# *CERTAIN ASPECTS OF THE REPRODUCTIVE PERFORMANCE OF ZEBU CATTLE IN CAMEROON*

by

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## SOME FOOD FOR THOUGHT

Animal Science that cannot be applied in practice is like rain in a hot stone; it evaporates and disappears.

*Jan C. Bonsma, Professor Emeritus, University of Pretoria*
*In: Livestock Production: a global approach (1980)*

Knowledge without common sense is folly;
Without method, it is waste;
Without kindness, it is fanaticism;
Without religion, it is death.
But with common sense, it is wisdom;
With method, it is power;
With charity, it is beneficence;
With religion, it is virtue and life and peace.

George *Farrar*

Cheerily, lad, look out on life,
Laughing at Fortune's frowns,
Grit is born of manly strife,
All have their ups and downs;
If you chance mishaps to meet,
Bear as a man should do,
Standing steadily on your feet.
Still to yourself be true.

Cheerily, lad, pursue your way,
Smile tho' your heart be sad,
Help your brothers when e'er you may,
Making the downcast glad;
Do your duty with hand and heart,
So tho' you win not fame,
You should have bravely played your part,
Victor in life's great game.

*Anonymous poet (Early 1900's)*

# DEDICATION

*In memory of my late parents, **Ferdinand** OMBIONYO and **Adrienne** MENGUETTI, without whom I would not have existed. You planted a tree but were not given the opportunity to watch it bear fruit;*

*To my aunt **Benedicte** KIBINDE who raised me and taught me from the start that nothing was easy and has to be eraned through hardship;*

*To my sister **Anne-Marie** EMENEKE, and my brothers **Henri** OMBIONO, **Justin** KIBONG, and **Frederic** OKO, for their constant support;*

*To my parents-in-law, **Isidore** KIAMA and **Victorine** OKOLO, who have always considered me as their very own;*

*To my life mate, **Agnès-Odile** MESSINE **née** BELEMBI,*
*and our children,*

***Bonaventure Aimé** SONGOLO,*

***Christophe Yannick** BOBIOKONO,*

***Jackie Diane Fidèle** KIBINDE,*

***Noel William** OMBIONYO,*

***David Guillaume** OMBIONO*

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Lord JESUS, thank you for making a lifelong dream come true. Hosanna in the highest. HALLELUJAH !

# DECLARATION

I declare that the thesis hereby submitted by me for the PHILOSOPHIAE DOCTOR degree at the University of the Free State is my own independent work and has not previously been submitted by me at another University/Faculty. I furthermore cede copyright of the thesis in favour of the University of the Free State.

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Messine Ombionyo

Bloemfontein, 5 December 2003

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# CHAPTER 1
# GENERAL INTRODUCTION

Reproductive performance is widely accepted as the most important economic trait in a beef cow herd. The relative economic importance of reproduction is ten times higher than that of production although only 10% of the variation in reproduction will respond to selection contrary to 40 to 50% of variation in production and products, respectively (Wilham, 1973). Various reports on beef cattle operations around the world have shown that one of the main reasons for the low productivity of cow-calf operations is the poor reproductive performance of the females. This limiting factor is even more important in the developing countries (Mukasa-Mugerwa *et a*l, 1991b).

One weaned calf per cow per any 365-d period is the goal of any well-managed beef cattle enterprise (Wiltbank, 1970; Dziuk and Bellows, 1983; Dawuda *et al.*, 1988a). Although this objective is often difficult to achieve under range conditions, it can almost be attained with good management practices (Dziuk and Bellows, 1983; Roche *et al.*, 2000). The question is, can this goal be achieved with the indigenous African cattle breeds in general, and with the Cameroonian Ngaoundere Gudali cattle managed under the local extensive conditions in particular? Information available shows that the Ngaoundere Gudali cows have low calving rates both under controlled (on-station) and traditional (on-farm) conditions - ranging from 45 to 65% (Dawa, 1988; IRZ/GTZ, 1989). Although this poor reproductive performance can be partially attributed to their genetic make-up, traits such as the late onset of puberty, leading to a late age at first calving (around 3.5 to 4.5 years), a long postpartum anoestrus and long calving intervals of approximately 530 d can be attributed to the environment in which the animals are maintained (Mbah *et al.*, 1987; IRZ/GTZ, 1989).

The milk production of beef cows is one of the main factors influencing the weaning weight of calves in all breeds (Clutter and Nielsen, 1987). Exact measurements for milk production are normally not available for beef cattle, as the milk produced by the cows of these breeds is not the primary end-product of the beef cow/calf enterprise, and therefore is consumed by the calf. As direct measurements are not always available for beef breeds, the weaning weights of the calves are often used as indicators of the dams' milk production potential (Diaz *et al.*, 1992). The Ngaoundere

Gudali cow has been shown to be a poor milk producer, averaging 2.1 to 2.7 liters of milk per day, for a total lactation period of 160 to 170 days - which is shorter than the 6 to 7 months expected from a typical beef cow (Mbah *et al.*, 1987). The Gudali female therefore cannot effectively nurse a calf beyond the age of 6 months without detrimental effects on the dam's body reserves and seriously compromising her chances of producing another calf within a 12-month period.

A survey in the traditional livestock sector of the Adamawa (Cameroon) showed that 70% of the farmers interviewed wean their calves later than 8 months of age (IRZ/GTZ, 1989). However, in general, the local farmers do not wean the calves and allow them to suckle their dams until a new calf is born - in which case the older calf is usually naturally rejected. This practice is however not acceptable and not sustainable. As the dam has little or no milk available for the calf beyond the sixth month of lactation, suckling at this time only leads to delayed postpartum ovarian function by inhibiting the pituitary gonadotrophin hormone release (Hafez and Hafez, 2000), and has no significant benefit to the calf growth rate at this stage. Therefore, the practice of late weaning contributes to increase the postpartum anoestrous period, the long intercalving periods and the general poor productive performance of the Gudali cow. Another factor contributing to the overall poor reproductive and productive performances of the breed is the high calf mortality rate of approximately 20%. High calf mortality rates have been reported, especially among the small-scale farmers in Cameroon, but no specific causes have been yet identified. It is also not known whether these mortalities can be attributed to the breed *per se*, to the management, to a high incidence of calf diseases or to an insufficient intake of antibodies by the newborn from the dam's colostrum early postpartum. Vann *et al.* (1995) cited reports showing that purebred *Bos indicus* calves have lower survival rates than *Bos taurus* calves. Passive immunity is dependent exclusively on intestinal absorption of maternal antibodies from the colostrum during the first 24 hours of life. Failure of adequate transfer is usually reflected by a low serum Immunoglobulin concentration, associated with an increased incidence of calf diseases and high mortality rates. Calves that are agammaglobulinemic or hypoglobulinemic have either failed to suckle or to suckle sufficient quantities of colostrum to acquire passive immunity (Vann *et al.*, 1995).

The Adamawa Highlands, as the main beef-producing region of Cameroon would certainly profit from any improvement in the reproductive performance of the Ngaoundere Gudali breed, a breed indigenous to this area and the second most important in number in Cameroon behind the Mbororo breeds (Mbah, 1992; Messine *et al.*, 1995). In general, it is thought that breed, environment, nutrition and management are the main contributing factors to the low reproductive indices of the Ngaoundere Gudali cattle. An improvement on the reproductive efficiency of the indigenous cattle breeds in general and that of the Ngaoundere Gudali in particular would have a positive impact on the overall beef production of the country. In the short term, improving the reproductive efficiency of local cattle would necessarily lead to an increase in the cattle population and beef production to meet the demands of an increasing human population. These higher numbers would in turn serve as a more stable ground for a higher selection pressure in order to improve further on the productive performance of the breeds and the sustainability of the local production systems. To achieve this goal, there is a need to improve the overall management and control of the most prevalent cattle diseases, particularly tick-borne diseases and trypanosomiasis.

The heritability of fertility in cattle is accepted to be low and thus progress through selective breeding is slow and cumbersome. Selection for certain productive traits in the Ngaoundere Gudali cattle in Cameroon started in the late 60s. Although extensive studies have been carried out since then, these focused mainly either on the calf growth (from birth to weaning, and from weaning to 18 months) or on the production of the mature animal (response to fattening and dry season supplementation). Very few studies have addressed aspects pertaining to the understanding of the reproductive performance of the Ngaoundere Gudali, its potential and means of improving this performance. The present study was carried out to contribute to the characterization of the most important productive and reproductive traits of Ngaoundere Gudali cattle breed farmed under traditional management conditions in the Cameroon Adamawa Highlands – with the aim of identifying possible management strategies to unlock the productive potential of this indigenous hardy breed. The effects of certain improved management practices on the overall productivity of this breed were investigated and some recommendations are made to improve its productive and reproductive efficiencies.

# CHAPTER 2

# LITERATURE REVIEW

# FACTORS AFFECTING THE PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF BEEF CATTLE

## 2. 1. INTRODUCTION

Reproductive performance is widely accepted as the most important economic trait in a beef cow operation (Wiltbank, 1994). According to Wilham (1973), reproduction in relative economic terms is 10 times more important than production. Reports of beef cattle cow-calf operations show the main reason for the low productivity in this sector to be the poor reproductive performance of the females (Dziuk and Bellows, 1983). This situation results from a combination of genetic, physiological, management and environmental factors, which influence all the different reproductive stages, starting from birth through weaning and puberty, age at first calving, postpartum period to the calving interval (Agyemang *et al.*, 1991).

## 2. 2. PUBERTY

There is some controversy as to the proper definition of puberty. According to McDonald (1975), puberty in the female is age at which first overt oestrus is observed and the period when an animal becomes sexually mature, sexual secondary characteristics become more conspicuous and is accompanied by a rapid increase in size of reproductive organs. For Robinson (1977), puberty is the process whereby animals become capable of reproducing themselves. Puberty in females is thus the period when an animal is able to ovulate and show overt oestrus signs for a period of time long enough to permit insemination or proper mounting, intromission and ejaculation leading to semen deposition at the proper location in the genital tract (Edey *et al.*, 1978). Moran *et al.* (1989) go a little further and define puberty as being attained by a heifer at the first oestrus that is followed by a normal luteal phase as a heifer that has ovulated could still be incapable to reproduce under normal conditions, or could conceive to a bull at a silent ovulation, albeit followed by a full luteal phase. Puberty is basically the result of a gradual adjustment between increasing gonadotropic activity and the ability of the gonads to simultaneously assume steroidogenesis and gametogenesis (Hafez and Hafez, 2000). Age at puberty is the age at which the females first express standing oestrus (Gonzales-Padilla *et al.*, 1975a; Gregory *et al.*, 1979a; Laster *et al.*, 1979) or oestrus with ovulation - not to be confused with sexual maturity (Bearden and Fuquay, 1980; Tizikara, 1984), which by definition is the period at which the animal is able to mate, conceive and bear the burden of pregnancy to term (Tizikara, 1984). According to Hafez and Hafez (2000), under normal breeding conditions, puberty occurs at approximately 12 months of age in cattle, although other researchers indicate a time period varying from 6 to 24 months (Moran *et al.*, 1989).

From an endocrine point of view, puberty in the female is the first behavioural oestrus accompanied by the development of a corpus luteum (CL) that is maintained for a period characteristic to the particular species (Kinder *et al.*, 1987; Moran *et al.*, 1989). Puberty is therefore the culmination of a gradual sexual maturation process that initiates before birth, occurs within the reproductive endocrine axis, and continues throughout the pre-and the peri-pubertal periods of the developing female. It is just one (though very important) of the many events gradually leading to adulthood (Kinder *et al.*, 1987; 1994).

The onset of puberty is more closely related to body weight than to age (Short and Bellows, 1971; Robinson, 1977; Dobson and Kamonpatana, 1986). Dairy cattle generally reach puberty at 30 to 40% of their mature body weight, whereas in European type beef cattle this percentage stands at 45 to 55% of the mature body weight (Hafez and Hafez, 2000) and at a higher percentage and a later age in zebu cattle (Dobson and Kamonpatana, 1986). This weight in cattle is quoted to be 250 to 300 kg at an age of 7-12 months (Dobson and Kamonpatana, 1986). However, live weight is not always easy to measure under practical conditions and thus age at puberty is therefore most often used to characterise puberty.

Early age at puberty (AP) is favourably associated with a higher pregnancy rate, calving rate during the first 25 days of the calving season, less oestrous cycles per conception for the first through the 4$^{th}$ lactation, higher milk potential and heavier progeny weaning (Andersen *et al.*, 1991). Age at puberty is thus a major determinant of lifetime reproductive efficiency in beef cows (Schillo *et al.*, 1992). In commercial beef cattle operations, efforts have been focussed on heifers conceiving at 14 to 16 months of age in order to calve at 2 instead of 3 years of age, making age at puberty a trait of great economic importance. The earlier the time of first calving, the sooner the recovery of the farmer's investment starts (Short *et al.*, 1994b). However, a higher percentage of animals bred at puberty have difficulties at parturition (Bearden and Fuquay, 1980), although early calving heifers have a higher average annual lifetime calf production (more and heavier calves) than late calving heifers (Lesmeister *et al.*, 1973). It is considered that heifers should be allowed to experience 2 to 3 oestrous cycles before the onset of their first breeding season because the fertility of the first oestrus is generally lower than that of the subsequent oestrous periods (Byerley *et al.*, 1987).

***2. 2. 1. Endocrine mechanisms regulating the onset of puberty in cattle***

From the few detailed studies carried out on the hormonal control of the peri-pubertal period in heifers, it is evident that puberty is under the control of the hypothalamo-pituitary-ovarian axis. The release of pituitary hormones (FSH and LH) is known to begin shortly after birth. Gonzales-Padilla *et al.* (1975a) and Schams *et al.* (1981) found that heifers that ovulated at approximately 9 months of age had low plasma FSH and LH concentrations at birth. These concentrations increased from birth to 3 months of age and then declined until around 6 months of age. The levels of these hormones then increase gradually culminating around 9 months in ovulation. While these changes in the mean blood level of LH may reflect the changes in the frequency of episodic secretion, they bear no relationship to changes in the amplitude of short-term pulses. The frequency of pulsatile LH secretion increases dramatically during the 50 days prior to ovulation. Although the amplitude of LH pulses also increases, the higher pulse frequency appears to be crucial in triggering ovulation (Kinder *et al.*, 1987). When heifers are ovariectomised before puberty, the frequency of the LH pulses increases (Day *et al.*, 1984). An injection of oestradiol to prepubertal heifers was found to result in LH release as early as 3 months of age (Peters and Ball, 1995). These studies show the particular role of pituitary LH on the onset of puberty.

FSH secretion has been shown to be more constant than LH in heifers, albeit some minor variations have been observed by Gonzales-Padilla *et al.* (1975a). The study by Schams *et al.* (1981) reported FSH secretion not to change greatly over the time of maturation, and this hormone may only play a permissive role in puberty. This parallel rise and increase of both LH and FSH during the prepubertal phase could be attributed to the simultaneous release of these hormones from the pituitary cells that synthesise both of these hormones.

Plasma oestrogen ($E_2$) and progesterone ($P_4$) are two very important steroid hormones in heifer reproduction and although they play an important role on the onset of puberty, neither one of them initiates the process (Moran *et al.*, 1989). The levels of these hormones remain low and constant throughout prepuberty (Schams *et al.*, 1981), relative to adult patterns, until the first ovulation is imminent (8 – 12 days) (Gonzalez-Padilla *et al.,* 1975c; Schams *et al.*, 1981; Day *et al.*, 1984). After the first oestrus, normal luteal patterns are observed, with plasma $P_4$ reaching levels of 4 ng/ml. Berardinelli *et al.* (1979) observed small luteal structures embedded within the ovary, but not always visible on the surface. These structures may be the source of prepubertal $P_4$ in the heifers. Plasma oestradiol concentrations, typical of mature cows, increase over the 8 days period before the first oestrus (Glencross, 1984).

Injections of $E_2$ evoked a release of LH in prepubertal heifers, but normally CLs were formed only in those animals pre-treated with $P_4$ (Gonzales-Padilla *et al.*, 1975c). In ovariectomised prepubertal heifers treated with $E_2$, the frequency of LH pulses is suppressed to frequencies similar to that in intact control heifers (Day *et al.*, 1984). The frequency of LH pulses in ovariectomised heifers treated with $E_2$ during the prepubertal period increased to that of ovariectomised heifers not treated with $E_2$ during the period when the age in attaining puberty matched that of the control heifers (Day *et al.*, 1984).

### *2. 2. 2. Factors affecting age at puberty in the heifer*

The heritability of age at puberty (or age at first oestrus in some cases) is ranked as moderate to high (Galina and Arthur, 1989a; Morris *et al.*, 1992; Brinks, 1994). Age at puberty has been shown to be affected by different factors such as genotype/breed of dam and sire (Gregory *et al.*, 1979a; Laster *et al.*, 1979; Grass *et al.*, 1982; Nelsen *et al.*, 1985; Galina and Arthur, 1989a, Morris *et al.*, 1992; Kinder *et al.*, 1994; Short *et al.*, 1994b), year and month of calving (Plasse *et al.*, 1968b; Lemka *et al*, 1973), body weight as affected by nutrition, growth rates before and after weaning (Short and Bellows, 1971; Denis and Thiongane, 1978; Bearden and Fuquay, 1980; Gauthier and Thimonier, 1984; Oyedipe *et al.*, 1982b; Greer *et al.*, 1983; Wiltbank, 1994), environmental factors (Plasse *et al.*, 1968a; Bearden and Fuquay, 1980; Gauthier and

Thimonier, 1984; Hansen, 1985), male effect (Izard and Vandenbergh, 1982), as well as management (Short *et al.*, 1994b).

**2. 2. 2. 1. Genotype**

The age and weight at puberty in cattle are primarily a function of the genetic make-up of the heifer, both between and within breeds (Wiltbank *et al.*, 1966; Short and Bellows, 1971; Laster *et al.*, 1979). There is abundant literature to show that AP is not the same in all breeds of cattle (Table 2.1). In general, *Bos taurus* dairy cattle tend to reach puberty at an earlier age and a higher body weight (BW) than *Bos indicus* breeds, with *Bos taurus* beef breeds being intermediate (Ferrell, 1982; Newman and Deland, 1991; Kinder *at al.,* 1994; Peters and Ball, 1995). Other studies, particularly in the U.S.A. (Martin *et al.*, 1992; Häuser, 1994), showed that heifers sired by breeds with a large mature body size (e.g. Charolais, Chianina, Limousin, Hereford) tend to be older and heavier at puberty than do heifers sired by breeds with a smaller mature size (e.g. Hereford, Angus). Ferrell (1982) reported that larger breed heifers (e.g. Simmental) are younger and heavier at puberty than the smaller frame size breeds (e.g. Angus). The milk production capacity was not taken into consideration. This can further complicate the relationship between mature size and age at puberty. Breeds historically selected for milk production (e.g. Simmental, Holstein, Brown Swiss, Gelbvieh, Braunvieh, Red Poll, Pinzgauer) reach puberty earlier than breeds of similar mature size that were not selected for milk production (Charolais and Chianina) (Gregory *et al.*, 1991; Martin *et al.*, 1992; Hauser, 1994). *Bos indicus* breeds (e.g. Brahman, Sahiwal), which reach puberty later than other breeds (Brangus, Santa Gertrudis, Chianina, Charolais and Limousin) seem to have been subjected to selection pressures and objectives as well as environmental differences that separate them from the *Bos taurus* breeds in terms of age at which they exhibit first oestrus (Martin *et al.*, 1992).

These findings imply that cows with a genetic ability for milk production reach puberty earlier and dairy crossbred (dairy *B. taurus* x beef *B. taurus*, or dairy *B. taurus* x *B. indicus*) would have the advantage of earlier reproductive maturation (Ferrell, 1982; Grass *et al.*, 1982; Gregory *et al.*, 1991). The crossbreeding of the two types (e.g. dairy *Bos taurus* x beef *Bos taurus* or *Bos taurus x Bos indicus*) generally improves the age at puberty of the beef *Bos taurus* or *Bos indicus* breeds (Galina and Arthur, 1989a; Martin *et al.*, 1992).

**Table 2. 1: Mean (± SD) age (months) at first calving in certain breeds under tropical conditions** (Galina and Arthur, 1989a)

| Breeds | Number of studies | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Holstein | 14 | 32.8 | 7.0 | 25.3 | 54.7 |
| Sahiwal | 10 | 40.8 | 7.2 | 27.1 | 52.6 |
| Gir | 07 | 48.0 | 5.9 | 41.1 | 58.2 |
| Milking Zebu | 62 | 33.1 | 4.3 | 25.6 | 50.7 |
| Jersey | 05 | 27.7 | 3.2 | 24.7 | 31.6 |
| Nelore | 05 | 43.9 | 3.0 | 39.4 | 47.3 |
| Guzerat | 03 | 44.2 | 3.9 | 39.7 | 47.0 |
| Brown Swiss | 05 | 35.6 | 9.4 | 28.5 | 51.9 |
| Hariana | 13 | 48.0 | 7.6 | 31.6 | 58.4 |
| Tharparkar | 09 | 43.2 | 8.1 | 29.2 | 53.4 |
| Beef Zebu* | 18 | 42.9 | 9.1 | 27.2 | 67.1 |
| TOTAL | 153 | 37.9 | 0.6 | 24.7 | 67.1 |

* Unidentified breeds

Toelle and Robinson (1985) reported scrotal circumference of bulls to be favourably correlated to several female reproductive traits in their daughters. Morris *et al.* (1992) and earlier work cited by Brinks (1994) showed favourable genetic correlation estimates (-0.71 to –1.07) between the mean age at first oestrus and the scrotal circumference of their siblings. These very strong genetic relationships indicate that AP and scrotal circumference are essentially regulated by the same genes. Increases in male (scrotal circumference) fertility, which is favourably related to growth from birth to yearling ages, can be associated with increases in female fertility (early age and high weight at first oestrus) (Morris *et al.*, 1992; Brinks, 1994).

#### 2. 2. 2. 2. Year and season of calving

Reproduction in cattle living in a temperate climate is not limited to one period of the year. Domestic cattle may have evolved in situations whereby natural selection for seasonal breeding was reduced due to the supplemental feeding, shelter and care of the young (Hansen, 1985). This notwithstanding, certain aspects of reproduction are altered by seasonal variations in environment and particularly by photoperiod and food availability.

Date of birth seems to play an important role on the age at which puberty is attained. Arije and Wiltbank (1971) reported that heifers born late in the spring calving season were lighter and younger at puberty than those born earlier. Grass *et al.* (1982) also indicated that heifers on a high plane of nutrition and born in spring reached puberty earlier than those born in winter under the same conditions. The opposite happened for heifers on a low plane of nutrition.

From the reviews of Hansen (1985) and Kinder *et al.* (1994), it is obvious that age at puberty was influenced by date/season of birth. The fact that there are discrepancies between reports is a reflection of the occurrence of sexual development over several seasons, leading to the confounding of season of birth with season at other stages of prepubertal development. In addition, the spectrum of environments that the animals are subjected to is determined by other factors e.g. breed and nutrition. The natural environmental conditions to which the heifers are exposed during the first 6 months of life influence age at puberty. So, for example, under temperate environments, heifers born in the autumn tend to reach puberty earlier than heifers born in the spring. Also, exposure during the second 6 months of life to the long photoperiods and temperatures that would normally exist during the second 6 months of life of autumn-born heifers was associated with earlier age at puberty (Schillo *et al.*, 1992). In contrast to these findings, Greer (1984) failed to detect any effect of season of birth on age at first oestrus in British breeds and beef breed heifer crosses in Montana (USA).

#### 2. 2. 2. 3. Nutrition and growth rate

Researchers differ in opinion as to which nutritional program is the best for reproductive development. Extremes have ranged from the provision of high-energy complete diets at weaning for creep-fed heifers, to the provision of maintenance diets to the calves after weaning for poorly mothered heifers. Research has however shown that neither extremes are desirable. On the one hand, high nutritional levels of nutrition have resulted in weak oestrous signs, sub-normal conception rates, reduced lifespan, decreased mammary gland development and impaired milking ability. On the other hand, low nutritional levels have led to poor reproductive performance, reduced milk production and poor weaning weights (Wiltbank *et al.*, 1966; Short and Bellows, 1971; Ferrell, 1982; Day *et al.*, 1984).

Greater preweaning weight gains are usually associated with a younger age and heavier weight at puberty. Growth rate during the pre- and post-weaning periods have also been shown to be inversely related to age at puberty in beef heifers (Wiltbank *et al.*, 1966; Arije and Wiltbank, 1971; Short and Bellows, 1971; Roberson *et al.*, 1987). Lamond (1970) proposed the concept of a "target body weight" which supposes that the heifers should be fed to achieve a certain body weight at which most heifers become pubertal by the onset of the breeding season. It has been shown that many nutritional factors interact with dietary energy intake to regulate the age at puberty. If rate of gain from weaning to puberty has a marked effect on age at first oestrus (Lamond, 1970; Fleck *et al.*, 1980), it is obvious that in heifers fed high levels of dietary energy and adequate levels of other nutrients during the prepubertal period, weight alone is not the factor that determines age at puberty. In this situation, other factors affect age at which puberty is attained. If heifers are light at weaning, the animals are destined to have a delayed time of onset of puberty, compared to their heavier contemporaries, even when specialised management techniques are implemented. However, these heifers can reach puberty at a younger age if given preferential treatment (Kinder et al, 1994).

Supplementing weaned heifers to obtain higher post-weaning growth rates results in younger ages and higher weights at puberty (Short and Bellows, 1971; Denis and Thiongane, 1978; Fleck *et al.*, 1980; Greer *et al.*, 1983; Wiltbank *et al.*, 1994). Well-fed heifers (on an acceptable plane of nutrition) tend to grow faster and will cycle earlier than slow growing heifers and will tend to calve earlier (Bearden and Fuquay, 1980; Fleck *et al.*, 1980; Gauthier and Thimonier, 1984; Buskirk *et al.*, 1995a,b; D'Hour *et al.*, 1998). Higher nutritional levels of dietary protein in the presence of isocaloric diets also reduce the interval from birth to first calving (Oyedipe *et al.*, 1982b), as both the pre- and post-weaning rates of gain influence the weight at which puberty occurs (Kinder *et al.*, 1994; Buskirk *et al.*, 1995a,b). To the contrary, it was found that ad libitum feeding of diets low in energy delayed the onset of pubertal oestrus, as heifers fed these diets could not increase feed intake sufficiently to equal the total digestible nutrient (TDN) intake of high energy-fed heifers. Similar situations may prevail under poor pasture conditions (Grass *et al.*, 1982).

Variation in feed intake affects the age at which puberty occurs in heifers (Grass *et al.*, 1982; Wiltbank *et al.*, 1985). Warnick (1994) recommended an ADG of 350 - 450 g from weaning to the beginning of the breeding season as the target for Brahman heifers.

**2. 2. 2. 4. The effect of management on puberty**

Management is the sum of decisions and actions made by a manager which then becomes the focal point for the success or failure of any program (Dziuk and Bellows, 1983). An adequate reproductive management project should be desirable because of the convenience, economics, disease or environmental control, and involves quite a vast array of disciplines. Management decisions on aspects such as age at first breeding of heifers are not always easy, as it can involve many other factors with complex interactions between them. So for example, heifers that conceive early in their first breeding season calve earlier and wean heavier calves than those that conceive late in their first breeding season (Short and Bellows, 1971). In addition, under satisfactory conditions, heifers which conceive early in their first breeding season maintain this production advantage throughout their lifetime (Lesmeister *et al.,* 1973).

When both biological and economical outcomes are considered, management decisions often produce results which are in part advantageous, and in part detrimental (Short *et al.*, 1994b). So, for example, heifers should reach puberty 1 to 3 months before the desired average age of breeding. Thus, to breed yearlings to calve at 2 years would mean that heifers should reach puberty at 12 to 14 months of age. Breeding at a younger age reduces the time required to reach a productive stage and therefore lowers the production costs during the non-productive stage (Tizikara, 1984). Costs per unit output would be lower when beef heifers are managed to calve first at two years rather than at 3 years of age (Nùñez-Dominguez *et al.*, 1991; Short *et al.*, 1994b). Lepen *et al.* (1993) were able to mate Nguni heifers as early as 13 to 15 months, without the initial reproductive performance, body mass and reconception being suppressed. The authors concluded that with effective herd and pasture management and under extensive acceptable pasture conditions, the Nguni breed could successfully calve before or at 24 months of age.

Usually, improved nutrition will reduce the age at puberty and the age at first calving (AFC), but calving difficulties will tend to become more common and the costs associated with breeding at a younger age will increase (Short *et al.*, 1994b). In practical terms, breeding too early means breeding at or close to the puberal oestrus. Byerley *et al.* (1987) demonstrated that fertility at the puberal oestrus in beef heifers is lower than that of the third oestrus. The higher fertility at this third oestrus may be related to maturational changes associated with cyclic activity. According to Short *et al.* (1994b), a heifer calving at 2 years of age has only attained about 80% of the breed mature weight and will continue to grow until the second parturition. This situation creates a competition for nutrients available for growth, lactation and rebreeding. These 2-year old calvers will wean lighter calves, have longer intervals from calving to their first oestrus postpartum, and lower pregnancy rates in the second year (Laster *et al.*, 1979; Bellows *et al.*, 1982). These problems can however be partially overcome by adequate management (Short *et al.*, 1994b).

Wiltbank (1970) suggested that initiating the breeding season for replacement heifers 20 days earlier than in the cow herd, could increase the pregnancy rate in the young females when rebred. This practice is aimed at making up for the 15 to 25 day longer postpartum interval delay to first oestrus of young dams nursing their first calf, compared to the older cows. However, this early breeding which allows the heifer additional time to return to oestrus and be rebred with the older cows, also means earlier calving - at a time when pastures may not be readily available either in quantity or quality for the lactating female to maintain or gain weight. The decision taken by the manager can therefore lead to a low or high lifetime reproductive performance (Short and Bellows, 1971; Dziuk and Bellows, 1983).

**2. 2. 2. 5. Hormonal induction of puberty**

Although the use of exogenous hormones to manipulate the reproductive activity of livestock is an integral part of management, it is considered separately here as this is a unique managerial decision. It is a direct interference with the normal physiological processes by either inhibiting or enhancing the production of naturally secreted hormones. In an attempt to stimulate the transient rise in $P_4$ that occurs prior to the first oestrus, hormones have been used to induce and/or synchronise puberty in beef heifers. Pre-pubertal heifers are treated with either progesterone implants or daily injections thereof usually combined with either an oestrogen or PMSG. These treatments with external $P_4$ will suppress pituitary LH release and therefore stimulate ovarian follicle development (Gonzales-Padilla *et al.*, 1975a,b).

The Syncro-Mate-B (SMB) regimen entails administering a norgestomet implant for 9 to 11 days, with an intramuscular injection of norgestomet and oestradiol valerate at the time of artificial insemination. It has been used to induce fertility in prepubertal heifers (Gonzales-Padilla *et al.*, 1975a,b; Burfening, 1979; Sheffield and Ellicott, 1982; Spitzer, 1982). Although puberty in young and (or) lightweight heifers has been induced, conception at the induced oestrus has usually been low. Burfening (1979) also used norgestomet with 79% of the light-weight heifers diagnosed pregnant against 95% of control heifers of normal body weight, making evident the higher foetal loss when heifers do not have an optimal weight at the time of puberty induction. It can be concluded that induction of puberty in heifers with progestins is possible, but fertility is relatively poor, particularly if these heifers are too young or lighter in bodyweight (Kinder *et al.*, 1994).

Galina and Arthur (1989a) reviewed the control of oestrus in tropical beef heifers and showed that studies have been carried out, with varying degrees of success. Escobedo *et al.* (1989) used the SMB regimen to induce puberty in *Bos taurus x Bos indicus* heifers and was able to induce oestrus, but this was not followed by the development of a CL. Rodrigues *et al.* (1999) treated prepubertal Brahman heifers with $E_2$ implants for 90 days to reduce the response of the hypothalamic –pituitary axis negative feedback and induce an earlier onset of puberty. The mean age and weight at puberty of non-treated heifers were greater than previously reported. It was concluded that, although the big variation in heifers may be indicative of the individual response to oestrogen, the treatment of heifers with exogenous oestrogen during specific periods of prepuberty is unable to reduce the age and weight at puberty in *Bos indicus* heifers. In most studies progesterone priming seems necessary for oestrogen therapy to be effective. There is however a scarcity of information on the mechanisms that regulate the onset of puberty in tropical cattle.

**2. 2. 2. 6. The effect of environment on puberty**

Cattle are not seasonal breeders. However, several studies have shown that there is seasonal variation in the bovine reproductive activity. Season has an effect on age at puberty, as shown by Plasse *et al.* (1968a), who noted a high incidence of anovulatory cycles during winter in Brahman heifers and an extension of the oestrous cycles in stressed heifers. Gauthier and Thimonier (1984) reported similar findings in Creole heifers. Beef heifers reared at 10°C reached puberty at 10.5 months, compared to those reared at 27°C which attained puberty at over 13 months (Bearden and Fuquay, 1980). Fleck *et al.* (1980) studied the effect of periodic weight changes on heifer development and reproductive performance following parturition and found heifers with higher body weight gains during the first winter as weanlings to have a higher breeding efficiency when bred as yearlings giving birth to larger calves, having less calving difficulties and recording higher breeding efficiency at the subsequent breeding, than those with a lower weight gain. It was concluded that adequate growth from weaning to yearling age is important for future production and reproduction as two-year olds. Plasse *et al.* (1968a) showed the reproductive activity of Brahman heifers, as measured by frequency of corpora lutea and uterine tone, to increase during the spring months, peak during summer and decrease to a minimum during winter.

The incidence of prepubertal oestrus may also be related to photoperiod. While some seasonal variation is undoubtedly caused by a variation in management, effects of season on puberty can be mimicked by altering daylength (Nelsen *et al.*, 1985). This suggests that photoperiod is one of the environmental stimuli responsible for seasonal effects (Hansen, 1985). These findings tend to support the fact that natural environmental conditions to which the animal is subjected to during its first 6 months of life, influence puberty (Kinder *et al.*, 1994).

According to Hansen (1985), discrepancies between trials concerning the effects of season on the onset of puberty in cattle could be attributable to many factors. So, for example, sexual development in heifers occurs over several seasons and heifers with the propensity to attain puberty at earlier ages may be affected by season of birth differently to others that attain puberty at older ages. The existence of seasonal effects on reproduction may therefore create the propensity for spring and summer calving. On the other hand, nutrition may interact with season to influence timing of onset of puberty (Little *et al.*, 1981; Grass *et al.*, 1982). The overall effects of season on the onset of puberty in beef cattle could therefore be attributed to daylength, ambient temperature and other less-defined variables (Schillo *et al.*, 1992).

**2. 2. 2. 7. The bull effect and induction of puberty**

Oro-nasal administration of bull urine to pre-pubertal heifers has resulted in an increase of the proportion of females reaching puberty during an 8-week treatment period (Izard and Vandenbergh, 1982). These authors concluded that bull urine may contain a priming pheromone that hastens the onset of puberty in heifers, and a positive association between bodyweight and the response to pheromonal cues in bull urine was suggested. Roberson *et al.* (1991) reported that exposure of replacement heifers to teaser bulls could increase the proportion of heifers attaining puberty by the initiation of breeding at 14 months of age. Furthermore, growth rates interact with the stimulatory effect of bulls to reduce the age at puberty in yearling heifers. These findings are supported by Kinder *et al.* (1994) who showed that, over a 4-year period, heifers exposed to epididectomised bulls and fed a diet for high growth rate reached puberty 73 days earlier than heifers not exposed and fed for lower growth rates. Additionally, heifers exposed to bulls but at a lower growth rate and those not exposed but attaining a high growth rate reached puberty 23 days earlier than heifers not exposed to bulls but on the reduced growth rate.

However, Berardinelli *et al.* (1978) and MacMillian *et al.* (1979) found short-term exposure of heifers to males to have no effect on the age at puberty. Roberson *et al.* (1987) found that long exposure of beef heifers to mature bulls had no influence on either the proportion or the age and weight at which they reached puberty.

***2. 2. 3. Assessing puberty in the heifer***

Literature shows direct selection (visual appraisal) for AP is seldom practised in beef cattle because of the time and labour involved (Brinks, 1994). Other methods have to be used. Under practical field conditions, age at puberty can be assessed either through behavioural oestrus (Andersen *et al.*, 1991), or by the identification (generally via rectal palpation) of functional ovarian structures (particularly a corpus luteum) (Galina and Arthur, 1989a; Andersen *et al.,* 1991; Brinks, 1994).

**2. 2. 3. 1. Behavioural oestrus**

Zebu heifers have been reported to come into oestrus at an advanced age. A review of cattle reproduction in the tropics showed tropical heifers to be first observed in oestrus at ages varying from 15.6 months in East African Zebu, 23.3 months in the Ongole, to 34 months in Sahiwal cattle in Pakistan (Galina and Arthur, 1989a). These heifers show a high incidence of anovulatory oestrus (behavioural oestrus not followed by ovulation and formation of a corpus luteum), termed non-pubertal oestrus (Kinder *et al.*, 1994). The mean interval between the first non-pubertal oestrus and normal oestrus was approximately 89 days. Johnson and Gambo (1979), working with White Fulani heifers in Nigeria, found only 9% of the 32 heifers to show 4 consecutive oestrous periods during a 112-day continuous observation period. Which was indicative of the fact that most heifers exhibited at least one silent oestrus. In addition to the zebu type cattle not usually displaying overt signs of oestrus, oestrus in heifers are even more difficult to detect because of the complex social structure in the herd. This social structure overrides sexual behaviour and masks the natural expression of oestrus (Galina *et al.*, 1996).

Plasse *et al.* (1968a) reported the average age at first detection of a CL by rectal palpation to be 19.4 months in Brahman cattle compared to 17 months in Brahman x Shorthorn crosses. The proportion of heifers detected with a first CL was largely influenced by season the highest being in summer and the lowest in winter. Other authors cited by Galina and Arthur (1989a), using rectal palpation, estimated the age at puberty to be from 21.5 (Criollo) to 24.5 months (Brahman).

However, neither oestrous detection nor palpation of a CL seem to be an accurate indication of the mechanisms that govern the onset of puberty (Galina and Arthur, 1989a). Schwalbach (1997) adapted a reproductive tract scoring system previously reported by Andersen *et al.* (1991) for *Bos taurus* breeds, to use in tropical beef breeds. The reason for this need was the smaller dimensions of the reproductive tracts of tropical breeds when compared with those of *Bos taurus* breeds.

**2. 2. 3. 2. Reproductive tract score (RTS) in heifers**

Reproductive tract scoring is a practical tool developed in the USA on *Bos taurus* cattle breeds to assess the potential of pre-pubertal heifers. It can be used in replacement heifer selection before the breeding season (Andersen *et al.*, 1991). Schwalbach (1997) adapted Andersen's RTS to rate composite beef breeds in South Africa (Table 2.2).

**Table 2. 2: A 5-Point reproductive tract scoring (RTS) system for evaluating the breeding potential of heifers** (adapted from Andersen *et al.*, 1991)

| | | Ovaries | | | |
|---|---|---|---|---|---|
| | | Approximate size | | | |
| Reproductive tract score | Uterine horns, Tone and diameter (mm) | Length (mm) | Height (mm) | Width (mm) | Ovarian structure |
| 1 | No tone, immature, Ø<20 (<10)* | 15 (10)* | 10 (8)* | 8 (6)* | No palpable follicles No CL |
| 2 | No tone Ø=20–25 (10-15)* | 18 (13)* | 12 (10)* | 10 (8)* | < 8 mm follicles No CL |
| 3 | Slight tone Ø=25–30 (15-20)* | 22 (17)* | 15 (13)* | 10 (8)* | 8-10 mm follicles No CL present |
| 4 | Good tone Ø=30 (20-25)* | 30 (25)* | 16 (14)* | 12 (10)* | > 10 mm follicles CL possible |
| 5 | Good tone, erect Ø>30 mm (>25)* | >32 (>25)* | 20 (18)* | 15 (13)* | > 10 mm follicles CL present |

()* Measurements adapted by Schwalbach (1997) for tropical beef heifers
Ø = Diameter estimates the pubertal status via rectal palpation of the uterine horns and ovaries.

Reproductive tract scoring examinations, if carried out 1 or 2 months prior to the onset of the breeding season, can be a useful check of the nutritional status and the diet, and the beginning of the breeding season can be adjusted accordingly. For example, the supplementary feeding of heifers with a low RTS (3) can be done so that these heifers can cycle earlier. Schwalbach (1997) demonstrated that Bonsmara heifers with a higher RTS calved earlier and weaned heavier calves than those with lower scores. Heifers should be bred a few weeks before the cows, thus permitting the concentration of time and labour during breeding and calving, and allowing for a longer postpartum interval the following year (Andersen *et al.*, 1991). There seems to be a strong relationship between the RTS prior to the breeding season and the pregnancy rates obtained (Brinks, 1994; Kinder *et al.*, 1994; Schwalbach, 1997).

## 2. 3. OESTROUS CYCLE IN CATTLE

In contrast to humans and other primates in which mating is not restricted to a specific time of the menstrual cycle and ovulation occurs in the mid cycle, mating in ruminants in general, and in cattle in particular, is limited to a short period of oestrus. This coincides with the time of ovulation. Knowing exactly when an animal should be mated, by natural or artificial means, is therefore of utmost importance.

### *2. 3. 1. Oestrous cycle and duration of the oestrous period*

In the non-pregnant cow, ovulation has been shown to occur approximately every 3 weeks. The oestrous cycle can be defined as the time elapsing between 2 successive oestrous manifestations or ovulations. The cow is a poly-oestrous and non-seasonal animal. At puberty, once the oestrous cycles are established, the cycles continue indefinitely, unless either pregnancy or a physiological disorder disrupts them. This oestrous cycle can be divided into 4 main phases (oestrus or period of sexual receptivity being day 0; metoestrus or post-ovulatory period being days 1 to 4; dioestrus or luteal phase being days 5 to 18; pro-oestrus being days 18 to 21). As these divisions are not very distinct in the cow, it is usually simpler to divide the cycle into two phases, the luteal (days 1 – 17) and the follicular phases (days 18 – 21) (Hafez and Hafez, 2000).

Many studies have been carried out to determine the length of the oestrous cycle in cattle indigenous to the tropics and the duration of oestrus has been found to be shorter in zebu than in the *Bos taurus* cattle (Plasse *et al.*, 1970; Mattoni *et al.*, 1988; Galina and Arthur, 1990a). Kabuga and Alhassan (1981) observing oestrus in Holstein-Friesian cows in Ghana found the cycles to vary in duration between 14 and 24 days (52%) and 37 and 46 days (17.5%). These authors concluded that some oestrous periods were missed, and that there was a possible high incidence of embryonic mortalities. Research in Nigeria (Adeyemo *et al.*, 1979; Johnson and Gambo, 1979; Zakari *et al.*, 1981; Johnson and Oni, 1986; Oyedipe *et al.*, 1986) and in Ethiopia (Mattoni *et al.*, 1988) have shown that the duration of the oestrous cycle in the zebu cattle varies between 16 and 30 days, with the average being 21 days. Galina and Arthur (1990a) set out a comprehensive review of these findings.

Studies have shown that the duration of the oestrous cycle in the cow is affected by season. Plasse *et al.* (1970), working on Brahman cattle, recorded a significant difference in the length of the cycle between summer and winter. Similar results have been reported by Zakari *et al.* (1981) with White Fulani and Sokoto Gudali in Nigeria. Oestrous cycles in the (dry) pre-rainy season were recorded to be longer (26.04 d) than those in the rainy season (20.8 d). Differences were also noted in the oestrous cycle length of the White Fulani (22.8 d) and Sokoto Gudali cattle (23.7 d). Mattoni *et al.* (1988) recorded the length of the cycle during the dry season to be 1.3 d shorter than during the rainy season. Lamothe-Zavaleta *et al.* (1991a) reported an average duration of the oestrous cycle of 20.5 d (ranging from 17 to 26 d) with a mean of 21.5 d for the rainy season versus 19.9 d during the dry period.

Considerable differences in the oestrous duration have been reported in tropical cattle, ranging from 10 to 30 hours. The differences can be partially attributed to difficulties related to oestrous detection. Homosexual activity is not as pronounced in zebu as in taurine cows (Rahka *et al.*, 1970; Galina and Arthur, 1990a). Standing to be mounted is generally the most practical single sign of oestrus. This acceptance to be mounted can be as short as 4 hours (Johnson and Oni, 1986) or as long as 14 to 20 hours (Dobson and Kamonpatana, 1986; Galina and Arthur, 1990a). Its duration is influenced by age (heifers have an oestrous period by 3 hours shorter than that of mature cows) and season also seems to play an important role in oestrous duration. The mounting behaviour generally lasts longer during the wet (4.7 hours), compared to the dry season (3.9 hours) (Zakari *et al.*, 1981; Lamothe-Zavaleta *et al.*, 1991a). Similarly, Plasse *et al.* (1970) had earlier detected a seasonal difference in oestrous behaviour between summer and winter. Mattoni *et al.* (1988) in Ethiopia however failed to observe a significant seasonal difference in length of oestrous period in the Boran cow. Generally there does not seem to be a significant breed effect in the duration of the oestrous period among zebu cattle in the tropics (Galina and Arthur, 1990a).

