal treatments to improve reproductive performance of anestrous beef cattle in tropical climates. *Anim. Reprod. Sci.* **82**: 479-486.

Basu, B., Bhatnagar, S., Taneja, K. and Rao, P. (1979). Comparative performance of Indian dairy breeds. *Indian J.Dairy Sci.* **32**: 497-499.

Bekana, M. (1997). Prostaglandin F2α and progesterone profiles in post-partum cows with short luteal phases. *Acta. Vet. Scand.* **38**:320-330.

Bekana, M., Gizachew, A. and Regassa, F. (2005). Reproductive performance of Fogera Heifers Treated with Prostaglandin F2α for Synchronization of Oestrus. *Trop. Anim. Health and prod.* **37**: 373-379.

Bekana, M., Odensvik, K. and Kindahl, H. (1996). Prostaglandin F2α metabolite and progesterone profiles in post-partum cows with retained fetal membranes. *Acta. Vet. Scand.*, **37**:251-263.

Belachew, B. and Regassa, F. (2010). Subclinical endometrities in Zebu x Friesian crossbred dairy cows: its risk factors, association with subclinical mastitis and effect on reproductive performance. *Trop. Anim. Health prod.* **42**:397-403.

Belete, A. (2006). Studies on cattle milk and meat production in Fogera district: Production systems, constraints and opportunities for development. MSc. Thesis, University of Hawassa, Awassa, Ethiopia.

Beyene, K. and Galal, E. (1982). A study of body weight from birth to one year of age in European-zebu crossbred cattle in Ethiopia. *Anim.produ.* **34**: 85-93.

Bó, A., Baruselli, S. and Martinez, F. (2003). Pattern and manipulation of follicular development in *Bos indicus* cattle. *Anim. Reprod. Sci.* **78**, pp. 307–326.

BoANR. (1999). Livestock Census. Regional State of Tigray, Bureau of Agriculture and Natural Resources. Mekelle, Ethiopia. Vol.1. Daltons supplies Ltd. Cattle and Pig weighing Tape. Addis Ababa, Ethiopia.

Bodensteiner, J., Wiltbank, C., Bergfelt, R. and Ginther, J. (1996). Alterations in follicular estradiol and gonadotropin receptors during development of bovine antral follicles. *Theriogenology*. **45**: 499-512.

Bureau of Agriculture and Natural Resource Development Tigray regional state (BOANRDT), (2003). Tigray land use study of Kafta-Humera Woreda, Regional Land Use Planning Team, **3**: 153-170.

Chenault, R., Kratzer, D., Rzepkowski, A. and Goodwin, C. (1990). LH and FSH response of Holstein heifers to fertirelin acetate, gonadoreline and buserelin. *Theriogenology*. **34**: 81-98.

Compere, R. (1960). Results obtained at the Mulungu station with the first cross of Swiss Brown on native cattle. *Bulletin Agricole du Congo Belge et du Ruanda Burundi* **51**: 617-645.

Cooper, M. (1974). Control of oestrous cycles in heifers with a synthetic prostaglandin analogue. *Vet Rec*. **95**: 200-203.

Córdova-Izquierdo, C.A. Córdova-Jiménez, M., Ruiz Lang, J.A. Saltijeral Oaxaca, C.G. Xolalpa Campos, M., Cortés Suárez, S., Luque Rodríguez, M., Méndez-Mendoza, M., Huerta Crispín, R. and Guerra Liera, E. (2009). Oestrus Synchronization and Percentage of Pregnancy in Dairy Calves Using Prostaglandins by Two via of Administration. *Austra. J.Basic and Appl. Sci*. **3(3):** 2834-2837.

CSA, (2010). Federal Democratic Republic of Ethiopia. Central Statistical Agency, Agricultural Sample Survey Report on Livestock and Livestock Characteristics. Volume II, 2009/10. Statistical bulletin 468, Addis Ababa, Ethiopia.

Cupp, S., Stumpf, T., Kojima, N., Werth, A., Wolfe, W., Roberson, S., Kittok, S. and Kinder, K. (1995). Secretion of gonadotrophins change during the luteal phase of the bovine oestrous cycle in the absence of corresponding changes in progesterone or 17β-oestradiol. *Anim. Reprod. Sci*. **37**:109-119.

Dennis, P. and Thiongane, I. (1978). Effect of intensive feeding on reproductive performance in female Gobra Zebu at the CRZ, Dehra. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux*. **31**: 85-90.

Dessalegn, G. (2008). Assessment of problems/constraints associated with artificial insemination service in Ethiopia. MSc. Thesis, Addis Ababa University, Faculty of Veterinary Medicine, Debre-Zeit, Ethiopia.

Dessalegn, M. (2009). On-farm phenotypic characterization of arado cattle breed in NorthWest Zone of Tigray, Ethiopia. MSc. Thesis, Addis Ababa University, Faculty of Veterinary Medicine, Debre-Zeit, Ethiopia.

Diskin, G., Austin, J. and Roche, F. (2002). Exogenous hormonal manipulation of ovarian activity in cattle. *Domest. Anim. Endocrinol.* **23**: 211–228.

Driancourt, M. (2001). Regulation of ovarian follicular dynamics in farm animals: Implications for manipulation of reproduction. *Theriogenology.* **55**:1211-1239.

Duarte, M., Valle, A., Lobo, B. and Bezerra, L. (1983). Phenotype and genetic study in reproductive and production characters in the Pitanguieras breed. 2. Calving interval. *Agronomia Tropical (Maracay, Venezuela),* **30**: 325-334.

Epstein, H. (1971). The origin of the domestic animals of Africa Volume I. Africana Publishing Corporation. New York. London. Munich. Pp. 208-211.