**2. 3. 2. Oestrous behaviour in cattle**

Zebu type cattle do not display strong overt signs of oestrus, which limits the extensive use of AI in the tropics (Galina and Arthur, 1990a; Galina *et al.*, 1996). It has been shown that tropical cattle have a tendency to show less overt signs of oestrus during a relatively short period of time (Plasse *et al.*, 1970; Nagaratnam *et al.*, 1983; Vaca *et al.*, 1983; Galina *et al.*, 1996). The zebu females tend to show a lack of mounting behaviour (Johnson and Gambo, 1979). In studies reported by Galina and Arthur (1990a), only 20 to 27% of zebu females were detected by mounting behaviour (overt oestrus). The same frequency (28.8%) was reported by Lamothe-Zavaleta *et al.* (1991a), while Mattoni *et al.* (1988) observed a vaginal mucous discharge in only 64% of the animals. In most studies, secondary signs of oestrus such as hyperactivity, bellowing, nervousness and a copious flow of cervico-vaginal secretions commonly observed in the taurine cow are uncommon in the zebu.

Methods for oestrous detection are those pertinent to the management system involved. The time of oestrous detection is critical. Oestrous behaviour is best detected in the cooler periods of the day (late night and early morning (Mattoni *et al.*, 1988; Lamothe-Zavaleta *et al.*, 1991a). However, for better results in oestrous detection, it has always been advised to also check for behavioural oestrus in the late afternoon, around sunset. Preferably, if manpower is not a limiting factor, three 30-minutes spells a day (0600, 1400 and 2200) can achieve detection rates of up to 80% in the cow (Dobson and Kamonpatana, 1986).

Several methods have been devised to increase oestrous detection efficiency, from chin and rump markers, rectal palpation and the arborisation pattern of the cervico-vaginal mucus to the use of live teaser animals. From numerous studies in the tropics, oestrous detection appears to be more efficient when done with the use of either a teaser bull (penis-deviated or caudectomised), or an androgenised cow. Androgenisation is a hormonal treatment of either intramuscular injections of oestradiol and progesterone for 7 days, or testosterone for 20 days (Galina and Arthur, 1989c).

Some work has also shown that, due to social interactions within the herd hierarchy, oestrous behaviour could be suppressed. Orihuela *et al.* (1989) found that cows higher in hierarchy order gave almost 60% of the mounts received by a cow in oestrus. This finding indicates the big aggressive cow to be less likely to stand to be mounted than the smaller passive cow. The former would therefore be more difficult to detect in oestrus. Oestrous expression is also influenced by the time of the year. As the cows in temperate areas calve more towards the winter, the interval from calving to first oestrus is reduced. This reduction is at the expense of fewer animals being detected in oestrus (Galina and Arthur, 1990a). Zakari *et al.* (1981) reported oestrous detection to be easier during the hot months of northern Nigeria. Daylight length, along with other environmental factors (temperature, rainfall and nutrition) appears to be of overriding importance in controlling the seasonal reproductive activity in cows (Rahka and Igboeli, 1971).

### *2. 3. 3. Endocrinology of the oestrous cycle in the cow*

The progesterone profile, as determined by the concentration in either blood (plasma or serum) or milk, appears to be similar in dairy and beef *Bos taurus* cows. Progesterone values can be as low as 1 ng/ml during the follicular phase, and up to 6 or 7 ng/ml during the luteal phase. Studies on the progesterone patterns during the luteal phase in tropical cattle are controversial. Certain authors report cattle in a tropical environment to produce less progesterone than those raised in the more temperate climates rarely exceeding 3 ng/ml (Agarwal *et al.*, 1977; Vaca *et al.*, 1983; Oyedipe *et al.*, 1986). Others report that progesterone concentrations can be as high as in taurine cows, i.e. as high as 7 ng/ml (Adeyemo and Heath, 1980; Terblanche and Labuschagne, 1981; Lamothe-Zavaleta *et al.*, 1991b). Although some heat stress related effects have been implied, Gauthier and Thimonier (1984) were unable to observe any effect of stress on progesterone levels in Creole cattle. Another likely explanation may be the size of the CL, which has been shown to be smaller in zebu than in European-type cattle breeds, making it difficult to detect by rectal palpation (Plasse *et al.*, 1968a; Vaca *et al.*, 1983; Randel, 1984).

Oestradiol patterns appear similar in taurine and zebu cows, with minimum levels being recorded during the luteal phase. The plasma concentrations begin to rise 4 to 5 days before oestrus, and culminate on day 0. Actually, plasma concentrations of LH and $E_2$ tend to increase as those of $P_4$ decrease. Gauthier and Thimonier (1984) reported a seasonal effect on the interval between the onset of oestrus and LH peak, and also recorded a seasonal effect on the duration of the luteal phase, which was longer (17.9

days) in July than in January (16.9 days). These phenomena were accompanied by a higher percentage of silent ovulations in winter when compared to summer.

### *2. 3. 4. Control of Oestrus in cattle*

The use of pharmaceutical agents to regulate the oestrous cycle has been widely used for different reasons. The cost of labour is high, so insufficient time is allowed to observe behavioural oestrus in the cows (Dobson and Kamonpatana, 1986). Visual appraisal is of little help in zebu cows, which are notorious for weak oestrous behavioural symptoms.

Hormonal preparations can be used to both synchronise animals and allow a short period of time to intensively study the behavioural interactions in the herd, while their use also facilitates the use of fixed-time AI. Additionally, in large herds, synchronised mating followed by controlled calving can be contemplated (Dobson and Kamonpatana, 1986). The agents generally used for oestrous synchronisation include prostaglandins and their analogues, progestagens/progestins, or a combination of prostaglandins and progestins, in the presence of GnRH or PMSG (Galina and Arthur, 1989c, 1990a; Odde, 1990).

The prostaglandins ($PGF_2\alpha$) or their synthetic analogues are easier to apply. However, their use is limited by the fact that only animals with an active CL will respond hence the need for rectal palpation before treatment. The $PGF_2\alpha$ causes the luteolysis of the CL, which results in a drastic reduction of progesterone levels in blood. The negative feedback on the hypothalamus is removed, and a follicular phase starts. As no response to treatment can be achieved before day 5 of the cycle, a regimen of 2 injections 10 to 12 days apart is usually implemented. Some researchers tend to agree on the dosage and route of administration, but do not agree on the success achieved following administration of the drug. Adeyemo *et al.* (1979) and Nagaratnam *et al.* (1983) detected more than 72% of the cows in oestrus while some other researchers report a rate of less than 40 % (Galina and Arthur, 1990a). The conception rates recorded following synchronised oestrus can range from 30 to 53%, and seem to be related to the level of management and whether the cows are inseminated at a fixed-time or at observed oestrus (Roche, 1977).

Progestagens can be used in both cyclic and non-cyclic cows and for this reason, have an advantage over prostaglandins. So, e.g. there is no need for the presence of a corpus luteum when progestagens are used. However, due to the short half-life of $P_4$, repeated or continuous application of the hormone is necessary. Oral administration of $P_4$ analogues in the feed is not practical, as regulating the intake is difficult. Slow releasing forms were therefore devised such as the intra-vaginal sponges, progesterone-releasing intra-vaginal devices (PRID) or an alternative continuous releasing formulation, the ear implant, containing the progestagen norgestomet, and usually referred to as Synchro-mate-B (SMB). Both PRID and implants are removed after 9 to 14 days, to cause a timed decline in circulating $P_4$ concentrations. A combination of PRID and $PGF_2\alpha$ given one day before PRID removal results in high pregnancy rates in suckling beef cows due to initiation of ovarian activity by the PRID in anoestrous animals, and a better synchronisation of cyclic cows by $PGF_2\alpha$ (Beal, 1983). Both the PRID and the progestagen implants lead to detection of a higher percentage of cows in oestrus when compared to prostaglandin treatment alone (70% versus 44%, respectively) (Lokhande *et al.*, 1983; Orihuela *et al.,* 1989).

In general, whatever the method of oestrous synchronisation used, the results obtained may be a reflection of the nutritional and the management status of the animals. In suckling primiparous beef cows, those well fed and treated with SMB 28 to 45 days postpartum, recorded a 68% first-service conception to fixed-time AI (Milksch *et al.*, 1978). Calf removal in low body condition score (BCS) cows 48h prior to oestrous synchronisation resulted in an increase in the number of cows exhibiting oestrus (77% versus 23%) and an increased first service conception (46% versus 32%) (Kiser *et al.*, 1980).

## 2. 4. FACTORS AFFECTING GESTATION LENGTH IN CATTLE

Length of gestation is generally calculated as the time interval from a fertile mating or AI to parturition and the production of a normally constituted calf. Length of gestation is primarily determined by the genetic make-up of the calf, but other factors may modify the interval. These factors include maternal, foetal, genetic and environmental variables (Hafez and Hafez, 2000).

***2. 4. 1. The effect of genotype and sex of the calf on gestation length***

On average, gestation length is approximately 282 d in taurine cows (Hafez and Hafez, 2000). Gregory *et al.* (1979a) reported a length of gestation of 284.7 d for Angus x Hereford calves and 287.9 d for Pinzgauer x Hereford crosses. Kabuga and Alhassan (1981) recorded a length of 279.4 d in Holstein-Friesian cows in Ghana, while Bourdon and Brinks (1982) showed the Red Angus to have the shortest gestation period (280.9 and 279.1 d), for male and female calves, respectively. Reynolds *et al.* (1990) reported different gestation lengths for calves sired by Angus (284.8 d), Pinzgauer (287.2 d), Red Poll (289.0 d) and Simmental (288.5 d) bulls with Hereford dams. Cows bred to breeds classified as large in mature size (e.g. Pinzgauer and Simmental) have a 1 d longer gestation period than cows bred to medium sized sires (e.g. Angus, Red Poll). Also, cows with a high milk production have a 2.8 d longer gestation length than cows with medium milk production. These studies, in general, indicate that gestation length is subject to genetic influences. According to these findings, the significant effects of body size and milk production indicate the importance of additive genetic effects. Furthermore, the size x milk production interaction of 1.4 d observed in the above study indicates that other genetic factors than body size and level of milk production of sire breed are important (Reynolds *et al.*, 1990). However, Azzam and Nielsen (1987) could not detect any breed of sire effect on gestation length in beef cattle.

Reports on the length of gestation of different *Bos indicus* breeds indicate a range between 285 and 294 d (Plasse *et al.*, 1968c, Reynolds *et al.*, 1980; Williamson and Humes, 1985; Paschal *et al.*, 1991; Browning *et al.*, 1995; Obese *et al.*, 1999). These studies also show that the *Bos indicus* calves are, on average, carried longer than their taurine counterparts (Plasse *et al.,* 1968c; Reynolds *et al.,* 1980; Lawlor *et al.*, 1984; Williamson and Humes, 1985; Herring *et al.*, 1996; Nadarajah *et al.*, 1989). Within each grouping, this gestation length is usually a reflection of the breed considered.

Plasse *et al.* (1968b) reported male Brahman calves to be carried *in utero* 1.9 days longer than female calves. Similarly, Bourdon and Brinks (1982) recorded the difference to be 1.5 d in favour of male calves. Beef bull calves were carried 1.4 to 1.8 d longer than heifers, and gestation length was also reported to be shorter in the dams carrying twins (Azzam and Nielsen, 1987).

### *2. 4. 2. Maternal factors affecting gestation length*

Age of the dam can influence the duration of gestation. Young heifers tend to carry their calves for a slightly longer period than older cows as shown in the Holstein (Nadarajah *et al.*, 1989; Ageeb and Hayes, 2000). Bourdon and Brinks (1982) found increases in age to be associated with longer gestation periods. Gestation length increased by almost 2 d from parity 1 to 2, and by 1 d or less from the second to last parity (Azzam and Nielsen, 1987). However, Obese *et al.* (1999) found no significant effect of parity on the gestation length of Sanga cattle in Ghana.

## 2. 5. AGE AT FIRST CALVING AND CALVING INTERVAL

Calving interval is one of the most important parameters used to assess the reproductive performance in cattle. It can be seen as the time elapsing between successive calvings. It is composed of the calving to conception interval and the gestation period. The calving to conception interval is a critical variable and depends on the time to complete uterine involution and resumption of ovarian cycles (acyclic period), the occurrence and detection of oestrus, and the fertility at mating.

Acyclicity or anoestrus is characterised by a total absence of oestral activity and can be confirmed by rectal palpation of the ovaries, ultrasound examination and, if possible, milk or plasma $P_4$ analyses. Anoestrus in a large proportion of cows in a herd is a reflection of a herd nutritional or health problem. Failure to detect oestrus in AI programs is a major cause for delayed service. Methods and aids are available (behavioural observations with the help of androgenised females or teaser bulls, milk progesterone assays, mount detectors, etc), but lack reliability (Peters, 1996). Factors that affect the age at first calving may also affect the length of the calving interval. These factors include the genetic makeup, age at puberty, age of the cow at calving, the year and month of calving, the environmental, nutritional and management conditions (Galina and Arthur, 1989b).

### *2. 5. 1. The effect of genotype on age at first calving and calving interval*

The expression of the genotype can be influenced by the interaction between nutritional, environmental and managerial factors. In general, European breeds of cattle and their crosses tend to have a superior reproductive performance, compared to tropical breeds (Table 2.3).

**Table 2. 3: Comparison of age at first calving (AFC) and calving interval (CI) in cows of different genotypes under tropical conditions** (Galina and Arthur, 1989b)

| Genetic type | Number of studies | AFC (months) | Number of studies | CI (months) |
|---|---|---|---|---|
| *Bos taurus* | 24 | 32.3 | 33 | 15.4 |
| *Bos taurus x Bos indicus* | 61 | 33.1 | 20 | 15.1 |
| *Bos indicus* | 50 | 44.8 | 25 | 15.2 |
| *Bos indicus x Bos indicus* | 7 | 41.3 | 4 | 16.2 |
| *Unspecified crossbred cattle* | 10 | 43.7 | 11 | 17.2 |
| *Bos taurus x Bos taurus* | | - | 3 | 15.1 |

Under tropical conditions, the average age at first calving (AFC) is lower in European breeds and their crossbred counterparts than for the indigenous zebu breeds (Alberro, 1980; Kabuga and Alhassan, 1981; Mbah *et al.*, 1987; Tawah *et al.*, 1999). Wilson (1985) recorded an AFC of 49.5 months in Fulani cattle, similar to the 48 months recorded in Gudali cattle (Mbah *et al.*, 1987). The average age at first calving of tropical breed varies between 40 and 50 months (Table 2.3).

Calving intervals tend to be shorter in the *Bos indicus* breeds in some studies and in the European breeds in others. The inter-calving period (ICP) is generally above 400 days in beef cattle in the tropics (Kabuga and Alhassan, 1981; Oyedipe *et al.*, 1982b; Wilson 1985; Mukasa-Mugerwa, 1989; Voh and Otchere, 1989; Tomo, 1997). This interval has been recorded as 417.6, 459.4, 625, 665 and 570.5 d in the Nguni and Africander in Mozambique (Dionisio and Syrstad, 1990), the N'dama (*Bos taurus*) (Agyemang *et al.*, 1991), the Sudanese Zebu in Mali (Wilson, 1985), and the Angoni in Mozambique (Tomo, 1997), respectively. In the same breed, the calving interval is likely to be influenced significantly by the management systems implemented.

Mentz *et al.* (1974) showed that in South Africa, the incisor teeth of Jersey cows raised under extensive conditions tend to exhibit excessive wear, due to the nature of the forage available, making the food intake of mature cows less adequate and therefore limiting their reproductive and productive lives. The expression of their genetic potential may also be hampered by a lower resistance to local diseases (Mbah *et al.*, 1987; Tawah *et al.*, 1999). Under tropical conditions, the more European genes there are in a cow's genetic make-up, the less efficient her reproduction tends to be (Galina and Arthur, 1989c). Alberro (1980), Kabuga and Alhassan (1981), Mbah *et al.* (1987) and Tawah *et al.* (1999) recorded excellent reproductive performances in European dairy breeds and their crosses under tropical conditions. The difference in the findings may be due to differences in the degree of crossbreeding, environmental harshness and management conditions (Galina and Arthur, 1989b).

***2. 5. 2. Environmental factors affecting age at first calving and calving intervals***

In the same breed and under the same geographical conditions, the main source of variation may be the farm/herd and/or the ethnic community, because of the differences in social behaviour towards the animals, the management decisions and availability of resources (Galina and Arthur, 1989b). The reported differences in reproductive performance within the same breed can be very large as is the case in the Adamawa (IRZ/GTZ, 1989). Doren *et al.* (1986) reported factors that affect the postpartum to conception period to be the most important determinants of the calving interval. It was shown that the weaning weight of the previous calf also accounts for the variation in the calving interval, and it is thus essential, when doing comparisons, to adjust for differences in breed type, body condition score, parity, early management, age, weight and weight changes of the dam.

The year and season of calving are very important factors affecting the ICP (Holroyd *et al.*, 1979; Dawuda *et al.*, 1988b; Mukasa-Mugerwa *et al.*, 1991b), as the conception rates are correlated to the rainfall in the month prior to natural mating or artificial insemination (Holroyd *et al.*, 1979). Dawuda *et al.* (1988b) reported longer mean intervals from calving to first oestrus in Bunaji cows that calved during the rainy season, compared to those calving in the dry season (152.8 and 122.9 d, respectively). Mukasa-Mugerwa *et al.* (1991b) reported similar results for the Arsi (zebu) in Ethiopia. This indicates that the reproductive efficiency of cows is directly related to the availability of good pastures (Galina and Arthur, 1989b). These findings mean that because the onset of the rainy season is quite variable in the tropics, body condition and nutritional status of animals depend almost entirely on the availability of good quality forage at particular times of the year. Carvalheira *et al.* (1995) showed that heifers born early in the rainy season were about 3 weeks older at first calving than those born late in the rainy season.

The first calving interval tends to be the longest (Denis and Thiongane, 1972; Galina and Arthur, 1989b) and, as the animals grow older, the ICP decreases (to 6 - 7 or 8 years of age). After the eighth year, there is an increase (Denis, 1971; Buck *et al.*, 1976; Wilson, 1985). There seems to be a longer interval after the calving of a male than of a female calf (Wilson, 1985). According to Buck *et al.* (1976), the animals less likely to achieve a high calving rate could be divided into specific groups. These groups were animals which had previously calved at the end or in the middle of the calving season, first calvers weighing less than the average of the herd at calving, and cows gaining less than 20 kg in body weight (BW) during the breeding season.

It is common knowledge that good quality forage enhances reproductive performance. However, the availability of feed resources is not evenly distributed throughout the year. Seasonal variation in the calving pattern, even when breeding is not restricted in the year, tends to reflect the availability of feed throughout the year (Wilson, 1985). Cows on a low plane of nutrition will tend to record lower calving rates than those on a higher nutritional plane. The mean interval from calving to the first postpartum ovulation was recorded to be 25 d longer in beef cows fed a low, as opposed to a high energy diet (Stagg *et al.*, 1995).

Other factors that may influence age at first calving and ICP include body condition of heifers and cows before and at calving. Additionally, milk production (more or less related to their body weight and size), the effects of suckling, age at weaning of the calf and calf mortality rates have a role to play. While the effects of body condition and suckling will be dealt with later, it is worth noting that there are considerable losses in calves between calving and weaning. Willis and Wilson (1974) found 30 % of the cows to lose at least one calf before weaning during their productive lifetime. Lemka *et al.* (1973) reported that only 48% of the heifer calves would subsequently calve in the herd. Also, heifers calving late for the first time are very likely to lose at least one calving season during their reproductive life due to long inter-calving intervals. Doren *et al.* (1986) reported the condition of the cow prior to parturition to influence the subsequent calving to conception interval, with thinner cows recording longer calving to conception intervals in later parities.

### *2. 5. 3. The effect of body weight and body condition score on the age at first calving and calving interval*

Periodical recording of the weight of young and mature animals is usually the best way to monitor their growth and to assess the efficiency of a particular nutritional program. However, under extensive conditions or when farmers do not have the necessary infrastructure, nutritionists, veterinarians as well as cattlemen can use the body condition score (BCS) of the cows as an indicator of their nutritional status. The BCS can describe the nutritional status of cows throughout the year and particularly at certain critical physiological stages (before and during breeding, before, at and after calving, etc). Body condition score is thus a score given to a cow to indicate her relative fatness and level of body reserves at any given time during its productive life (Corah, 1995). The method consists on the evaluation of the degree of muscle and fat tissue deposition in specific parts of the body by means of both visual appraisal and palpation of the particular body sites. The anatomic areas of interest are normally (1) the loin area (between the hip bones and the last rib), (2) the area surrounding the tail head, pin bones and the cavity under the tail head, and (3) the rump and flank (rib) areas (Van Niekerk and Louw, 1982; Schwalbach, 1997) (Table 2.4). There are two compatible scales used: (i) the 1 to 5 scale, first described in Europe and widely used in South Africa (Van Niekerk and Louw, 1982), and (ii) the 1 to 9 scale mainly used in America. The latter one was adapted from the European method by replacing the half points by full points and consequently extending the score range (Herd and Sprott, 1987; Kunkle *et al.*, 1994; Corah, 1995). All researchers agree that a BCS of 3 to 3.5 (European scale) or 5 to 6 (9-point scale) is the ideal nutritional status to target for calving. At a score of 2.5 (European) / 4 (American), the fat reserves will be converted into energy to give a reasonable performance. Below these scores, the animal may enter a catabolic state, during which a considerable amount of body reserves is mobilised to assure the daily metabolic maintenance needs of the animal. If the cow is nursing, her calf's and her own maintenance can be compromised (Herd and Sprott, 1987). Above 3.5 (BCS>6), the cow tends to accumulate energy reserves in the form of fat. However, animals with a BCS of 4.5 to 5 (BCS>7) usually have low fertility, are poor producers and therefore tend to accumulate fat.

**Table 2. 4: The 9-point scoring system for evaluating body condition (BCS) in beef cows** (Corah, 1995)

| Body condition | Score | Description |
|---|---|---|
| Thin | 1 | Severely emaciated: Bone structure of shoulder, ribs, back, hooks and pins sharp to touch and easily visible. Little evidence of fat deposits or muscling. |
| | 2 | Emaciated, similar to 1 above, but not weakened. Little visible muscle tissue. Spinal processes feel sharp to the touch and are easily seen with a space between them. |
| | 3 | Very thin, beginning of fat cover over loin, back and foreribs, and some muscle visible. Backbone easily visible. Processes of the spine can be identified individually by touch and may still be visible. Spaces between the processes are less pronounced. |
| Borderline | 4 | Thin, with fat cover over foreribs, but other $12^{th}$ and $13^{th}$ ribs still easily visible. Shoulders and hindquarters still showing fair muscling. Transverse spinous processes can be identified only by palpation to feel rounder rather than sharp. |
| | 5 | Moderate to thin. Last two or three ribs can usually be seen. Little evidence of fat in brisket, over ribs or around tailhead. Transverse spinous processes can be felt with firm pressure to feel rounded. Spaces between processes not visible, only distinguishable with firm pressure. |
| Optimal | 6 | Good smooth appearance throughout. Some fat deposition in brisket and over tailhead. Ribs fully covered, not noticeable to the eye. Hindquarters plump and full. |
| | 7 | Very good flesh, brisket full, tailhead shows pockets of fat, and back appears square due to fat. Ribs very smooth. Spinous processes can barely be distinguished at all. |
| Obese | 8 | Obese, back very square, brisket distended, heavy fat pockets around tailhead, and cow has square appearance due to excessive fat. Neck thick and short. |
| | 9 | Rarely seen. Very obese. Description of 8 taken to greater extremes. Heavy deposition of udder fat. Animal's mobility can be impaired by excess amount of fat. |

There is ample evidence demonstrating an interaction between BCS at calving and the subsequent feeding level in terms of their influence on the interval to postpartum oestrus (Robinson, 1996). Wright *et al.* (1992b) reported thin cows (BCS 2.2) with a low intake (60 Megajoules/d) compared to a high intake (115 Megajoules/d) to have a longer interval to oestrus (116 vs. 80 d). Robinson (1996) showed that the magnitude of energy deficiency due to postpartum interval to first oestrus is equivocal. In some cases, the advantages in the initiation of normal cyclicity are outweighed by poorer fertility.

Short and Adams (1988) and Short *et al.* (1990) classified the use of nutrients by the cow in order of priority, and showed that reproductive functions (pregnancy) are ranked fifth below basal metabolism, activity, growth and basic energy reserves. Hence the importance given by many authors to the body condition of cows at different stages of the reproductive cycle (Dawuda *et al.*, 1988b; Marakechian and Arthur, 1990; Mukasa-Mugerwa *et al.*, 1991a,b).

## 2. 6. FACTORS AFFECTING BIRTH AND WEANING WEIGHTS, PRE- AND POST-WEANING GROWTH RATES IN BEEF CATTLE

### *2.6.1. Birth weight*

The birth weight (BWT) of calves, commonly used as the initial reference point with regard to the development of an individual animal, represents, in fact the culmination of the most dynamic growth and developmental processes in mammalian biology (Holland and Odde, 1992). A zygote weighing about 1.0ng at fertilisation will at parturition, attain a weight of 20 to 40 kg. Since length of gestation is relatively constant within a breed, variations in birth weight are a result of a variation in growth rates during the prenatal development. Thus, it can be said that BWT is the result of foetal growth, and factors that affect foetal growth will ultimately affect BWT. The relevant factors can be grouped under genetic (sire, dam, breed effects, heterosis, inbreeding) or environmental (maternal body weight, size, age of dam, maternal ability, lactational and nutritional status, year, season of birth, etc.) factors.

2. 6. 1. 1. The effect of breed on birth weight

Certain breeds of cattle have a clear advantage at birth and weaning over others. In a review on BWT, Anderson and Plum (1965) reported the lowest mean BWT as 19.1 kg in the Sindhi cattle, while the highest mean weight at birth was recorded in the Charolais breed (48 kg). Within the same breed, these differences, as determined by the expected progeny differences (EPD), show Gelbvieh cattle to have the greatest range in BWT EPD (12.6 kg), followed by the Polled Hereford (11.4 kg), and Charolais (11.1 kg), while the Simbra show the lowest range (3.9 kg) (Holland and Odde, 1992). Abassa *et al.* (1993) and Tawah *et al.* (1993) found Wakwa calves to be heavier at birth and at weaning than their Gudali counterparts, while Fordyce *et al.* (1993) showed a birth advantage of Brahman x Shorthorn crosses over Sahiwal x Shorthorn crosses.

2. 6. 1. 2. The effects of month, season and year of birth on birth weight

Due to numerous environmental factors such as quality and quantity of feed, temperature, season and location involved, the year of birth effect has been reported in some studies (Rege and Moyo, 1993; Tawah *et al.*, 1993; Tomo, 1997), but not in others (Lubout *et al.*, 1986). These differences usually reflect the effect of rainfall on the availability of pastures, but can also result from an improvement of management from year to year. So, for example, Fordyce *et al.* (1993) found the year with the longest dry period prior to the start of the wet season to produce the lightest calves, whereas calves born after the best dry seasons (when rainfall was the highest) were the heaviest. Other factors such as change in management, cow age, previous lactational performance may also contribute to the year effect. In Cameroon, different studies have shown a significant year difference in both the birth and weaning weights of the local cattle (Lhoste, 1968; Abassa *et al.*, 1993; Tawah *et al.*, 1993).

The effects of season of birth on calf BWT have been demonstrated in different studies (Lubout *et al.*, 1986; Newman and Deland, 1991; Holland and Odde, 1992; Fordyce *et al.*, 1993; Tawah *et al.*, 1993; Rege and Moyo, 1993; Tomo, 1997), but these effects are variable and inconsistent. Under temperate conditions, calves born during spring have sometimes been reported to be heavier than those born in the fall, but others have shown fall and winter calves to be heavier (Holland and Odde, 1992). In Australia, where the onset of the calving season is on average 2 weeks before the growing season for the grass, late calves tend to be heavier. Additionally, BWT tends to increase with an increase in the quality of dry season feed. This suggests that improved nutrition in the last trimester of pregnancy can increase foetal growth, even though it may not be fully expressed in the dam body condition (Fordyce *et al.*, 1993). These results are in contradiction to findings of studies in Cameroon, which show Gudali calves born in the dry season to be 0.7 kg and 24.2 kg heavier at birth and weaning, respectively, than those born during the wet season. However, Wakwa calves born either in the dry or the wet season showed similar BWT but the dry-season born calves were 16.5 kg heavier at weaning (Tawah *et al.*, 1993). Tomo (1997) also reported that calves born in the dry season in Mozambique were 5% heavier than those born during the wet season.

2. 6. 1. 3. The effect of age of dam and parity on birth weight

Young cows give birth to lighter calves (Holland and Odde, 1992), possibly because of the competition for nutrients between the growing dam and the developing foetus. This BWT suppression was no longer observed when a mature age was attained at approximately 6 years of age. Increases in age (up to and including the 5-to-10 year-old groups) were associated with heavier BWT whereas calves from cows 11 years and older again had a lighter BWT (Bourdon and Brinks, 1982; Holland and Odde, 1992). This effect may be associated with the increase in cow weight with age. Holland and Odde (1992) reported a significant relationship between dam weight and the calf BWT. In fact, calf weight at birth, which represents 5 to 10% of the dam weight, is reported to increase proportionally with increases in dam weights. The age of the dam appears to affect BWT of both sexes equally for cows aged between 3 and 10 years. Abassa *et al.* (1993) however failed to detect any significant effect of age of dam on BWT of Gudali and Wakwa calves in the Cameroon Highlands. Tomo (1997) reported similar results in Angoni cattle in Mozambique.

*2. 6. 1. 4. The effect of sex of the calf on birth weight*

Sex of the calf has been shown to have a significant effect on BWT (Bourdon and Brinks, 1982; Kassa-Mersha and Arnason, 1986; Reynolds *et al.*, 1990; Holland and

Odde, 1992; Abassa *et al.*, 1993; Rege and Moyo, 1993; Tawah *et al.*, 1993; Tomo, 1997). Bull calves generally weigh 0.8 to 2.3 kg more at birth than heifer calves (Bourdon and Brinks, 1982; Kassa-Mersha and Arnason, 1986; Tomo, 1997). Reynolds *et al* (1990) demonstrated an advantage of 2.8 kg of males over female calves, whereas Holland and Odde (1992) found male calves to have a consistent 5 – 8% BWT advantage over female counterparts. Tawah *et al.* (1993) also reported a heavier BWT for Gudali and Wakwa male calves in Cameroon over their female counterparts (0.8 and 1 kg, respectively). These results are in agreement with those of Abassa *et al.* (1993) and Ebangi (1999). The male advantage can generally be explained by the longer gestation period of male calves, compared to that of female calves and to a dimorphism that is clearly in favour of male calves.

*2. 6. 1. 5. Effect of dam lactational and nutritional status on birth weight*

Non-lactating cows have been shown to bear heavier calves than cows that lactated the previous year. The lighter BWT of calves from previously lactating cows is possibly attributed to lower body reserves of the cow due to milk production during the previous year. The lactational status does not seem to affect the sex of the calf equally, as male BWT seem to be more affected than the female BWT. Further, calves from excessively fat cows prior to or during gestation show a decrease in BWT (Tawonezwi, 1989). This is in contrast with other studies (Holland and Odde, 1992). Bellows and Short (1978) showed Hereford x Angus crosses fed a high level of energy during the last trimester to bear calves 1.9 kg heavier at birth than cows fed on a low level of energy. Fordyce *et al.* (1993) also recorded improved nutrition of cows in the last trimester of pregnancy to increase foetal growth, even if it may not be fully expressed in the BCS of the dam.

2. 6. 1. 6. Other factors affecting birth weight

Other factors also affecting birth and weaning weights in cattle, as cited by Holland and Odde (1992) include:

- Number of foetuses: The individual BWTs of naturally occurring twins are 10 to 30% lower than single births;
- Gestation length: The BWT and gestation length are positively correlated, as longer gestation periods allow for additional foetal growth;

- Dam body weight/size: The BWT is, on average, 5 – 10% of the dam weight; there is a trend for light body weight breeds to produce calves lighter than larger frame breeds. In cows of comparable age, calf BWT declines within a breed, as dam body weight increases. Similarly, as dam weight increases due to age, the calf BWT decreases.
- Maternal ability (the physiological capacity of the dam to nurture the developing foetus) allows for maximal BWT expression in calves of certain breeds, while suppressing foetal growth in others. This influence seems to start between day 232 and day 274 of gestation. BWT suppression may be due to limitations of the utero-placental function and uterine blood flow.
- Cow fertility: Newman and Deland (1991) found lower fertile cows to calve heavier calves than highly fertile cows. The stunted growth of highly fertile cows could be attributed to considerable drainage in body reserves as a result of early and regular reproduction. Low fertile cows are given the opportunity after calving to recover their body reserves before the next conception.

### *2. 6. 2. Weaning weight*

Weaning weight (WWT) serves as the cow/calf producer's economic indicator of the quantity of product (weaner beef) available for sale, but selection for a higher weaning weight may increase the calving interval. If the calving interval extends beyond 365 days, the calves will be raised from birth to weaning at later periods over the years, or calving will eventually be skipped completely. This is particularly true if the breeding season is limited (Doren *et al.*, 1986). Apart from management, a certain number of factors may have a direct or indirect effect on weaning weight.

#### 2. 6. 2. 1. The effect of breed on weaning weight

Breed significantly affects WWT in cattle (Abassa *et al.*, 1993; Rege and Moyo, 1993; Tawah *et al.*, 1993). In general, *Bos taurus* calves are heavier at weaning than their zebu counterparts, under improved management conditions. The slow growth of the zebu types under extensive management conditions can be described as an adaptive mechanism for coping with periods of feed scarcity (Bonsma, 1980). For selection purposes, it is important to know what the average WWT for each breed under similar conditions is. Calves should be selected for replacement based on a weaning index.

For this purpose, it is important to select among contemporaries born within a limited calving season.

2. 6. 2. 2. The effect of season and year of birth on weaning weight

Year of birth significantly affects the weaning weight in beef cattle (Maule, 1973; Lubout *et al.*, 1986; Abassa *et al.*, 1993; Rege and Moyo, 1993; Tawah *et al.*, 1993). Year differences in the rainfall and the quality and quantity of feed available as forage are well documented. This year effect would therefore be a direct reflection of the change in rainfall and/or management as well as that of cow age and stage of production. Tomo (1997) however did not detect any effect of year of birth on the weaning weight of Angoni calves in Mozambique.

Ngaoundere Gudali calves born during the dry season in Cameroon are 24.2 kg heavier at weaning than those born during the wet season, and the dry-season born Wakwa calves were also 16.5 kg heavier at weaning (Tawah *et al.,* 1993). Similar effects have been described in other studies (Maule, 1973; Lubout *et al.*, 1986; Abassa *et al.*, 1993; Tomo, 1997). Seasonal availability of pastures, heat stress and solar radiation, which vary from one season to another, are the main contributing factors.

*2. 6. 2. 3. The effect of age of the dam and sex of the calf on weaning weight*

Weaning weight is significantly affected by age of the dam (Lubout *et al.*, 1986; Abassa *et al.*, 1993; Rege and Moyo, 1993; Tawah *et al.*, 1993). Weaning weight tends to be the highest when the cow reaches a mature age (usually between 6 to 9 years), before steadily declining. This trend corresponds to the peak age for milk production. On the other hand, heavier mature cows tend to wean heavier calves than their lighter counterparts. In some cases, no significant differences in cow reproductive status, dam weight change during lactation or calf age at weaning have been reported (Tomo, 1997). Abassa *et al.* (1993) failed to detect any effect of parity on the weaning weight of Gudali cattle in Cameroon.

Sex of the calf has been reported to significantly affect WWT (Lubout *et al.*, 1986; Abassa *et al.*, 1993; Rege and Moyo, 1993; Tawah *et al.*, 1993). Generally, male calves are 5 to 6% heavier than female counterparts at weaning. However, Tomo (1997) could not detect a sex effect either on the WWT or on the adjusted WWT. A possible suppression of the normal sexual dimorphism as a result of inbreeding of the dam, and a stressful environment was suggested.

2. 6. 2. 4. The effect of dam lactational status and suckling regimen of the calf on weaning weight

Dams not lactating during the previous year were found to wean heavier calves than do those that were lactating (Tawonezwi, 1989). The suckling regimen before weaning also has an effect on calf growth. Gaya *et al.* (1978) showed in a restricted suckling trial that Creole calves suckling twice a day attained a higher WWT than those suckled only once. Randel (1981) found no difference in the WWT between once-daily and normally suckled calves from Brahman x Hereford heifers (147.3 and 146.8 kg, respectively). In Mali, Coulibaly and Nialibouly (1998) showed that suckling regime had an effect on calf weaning age and growth rate. Calves allowed to suck *ad libitum* had a heavier WWT, followed by the calves whose dams were milked out completely before the milk was bottle-fed ad libitum. The lighter calves came from dams that were partially milked before being allowed to suckle their calves. Both the pre- and post-weaning daily gains followed the same pattern.

**2. 6. 3. Factors affecting pre- and post-weaning growth rate in beef cattle**

2. 6. 3. 1. The effect of breed on pre- and post-weaning growth rates

Fordyce *et al.* (1993) showed that Brahman x Shorthorn crosses were generally heavier than Sahiwal x Shorthorn crosses and grew faster both before and after weaning. The half zebu crosses grew faster than ¾ zebu crosses. Abassa *et al.* (1993) and Tawah *et al.* (1993) reported that Wakwa calves grew faster than their Gudali counterparts. In general, it is admitted that European taurine type of cattle have higher growth rates than zebu cattle types (Bonsma, 1980).

2. 6. 3. 2. The effect of year and season of birth on pre- and post-weaning growth rates

Year differences in rainfall and the quantity of feed available are well documented. The year effect on growth rates could therefore be a reflection of the change in rainfall and/or management (Reynolds *et al.*, 1990; Tawah *et al.*, 1993; Tomo, 1997) as well as that of cow age and status. Similarly, season of birth of the calf has been reported to significantly affect both the pre- and post-weaning growth (Rege and Moyo, 1993; Tomo, 1997). Tomo (1997) reported that Angoni calves born during the dry season had a 8.6% higher pre-weaning growth and a 6.8% weight gain advantage over rainy season born calves. These results could be explained by a higher milk production by dams calving in the dry season. However, calves born in the wet season were 144 and 139.1% higher in growth rate and weight gain, respectively, from weaning to 12 months of age. The tendency can possibly be explained by improvements in management (Rege and Moyo, 1993).

2. 6. 3. 3. The effect of the age of dam and the sex of the calf on pre- and post-weaning growth rates

In most studies, it has been shown that male calves grow faster than females and are heavier at weaning (Abassa *et al.*, 1993; Tawah *et al.*, 1993). Reynolds *et al.* (1990) however found female calves to gain 29 g more per day and to be heavier at 200 d than males in one year. Tomo (1997) reported no significant sex effect on pre- and post-weaning gain and growth rates. This lack of a sex effect was attributed to either inbreeding, environmental stress or management differences.

The age and parity of the dam have been reported to have an influence on the pre-weaning but not on the post-weaning growth rates of cattle (Elzo *et al*, 1987; Tawonezwi, 1989; Tomo, 1997). In Simmental cattle, Elzo *et al.* (1987) were able to show that the age of dam effects were markedly different relative to mature age. The largest effects (loss of 36.9 kg) were observed with 2-year old and younger dams. Thereafter, the magnitude of these effects decreased almost linearly to maturity (loss of 2.3kg for the 4.5 to 5-year old dams) and were again negative after maturity (effects for 10- to 11-year old dams rearing males were 5.1 kg lower than mature 5 to 8-year old dams). The authors concluded that the milk production being one of the major factors affecting WWT, differential milk production ability could account for the difference in age of dam effects between young and old cows.

2. 6. 3. 4. Other factors affecting pre- and post-weaning growth rates

Calves suckling high milk producing dams grow faster and are heavier at weaning than those from low producing dams, solely because of differences in maternal environment. This advantage is maintained through a fairly rapid post-weaning growth period (Clutter and Nielsen, 1987). Similar results have been reported by Day *et al.* (1984) who noted the frequency of suckling to decline as milk production level increased with progression of lactation but duration of lactation being unaffected.

The suckling regimen can impair or boost calf growth pre- and/or post-weaning performances, depending on the quantity of milk the calf has access to (Gaya *et al.*, 1978; Coulibaly and Nialibouly, 1998). Calves with a free access to the dam's milk outperform those with restricted access until weaning. However, compensatory growth has been observed between weaning and 18 months of age in calves whose dams were milked before being allowed to nurse their calves (Coulibaly and Nialibouly, 1998).

## 2. 7. FACTORS AFFECTING THE POSTPARTUM PERIOD IN BEEF CATTLE

After parturition, cows are infertile for a period of time, namely the postpartum anoestrus period, during which the dam can recover following pregnancy. In order to maintain an efficient 365 day breeding cycle, cows should be rebred within 75 to 82 days after calving (Short *et al.*, 1994a). Extended intervals of postpartum anoestrus result in cows failing to conceive again during the same year, or conceiving later in the breeding season. It has been shown that cows that conceive late in the breeding season calve later and produce lighter calves at weaning than those that calve earlier (Werth *et al.*, 1991; Fike *et al.*, 1996; Schwalbach, 1997). Postpartum infertility is generally caused by 4 main factors, namely general infertility, limited uterine involution, short oestrous cycles or anoestrus (Short *et al.*, 1990).

The general infertility component decreases fertility by 20 to 30% for any oestrus, regardless of whether it occurs after calving or at any other physiological state. Uterine involution on the other hand, seems to have no relationship to the length of the postpartum anoestrous period (Kiracofe, 1980), but is a physical barrier to fertility (sperm transport and implantation) during the early postpartum period (20 – 30 days)

(Short *et al.*, 1990). Short oestrous cycles also contribute to infertility during the first 30 to 40 days after calving. Cows exhibit a normal oestrous cycle length by 40 days postpartum, but there is evidence that short cycles may even occur later (Lishman *et al.*, 1979). These short oestrous cycles produce normal ovulations with ova released that may be fertilised but normally no pregnancies take place, as the CLs formed are small and functionally immature. These CLs tend to regress before the ovary has received the signal from the uterus that a pregnancy has been established (Rutter and Randel, 1984).

A major factor that determines the inter-calving interval, however, seems to be the resumption of ovarian activity after parturition (Galina and Arthur, 1989b;c). Tropical breeds have periods of prolonged postpartum anoestrus (interval from parturition to first observed oestrus) referred to as the postpartum interval (PPI). This period is characterised by an absence of overt behavioural signs of oestrus despite ovulation occurring in some cases, and may lead to extremely long calving-to-first-service intervals, which in turn result in excessively long calving intervals (Galina and Arthur, 1989c; Mukasa-Mugerwa, 1989). Postpartum infertility due to anoestrus impairs efficient production in the beef cattle industry (Short *et al.*, 1990). Primiparous cows generally demonstrate longer postpartum anoestrous intervals, compared to multiparous cows (Wiltbank, 1970; Bellows and Short, 1978; Fike *et al.*, 1996). For this reason, it is recommended to breed the heifers a month before the cows, so as to give the cows an extra month to recover following calving. In this way, primiparous cows can join the multiparous cow group when exposed to the bull the following season. The PPI is also affected by other factors, some of which can be considered minor (season, genotype, age or parity, presence or absence of a male, uterine palpation, dystocia, etc), while other factors are major, namely suckling and nutrition.

### 2. 7. 1. Major factors affecting postpartum reproductive performance in cows

The major factors affecting postpartum reproduction are nutrition and the suckling stimulus or milking of the dam.

#### 2. 7. 1. 1. Effect of nutrition on the post-partum activity

Nutritional effects are one of the most important factors controlling the length of the postpartum anoestrous period in cattle (Wiltbank *et al.*, 1962; Dunn *et al.*, 1969) and has enjoyed much attention over the years (Dunn and Kaltenbach, 1980; Short and Adams, 1988; Randel, 1990; Short *et al.*, 1990; Short *et al.*, 1994a). Nutritional effects are linked to postpartum anoestrus, via a complex interaction of many variables. These include the quantity and quality of feed, the body nutrient reserves, and the competition for nutrients between the different body functions, including reproduction (Dunn and Kaltenbach, 1980; Richards *et al.*, 1986; Short and Adams, 1988; Randel, 1990; Short *et al.*, 1990; Short *et al.*, 1994a).

The allocation of nutrients for different activities in the body is referred to as nutrient partitioning, and Short and Adams (1988) demonstrated the following interactions existing among nutrition and production:

(1) Cattle and other ruminants have a unique niche in agriculture as they have the ability to convert low-quality forages into high quality animal proteins;
(2) Excess nutrients can be stored during periods of excess to be retrieved at a later stage to maintain production. Similarly, extended periods of decreased nutrient availability (due to low quantity and/or poor quality) will decrease production;
(3) Nutrients are partitioned by a priority order to first maintain body functions of the cow (maintenance) and then to propagate the species (reproduction).

The priority for partitioning of nutrients has been established as 1) basal metabolism, 2) activity, 3) growth, 4) basic energy reserves, 5) pregnancy, 6) lactation, 7) additional energy reserves, 8) oestrous cycles and initiation of pregnancy, and 9) excess reserves. The priority may change depending on the physiological state of the animal (Short and Adams, 1988).