Ferguson, J. and Galligan, D. (1993). Prostaglandin synchronization programs in dairy herds (part I). *Compend. Contin. Educ. Pract. Vet.* **15**: 646-655.

Folman, Y., Kaim, M., Herz, Z. and Rosenberg, M. (1990). Comparison of methods for the synchronization of estrous cycles in dairy cows. 2. Effects of progesterone and parity on conception. *J. Dairy Sci.* **73**: 2817-2825.

Galukande, E., Mahadevan, P. and Black, J. (1962). Milk production in East African Zebu cattle. *Anim. Produ.* **4**: 329-336.

Garverick, A., Zollers, G. and Smith, F. (1992). Mechanisms associated with corpus luteum lifespan in animals having normal or subnormal luteal function. *Anim. Reprod. Sci.* **28**:111-124.

Gashaw, G., Varvikko, T. and Khalili, H. (1991). Smallholder dairy production in Northern Shoa Province, central highlands of Ethiopia. 1. Assessment of feed resources in relation to the requirements on a smallholder farm. In: Development of Appropriate Feeding Systems for Dairy Cattle in the Ethiopian Highlands. Final Report. ILCA and MOA. Addis Ababa, Ethiopia.

Geary, T. and Whittier, J. (1999). Various protocols for synchronization of estrus or ovulation using GnRH and prostaglandin. *Beef Program Report.* Department of Animal Science, Colorado State University.

Geary, T., Downing, R., Bruemmer, E. and Whittier, C. (2000). Ovarian and estrous response of suckled beef cow to SelectSynch estrous synchronization protocol. *Prof. Anim. Sci.* **16**:1-5.

Gidey, Y. (2001). Assessment of calf crop productivity and total herd life of fogera cows at Andassa Ranch in North Western Ethiopia. MSc. Thesis, Alemaya University, Ethiopia.

Gilmour, D. (1999). Milking . *Falvey L. and Chantalakhana C. (eds.) Smallholder Dairying in the Tropics.* ILRI (International Livestock Research Institute), Nairobi, Kenya. Pp. 462.

Ginther, J., Bergfelt, R., Kulick, J. and Kot, K. (2000). Selection of the dominant follicle in cattle: Role of two-way functional coupling between follicle- stimulating hormone and the follicles. *Biol. Reprod.* **62**:920-927.

Ginther, J., Wiltbank, C., Fricke, M., Gibbons, R. and Kot, K. (1996). Selection of the dominant follicle in cattle. *Biol. Reprod.* **55**: 1187-1194.

Goshu, M. (1981). Evaluation of indigenous strains for milk production. In: Summary of Animal Production Research (1968-1980). Addis Ababa University and Debre Zeit Agricultural Research Centre.

Grieger, M., Lamb, C., Rozell, G., Thompson, E and Stevenson, J. (1998). Site of semen deposition and fertility in beef cows inseminated according to estrus or at a fixed time after synchronization with GnRH-$PGF_{2\alpha}$. *J. Anim. Sci.* **76**: 279.

Guilbault, A., Lussier, G., Grasso, F. and Matton, P. (1990). Influence of a GnRH analogue on follicular dynamics in cows pretreated or not with FSH-P4. *Theriogenology.* **33**: 240.

Haile-Mariam, M., Banjaw, K., Gebre-Meskel, J. and Ketema, T. (1993). Productivity of Boran cattle and their Friesian crosses at Abernossa Ranch, Rift Valley of Ethiopia. I Reproductive performance and preweaning mortality. *Trop. Anim. Health and Prod.* **25**: 239-248.

Hanotte, O., Bradley, G., Ochieng, W., Verjee, Y., Hill, W. & Rege, E. (2002). African pastoralism: genetic imprints of origins and migrations. *Sci.* **29:**336–339.

Hansen, R., Randel, D. and Peterson, A. (1987). Bovine corpus luteum regression and estrous response following treatment with alfaprostol. *J. Anim. Sci.* **64:** 1280-1284.

Heinonen, K., Shiferaw, T. and Heinonen, M. (1996). Oestrous synchronisation in Ethiopian highland zebu cattle by means of intravaginal cloprostenole administration. *Trop. Anim. Health Prod.* **28 (1):**121-5.

Henao, G., Olivera-Angel, M. and Maldonado-Estrada, G., (2000). Follicular dynamics during postpartum anestrous and the first estrous cycle in suckled or non-suckled Brahman (*Bos indicus*) cows. *Anim. Reprod. Sci.* **63**: 127–136.

Hopper, W., Silcox, W., Byerley, D. and Kiser, E. (1993). Follicular development in prepubertal heifers. *Anim. Reprod. Sci.* **31**: 7–12.

IBC (Institute of Biodiversity Conservation) (2004). *The state of Ethiopia's Farm Animal Genetic Resources*: A contribution to the first report on the state of the world's animal genetic resources. May 2004, Addis Ababa, Ethiopia.

Kanuya, L., Matiko, K., Kessy, M., Mgongo, O., Ropstad, E. and Reksen, O. (2006). Study on reproductive performance and related factors of zebu cows in pastoral herds in a semi-arid area of Tanzania. *Theriogenology,* **65**: 1859-1874.

Kassa, T. and Tegegne, A. (1998). Factors affecting reproductive performance of Zebu and crossbred cows under small scale dairy farms. *Trop. Agric.* **75**: 4-12.

Kastelic, P. and Ginther, J. (1991). Factors affecting the origin of the ovulatory follicle in heifers with induced luteolysis. *Anim. Reprod. Sci.* **26**: 13-24.

Kelay, B. (2002). Analyses of Dairy Cattle Breeding Practices in Selected Areas of Ethiopia. PhD. Thesis, Humboldt University of Berlin, Germany.