One of the simplest ways to estimate the level of energy reserves (which can constitute up to 50% of an animal's maximum body weight) is use of the body condition score (BCS) (Bellows *et al.*, 1982; Richards *et al.*, 1986; Kinder *et al.*, 1994; Corah, 1995; Spitzer *et al.*, 1995; Schwalbach, 1997). Oestrous cycles are normally maintained when the BCS is 2.5 or higher (scale of 1 to 5), depending on the breed and physiological state of the animal. But when the BCS is too high (fat animal), occurrence of oestrus and reproduction can be inhibited. The effect of nutrition on the postpartum reproductive activity will depend on whether nutritional differences existed before or after calving. The BCS can be improved by increasing the quality of the forage or supplementing the nutrition of the cow during late pregnancy or the first few weeks postpartum or both (Galina and Arthur, 1989c). The differences in BCS existing during the pre-calving period are more important than those existing after calving, and a feed supplementation for a few weeks before parturition yields better results than during the postpartum period. Cows gaining weight before and after parturition tend to have higher conception rates than those losing weight during these periods (Selk *et al.*, 1988; DeRouen *et al.*, 1994; Spitzer *et al.*, 1995; Morrison *et al.*, 1999). Dziuk and Bellows (1983) and Richard *et al.* (1986) recommended a minimum BCS of 2.5 (scale of 1-5) at calving. It was indicated to be the minimum BCS that would ensure sufficient body energy reserves for acceptable reproductive performance. Spitzer *et al.* (1995) reported greater postpartum weight gains to increase the luteal activity at the onset of breeding, and increase the pregnancy rates at days 20, 40, and 60 of the breeding season. Morrison *et al.* (1999) further indicated that prepartum body weight and/or BCS are of little consequence if the mature beef cows do not calve at a BCS below 2.5. These results indicate that cows calving with a higher BCS bear heavier calves at birth, and exhibit oestrus and become pregnant in a specific-breeding season. In the tropics, where animals are usually more prone to a deficiency in protein intake than energy, protein supplementation or non-protein nitrogen (also known as rumen stimulatory licks), could increase the pregnancy rates by as much as 20% (Galina and Arthur, 1989c).

2. 7. 1. 2. The effect of suckling on the post-partum period

The manipulation of the age of weaning has been used for decades in the dairy industry as a management tool to increase the quantity of saleable milk. It is now also used more and more often to increase the productivity of beef cattle in the tropics (Moore, 1984). Calf removal for a short period of time has been shown to have a positive influence on the calving interval and Randel (1981) demonstrated that suckling once a day (from the $30^{th}$ day after calving) shorten the calving to conception interval to 68.9 days, compared to 168.2 days in cows suckled permanently. Cows nursing two calves also exhibit a longer calving to conception interval (94.6 d) compared to those with a single calf (67 d). Bonavera *et al.* (1990) were unable to find any difference in either the ovulation and conception rates, or the intervals from calving to first oestrus, or to conception in cows whose calves were removed for a short period (72 hours).

Suckling induces a delay in the return to oestrus and ovulation and, subsequently, a delay in conception in postpartum cows (Randel, 1981). Acosta *et al.* (1983) proposed the hypothesis that the suckling stimulus increases the time to first oestrus by increasing the sensitivity of the hypothalamus to the negative feedback of estrogens during the postpartum period resulting in a decreased LH release. Suckling may also act by suppressing gonadotrophin release in the hypothalamus (Carruthers and Hafs, 1980; Zalesky *et al.*, 1990) and ovarian activity (Short *et al.*, 1994a). According to William *et al.* (1996), mechanisms regulating suckling-mediated anovulation in cattle integrate hormonal, sensory and behavioural signals that influence the puerperal reproduction. This entails the post-gestational recovery of the hypothalamic-hypophyseal-ovarian axis (anterior pituitary repletion of LH, oestradiol positive feedback, endogenous opioid tone and GnRH secretion), maternal behaviour, nutrition, photoperiod, metabolic hormones and bio-stimulation with the aid of males. These mechanisms probably offer tools for reducing the length of postpartum anovulatory period.

The length of the postpartum interval is longer in suckled than in milked cows. Several studies have shown suckling to be a major cause of long inter-calving periods in cows (Short *et al.*, 1972; Laster *et al.*, 1973; Bellows *et al.*, 1974; Carruthers and Hafs, 1980; Dawuda *et al.*, 1988a, Short *et al.*, 1990; Mukasa-Mugerwa *et al.*, 1991a,b). Cows that have their calves weaned at birth have shorter PPI's compared to cows that are being suckled (Short *et al.*, 1972; Williams, 1990). When calves are weaned some time after birth but before the oestrous cycles resume (around 20 to 40 days postpartum), cows will return to oestrus within a few days (Laster *et al.*, 1973; Bellows *et al.*, 1974). Suckling thus seems to be the main factor responsible for extending the postpartum anoestrous period, particularly in zebu cows. Acosta *et al.* (1983) reported that during nursing, $E_2$ suppressed serum LH release.

Randel (1981) assigned Brahman x Hereford first-calf heifers to either normal or once-daily suckling starting 30 days post-calving and results indicated that suckling once-daily shortens the postpartum interval, without depressing the cow/calf performance.

The quantity of milk available to the calf, the number of suckling times and the duration of suckling all play a role in duration of the postpartum anoestrus, but the time when suckling takes place seems to be the most critical aspect of the postpartum anoestrus (Carruthers and Hafs, 1980; Stewart *et al.*, 1993a, 1995; Gazal *et al.*, 1999). Melatonin levels are higher late at night and this hormone is the mediator of the delay in the postpartum anoestrous period in beef and dairy cows. When the cows are suckled during the night, when melatonin levels are high, this results in a stronger inhibiting effect of prolactin in the hypothalamus. Thus if partial weaning has to be adopted, day suckling might therefore be a good option (Sharpe *et al.*, 1986; Stewart *et al.*, 1995).

Some studies have shown that cow/calf interactions, independent of suckling and lactation, may increase the length of postpartum anoestrus in beef cows. Hoffman *et al.* (1996) reported that calf presence, without suckling, was one factor that delays the onset of first postpartum ovulation of beef cows. A cow/calf nursing orientation with tactile stimuli to the inguinal area, but not limited to the teat and (or) udder, is sufficient to prolong anovulation due to the release of oxytocin (Viker *et al.*, 1993).

The regulation of the suckling and lactation stimulus has been shown to be a viable management option to decrease the PPI in cattle. The cow can be released from the inhibitory effects of suckling either by allowing the effects to wane with time, or by weaning the calf (Short *et al.*, 1994a). Weaning can occur immediately after calving or at anytime up to 9 or 10 months following calving. It can either be complete, short-term (temporary calf removal for 48 to 96 hours or longer) or partial (restricted suckling during short periods of time each day) (Randel, 1981; Wells *et al.*, 1986; Ryle and Orstov, 1990; Williams, 1990; Khan and Preston, 1992; Stewart *et al.*, 1993a,b; Short *et al.*, 1994a; Sanh *et al.*, 1995, 1997). Response to any given weaning treatment will vary with nutrition and genotype of the cow, and age of the calf (Short *et al.*, 1990). In addition, fundamental biology can be applied to reproductive management through the traditional calf manipulation of suckling frequency thresholds, daytime versus night-time suckling, alien cow/calf cohabitation, as well as hormonal therapy. However, the practical use of these options is often not feasible (Williams *et al.*, 1996).

2. 7. 2. Minor factors influencing the length of the postpartum interval

The minor effects are often subtle or fixed, and could possibly be manipulated by management. However, it is advised that these factors be taken into account when management strategies are considered (Short *et al.*, 1990). Season was one of the first factors to be associated with postpartum anoestrus. Season affects the number of animals that can be inseminated in a herd of cattle (Galina and Arthur, 1989c). These seasonal effects may be direct (e.g. effects of weather changes on the physiology of the animal) or indirect (i.e. associated with the influence of climate on pastures and the appetite of the animal). Galina and Arthur (1989b) and Short *et al.* (1990) noted the possible effects of photoperiod, humidity and solar radiation on reproduction - effects that can be modified by nutrition, breed or suckling status. True seasonal effects associated with photoperiod and temperature can however be confounded with nutritional changes as the year progresses and feed availability and quality vary (Short *et al.*, 1994a).

Breed and genotype effects on the postpartum anoestrous period exist. Dairy breeds that are milked have a shorter PPI than suckled beef breeds, but when dairy breeds are suckled, they have a longer PPI than beef cows (Short *et al.*, 1990). Differences have also been reported between beef breeds, and these differences are more pronounced at lower dietary intake levels. These genotype effects may be due to physiological differences between breeds or to confounding effects such as the quantity of milk produced, appetite or feed intake (Short *et al.*, 1990).

Age and parity of the cow have an effect on the PPI. Younger cows generally have a longer PPI and a lower reproductive potential (Sasser *et al.*, 1988; Laflamme and Connor, 1992; Bellows and Short, 1994). Dystocia is also associated with age and will increase the PPI and delay rebreeding. The effects of dystocia can be avoided, or at least minimised by the appropriate supplementary feeding of heifers prior to the breeding and calving seasons, the use of bulls with an ease-of-calving record, as well as the selection of replacement heifers on the basis of their growth and conformation (Laster *et al.*, 1973; Doornbos *et al.*, 1984).

The presence of the bull could decrease the PPI in cows. Studies have shown that cows grazing with bulls demonstrate a shorter duration of postpartum anoestrus, compared to cows isolated from bulls (Zalesky *et al.*, 1984). The exposure of primiparous as well as multiparous cows to androgenised cows or a sterile teaser bull, or the grazing in the vicinity of a yearling or a mature bull has the same effect (Alberio *et al.*, 1987; Gifford *et al.*, 1989; Custer *et al.*, 1990; Naasz and Miller, 1990; Cupp *et al.*, 1993; Hornbuckle *et al.*, 1995; Fike *et al.*, 1996). These cows resume ovarian luteal activity, as evidenced by behavioural oestrus, much earlier than those not exposed to a male. A more dramatic effect is noticed in primiparous cows (Gifford *et al.*, 1989). These practices have been recommended as a useful management tool in early postpartum anoestrous beef cows - before the onset of the breeding season. Monje *et al.* (1992) however showed that although the presence of the male stimulates postpartum reproductive activity, the response is modified by the nutritional status of the cow. A lengthening of the intervals from calving to oestrus and calving to ovulation were observed in undernourished animals and this fact could explain the lack of response to the male stimulus.

# CHAPTER 3

# LOCATION OF THE STUDY AND DESCRIPTION OF THE GUDALI CATTLE BREED

## 3. 1. DESCRIPTION OF THE STUDY AREA

### 3. 1. 1. Geographical location of the Adamawa region, Cameroon

The Adamawa Highlands are situated 900 to 1500 m above sea level with summits as high as 1800 m, between the latitudes 6° and 8° North, and longitudes 10° and 16° East, covering a total area of approximately 72000 $km^2$. The area stretches from the Federal Republic of Nigeria in the West, through Cameroon, to the Central African Republic in the East. The Cameroonian part of the Highlands, which corresponds to the Adamawa Province (Figure 3.1), is bordered in the North by an abrupt cliff, which separates it from the vast Benoue and Faro plains of the Northern Province (Dii and Koutine plains, respectively, at altitudes of between 500 and 800 m). Along the South and South-East, these highlands slope down progressively towards the Centre and Eastern Provinces of Cameroon. In the East and West, the Adamawa Highlands extend beyond the frontiers of the Central African Republic and the Federal Republic of Nigeria, respectively. Their border in the South-West is the Tikar plain from which the highlands are separated by another steep cliff.

### 3. 1. 2. Soils of the Adamawa region

The Adamawa soils are more or less representative of the granitic, volcanic, metamorphic and sedimentary rocks found on the Plateau and can be described as follows:

- Granite covers the majority of the central and western parts of the plateau and part of the far East; it may be either homogenous, ferromagnetic and rich in quartz, or rich in feldspath.
- The volcanic rocks exist mainly in the centre of the plateau as well as East of the city of Ngaoundere. These rocks are a manifestation of old, as well as recent volcanic activity. Six of these volcanoes are at the origin of crater lakes. This volcanic activity gave rise to some mineralised water springs, locally referred to as "lahoré", which are highly appreciated by herdsmen and their animals.

- Finally, metamorphic rocks are found in the West of the highlands, with sedimentary rocks dispersed in the South and West of the city of Ngaoundere.

According to Yonkeu (1993), although the rocks constitutive of the region may differ, the soil types that these rocks generate are not always different. To the contrary, it may happen that, due to the action of erosion and the influence of climate, the same rock may generate different soil types. The soils of Adamawa can therefore be classified in 4 main groups (according to the Food and Agriculture Organisation World Reference Base for Soil Resources classification):

- Ferralsols in the South-East of the plateau are light on the surface, with a texture of clay and sand. These soils are generally permeable, with low water retention.
- Nitisols from old basaltic rocks which make up the majority of the Adamawa plateau. These soils are generally very deep (5 to 10 m), seem homogenous, with a red colour. Darker for the first few centimetres, they are poor in humus.
- Lithosols and Rankers, which are non-climatic soils, originating from the erosion of old crusts. The aluminium crust, also referred to as the ferralitic crust, is characteristic of the Adamawa South of Ngaoundere up to Tibati, and near the cities of Bagodo, Minim and Martap. These soils have a very thin layer of arable soil on the surface (generally less than 60 cm) and a very deep crust (up to 20 m when the crust's content is high in aluminium).
- Gleysols or hydromorphic soils are generally found in the flooded areas. These are a result of the action of water erosion on rock over hundreds of years.


**Figure 3. 1: Map of the Republic of Cameroon**

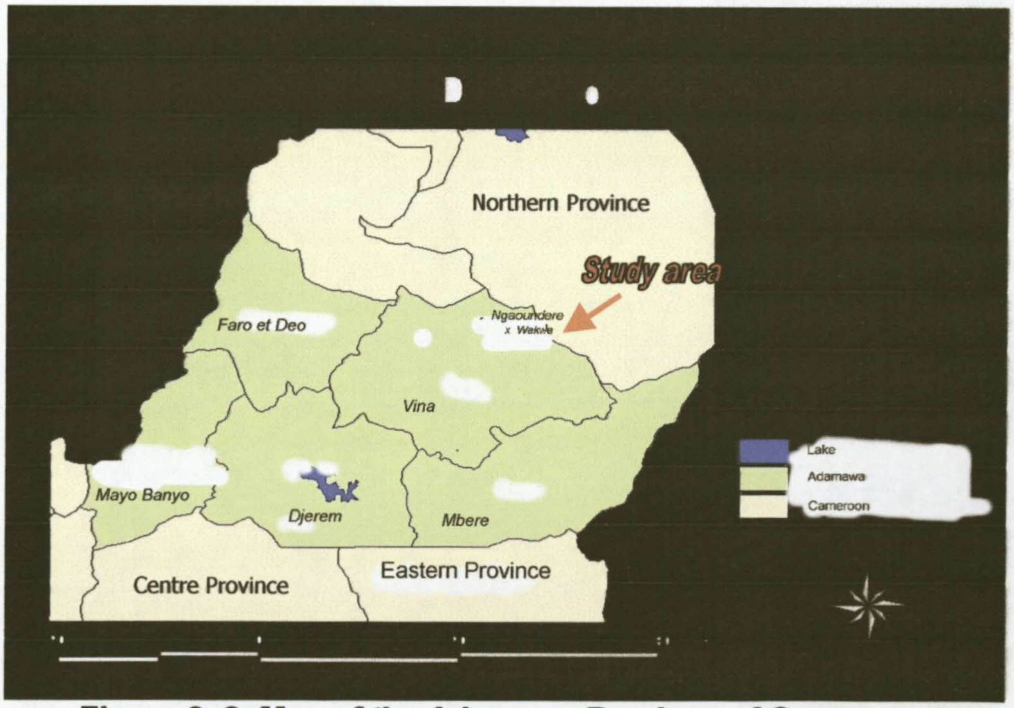


**Figure 3. 2: Map of the Adamawa Province of Cameroon**

### 3. 1. 3. Climate of the Adamawa region

The climate of the Adamawa region is of the Sudano-Guinean type, the same that is found in the Fouta Djallon (West Africa), in the Great Lakes Region (Rwanda, Burundi, East of the Democratic Republic of the Congo) of Central Africa, as well as in East Africa (Southern Tanzania) (Aubreville, 1950).

There are two distinct seasons, namely a rainy season of 7 to 9 months (late March/ early April to late October/ early November) and a 3 to 5 month dry season (early November to late March / early April). The average rainfall is 1530 mm, with approximately 1500 mm rainfall precipitating during the rainy season and about 50 mm in the dry season. The mean annual temperature is 22°C, ranging between 19.9°C in December/January and 24.4°C in March/April. The relative humidity varies between 65.5 and 67.3% (max. of 90% in July/August, during the rainy season; min. of 16.7 to 20.9% in December/February, during the dry season) (Pamo and Yonkeu, 1987).

### 3. 1. 4. Vegetation of the Adamawa region

The temperature is generally not a limiting factor for vegetation growth in the tropics (generally above 10°C and below 45°C), with the dry season tending to retard the growth of the vegetation. The vegetation's growth period in the Adamawa runs from March/April to October/November. Due to the physical environment (the northern cliff which clearly marks the demarcation with the Sudan savannah; the appearance of forests at an altitude of 900 m) and the frequent bush fires (caused by hunters, crop and livestock farmers, honey seekers, etc), the vegetation is clearly different. The area between the natural boundaries of the Adamawa Highlands corresponds to the predominantly woody savannah, interspersed with zones of mixed shrubs (*Piliostigma thonningii, Harungana madagascariensis, Syzigium sp., Hymenocardia acida, Terminalia sp.,* etc), trees (*Daniella oliveri, Lophira lanceolata, Croton macrotachius, Mangifera indica, etc*), and water-logged areas covered with grasses (*Hyparrhenia rufa, H. diplandra, H. sp., Pennisetum purpureum, Panicum maximum, Andropogon guyanensis,* etc). A more extensive description of the vegetation of the Adamawa has been documented (Piot and Rippstein, 1975; Rippstein, 1985; Yonkeu, 1993).

### 3. 1. 5. Human population of the Adamawa region

The Adamawa Province, one of 10 in the Republic of Cameroon, is divided of the following 5 administrative divisions: Djerem (capital city: Tibati); Faro and Deo (Tignere); Mayo Banyo (Banyo); Mbere (Meiganga), Vina (Ngaoundere). The people living in Adamawa are from very diverse cultural origins. Many ethnic groups live in close proximity, in as much harmony as this diversity may allow. The most important groups numerically (or in traditional/religious terms) are the Fulbe or Fulani or Peulh, Mbororo, Gbaya, Mbum, Duru (otherwise called Dii), and the Tikar (Vute, Mambila, etc.). Alongside these groups, are other smaller groups like the Hausa, Nyem-Nyem, Koutine (preferably calling themselves Pere), etc.

This province, with an estimated human population of 422,500 people (IRZ/GTZ, 1989), represents approximately 4% of the national population and reflects a very low population density (approximately 6.8 inhabitants per $km^2$). This low density, coupled with the relatively favourable natural environment and the low level of crop activities, makes most of the area suitable for livestock production to supply meat to the less hospitable areas of Cameroon and abroad.

Although no livestock census has ever been undertaken, the Adamawa cattle population was estimated to be more than 2.5 million head in 2002 which represents more than 28% of the Cameroon's total cattle population, and caters for more than 1/3 of the country's domestic beef supply (Mbah, 1992). This is thus the most important beef production zone in the country, with other livestock species (sheep, goats, poultry and pigs) being farmed but to a lesser degree.

## 3. 2. CATTLE BREEDS OF THE ADAMAWA REGION

Mandon (1948), Lhoste (1969), Mbah (1992) and Messine *et al.* (1995) have described the most important cattle breeds of Cameroon. The three major cattle breeds found in the Adamawa Highlands of Cameroon are all zebu (*Bos indicus*) types, namely the Gudali with its Ngaoundere, Banyo and Yola subtypes, the Aku (White Fulani) and the Djafun (Red Fulani). In this region, crosses between the above breeds as well as between the American Brahman zebu and the Ngaoundere Gudali can also be found, but in smaller numbers.

The Ngaoundere Gudali is the most predominant breed in the Vina area, where the Wakwa Regional Centre of Agricultural Research for Development is located. This breed has been studied in the area since the early '40s and selected since the late '60s. It was termed "the Charolais of Africa' by French researchers in the early 60s. Considered by some to be derived from the Sokoto Gudali of Nigeria and brought into Cameroon by the migrant Fulbe pastoralists, the Ngaoundere Gudali is a beefy short-horned zebu characterised by a large dewlap, a navel sheath in the females, a pendulous preputial sheath in the males, erect ears, and a well developed cervico-thoracic hump (Plates 3.1 and 3.2). The coat colour varies greatly from white to dark brown or black. This colour may be uniform or speckled, with different shades and mixtures of the above. The dominant colours actually depend on the area and the farmers' preferences. The hair is smooth and short, the horns have variable shapes but are usually shorter than those of the Red or White Fulani breeds. The breed is fairly large in frame, with an average adult weight of about 550 and 350 kg for males and females, respectively. Raised as dual-purpose animals (meat and milk) by local farmers, on-station studies have shown that these animals are poor milk producers and grow rather slowly given the available resources at their disposal, but perform better than most other indigenous breeds of cattle. Fattening trials show that the animals respond very well when well fed (carcass dressing percentage is between 50 and 52%), but tend to transform the extra feed into fat rather than meat. Height at the withers, chest girth and scapulo-ischial length average 123, 127 and 128 cm, respectively, at the adult stage for both sexes (Mandon, 1957). Considered as docile animals when in permanent contact with the owners or farm workers, they are used in some areas as draught animals (ploughing). However, they can be very wild when they are not handled frequently as is the case in large production units (state and private institutions alike). Plates 3.1 to 3.3 show some examples of the breed.

Plate 3. 1: Some Ngaoundere Gudali cows with calves

Plate 3. 2: A Ngaoundere Gudali bull

**Plate 3. 3: A herd of Ngaoundere Gudali cattle of the traditional sector**

## 3. 3. CATTLE PRODUCTION SYSTEMS IN THE ADAMAWA HIGHLANDS

A number of research studies have been carried out over the years in the Adamawa region, with the aim of describing the cattle production systems, identifying constraints and proposing solutions (Rippstein, 1985; IRZ/GTZ, 1989). These studies have allowed for the characterisation of two prominent livestock production systems in Cameroon, the traditional extensive and a semi-intensive system. These two systems, and particularly the traditional system, discriminate between full-time and part-time livestock farmers. In the traditional sector, livestock farmers can be grouped into pastoralists, agro-pastoralists and part-time farmers, while the semi-intensive system is comprised of privately owned ranches, as well as state institutions.

Pastoralists are full-time livestock farmers, with little or no crop activity. These farmers can be further subdivided into sedentary (permanently settled), semi-sedentary (transhumant) or nomadic farmers. The first, mainly of the Fulbe ethnic group, use hired labour to grow subsistence crops (cereals). The transhumant farmers (a majority of Fulbe, but other tribes are represented) have a permanent settlement for the rainy season only and take their animals away for transhumance during the rainy season along the riverbanks, at variable distances (from a few to more than 50 km). Transhumant farmers grow some cereal and other crops around the "kraal" during the rainy season. Nomadic cattle farmers (exclusively the Mbororo) on the other hand, depend permanently on cattle production, with virtually no crop activity. Very mobile, they change their location according to the availability of vegetation for their animals. However, with the increasing cattle population in some areas followed by an increase in farming land and a decrease in pastures, more Mbororo farmers are progressively limiting their migratory movements and settling down. While the first two groups rear mainly Gudali cattle, the last group is usually associated with the more rugged Aku and Djafun breeds, adapted to trek long distances in search of grazing.

Agro–pastoralism is practised by farmers who have both livestock and crop activities, at different levels. The main crops produced mainly for own consumption are cereals (millet, sorghum), cassava and sweet potatoes. Some tuber (yams) and cereal (maize) are produced as cash crops for sale. The agro-pastoralists can be grouped into "livestock-crop" and "crop-livestock" farmers, depending on which activity is the most important. Livestock-crop farmers can be distinguished from the crop-livestock farmers by the livestock enterprise as a primary activity. Crops and animal husbandry do not have equal importance, as revenue generators for the household. Surplus income generated from livestock can be invested to produce crops beyond the levels of home consumption. These farmers usually own a considerable number of animals and hire people or use family labour to tend to the herds. Crop-livestock farmers (livestock production is a secondary activity) are normally traditional crop farmers who until recently were 100% in crop farming. Realising the profit that can be made from livestock farming, these farmers invest the excess income from crops in livestock as a form of savings. These crop farmers usually own only a few head of cattle, which are usually incorporated in larger herds and supervised by hired labour or other cattle owners. Sheep and goat farming are also important aspects of livestock production.

Part-time livestock farming is practised by a group of people who do not depend solely or primarily on the income from pastoral activities for the well being of their families. Generally, these are wealthier people from the traditional hierarchy, the business world (butchers, businessmen, etc) or the civil service who have a long tradition of cattle farming. Despite having more specialised activities, they invest their extra income in cattle. These part-time farmers usually own from a few to hundreds or even thousands of head of cattle. Their herds are either kept on communal land (hired herdsmen or family members) or on the owners' delimited pastures. The relation with the animals is casual and the visits once a month or once a fortnight. To reduce risks of loss to theft, accidents or diseases, the herds are usually split among different herdsmen at distant locations. The impact of this group who do not depend on the livestock activity for their livelihood contributes tremendously to the increase in cattle numbers in Cameroon, as the off-take rates (percentage of animals leaving the herds for sales, gifts or reasons other than mortality) are generally low, leading to general overstocking of the natural pastoral resources.

Private Ranchers (as opposed to state-run livestock institutions) in Cameroon differ from the other part-time farmers in that their principal objective is production of breeding and fattening of animals for sale. These farmers are highly dependent on the revenue generated by their exploitations. They manage their livestock activities closely and on a frequent basis (at least one visit a week), and are ready to invest on any idea of improvement that can be converted into cash. One of the main features here is the ownership of the grazing land, either from inheritance, as a gift from a local landlord, from purchasing or hiring. The land is usually enclosed within a barbed wired fence. The ranchers' herds however have the possibility to graze on the communal pastures. They therefore contribute to the depletion and degradation of the communal pastures while keeping the grazing under control within the limits of their ranches.

The traditional livestock sector is the most important in terms of heads of cattle, as well as the number of people employed. Cattle are generally kept extensively. The traditional cattle rearing ethnic groups are principally the sedentary and semi-sedentary Fulbe (rearers of the Gudali cattle) and the Nomadic Mbororo (also called Fulani, who breed the White Fulani or Aku and the Red Fulani or Djafun breeds). In the last 15 to 20 years, there has been some evolution towards the "opening" of the trade to others tribal groups with little or no experience in cattle farming. The main cattle production goal is financial security and savings, self-sufficiency in terms of milk, and the production of meat animals for stock replacement and sale. The inputs are usually limited to the minimum necessary for the herd continuity, and the off-take is low. The average cattle herd size is 140 head per farmer, with a wide variation in numbers from 5 to 10,000 animals (IRZ/GTZ, 1989).

## 3.4. GENERAL MANAGEMENT PRACTICES AT THE WAKWA RESEARCH AND PRODUCTION UNITS

The Gudali animals from the Wakwa Animal Production Station were originally purchased from the local markets and from some farmers. These cows and bulls have been subjected to intense selection (progeny testing), since the late 1960s – in an effort to enhance their beef production without any serious detrimental effects to the adaptation qualities of the breed.

At birth, all calves are weighed within 72 hours. Each calf is assigned an ear tag with a chronological number that is recorded in the field books along with the date of birth of the calf, its sex, the dam and sire identification, breed(s) and herd. At the same time, a chronological permanent number is also attributed and entered in the Adamawa Herd Book with all the above information. No special care is given to the calves, except when problems develop, e.g. bucket feeding of colostrum when the dam is agalactic or has mastitis, etc.. The calves are weighed with their dams on a monthly basis while remaining in the experimental herds. The weighing process also serves the purpose of the monthly survey of the increase/decrease in numbers, the general body condition of the animals and the referral of specific cases to the relevant subject matter specialists (veterinarians, physiologists, pathologists, nutritionists, etc). All the calves remain with their dams in natural pastures paddocks enclosed with barbed wire over iron or wood posts until group weaning which takes place once a month at the approximate age of 8 months (plus or minus two weeks).

At weaning, each calf is hot iron branded on the right thigh. The branding consists of the marking with the permanent number indicated above. From the early 1960s to late 1984, this number was a simple 4-digit chronological figure that was continued over the years. Given the relatively small area on the weaner thigh, it was decided in 1984 (when the number 9999 was reached) that each number would henceforth consist of 2 figures. There would be a 3-digit chronological number of birth on top, and a 2-digit year of birth below but the number is read from the bottom up. So, for example, a cow registered with No 99-205 is marked as 20599, it was born (or bought) in 1999 and was the 205$^{th}$ animal entered in the books that year. After weaning, all the weaners are isolated for 3 to 7 days in an enclosed pen, away from the dams. Weaner selection, if there are sufficient calves, may take place at this stage. The main selection criteria are the pedigree (particularly for calves born out of the normal calving season), their general conformation, coat colour, and their liveweight at the time of weaning. For each criterion retained, a weaner receives a grade or an index but the one with the most weight and which comes at the end of the evaluation is the bodyweight. So for example, any weaner that has passed the other tests satisfactorily has to score at least a 70 to 80% mark. This mark is calculated as the ratio of the weight of any specific calf, divided by the average weight of the contemporary group, multiplied by 100. Afterwards, the calves that have not been culled join the male or female weaner herds where they stay until such a time that they are judged fit to enter the breeding herds. Each year, all the animals undergo the same selection process (which usually takes place around mid May, two weeks before the breeding herds are re-constituted for the new mating season).

The heifers and young bulls are selected based on their overall growth rate during the previous year, body condition score at the time of selection, the reproductive history of the sire and dam, and also on the temperament of the individual animals (all dangerous or stubborn animals are culled automatically). In addition to the other criteria, bulls are judged on visual appraisal (general body conformation, masculinity, testicular development, etc), but no breeding soundness examination is conducted. Multiparous cows are judged on their fertility (ability to produce at least one calf every two years), mothering ability, the presence of functional teats, the number of calves weaned, as well as the occurrence of abortions and stillbirths. At the end of the selection process, a compounded index is computed and, based on this index, the best animals are retained on-station for the breeding herds, the second best are sold for breeding to the local livestock farmers, and the rest are sold to butchers. The average culling rate, which varies with the number of animals available and the expected number of breeding herds to be constituted for that year, can be up to 50 or 60% for the males, and around 20% for the females.

A breeding season was instituted since the early 1970 when some studies showed that there were serious weight losses due to the dry season that runs from November one year to March the next year. The objective of this breeding season was to target a calving period that would be less stressful both for the calf and the dam. The best period was found to be the months of June to November, for births that were to take place from the end of the dry season (March) to the end of the rainy season (September/October). The same breeding season is still in force today. At the end of the month of May, once the selection process has been completed, all the cows and heifers (at least 300 kg of bodyweight or 3 years of age) retained for breeding are put in single-sire herds. Each selected bull is assigned to 25 to 30 females, and care is taken to avoid inbreeding. There is always a back-up bull for each breeding bull in the herds. At the end of the mating season, the bulls are separated from the females and put back into the males' herd until the next breeding season.

All animals were previously allowed to graze 24 hours a day on natural pastures in fenced paddocks, at a stocking rate of 1 to 1.5 ha per tropical livestock unit (TLU) - estimated at 250 kg. Since 1993, due to the high incidence of animal thefts (aggravated by the fact that the rural area at the creation of the units is now at the outskirts of the growing university city of Ngaoundere), all animals are locked up for the night in thoroughly fenced kraals and only released in the morning between 06:00 and 07:00. Every fortnight, all animals are offered salt diluted to saturation in water. Supplementary feeding is offered only during the dry season to all animals at a rate of 100 to 200 g of cottonseed cake per 100 kg bodyweight per day, depending on the availability of feed and/or the severity of the drought. Supplementation usually lasts approximately 90 days (January 02 to March 31), but is normally stopped before this date when the rains are early, or continued beyond the above date when rains are overdue.

Prophylaxis against the most common diseases is done on a routine basis. To control biting flies and tick borne diseases, the animals are dipped in an acaricide tank weekly during the dry season and twice weekly during the rainy season. Commercially available anti-helminthic drugs are used twice a year on all calves and yearlings - at the onset and end of every rainy season. All adults are treated on a symptomatic basis. The vaccination against the major prevalent diseases (rinderpest, blackquarter, bovine contagious pleuro-pneumonia, pasteurellosis) is performed annually. When necessary, individual diseases/illnesses are attended to by a resident veterinarian on-station with the appropriate treatment.

At the Wakwa Research and Production Stations, individual records are kept on cards for each animal bought or born on-station. All the particulars of each animal indicate the herds the animal has been into, the period, the different monthly weights, all the calves, stillbirths and miscarriages for the females, etc... In addition to the individual data cards, other group data kept on the animals can be found in the individual herd records (date and weight at birth, weaning dates and weights, presence/absence at any given weighing session, etc). The records existing on cards at the Wakwa units cover the years 1963 to 1994, with the exception of certain years when these data were not available because of the unavailability of a weighing scale. Since 1994, the card system was put on hold for lack of staff.

## 3.5. HORMONE AND IMMUNOGLOBULIN ASSAYS

The progesterone and immunoglobulin research methodologies are presented in the relevant chapters. The assays, conducted according to the manufacturers' specifications, are described in Annexes 1 and 2, respectively.

# Annex 1

## PROGESTERONE ASSAY PROTOCOL USING THE ACS:180 Automated Chemiluminescence System™ (Bayer HealthCare LLC)

### 1. Reagents used (provided and required)

* ACS:180 PRGE Lite Reagent (monoclonal mouse anti-progesterone antibody labelled in acridium ester in buffered saline with sodium azide - 0.1% - and preservatives);

* ACS:180 PRGE Solid Phase (progesterone derivative covalently coupled to paramagnetic particles in phosphate buffer with sodium azide - 0.11% - and preservatives);

* ACS:180 PRGE Releasing Agent (steroid releasing agent in buffered saline with sodium azide - 0.1% - and preservatives);

* ACS:180 PRGE Master Curve card;

* Calibrator E (low and high calibration);

* Wash Reagent 2 (carbohydrate in buffer with sodium azide - 0.11% - and preservatives).

### 2. Assay principle

The ACS:180 Progesterone assay is a competitive immunoassay using direct, chemiluminescent technology. Progesterone in the sample binds to an acridium ester-labelled mouse monoclonal anti-progesterone antibody in the Lite reagent. Unbound antibody binds to a progesterone derivative, covalently coupled to paramagnetic particles in the Solid Phase. The system automatically performs the following steps: washing the sample probe with 225 µl of Wash Reagent 2; dispensing 20 µl of sample and 90 µl of Releasing Agent into a cuvette; dispensing 100 µl of Lite Reagent and incubating for 2.5 minutes at 37° C; dispensing 200 µl of Solid Phase and incubating for 5.0 minutes at 37° C; separating, aspirating, and washing the cuvette with reagent water; dispensing 300 µl each of Reagent 1 and Reagent 2 to initiate the chemiluminescent reaction; reporting results according to the selected option.

An inverse relationship exists between the amount of progesterone present in the sample and the amount of relative light units (RLUs) detected by the system.

**3. Performance characteristics (according to the manufacturers)**

**Specificity**: The ACS:180 Progesterone assay shows high specificity for progesterone. The following percent cross-reactivity (apparent result compared to amount added) were obtained in samples spiked with plasma: 11-deoxycorticosterone 0.08%, corticosterone 0.9%, pregnenolone 0.46%, 17α-dihydroxyprogesterone 0.31%. Cortisol, Testosterone, Androstenediol, Prednisolone, Aldosterone, 17β-Estradiol, Estrone and Estriol were not detectable.

**Sensitivity and assay range**: The ACS:180 Progesterone assay measures progesterone concentrations up to 60 ng/ml (190.8 nmol/l) with a minimum concentration of 0.11 ng/ml (0.35 nmol/l). Analytical sensitivity is defined as the concentration of progesterone that corresponds to the RLUs that are two standard deviations less than the mean RLUs of 20 replicate determinations of the Progesterone zero standard.

**Method comparison**: For 244 samples in the range of 0.11 to 46.3 ng/ml (0.35 to 147.3 nmol/l), the relationship between the ACS:180 Progesterone assay and an alternate RIA method is described by the equation ACS:180 Progesterone = 0.98 (alternate method) + 0.15 ng/ml (Coefficient of correlation r=0.97).

**Precision**: Six samples were assayed 3 times in each of 24 assays on 3 systems over a period of 3 days. The within-run (intra-assay) coefficient of variation ranged from 3.3 to 10%, and the total (inter-assay) coefficient of variation from 3.8 to 12.0%.

# ANNEX 2

## QUANTITATIVE DETERMINATION OF IMMUNOGLOBULINS USING THE BN™ SYSTEM (Dade Behring Marburg, Germany)

a) Reagents

* Provided

- N Antiserum to Human IgG
- N Antiserum to Human IgA
- N Antiserum to Human IgM

N Antisera are liquid animal sera produced by immunisation of rabbits with highly purified human immunoglobulin (IgG, IgA or IgM). Labile components are removed from the antisera by a special procedure. Filtration and addition of sodium azide as a preservative (1g/l) essentially exclude microbial contamination. After solid phase immunoadsorption, the purified specific antisera are specially tested and adjusted such that optimal suitability for use on the BN System is guaranteed. The antibody titles are determined by radial immunodiffusion and are printed on the vial labels. The titres indicate the quantity of antigen in mg, which will be precipitated in an agarose gel by 1 ml of the corresponding antiserum.

* Required, not provided

- BN System,
- N Protein Standard SL
- N Protein Control SL/L, M and H
- N Protein Control LC
- N Reaction Buffer
- N Diluent,
- N Supplementary Reagent/Precipitation

**b) Principle of the method**

In an immunochemical reaction, the proteins contained in the serum, urine or cerebro-spinal fluid sample form immune complexes with specific antibodies. These complexes scatter a beam of light passed through the sample. The intensity of the scattered light is proportional to the concentration of the protein in the sample. The result is evaluated by comparison with a standard of known concentration.

Assay protocols are provided by the manufacturer in the Instruction Manual and Software of the instrument. All steps are performed automatically by the system.

**a) Performance characteristics of the method**

*1. Sensitivity and measuring range:* The sensitivity of the assay is established by the lower limit of the reference curve and depends therefore upon the concentrations of the proteins in the N Protein Standard SL. Typical measuring ranges are given in the BN System's instruction Manual. The reference intervals for IgG are 7.0 to 16.0 g/l.

*2. Specificity:* N antisera are specific for the respective protein

*3. Precision:* The intra- and inter-assay coefficients of variation obtained with N Antisera to Human Immunoglobulins G on the BN System are 2.1 and 2.7%, respectively.

*4. Method comparison:* The correlation of the results of 100 serum samples assayed with N antisera to Human IgG on the BN System and par radial immunodiffusion gave the following regression:

Y (BN) = 1.09 x (RID) – 0.12 g/l where RID is the result of the radial immunodiffusion.

# CHAPTER 4

# NON-GENETIC FACTORS AFFECTING LENGTH OF GESTATION AND POSTPARTUM INTERVALS IN GUDALI ZEBU CATTLE OF THE ADAMAWA (CAMEROON)

## 4. 1. INTRODUCTION

Ngaoundere Gudali cattle, one of the most popular breeds farmed by the traditional cattle farmers in the Adamawa Highlands of Cameroon (for its meat quality and adaptation to the local environment), has been studied extensively. A considerable amount of work has been published on its productive performance and that of its crosses with some exotic breeds (Mandon, 1957; Lhoste, 1967, 1968; Lhoste and Pierson, 1973; Mbah *et al.*, 1987; Saint-Martin *et al.*, 1988; Abassa *et al.*, 1993; Tawah *et al*, 1993; Ebangi, 1999). Very little information is however available on the reproductive performance of the Ngaoundere Gudali cattle (Mbah *et al.*, 1987, 1991).

Length of gestation and the duration of the post-partum anoestrous period are among the most important cow efficiency traits in cow-calf operations, but these aspects have so far received little or no attention in Cameroon. No information is available on either the average length of gestation or the duration of the open period (calving to conception) of the Ngaoundere Gudali cattle.

Reports on the gestation length of different *Bos indicus* breeds indicate a distribution range of between 285 and 294 days (Plasse *et al.*, 1968c; Williamson and Humes, 1985; Paschal *et al.*, 1991; Browning *et al.*, 1995; Obese *et al.*, 1999). These studies also show that *Bos indicus* calves are, on average, carried longer *in utero* than their taurine counterparts. Although gestation length shows a limited range, the gestation length typical for the breed has to be considered (Reynolds *et al.*, 1980; Lawlor *et al.*, 1984; Herring *et al.*, 1996; Nadarajah *et al.*, 1989).

Tropical cattle breeds generally have prolonged anoestrous periods (parturition to first observed oestrus or first service). This postpartum interval leads to an extended calving-to-conception interval, which in turn leads to extremely long intercalving periods (Galina and Arthur, 1989b,c; Mukasa-Mugerwa, 1989). Apart from the long anoestrous periods, the long postpartum intervals observed in *Bos indicus* cattle can be related to a number of factors such as nutrition (Dunn and Kaltenbach, 1980; Short *et al.*, 1994a), suckling (Dawuda *et al.*, 1988a; Short *et al.*, 1990, 1994a; Mukasa-Mugerwa *et al.*, 1991a; b; Williams *et al.*, 1996), and age/parity (Fike *et al.*, 1996).

The aim of the present study was to determine the gestation length and duration of the open period of the Ngaoundere Gudali cattle in Cameroon, as well as the factors that could significantly affect these parameters, using the breeding data available at the Wakwa Research Centre.

## 4. 2. MATERIALS AND METHODS:

### 4. 2. 1. Location and environment

Data collected over an 8-year period (1981-1988) in the Ngaoundere Gudali herds of the Wakwa Regional Centre of the Institute of Agricultural Research for Development (Ministry of Scientific and Technical Research), and the Wakwa Animal Production Station (Ministry of Livestock, Fisheries and Animal Husbandry) in Cameroon were used for this study. These units are located on the Adamawa plateau, 10 to 12 km east of Ngaoundere at a latitude of 7°30'N and longitude of 13°30'E, along the road leading to the city of Meiganga. Wakwa is situated at an altitude of approximately 1200m above sea level. The climate is of a Sudano-Guinean type, with two distinct seasons, a rainy season of 7 months (end of March/ onset of April to end of October/ onset of November) and a 5 month dry season (onset of November to end of March/ onset of April). The average rainfall is 1530 mm, with approximately 1500 mm of precipitation during the rainy season and about 50 mm in the dry season. The mean annual temperature is 22°C, ranging between 19.9°C in December/January and 24.4°C in March/April. The relative humidity varies between 65.5 and 67.3% (maximum of 90% in July/August, during the peak of the rainy season; minimum of 16.7 – 20.9 in December/February, during the driest period of the dry season). For more details on the study area (environmental conditions as well as the general aspects of the management), refer to Chapter 3.

**Experimental Design: data collection, processing and analysis**

All the animals of which data were recorded (N=885) were pure-bred Gudali cattle belonging to the Wakwa units. These cattle were either bought from local cattle markets, selected by co-operating livestock farmers, or born on-station. Gudali animals from the Wakwa Animal Production Station have been subjected to intense selection (progeny testing) since the late 1960's - in an effort to enhance their beef production traits, without any serious detrimental effects to the adaptation qualities of the breed. Management was consistent throughout the study period (Chapter 3). During the breeding season (June to November), some herds were observed closely by the herdsmen, at least once in the morning (between 06:00 and 07:00) for about 30 minutes. All cows exhibiting oestrus and bred by the bull were identified and recorded. During the subsequent calving season, the sex of the calf was recorded and, where possible, the calf was weighed within 48 - 72 hours following birth. Gestation length was determined as the time interval from the date of the last service observed and the date of calving. According to the methodology as described by *Plasse et al.* (1968c), only gestation lengths between 260 and 320 days were accepted as reliable. Thus, only 697 gestation periods falling within this range were included in the final statistical analysis.

Data was analyzed by fitting a mixed effects linear model, using the general linear models (GLM) procedure of the Statistical Analysis System (SAS, 1991). The model used for length of gestation was

$$Y_{ijklmn} = \mu + F_I + M_{j(I)} + S_k + SE_l + P_m + X + \varepsilon_{ijklmn}$$

where $Y_{ijklmn}$ = gestation period of the $n^{th}$ calf in the ijklm subclass; $\mu$ = population mean; F = effect of year (j=1...8) of mating; M = effect of month (j=1...7) of mating; S = effect of sex of calf (k=1, 2); SE = effect of sex of previous calf; P = effect of parity (m=1...7); X = birth weight of calf used as a covariate: $\varepsilon_{ijklmn}$.=residual effect assumed identically and independently distributed with mean zero and variance $\sigma^2$.

A stepwise regression was used to remove all variables from the model that did not meet the criterion (P<0.15). The month at which the last service was detected was nested within years. Preliminary analyses did not show any significant effect of either the sex of the previous calf or possible interactions. Therefore, these effects and associated interactions were removed from the final model.

As many cows were used over the years, 534 calving to conception intervals (days open postpartum intervals) ranging from 24 to 749 days were used to calculate the time elapsing between the date of the last calving and the date of the last recorded natural service prior to conception (conception date). The fixed effects model fitted for the postpartum interval was as follows

$$Y_{ijklmn} = \mu + M_i + MO_j + S_k + SE_l + P_m + X + \varepsilon_{ijklmn}$$

where Y= Number of days open; M = effect of month of last service, MO = effect of month of calving, S = effect of sex of calf, SE = effect of sex of previous calf, P = effect of parity, X = age of cow at calving, used as a covariate, $\varepsilon_{ijklmn}$.= residual effect assumed identically and independently distributed with mean zero and variance $\sigma^2$. The sex of the previous calf, initially introduced in the model, was not significant and was removed. The analysis of variance of the open days period (ODP, or postpartum interval to conception) showed a large distribution (minimum=24, maximum=749; coefficient of variation = 60.89%; standard deviation = 162.36)

## 4. 3. RESULTS AND DISCUSSION:

Analysis of variance for factors that affect length of gestation and days open (from calving to conception) are presented in Table 4. 1.

**Table 4. 1: Least-squares analysis of variance for length of gestation and open period (days)**

| Source of variation | Length of gestation | | | Open days period | | |
|---|---|---|---|---|---|---|
| | d.f. | MS | P | d.f. | MS | P |
| Month of service | 29 | 215.48 | 0.0003 | - | - | - |
| Sex of calf | 1 | 552.57 | 0.0167 | 1 | 19708.56 | 0.1904 |
| Parity | 7 | 150.68 | 0.1416 | 2 | 897250.51 | 0.0001 |
| Month of Calving | - | - | - | 5 | 100132.49 | 0.0004 |
| Birth Weight | 1 | 1651.78 | 0.0001 | - | - | - |
| Age at Calving | - | - | - | 1 | 32010.79 | 0.0001 |
| Residual | 539 | 95.96 | | 225 | 25268.51 | |
| $R^2$ | | 14.32 | | | 11.58 | |
| CV (%) | | 3.33 | | | 60.89 | |
| RSD | | 9.80 | | | 162.36 | |

MS = Mean Squares; P = Probability level; d.f. = Degrees of freedom; CV = Coefficient of variation; $R^2$ =Coefficient of determination; RSD = Residual Standard Deviation

Of the 697 oestrus observations used in the study, only 578 were included in the final model due to missing data. It was obvious from the frequency distribution of the length of gestation (Figure 4.1) that the raw data included errors - the curve is skewed towards a length of gestation of over 300 days. A possible explanation for this deviation is that, given the conditions under which the oestrous/service observations were made (once a day), mating resulting in conception may have occurred one or more cycles after the last recorded service and were missed - resulting in gestation lengths longer than the actual period.

The mean gestation length recorded in the Ngaoundere Gudali cows was 293.4 ± 0.4 days (Table 4.2). This is in agreement with other reports on the length of gestation in zebu cattle (Plasse *et al.*, 1968c; Browning *et al.*, 1995; Obese *et al.*, 1999; Ageeb and Hayes, 2000).

The sex of the calf significantly ($P<0.05$) affected the length of gestation, with males being carried *in utero* approximately 3 days longer by their dams than their female counterparts (294.1 ± 1.2 versus 291.1 ± 1.2 days). This result is in agreement with the findings of Nadarajah *et al.* (1989) with Holsteins, and Browning *et al.* (1995) on the Brahman. However, Reynolds *et al.* (1980) and Obese *et al.* (1999) found sex of the calf to have no effect on gestation length. Birth weight, introduced as a covariate, was found to be highly significant ($P<0.01$) and tended to increase as the gestation period lengthened.

It would appear that the month during which service and conception take place plays a significant ($P<0.01$) role in gestation length, but this role could not clearly be determined in this study, as the length of gestation fluctuated from year to year. This significance may have resulted from the variability in the accuracy of the detection of the successful mounts by the staff involved, as natural service detection was only performed once daily. Given the low frequency of mounting behaviour usually reported among tropical cattle (20 to 28%) and some evidence that oestrus is better detected during the late hours of the night and early hours of the morning (Mattoni *et al.*, 1988; Galina and Arthur, 1990a; Lamothe-Zavaleta *et al.*, 1991a), it is possible that a significant number of services went undetected. Better results could have been obtained with three observation sessions a day for periods of 30-minutes each (e.g. 06:00, 14:00 and 20:00) (Dobson and Kamonpatana, 1986).

The parity (and subsequently the age of the cow at breeding) had no significant effect on the length of gestation. These findings were similar to those of Obese *et al.* (1999) in Sanga cattle in Ghana. However, it has been reported in other studies that the length of gestation period tended to increase with the parity and age of the cow in the Holstein (Nadarajah *et al.*, 1989; Ageeb and Hayes, 2000).

Nadarajah *et* al (1989) found the length of gestation to be more dependent on the servicing sire than on the dam through her sire. Azzam and Nielsen (1987) reported gestation length to have an average heritability estimate of 0.40 - which could indicate the possibility for selection for a shorter gestation length in cattle. These reports show that the genetic make-up of the calf born may have a prominent effect on the length of gestation, and this trait could be worth selecting for. However, selecting for shorter gestation lengths would in turn reduce calf size and weight (Nadarajah *et al.*, 1989; Browning *et al.*, 1995). This reduction in weight may not be desirable in a breed that already experiences a low calf birth weight (23 to 24 kg) and within which non-pathogenic cases of dystocia are rare.

**Table 4. 2:** Least-squares means (± SE) for gestation length and open period (days) in Gudali cows

| Source of variation | | N | Gestation length (days) | N | Length of period open (days) |
|---|---|---|---|---|---|
| **Overall** | | 697 | 293.4 ± 0.4 | 534 | 266.7 ± 7.4 |
| **Sex** | | | * | | NS |
| Male | | 277 | 294.1 ± 1.2 | 261 | 243.2 ± 13.0 |
| Female | | 301 | 291.1 ± 1.2 | 273 | 238.5 ± 12.1 |
| **Parity** | | | NS | | *** |
| | 1 | 144 | 294.1 ± 1.2 | 186 | 320.7 ± 13.5 |
| | 2 | 144 | 292.6 ± 1.9 | 148 | 250.8 ± 14.4 |
| | 3 | 127 | 294.7 ± 1.2 | 89 | 224.9 ± 18.6 |
| | 4 | 75 | 294.7 ± 1.4 | 67 | 207.9 ± 20.9 |
| | 5 | 52 | 290.9 ± 1.6 | 44 | 200.2 ± 25.8 |
| | 6 | 20 | 289.7 ± 2.4 | - | - |
| | 7 | 11 | 294.6 ± 3.1 | - | - |
| | 8 | 5 | 293.0 ± 4.6 | - | - |
| **Month of calving** | | | | | *** |
| | March | - | - | 68 | 315.7 ± 20.1 |
| | April | - | - | 196 | 265.8 ± 12.3 |
| | May | - | - | 132 | 213.5 ± 14.4 |
| | June | - | - | 81 | 216.4 ± 18.7 |
| | July | - | - | 38 | 211.1 ± 27.2 |
| | August | - | - | 19 | 222.7 ± 37.8 |
| **Month of service** | | | *** | | |
| Year 1 | June | 31 | 292.6 ± 2.0 | - | - |
| | July | 15 | 296.1 ± 2.7 | - | - |
| | Aug | 11 | 292.2 ± 3.1 | - | - |
| | Sep | 10 | 292.4 ± 3.3 | - | - |
| | Oct | 7 | 290.8 ± 3.9 | - | - |
| | Nov | 1 | 290.8 ± 9.9 | - | - |
| Year 2 | June | 59 | 291.9 ± 1.5 | - | - |
| | July | 20 | 296.5 ± 2.4 | - | - |
| | Aug | 16 | 297.6 ± 2.6 | - | - |
| | Sep | 16 | 298.7 ± 2.6 | - | - |
| | Oct | 4 | 289.2 ± 5.1 | - | - |
| Year 3 | June | 39 | 293.8 ± 1.7 | - | - |
| | July | 28 | 292.5 ± 2.0 | - | - |
| | Aug | 37 | 293.2 ± 1.8 | - | - |
| | Sep | 13 | 291.2 ± 2.9 | - | - |
| | Oct | 25 | 288.4 ± 2.1 | - | - |
| | Nov | 4 | 281.7 ± 5.0 | - | - |
| Year 4 | June | 35 | 290.3 ± 1.9 | - | - |
| | July | 6 | 306.0 ± 4.1 | - | - |
| | Aug | 3 | 277.9 ± 5.6 | - | - |
| Year 5 | June | 61 | 294.3 ± 1.4 | - | - |
| | July | 13 | 297.4 ± 2.8 | - | - |
| | Aug | 2 | 310.8 ± 7.0 | - | - |
| Year 7 | July | 44 | 295.0 ± 1.6 | - | - |
| | Aug | 7 | 300.7 ± 3.7 | - | - |
| | Sep | 1 | 276.9 ± 9.9 | - | - |
| Year 8 | June | 55 | 293.1 ± 1.5 | - | - |
| | July | 12 | 291.3 ± 2.9 | - | - |
| | Aug | 2 | 283.8 ± 7.0 | - | - |
| | Oct | 1 | 294.6 ± 9.9 | - | - |

NS = Non significant; * = Significant, *** = Highly significant

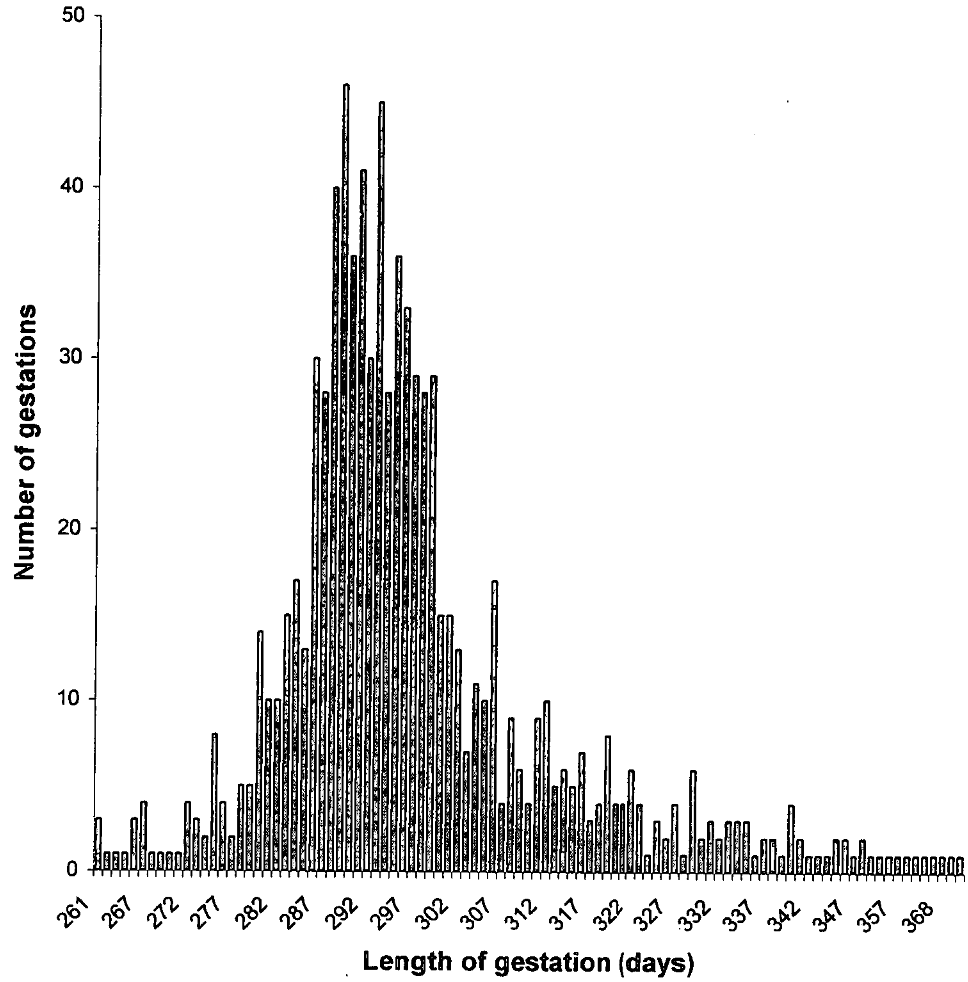


**Figure 4. 1: Frequency distribution of length of gestation in Ngaoundere Gudali cattle**

The distribution of the length of the open period (calving to conception) is illustrated in Figure 4. 2. The mean number of open days recorded was 267.7 ± 7.4 days, with a range of 37 to 749 days. While 23.2 % of the observed cows conceived within 90 days of calving, 55.6 % conceived by 360 days, and the rest (44.4 %) did not conceive within a year (13 to 25 months postpartum). This may partly explain the long intercalving period, characteristic of the breed. Plasse *et al.* (1968a) found an interval from parturition to conception of 65.3 days in the Brahman cattle, whereas an interval of 203.9 days was reported in Holstein-Friesian cattle under central Sudan conditions (Ageeb and Hayes, 2000). Mulugeta (2003) recorded a postpartum anoestrous interval of 77.2 days for Horro cattle in Ethiopia, but the interval to conception was not indicated.

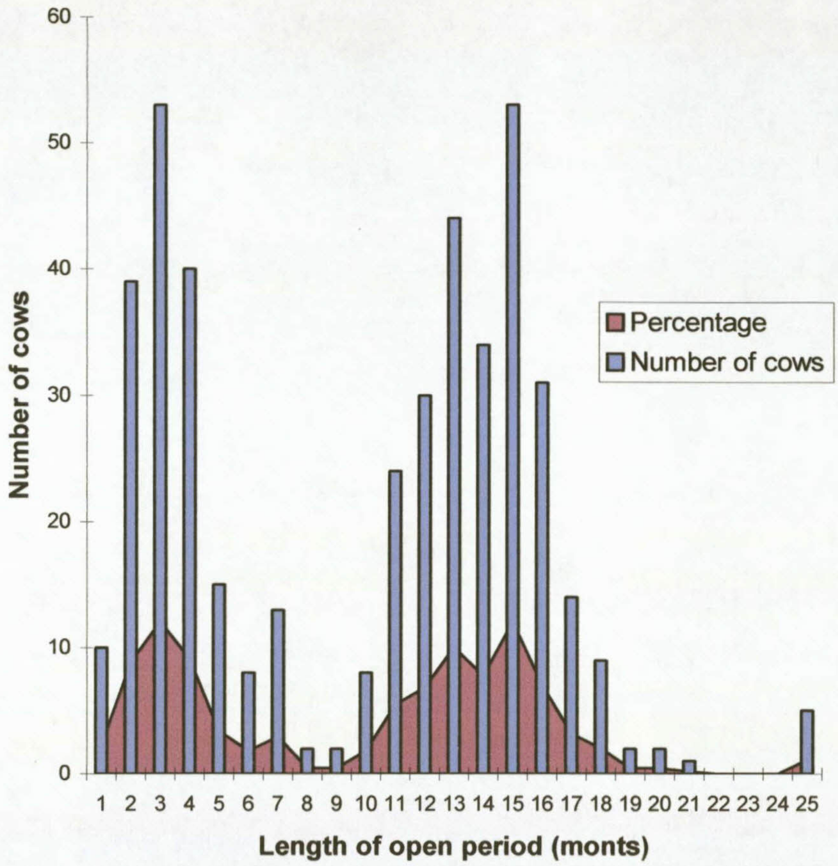


**Figure 4. 2: Distribution of the duration of the open days period in Ngaoundere Gudali cows**

From Figure 4.2, it is apparent that the distribution of the calving to conception interval is bimodal, with a group of intervals centred around 60 to 150 days (33.5 %) and another group between 12 and 17 months (43.7 %). As this interval was significantly (P<0.001) affected by month of calving and parity, but not by sex of the calf, it is thought that the second group was comprised mostly of cows that calved too late in the breeding season, could not be rebred and skipped the subsequent calving season. It could also be cows that did not conceive in one breeding season, and had to wait another 6 to 12 months to be re-bred and thus conceived two mating seasons later. These possibilities are created by the long (6 months) mating season, allowing cows to calve during the following year's mating season.

The combined effects of the seasonal availability of feed and variation in management could also be a possible explanation for these two peak intervals for open days, almost 12 months apart. As can be deducted from Figure 4.3, cows that are bred at the beginning of the mating season (i.e. in June) will calve at the end of the dry season (March), or at the onset of the rainy season (early to mid-April). These cows will thus be lactating when feed scarcity is at its highest, and will need a longer time to restore their body reserves mobilised to nurse their calves, that will only be weaned 8 months later (around November-December), when the breeding season is nearing its end. Very few of these cows may be bred then and most would skip a year, until the following breeding season. This explains why these cows have the longest open period (315.7 ± 20.1 days), compared to cows conceiving later in the breeding season. These cows that are actually bred later in the rainy season (July, August or September) will start calving from the end of April to the end of August and stand a better chance of being rebred during the same mating season, as pastures are available in quantity, and their quality is at the highest when the nursing cows are at their peak of production. These cows do not need to mobilise their body reserves in excess and therefore stand a better chance of reconception during the same breeding season. From these results, the best calving period in terms of shorter postpartum interval would therefore be the early rainy season, from May to July. This would mean a 3-month breeding season extending from late July/early August to late October/ early November.

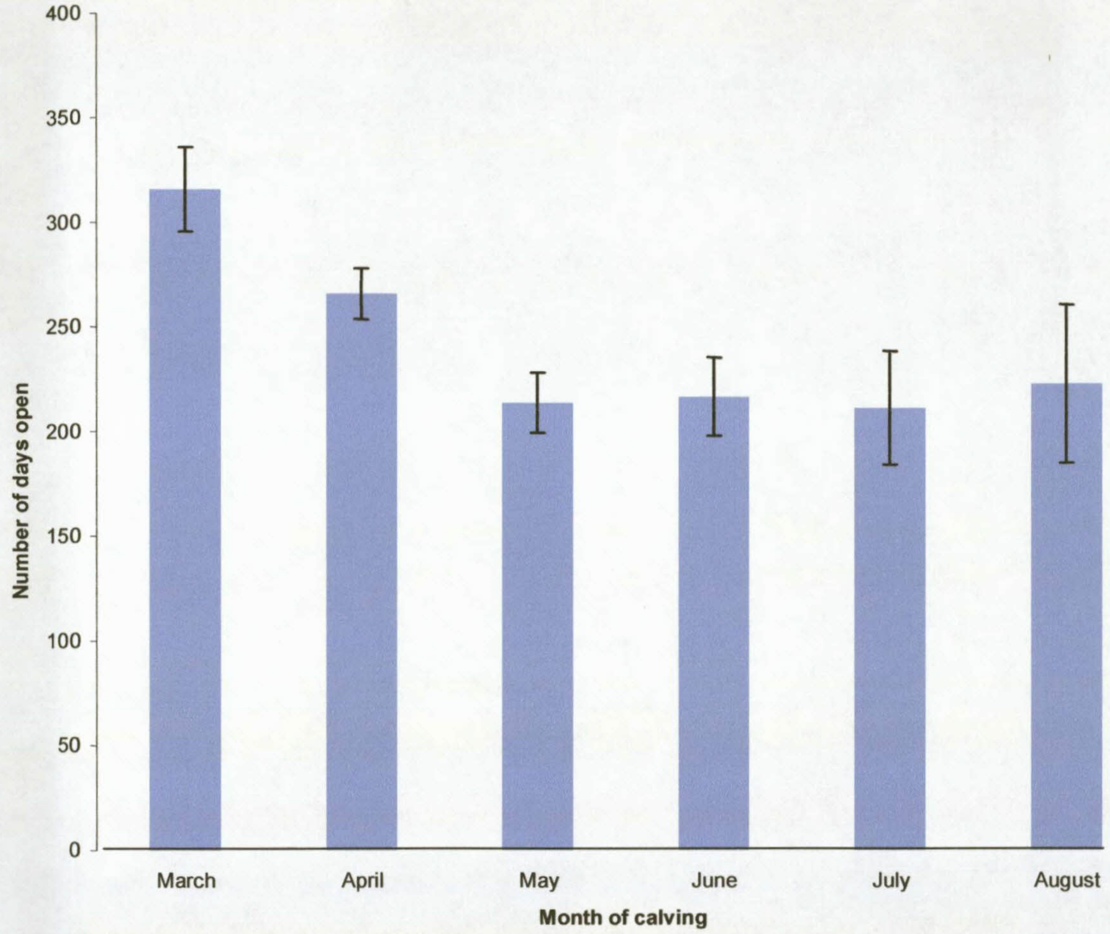


**Figure 4. 3: Month of calving and length of the open period in Ngaoundere Gudali cows**

These findings are similar to previous results on the same breed reported by Abassa *et al.* (1993), Tawah *et al.* (1993) and Ebangi, (1999), but focussed on different aspects. The present calving season was instated in order to protect the dam and calf from the adverse effects of the dry season (Lhoste, 1967; 1968). Tawah *et al.* (1993) and Ebangi (1999) found cows calving during the rainy season to have heavier calves at birth, but these calves were lighter at weaning. On the other hand, it was also shown that cows calving at the end of the dry season or at the beginning of the rainy season had lighter calves at birth, but weaned heavier calves.

The season, through its effect on the availability of feed, plays an important role in the period from calving to conception. It has been reported that dairy cows are in a phase of negative energy balance during the first few weeks following parturition as the feed consumption does not meet the nutritional needs of lactation (Roche *et al.*, 2000). This negative energy balance would be exacerbated in Ngaoundere Gudali cows calving late in the rainy season or at the beginning of the dry season, when forage from natural pastures is less available and the dam is losing weight (Lhoste, 1967). Nutritional management during the transition period – preferably 3 weeks before and 3 weeks after parturition – is thus of great importance as it may have significant carry-over effects on reproductive efficiency during the subsequent mating season.

The sex of the calf born did not significantly affect the duration of the open period, although this period was on average 5 days longer after the birth of a male than that of a female calf. This difference was expected, as male calves are usually heavier at birth (Holland and Odde, 1992) and tend to grow faster (Reynolds *et al.*, 1990). This faster growth, which is achieved through a larger intake of milk, increases the nutritional stress on the cow, resulting in additional inhibitory action on the resumption of the ovarian activity and therefore lengthens the open period. To the contrary however, Mulugeta (2003) reported longer postpartum intervals following the birth of a female calf (81.6 and 72.6 days for male and female calves, respectively) in Horro cattle of Ethiopia.

Parity significantly ($P<0.001$) affected the duration of the open period (Table 4.1 and Figure 4.4). Cows on their first parity had the longest open period (320.7 days) which tended to decrease as the cows got older (200.2 days at the 5th parity). Although it would be economically advantageous for the farmer that the heifers calve early, early calving does not appear to be practical in a low input livestock system. Since inputs are kept to the minimum, little or no supplementation is given to lactating cows even during the times of feed scarcity (dry season). Early calving heifers kept under satisfactory nutritional conditions tend to wean lighter calves, have longer intervals from calving to first oestrus and conception, and lower pregnancy rates in their second mating season (Laster *et al.*, 1979; Bellows *et al.*, 1982). When the conditions are sub-optimal, the primiparous heifers are more likely to skip a year or more before being able to conceive than multiparous cows. In this case, the gain in the form of an early lighter calf may be outweighed by a longer calving interval.

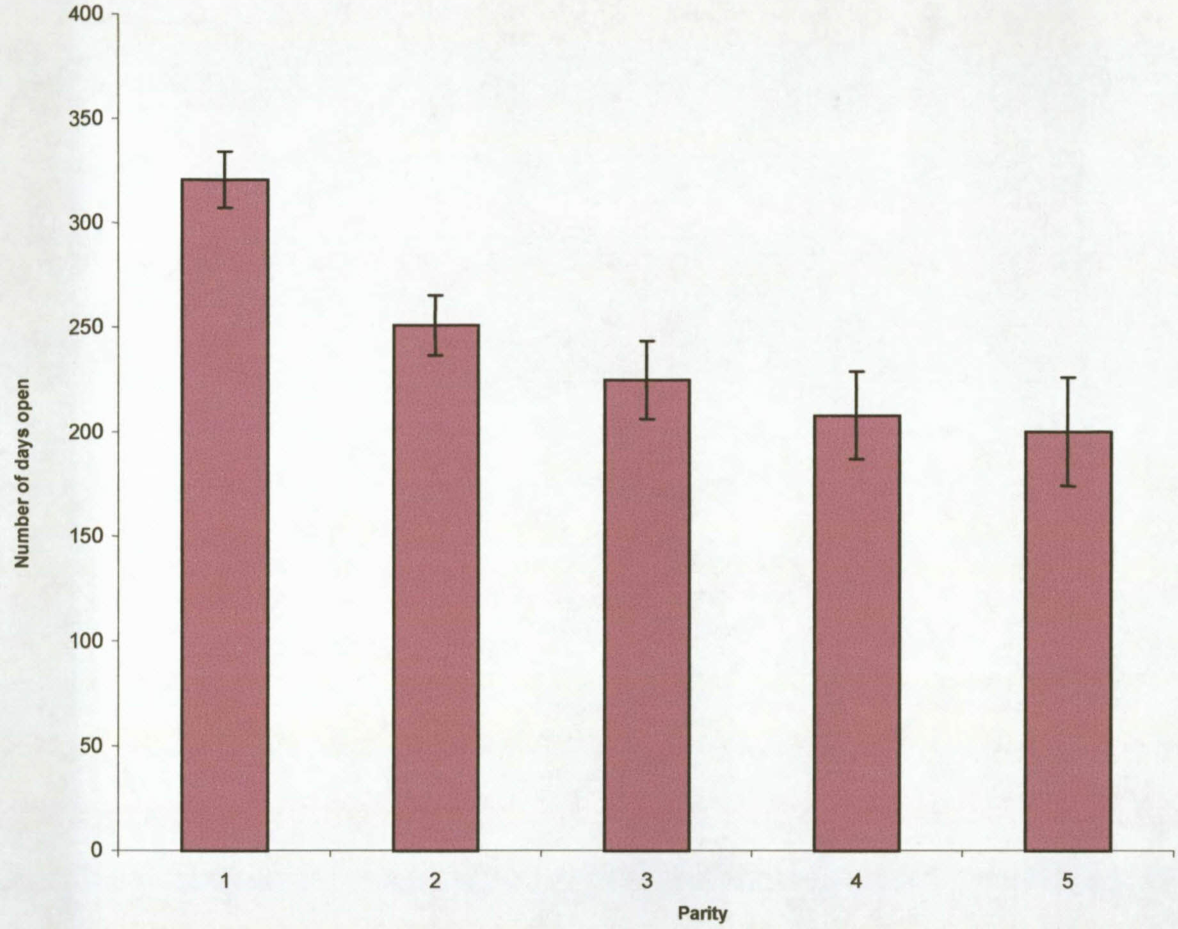


**Figure 4. 4: Effect of parity on the duration of the open period in Ngaoundere Gudali cows**

Under ideal conditions, heifers that conceive early in their first breeding season maintain this production advantage throughout their lifetime, whereas heifers calving late for the first time are more likely to skip at least one calving season during their reproductive life, due to long inter-calving intervals (Lesmeister, 1973). Young cows tend to have the longest calving intervals, due to their concurrent nutrient requirements for growth and lactation (Wiltbank, 1970; Bellows and Short, 1978; Mukasa-Mugerwa *et al.*, 1991b; Fike *et al.,* 1996). This poses an additional limitation for the traditional husbandry system practised in the tropics, that is characterised by low inputs. Under the traditional husbandry systems in the Adamawa highlands, early breeding of heifers before the age of 24 months is not advised.

Tropical cattle breeds in general, and the Ngaoundere Gudali in particular, show a prolonged postpartum anoestrus, which may be caused by the absence of overt behavioural signs of oestrus despite ovulation, leading to long calving-to-service periods and, ultimately, to long inter-calving intervals (Galina and Arthur, 1989c; Mukasa-Mugerwa, 1989). This may also be attributed to short oestrous cycles that in some cases follow parturition - with normal ovulations and ova release, but no pregnancy taking place (Rutter and Randel, 1984). The effect of the season through the availability of nutritive pastures cannot be over-emphasised, as has been shown in the present study.

## 4. 4. CONCLUSION

Month of service and sex of calf were found to be significant sources of variation in the gestation length of the Ngaoundere Gudali cattle, whereas parity did not affect this parameter. Male calves are carried 3 days longer *in utero* by their dams than their female counterparts, but this difference is not significant. The significant effect of season on the gestation length was attributed to the variability of the accuracy of oestrous/service detection by the staff involved, as these observations were not done frequently enough. It is therefore suggested that in the future, a frequency of 3 observations per day for periods of at least 30 minutes each be adopted for more accurate oestrus observations.

The duration of the open period was significantly affected by month of calving and parity, but not by the sex of the calf. Primiparous cows had the longest open period, and this reduced as parity increased. Cows calving in March and April (at the end of the dry season/ beginning of the rainy season) had longer open periods than those calving later particularly as from May. This latter group stands a better chance of being rebred during the same breeding season than the former leading to a shorter open period. The mating season should be planned in such a way that cows would start calving in May, which means programming the breeding season to start two months later (late July/early August) and end one month earlier (late October/early November) than the current practice.

# CHAPTER 5

# CERTAIN NON-GENETIC FACTORS AFFECTING AGE AT FIRST CALVING AND CALVING INTERVALS IN NGAOUNDERE GUDALI ZEBU CATTLE OF THE ADAMAWA (CAMEROON)

## 5. 1. INTRODUCTION

Reproductive performance is widely accepted as the most important economic trait in a beef cow herd (Wiltbank, 1994). The relative economic importance of reproduction is ten times higher than that of production, although only 10% of variation in reproduction will respond to selection against 40 and 50% of variation in production and products, respectively (Willham, 1973). Reports on beef cow-calf operations around the world show the main reason of the low productivity in this sector to be the poor reproductive performance of females in most breeds (Dickerson, 1970; Dziuk and Bellows, 1983). This poor performance is manifested among others by delayed puberty and late age at first calving, low conception rates and long intercalving periods (Wilson, 1985; Voh and Otchere, 1989; Galina and Arthur, 1989a, b). According to Bonsma (1980), the poor reproductive performance of beef females is an adaptive mechanism to a harsh environment. The most important sign of adaptability in all animals to a certain environment is their ability to produce and reproduce regularly. However, the low reproductive efficiency of the tropical cattle breeds has been viewed by many as a hindrance to any rapid genetic progress and a direct cause of economic loss, especially under traditional extensive production systems (Mukasa-Mugerwa *et al.*, 1991b). The low reproductive performance of the tropical cattle breeds can be attributed to a combination of genetic, physiological, managerial and environmental factors which influence the different reproductive stages of a bovine female among which puberty and postpartum period are the most sensitive (Agyemang *et al.*, 1991). Although extensive studies have been carried out on the productivity of the Ngaoundere Gudali cattle, these studies have tended to focus mainly on the calf stages (birth to puberty) or on the meat (and milk) production aspects of the mature animal. Little emphasis has been given to the reproductive aspects of this breed. The full understanding of the causes for the low reproductive performance of the Ngaoundere Gudali is necessary before any serious attempt geared at a sustainable improvement in production can be contemplated. The objective of this study was to identify some of the non-genetic factors that affect the reproductive performance of the Ngaoundere Gudali females during their reproductive life with emphasis on the age at first calving and the calving intervals.

**5. 2. MATERIALS AND METHODS:**

*Site and animal management:*

The study was carried out at the Wakwa Agricultural Research for Development. Wakwa is situated at about 10 km south of Ngaoundere, on the road to Meiganga. The full description of the geographical location and climatic conditions of the Adamawa Highlands, and those of the Wakwa locality in particular, as well as herd management practices carried out at the Centre is set out in Chapter 3. Mandon (1948, 1957), Lhoste (1969), Messine *et al.* (1995) and Ebangi (1999) have previously described certain aspects of the Ngaoundere Gudali cattle, one of the most popular cattle breeds in Cameroon. This breed has been subject to selection at the Wakwa Animal Research Centre since the late 1960s (Lhoste, 1968; 1969).

*Data collection, editing and analysis:*

The study involved the records of animals from the Wakwa Animal Production Station (Ministry of Livestock, Fisheries and Animal Husbandry) and the Wakwa Regional Centre for Agricultural Research for Development (Ministry of Scientific and Technical Research).

Individual data collected from the records included the following: number, breed and date of birth of the female, number, date of birth, breed, parity and sex of the calf. From the above data, the following parameters were calculated: (i) age at first calving (difference in days between date of birth and date at first calving) and (ii) calving intervals (difference in days between two consecutive recorded calvings). Two different seasons were identified, namely the dry season (from November 1 to March 31) and the rainy season (April 1 to October 31). Data were edited, bearing in mind to analyze only data that seemed reliable. For example, regarding age at first calving, all cows above the age of 1825 days (5 years) or below 730 days (2 years) were discarded. On the one hand, the on-going policy was to immediately cull all females that had not calved by the age of 5 years. On the other hand, it was thought unlikely that a female could have conceived as early as 12 to 15 months. Calving intervals between a normal birth and an abortion were consistently discarded. The remaining data were analyzed using the procedures of the generalized models of the Statistical Analysis Systems (SAS, 1991). A total of 1121 records on the age at first calving (AFC) and 2826 on calving intervals (CI) were analysed. The stepwise regression analysis was carried out on the independent variables listed and only those that met the selection criterion (P<0.15) were used in the final model as follows for (1) age at first calving and (2) calving intervals:

(1) $AFC = \mu + M_i + S_j + Y_k + \sigma_{ijkl}$, where AFC = age at first calving, M, S and Y = effect of month, season and year of birth of cow, respectively.

(2) $CI = \mu + M_i + Y_j + B_k + P_l + X + \sigma_{ijklm}$, where CI = calving interval, M and Y = effect of month and year of calving, respectively; B = effect of breed of previous calf; P = effect of parity; X = age at first calving, introduced as a covariate.

## 5. 3. RESULTS AND DISCUSSION

The results of the analysis of variance and least-square means for age at first calving are set out in Tables 5.1 and 5.2, respectively.

**Table 5. 1: Analysis of variance for age at first calving in Ngaoundere Gudali cattle**

| Source of variation | d.f. | M S | P |
|---|---|---|---|
| Month of birth | 10 | 90775.97 | 0.0009 |
| Season of birth | 1 | 421965.73 | 0.0002 |
| Year of birth | 34 | 375665.79 | 0.0001 |
| Residual | 1075 | 30215.51 | |
| $R^2$ | | 32.75 | |
| C.V. | | 12.17 | |
| R. S. D. | | 173.83 | |

MS = Mean Squares; P = Probability level; d.f. = degrees of freedom; CV = Coefficient of variation; $R^2$ = Coefficient of determination; RSD = Residual standard deviation

The overall mean (± SE) AFC was 1427.9 ± 6.2 days, which amounts to 47.6 months. This value falls within the 40 to 50 months interval reported by Galina and Arthur (1989a) for zebu cattle in the tropics. This result is in agreement with some other findings in similar study areas in Africa e.g. 48 months in Cameroon for Gudali cattle (Mbah *et al.*, 1987); 49.5 months reported for Fulani cattle of Central Mali (Wilson, 1985); 4 years reported in Nigeria for Bunaji cattle (Voh and Otchere, 1989). These results confirm the general trend that tropical zebu cattle breeds are late first calvers. However, other reports have shown that when proper improved and adapted management practices are undertaken, age at first calving can be significantly reduced to about 40 months of age (Oyedipe *et al.*, 1982b; Galina and Arthur, 1989a). Some scope-limited trials at the Wakwa Research Centre tend to confirm this opinion (CRZ Wakwa, 1985; Saint-Martin, unpublished). When heifers were well fed after weaning and well supplemented during the dry season preceding their first breeding, they were successfully bred at 24 to 30 months of age. However, the long-term implications of such management practices have not been studied.

Month, season and year of birth all had a highly significant ($P<0.001$) effect on the AFC in Gudali cattle. The females born during the rainy season were 3 months older at first calving (1490.8 days) than those born during the dry season (1405.6). Most calvings at the Wakwa Research and Production Units take place during the dry season (early April to late October) as a result of a breeding season spanning from early June to the end of November. The age at which the heifers are bred was also set at 3 years. When the breeding season starts, most of the heifers born during the rainy season are usually older than the minimum age of 36 months for breeding. At the same period, the heifers born during the dry season of the same calving period are approximately 36 months of age when they are exposed to the bull for the first time, which gives them a slight advantage. The age of the heifer should therefore not be the sole criterion for incorporating them into breeding herds. Complementary criteria such as body weight (a minimum of 250 kg) and the apparent maturity of the heifer checked monthly throughout the breeding season (visual appraisal, use of BCS and RTS) should be used. Secondly, entry into the breeding herd should not be limited to heifers older than 36 months at the onset of the breeding season, it should be open to all heifers reaching the target breeding weight during the breeding season. In this way, heifers older than 2 years but with a minimum target weight and good BCS could be bred, and selection for early maturing animals could be carried out.

**Table 5. 2: Least square means (± SE) for age at first calving (days) in Ngaoundere Gudali cattle**

| Source of variation | N | AFC (± SE) |
|---|---|---|
| **Overall** | 1121 | 1427.9 ± 6.2 |
| **Month of Birth** | | *** |
| January | 27 | 1408.5 ± 36.6 |
| February | 37 | 1319.2 ± 30.7 |
| March | 153 | 1430.6 ± 16.3 |
| April | 257 | 1465.2 ± 13.3 |
| May | 249 | 1484.9 ± 13.7 |
| June | 164 | 1486.8 ± 15.7 |
| July | 89 | 1519.6 ± 20.1 |
| August | 69 | 1544.4 ± 22.5 |
| September | 33 | 1477.6 ± 31.8 |
| October | 27 | 1447.0 ± 37.1 |
| November | 9 | 1513.3 ± 60.2 |
| December | 7 | 1356.7 ± 67.9 |
| **Season of Birth** | | *** |
| Dry | 233 | 1405.6 ± 21.0 |
| Rainy | 888 | 1490.8 ± 10.9 |
| **Year of Birth** | | *** |
| 62 | 2 | 1696.9 ± 123.7 |
| 63 | 2 | 1526.2 ± 125.8 |
| 64 | 13 | 1466.8 ± 50.5 |
| 65 | 25 | 1466.6 ± 37.7 |
| 66 | 53 | 1438.4 ± 26.5 |
| 67 | 43 | 1484.4 ± 29.4 |
| 68 | 39 | 1450.7 ± 30.4 |
| 69 | 41 | 1502.5 ± 29.9 |
| 70 | 32 | 1461.3 ± 32.9 |
| 71 | 19 | 1502.2 ± 41.9 |
| 72 | 44 | 1570.4 ± 28.7 |
| 73 | 36 | 1494.7 ± 30.8 |
| 74 | 24 | 1519.1 ± 37.0 |
| 75 | 71 | 1434.5 ± 23.7 |
| 76 | 64 | 1303.1 ± 24.6 |
| 77 | 59 | 1432.5 ± 25.3 |
| 78 | 47 | 1431.4 ± 27.7 |
| 79 | 43 | 1396.4 ± 29.1 |
| 80 | 41 | 1383.8 ± 29.1 |
| 81 | 43 | 1432.3 ± 29.0 |
| 82 | 50 | 1241.6 ± 27.1 |
| 83 | 71 | 1248.5 ± 23.2 |
| 84 | 39 | 1208.3 ± 29.8 |
| 85 | 84 | 1219.6 ± 21.7 |
| 86 | 13 | 1465.4 ± 49.7 |
| 87 | 28 | 1514.9 ± 35.6 |
| 88 | 3 | 1491.0 ± 101.6 |
| 90 | 9 | 1445.5 ± 59.4 |
| 91 | 10 | 1600.4 ± 55.7 |
| 92 | 8 | 1440.1 ± 62.0 |
| 93 | 21 | 1388.0 ± 41.3 |
| 94 | 9 | 1502.3 ± 58.1 |
| 95 | 13 | 1469.4 ± 48.5 |
| 96 | 14 | 1598.2 ± 47.8 |
| 97 | 8 | 1459.9 ± 63.4 |

*** = Highly significant

A significant effect of year of birth on AFC was detected but no clear trend was manifested as this parameter fluctuated over time. The following 5$^{th}$ degree polynomial equation relating the age at first calving to the year of birth could be fitted to investigate the possibility of a trend, however remote:

$$Y=-0.0007x^5 + 0.0632x^4 - 1.9781x^3 + 26.787x^2 - 151.35x + 1769.1 \ (R^2=0.51)$$

From the curve compiled, the relation between AFC and year of birth of the female seemed to depend more on other factors that could not be determined or were not considered in this study. This trend is depicted in Figure 5.1.

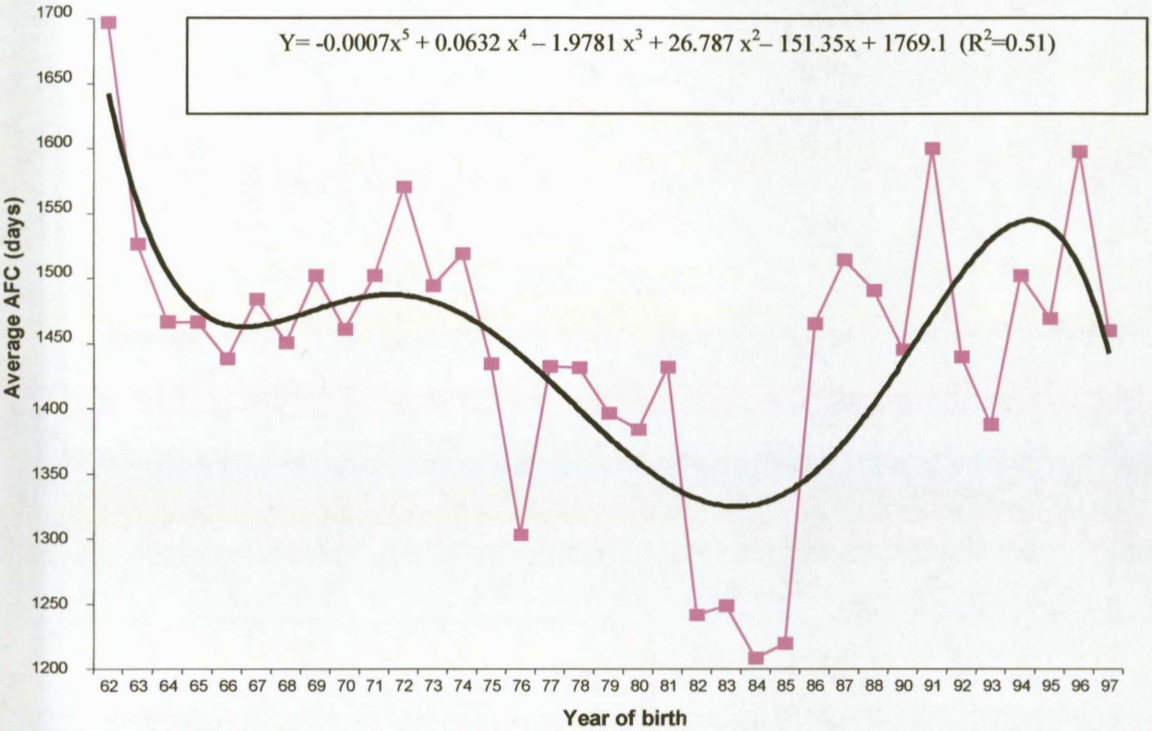


**Figure 5. 1: Age at first calving in the Ngaoundere Gudali over the years (1962 – 1997)**

The effect of month of birth on AFC is illustrated in Figure 5.2. The fitting of a quadratic curve shows that, overall, heifers born during the rainy season tend to have the longer age at first calving, the oldest heifers at first calving being the animals born between May and September. Heifers born in the dry season, particularly those born between November and February, tend to be the youngest at first calving. This result confirms the observation made earlier regarding the slight breeding advantage that the dry season born heifers have over their rainy season counterparts.