Kiwuwa, H., Trail, M., Kurtu, Y., Worku, G., Anderson, .M. and Durkin, J. (1983). Crossbred dairy cattle productivity in Arsi region, Ethiopia. ILCA Research Report No.11. ARDU and ILCA, Addis Ababa, Ethiopia.

Kojima, F., Bader, F., Stegner, E., Schafer, J., Clement, C., Eakins, L., Smith, F. and Patterson, J. (2004). Substituting EAZI-BREED CIDR inserts (CIDR) for melengestrol acetate (MGA) in the MGA Select protocol in beef heifers. *J. Anim. Sci.* **82**: 255.

Kojima, N., Salfen, B., Bader, F., Ricke, A., Lucy, C., Smith, F. and Patterson, J. (2000). Development of an estrus synchronization protocol for beef cattle with short-term feeding of Melengestrol acetate. *J. Anim. Sci.* **78**: 2186–2191.

Kristula, M., Bartholomew, R., Galligan, D. and Uhlinger, C. (1992). Effects of a prostaglandin F2a synchronization program in lactating dairy cattle. *J. Dairy Sci.* **75**: 2713-2718.

Kumar, S. (1982). Sources of variation in reproductive traits of Hariana and Tharparkar cows. *Indian J. Anim. Sci.* **52**: 203-209.

Lane, E., Austin, E. and Crowe, M.A. (2008). A review: Oestrous synchronisation in cattle: Current options following the EU regulations restricting use of oestrogenic compounds in food producing animals. *Anim. Reprod. Sci.* **109**: 1-16.

Lemma, T., Tegegne, A., Puskur, R. and Hoekstra, D. (2008). Moving Ethiopian smallholder dairy along a sustainable commercialization path: missing links in the innovation systems. In: Proceedings of the national symposium on smallholder dairy production in central highlands of Oromia regional state, Ethiopia: Challenges and Future prospects. Pp. 118-138.

Lobago, F., Bekana, M., Gustafsson, H. and Kindahl, H. (2006). Reproductive performances of dairy cows in small holder production system in Sellale, Central Ethiopia. *Trop. Anim. Health prod.* **38**:333-342.

Lucy, C., McDougall, S. and Nation, P. (2004). The use of hormonal treatments to improve the reproductive performance of lactating dairy cows in feedlot or pasture-based management systems. *Anim. Reprod. Sci.* **82**: 495–512.

Lucy, C., Savio, D., Badinga, L., Sota, L. and Thatcher, W. (1992). Factors that affect ovarian follicular dynamics in cattle. *J. Anim. Sci.* **70**: 3615 - 3626.

Macmillan, L., Segwagwe, E. and Pino, S. (2003). Associations between the manipulation of patterns of follicular development and fertility in cattle. *Anim. Reprod. Sci.* **78:** 327–344.

Martinez, F., Adams, P., Kastelic, P., Bergfelt, R. and Mapletoft, J. (2000). Induction of follicular wave emergence for estrus synchronization and artificial insemination in heifers. *Theriogenology.* **54**: 757-769.

Martinez, J. and Thibier, M. (1984). Fertility in anoestrous dairy cows following treatment with prostaglandin F2α or the synthetic analogue fenprostalene. *Vet. Rec.* **115**: 57-59.

Mason, L. (1996). A World Dictionary of Livestock Breeds, Types and Varieties. Fourth Edition. C.A.B International. Pp. 273.

Matiko, K., Kanuya, L., Waldmann, A., Ropstad, E. and Reksen, O. (2008). Environmental constraints on post-partum ovarian activity in Tanzanian Zebu cows. *Theriogenology*. **69**: 896-904.

Mattoni, M, Mukasa-Mugerwa, E., Cecchini, G. and Sovani, S. (1988). The reproductive performance of East African (*Bos indicus*) zebu cattle in Ethiopia. 1. Oestrous cycle length, duration, behaviour and ovulation time. *Theriogenology*. **30**: 961-971.

McCracken, J., Custer, E. and Lamsa, J. (1999). Luteolysis: A neuroendocrine- mediated event. *Physiol. Reviews*. **79**:263-324.

McDowell, R. (1971). Feasibility of commercial dairying with cattle indigenous to the tropics. *Cornell international Agricultural Development Bulletin* No. 21. Cornell University, Ithaca, New York, USA. Pp. 22.

Mekonnen, H. (2008). Seroprevanlce study of bovine brucellosis and its public health significance in Western Tigray, Ethiopia. MSc. Thesis, Addis Ababa University, Faculty of Veterinary Medicine, Debre-Zeit, Ethiopia.

Meles, H. (2007). Estrus synchronization using Gonadotropin Releasing Hormone and Prostaglandin F2a in local heifers and cross breeds in Wolisso woreda, South-Western Oromiya Region. MSc. Thesis. Addis Ababa University, Faculty of Veterinary Medicine, Debre-Zeit, Ethiopia.

Meneghetti, M. and Vasconcelos, J. (2008). Calving date, body condition score, and response to a timed AI protocol in first-calving beef cows, *Braz. J. Vet. Anim. Sci.* **60**:786–793.

Meyer, J., Radcliff, R., Rhoads, M., Bader, J., Murphy, C. and Lucy, M. (2007). Timed artificial insemination of the consecutive services in dairy cows using prostaglandin $F_{2\alpha}$ and gonadotropin-releasing hormone, *J. Dairy Sci.* **90**: 691–698.

Millar, P. (2005). GnRHs and GnRH receptors, *Anim. Reprod. Sci.* **88**: 5–28.

Million, T. and Tadelle, D. (2003). Milk production performance of Zebu, Holstein Friesian and their crosses in Ethiopia, Debre Zeit Agriculture Research Centre, Humboldt University of Berlin, Animal Breeding for Tropics and sub-tropics. 13, Haus 9, 10115 Berlin, Germany.

Ministry of Agriculture (MOA) (1997). National Livestock Development Programme, Animal and Fisheries Resources Development Department, January 1997, Addis Ababa, Ethiopia.

Montiel, F. and Ahuja, C. (2005). Body condition and suckling as factors influencing the duration of postpartum anestrus in cattle: a review. *Anim. Reprod. Sci.* **85**: 1-26.

Mukasa-Mugerwa, E., Bekele, E. and Tessema, T. (1989). Type and productivity of indigenous cattle in Central Ethiopia. *Trop. Anim. Health Produ.* **21**: 120.

Mukasa-Mugerwa, E. (1989). A review of a reproductive performance of female *Bos indicus* (zebu) cattle. ILCA Monograph 6. ILCA, Addis Ababa, Ethiopia.

Mukasa-Mugerwa, E. and Tafesse, M. (1988). Fertility in Arsi (*Bos-indicuse*) cattle after synchronization lutalyse. *Indian J. Anim. Sci.* **58**:1284-1287.

Mukassa-Mugerwa, E., Tegegne, A., Mesfin, T. and Teklu, T. (1991). Reproductive efficiency of *Bos-indicus* (Zebu) cows under AI management in Ethiopia. *Anim. Reprod. Sci.* **24**:63-72.

Musa, L., Peters, K. and Ahmed, M. (2006). On farm characterization of Butana and Kenana cattle breed production systems in Sudan. Livestock research for rural development. Volume 18. Article 177. Pp. 22-29.

Nagaraja, R. and Devaraj, M. (2006). Multi facet Roles of GnRH in Reproduction. Veterinary college, Karnataka Veterinary, animal and Fisheries Sciences University.

National Meteorological Agency (NMA), (2009). Bole Engineering, Research and Operational Complex, Federal Democratic Republic of Ethiopia.

Nebel, R. and Jobst, M. (1998). Evaluation of systematic breeding programs for lactating dairy cows: a review. *J. Dairy Sci.* **81**: 1169-1174.

Negussie, E., Brannang, E., Banjaw, K. and Rottmann, O. (1998). Reproductive performance of dairy cattle at Asella livestock farm, Arsi, Ethiopia. I. Indigenous cows versus their F1 crosses. *J. Anim. Breed. Genet.* **115**: 267-280.

Nicole, R. (2007). Comparison of CIDR-based protocols to synchronize estrus in beef heifers. MSc. Thesis. The Faculty of the Graduate School at the University of Missouri-Columbia.

Niswender, D., Davis, T., Griffith, R., Bogan, L., Monser, K., Bott, C., Bruemmer, E. and Nett, T. (2007). The autoregulation of luteal function. In: Reprod: in Domestic Ruminants. Pp. 192-206.

Oquba-Michael, B. (2003). The state of Eritrea Ministry of Agriculture. Department of regulatory service, Animal and plant health division. Annual report. Pp. 29-35.

Oyedipe, O., Osori, K., Akerejola, O. and Saror, D. (1982). Effect of level of nutrition on onset of puberty and conception rates of zebu heifers. *Theriogenology.* **18**: 525-539.

Patterson, D., Kojima, N. and Smith, M. (2003). A review of methods to synchronize estru in replacement beef heifers and postpartum cows. *J. Anim. Sci.* **81(2)**:166-177.

Patterson, D., Mallory, D., Nash, J. and Smith, M. (2010). Estrus synchronization protocols for heifers. In: Proceedings, Applied Reproductive Strategies in Beef Cattle, January 28-29, 2010; San Antonio, TX. Pp.4-12.

Pawson, A. and McNeilly, A. (2005). The pituitary effects of GnRH, *Anim. Reprod. Sci.* **88**: 75–94.

Payne, W. and Wilson, T. (1999). An introduction to animal husbandry in the tropics. 5th ed. Blackwell Publishing Ltd, Iowa State University Press, U.S. Pp. 826.

Peters, A. (1984). Reproductive activity of the cow in postpartum period. I. Factors affecting the length of the postpartum acyclic period. *British Vet. J.* **140**: 76-82.

Peters, A. and Ball, P. (1995). The ovarian cycle. In: Reproduction in Cattle, Blackwell Science Ltd. Oxford. Pp. 23-46.

Pursley, R., Mee, O. and Wiltbank, C. (1995). Synchronization of ovulation in dairy cows using PGF2 and GnRH. *Theriogenology.* **44**: 915-923.

Ralambofilinga, A. (1978). Notes on the oestrous cycle and reproduction in N'Dama females. *Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux.* **31**: 91-94.

Randel, D., Lammoglia, A., Lewis, W., Neuendorff, A. and Guthrie, J. (1996). Exogenous PGF2α and GnRH-induced LH release in postpartum cows. *Theriogenology.* **45**: 643-654.

Rege, J. (1999). Economic valuation of farm animal genetic resources.In: Proceedings of an FAO/ILRI Workshop held at FAO Headquarters, Rome, Italy, 15–17 March 1999. ILRI (International Livestock Research Institute), Nairobi, Kenya. Pp. 80.

Reinhardt, V. (1978). Effect of a suckling calf on the reproductive performance of its dam (*Bos indicus*) *Zuchthygiene,* **13**: 74.

Reist-Marti, B., Simianer, H., Gibson, J., Hanotte, O. and Rege, J. (2003). Weitzman's approach and conservation of breed diversity: an application to African breeds. *Conserv. Biol.* **17**, 1299–311.

Rhodes, M., Fitzpatrick, A., Entwistle, W. and Kinder, E. (1995). Hormone concentrations in the caudal vena cava during the first ovarian follicular wave of the oestrous cycle in heifers. *J. Reprod. Fertil.* **104**:33-39.

Richard, W. (1993). Dairying. Tropical Agricultur. 1st edu. Macmillan Press London. Pp.43-48.