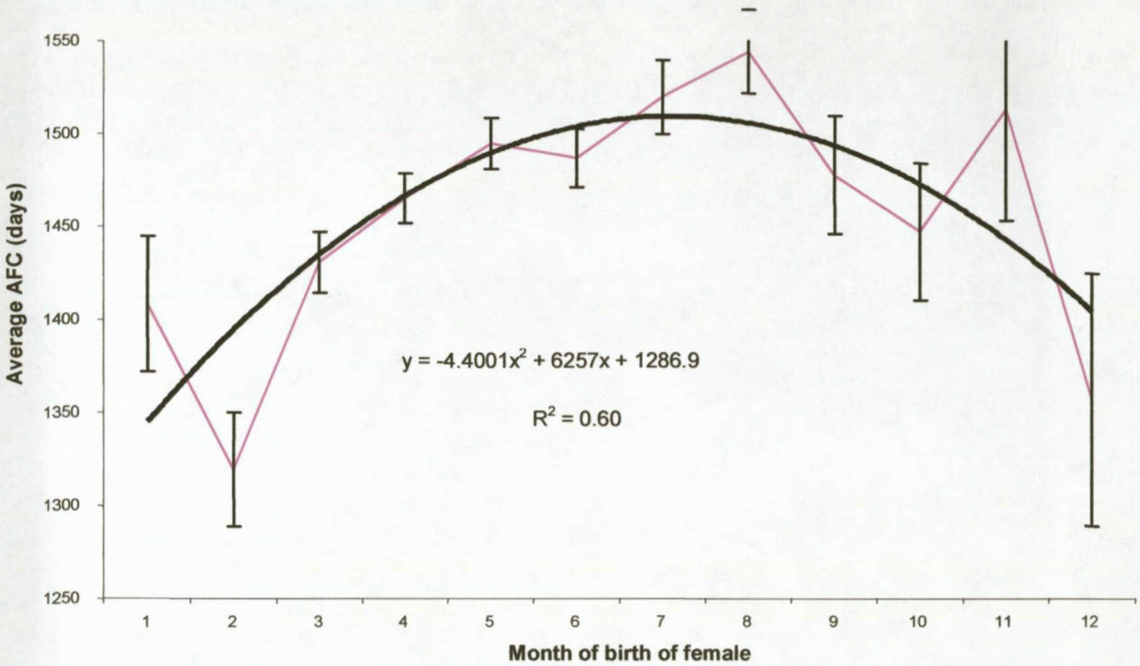


**Figure 5. 2: Age at first calving in the Ngaoundere Gudali according to the month of birth for the years 1962 to 1997**

The analysis of variance for calving intervals in the Gudali cow is set out in Table 5.3.

**Table 5. 3: Analysis of variance for calving intervals in the Ngaoundere Gudali cattle**

| Effects | d.f. | M S | P |
|---|---|---|---|
| Month of calving | 11 | 60244.50 | 0.0091 |
| Year of calving | 33 | 91207.123 | 0.0001 |
| Breed of calf | 2 | 193972.42 | 0.0007 |
| Parity | 6 | 4183954.62 | 0.0001 |
| Age at first calving | 1 | 19978146.23 | 0.0001 |
| Residual | 2773 | 26436.96 | |
| $R^2$ | | 30.64 | |
| C. V. | | 30.13 | |
| R. S. D. | | 162.59 | |

MS = Mean Squares; P = Probability level; d.f. = degrees of freedom; CV = Coefficient of variation; $R^2$ = Coefficient of determination; RSD = Residual standard deviation

The calving interval was significantly (P<0.01 to P<0.001) affected by all variables considered, e.g. the breed of the calf, the year and month of calving, and the parity. The overall mean calving interval recorded was 539.7 ± 0.1 days i.e. approximately

18 months. This intercalving period is possible to achieve due to a degree of feed supplementation during the dry season usually in the form of cotton seed cake. Under a system with no or little inputs as is the case in most of the Adamawa region, farmers should only expect their cows to calve every other year, which would give a conception rate of approximately 55 to 60% per annum (Wilson, 1985). The intercalving period (ICP) recorded in this study is in agreement with other reports showing that the ICP in zebu beef cattle in the tropics is usually above 400 days (Galina and Arthur (1989b). Wilson (1985) reported an ICP of 665 days in Fulani cattle and Voh and Otchere (1989) estimated this interval to be approximately 2 years in the Bunaji cattle of Nigeria. Mukasa-Mugerwa *et al.* (1991b) quoted the ICP to be 620 days in the Arsi cattle of Ethiopia.

**Table 5. 4: Least squares mean (± SE) values for calving intervals (days) in Ngaoundere Gudali cattle**

| Source of variation | N | Means ± SE. |
|---|---|---|
| **Overall** | 2826 | 539.7 ± 0.6 |
| **Month of calving** | | ** |
| January | 73 | 553.8 ± 2.3 |
| February | 49 | 600.5 ± 4.2 |
| March | 373 | 546.1 ± 0.5 |
| April | 749 | 526.6 ± 0.3 |
| May | 643 | 433.2 ± 0.3 |
| June | 450 | 537.9 ± 0.4 |
| July | 214 | 541.5 ± 0.9 |
| August | 153 | 552.4 ± 1.4 |
| September | 63 | 575.6 ± 2.8 |
| October | 35 | 594.6 ± 7.8 |
| November | 15 | 485.1 ± 8.8 |
| December | 10 | 795.6 ± 34.8 |

**Table 5. 4: Least squares mean (± SE) values for calving intervals (days) in Ngaoundere Gudali cattle (continued)**

| | | |
|---|---|---|
| **Year of calving** | | |
| 62 | 15 | *** |
| 63 | 8 | 561.9 ± 11.6 |
| 64 | 64 | 590.1 ± 16.7 |
| 65 | 119 | 535.4 ± 2.3 |
| 66 | 171 | 574.3 ± 1.6 |
| 67 | 120 | 596.6 ± 1.2 |
| 68 | 136 | 583.5 ± 1.9 |
| 69 | 126 | 523.0 ± 1.4 |
| 70 | 123 | 554.3 ± 1.4 |
| 71 | 62 | 586.2 ± 1.8 |
| 72 | 144 | 545.6 ± 2.9 |
| 73 | 108 | 473.1 ± 1.0 |
| 74 | 63 | 515.9 ± 2.0 |
| 75 | 209 | 539.5 ± 3.2 |
| 76 | 224 | 518.6 ± 0.8 |
| 77 | 193 | 506.8 ± 0.8 |
| 78 | 135 | 537.2 ± 1.1 |
| 79 | 101 | 504.5 ± 1.3 |
| 80 | 108 | 509.7 ± 1.8 |
| 81 | 81 | 463.2 ± 1.4 |
| 82 | 100 | 530.7 ± 2.1 |
| 83 | 88 | 520.9 ± 1.7 |
| 84 | 41 | 529.8 ± 1.9 |
| 85 | 104 | 519.3 ± 3.0 |
| 86 | 21 | 643.8 ± 2.6 |
| 87 | 61 | 505.3 ± 6.9 |
| 88 | 4 | 593.9 ± 3.8 |
| 90 | 24 | 605.0 ± 37.6 |
| 91 | 16 | 530.0 ± 8.5 |
| 92 | 15 | 6285 ± 12.8 |
| 93 | 30 | 667.1 ± 18.8 |
| 94 | 6 | 610.9 ± 8.3 |
| 95 | 7 | 633.5 ± 25.4 |
| **Breed of calf** | | 566.7 ± 22.6 |
| Gudali | 2673 | *** |
| Brahman crosses | 59 | 535.5 ± 0.1 |
| Taurine crosses | 95 | 689.2 ± 4.1 |
| **Parity** | | 565.0 ± 2.1 |
| 2 | 948 | *** |
| 3 | 710 | 600.3 ± 0.2 |
| 4 | 487 | 520.0 ± 0.3 |
| 5 | 322 | 506.9 ± 0.4 |
| 6 | 195 | 518.3 ± 0.6 |
| 7 | 96 | 487.3 ± 0.9 |
| 8 and more | 69 | 499.0 ± 2.4 |
| | | 443.8 ± 1.8 |

** = Very significant; *** = Highly significant

The effect of month of calving on the CI is illustrated in Figure 5.3 and the results clearly show cows calving in the middle of the rainy season tend to have the shortest calving intervals as opposed to those calving either during the dry season, or at the end of the rainy season. These shorter CI could be a reflection of better environmental conditions during this particular time of the year (moderate temperatures, abundance of high quality forage and water).

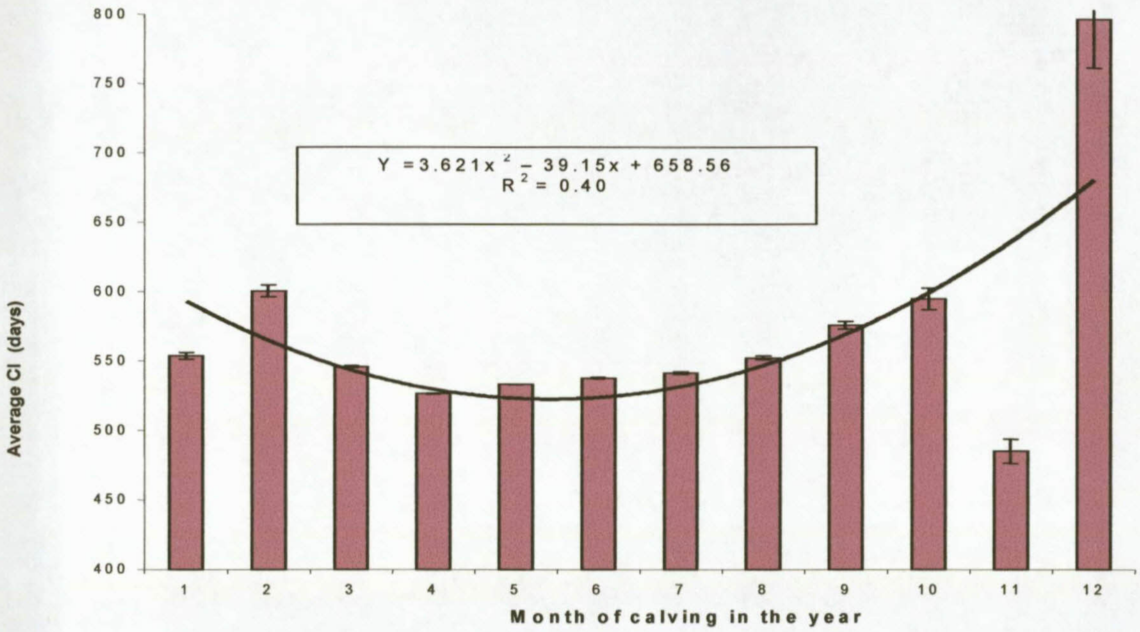


**Figure 5. 3: Frequency distribution of calving intervals in Ngaoundere Gudali cows according to the month of calving for the period between 1962 and 1995**

Due to a decrease in the quality and availability of the pastures as the rainy season progresses and the dry season sets in, these intervals get longer. The late wet season calving females and those calving during the dry season are more likely to miss being bred and could have another opportunity only during the next breeding season.

Over the years, the calving intervals varied significantly ($P<0.001$), but without a clear trend towards any definite decrease in the calving interval over time except for the period between 1972 to 1983 (Figure 5.4). During this period, the calving intervals remained constantly below 550 days. These lower values in CI could have been a reflection of an undocumented change in management during that period.

Young cows tended to have the longest inter-calving intervals (600.3 ± 0.2 days between parities 1 and 2), as opposed to multiparous cows. This long ICP is a result of the heifers' concurrent nutrient requirements for growth and lactation (Mukasa-

Mugerwa *et al.*, 1991b). Age of the cow at calving (used as a covariate) had a highly significant (P<0.01) effect on the ICP. Furthermore, Figure 5 clearly illustrates the trend of a decrease in calving interval, with a concurrent increase in age and parity.

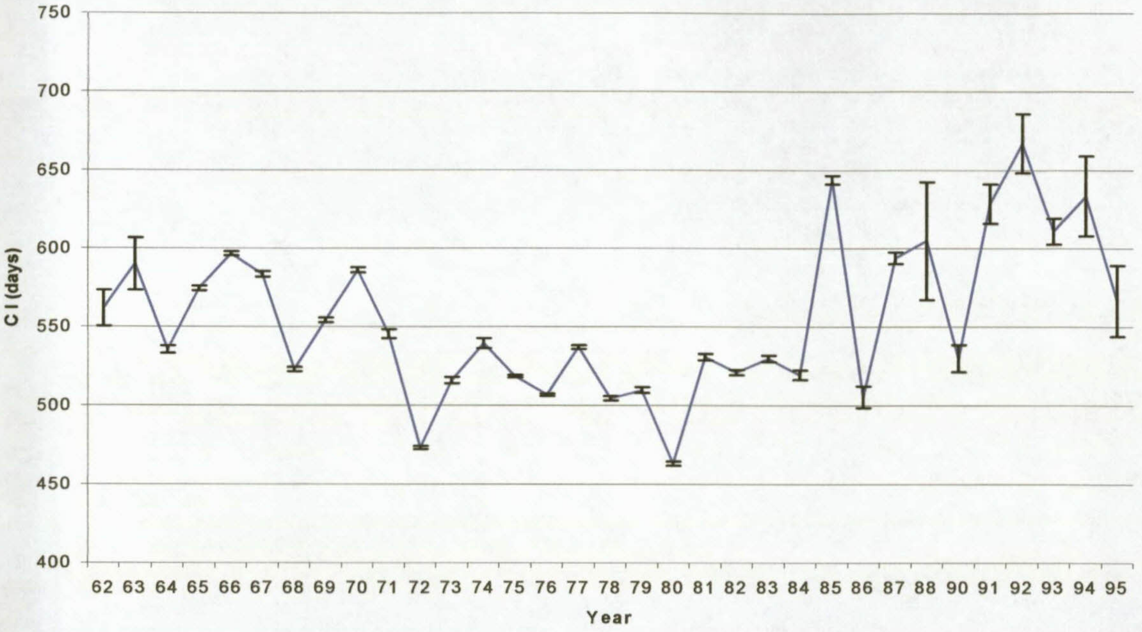


**Figure 5. 4: Fluctuation in calving intervals over years in the Ngaoundere Gudali cattle (1962 – 1995)**

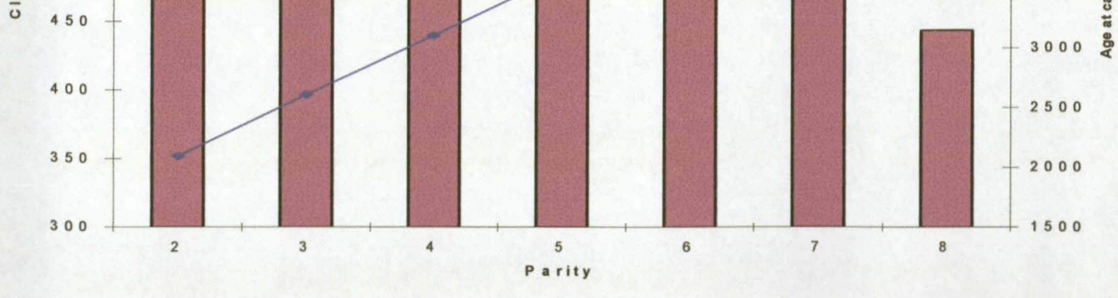


**Figure 5. 5: Evolution of calving intervals with age and parity in Ngaoundere Gudali cows**

The general trend towards the reduction of CI with increasing parity (and age at calving) has previously been reported in tropical zebu breeds of cattle in Africa (Denis, 1971; Oyedipe *et al.*, 1982; Wilson, 1985; Dawuda *et al.*, 1988a). However, contrary to these reports, no significant increase in the calving interval as cows became older was detected in this study. It is possible that the culling of the old cows (beyond parity 8, or aged more than 12 years) at the Wakwa Research station was done before fertility decreased due to old age. Therefore there was not sufficient evidence to confirm this trend in the Gudali cows.

The breed of the previous calf significantly affected the length of the CI in Gudali cows. The lowest calving interval was recorded following the birth of a purebred Gudali calf (535.5 ± 0.1 days) and the longest following a Brahman x Gudali cross (689.2 ± 4 days). The calving interval following the birth of a taurine crossbred (Charolais x Gudali or Holstein x Gudali) was intermediate in length (565.0 ± 2.1 days), 30 days more than the purebred Gudali calf. Brahman and taurine crosses born at the Wakwa Research and Production Units have been shown to be heavier at birth and at weaning than the purebred Ngaoundere Gudali calves (Mbah *et al.*, 1987; Saint-Martin *et al.*, 1988; Abassa *et al.*, 1993; Tawah *et al.*, 1993; Ebangi, 1999). These bigger framed and faster growing calves are more demanding in terms of overall milk requirements from their dams - that are ultimately known to be poor milk producers (Mbah *et al.*, 1987; Tawah *et al.*, 1999). As a result of this increased lactational stress, the Ngaoundere Gudali dams nursing crossbred calves tend to show a longer postpartum anoestrous period, leading to a longer calving interval.

Most of the time, the Ngaoundere Gudali cattle on the Adamawa plateau depend solely on natural pastures for their nutritional requirements, with quality that is high at the onset and middle of the rainy season but declines rapidly due to lignification. This change in quality is exacerbated by the abundance of forage during the wet season (April to October) followed by the scarcity for the rest of the year. During the dry season, it has been reported that unsupplemented animals in the Adamawa may lose up to 20% of their body weight (Lhoste, 1968). Cattle farmers should therefore be trained in the use of sustainable pasture management methods, although under extensive systems in Cameroon land tenure is communal. The stocking rates could be checked, and whenever possible, the available pastures improved upon by the introduction of more productive or hardier species. The fodder generated could then be used more efficiently in order to improve the nutritional status of the animals not only during the dry season but also at specific nutritionally demanding physiological stages (growing heifers, pregnant and lactating cows). A better post-weaning growth would lead to an earlier age at puberty and better body condition at mating thus decreasing the age at first calving. Strategic supplementary feeding and weaning of calves on pastures (partial, temporary or complete) could also be envisaged to reduce both the negative energy balance postpartum and the inhibitory effect of suckling on resumption of ovarian activity. Cows in good body condition before and after parturition are more likely to give birth to healthier and heavier calves, produce more milk for faster growing calves and be prone to re-cycle earlier than those that are underfed. Improving the nutrition and management of the Ngaoundere Gudali cattle in a sustainable way will lead to a substantial increase of the overall reproductive efficiency of the breed.

## 5. 5. CONCLUSION

Many reports have persistently stated the indigenous tropical cattle breeds to have a poor reproductive performance. The present study has confirmed these findings by showing that the Ngaoundere Gudali cattle of Cameroon exhibit a late age at first calving (approximately 4 years) and long intercalving periods (18 months). These figures, although in line with most of those reported in the tropics, are unsatisfactory, given the potential of the breed and the good environmental conditions of the Adamawa plateau.

The reproductive performance of Ngaoundere Gudali cattle is markedly affected by the seasonal availability of feed resources. For the cows, the best time of the year to calve is during the rainy season, while heifers born in the dry season tend to calve earlier for the first time than those born during the rainy season. This discrepancy for the ideal calving season warrants further investigation.

# CHAPTER 6

# FACTORS AFFECTING BIRTH WEIGHT AND PRE- AND POST-WEANING GROWTH IN NGAOUNDERE GUDALI CATTLE OF CAMEROON

## 6. 1. INTRODUCTION

Cameroon is to a large extent an agriculture-oriented country, with an animal production component accounting for up to 16% of the agricultural production and 30% of the total income of the rural work force. Cattle production, particularly beef, although represented in most agro-ecological zones of the country, is concentrated in the Sudano-Sahel, Sudano-Guinean and Western Highland areas of the country. Beef production is seen as the major component of animal production, with an estimated population of over 4.5 million head of cattle. This sector of the national economy accounts for approximately 61% of the country's total meat production (Maikano *et al.*, 1992; Teuscher *et al.*, 1992).

The cattle population of Cameroon is largely constituted of *Bos indicus* (Zebu) types, whose production potential, despite the high numbers, is often reported to be low in terms of reproductive and productive rates. Currently, knowledge of the productive and reproductive potential of the indigenous Cameroonian cattle breeds is scanty because of the little research work done on these breeds and mainly aimed at the characterization of the breed. Breed characterization is an important component of animal production, and entails the gathering of information at different physiological stages. Selection has been carried on the Ngaoundere Gudali breed, jointly by the Wakwa Agricultural Research Centre and Production Station since 1969 with the aim of improving the beef production potential of the breed. This work has largely been published, but has focused mainly on the performance comparison of the Ngaoundere Gudali and its crosses with other exotic breeds at specific physiological stages (Lhoste, 1968; Abassa *et al.*, 1993; Tawah *et al.*, 1993; Ebangi, 1999).

Production and reproduction are under the influence of factors that can be classified as genetic and environmental factors, and interaction between the two. Genetic factors include the sire direct, maternal, additive and total effects (Ebangi, 1999). Environmental factors include factors such as year, season, herd, location, nutrition, management, etc. Knowledge of the effect of these factors is important in determining how they affect cattle production and reproduction efficiency in Cameroon. The objective of this study was thus to investigate the growth traits of the Ngaoundere Gudali cattle for the first 36 months, from birth to the onset of their reproductive life, and to relate growth performance to some of the most important non-genetic factors under local conditions in the Adamawa region of Cameroon.

## 6. 2. MATERIALS AND METHODS

Body weights at birth, 1 and 3 months of age, and every 3 months thereafter until the age of 36 months were retrieved from the Adamawa Herd Book and analyzed in the study. This Herd Book is maintained at the Wakwa Regional Centre of the Institute of Agricultural Research for Development (Ministry of Scientific and Technical Research), and the Wakwa Animal Production Station (Ministry of Livestock, Fisheries and Animal Industries). Due to problems relating to poor data recording and record keeping and frequent scale misfunctions, the years 1966 to 1994 were utilized for birth weights, and 1969 to 1985 for the bodyweights at the different ages. The general location of the Wakwa units as well as the management practices are set out in Chapter 3.

All calves were identified and weighed within 3 days of birth, and monthly thereafter, along with their dams. Weaning took place once a month when the calves were between 7.5 and 8.5 months of age. Due to some unforeseen circumstances, weaning sometimes took place earlier or later than the normal practice. For this reason, calves were subdivided into the following 4 weaning age groups: Very Early Weaning (before 175 days); Early Weaning (between 176 and 225 days); Normal Weaning (between 226 and 255 days); and Late Weaning (later than 256 days). Following weaning, calves were transferred either to the heifer or young male herds until deemed ready for breeding (approximately 3 years for the heifers and 4 to 5 years for the bulls) or culled. The selection criteria included a growth index allocated at certain ages such as weaning or yearling, the calf's pedigree, conformation and coat color, the mothering ability and past reproductive history of the dam, etc. The body weights were used to assess the growth rate of the animals at specific stages, particularly at times when decisions are to be taken (weaning, 24 and 36 months of age). Adjusted weaning weight was calculated as follows:

$$\text{Adjusted Weaning Weight (kg)} = \frac{\text{Weaning weight (kg)} - \text{Birth weight (kg)} \times 205 \text{ days}}{\text{Weaning age (days}}$$

A cow weaner productivity index (Van Zyl *et al.*, 1992) which combines both the calf growth and dam productivity was calculated as follows:

$$\text{Weaner productivity (days)} = \frac{\text{Weaning weight (kg)} \times 365 \text{ days}}{\text{Intercalving period (days)}}$$

Data were checked for validity and consistency. Checks were made on dates, sex, seasons, date and age at weaning, etc. Birth weights were often not available or taken at unidentified dates in the years 1970, 1986, 1987, 1988 and 1994. These corresponding pre- and post-weaning growth rates were thus omitted. Only 3401 records on birth weights, 500 to 800 on ADG (depending on the period, due to missing values), and 1828 on weaning weights and weaner productivity index were submitted for analysis.

Independent variables considered in the analysis included month, season and year of birth of the calves, sex of the calf, parity of the dam and sex of the previous calf. Interactions between variables were also considered in the statistical model. Month and season were taken as random factors nested within season and year, respectively, with the dry season incorporating the months of November to March. When analysing the weaning weights and post-weaning growth rates, weaning age and month of weaning were included into the model, with birth weight and previous 3 months weight as covariates.

The fitted statistical model was as follows:

$$Y_{ijklmnop} = \mu + F_i + S_{i(i)} + M_{k(j)} + SX_l + P_m + MW_n + WE_o + X + \varepsilon_{ijklmnop}$$

Where $Y_{ijklmnop}$ is the performance trait (BWT, ADG, WWT, AWWT, xWT) for the $n^{th}$ calf of the ijklm subclass; μ = overall mean; $M_k$ = effect of month of calving (k=1, 2,...12) nested within $S_j$ = effect of season of calving (j=1, 2); $F_i$ = effect of year of calving (i=69, 70 ...90); $SX_l$ = sex of calf (l=1, 2); $P_m$ = parity (m=1, 2 ... 7); $MW_n$ = effect of month of weaning (n=1, 2 ... 12); $WE_o$ = effect of weaning age group (o=1, 2, 3, 4); X = covariates introduced in the model at different ages (birth weight for weaning weight, previous 3 months weight, age of dam at calving); $\varepsilon_{ijklmnp}$ = residual effect assumed identically and independently distributed with mean zero and variance $\sigma^2$; BWT = birth weight, ADG = average daily weight gain, WWT = weaning weight, AWWT = adjusted weaning weight, xWT = weight at age x (x = 1, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36 months). Due to the fact that the month and season of weaning were no longer significant, these factors were eliminated the model from 24 months of age.

The generalised linear model procedures of the Statistical Analysis Systems (SAS, 1991) were used to run the analysis of variance and compute the least squares means. Effects included in the final analysis were those found to be significant at the 0.15 level when a preliminary stepwise regression analysis was run. When a significance (P<0.05) was recorded in the ANOVA, the Tukey-Kramer Adjusted Test was used to separate the individual least square means (LSM).

## 6. 3. RESULTS AND DISCUSSION

The analyses of variance for birth weight (BWT) in the Ngaoundere Gudali calves are set out in Table 6.1, and the corresponding least squares means (± SE) in Table 6.2. The BWT was significantly (P<0.001) affected by the sex of calf, month and year of birth but not by parity of the dam. The model used could account for only 21.2% of the variation, implying that more than 78% of the variance was unaccounted for. A large proportion of the variation could certainly be attributed to genetic (sire direct and maternal) effects, as well as to the possible genotype x environment interactions e.g. during the gestation period, the calf is 100% dependent on the dam for nutrients. Andersen and Plum (1965) reported birth weight to be highly heritable ($h^2$ = 0.35 to 0.51).

**Table 6 1: Least-squares analysis of variance for birth weight (kg) in Ngaoundere Gudali calves**

| Effects | Df | M. S. | P |
|---|---|---|---|
| Sex of calf | 1 | 663.969 | 0.0001 |
| Month of birth | 10 | 57.002 | 0.0001 |
| Season of birth | 1 | 113.049 | 0.0001 |
| Year of birth | 26 | 68.406 | 0.0001 |
| Parity | 6 | 15.438 | 0.0665 |
| CV (%) | 11.34 | | |
| $R^2$ (%) | 21.23 | | |
| R.S.D. | 2.73 | | |

M.S. = Mean Squares; P = Probability level; d.f. = degrees of freedom; CV = Coefficient of variation; $R^2$ =Coefficient of determination; R.S.D. = Residual Standard Deviation

The overall mean (± SE) for BWT was 24.1 ± 2.8 kg, with the male calves weighing significantly more ($P<0.001$) than their female counterparts (approximately 1 kg or 4%; 24.6 ± 0.1 versus 23.7 ± 0.1 kg, respectively). Abassa *et al.* (1993) and Tawah *et al.* (1993) previously reported this sexual dimorphism in the breed and they showed a 0.8 kg advantage in favour of male calves which is similar to the results found in this study. This finding has also been reported in other studies involving different tropical zebu breeds (Reynolds *et al.*, 1980; 1990; Bourdon and Brinks, 1982; Holland and Odde, 1992; Tomo, 1997).

According to Bourdon and Brinks (1982) and Tomo (1997), bull calves are 1.3 to 2.3 kg heavier than heifer calves at birth. This advantage was found to be as high as 2.8 kg by Reynolds *et al.* (1990) in some taurine, zebu and taurine x zebu crosses, while Holland and Odde (1992) reported a 5 to 8% advantage of male calves over female calves at birth across breeds. This male calf advantage could, at least partially, be explained by the longer gestation period of male calves, compared to that of female calves (Holland and Odde, 1992). However, the Ngaoundere Gudali failed to show any significant effect of sex of calf on gestation length (Chapter 4).

**Table 6 2: Least-squares means (± SE) for birth weight (kg) in Gudali calves**

| Source of variation | N | BWT |
|---|---|---|
| **Overall** | 3401 | 24.1 ± 2.8 |
| **Sex** | | *** |
| Male | 1722 | $24.6 \pm 0.1^{a}$ |
| Female | 1679 | $23.7 \pm 0.1^{b}$ |
| **Month of birth** | | *** |
| January | 44 | $24.4 \pm 0.4^{ab}$ |
| February | 79 | $23.7 \pm 0.3^{bc}$ |
| March | 351 | $23.4 \pm 0.2^{c}$ |
| April | 835 | $23.7 \pm 0.1^{bc}$ |
| May | 785 | $24.2 \pm 0.1^{bc}$ |
| June | 463 | $24.4 \pm 0.2^{ab}$ |
| July | 350 | $24.7 \pm 0.2^{ab}$ |
| August | 266 | $25.2 \pm 0.2^{a}$ |
| September | 111 | $24.9 \pm 0.3^{ab}$ |
| October | 73 | $24.6 \pm 0.3^{bc}$ |
| November | 21 | $23.1 \pm 0.6^{c}$ |
| December | 23 | $23.8 \pm 0.6^{bc}$ |
| **Season of birth** | | *** |
| Dry | 518 | $23.7 \pm 0.2^{a}$ |
| Rainy | 2883 | $24.5 \pm 0.1^{b}$ |
| **Parity** | | NS |
| 1 | 997 | $23.8 \pm 0.1^{c}$ |
| 2 | 783 | $24.2 \pm 0.1^{a}$ |
| 3 | 616 | $24.1 \pm 0.2^{abc}$ |
| 4 | 430 | $24.1 \pm 0.1^{abc}$ |
| 5 | 276 | $24.3 \pm 0.2^{ab}$ |
| 6 | 150 | $25.0 \pm 0.3^{bc}$ |
| 7 and above | 149 | $24.1 \pm 0.3^{abc}$ |
| **Year of birth** | | *** |
| 66 | 22 | $25.2 \pm 0.6^{a}$ |
| 67 | 81 | $23.0 \pm 0.3^{f}$ |
| 68 | 84 | $24.1 \pm 0.3^{fghij}$ |
| 69 | 104 | $25.1 \pm 0.3^{abcd}$ |
| 70 | 104 | $24.0 \pm 0.3^{efghij}$ |
| 71 | 195 | $24.8 \pm 0.2^{bcde}$ |
| 72 | 255 | $24.6 \pm 0.2^{bcdefg}$ |
| 73 | 251 | $24.4 \pm 0.2^{bcdefg}$ |
| 74 | 182 | $23.2 \pm 0.2^{hij}$ |
| 75 | 171 | $23.5 \pm 0.2^{ghij}$ |
| 76 | 185 | $23.4 \pm 0.2^{hij}$ |
| 77 | 193 | $23.1 \pm 0.2^{ij}$ |
| 78 | 201 | $23.9 \pm 0.2^{hij}$ |
| 79 | 214 | $23.6 \pm 0.2^{efghij}$ |
| 80 | 160 | $24.2 \pm 0.2^{bcdefgh}$ |
| 81 | 121 | $24.8 \pm 0.3^{bcde}$ |
| 82 | 154 | $23.7 \pm 0.3^{efghij}$ |
| 83 | 200 | $24.3 \pm 0.2^{defghi}$ |
| 84 | 133 | $24.7 \pm 0.3^{bcdef}$ |
| 85 | 69 | $25.6 \pm 0.4^{abc}$ |
| 86 | 24 | $22.1 \pm 0.6^{k}$ |
| 89 | 50 | $24.4 \pm 0.4^{bcdefg}$ |
| 90 | 68 | $23.2 \pm 0.4^{hij}$ |
| 91 | 64 | $23.4 \pm 0.4^{ij}$ |
| 92 | 68 | $25.6 \pm 0.4^{abc}$ |
| 93 | 40 | $25.3 \pm 0.5^{ab}$ |
| 94 | 8 | $24.6 \pm 1.0^{bcdefg}$ |

Means for the same factor with different superscripts differ significantly. *** = very significant, NS = non significant

Due to the existence of a 6-month mating season (onset of June to the end of November), most of the calves were born during the rainy season and were 0.84 kg heavier than those born at the end of the dry season. Calves that were born later in the wet season got heavier, with the maximum weight achieved by the calves born in August (Figure 6.1). The BWT that had been maintained around 24 kg throughout the rainy season started to decline significantly in the dry season (from November). The effects of season and month of birth on BWT have been shown to be variable and inconsistent across studies. Holland and Odde (1992) reported that, in temperate climates, spring-born calves are heavier in some studies, whereas the fall- or winter-born calves were again heavier in others. Higher feed availability and quality during the rainy season puts the present results obtained in agreement with those reported by Fordyce *et al.* (1993) showing that improved nutrition in the last trimester of pregnancy increases foetal growth. To the contrary, Tawah *et al.* (1993) found that Gudali calves born during the dry season were 0.7 kg heavier at birth that those born in the rainy season. Tomo (1997) in Mozambique also found Angoni calves born during the dry season to be 5% heavier than those born during the rainy season.

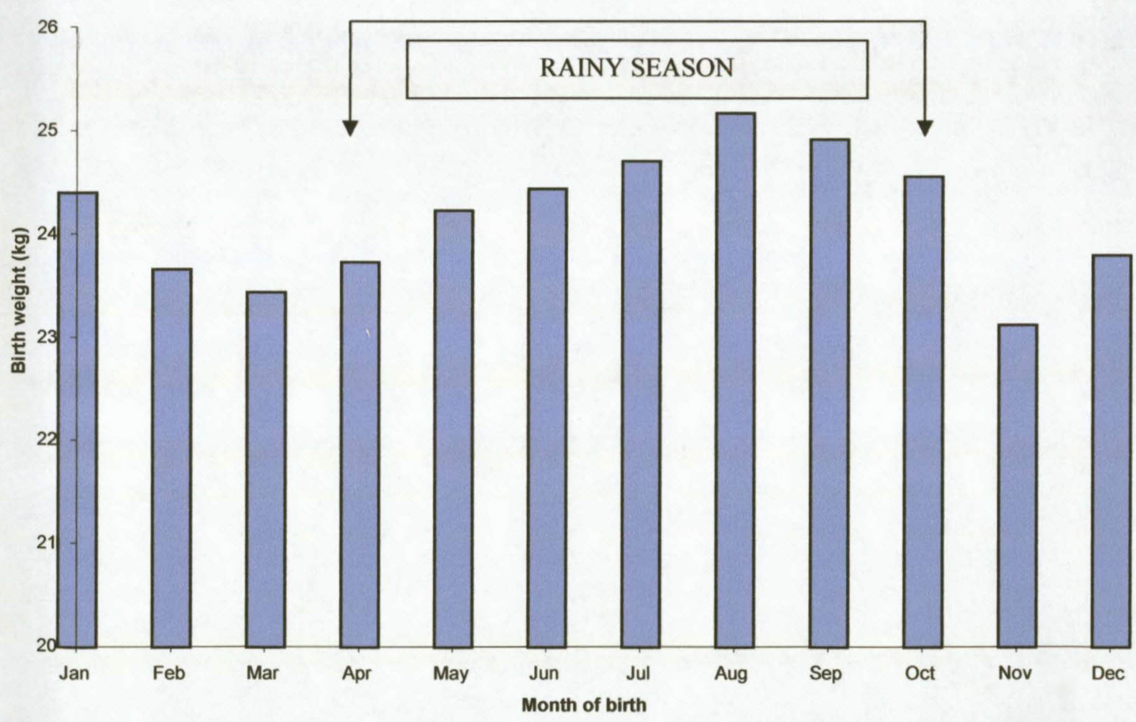


**Figure 6. 1: Month and season of calving effect on birth weight of Gudali calves**

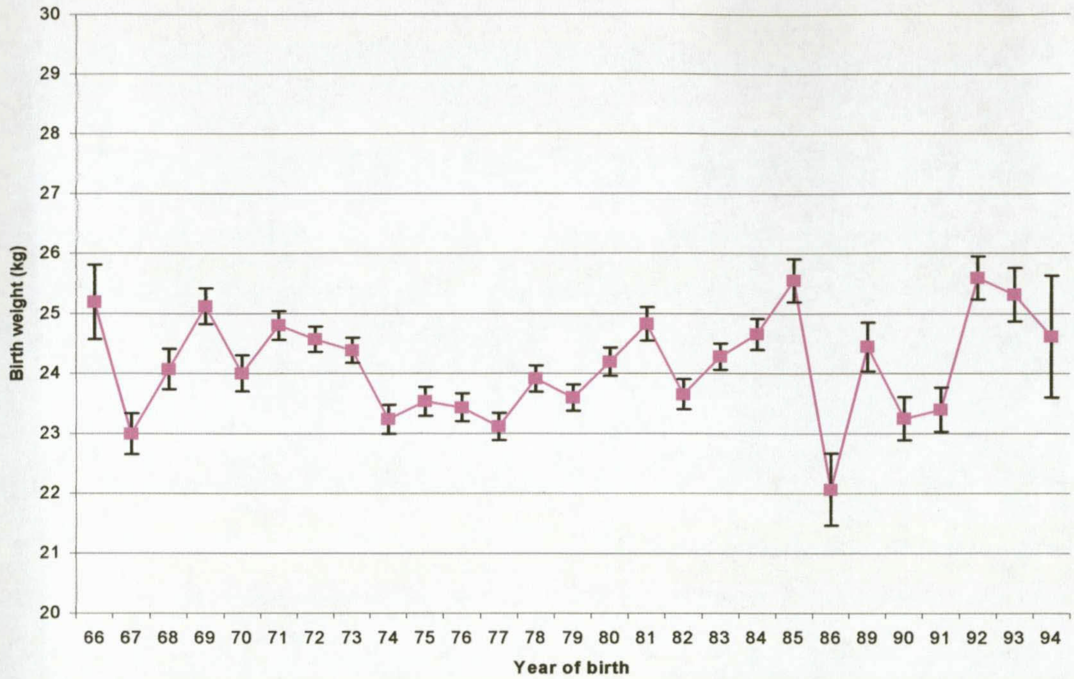


**Figure 6. 2: Evolution of mean birth weights of Gudali calves between 1966 and 1994**

The effect of year on birth weight recorded in this study reflects the large variation in environmental factors (rainfall and nutritive value, as well as availability of the pastures) experienced by the animals throughout the observation period. No definite trend towards any increase or decrease of BWT could be noted over the years (Figure 6.2.).

No significant effect of parity on BWT was detected in this study. However, it can be noted in Table 6.2 and in Figure 6.3 females calving for the first time tend to have lighter calves. The calves' BWT increased slightly up to the 6$^{th}$ parturition before decreasing subsequently. Young cows are often reported to give birth to lighter calves, possibly due to some competition for nutrients between the still-growing dam and the developing foetus (Holland and Odde, 1992). Abassa *et al.* (1993) and Ebangi (1999) in Cameroon, and Tomo (1997) in Mozambique failed to detect any significant effect of age of the dam/parity on BWT in Gudali and Angoni zebu cattle, respectively.

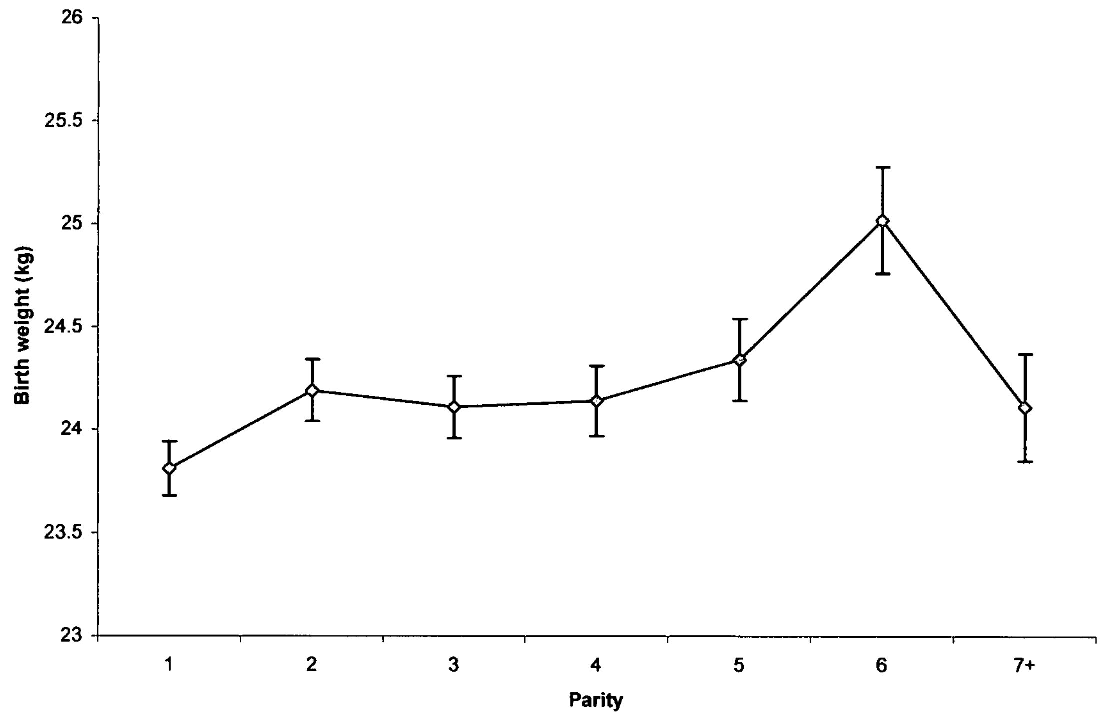


**Figure 6. 3: Effect of parity on the mean birth weight of Ngaoundere Gudali calves**

The least squares analysis of variance and least square means (± SE) for weaning weight (WWT) and adjusted weaning weight (AWWT) of Ngaoundere Gudali calves are set out in Tables 6.3 and 6.4, respectively. Month of birth within season, sex of the calf, season and year of birth, and age of the calf at weaning all had a highly significant ($P<0.001$) effect on both WWT and AWWT. Neither parity nor season of weaning however had a significant effect on the above mentioned parameters. From the coefficient of determination, it is apparent that this model does not account for the majority of the variability recorded, probably due to the fact that, as stated earlier, the model does not make provision for genetic factors and genotype x environment interactions.

**Table 6 3: Least-squares analysis of variance for weaning and adjusted weaning weights in Ngaoundere Gudali calves.**

| Source of Variation | Weaning weight | | | Adjusted weaning weight | |
|---|---|---|---|---|---|
| | df | M S | P | M S | P |
| Month of birth | 10 | 14224.39 | 0.0001 | 9638.96 | 0.0001 |
| Season of birth | 1 | 26133.01 | 0.0001 | 12384.10 | 0.0001 |
| Year of birth | 15 | 6949.94 | 0.0001 | 4986.76 | 0.0001 |
| Sex of calf | 1 | 33840.32 | 0.0001 | 24446.58 | 0.0001 |
| Parity of dam | 6 | 1182.50 | 0.0895 | 776.47 | 0.1354 |
| Weaning Age Group | 3 | 6458.17 | 0.0001 | 13230.59 | 0.0001 |
| Weaning Season | 1 | 1684.93 | 0.1065 | 812.41 | 0.1920 |
| Birth Weight | 1 | 5771.76 | 0.0028 | 560.56 | 0.2784 |
| Residual | 1789 | 645.92 | | 476.89 | |
| CV (%) | | 17.01 | | 20.34 | |
| $R^2$ (%) | | 29.46 | | 29.57 | |
| RSD | | 25.41 | | 21.84 | |

[1] MS = Mean Squares; P = Probability level; d.f. = degrees of freedom; CV = Coefficient of variation; $R^2$ =Coefficient of determination; RSD = Residual Standard Deviation

**Table 6 4: Least squares means (± SE) for weaning and adjusted weaning weights (kg) of Ngaoundere Gudali calves**

| Source of variation | N | Weaning weight | N | Adj. weaning weight |
|---|---|---|---|---|
| **Overall** | 1828 | 149.4 ± 1.4 | 1828 | 107.4 ± 1.1 |
| **Sex** | | *** | | *** |
| Male | 839 | 157.0 ± 2.8$^{a}$ | 839 | 124.2 ± 2.4$^{a}$ |
| Female | 989 | 148.0 ± 2.7$^{b}$ | 989 | 116.6 ± 2.3$^{b}$ |
| **Season of birth** | | *** | | *** |
| Dry | 254 | 166.6 ± 4.5$^{a}$ | 254 | 130.1 ± 3.9$^{a}$ |
| Rainy | 1574 | 138.4 ± 1.9$^{b}$ | 1524 | 110.7 ± 1.6$^{b}$ |
| **Month of birth** | | *** | *** | *** |
| January | 22 | 175.5 ± 5.9$^{ab}$ | 22 | 138.7 ± 5.0$^{ab}$ |
| February | 41 | 187.1 ± 4.7$^{a}$ | 41 | 148.9 ± 4.0$^{a}$ |
| March | 179 | 157.3 ± 2.9$^{bcd}$ | 179 | 129.6 ± 2.5$^{ab}$ |
| April | 422 | 150.5 ± 2.5$^{cde}$ | 422 | 121.5 ± 2.2$^{bc}$ |
| May | 513 | 141.8 ± 2.4$^{defg}$ | 513 | 113.3 ± 2.0$^{cd}$ |
| June | 232 | 134.9 ± 2.7$^{efg}$ | 232 | 107.7 ± 2.3$^{cde}$ |
| July | 181 | 122.5 ± 2.9$^{g}$ | 181 | 98.0 ± 2.5$^{ef}$ |
| August | 118 | 129.3 ± 3.5$^{fg}$ | 118 | 102.8 ± 3.0$^{def}$ |
| September | 60 | 147.6 ± 4.4$^{def}$ | 60 | 118.0 ± 3.8$^{cd}$ |
| October | 48 | 142.1 ± 5.0$^{efg}$ | 48 | 113.5 ± 4.3$^{cd}$ |
| November | 10 | 169.7 ± 8.7$^{abc}$ | 10 | 138.6 ± 7.5$^{a}$ |
| December | 2 | 143.7 ± 18.2$^{efg}$ | 2 | 94.7 ± 15.6$^{f}$ |
| **Year of birth** | | *** | | *** |
| 1969 | 33 | 150.6 ± 5.3$^{cde}$ | 33 | 117.7 ± 4.6$^{g}$ |
| 1971 | 139 | 147.1 ± 3.5$^{de}$ | 139 | 115.4 ± 3.0$^{g}$ |
| 1972 | 222 | 151.7 ± 3.2$^{cde}$ | 222 | 119.4 ± 2.8$^{defg}$ |
| 1973 | 30 | 153.7 ± 5.4$^{cd}$ | 30 | 121.9 ± 4.6$^{def}$ |
| 1974 | 127 | 146.8 ± 3.5$^{de}$ | 127 | 116.3 ± 3.0$^{efg}$ |
| 1975 | 104 | 153.9 ± 3.6$^{bc}$ | 104 | 122.1 ± 3.1$^{cd}$ |
| 1976 | 127 | 162.5 ± 3.5$^{b}$ | 127 | 128.5 ± 3.0$^{bc}$ |
| 1977 | 93 | 160.6 ± 3.6$^{cde}$ | 93 | 127.5 ± 3.1$^{cd}$ |
| 1978 | 169 | 150.0 ± 3.2$^{e}$ | 169 | 118.4 ± 2.7$^{fg}$ |
| 1979 | 186 | 154.9 ± 3.2$^{de}$ | 186 | 122.4 ± 2.8$^{def}$ |
| 1980 | 139 | 146.2 ± 3.3$^{de}$ | 139 | 114.9 ± 2.8$^{g}$ |
| 1981 | 90 | 138.3 ± 4.6$^{e}$ | 90 | 107.7 ± 3.9$^{cd}$ |
| 1982 | 117 | 148.5 ± 4.1$^{de}$ | 117 | 116.8 ± 3.5$^{cde}$ |
| 1983 | 145 | 148.3 ± 3.4$^{de}$ | 145 | 116.8 ± 2.9$^{def}$ |
| 1984 | 94 | 177.7 ± 3.7$^{a}$ | 94 | 141.5 ± 3.2$^{b}$ |
| 1985 | 13 | 149.0 ± 8.2$^{de}$ | 13 | 119.0 ± 7.1$^{a}$ |
| **Parity** | | NS | | NS |
| 1 – 2 | 458 | 153.5 ± 2.8$^{a}$ | 458 | 121.4 ± 2.4$^{a}$ |
| 2 – 3 | 410 | 155.9 ± 2.9$^{a}$ | 410 | 123.1 ± 2.5$^{a}$ |
| 3 – 4 | 335 | 153.4 ± 2.9$^{a}$ | 335 | 121.2 ± 2.5$^{a}$ |
| 4 – 5 | 248 | 152.1 ± 3.0$^{a}$ | 248 | 120.7 ± 2.6$^{a}$ |
| 5 – 6 | 171 | 154.4 ± 3.3$^{a}$ | 171 | 121.62± 2.8$^{a}$ |
| 6 – 7 | 103 | 150.5 ± 3.6$^{a}$ | 103 | 118.73± 3.1$^{a}$ |
| 7 and above | 103 | 147.6 ± 3.6$^{a}$ | 103 | 116.0 ± 3.1$^{a}$ |
| **Weaning age group** | | *** | | *** |
| 1 | 22 | 139.4 ± 6.3$^{c}$ | 22 | 145.9 ± 5.4$^{a}$ |
| 2 | 254 | 151.1 ± 3.2$^{b}$ | 254 | 120.8 ± 2.7$^{b}$ |
| 2 | 1313 | 155.8 ± 2.4$^{b}$ | 1313 | 109.2 ± 2.1$^{c}$ |
| 4 | 239 | 163.6 ± 2.7$^{a}$ | 239 | 105.8 ± 2.4$^{c}$ |
| **Weaning season** | | NS | | NS |
| Dry | 1529 | 155.6 ± 3.5$^{a}$ | 1529 | 122.5 ± 3.0$^{a}$ |
| Rainy | 299 | 149.4 ± 3.0$^{a}$ | 299 | 118.3 ± 2.5$^{a}$ |

Means for the same factor with different superscripts differ significantly; NS = non significant; *** = highly significant

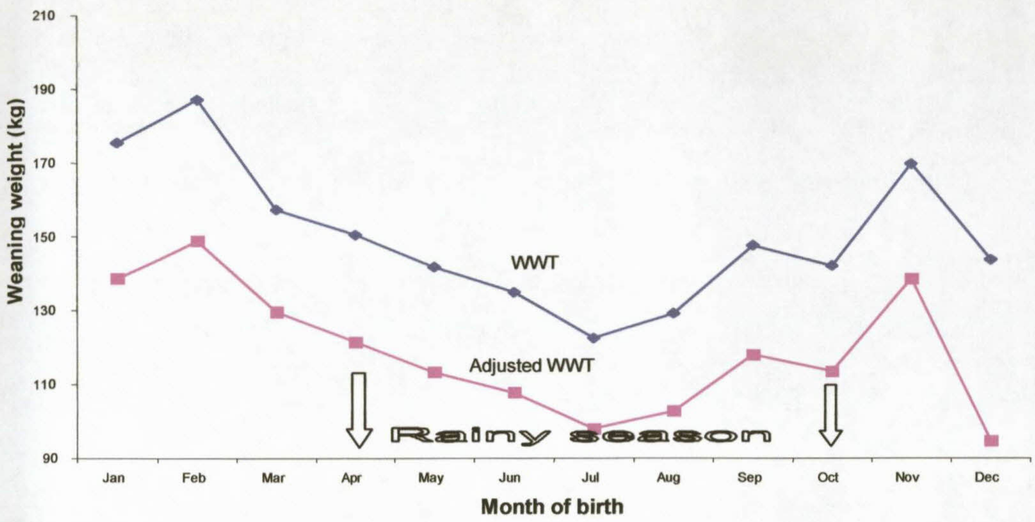


**Figure 6. 4: Effect of month of birth on weaning weight in Gudali calves**

The overall mean WWT recorded was 149.4 ± 1.4 kg, similar to the 149.8 kg reported by Ebangi (1999) for the same breed, while the calculated AWWT was 107.4 ± 1.1 kg. Male calves were 6.1% (WWT) and 6.6% (AWWT) heavier than the female calves (157.0 vs. 148.0, and 124.2 vs. 116.6, respectively) at weaning. This sex effect on WWT was previously reported in zebu breeds, including the Ngaoundere Gudali (Lubout *et al.*, 1986; Abassa *et al.*, 1993; Rege and Moyo, 1993; Tawah *et al.*, 1993; Ebangi, 1999). However, Tomo (1997) was unable to detect any effect of sex of the calf on the weaning weight in Angoni cattle and attributed the lack of sexual dimorphism to a high level of inbreeding.

There was a 20.4% and 17.6% advantage in WWT and AWWT for dry-season-born calves, when compared to those born during the rainy season (Figure 6.5). This could be explained by the fact that most of the dry season-born calves are born late in the dry season. They are thus exposed to the best part of the rainy and vegetation growing season from their third month of age, and therefore grow faster. During this period sufficient nutritious pastures are available both for the dams' optimum milk production and the gradually increasing consumption of tender roughage by the calves. This early availability of feed during lactation could also have for allowed a higher milk production by the dams for a longer period of time.

In contrast, calves born later in the rainy season, although heavier at birth, were weaned in the peak of the dry season. Most of their growth took place during the dry season when the dams did not always have sufficient forage available to meet both their maintenance requirements and those of the growing calf. The suckling calves were therefore lighter in bodyweight at weaning.

The difference in weaning weight found between the dry- and rainy-season groups of calves in this study (28.2 kg) is larger than that reported by Tawah *et al.* (1993) and Ebangi (1999) (24.2 and 19 kg, respectively) for Gudali cattle in Cameroon. The effect of season on WWT has been described in other studies on zebu breeds, although in some no significant effect of season of birth on the weaning weight could be recorded (Maule, 1973; Lubout *et al.*, 1986, Abassa *et al.,* 1993; Tomo, 1997).

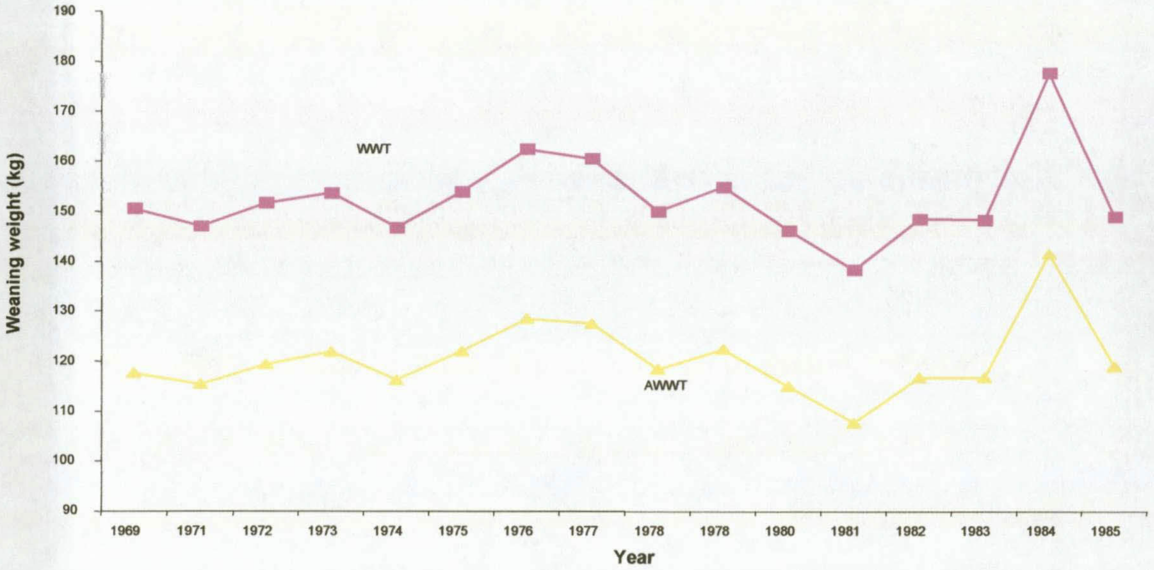


**Figure 6. 5: Average weaning weight (real WWT and adjusted WWT) of Ngaoundere Gudali calves for the years 1969-1985**

The effect of year of calving was highly significant ($P<0.001$) for both WWT and AWWT. However, there was no evident trend over the years (Figure 6.5) probably due the large variation in environmental conditions (irregular onset of the rainy season, total rainfall, heat stress and solar radiation, the seasonal availability of forages). Although Tomo (1997) did not detect any significant effect of year of birth in Angoni cattle, other studies with different breeds obtained results in agreement with those of the present study (Maule, 1973; Lubout *et al.*, 1986, Abassa *et al.*, 1993; Tawah *et al.*, 1993; Ebangi, 1999).

No significant effects of parity and age of the cow were observed on WWT and AWWT in this study. Lhoste (1968) and Abassa *et al.* (1993) failed to detect any effect of parity in the Ngaoundere Gudali breed of Cameroon, as did Tomo (1997) in Angoni cattle in Mozambique. However, many authors have reported a significant effect of age of the cow on weaning weight, particularly when the cows reached a mature age and higher peak milk production. The weaning weights tended to increase significantly (Lubout *et al.*, 1986; Mbah *et al.*, 1991; Rege and Moyo, 1993; Tawah *et al.*, 1993).

Weaning age was found to be a very important determinant of the WWT and AWWT in Gudali calves. The earlier the calf was weaned the lower its WWT, but the higher its AWWT. The WWT and AWWT differences between the calves weaned beyond 8.5 months and the other three age groups (less than 175 days, between 176 and 225 days, and between 226 and 255 days) were 24.2 and –40.1, 12.2 and –15.0, and 7.8 and –3.4 kg, respectively. This demonstrates that the higher WWT of calves weaned beyond 8.5 months does not compensate for the extra time that the calf remains suckling the dam.

The season of weaning did not significantly affect either the WWT or AWWT despite the apparent 20.4% advantage in WWT recorded in favour of the dry season born calves. The calves weaned during the dry season (November to March) were only 6.2 kg heavier at weaning than those weaned during the rainy season. Ebangi (1999) found that, although calves born in the dry season had lower birth weights than those born in the rainy season, the tendency was reversed at weaning as the former outperformed the latter by 17.6 kg. One possible explanation for the difference observed between the results of the two studies could be the unbalanced data structure in this study. 1529 records of weaning weights were from rainy season born calves, compared to only 299 for dry season born calves. It was not possible to differentiate between the early and late rainy season effect recorded from late and early dry season, as there probably is a carry-over effect from one season to another and a high overlapping could be expected between the births during the two seasons. This is further caused by the year to year variation on the onset of the rainy and dry seasons.

The recommendation for a calving season based on the length of the postpartum interval pointed to the rainy season, while the dry season born calves were recorded to be heavier at weaning. In the first case, a calving season during the rainy period would have favoured the productivity of the dam, while being disadvantageous for calf productivity. The cow weaner productivity index, which takes into account both the productivity of the dam and that of the calf, was chosen to help determine the overall best calving period. Least square means for the month of birth effect on weaner productivity index in the Ngaoundere Gudali cattle are set out in Table 6.5 and illustrated in Figure 6.6.

**Table 6 5: Least squares means (± SE) for weaner productivity (kg) in Ngaoundere Gudali cows according to their month of calving**

| Month of birth | Season | Mean index |
|---|---|---|
| January | Dry | 116.3 ± 3.5$^{ab}$ |
| February | Dry | 121.0 ± 2.7$^{a}$ |
| March | Dry | 108.7 ± 1.9$^{c}$ |
| April | Rainy | 103.1 ± 1.8$^{de}$ |
| May | Rainy | 97.4 ± 1.7$^{ef}$ |
| June | Rainy | 92.2 ± 1.9$^{g}$ |
| July | Rainy | 84.5 ± 2.0$^{h}$ |
| August | Rainy | 86.6 ± 2.2$^{h}$ |
| September | Rainy | 101.4 ± 2.7$^{de}$ |
| October | Rainy | 99.9 ± 2.9$^{e}$ |
| November | Dry | 111.5 ± 4.2$^{bc}$ |
| December | Dry | 108.0 ± 5.1$^{cd}$ |

Means for the same factor with different superscripts differ significantly

The overall mean value for the weaner productivity index was 101.0 ± 17.3 kg. As for the weaning weights, this index differed significantly ($P<0.001$) according to the season of calving (113.1 ± 2.0 and 95.0 ± 1.5 kg for dry and rainy season born calves, respectively). It also differed with the sex of the calves (107.7 ± 1.6 and 100.4 ± 1.4 kg for male and female calves, respectively), and the month of birth of the calves.

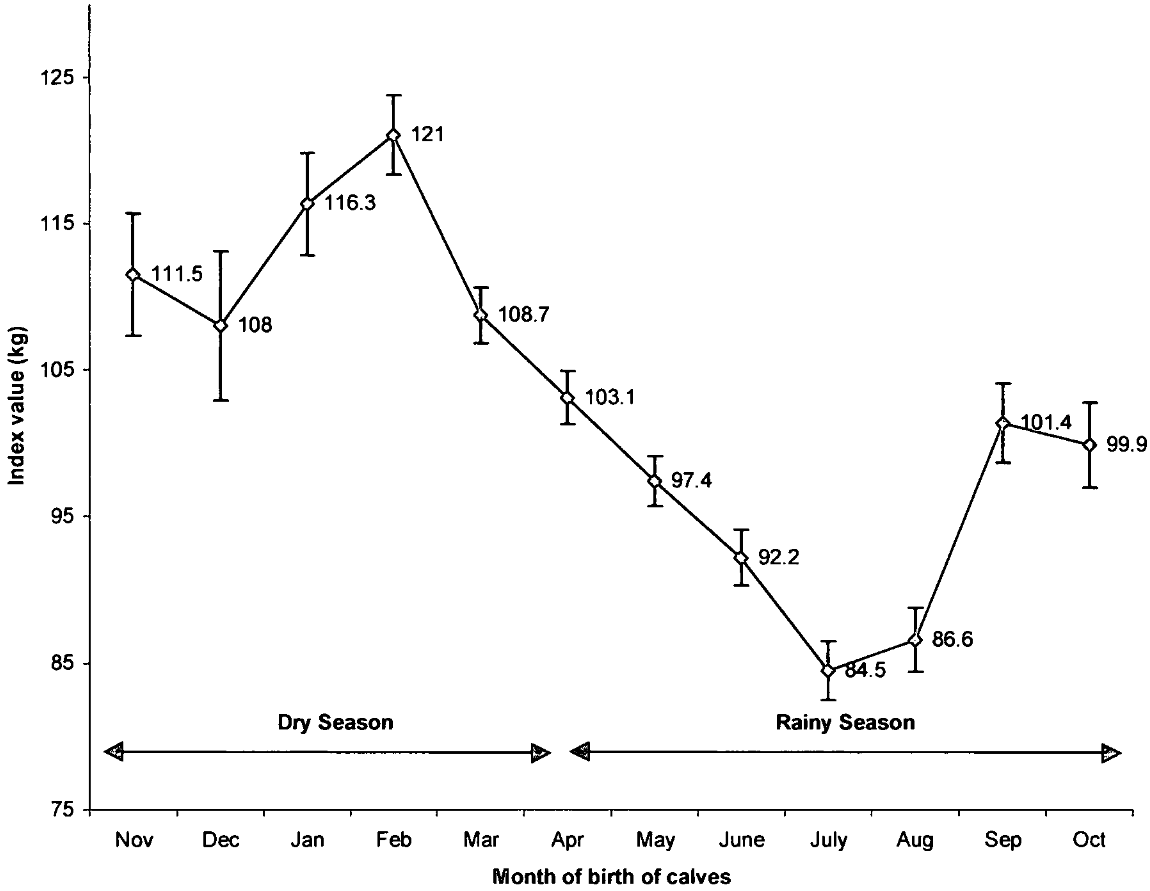


**Figure 6. 6: Weaner productivity index for Ngaoundere Gudali cows**

From Table 6.5 and Figure 6.6 the weaner productivity index indicates calving at the end of the dry season (January to March) to lead to the highest productivity. By implication, the cows would have to be bred during the months April to June. However, in a controlled management set-up, breeding during the early rainy season (April) would be difficult to implement at present in the Adamawa region. This is the period during which a scarcity of water and roughage exist and the low quality of the meagre grazing put the animals in stress, they are usually in a negative energy balance, even when supplemented. It is common practice among traditional cattle farmers to burn the bush during the dry season, which results in a feed shortage, particularly when the onset of the rains is later than expected. The bulls and postpartum cows would be losing weight and it is not be recommended to breed at this time of the year as the nutritional deficiencies and high ambient temperatures may impair reproduction. Additionally, it is shown in Chapter 7 that, from the distribution of the births throughout the year, a small proportion of the calves are actually born during the dry season. The data used in the calculation show that of the 1828 calves that were weaned, only 13.9% of the births occurred during the dry season, compared to 86.1% during the rainy season. The weaner productivity index results in this study therefore seem to lead to polemic (conflicting) recommendations. More research is definitely needed before a final recommendation on the best mating season could be made. Possible alternative avenues could be the following:

1) moving the onset of the mating season, one month at a time (May instead of June). Mating would start and finish one month earlier than is the current practice and thus more calves would be born at the end of the dry season and these calves are expected to be heavier at weaning. Thereafter, if these expectations are met, the breeding season could be reduced progressively by 3 months (May to July) to a final 3 month calving period (February to April). Ultimately, a breeding season starting in April could also be envisaged. However, the process would have to be gradual in order to minimise reproductive losses from those cows that would calve late and miss a year;

2) an all-year-round breeding season for 2 or 3 years to allow generating of enough information as to the best period both for breeding and calving.

Whatever the option, care has to be taken to provide enough supplementary feed, in the form of stored roughage (cut and stored pasture grass, cultivated high nutritive forage, silage) and industrial by-products that could readily be provided to the animals when most needed. The final criteria for selecting a breeding season should also take into consideration the economic implications (profitability) of the enterprise.

More cows calving at the best time of the year (rainy season) would mean more healthy calves produced per herd per year. On the other hand, dry season calving would mean more kilogram weaner production per year. The improvement in production and/or reproduction derived from a shorter breeding season would be measured in terms of the concentration of the calvings within a relatively short period of time, and an increase in the conception rate in the herds. A subsequent decrease in the open period duration would also lead to a better chance of the cows re-conceiving after calving.

Summarised in Tables 6.6 and 6.8 are the least squares analyses of variance for pre-weaning weight and ADG. The corresponding least square means (± SE) are presented in Tables 6.7 and 6.9, respectively. Pre-weaning weights were significantly influenced ($P<0.001$) by the month of birth, season and year (except for the 3-month weight that was not affected by season of birth), and sex of the calf. The sex of calf, month of birth and year but not season of birth significantly affected pre-weaning ADG.

The overall mean weights and ADG (± SE) recorded were 58.3 ± 0.4 and 1.1 ± 0.4, 96.9 ± 0.4 and 0.8 ± 0.2, and 143.6 ± 0.6 kg and 0.7 ± 0.1 kg/day at 1, 3 and 6 months of age, respectively. Male calves were consistently heavier by 11.0, 3.1 and 3.3% than their female counterparts at these stages. The smaller difference in weight between the sexes at 3 months can be explained by a 25% lower ADG recorded for male calves (0.7 kg) compared to female calves (0.8 kg) at that stage. Reynolds *et al.* (1990) had previously quoted this type of inconsistency in the growth in zebu cattle. Other studies on the Ngaoundere Gudali have reported that male calves grow significantly faster up to weaning than female calves (Abassa *et al.*, 1993; Tawah *et al.*, 1993; Ebangi, 1999).

**Table 6 6: Least-squares analyses of variance for pre-weaning body weights in Ngaoundere Gudali calves**

| Source of Variation | 1 month | | | 3 months | | | 6 months | | |
|---|---|---|---|---|---|---|---|---|---|
| | df | MS | P | Df | MS | P | df | MS | P |
| Month of birth | 8 | 348.15 | 0.0019 | 8 | 798.45 | 0.0001 | 8 | 5889.19 | 0.0001 |
| Season of birth | 1 | 2189.63 | 0.0001 | 1 | 260.06 | 0.1225 | 1 | 15158.73 | 0.0001 |
| Year of birth | 13 | 911.58 | 0.0001 | 13 | 593.49 | 0.0001 | 14 | 8.11.34 | 0.0001 |
| Sex of calf | 1 | 4492.35 | 0.0001 | 1 | 1116.01 | 0.0014 | 1 | 3382.19 | 0.0001 |
| Birth Weight | 1 | 1207.74 | 0.0011 | - | - | - | - | - | - |
| Weight at one month | - | - | - | 1 | 51705.04 | 0.0001 | - | - | - |
| Weight at three months | - | - | - | - | - | - | 1 | 133988.39 | 0.0001 |
| Residual | 725 | 112.16 | | 698 | 108.75 | | | 185.32 | |
| CV (%) | | 18.17 | | | 10.76 | | | 9.48 | |
| $R^2$ (%) | | 24.76 | | | 57.97 | | | 66.71 | |
| RSD | | 10.59 | | | 10.43 | | | 13.61 | |

**Table 6 7: Least-squares analyses of variance for pre-weaning average daily gain in Ngaoundere Gudali calves**

| Source of Variation | 1 month | | | 3 months | | | 6 months | | |
|---|---|---|---|---|---|---|---|---|---|
| | df | MS | P | Df | MS | P | df | MS | P |
| Month of birth | 9 | 0.34 | 0.0034 | 8 | 0.18 | 0.0001 | 8 | 0.20 | 0.0001 |
| Season of birth | 1 | 1.21 | 0.0019 | 1 | 0.13 | 0.0181 | 1 | 0.44 | 0.0001 |
| Year of birth | 13 | 1.01 | 0.0001 | 14 | 0.25 | 0.0001 | 14 | 0.02 | 0.0001 |
| Sex of | 1 | 4.99 | 0.0001 | 1 | 1.18 | 0.0001 | 1 | 0.07 | 0.0007 |
| Birth Weight | 1 | 1.41 | 0.0008 | 1 | 0.09 | 0.0493 | - | - | - |
| Weight at three months | - | - | - | - | | | 1 | 3.84 | 0.0001 |
| Residual | 725 | 0.12 | - | 877 | | | 774 | | |
| CV (%) | | 30.99 | | | 19.27 | | | 11.66 | |
| $R^2$ (%) | | 25.40 | | | 25.78 | | | 65.41 | |
| RSD | | 0.35 | | | 0.15 | | | 0.08 | |

[1] MS = Mean Squares; P = Probability level; d.f. = degrees of freedom; CV = Coefficient of variation; $R^2$ =Coefficient of determination; RSD = Residual Standard Deviation.

**Table 6 8: Least-square means (± SE) for pre-weaning weights in Ngaoundere Gudali calves**

| Source of variation | N | 1 MONTH | N | 3 MONTHS | N | 6 MONTHS |
|---|---|---|---|---|---|---|
| **Overall** | 750 | 58.3 ± 0.3 | 699 | 96.9 ± 0.4 | 812 | 143.6 ± 0.6 |
| **Sex** | | *** | | ** | | *** |
| Male | 298 | 55.7 ± 1.3 | 273 | 96.6 ± 1.2 | 294 | 149.7 ± 1.7 |
| Female | 452 | 50.2 ± 1.2 | 426 | 93.7 ± 1.2 | 518 | 144.9 ± 1.6 |
| **Month of birth** | | ** | | *** | | *** |
| January | 6 | 40.4 ± 4.4 | 6 | 98.6 ± 4.4 | 5 | 165.3 ± 6.2 |
| February | 6 | 50.0 ± 4.5 | 7 | 97.0 ± 4.1 | 10 | 162.4 ± 4.5 |
| March | 86 | 52.9 ± 1.3 | 81 | 95.10 ± 1.3 | 104 | 152.9 ± 1.6 |
| April | 214 | 58.7 ± 0.9 | 199 | 98.4 ± 0.9 | 236 | 149.8 ± 1.2 |
| May | 180 | 61.1 ± 1.0 | 167 | 99.2 ± 1.0 | 228 | 144.1 ± 1.2 |
| June | 111 | 60.1 ± 1.2 | 101 | 100.8 ± 1.2 | 99 | 135.0 ± 1.6 |
| July | 80 | 58.2 ± 1.3 | 77 | 94.8 ± 1.3 | 72 | 128.5 ± 1.8 |
| August | 40 | 61.4 ± 1.8 | 39 | 91.9 ± 1.8 | 37 | 124.0 ± 2.4 |
| September | 19 | 52.2 ± 2.6 | 15 | 87.7 ± 2.9 | 13 | 127.2 ± 4.1 |
| October | 8 | 55.2 ± 3.9 | 7 | 80.9 ± 4.1 | 8 | 132.3 ± 1.3 |
| **Season of birth** | | *** | | NS | | *** |
| Dry | 98 | 47.8 ± 2.1 | 94 | 96.9 ± 2.1 | 119 | 160.2 ± 2.7 |
| Rainy | 652 | 58.1 ± 0.9 | 605 | 93.4 ± 0.9 | 693 | 134.4 ± 1.3 |
| **Year of birth** | | *** | | *** | | *** |
| 69 | 32 | 47.8 ± 2.3 | 32 | 89.9± 2.3 | 33 | 153.3 ± 2.9 |
| 71 | 78 | 47.8 ± 1.7 | 77 | 94.5± 1.7 | 94 | 148.9 ± 2.0 |
| 72 | 179 | 50.8 ± 1.4 | 173 | 94.3 ± 1.4 | 175 | 150.5 ± 1.7 |
| 73 | 27 | 50.3 ± 2.4 | 27 | 96.3 ± 2.4 | 28 | 146.2 ± 3.0 |
| 74 | 61 | 50.9 ± 1.7 | 56 | 90.4 ± 1.8 | 65 | 146.5 ± 2.2 |
| 75 | 67 | 53.3 ± 1.8 | 55 | 97.2 ± 1.8 | 69 | 145.5 ± 2.1 |
| 76 | 78 | 59.4 ± 1.6 | 75 | 101.4 ± 1.6 | 83 | 154.0 ± 2.0 |
| 77 | 44 | 57.1 ± 2.0 | 40 | 100.4 ± 2.0 | 56 | 152.2 ± 2.3 |
| 78 | 64 | 56.3 ± 1.8 | 56 | 89.8 ± 1.8 | 56 | 139.7 ± 2.3 |
| 79 | 39 | 59.9 ± 2.1 | 37 | 97.0 ± 2.1 | 66 | 144.9 ± 2.2 |
| 80 | 20 | 54.5 ± 2.5 | 20 | 95.4 ± 2.5 | 32 | 144.3 ± 2.7 |
| 81 | - | - | - | - | 3 | 152.0 ± 8.1 |
| 82 | 41 | 59.4 ± 2.0 | 34 | 92.4 ± 2.1 | 28 | 142.9 ± 3.0 |
| 83 | 16 | 49.8 ± 2.9 | 13 | 93.1 ± 3.2 | 19 | 145.4 ± 3.6 |
| 84 | 4 | 44.0 ± 5.5 | 4 | 99.9 ± 5.4 | 5 | 143.4 ± 6.3 |

** = Very significant, *** = Highly significant, NS = Non significant

Overall, calves born during the rainy season were 21.7% heavier at 1 month of age than their dry-season counterparts but this trend was reversed from the 3rd month, when the dry-season born calves started recording a higher growth rate (Figure 6.6). This could be a reflection of the changing quality of pastures. Calves born at the end of the dry season experienced better conditions from the age of 3 months, when the rainy season started, and the opposite occurred for calves born late in the rainy season. Tomo (1997) found dry season-born calves to be 8.6 % heavier and gain 6.8 % more weight before weaning than the calves born during the rainy season and for the same reasons. Since 1-month old calves were totally dependent on the dam's milk, the extra growth despite the bad season was at the expense of the cow. This partially explains the large dry season body weight losses incurred by nursing dams (Lhoste, 1968).

**Table 6 9: Least-squares means (± SE) of pre-weaning average daily gain (g) in Ngaoundere Gudali calves**

| Source of Variation | N | ADG 1 MONTH | N | ADG 3 MONTH | N | ADG 6 MONTH |
|---|---|---|---|---|---|---|
| **Overall** | 751 | 1139.2 ± 353.0 | 903 | 799.9 ± 154.2 | 800 | 664.6 ± 77.5 |
| **Sex of calf** | | *** | | *** | | *** |
| Male | 298 | 1057.1 ± 57.0 | 331 | 754.4 ± 17.8 | 292 | 693.9 ± 9.7 |
| Female | 453 | 873.1 ± 55.1 | 572 | 672 ± 17.0 | 508 | 672.2 ± 9.6 |
| **Month of birth** | | ** | | *** | | *** |
| January | 6 | 544.9 ± 146.2 | 6 | 649.1 ± 63.9 | 5 | 784.7 ± 35.4 |
| February | 6 | 863.4 ± 151.2 | 8 | 664.1 ± 56.4 | 8 | 765.1 ± 28.6 |
| March | 86 | 961.1 ± 41.2 | 110 | 715.9 ± 16.77 | 100 | 717.2 ± 9.1 |
| April | 214 | 1154.2 ± 30.3 | 252 | 808.8 ± 12.7 | 233 | 699.9 ± 6.9 |
| May | 180 | 1234.5 ± 32.2 | 260 | 836.6 ± 12.1 | 225 | 667.2 ± 6.6 |
| June | 111 | 1199.3 ± 38.4 | 112 | 851.2 ± 16.7 | 99 | 615.4 ± 9.2 |
| July | 80 | 1136.7 ± 44.5 | 84 | 769.8 ± 19.2 | 72 | 576.1 ± 10.5 |
| August | 40 | 1243.2 ± 60.0 | 46 | 761.5 ± 24.7 | 37 | 551.0 ± 13.8 |
| September | 19 | 937.0 ± 86.3 | 17 | 624.8 ± 39.5 | 13 | 563.3 ± 23.1 |
| October | 8 | 1038.6 ± 128.9 | 8 | 604.1 ± 56.0 | 8 | 600.2 ± 28.6 |
| November | 1 | 812.5 ± 359.3 | - | - | - | - |
| **Season of birth** | | *** | | * | | *** |
| Dry | 99 | 795.5 ± 104.2 | 124 | 676.4 ± 29.2 | 113 | 755.6 ± 15.9 |
| Rainy | 652 | 1134.8 ± 30.4 | 779 | 750.9 ± 13.4 | 687 | 610.4 ± 7.4 |
| **Year of birth** | | *** | | *** | | *** |
| 69 | 32 | 793 ± 84.5 | 33 | 623.1 ± 31.7 | 33 | 711.0 ± 16.5 |
| 71 | 78 | 794 ± 68.9 | 94 | 659.2 ± 22.5 | 93 | 686.6 ± 11.9 |
| 72 | 179 | 894.8 ± 59.8 | 176 | 707.4 ± 19.2 | 173 | 695.9 ± 10.0 |
| 73 | 28 | 876.2 ± 81.4 | 28 | 728.1 ± 33.4 | 28 | 678.1 ± 17.1 |
| 74 | 61 | 897.1 ± 69.4 | 74 | 646.6 ± 23.2 | 64 | 682.5 ± 12.8 |
| 75 | 67 | 977.2 ± 69.8 | 74 | 726.0 ± 23.5 | 67 | 677.5 ± 12.6 |
| 76 | 78 | 1180.3 ± 66.1 | 94 | 844.7 ± 21.5 | 81 | 725.3 ± 11.5 |
| 77 | 44 | 1104.3 ± 76.5 | 70 | 795.1 ± 24.2 | 56 | 714.4 ± 13.4 |
| 78 | 64 | 1076.3 ± 70.4 | 75 | 709.4 ± 23.6 | 56 | 645.0 ± 13.4 |
| 79 | 39 | 1195.2 ± 78.9 | 76 | 789.2 ± 24.2 | 62 | 676.9 ± 13.2 |
| 80 | 20 | 1015.3 ± 94.2 | 39 | 759.4 ± 27.6 | 32 | 663.4 ± 15.1 |
| 81 | - | - | 5 | 596.2 ± 71.5 | 3 | 700.0 ± 46.0 |
| 82 | 41 | 1181.2 ± 77.8 | 40 | 763.5 ± 28.7 | 28 | 662.4 ± 17.1 |
| 83 | 16 | 861.3 ± 105.2 | 20 | 645.3 ± 38.8 | 19 | 675.9 ± 0.021 |
| 84 | 4 | 665.3 ± 187.1 | 5 | 711.6 ± 71.1 | 5 | 650.7 ± 35.9 |

** = Very significant, *** = Highly significant, NS = Non significant

A significant year effect on calf weight at different ages was noted. So, for example, the average weight at 1 month seemed to increase gradually from 1971 to 1976, where it remained almost constant at approximately 55 to 59 kg up to 1982 before decreasing in the next two years. The ADG for this group followed the same pattern (Table 6.9), with the year of birth significantly affecting the ADG, but with no clear trend. As the management practices have been relatively similar over the study period, the year effect may be the expression of a variation in environmental factors over the years. The fluctuations in the rainfall may have affected the quantity and quality of available pastures, which in turn had an effect on the cow and calf's nutritional status. The stress generated by the lack/scarcity of feed during the dry season seems to have affected new born calves through their dams more than older calves, as evidenced by the fact that the weights and ADG at 3 and 6 months were less affected. Reynolds *et al.* (1990), Tawah *et al.* (1993), Tomo (1997) and Ebangi (1999) have previously reported a year effect on pre-weaning growth of zebu cattle.

The least-squares analyses of variance for post-weaning weight (Table 6.10) and average daily gain (Table 6.11) show sex differences to be significant for all variables considered in the model from 9 to 36 months except at 12 and 27 months of age. The respective least-square means (± SE) values are set out in Tables 6.12 and 6.13.

**Table 6 10: Least-squares analyses of variance for post-weaning weight (every 3 months, from 9 to 36 months of age) in Ngaoundere Gudali cattle**

| Source of Variation | 9 MONTHS | | | 12 MONTHS | | | 15 MONTHS | | | 18 MONTHS | | | 21 MONTHS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d.f. | MS | P | d.f. | MS | P | d.f. | MS | P | d.f. | MS | P | d.f. | MS | P |
| Month of birth | 8 | 1101.65 | 0.0001 | 8 | 549.78 | 0.0024 | 8 | 710.33 | 0.0007 | 8 | 315.74 | 0.2645 | 8 | 1857.47 | 0.0001 |
| Season of birth | 1 | 804.56 | 0.0168 | 1 | 3476.52 | 0.0001 | 1 | 368.87 | 0.1818 | 1 | 1019.53 | 0.0445 | 1 | 127.23 | 0.4632 |
| Year of birth | 13 | 1384.63 | 0.0001 | 13 | 3043.77 | 0.0001 | 13 | 4652.77 | 0.0001 | 13 | 2590.57 | 0.0001 | 14 | 1336.00 | 0.0001 |
| Sex of calf | 1 | 4920.81 | 0.0001 | 1 | 6.28 | 0.8528 | 1 | 3639.73 | 0.0001 | 1 | 1475.66 | 0.0157 | 1 | 953.81 | 0.0448 |
| Weaning Age Group | 3 | 66.80 | 0.6982 | 3 | 862.73 | 0.0028 | 3 | 283.39 | 0.2499 | 3 | 127.78 | 0.6772 | 3 | 99.05 | 0.7391 |
| Weaning Month | 9 | 259.66 | 0.0557 | 8 | 299.20 | 0.1094 | 8 | 286.17 | 0.1988 | 9 | 418.43 | 0.0941 | 9 | 645.01 | 0.0038 |
| Weaning Season | 1 | 8848.15 | 0.0141 | 1 | 28.70 | 0.6916 | 1 | 158.59 | 0.3811 | 1 | 38.92 | 0.6943 | 1 | 490.13 | 0.1501 |
| Previous weight | 1 | 148173.28 | 0.0001 | 1 | 176523.89 | 0.0001 | 1 | 228701.10 | 0.0001 | 1 | 313533.47 | 0.0001 | 1 | 405248.65 | 0.0001 |
| Residual | 707 | 139.98 | | 747 | 182.25 | | 798 | 206.51 | | 831 | 251.78 | | 816 | 236.17 | |
| CV (%) | | 7.74 | | | 8.44 | | | 7.93 | | | 8.05 | | | 7.48 | |
| $R^2$ (%) | | 77.24 | | | 70.62 | | | 75.70 | | | 77.73 | | | 81.04 | |
| RS D | | 11.83 | | | 13.50 | | | 14.37 | | | 15.87 | | | 15.37 | |

| Source of Variation* | 24 MONTHS | | | 27 MONTHS | | | 30 MONTHS | | | 33 MONTHS | | | 36 MONTHS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d.f. | MS | P | d.f. | MS | P | d.f. | MS | P | d.f. | MS | P | d.f. | MS | P |
| Month of birth | 10 | 14843.55 | 0.0001 | 10 | 8624.77 | 0.0001 | 10 | 10826.03 | 0.0001 | 10 | 3489.17 | 0.0001 | 10 | 16434.31 | 0.0001 |
| Season of birth | 1 | 4747.19 | 0.0002 | 1 | 34.09 | 0.7989 | 1 | 24413.65 | 0.0001 | 1 | 1263.60 | 0.0990 | 1 | 3587.11 | 0.0058 |
| Year of birth | 14 | 3813.02 | 0.0001 | 13 | 6115.37 | 0.0001 | 13 | 38885.16 | 0.0001 | 13 | 6609.85 | 0.0001 | 13 | 1050.49 | 0.0070 |
| Sex of calf | 1 | 3679.25 | 0.0012 | 1 | 1639.86 | 0.0776 | 1 | 14189.92 | 0.0001 | 1 | 14625.96 | 0.0001 | 1 | 9593.56 | 0.0001 |
| Weaning Age Group | 3 | 521.08 | 0.2147 | 2 | 974.37 | 0.1571 | 3 | 165.34 | 0.9015 | 3 | 211.48 | 0.7124 | 3 | 172.28 | 0.7753 |
| Previous weight | 1 | 362891.56 | 0.0001 | 1 | 244538.34 | 0.0001 | 1 | 21797.97 | 0.0001 | 1 | 244031.79 | 0.0001 | 1 | 253824.45 | 0.0001 |
| Residual | 764 | 348.66 | | 531 | 524.56 | | 611 | 858.95 | | 591 | 462.76 | | 521 | 466.62 | |
| CV (%) | | 8.35 | | | 8.72 | | | 10.42 | | | 7.61 | | | 7.07 | |
| $R^2$ (%) | | 70.99 | | | 68.82 | | | 63.80 | | | 81.83 | | | 76.67 | |
| RSD. | | 18.67 | | | 22.9 | | | 29.31 | | | 21.51 | | | 21.60 | |

MS = Mean Squares; P = Probability level; d.f. = degrees of freedom; CV = Coefficient of variation; $R^2$ =Coefficient of determination; RSD = Residual Standard Deviation.