Roberts, S. (1986). Veterinary obstetrics and genital disease. Theriogenology. 3rd Ed. Edwards Brothers, Inc. Ann. Arbors. Michigan. Pp. 48-104.

Roelofs, J., López-Gatius, F., Hunter, R., Van Eerdenburg, F. and Hanzen, C. (2010). When is a cow in estrus? Clinical and practical aspects. *Theriogenology*. **74**: 327-344.

Rosenberg, M., Kaim, M., Herz, Z, and Folman, Y. (1990). Comparison of methods for synchronization of estrous cycle in dairy cows. 1. Effects on plasma progesterone and manifestation of estrus. *J. Dairy Sci.* **73**: 2807-2816.

Sakas, M., Kawate, N., Nakagawa, C., Fukushima, M., Noda, M., Takeda, K., Ueno, S., Inaba, K., Kaida, H. and Sawada, T. (2007). Preventive effects of CIDR based protocols on premature ovulation before timed AI in ovysynch in cycling beef cows. *The Vet. J.* **173**: 691-693.

Salverson, R. and George, P. (2005). Understanding estrus synchronization of cattle http://agbiopubs.sdstate.edu/articles/FS921C.pdf.

Santos, E., Juchem, O., Cerri, L., Galvao, N., Chebel, C., Thatcher, W., Dei, S. and Bilby, R. (2004). Effect of bST and reproductive management on reproductive performance of Holstein dairy cows. *J. Dairy Sci.* **87(4)**:868-81.

Savio, D., Boland, P., Hynes, N., Mattiacci, R. and Roche, F. (1990). Will the first dominant follicle of the estrous cycle of heifers ovulate following luteolysis on day 7? *Theriogenology.* **33**:677-687.

Schafer, J., Bader, F., Meyer, P., Haden, K., Ellersieck, R., Lucy, C., Smith, F. and Patterson, D. (2007. Comparison of progestin-based protocols to synchronize estrus and ovulation before fixed-time artificial insemination in postpartum beef cows. *J. Anim. Sci.* **85**:1940-1945.

Senger, L. (2003). Pathways to Pregnancy and Parturition. Second Ed. Current Conceptions, Inc., Pullman, WA. Pp.35-49.

Silva, E., Sterry, R., Kolb, D., Wiltbank, M. and Fricke, P. (2007). Effect of pretreatment with prostaglandin $F_{2\alpha}$ before resynchronization of ovulation on fertility of lactating dairy cows, *J. Dairy Sci.* **90**: 5509–5517.

Sisay, A., Ebro, A. and Tegegne, A. (1998). Fertility of Bos-indicus and Bos-indicus X Bos-taurus crossbred cows and heifer after estrus synchronization in the rift valley of Ethiopia. In: woman and Animal production. In: Proceedings of the 6th annual conference of the Ethiopian society of Animal production, ESAP, Addis Ababa, Ethiopia, 123-129.

Sprott, R. (2003). Calf removal: A way to stimulate reproduction in cows. Bull L-5443. Texas Agric. Exp. Sta., College Station, Texas. Pp. 137-42.

SPSS (Statistical Packages for the Social Science), (2005). Version 15.0. SPSS Inc.1989-2002, USA.

Staal, J., Pratt, N. and Jabbar, M. (2008). Dairy development for the resource poor: Part II: Kenya and Ethiopia dairy development case studies. PPLPI (Pro-Poor Livestock Policy initiative) working paper No. 44-2, IRLI (International Livestock Research Institute), Nairobi, Kenya.

Stevenson, J. and Pursley, J. (1994). Use of milk progesterone and prostaglandin F2α in a scheduled artificial insemination program. *J. Dairy Sci.* **77**: 1755-1760.

Stevenson, J., Kobayashi, Y. and Thompson, E. (1999). Reproductive Performance of Dairy Cows in Various Programmed Breeding Systems Including OvSynch and Combinations of Gonadotropin-Releasing Hormone and Prostaglandin F2α. *J. Dairy Sci.* **82**:506–515.

Stevenson, J., Thompson, E., Forbes, L., Lamb, G., Grieger, M. and Corah, L. (2000). Synchronizing estrus and ovulation in beef cows after combinations of GnRH, norgestomet and prostaglandin $F_{2\alpha}$ with or without timed insemination. *J. Anim. Sci.* **78**:1747-1758.

Swensson, C., Schaar, J., Brannang, E. and Meskel, B. (1981). Breeding activities of the Ethio-Swedish integrated rural development project. III: Reproductive performance of Zebu and crossbred cattle. *World Animal Review.* **38**: 31-36.

Tegegne, A., and Franceschini, R. (1993). Evaluation of Luteoysis and Oestrus Synchronization using a Prostagnandin analogue (Prosolvin) in Borana X Friesian Crossbred Heifers in Ethiopia. *J. Appl. Anim. Res.* **4**: 107-114.

Tegegne, A., Ayalew, W., Gebre-Medhin, B. and Fernandez-Rivera, S. (2003). Opportunities for improving milk production in Ethiopia. pp. 107-122. Presented in Ethio-Forum 2002. Resource management for poverty reduction: Approaches and technologies. Ethiopian Social Rehabilitation and Development Fund. Addis Ababa, Ethiopia.

Tegegne, A., Entwistle, K. and Mukassa-Mugerwa, E. (1992). Effect of supplementary feeding and suckling intensity on postpartum reproductive performance of small East African Zebu cows. *Theriologenology.* **38**: 97-106.

Tegegne, A., Galal, E. and Kebede, B. (1981). A study on the reproduction of local zebu and F_1 crossbred (European x Zebu) cows. I. Number of services per conception, gestation length and days open till conception. *Ethiopian J. of Agri. Sci.* **3**: 1-14.