**Table 6 11: Least-squares means (± SE) of post-weaning weights (kg) in Ngaoundere Gudali cattle (at 9, 12, 18 24 and 36 months)**

| Source of variation | N | 9 MONTHS | N | 12 MONTHS | N | 18 MONTHS | N | 24 MONTHS | N | 36 MONTHS |
|---|---|---|---|---|---|---|---|---|---|---|
| **Overall** | 745 | 152.9 ± 0.7 | 784 | 159.9 ± 0.7 | 869 | 197.2 ± 0.9 | 795 | 223.5 ± 1 | 551 | 305.5 ± 1.4 |
| **Sex of calf** | | *** | | NS | | * | | *** | | *** |
| Male | 273 | 166.4 ± 3.2 | 288 | 150.6 ± 3.9 | 313 | 203.9 ± 4.2 | 288 | 227.6 ± 3.0 | 151 | 317.2 ± 3.9 |
| Female | 472 | 160.3 ± 3.1 | 496 | 150.9 ± 3.6 | 556 | 201.0 ± 4.1 | 507 | 222.7 ± 2.8 | 400 | 306.4 ± 3.6 |
| **Month of birth** | | *** | | ** | | NS | | *** | | *** |
| January | 4 | 192.6 ± 9.7 | 4 | 131.5 ± 10.5 | 4 | 214.8 ± 13.3 | 5 | 211.2 ± 8.8 | 4 | 300.7 ± 11.4 |
| February | 6 | 173.4 ± 8.5 | 4 | 126.1 ± 9.8 | 11 | 217.3 ± 9.9 | 9 | 201.9 ± 6.9 | 6 | 299.4 ± 10.0 |
| March | 87 | 155.2 ± 6.8 | 92 | 140.9 ± 6.9 | 71 | 208.5 ± 8.2 | 104 | 208.5 ± 3.1 | 68 | 286.9 ± 4.3 |
| April | 248 | 152.1 ± 5.1 | 252 | 152.4 ± 5.2 | 249 | 200.6 ± 5.1 | 240 | 206.3 ± 2.7 | 183 | 345.0 ± 13.2 |
| May | 195 | 143.0 ± 3.8 | 212 | 162.8 ± 3.8 | 281 | 200.3 ± 3.6 | 235 | 226.8 ± 2.7 | 131 | 281.0 ± 21.1 |
| June | 93 | 136.4 ± 4.1 | 94 | 174.5 ± 3.9 | 113 | 198.2 ± 3.9 | 91 | 246.3 ± 3.2 | 76 | 288.0 ± 3.6 |
| July | 66 | 139.5 ± 4.6 | 72 | 176.7 ± 5.0 | 73 | 187.3 ± 5.5 | 59 | 252.2 ± 3.5 | 45 | 310.0 ± 3.5 |
| August | 35 | 186.8 ± 12.8 | 41 | 192.4 ± 9.8 | 45 | 198.0 ± 10.7 | 36 | 236.2 ± 4.1 | 25 | 336.4 ± 4.1 |
| September | 5 | 159.0 ± 9.8 | 7 | 157.9 ± 8.3 | 16 | 177.8 ± 12.5 | 6 | 237.4 ± 8.3 | 3 | 336.2 ± 4.7 |
| October | 10 | 154.0 ± 9.5 | 6 | 163.7 ± 9.7 | 6 | 177.2 ± 12.1 | 5 | 239.1 ± 8.9 | 5 | 336.1 ± 5.5 |
| November | - | - | - | - | - | - | 3 | 234.84± 11.2 | 3 | 314.4 ± 13.4 |
| December | - | - | - | - | - | - | 2 | 220.2 ± 17.8 | 2 | 325.9 ± 10.6 |
| **Season of birth** | | * | | *** | | * | | *** | | ** |
| Dry | 97 | 173.7 ± 6.8 | 100 | 132.8 ± 7.2 | 86 | 213.5 ± 9.1 | 123 | 215.3 ± 4.6 | 83 | 302.6 ± 5.7 |
| Rainy | 648 | 153.0 ± 3.2 | 684 | 168.6 ± 2.7 | 783 | 191.3 ± 3.4 | 672 | 237.9 ± 3.0 | 468 | 321.0 ± 3.9 |
| **Year of birth** | | *** | | *** | | *** | | *** | | ** |
| 69 | 33 | 159.2 ± 3.7 | 32 | 139.0 ± 4.3 | 32 | 211.5 ± 5.2 | 27 | 227.9 ± 5.0 | 23 | 312.2 ± 6.3 |
| 71 | 95 | 163.5 ± 3.3 | 92 | 145.4 ± 3.9 | 76 | 194.2 ± 4.6 | 1 | 230.1 ± 25.4 | 1 | 288.8 ± 29.9 |
| 72 | 182 | 161.0 ± 3.2 | 179 | 152.0 ± 3.7 | 166 | 199.2 ± 4.4 | 73 | 232.9 ± 3.8 | 50 | 310.2 ± 5.0 |
| 73 | 20 | 162.4 ± 4.3 | 17 | 142.7 ± 5.0 | 21 | 200.2 ± 5.5 | 154 | 224.6 ± 3.4 | 123 | 308.9 ± 4.2 |
| 74 | 41 | 167.3 ± 3.7 | 51 | 149.7 ± 4.1 | 77 | 207.0 ± 4.7 | 18 | 215.5 ± 5.4 | 17 | 321.9 ± 6.4 |
| 75 | 89 | 170.5 ± 3.4 | 95 | 161.1 ± 3.9 | 98 | 206.2 ± 4.6 | 76 | 215.2 ± 3.5 | 25 | 300.7 ± 5.4 |
| 76 | 84 | 156.3 ± 3.4 | 83 | 166.0 ± 3.9 | 63 | 216.5 ± 4.7 | 92 | 215.5 ± 3.8 | 81 | 315.4 ± 5.0 |
| 77 | 53 | 162.2 ± 3.6 | 58 | 153.7 ± 4.1 | 71 | 193.9 ± 4.6 | 95 | 237.0 ± 3.8 | 79 | 315.6 ± 5.3 |
| 78 | 45 | 166.6 ± 3.7 | 55 | 144.1 ± 4.2 | 78 | 206.1 ± 4.8 | 64 | 231.6 ± 3.8 | 52 | 306.2 ± 5.1 |
| 79 | 50 | 171.8 ± 3.7 | 60 | 139.8 ± 4.2 | 84 | 210.4 ± 4.7 | 54 | 230.3 ± 40.2 | 51 | 315.9 ± 4.9 |
| 80 | 5 | 165.3 ± 6.3 | 5 | 161.3 ± 7.2 | 35 | 205.7 ± 5.0 | 76 | 218.5 ± 3.9 | 4 | 312.5 ± 11.6 |
| 81 | - | - | - | - | 10 | 184.2 ± 7.2 | 7 | 218.7 ± 7.9 | 30 | 299.9 ± 5.7 |
| 82 | 23 | 144.9 ± 4.8 | 33 | 150.6 ± 5.1 | 53 | 203.0 ± 5.2 | 8 | 228.5 ± 8.0 | 2 | 336.1 ± 16.5 |
| 83 | 20 | 156.3 ± 4.2 | 19 | 164.1 ± 4.9 | - | - | 45 | 248.1 ± 4.8 | 13 | 320.9 ± 8.5 |
| 84 | 5 | 179.8 ± 6.1 | 5 | 141.0 ± 6.9 | 5 | 196.0 ± 9.1 | 5 | 202.3 ± 9.2 | - | - |

* = Significant (P<0.05); ** = Very significant (P<0.01); *** = Highly significant (P<0.001); NS = Not significant

**Table 6.11: Least-squares means (± SE) of post-weaning weights (kg) in Ngaoundere Gudali cattle (at 9, 12, 18 24 and 36 months) (continued)**

| Source of variation | N | 9 MONTHS | N | 12 MONTHS | N | 18 MONTHS | N | 24 MONTHS | N | 36 MONTHS |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weaning Age Group** | | NS | | ** | | NS | | NS | | NS |
| 1 | 5 | 158.0 ± 8.7 | 9 | 144.2 ± 8.6 | 16 | 202.9 ± 9.7 | 15 | 218.7 ± 5.7 | 15 | 307.9 ± 6.9 |
| 2 | 29 | 165.8 ± 4.3 | 39 | 152.2 ± 4.8 | 69 | 205.8 ± 5.3 | 61 | 229.1 ± 4.5 | 27 | 311.6 ± 5.9 |
| 3 | 588 | 164.3 ± 2.1 | 615 | 150.5 ± 2.5 | 656 | 200.8 ± 2.4 | 602 | 224.9 ± 2.6 | 415 | 313.4 ± 3.6 |
| 4 | 123 | 165.4 ± 2.2 | 121 | 156.1 ± 2.6 | 128 | 200.2 ± 2.6 | 117 | 227.8 ± 2.9 | 94 | 314.3 ± 3.8 |
| **Weaning Month** | | NS | | NS | | NS | | | | |
| January | 177 | 172.7 ± 4.9 | 193 | 145.1 ± 4.5 | 238 | 198.5 ± 6.2 | - | - | - | - |
| February | 96 | 172.2 ± 6.1 | 90 | 144.8 ± 6.7 | 108 | 200.2 ± 7.5 | - | - | - | - |
| March | 65 | 168.9 ± 7.9 | 73 | 146.9 ± 8.5 | 74 | 204.7 ± 9.8 | - | - | - | - |
| April | 34 | 125.1 ± 15.3 | 38 | 125.4 ± 13.3 | 41 | 192.0 ± 14.8 | - | - | - | - |
| May | 6 | 171.9 ± 10.6 | 7 | 150.0 ± 9.2 | 19 | 213.3 ± 13.7 | - | - | - | - |
| June | 7 | 173.1 ± 12.6 | 7 | 140.4 ± 10.0 | 5 | 204.3 ± 14.0 | - | - | - | - |
| August | 2 | 161.1 ± 12.6 | 2 | 170.3 ± 13.3 | 1 | 232.4 ± 19.2 | - | - | - | - |
| September | 2 | 158.5 ± 11.6 | 2 | 173.2 ± 13.0 | 9 | 202.8 ± 7.6 | - | - | - | - |
| October | 1 | 151.4 ± 13.5 | - | - | 6 | 176.9 ± 8.3 | - | - | - | - |
| November | 97 | 169.5 ± 3.8 | 106 | 161.5 ± 3.4 | 91 | 199.2 ± 4.0 | - | - | - | - |
| December | 258 | 166.1 ± 4.4 | 266 | 149.8 ± 5.1 | 277 | 203.5 ± 5.2 | - | - | - | - |
| **Weaning Season** | | * | | NS | | NS | | | | |
| Dry | 693 | 169.9 ± 1.1 | 728 | 149.6 ± 4.6 | 788 | 201.2 ± 5.3 | - | - | - | - |
| Rainy | 52 | 156.9 ± 4.1 | 56 | 151.9 ± 4.5 | 81 | 203.6 ± 4.9 | - | - | - | - |

* = Significant; ** = Very significant, *** = Highly significant, NS = Not significant

**Table 6.12: Least-squares analyses of variance for post-weaning average daily gain in Ngaoundere Gudali cattle**

| Source of variation | ADG 9 MONTH | | | ADG 12 MONTHS | | | ADG 15 MONTHS | | | ADG 18 MONTHS | | | ADG 21 MONTHS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | MS | P | N | MS | P | N | MS | P | N | MS | P | N | MS | P |
| Month of birth | 8 | 0.0148 | 0.0001 | 8 | 0.0040 | 0.0036 | 8 | 0.0033 | 0.0007 | 8 | 0.0011 | 0.2217 | 8 | 0.0047 | 0.0001 |
| Season of birth | 1 | 0.0106 | 0.4223 | 1 | 0.0274 | 0.0313 | 1 | 0.0020 | 0.4917 | 1 | 0.0033 | 0.1313 | 1 | 0.0004 | 0.7848 |
| Year of birth | 13 | 0.0193 | 0.0001 | 13 | 0.0226 | 0.0001 | 13 | 0.0231 | 0.0001 | 13 | 0.0089 | 0.0001 | 14 | 0.0033 | 0.0001 |
| Sex | 1 | 0.0641 | 0.0001 | 1 | 0.0002 | 0.7212 | 1 | 0.0191 | 0.0001 | 1 | 0.0046 | 0.0209 | 1 | 0.0020 | 0.0695 |
| Weaning Age | 3 | 0.0011 | 0.6405 | 3 | 0.0072 | 0.0016 | 3 | 0.0015 | 0.2499 | 3 | 0.0005 | 0.6295 | 3 | 0.0003 | 0.6890 |
| Group | 8 | 0.0038 | 0.0451 | 8 | 0.0024 | 0.0962 | 8 | 0.0014 | 0.1988 | 9 | 0.0011 | 0.2213 | 9 | 0.0016 | 0.0040 |
| Weaning Month | 1 | 0.0101 | 0.0226 | 1 | 0.0001 | 0.7743 | 1 | 0.0007 | 0.4779 | 1 | 0.0002 | 0.6365 | 1 | 0.0011 | 0.1707 |
| Weaning Season | 1 | 1.9960 | 0.0001 | 1 | 1.3079 | 0.0001 | 1 | 1.0746 | 0.0001 | 1 | 1.0290 | 0.0001 | 1 | 0.9869 | 0.0001 |
| Previous weight Residual | 697 | 0.0019 | | 730 | 0.0014 | | 783 | 0.0010 | | 815 | 0.0008 | | 838 | 0.0006 | |
| CV (%) | | 9.20 | | | 9.92 | | | 9.17 | | | 9.18 | | | 8.53 | |
| $R^2$ (%) | | 77.57 | | | 70.61 | | | 75.57 | | | 77.68 | | | 80.87 | |
| RS D | | 0.0439 | | | 0.0374 | | | 0.0320 | | | 0.0294 | | | 0.0245 | |

| Source of variation | ADG 24 MONTHS | | | ADG 27 MONTHS | | | ADG 30 MONTHS | | | ADG 33 MONTHS | | | ADG 36 MONTHS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | MS | P | N | MS | P | N | MS | P | N | MS | P | N | MS | P |
| Month of birth | 9 | 0.0311 | 0.0001 | 9 | 0.28943 | 0.002 | 9 | 0.0139 | 0.0001 | 9 | 0.00354 | 0.0001 | 9 | 0.01618 | 0.0001 |
| Season of birth | 1 | 0.0131 | 0.5322 | 1 | 0.00001 | 0.9823 | 1 | 0.0094 | 0.4321 | 1 | 0.00003 | 0.9263 | 1 | 0.00026 | 0.9011 |
| Year of birth | 13 | 0.0110 | 0.0001 | 13 | 0.01366 | 0.0581 | 12 | 0.0536 | 0.0001 | 12 | 0.00738 | 0.0001 | 12 | 0.00124 | 0.0001 |
| Sex | 1 | 0.0066 | 0.0018 | 1 | 0.01112 | 0.2407 | 1 | 0.0170 | 0.0001 | 1 | 0.01399 | 0.0001 | 1 | 0.00741 | 0.0001 |
| Previous weight | 1 | 0.6792 | 0.0001 | 1 | 0.58856 | 0.0001 | 1 | 0.0266 | 0.0001 | 1 | 0.24096 | 0.0001 | 1 | 0.21340 | 0.0001 |
| Residual | 750 | 0007 | | | | | 601 | 0.0010 | | 583 | 0.00047 | | 517 | 0.00038 | |
| CV (%) | | 9.35 | | | 30.13 | | | 11.31 | | | 8.33 | | | 7.50 | |
| $R^2$ (%) | | 70.61 | | | 20.91 | | | 64.91 | | | 81.79 | | | 77.52 | |
| RSD. | | 0.0259 | | | 0.0898 | | | 0.0323 | | | 0.0217 | | | 0.0195 | |

MS = Mean Squares; P = Probability level; d.f. = degrees of freedom; CV = Coefficient of variation; $R^2$ =Coefficient of determination; RSD = Residual Standard Deviation; Weaning Age Groups: 1 (weaned at maximum 175 days), 2 (weaned at 176 to 225 days); 3 (weaned at 226 to 255 days); 4 (weaned beyond 256 days); ADG = Average Daily Gain (from six to 9, 9 to 12, 12 to 15, etc)

**Table 6.13: Least-squares means (± SE) of post-weaning average daily gain (g) in Ngaoundere Gudali cattle at 9, 12, 18, 24 and 36 months of age**

| Source of variation | N | 9 MONTHS | N | 12 MONTHS | N | 18 MONTHS | N | 24 MONTHS | N | 36 MONTHS |
|---|---|---|---|---|---|---|---|---|---|---|
| **Overall** | 734 | 477.3 ± 43.9 | 767 | 377.1 ± 37.4 | 853 | 320.5 ± 29.4 | 776 | 276.9 ± 25.9 | 542 | 260.5 ± 19.5 |
| **Sex of calf** | | *** | | NS | | * | | ** | | *** |
| Male | 271 | 529.1 ± 13.0 | 282 | 349.8 ± 10.4 | 307 | 332.7 ± 7.8 | 281 | 282.1 ± 3.9 | 148 | 280.1 ± 3.4 |
| Female | 463 | 506.8 ± 12.8 | 485 | 350.9 ± 10.2 | 546 | 327.5 ± 7.7 | 495 | 275.5 ± 3.6 | 394 | 270.5 ± 3.0 |
| **Month of birth** | | **** | | ** | | NS | | *** | | *** |
| January | 4 | 625.4 ± 36.6 | 4 | 300.0 ± 29.2 | 4 | 351.8 ± 24.7 | 5 | 260.6 ± 11.8 | 4 | 258.4 ± 10.0 |
| February | 4 | 554.4 ± 35.3 | 3 | 274.5 ± 29.3 | 10 | 358.9 ± 18.5 | 7 | 236.7 ± 10.3 | 6 | 257.9 ± 8.5 |
| March | 84 | 487.8 ± 26.5 | 87 | 323.4 ± 19.3 | 67 | 339.2 ± 15.3 | 99 | 255.1 ± 3.0 | 64 | 244.8 ± 3.13 |
| April | 245 | 475.8 ± 19.7 | 249 | 356.8 ± 14.4 | 246 | 325.9 ± 9.5 | 237 | 253.7 ± 2.3 | 181 | 246.7 ± 2.2 |
| May | 192 | 442.3 ± 14.5 | 204 | 385.8 ± 10.5 | 273 | 325.4 ± 6.8 | 229 | 282.2 ± 2.2 | 131 | 267.1 ± 2.2 |
| June | 93 | 417.7 ± 15.3 | 94 | 416.5 ± 10.8 | 113 | 323.1 ± 7.3 | 91 | 309.1 ± 3.2 | 76 | 291.6 ± 2.8 |
| July | 66 | 427.6 ± 17.0 | 72 | 421.5 ± 14.0 | 73 | 303.2 ± 10.2 | 59 | 316.6 ± 3.8 | 45 | 291.3 ± 3.5 |
| August | 35 | 607.1 ± 46.3 | 41 | 466.8 ± 27.3 | 45 | 324.7 ± 19.9 | 36 | 294.6 ± 4.7 | 25 | 291.7 ± 4.3 |
| September | 5 | 502.8 ± 35.1 | 7 | 372.3 ± 22.8 | 16 | 285.3 ± 23.2 | 6 | 296.1± 10.9 | 3 | 271.7 ± 11.9 |
| October | 6 | 487.2 ± 34.2 | 6 | 390.1 ± 26.7 | 6 | 283.5 ± 22.4 | 5 | 303.2 ± 11.8 | 5 | 282.6 ± 9.1 |
| November | - | - | - | - | - | - | 2 | 303.5 ± 18.7 | 2 | 330.8 ± 14.5 |
| **Season of birth** | | NS | | * | | NS | | NS | | NS |
| Dry | 92 | 555.9 ± 27.3 | 94 | 299.3 ± 20.4 | 81 | 350.0 ± 17.0 | 113 | 264.0 ± 6.3 | 76 | 273.0 ± 5.1 |
| Rainy | 642 | 480.1 ± 1 | 673 | 401.4 ± 7.4 | 772 | 310.2 ± 6.2 | 663 | 293.7 ± 2.8 | 466 | 277.6 ± 2.7 |
| **Year of birth** | | *** | | *** | | *** | | *** | | *** |
| 69 | 33 | 501.6 ± 14.9 | 32 | 316.1 ± 12.1 | 32 | 346.9 ± 9.7 | 27 | 284.2 ± 6.1 | 23 | 274.7 ± 5.0 |
| 71 | 94 | 517.2 ± 13.6 | 91 | 334.5 ± 10.8 | 75 | 315.1 ± 8.6 | 72 | 288.7 ± 4.5 | 49 | 271.5 ± 4.1 |
| 72 | 180 | 508.0 ± 13.2 | 177 | 353.1 ± 10.5 | 164 | 323.3 ± 8.2 | 153 | 277.8 ± 3.9 | 123 | 271.1 ± 3.2 |
| 73 | 20 | 514.2 ± 17.0 | 17 | 327.7 ± 13.9 | 21 | 326.0 ± 10.3 | 17 | 266.3 ± 7.2 | 16 | 287.1 ± 5.6 |
| 74 | 40 | 533.5 ± 14.7 | 50 | 347.6 ± 11.5 | 76 | 338.4 ± 8.7 | 74 | 265.1 ± 4.1 | 24 | 261.4 ± 4.5 |
| 75 | 87 | 545.4 ± 13.9 | 91 | 377.7 ± 11.0 | 95 | 337.0 ± 8.6 | 88 | 264.0 ± 4.4 | 78 | 277.5 ± 3.8 |
| 76 | 82 | 492.9 ± 13.6 | 81 | 392.6 ± 10.9 | 63 | 356.3 ± 8.8 | 94 | 295.2 ± 4.5 | 77 | 277.5 ± 4.1 |
| 77 | 53 | 514.2 ± 14.4 | 58 | 358.6 ± 11.7 | 71 | 314.1 ± 8.6 | 64 | 286.6 ± 4.7 | 52 | 268.2 ± 4.1 |
| 78 | 45 | 530.5 ± 14.6 | 55 | 332.0 ± 11.7 | 78 | 336.8 ± 8.9 | 54 | 285.4 ± 4.9 | 51 | 277.7 ± 3.8 |
| 79 | 47 | 548.9 ± 15.0 | 53 | 321.4 ± 12.1 | 75 | 345.6 ± 8.9 | 68 | 267.9 ± 4.7 | 4 | 273.8 ± 10.3 |
| 80 | 5 | 524.5 ± 23.5 | 5 | 379.5 ± 20.2 | 35 | 335.8 ± 9.2 | 7 | 270.9 ± 10.5 | 30 | 262.8 ± 4.5 |
| 81 | - | - | - | - | 10 | 295.7 ± 13.3 | 8 | 287.4 ± 9.9 | 2 | 294.2 ± 14.2 |
| 82 | 23 | 448.6 ± 18.7 | 33 | 349.5 ± 14.4 | 53 | 330.6 ± 9.6 | 45 | 315.5 ± 5.0 | 13 | 281.0 ± 6.3 |
| 83 | 20 | 492.7 ± 16.6 | 19 | 389.3 ± 13.7 | - | - | - | - | - | - |
| 84 | 5 | 579.1 ± 23.0 | 5 | 325.6 ± 19.3 | 5 | 319.5 ± 15.0 | 5 | 248.6 ± 12.4 | - | - |

**Table 6.13: Least-squares means (± SE) of post-weaning average daily gain (g) of Ngaoundere Gudali cattle at 9, 12, 18, 24 and 36 months of age (continued)**

| Effects | N | ADG-9 | N | ADG-12 | N | ADG-18 | N | ADG-24 | N | ADG-36 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Weaning Age Group** | | NS | | ** | | NS | | | | |
| 1 | 5 | 497.4 ± 33.0 | 9 | 332.9 ± 23.9 | 16 | 328.6 ± 18.0 | - | - | - | - |
| 2 | 29 | 527.6 ± 17.3 | 39 | 354.3 ± 13.3 | 69 | 337.1 ± 9.9 | - | - | - | - |
| 3 | 579 | 521.2 ± 8.7 | 601 | 348.9 ± 7.1 | 642 | 328.0 ± 4.6 | - | - | - | - |
| 4 | 121 | 525.6 ± 8.7 | 118 | 365.3 ± 7.3 | 126 | 326.6 ± 4.9 | - | - | - | - |
| **Weaning Month** | | * | | NS | | NS | | | | |
| January | 174 | 551.0 ± 18.1 | 186 | 334.7 ± 15.3 | 231 | 323.1 ± 11.4 | - | - | - | - |
| February | 96 | 550.1 ± 22.5 | 89 | 335.8 ± 18.7 | 107 | 324.4 ± 14.1 | - | - | - | - |
| March | 65 | 539.1 ± 29.4 | 73 | 342.0 ± 23.7 | 74 | 332.6 ± 18.2 | - | - | - | - |
| April | 34 | 371.9 ± 56.6 | 38 | 280.4 ± 37.0 | 41 | 307.2 ± 27.5 | - | - | - | - |
| May | 6 | 546.4 ± 39.2 | 7 | 347.2 ± 25.6 | 19 | 348.3 ± 25.4 | - | - | - | - |
| June | 7 | 550.0 ± 38.2 | 7 | 320.3 ± 27.8 | 5 | 333.1 ± 25.9 | - | - | - | - |
| July | - | - | - | - | - | - | - | - | - | - |
| August | 2 | 503.9 ± 46.7 | 2 | 402.2 ± 36.9 | 1 | 384.7 ± 35.5 | - | - | - | - |
| September | 2 | 500.7 ± 43.1 | 2 | 413.1 ± 36.1 | 9 | 332.5 ± 14.2 | - | - | - | - |
| October | - | - | - | - | 5 | 290.8 ± 17.3 | - | - | - | - |
| November | 93 | 539.1 ± 14.1 | 100 | 380.0 ± 9.5 | 87 | 324.5 ± 7.5 | - | - | - | - |
| December | 255 | 527.7 ± 16.4 | 263 | 348.2 ± 14.2 | 274 | 332.6 ± 9.6 | - | - | - | - |
| **Weaning Season** | | * | | NS | | NS | | | | |
| Dry | 683 | 541.3 ± 15.4 | 711 | 348.1 ± 13.0 | 773 | 327.4 ± 9.8 | - | - | - | - |
| Rainy | 51 | 494.6 ± 17.3 | 56 | 352.6 ± 12.7 | 80 | 332.8 ± 9.1 | - | - | - | - |

* = Significant; ** = Very significant; *** = Highly significant; NS = Not significant

Male calves retained a higher body weight following weaning, being 4.0, 1.5, 2.2 and 3.6 % heavier at 9, 18, 24 and 36 months, respectively than their female counterparts. A post-weaning advantage in growth rate of male over female Ngaoundere Gudali calves has previously been reported by Abassa *et al.* (1993), Tawah *et al.* (1993) and Ebangi (1999).

All calves experienced a negative growth rate between the ages of 8 and 9 months (the adopted normal weaning age is 8 months ± 2 weeks), due to either the direct effect of weaning, or the stress due to the new environment the calves were moved to. Weaned calves are taken away from their dams to a new herd, the weaner herd, usually situated at some distance from the breeding herd for the ease of transition. It is likely that weaning in familiar surroundings would have made the weaning process more bearable. Maybe taking the mothers away to a different paddock (rather than moving the calves away) would be an alternative worth considering in the Adamawa.

The season of birth significantly ($P<0.05$) affected the post-weaning weights and ADG up to 15 months. Overall, calves born during the dry season outperformed their rainy season born counterparts. Although the bodyweights at 12, 24 and 36 months of age tended to favour the rainy season born animals, the overall trend was not different (Figure 6.7).

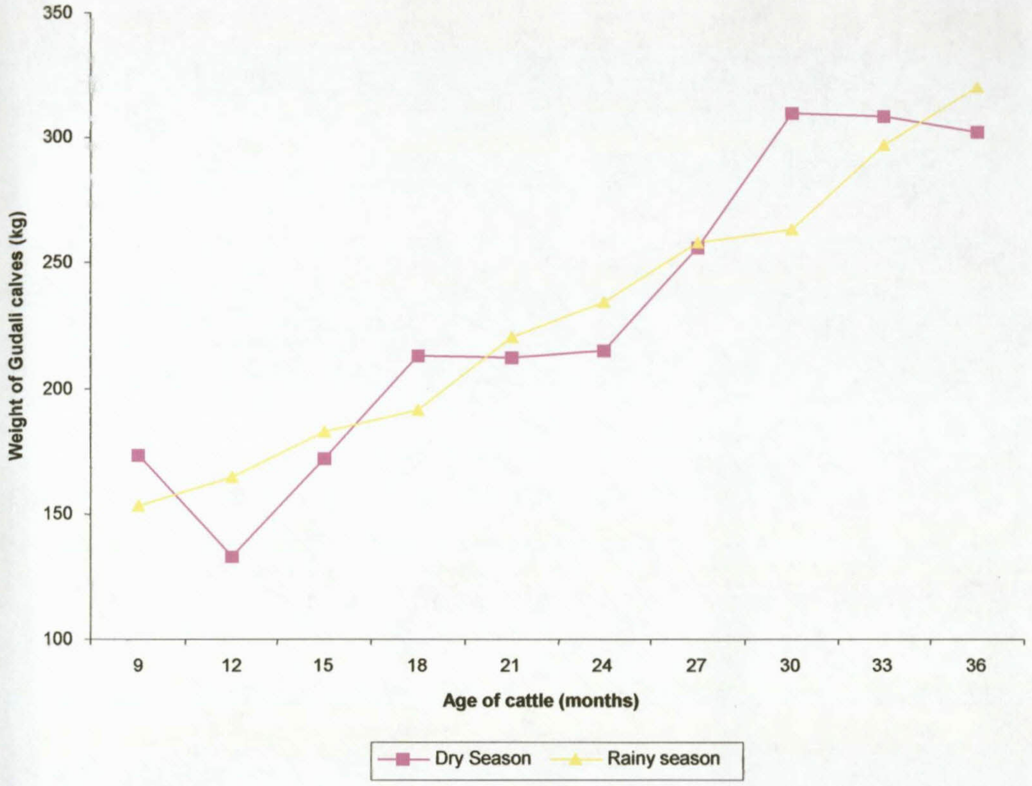


**Figure 6. 7: Post-weaning weight (kg) of Gudali calves according to season of birth**

The cruel effects of the dry season once more point to the fact that corrective measures have to be taken to avoid recurrent weight losses during the dry season followed by gains during the rainy season. Despite the compensatory growth that takes place at the onset of every rainy season, the overall growth rate would certainly improve if the weight loss during the dry season months could be minimised.

The results of this study also show that the Ngaoundere Gudali heifers can reach a weight of 222.7 ± 2.8, 258.4 ± 4.0 and 281.5 ± 4.7 kg at 24, 27 and 30 months of age, respectively. These bodyweights suggest that it might not be necessary to wait until the heifers reach the age of 36 months before entering the breeding herd, as is currently the practice. A 'target' bodyweight of 300 kg (or 3 years) on-station is usually expected before a heifer is bred. The weight at 30 months seems more appropriate, but an earlier age at breeding (between 24 and 30 months) is possible. It would be worth investigating the effect that this earlier age (and weight) at mating

would have on the reproductive performance of the Ngaoundere Gudali, both in the short and long term.

Year of calving was shown to have a highly significant ($P<0.001$) effect on both the body weights and the average daily gain throughout the period covered by the present study. However, no specific trend was noted regarding a consistent increase or decrease of these parameters at specific ages over time. The year of calving effect is therefore a reflection of the yearly variations in total rainfall that could have affected the total forage available to the suckling dams and the other animals in the herds.

The age at which weaning took place was seems not to be an important factor affecting either weight or ADG beyond the age of 12 months of age. No significant difference in the studied variables could be attributed to this factor. It is likely that after the age of 12 months and as early as 15 months, early weaned calves were able to reduce the weight gap existing between their group and the 3 others by a faster growth rate (compensatory growth).

## 6. 4. CONCLUSION

Birth weights in Ngaoundere Gudali cattle were significantly affected by sex of the calf, month and year of calving but not by the age parity of the dam. Male calves were born heavier than their female counterparts. Calves born during the rainy season were heavier at birth than the dry season born calves. The breeding season currently implemented extends from June to November, leading to a concentration of births from the end of the dry season/onset of the rainy season until the end of the rainy season. Calves that are born towards the end of the dry season show a clear advantage in ADG from 3 months of age and are heavier at weaning than those born later in the rainy season. The effect on the post-weaning growth of the transfer of the calves away from their dams to new surroundings at weaning, versus leaving the calves in familiar surroundings and moving their dams away needs to be addressed under the current traditional farming systems in the Adamawa.

A weaner productivity index was used to evaluate the best period for weaning and it showed the best calving period both for calf weaning weight and dam productivity in terms of best postpartum interval to be at the end of the dry season from January to March. The best breeding season should therefore extend from April to July. However, due to the structure of the data used in this study, skewed towards rainy season births, it was proposed that further research be carried out on both the optimum length of the breeding season and the months during which it should take place for improved herd fertility.

The present work has also shown that heifers can achieve average body weights of 222 to 290 kg between the ages of 24 and 30 months, respectively. The breeding of Ngaoundere Gudali heifers as early as 24 to 27 months of age (on a weight basis) instead of the present 36 months, and the possibility of reducing the age at first calving from 4 to 3 years should be investigated.

# CHAPTER 7

# FACTORS AFFECTING THE LENGTH OF THE OESTROUS CYCLE, SERUM PROGESTERONE LEVELS AND DURATION OF OESTRUS IN POSTPARTUM NGAOUNDERE GUDALI CATTLE

## 7. 1. INTRODUCTION

Reproductive performance is the single most important factor determining the productivity in the beef herd. Reports of beef cattle cow-calf operations show that the main reason for the low productivity is the poor reproductive performance of females (Dickerson, 1970; Dziuk and Bellows, 1983). This situation results from a combination of genetic, physiological, management and environmental factors, which affect the female in all the different reproductive stages, including the length of the oestrous cycle (Agyemang *et al.*, 1991). Research in Nigeria (Adeyemo *et al.*, 1979; Johnson and Gambo, 1979; Zakari *et al.*, 1981; Johnson and Oni, 1986; Oyedipe *et al.*, 1986) and Ethiopia (Mattoni *et al.*, 1988) have shown the duration of the oestrous cycle in zebu cattle to vary between 16 and 30 days, with an average of 21 days. Other studies have shown the duration of the oestrous cycle to be affected by season (Plasse *et al.*, 1970; Zakari et al., 1981) and to be shorter in zebu than in the *Bos taurus* cattle breeds (Plasse *et al.*, 1970; Mattoni *et al.*, 1988; Galina and Arthur, 1990a). However, little is known of the effect of these parameters on the reproduction of Ngaoundere Gudali cattle, one of the most popular cattle breeds of the Adamawa Highlands in Cameroon.

The few existing reports on reproductive performance are based either on information from a very limited number of animals or on results from questionnaires (Mbah *et al.*, 1987; Dawa, 1988; IRZ/GTZ, 1989). These data suggest the Ngaoundere Gudali cow to have a poor reproductive performance in terms of a low calf crop, late age at first calving and long calving interval (Mbah *et al.*, 1987; Dawa, 1988; IRZ/GTZ, 1989). No research work has been carried out to-date, aimed at understanding the basic reasons for the breed's poor reproductive performance, despite its relatively good productive performance (Abassa *et al.*, 1993; Tawah *et al.*, 1993; Ebangi, 1999). It has therefore been deemed necessary to establish the reproductive characteristics of the breed and the effects of the different environmental factors on these parameters, in order to devise management strategies geared at improving its reproductive efficiency.

This study was an integral part of a larger study aimed at characterising the basic reproductive parameters of the Ngaoundere Gudali cattle in the Adamawa region. The trial was aimed specifically at determining the time when the postpartum Ngaoundere Gudali female should be mated based on the length of the oestrous cycle and oestrous duration, and to determine the serum progesterone profile during the oestrous cycle.

## 7. 2. MATERIALS AND METHODS

The study was conducted on the beef herd of the Wakwa Regional Centre of Agricultural Research for Development, from November 2001 to May 2002. A herd of 40 postpartum Ngaoundere Gudali cows, aged 5 to 8 years, that had been diagnosed non-pregnant by rectal palpation, were used. The cows were maintained on natural pastures, with a dry season supplement (cotton seed cake at a rate of 200g per 100 kg body weight) being offered from mid-January to mid-April. Access to water was unrestricted during the day and the animals were housed in a pen at night. A more detailed description of the management procedures at the experimental farm is set out in Chapter 3. Oestrus was checked twice daily (06:00 to 07:00 and 16:00 to 17:00) with the aid of a teaser bull. All the behavioural signs of oestrus and the duration thereof were recorded. The onset of oestrus was taken as the time when the cow allowed the teaser bull to mount her (heterosexual behaviour) or was mounted by another anoestrous cow, and stood still. The mean duration of the oestrous cycle was determined as the number of days elapsing between two consecutive observed episodes of standing oestrus. When a cow first allowed herself to be mounted, the cow was isolated in a pen with a teaser bull and the oestrous behaviour observed for spells of 30 minutes, at hourly intervals, until the cow no more allowed mountings. Duration of oestrus was then calculated as the time elapsed between first and last observed acceptance to be mounted (Chicoteau *et al.,* 1989).

During the months of April and May, when feed became more readily available with the onset of the rains and cyclic activity seemed to be more regular, blood samples were drawn every second day from 10 cows via the jugular vein - starting on Day 1 (day of oestrous detection = Day 0), until Day 0 of the next oestrous cycle. The blood samples were allowed to clot at room temperature for 30 to 60 minutes, centrifuged (2500 rpm for 10 minutes), and the serum collected. Serum was stored in 1 ml aliquots at –20°C, until assayed for serum progesterone concentration. Progesterone analysis was performed on an ACS:180 Automated Chemiluminescence System™ (Bayer Health Care) according to a short protocol provided by the manufacturers as set out in Chapter 3.

The historical data collected over the years from the artificially inseminated herd at the Wakwa Centre were used to monitor the seasonal occurrence of oestrus in the Ngaoundere Gudali cows. In this herd, oestrus was detected twice a day (06:00 – 07:00 hours, 16:00 – 17:00 hours) with the aid of a teaser bull, and AI, performed 12 hours after oestrus detection, was practised all year round. A total of 1504 occurrences of oestrus over a 9 year period (January 1980 to December 1988) were analysed to determine the seasonal distribution of oestrous occurrences and relate it to the distribution of births.

All data were analysed with the Generalised Model Procedures of the Statistical Analysis Systems (SAS, 1991). The results, unless otherwise indicated, are presented as the mean ± standard error (SE).

## 7. 3. RESULTS AND DISCUSSION

A total of 81 oestrous cycles were observed in 25 of the 40 postpartum cows monitored, meaning that 37.5% (15/40) of the cows were in anoestrus or did not show oestrus during the 200 days observation period. The mean cycle length recorded was 21.8 ± 0.5 days, with a median of 21 days. The oestrous cycle lengths recorded ranged from a minimum of 15 days to a maximum of 35 days, and the frequency distribution of the oestrous cycles is illustrated in Figure 7.1.

Most of the oestrous cycles (67.9%) had a length comprised of between 18 and 22 days, while 18.52% of the cycles lasted between 23 and 28 days. Only 4.9 and 8.6% of the cycles had a length of 15 to 17 and 30 to 35 days, respectively. These results are in agreement with oestrous cycle durations recorded from zebu breeds in Nigeria (Adeyemo *et al.*, 1979; Johnson and Gambo, 1979; Johnson and Oni, 1986;

Oyedipe *et al.*, 1986; Dawuda *et al.*, 1989) and Ethiopia (Mattoni *et al.*, 1988). Many reports in other tropical areas recorded the oestrous cycle length of tropical indigenous cattle breeds to be between 16 and 30 days (Galina and Arthur, 1990a). Kabuga and Alhassan (1981) reported 52% of the oestruses observed in Holstein cows in Ghana to vary in duration between 14 and 24 days, and 17.5% between 37 and 46 days. These authors concluded that some oestrous periods could have been omitted, and a high incidence of embryonic mortalities could possibly have contributed to the long oestrous cycles. In the present study, it was possible that the occurrence of silent oestruses and oestrus manifested at night might have been missed.

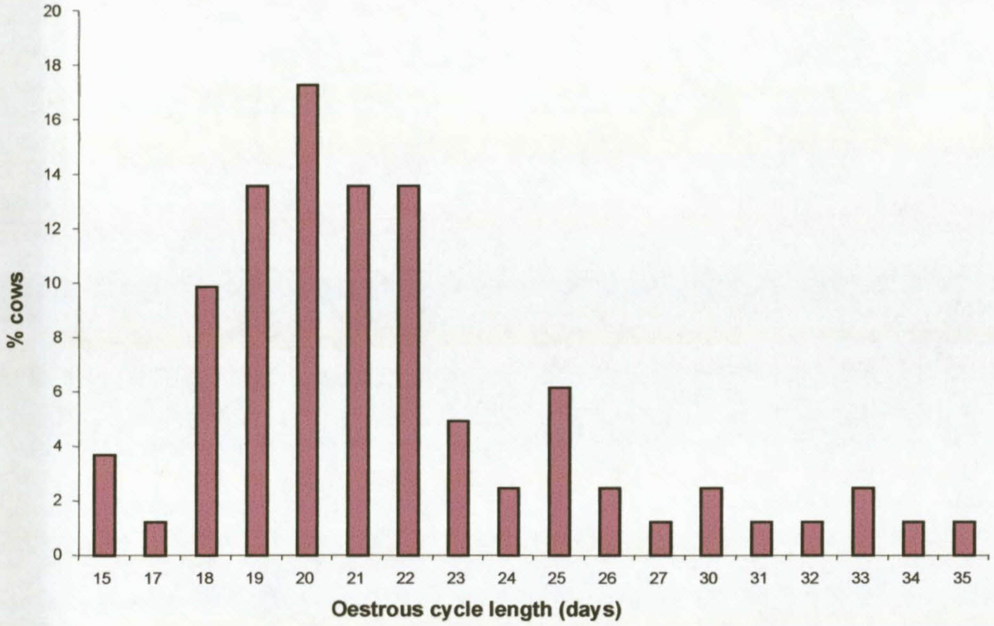


**Figure 7.1: Frequency distribution of oestrous cycle length of Ngaoundere Gudali cows**

The restricted duration of the observation periods, the relatively small number of animals available for the study and the unfavourable time of the year did not allow for the observation of more than two oestrous periods in most of the cows. It was therefore not possible to identify any difference in oestrous cycle duration between the first postpartum oestrous cycle and subsequent oestrous cycles. Dawuda *et al.* (1989), in a study regarding the occurrence of silent oestrus in Bunaji cows, reported differences in length for the first, second and third oestrous cycles between the silent oestrus and oestrous cows to be not significant.

The oestrous cycles were significantly ($P<0.05$) longer during the dry season (24.1 ± 0.7 days), compared to the rainy season (20.6 ± 0.5 days). The significant effect of season on the duration of the oestrous cycle has been previously reported in other tropical breeds (Plasse *et al.*, 1970; Zakari *et al.*, 1981; Mattoni *et al.*, 1988; Lamothe-Zavaleta *et al.*, 1991a). These reports are generally all in agreement with the tendency for longer oestrous cycles during the dry season. As has been the case in this study, Zakari *et al.* (1981) working with the White Fulani and Sokoto Gudali in Nigeria, showed the oestrous cycles to be on average longer (26.04 days) in the pre-rainy season than during the rainy season (20.8 days). However, Mattoni *et al.* (1988) and Lamothe-Zavaleta *et al.* (1991a) respectively reported oestrous cycles to be 1.3 and 2.1 days longer during the rainy season than during the dry period.

From the observations recorded during the monitoring period, there seems to be a significant ($P<0.05$) influence of season on the number of cows in oestrus. Twenty eight cows (34.6%) were detected in oestrus during the 3 hotter months of the dry season (January to March), and the rest (53/81 or 65.4%) were cyclic during the 2 cooler months of the rainy season (April and May). On the other hand, from the historical data collected from the AI herd over a 9 year period (1980 to 1988), it can be noted that the majority of the cows in oestrus were detected during the rainy season, which runs from April to October. The monthly distribution of the oestrous observations is shown in Figure 7.2.

Only 28.9% (434 out of a total of 1504) of the oestrous manifestations during the 9-year observation period were detected during the dry season (November to March) and early rainy season (April and May), compared to 71.1% (1070 observations) during the rest of the rainy season (June to October), when the daily temperatures were lower. The low incidence of oestrus at the onset of the rains during the months of April and May could be related as a carry-over effect of the previous dry period. During these two months, grass regrowth had just begun and did not meet the requirements of the cows, whose body reserves were depleted by a long and harsh dry season. The seasonal peak of the occurrence of oestrus correlates well with the seasonal concentration of births which occurred 9 months later. These data suggest that oestrous manifestation in the Ngaoundere Gudali cows is more prominently expressed during the rainy season - probably due to the beneficial combination of availability of green and nutritious pastures, and of the mild ambient temperature.

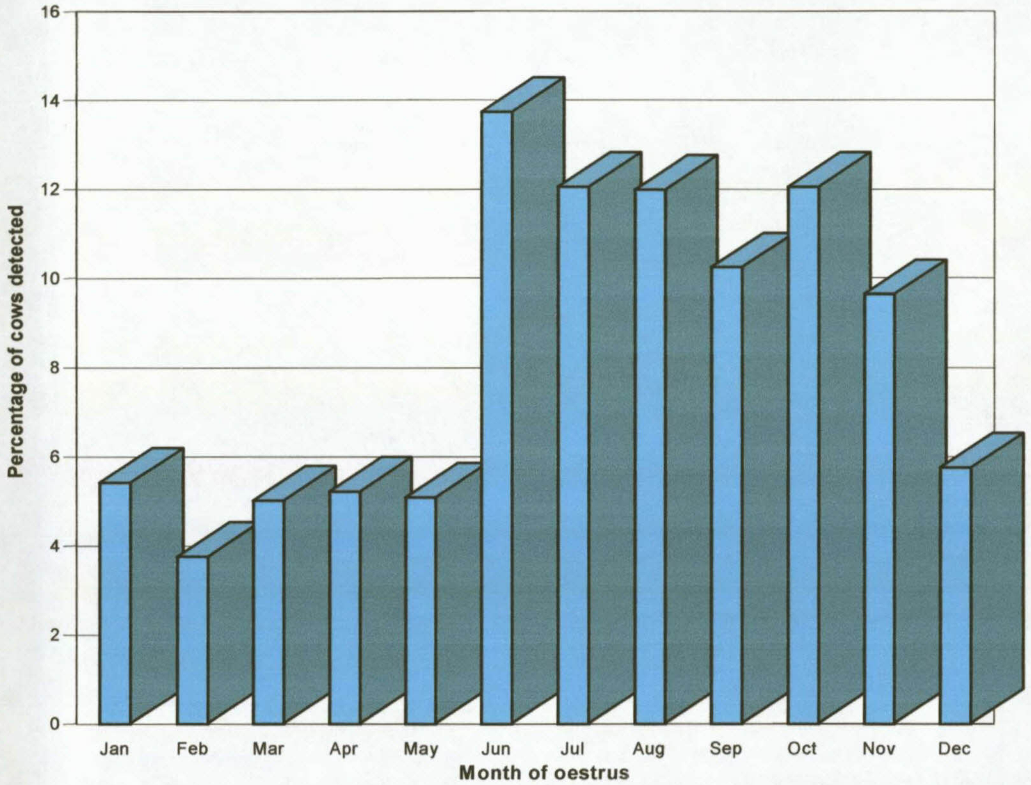


**Figure 7. 2: Average monthly distribution of oestrus over a period of 9 years in Ngaoundere Gudali cows**

The most detrimental effect of the dry season in the Adamawa Highlands is manifested mainly via the poor quality and low quantity of the vegetation. Usually, bush fires set during this period of the year by hunters, honey seekers and farmers in search for either game, wild honey or new land for the sowing/planting season, worsen the forage availability, forcing the animals to walk longer distances in search of fodder along the river banks. Lhoste (1967) reported losses in bodyweight of up to 20% in lactating cows during this period. It could therefore be hypothesised that during the dry season, many animals are in a state of nutritionally-induced anoestrus

- which most of the times might be associated with lactational anoestrus, as a majority of the dams calving during the rainy season are still nursing during the following dry season. Additionally, it has been observed at the station that, during the dry season, the animals tend to seek shade, which reduces their grazing time. This observation is supported by the results of Chicoteau *et al.* (1989) who showed a negative correlation between oestrous behaviour and ambient temperature - meaning that oestrous behavior decreased as day temperature increased. Rahka and Igboeli (1971) suggested that daylength, along with other environmental factors such as temperature, rainfall and nutrition, are of overriding importance in the expression of oestrus. The current results agree with this observation, but are contrary to the findings of Zakari *et al.* (1981) in Northern Nigeria where oestrous detection seemed to be manifested more clearly during the hotter months.

The present results also confirm reports stating that cows tend to express oestrus more prominently during the cooler hours of the day. Although the observation periods in this case (06:00-07:00 and 16:00-17:00) are relatively cooler, oestrous detection could probably have been improved if oestrus had been observed later in the afternoon and more frequently. Dobson and Kamonpatana (1986) reported detection rates of up to 80% with three 30-minutes spells per day at 06:00, 14:00 and 22:00. Similarly, Mattoni *et al.* (1988) and Lamothe-Zavaleta *et al.* (1991a) found oestrus to be best detected in the early hours of the morning and early hours of the night/late afternoon. Dawuda *et al.* (1989) suggested either a 24-hour observation period or the use of more reliable and sophisticated methods for oestrous detection (closed circuit television or time lapse video recorders - not very practical under extensive farming conditions at the research station). In most situations the use of a teaser bull or an androgenised cow is advised to achieve a higher efficiency of oestrous detection (Galina and Arthur, 1989c).