Tegegne, A., Warnlck, A., Mukasa-Mugerwa, E. and Ketema, H. (1989). Fertility of Bos indicus and Bos taurus crossbred cattle after estrus synchronization. *Theriogenology.* **31**:361-370.

Tenhagen, B., Kuchenbuch, S. and Heuwieser, W. (2005). Timing of ovulation and fertility of heifers after synchronization of estrus with with GnRH and PGF2a. *Reprod. Domest. Anim.* **40**: 62-67.

Tesfaye, L. and Puskur, R. (2007). Understanding and Analyzing Dairy and Forage innovation systems in Ethiopia. IPMS of Ethiopian farmers' project, International Livestock Research Institute (IRLI), Addis Ababa, Ethiopia.

Thatcher, W., Moreira, F., Pancarci, M., Bartolome, A. and Santos, E. (2002). Strategies to optimize reproductive efficiency by regulation of ovarian function. *Domest. Anim. Endocrinol.* **23**: 243–254.

Tsiligianni, T., Karagiannidis, A., Brikas, P. and Saratsis, P. (2001). Physical properties of bovine vaginal mucus during normal and induced (progesterone and/or PGF2α) estrus. *Theriogenology.* **55**: 629-640.

Twagiramungu, H., Guilbault, L. and Dufour, J. (1995). Synchronization of ovarian follicular waves with a gonadotropin-releasing hormone agonist to increase the precision of estrus in cattle: a review. *J. Anim. Sci.* **73**: 3141-3151.

Vasconcelos, J., Filho, O., Perez, G. and Silva, A. (2009). Intravaginal progesterone device and/or temporary weaning on reproductive performance of anestrous crossbred Angus × Nelore cows, *Anim. Reprod. Sci.* **111**: 302–311.

Voh, A., Oyedipe, O., Buvanendran, V. and Kumi-Diaka, J. (1987). Estrus response of indigenous Nigerian Zebu cows after prostaglandin F2 alpha analogue treatment under continuous observations for two seasons. *Theriogenology*. **28**: 77-99.

Walters, D. and Schallenberger, E. (1984). Pulsatile secretion of gonadotrophins, ovarian steroids and ovarian oxytocin during the periovulatory phase of the oestrous cycle in the cow. *J. Reprod. Fertil.* **71**:503-512.

Wenzel, W. (1991). A review of prostaglandin F2α products and their use in dairy reproductive herd health programs. *Vet. Bull*. **61**: 433-447.

Whitter, D., Hall, B., Amanda, B. and Mark, C. (2002). Effect of dose of GnRH used in Ovsynch system on AI pregnancy rates in beef cows. In: Annual meeting of the American Association of Bovine Practitioners, Madison, Wisconsin.

Wiltbank, C., Gumen, A. and Sartori, R. (2002). Physiological classification of anovulatory conditions in cattle. *Theriogenology.* **57**: 21–52.

Wiltbank, J. (1990). Challenges for improving calf crop. In: Proc. 39th Annu. Beef Cattle Short Course.. Univ. of Florida, Gainesville. Pp. 1-22.

Wolfenson, D., Thatcher, W., Savio, D., Badinga, L. and Lucy, C. (1994). The effect of a GnRH analogue on the dynamics of follicular development and synchronization of estrus in lactating cyclic dairy cows. *Theriogenology*. **42**: 633-644.

Yavas, Y. and Walton, S. (2000). Induction of ovulation in postpartum suckled beef cows: a review. *Theriogenology.* **54**, Pp. 1–23.

Zerabruk, M. Vangen, O. and Haile M. (2007). The status of cattle genetic resources in North Ethiopia: On-farm characterization of six major cattle breeds. *Animal Genetic Resources Information.* **40**: 15-32.

8. ANNEXES

Annex.1. Questionnaire Survey on the herd composition and herd and individual animal reproductive performance

How many *Begait* cattle do you have in your farm?

Group	status	Number
Cows	Pregnant	
	Non pregnant	
	Milking/suckling	
	Dry	
Young females	Heifers ≥ 3years old	
	Females < 3years old	
Male cattle	Bulls ≥ 3years old	
	Males < 3years old	
Total number of Calves born from September, 2009 - August, 2010	alive	
	dead	
Total number of cattle		

What was the age of your cows when they gave their first calf?

When your cow did give her recent birth?

When your cow did give her previous birth?

In which (Write 3) month most of your cows show estrus signs

Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug

When do you observe more number of calving and death of calves in your herd?

	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
calving												
Calf death												

Annex-2. Pre-structured formats and tables for data collecting during the study period

Annex-2.1. Data recording format on reproductive performance of *Begait* cattle

Nº.	ID	Production site and system (M,B,W,KA)	Parity	Age	Reproductive Performance						
					Pregnancy Status	AFS (months)	AFC (month)	PC (month & year)	Calf-live/dead	RC (month & year)	CI (month)
ID											
=											
Id											

entity Number; AFS=Age at First Service; AFC=Age at First Calving; PC=Previous Calving; RC=Recent Calving; CI=Calving Interval; M=Maikadra (sample taken from in and around Maikadra; agro-pastoral area); B= Bereha (sample taken from herds in Bereha; pastoral area); W=Sample taken from housed farms in Wukro; KA= Sample taken from crop-livestock production system in and around Wukro.

Annex-2.2. Data recording format on Lactation Performance of *Begait* cattle

Nº	ID	Production Site (in-situ or ex-situ)	Production system (M,B,W,KA)	Parity	Age	No. of milking per day (once or twice)	Lactation performance					
							Daily milk yield (Lt) (Stage of lactation)				Lactation length (day)	Total milk yield
							early	middle	late	Average		

ID=Identity Number; Lts= liters; M=Maikadra (sample taken from in and around Maikadra; agro-pastoral area); B= 'Bereha' (sample taken from herds in 'Bereha'; pastoral area); W=Sample taken from housed farms in Wukro; KA= Sample taken from crop-livestock production system in and around Wukro.

Annex-2.3. Data recording format on Evaluation of the Estrus Response, Estrus Characteristics and Synchronized Pregnancy of *Begait* cattle after estrus induction with $PGF_{2\alpha}$

ID	Parity	Age	Duration after Calving	Date of 1st injection of $PGF_{2\alpha}$	Response		Date of 2nd injection of $PGF_{2\alpha}$	Response		Observed Estrus Signs					Return to Estrus on day 18-24	Pregny af 3mor
					(+ve Or -ve	Hours after injection		(+ve Or -ve	Hours after injection	*Mo*	*VD*	*Restl*	*Bel*	*SRV*		

ID= Identity Number; MO= Mounting; VD= Vaginal Discharge; Bel=Bellowing; Restl= Restlessness; SRV= Swelling and redness of vulva; +ve= Positive; -ve= Negative.

Annex-2.4. Data recording format on Evaluation of the Estrus Response, Estrus Characteristics and of *Begait* cattle after estrus induction with GnRH- $PGF_{2\alpha}$ protocol

ID	*Parity*	*Age*	Duration after Calving	*Date of injection of GnRH*	Response		*Date of injection of $PGF_{2\alpha}$*	Response		Observed Estrus Signs					Return to Estrus on day 18-24	Pregnancy after 3mon
					(+ve Or -ve	*Hours after injection*		(+ve Or -ve	*Hours after injection*	*Mo*	*VD*	*Restl*	*Bel*	*SRV*		

ID= Identity Number; MO= Mounting; VD= Vaginal Discharge; Bel=Bellowing; Restl= Restlessness; SRV= Swelling and redness of vulva; +ve= Positive; -ve= Negative

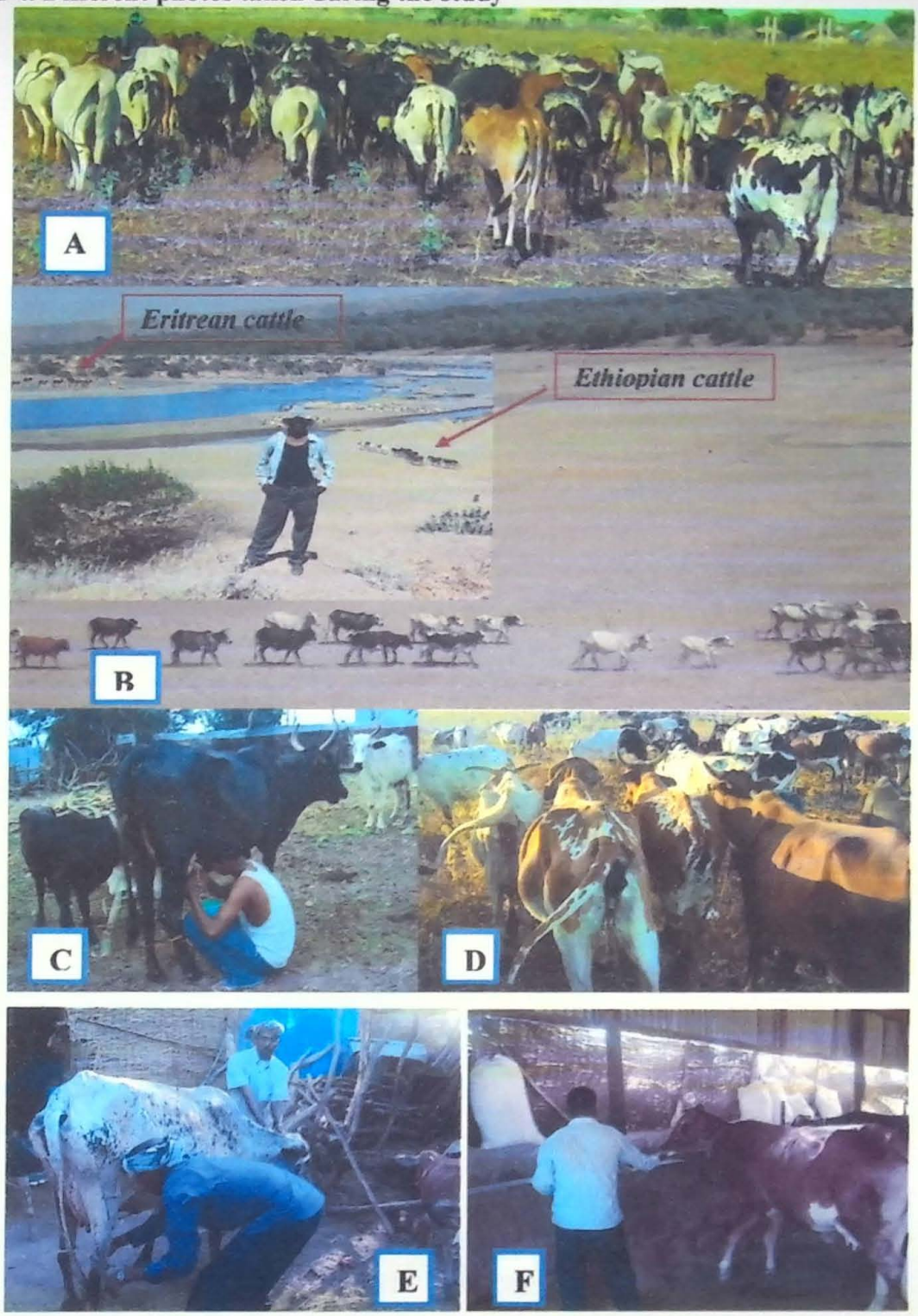
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Annex-3. Body Condition Scoring

Score	Description
0	Emaciated animal with an apparent subcutaneous, spinous process in the lumbar region feel sharp
1	spinous process are sharp, but less than in the score zero. There is some subcutaneous fat on these processes and on the point of the hip
2	Individual spinous processes are still fairly sharp to touch and ribs cannot be seen individually.
3	Spinous processes can be felt, but have surrounded feel and ribs cannot be seen individually.
4	Individual spinous processes can only be felt with firm pressure and point of hip are covered with fat and rounded
5	Spinous processes cannot be felt even with firm pressure, animal has a blocky appearance.

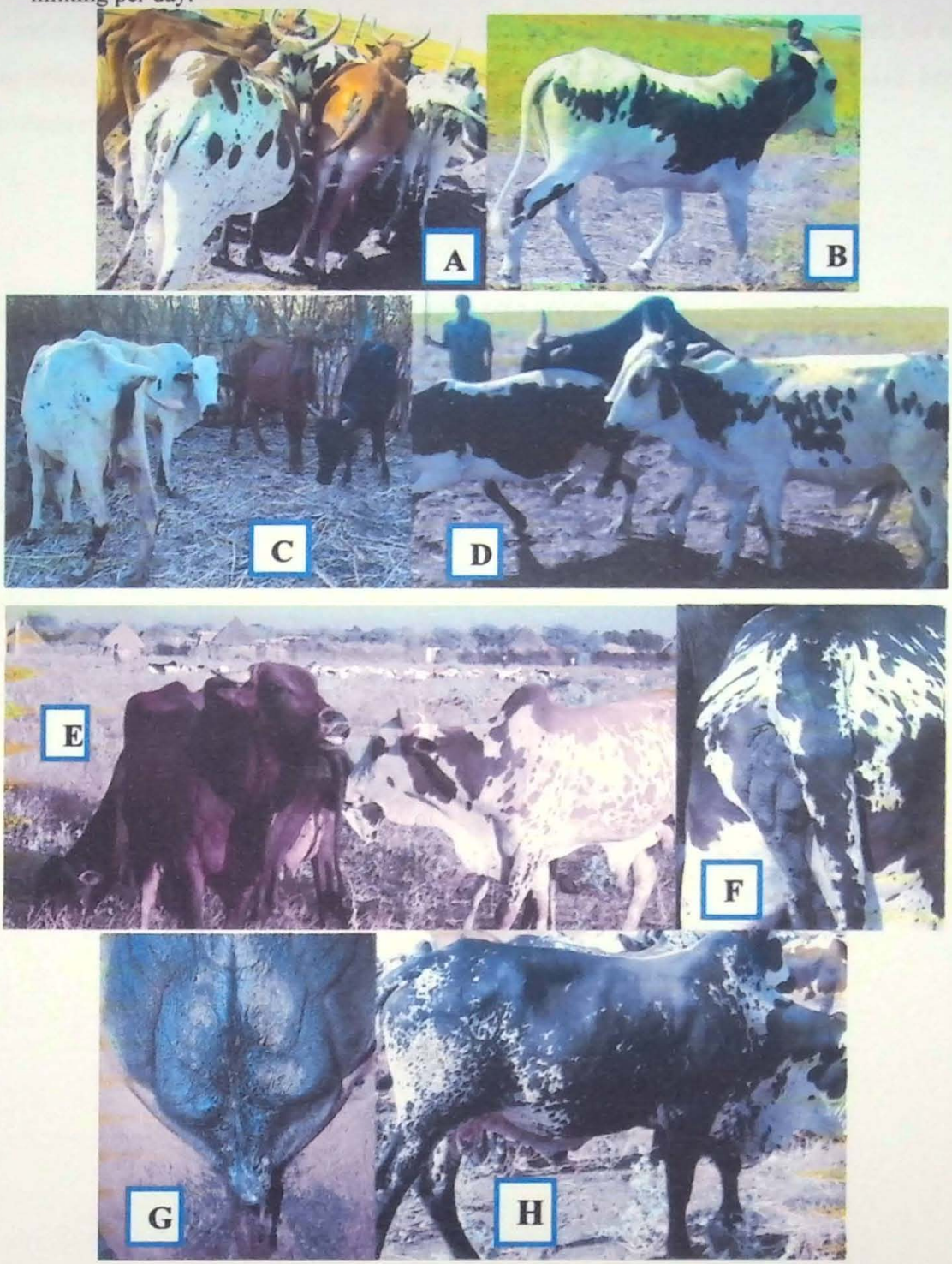
Source: Richard (1993)

Annex-4. Different photos taken during the study



Annex-4.1. Cows selected for the study of reproductive and lactation performance in the study area. **A**: taken from maykadra; **B**: taken at Tekeze river where cattle belongs to Eritrea and Ethiopia use the common drinking water; **C:** taken from agro-pastoral production); **D**: once milking per day

(from pastoral); **E**: once milking per day, crop-livestock production; **F**: in confinement, twice milking per day.



Annex-4.2. Animals selected and responded for the study of estrus synchronization in the study area. **A**: cows with good BCS; **B**: *Begait* heifer 3 years old; **C**: cows with poor BCS; **D**: mounting activity; **E**: bulls flehming or sniffing of the genitalia of cows; **F**: swelling of vulva; **G**: vaginal discharge and **H**: bull participated in the research for mating the synchronized cows

and heifers. (A, B and C are cattle selected for the treatments, while D, E, F, and G are some observed physiological and behavioral signs of estrus after treatment).

9. SIGNED DECLARATION SHEET

I, the undersigned declare that this thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

Name: BERIHU GEBREKIDAN TEKLEHAYMANOT

Signature: _____

Date: JUNE 28, 2011