In the 10 cows from which blood samples were collected, only 6 could be used in the evaluation of the serum progesterone concentrations beyond day 17 of the oestrous cycle. The other 4 cows were either pregnant or had persistent corpora lutea - as indicated by levels of serum progesterone constantly above 6 ng/ml. Figure 7.3 illustrates serum progesterone levels to be lowest (0.4 ng/ml) between days 1 and 3 of the cycle, before rising from day 5 to reach peak values between days 15 to 19

(5.5 to 6.5 ng/ml). The serum progesterone concentrations thereafter declined rapidly to reach very low basal levels of less than 1 ng/ml by day 21 (oestrus). Figure 7.4 depicts the serum progesterone profile of 1 non-pregnant cycling postpartum Gudali cow with a 21-day oestrous cycle.

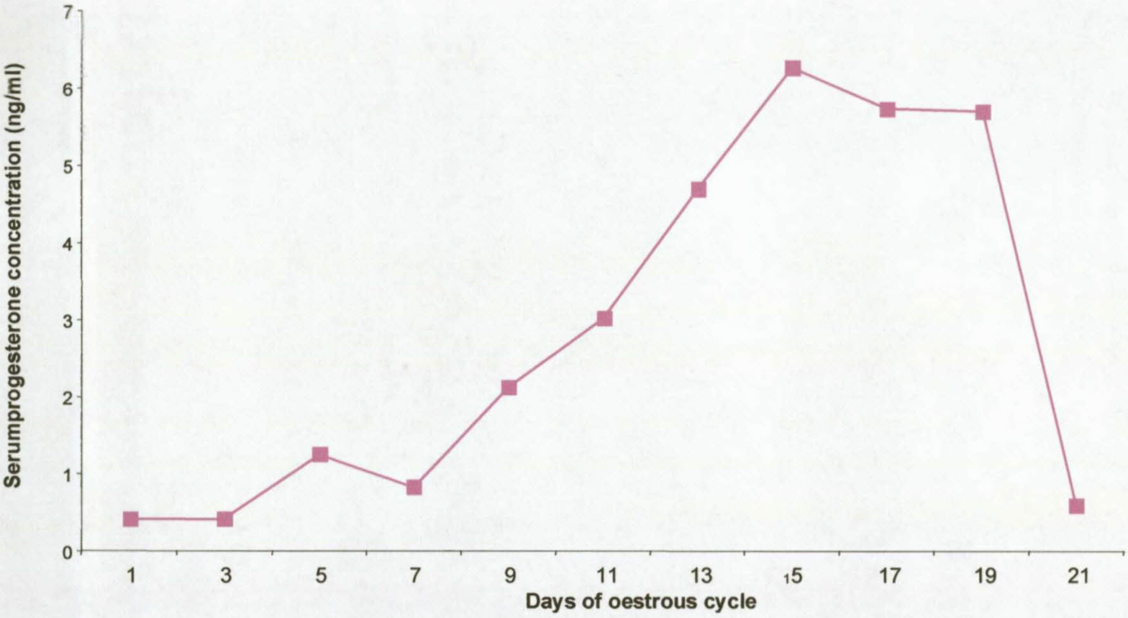


**Figure 7. 3: Mean serum progesterone concentration profile during the oestrous cycles in Ngaoundere Gudali cows**

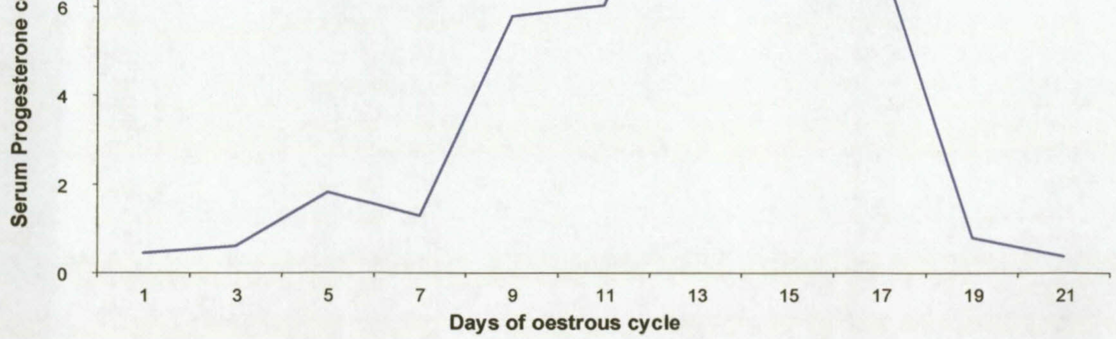


**Figure 7. 4: Serum progesterone concentration of a cycling postpartum Ngaoundere cow (No 96005) during a 21 day oestrous cycle**

For practical reasons, only the oestrous observations performed early in the morning before the cows went to the pasture are to be trusted. The lack of labour, the distance between the grazing area and the workers living quarters, the lack of facilities during the rains and the unavailability of light in the holding pens at night made the late afternoon and night observations very difficult.

The most prominent sign of oestrus was the acceptance of the female in oestrus to be mounted by the teaser bull or another female. The mean duration of oestrus periods recorded varied between 5 and 13 hours, with a mean of 9.8 ± 0.6 hours.

The time recorded for the duration of oestrus in this study are lower than that reported in the literature for tropical zebu cattle - except for the results by Johnson and Oni (1986) in Nigeria. These authors showed the acceptance of mounting behavior to be as short as 4 hours in Bunaji cattle. Most other reports quote a range to be 10 to 20 hours for zebu cows (Dobson and Kamonpatana, 1986; Galina and Arthur, 1990a; Lamothe-Zavaletta *et al.*, 1991a). The differences recorded in other studies could possibly be attributed to the different methods (duration and intervals) used for oestrous detection. In the present study, some of the cows may have been already in oestrus for some time before and after the actual observations were made. The actual onset and termination of the oestrous period could therefore have been missed and this low observation frequency could partially explain the shorter duration of the oestrous period recorded.

All these observations were carried out during the rainy season. The effect of season on the duration of oestrus could therefore not be determined. Zakari *et al.* (1981) found mounting behaviour to be affected by season - it lasted longer in the wet (4.7 hours) compared to the dry season (3.9 hours). However, Plasse *et al.* (1970) could not detect any significant seasonal effect on oestrous period duration between summer and winter in Brahman cattle, although a higher incidence of quiet ovulations were observed in winter. Mattoni *et al.* (1988) failed to observe any significant difference in the length of the oestrous period in Boran cattle in Ethiopia. Similarly, Lamothe-Zavaleta *et al.*, (1991a) found no significant seasonal effect on the duration of oestrus (9.5 and 10.8 h in the rainy and dry season, respectively).

The last authors however found a significant and negative relationship between the daily maximum temperature and the duration of the oestrous period.

## 7. 4. CONCLUSION

The length of the oestrous cycle in the Ngaoundere Gudali cows was 21.8 ± 0.5 days, with a range of 15 to 35 days. A significant effect of the season on both the length of oestrous cycle and occurrence of oestrus was detected. The cycles tended to be longer during the rainy season (24.1 ± 0.7 days), compared to the dry season (20.6 ± 0.5 days). 65.4% of the cycles were detected during the rainy season, with the majority concentrated in the period between July and October. The availability of nutritious (high protein) pastures during the rainy season seems to have a beneficial effect on the expression of the oestrous cycles.

The mean duration of oestrus was recorded as 9.8 ± 0.6 hours - shorter than that reported in the literature for tropical zebu cattle, but this could be partially attributed to the low frequency of oestrous observation periods used in this study. More frequent observations around the time of expected oestrus is advised for future studies - as the exact monitoring of the oestrous period holds great potential, especially when controlled mating or AI is contemplated.

The serum progesterone concentration was below 1 ng/ml for the first 3 days of the oestrous cycle and started to increase on day 5 and peaked between days 15 to 19 of the cycle. These progesterone concentrations declined to very low levels on Day 21. There was a large individual variation in the serum progesterone level at any given stage of the oestrous cycle. More in-depth studies are needed with a greater number of cows and a higher blood sampling frequency to really qualify the pattern of the circulating progesterone in the Ngaoundere Gudali cows, both during the oestrous cycle and early pregnancy.

# CHAPTER 8

# EFFECT OF SUCKLING AND WEANING REGIMES ON POSTPARTUM OVARIAN ACTIVITY OF NGAOUNDERE GUDALI COWS

## 8. 1. INTRODUCTION

In order to be productive, beef cows need to re-conceive, as early as possible after calving - during the postpartum period while nursing a calf. Decreasing the interval from parturition to conception increases the reproductive efficiency in cattle, by reducing the intercalving period. The following 4 factors are generally indicated as the main causes for postpartum infertility, namely general infertility, limited uterine involution, short oestrous cycles and anoestrus (Short *et al.*, 1990). Whereas general infertility could decrease the fertility rate by 20 to 30% for any oestrous cycle, uterine involution places a physical barrier to fertility during the early postpartum period (Kiracofe, 1980; Short *et al.*, 1990). Short oestrous cycles also contribute to infertility during the first 30 to 40 days after calving, resulting in earlier regression of the corpus luteum. The fourth and more important factor that determines the inter-calving interval, however, seems to be the delayed resumption of ovarian activity after parturition (Galina and Arthur, 1989b,c). Postpartum infertility due to the occurrence of anoestrus impairs efficient beef production and is affected by many other factors such as the nutritional status of the cow, season, genotype, age or parity, presence or absence of a male, uterine palpation, dystocia, suckling by the calf and management among others (Short *et al.*, 1990). In certain breeds and particularly in zebu cattle, a particular form of anoestrus caused by lactation and known as lactational anoestrus is a major limitation for good reproductive efficiency in the cow.

High calf mortality rates (up to and above 20%) have been reported in the Adamawa beef herds and the situation does not seem to have improved (IRZ/GTZ, 1989). This high mortality, characterised by a high incidence of scours in young calves, seriously hampers the herd productivity and decreases the number of calves weaned annually. Preventive measures to reduce calf mortality must be considered. These management interventions should include practices that promote the transfer of passive immunity from the dam to the neonate calves. Calves are born hypo-gammaglobulinaemic (very low levels of gamma globulins, particularly IgA, IgG and IgM) and the consumption of sufficient colostrum after birth is required to provide passive immunity, until calf immunity is established (Brambell, 1970). The absorption of macromolecules through the intestinal epithelial cells to the lymphatic system reduces rapidly after birth and ceases approximately 24 hours after birth. Calves that do not ingest sufficient antibody-rich colostrum by 24 hours after birth will have low levels of passive immunity against the most common diseases of neonate calves, and increased mortality rates (Kruse, 1970). It would be of prime importance to determine the levels of immunoglobulins in Ngaoundere Gudali new-born calves in order to evaluate the current management practices involved in calf-rearing.

Suckling induces a delay in ovulation either by increasing the sensitivity of the hypothalamus to the negative feedback of estrogens or by suppressing gonadotrophin release by the hypothalamus, which in turn suppresses ovarian activity (Carruthers and Hafs, 1980; Acosta *et al.*, 1983; Zalesky *et al.*, 1990; Short *et al.*, 1994a). Numerous studies have shown suckling to be a major cause of long intercalving periods in beef cattle in general, and zebu cows in particular (Short *et al.*, 1972; Laster *et al.*, 1973; Bellows *et al.*, 1974; Carruthers and Hafs, 1980; Dawuda *et al.*, 1988a, Short *et al.*, 1990; Mukasa-Mugerwa *et al.*, 1991a,b). Some studies suggest the time of the day when suckling occurs to be the most critical cause of prolonged postpartum anoestrus (Carruthers and Hafs, 1980; Stewart *et al.*, 1993a, 1995; Gazal *et al.*, 1999). The regulation of the suckling and lactation stimulus has been shown to be a viable management option to decrease the postpartum interval - either by allowing these inhibitory effects to wane with time, or by weaning the calf (Ryle and Orskov, 1990; Williams, 1990; Khan and Preston, 1992; Short *et al.*, 1994a; Sanh *et al.*, 1995; 1997; Hoffman *et al.*, 1996). Additionally, the manipulation of the age of the calf at weaning has been used for decades in the dairy industry as a management tool to increase the quantity of saleable milk, but it can also be used to increase the productivity of beef cattle in the tropics (Moore, 1984). Weaning can thus occur immediately after birth to 10 months following calving. It can either be complete, short-term (temporary calf removal for 48 to 96 hours or longer) or partial weaning (restricted suckling for short periods of time during the day) (Randel, 1981; Wells *et al.*, 1986; Ryle and Orskov, 1990; Williams, 1990; Khan and Preston, 1992; Stewart *et al.*, 1993a,b; Short *et al.*, 1994a; Sanh *et al.*, 1995, 1997). Restricted suckling following milking is unlikely to reduce the calf growth rate, but it usually reduces the intercalving interval and may also increase the amount of saleable milk from properly fed animals. This practice could therefore be an advantageous economic alternative for milk production by resource-poor extensive farmers (Ryle and Orskov, 1990; Khan and Preston, 1992).

Under Adamawa traditional extensive livestock farming conditions, unrestricted suckling is the most common practice. The calf is left with the dam throughout the day and night to suckle ad libitum. However, when the cow is milked for sale or household consumption, the calf is usually separated from the dam at night. The calf is then brought to the cow in the morning and during milking to stimulate the milk let down reflex - before being allowed to suckle the milk remaining in the dam's udder after hand milking. Thereafter, the calf remains with the dam throughout the day. This traditional practice, geared at increasing the amount of saleable or consumable milk output may reduce the negative effect of suckling on the resumption of the ovarian activity of postpartum cows. The effect of such a practice on the resumption of ovarian activity and calf growth rate therefore needs to be assessed and compared to the option of continuous suckling.

At the Wakwa Research and Production Units, calves are weaned at 8 months of age (CRZ Wakwa, 1975-1985). A survey in the traditional agricultural sector of Cameroon showed that up to 70% of the farmers interviewed wean their calves later than 8 months of age, while a good proportion of the local farmers do not wean their calves at all. These calves are allowed to suckle their dams until a new calf is born, in which case the older calf is usually naturally rejected - although cases of a dam nursing both calves are not uncommon. However, this practice is not sustainable, as the Ngaoundere Gudali cow has been shown to be a poor milk producer. Its milk production varies between 2.1 and 2.7 liters per day, for a total lactation period of 160 to 170 days - which is shorter than the period during which the calf normally suckles the dam (Mbah *et al.,* 1987). As dams have little or no milk available for the calf beyond the 6th month of lactation, suckling at this time can only have detrimental effects on the cow's reproductive performance, while being of little value to the calf. This limits the cow's chances of producing another calf within a 12 month period.

The objectives of this study were:

(i) to investigate the duration of uterine involution in the Ngaoundere Gudali cow,

(ii) to determine which of 2 suckling regimes (12-hour day suckling or 24-h unrestricted suckling) will induce earlier resumption of postpartum ovarian activity, and

(iii) to investigate the effect of 2 weaning ages (6 or 8 months) on the productive efficiency of the dam and growth of the calf.

## 8. 2. MATERIALS AND METHODS

Forty postpartum Ngaoundere Gudali cows were monitored for oestrus (visual checks) twice a day (30-minute periods at 7:00 and 7:30, 17:00 and 17:30), starting approximately 20 days after calving until 90 days postpartum with the aid of a teaser (penis deviated) bull. An adapted RTS technique for post-partum cows determined by rectal palpation (Table 8.1) was performed on days 15, 30, 45, 60 and 75 postpartum to monitor the uterine involution and resumption of ovarian activity. Uterine involution was considered complete when the concerned uterus was estimated to have returned to the normal tone and position in the pelvis (Schwalbach *et al.*, 2000). At the onset of the breeding season (which occurred approximately 50 days after the first calving), a fertile bull was introduced to the females. All cows were observed for oestrus and mating every morning and evening for periods of 30 minutes in the holding pens. The reproductive status (pregnant or non-pregnant) of the dams was determined at 150 days post-mating by rectal palpation, and correlated with the reproductive tract score at 60 and 75 days.

Two suckling regimes were compared in Gudali cows under extensive conditions. At the onset of the calving season (April and May), the animals were randomly assigned to the following groups:

- Restricted Suckling (RS) Group. Twenty cow-calf pairs were used. Calves were allowed to freely associate with their dam from calving until the age of 30 days. Later, the calves were isolated from the dam at night (Plate 8.1), until weaning at either 180 days (n=10) or 240 days (n=10)
- Control or Unrestricted Suckling (US) Group. Twenty cow-calf pairs were monitored. The calves were allowed to stay with their dams permanently, as is the

practice by most farmers, from birth until weaning at the age of either 180 days (n=10) or 240 days (n=10)

In both groups, calves had unrestricted access to their dam from birth up to day 30 of age. Due to the high maternal defensive instinct of the Ngaoundere Gudali dams, calves could not be easily accessed for the first 72 hours following birth, after which calves were weighed and a blood sample drawn from each calf via the jugular vein in 10 ml plain vacutainer tubes. The blood samples were allowed to clot at room temperature (30 to 60 minutes) before centrifugation at 2500 rpm for approximately 10 minutes. The serum was aspirated and stored at -20°C until analysed for gammaglobulins. The Immunoglobulin G content of each sample was measured using the BN™ system (Dade Behring Marburg GmbH, Germany) to estimate the level of serum gammaglobulins, and thus the level of passive immunity (maternal-derived antibody levels) 72 hours after birth in the Ngaoundere Gudali calves. The protocol on the immunoglobulin quantitative determination is set out in Chapter 3. The manufacturers provided the following equation to express the immunoglobulin levels relative to the radial immunodiffusion method:

$Y(BN) = 1.09 \times (RID) - 0.12$ g/l

where Y (BN) is the IgG levels established by the BN System, and

RID is the result of the radial immunodiffusion method.

The reading was thus converted as RID (g/l) $= [Y(BN) - 0.12]/1.09$.

Both the calves and dams were weighed monthly and bodyweights recorded for a 12 month period. The monthly bodyweights of the calves were used to determine the average daily gain (ADG) of the calves relative to the suckling regime. In addition, at each weighing, the body condition score (BCS) of the dams was recorded. The relationship between BCS at calving and around oestrus was determined. Factors considered when comparing the different suckling regimes included the weight of the calf at birth, age and parity of the dam, weight gain of the calf pre- and post-weaning, BCS of the dam (at calving, and at time of oestrous detection). More detailed information on the management conditions at the Wakwa Research Station is set out in Chapter 3.

All calves (n=40) from the suckling trial were randomly allocated to two treatment groups in such a way that half of the calves from each suckling group (RS or US) were allocated to one of the following weaning treatments:

Group 1: Intermediate Weaning (IW) at 180 days (6 months) (n=20)

Group 2: Control Weaning (CW) at 240 days (8 months), as commonly practiced (n=20)

At weaning, calves were isolated in a pen for 3 to 7 days, during which they had free access to fresh cut grass/hay, water and some concentrate constituted of polishing from the corn mill, cottonseed cake, bone meal and salt. In addition, calves were fitted with a nose mask to prevent them from suckling their dams after their release (see Plate 8.2) - this mask did not inhibit grazing.

**Table 8. 1: The 5-point scoring system for determining the reproductive tract score of postpartum cows** (from Schwalbach *et al.*, 2000)

| Score | Vulva and vagina | Cervix | Uterus | Ovaries |
|---|---|---|---|---|
| 1 | Purulent discharge,<br>Recto-vaginal fistulae<br>Pale mucosae | On the pelvic brim<br>Not involuted<br>Cervicitis<br>Severe fibrosis | Not involuted, asymmetric<br>Over the pelvic brim<br>Irregular surface, with content | Not active<br>No palpable structures<br>Flat and small |
| 2 | Vaginitis or severe vulvae lesions with consequences to the shape and closure | Intrapelvic<br>Not completely involuted<br>Mild cervicitis<br>Mild fibrosis | Not completely involuted<br>At the brim<br>Distinct asymmetry (1:1.5)<br>Thick wall with content<br>No tone | Not active<br>No palpable structures but not flat |
| 3 | Vulvae lesions with consequences to the shape, but normal closure.<br>Dry pale/pink mucosae | Intrapelvic<br>Involuted but with a small area of fibrosis (scar tissue0 | Not completely involuted<br>Uterus intra-pelvic, nearly symmetrical (1:1.2)<br>Thin wall with no content,<br>No tone | Small developing follicles (<5 mm)<br>Rounded ovaries |
| 4 | Normal<br>Moist pink mucosae | Intrapelvic<br>Normal | Involuted<br>Intrapelvic<br>Symmetrical (1:1.1)<br>Thin wall with no content<br>Good tone | One ovary active with follicles (>10 mm)<br>CL possible |
| 5 | Normal<br>Moist pink mucosae | Intrapelvic<br>Normal | Involuted<br>Intrapelvic<br>Symmetrical (1:1.1)<br>Thin wall with no content<br>Excellent tone | Both ovaries active, with follicles (>10 mm)<br>CL present |

Weaning weights were adjusted for 205 days and the treatments compared. Additionally, the cow weaner production efficiency index for cow productivity was determined as follows:

$$\text{Weaner calf production per cow per year (kg)} = \frac{\text{Mean calf weaning weight x 365 days}}{\text{Mean intercalving period}}$$

Factors taken into consideration when analysing the weaning weights included the suckling regime, the weaning age, the body condition of the dam at calving and at oestrus, and the date of oestrous observation. The postpartum interval was calculated as the interval (days) between calving and the date on which the postpartum cow was observed in oestrus (and eventually mated).

All data were analysed with the Generalised Model Procedures of SAS (1991) using birth weight as a covariate. The results, unless otherwise indicated are presented as the mean ± standard error (SE).

**Plate 8. 1: Ngaoundere Gudali calves tied to a rope away from the dams during the night (picture taken in the morning before milking)**

**Plate 8. 2: Ngaoundere Gudali herd showing a calf fitted with a nose stopper (second from left)**

## 8. 3. RESULTS AND DISCUSSION

Of the initial 40 cow-calf pairs, a complete set of results could be obtained only from 38 pairs. One cow of the RS group lost her calf aged approximately one month, thereafter came in oestrus and was bred within 40 days of the death of the calf. In the US group, one cow was found dead before the weaning of the calf and this calf was withdrawn from the experiment and bucket-fed with milk from other cows. The average RTS of the postpartum cows at different stages postpartum are shown in Table 8.2.

**Table 8. 2: Mean (± SE) reproductive tract score (RTS) of postpartum Ngaoundere Gudali cows as a function of the suckling regime**

| Suckling regime | Period of scoring post-partum (days) | | | | |
|---|---|---|---|---|---|
| | 15 | 30 | 45 | 60 | 75 |
| Unrestricted | $1.9 \pm 0.1^{a,}$ | $2.4 \pm 0.1^{a}$ | $3.1 \pm 0.1^{a,*}$ | $3.5 \pm 0.1^{a,**}$ | $4.1 \pm 0.1^{a,**}$ |
| Restricted | $1.8 \pm 0.1^{a}$ | $2.6 \pm 0.1^{a}$ | $3.6 \pm 0.1^{b}$ | $4.2 \pm 0.1^{b}$ | $4.6 \pm 0.1^{b}$ |

Means ± SE in the same column with different superscript are significantly different;
$^{*}$ = Significant (P<0.05) $^{**}$ = Highly significant (P<0.01)

The above results (Table 8.2) show no significant difference in the mean RTS of the cows from both groups 15 and 30 days postpartum. From day 45 postpartum, there was a noticeable difference ($P<0.05$) in the tract score between the 2 groups. Cows that had their calves permanently by their side day and night recorded a lower RTS (3.1 ± 0.1), compared to those that could suckle their calves only during the day (3.6 ± 0.1). The difference became even more marked by days 60 and 75 postpartum. The conception rates in both groups following mating were highly correlated to the RTS at 60 ($r = 0.56$) and 75 ($r = 0.55$) days postpartum.

Uterine involution was completed earlier in a larger proportion of cows under the restricted suckling treatment. At 45 days postpartum, the uterus of 11 out of 19 cows (57.9%) in the RS group was completely involuted, compared to only 3 (5.8%) in the US group. The gap between the 2 groups however closed approximately by day 60 (84.2% versus 52.6%) and was insignificant by day 75 as almost all the cows had involuted (Table 8.3).

**Table 8. 3: Average number (and percentage) of postpartum Ngaoundere Gudali cows with complete uterine involution under two suckling regimes.**

| Suckling regime | Days postpartum | | | | |
|---|---|---|---|---|---|
| | 15 | 30 | 45 | 60 | 75 |
| Unrestricted | 0/19 (0%) | 0/19 (0%) | 3/19 (15.8%) | 10/19 (52.6%) | 18/19 (94.7%) |
| Restricted | 0/19 (0%) | 2/19 (10.5%) | 11/19 (57.9%) | 16/19 (84.2%) | 19/19 (100%) |

The number and percentage of postpartum cows from the two suckling treatments detected in oestrus is shown in Table 8.4.

**Table 8. 4: Cumulative number and percentage of Ngaoundere Gudali cows detected in oestrus from day 15 postpartum**

| Suckling regime | Period of oestrus detection postpartum (days) | | | | | |
|---|---|---|---|---|---|---|
| | 15-30 | 30-45 | 45-60 | 60-75 | 75-90 | > 90 |
| US | 0/19 (0.0%) | 0/19 (0.0%) | 0/19 (0.0%) | 0/19 [a,*] (0.0%) | 3/19 [a,**] (15.8%) | 19/19 [a,**] (100%) |
| RS | 0/19 (0.0%) | 0/19 (0.0%) | 0/19 (0.0%) | 5/19 [b] (26.3%) | 16/19 [b] (84.2%) | 19/19 [a] (100%) |

Means in the same column with different superscript are significantly different
* = Significant ($P<0.05$) ** = Very significant ($P<0.01$)

No cow was observed in oestrus within the first 45 days following parturition. Five cows of the 19 (26.3 %) in the RS group were in oestrus within 75 days with none from the US group being cyclic. Between 75 and 90 days postpartum, 84.2 % and 15.8 % were observed in oestrus and mated in the RS and US groups, respectively. The rest of the cows from both groups were bred within a period of 6 months after calving.

The mean postpartum interval (from calving to first oestrus) was significantly ($P<0.001$) shorter in the RS group (83.4 ± 5.1 days), compared to the US group (126.4 ± 5.1 days). Azzam *et al.* (1991) reported that, during the first 4 weeks postpartum, most beef cows are not capable of exhibiting oestrous cycles, regardless of whether bulls are present or not. It is only after 7 weeks postpartum that some cows are capable of responding to bulls by shortening their postpartum interval to oestrus. This finding indicates that the response to the male stimulus (bull effect) only starts a few weeks after parturition. Sanh *et al.* (1995) reported that cows whose calves had a restricted suckling (RS) treatment recorded a slightly longer interval than cows whose calves were artificially reared (AR) (97 versus 93 days). It was also reported that the Boran cows recorded a longer postpartum interval than the exotic breeds (103 and 88 days, respectively). The findings of this study have shown that few Ngaoundere Gudali females resume ovarian activity before 60 days postpartum. Unrestricted suckling significantly delayed the post-partum resumption of ovarian activity, and seems to be a main factor contributing to the extended postpartum anoestrous period observed in Ngaoundere Gudali cows.

The results of this study have produced evidence that the current practice of continuous suckling of dams by the calves on the Adamawa highlands significantly contributes to the prolonged anoestrous period. Randel (1981) showed that suckling once a day (from the $30^{th}$ day after calving) shortened the calving to conception interval to 68.9 days, compared to 168.2 days in cows suckling for the entire day. The length of the postpartum intervals recorded in the present study are longer than those reported by Eduvie (1985) for White Fulani and Sokoto Gudali in Nigeria, with intervals to first oestrus of 52.77 and 23.36 days for suckled and non-suckled cows, respectively. This interval is however lower than quoted by Dawuda *et al.* (1988a) and Sanh *et al.* (1995). The large variation with the present study could be attributed to the fact that the calving took place at the beginning of the rainy season (April and May), when the cows coming from a 5-month long dry season were in a relatively poor body condition and negative energy balance. Eduvie (1985) reported a significant effect of season of calving on the intervals from calving to first ovulation, but not to completion of uterine involution. Dawuda *et al.* (1988a) showed that season of calving significantly affected the interval from calving to first overt oestrus in Bunaji cows (152.8 and 122.9 days during the dry and rainy seasons, respectively).

The level serum IgG concentration in newborn calves around 72 hours following birth in 35 calves recorded a mean concentration of 7.76 ± 0.51 g/l, with a minimum of 0.04 and a maximum of 12.73 g/l. In 17.1% (6/35) of the calves, the immunoglobulin levels were below 5 g/l, 71.4% were between 5 and 9.9 g/l and the rest (4/35) between 10 and 12.7 g/l. These serum IgG concentrations are below the values quoted in the literature. Reported values, usually measured at 24 or 48 hours following birth, vary greatly, but a level above 16 g/l is desirable to avoid calves prone to diseases (Langholz *et al.*, 1987). Although there seems to be no breed effect, the colostral immunoglobulin concentrations (and thus the serum IgG) are reported to be affected by the lactation number/age of the dam and the season of calving (Langholz *et al.*, 1987). These authors report an average concentration of IgG in 4 genetic groups of European type cattle and crosses to vary between 2.2 and 16.5 g/ml, but emphasize on the necessity for early colostrum suckling (within the first 3 hours after birth). O'Kelly (1991) reported mean values at 24 hours following calving to be 14.7 to 50.1 g/l, irrespective of the breed. The serum IgG concentration at 48 hours was reported to be 13.5 to 43.6 g/l. These levels were quoted as 1.1 g/l in Holstein calves fed Immunoglobulin unsupplemented colostrum and 14.6 g/l in calves fed Immunoglobulin supplemented colostrum (Crawford et *al.,* 1995). Quigley *et al.* (1995) reported housing and colostrum intake to affect the serum immunoglobulin concentration in calves. The IgG concentration at 24 hours of age was 39.1 and 39.44 g/l for Jersey calves that nursed the dam and were either lodged in a common barn or individual hutches, respectively, compared to those that were bottle-fed (24.4 and 23.2 g/l for calves housed in barn and in hutches, respectively).

The results in the present study point either to a low concentration of IgG in the maternal colostrum of Ngaoundere Gudali dams, leading to an insufficient immunoglobulin intake by the calves, or to a limited absorption of the ingested colostral IgG. The present data, due to limitations, could not answer these questions. Further investigations are necessary on a larger number of calves born at different times of the year. The level of IgG in the colostrum, the amount and the time at which the colostrum is first suckled by the calf, the rearing system and the incidence of neonatal illnesses have to be investigated so that a better picture of the situation can be got in order to advise farmers on better management practices to boost the passive immunity of their calves.

No relationship could be established between the weaning regime and the resumption of ovarian activity in this study as all the cows had been observed in oestrus (and mated) within 6 months of calving. The effect of weaning age on the interval from calving to conception/parturition or on the conception rate could not be assessed as all cows were mated before the weaning of their calves.

The least square means (± SE) for unadjusted and adjusted weaning weights, calving to conception interval, weaner production per year, pre- and post-weaning ADG are set out in Table 8.6 and 8.7, and Figure 8.1.

The estimated inter-calving interval, based on the confirmation of pregnancy by day 150 post-mating, was calculated as the sum of the calving to conception interval (see 7.2) and the average length of gestation of 293 days. This overall inter-calving interval was calculated to be 397.9 ± 5.0 days, significantly ($P<0.01$) longer in cows in which calves suckled ad libitum (419.4 ± 6.5 days) than in cows in the restricted suckling group (376.4 ± 3.2 days).

**Table 8. 5: Least squares means (± SE) for unadjusted (WWT) and adjusted weaning weights (AWWT), intercalving interval (II), cow weaner production Index (WPI) and pre-weaning (PreWean) ADG for Gudali cattle under two suckling regimes**

| | | Suckling Regime | |
|---|---|---|---|
| **Variable** | **Overall Mean** | **Unrestricted Suckling** | **Restricted Suckling** |
| WWT (kg) | 114.8 ± 3.7 | 134.1 ± 3.0[a] | 95.3 ± 3.0[b] |
| AWT (kg) | 112.2 ± 2.0 | 112.8 ± 0.7[a] | 92.4 ± 3.0[b] |
| II (days) | 397.9 ± 5.0 | 419.4 ± 6.5[a] | 376.4 ± 3.2[b] |
| WPI (kg) | 102.4 ± 1.8 | 116.6 ± 2.4[a] | 92.3 ± 2.4[b] |
| PreWean ADG (g) | 426.6 ± 58.5 | 487.1 ± 16.4[a] | 366.1 ± 16.4[b] |

[a, b] = Means in the same row with different superscripts differ significantly (P<0.05)

**Table 8. 6: Least squares means (± SE) for unadjusted (WWT) and adjusted weaning weights (AWWT), cow weaner production Index (WPI) and post-weaning (PostWean) ADG for Gudali calves under two weaning regimes**

| | | Weaning Regime | |
|---|---|---|---|
| **Variable** | **Overall Mean** | **6 months** | **8 months** |
| WWT (kg) | 114.8 ± 3.7 | 98.4 ± 3.0[a] | 131.0 ± 3.0[b] |
| AWT (kg) | 112.2 ± 2.0 | 112.1 ± 3.0[a] | 111.9 ± 3.0[a] |
| WPI (kg) | 104.6 ± 1.8 | 90.0 ± 2.4[a] | 118.9 ± 2.4[b] |
| PostWean (g) | 150.8 ± 54.4 | 176.0 ± 12.4[a] | 123.8 ± 12.4[b] |

[a, b] = Means in the same row with different superscripts differ significantly (P<0.05)

The overall mean weaning weight recorded was 114.8 ± 3.7 kg, lower than the average for the breed (Abassa *et al.*, 1993; Tawah *et al.*, 1993; Ebangi, 1999). This difference is certainly a reflection of the variation in environmental conditions over the years, and the possible incidence of pasture degradation in recent years, due to overstocking of the Research Station paddocks by encroaching neighbouring traditional farmers. The average WWT was significantly (P<0.05) different between the two suckling regimes (134.1 versus 95.3 kg for the US and the RS, respectively).

These results indicate that restricted suckling slowed calf growth rate and decreased weaning weight. However, when considering either the weaning regime alone or the combinations of weaning regime within each of the suckling regimes, significant differences (P<0.05) realised. Calves weaned at 8 months were consistently heavier (P<0.01) than those weaned at 6 months. Calves with unrestricted access to the dam's milk and were weaned at 8 months of age were 34.9, 28.7 and 71.1 kg heavier than the RS calves weaned at 8 months, the US and RS calves weaned at 6 months, respectively.

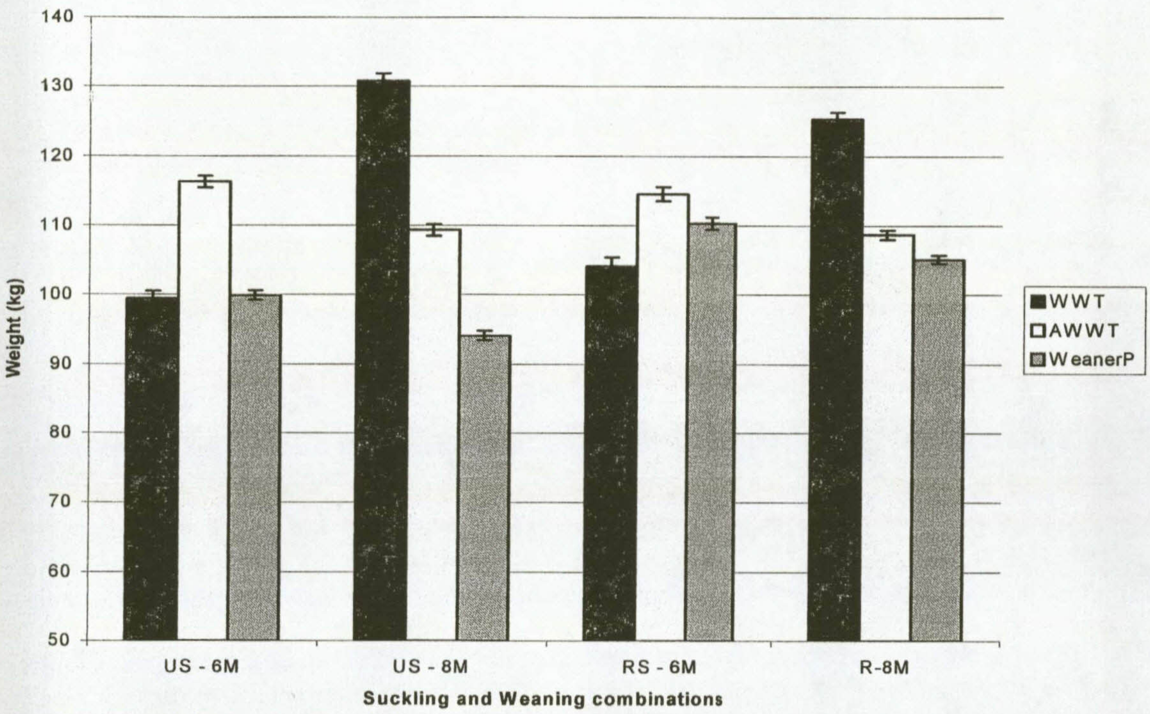


**Figure 8 1: Effect of suckling and weaning regime combinations on the weaning weight and weaner productivity in the Ngaoundere Gudali cattle**

When the weaning weight was adjusted to 205 days, however, although the average AWWT was significantly different between the US and RS groups (131.6 vs. 92.4 kg, respectively), the weight of calves weaned at 6 months was not different from that of calves weaned at 8 months (112.1 vs. 111.9 kg, respectively). This AWWT shows that in a calf weaner operation, it might be wiser to wean calves earlier than is currently the practice at 8 months.

Overall, the pre-weaning growth rate was significantly higher in the US group than in the RS group by 121.0 g/day. The difference stems from the fact that these calves had unlimited access to the dam's milk during most their growth period. However, the average weaner calf production efficiency index per cow per year, calculated on the basis of the unadjusted WWT values and the estimated intercalving interval, was 104.6 ± 1.8 kg. It was significantly higher (P<0.001) for the calves weaned at 8 months over those weaned earlier (118.9 ± 2.4 kg and 90.0 ± 2.4, respectively). In decreasing order of efficiency, the suckling x weaning combinations could be ranked as follows: US + weaning at 8 months (index of 128.1), RS + weaning at 8 months (109.7), US + weaning at 8 months (105.1) and RS + weaning at 6 months (74.8). The post-weaning growth to 12 months of age was significantly different (P<0.01) between the two weaning regimes. Calves weaned early gained more weight on a daily basis (176.0 ± 12.4 g) than those weaned at 8 months (123.8 ± 12.4 g). This reveals some compensatory growth that occurred in the early-weaned group up to a yearling age. In the traditional husbandry system of the Adamawa, weaned calves are only regarded as assets for the future to increase the herd size and the sale of animals is considered at an adult age only. However, restricted suckling and early weaning should be considered because of the reduction in the calving to conception interval.

The higher cow weaner production efficiency index achieved by the calves of the 8-months weaning group was probably related to the longer time that these calves spent suckling the dams and the higher quantity of milk consumed. This index (which combines the reproductive performance of the dam and the growth of the calf) points to the fact that weaning at 6 months of age is a little too early for the Ngaoundere Gudali calves, particularly under traditional management conditions. However, weaning at 8 months or later can be considered as late, an alternative would be either to test the weaning at 7 months against the current practice, or wean at 6 months bearing in mind the compensatory calf growth that is expected later and the positive effects on the cow reproduction. In the Adamawa highlands as in most traditional systems, weaner production is not a goal, it is the final, adult animal that is marketed. Nevertheless, the gain in the reduction in the calving to conception interval should be considered. This study also confirms the idea that if producers select for and achieve higher weaning weights, calving interval in a grazing-based production system may be increased and the total weight of weaned calves produced annually may remain unchanged or even be reduced (Doren *et al*., 1986).

## 8. 4. CONCLUSION

Uterine involution in Ngaoundere Gudali cows was found to be complete between 45 and 60 days after calving. Restricted suckling has a beneficial effect in accelerating the uterine involution, the resumption of ovarian activity, and shortening the intercalving intervals - although it resulted in a significant decrease in calf growth rate and weaning weight. The early weaning of Ngaoundere Gudali calves at 6 months leads to lower weaning weights and a lower cow weaner production efficiency index when compared to weaning at 8 months of age. However, this index should be noted with reservations in the context of the Adamawa traditional husbandry systems. Weaning calves at 6 or 7 months of age should be considered to reduce the intercalving intervals and improve overall herd productivity, as early weaned calves showed post-weaning compensatory growth and identical weights at 12 months to those calves weaned at 8 months of age. More research is needed on these aspects, before any definitive recommendation can be made on the weaning age of Gudali calves.

# CHAPTER 9

# GENERAL CONCLUSIONS AND RECOMMENDATIONS

Productive and reproductive traits of Ngaoundere Gudali cattle were evaluated in this study. These traits included the age at first calving, the gestation length, the postpartum period and calving intervals, the birth and weaning weights as well as the pre- and post-weaning growth rates, the length of the oestrous cycle and duration of oestrus. The serum progesterone profile during the oestrous cycle, and the effect of 2 suckling and 2 weaning regimes on the postpartum ovarian activity of the Ngaoundere Gudali cow were also investigated. The present study focussed on identifying some of the non-genetic factors such as sex of the calf, age/parity of the dam, age at weaning, season of calving which may be a significant source of variation for the traits under scrutiny. The most important factor identified was the season during which calves are born, which considerably influences the performance of the dams as well as that of the calves. The Adamawa Highlands, like most of the tropical environment of Cameroon, are characterised by marked seasonal variations in rainfall, which result in a large variation in the quantity and quality of feed available for grazing animals.

Month of service and sex of the calf were significant sources of variation in the gestation length of the Ngaoundere Gudali cattle, whereas age and parity of the dam did not affect this parameter. Male calves are carried 3 days longer *in utero* by their dams than their female counterparts, but these differences were not significant. Birth weights in Ngaoundere Gudali cattle were significantly affected by the sex of the calf, the month and year of calving, but not by the age/parity of the dam. Male calves were born heavier than their female counterparts, and tended to retain this advantage throughout most of their growth phase. Calves born during the rainy season were heavier at birth than the dry season born calves. However, calves born towards the end of the dry season showed a clear advantage in ADG from 3 months of age and were heavier at weaning than those born later in the rainy season. The month of calving and parity of the dam significantly affected the duration of the open period (interval from calving to conception), but not the sex of the calf. Primiparous cows had the longest open periods and the length of the open period reduced as parity increased. Cows calving in March and April (at the end of the dry season/ beginning of the rainy season) had longer open periods and longer calving intervals than those calving later, particularly from May. This latter group of cows calve during a more favourable period in terms of nutrition, and therefore stand a better chance of being rebred during the same breeding season.

The Ngaoundere Gudali cattle of the Adamawa highlands of Cameroon, bred under traditional extensive conditions, have a late age at first calving (approximately 4 years) and long intercalving period (18 months). These figures, although in line with most of those reported in the tropics, are unsatisfactory given the potential of the breed and the good environmental conditions of the Adamawa plateau. The reproductive performance of Ngaoundere Gudali cattle is markedly affected by the seasonal availability of feed resources, as it could be seen from the significant effect of season of birth on the age at first calving and on calving intervals. The present study has shown that Ngaoundere Gudali heifers achieve average body weights of 222 to 290 kg at 24 and 30 months, respectively. The breeding of Ngaoundere Gudali heifers as early as 24 to 27 months of age (on a weight basis) instead of the present 36 months, and the possibility of reducing the age at first calving from 4 to 3 years, should be investigated. Heifers born in the dry season tended to calve earlier for the first time than those born during the rainy season. The breed of the previous calf significantly affected the calving intervals. Cows calving a purebred Gudali calf had a significantly shorter subsequent calving interval than those calving crossbred calves of exotic breed (Brahman, Charolais, Holstein).

A weaner productivity index was used to determine the best period for calving in order to obtain the maximum dam productivity in terms of kilogram weaned calves produced per cow per year. Cows calving at the end of the dry season (from January to March) recorded the highest productivity index. The best breeding season should therefore extend from April to July. However, due to the nature of the data used in this study, skewed towards births in the rainy season, further research is proposed to determine the optimum period and length of the breeding season.

The mean length of the oestrous cycle recorded in the Ngaoundere Gudali cows was 21.8 ± 0.5 days, with a range of 15 to 35 days. A significant effect of the season on both the length of oestrous cycle and the occurrence of oestrus was recorded. The cycles tended to be significantly longer during the rainy season (24.1 ± 0.7 days), compared to the dry season (20.6 ± 0.5 days). Oestrus was more frequently detected during the rainy season with the majority concentrated in the period July to October. The availability of nutritious (high protein) natural pastures seems to have a beneficial effect on the expression of oestrous cycles in Ngaoundere Gudali cows.

The mean duration of oestrus was recorded as 9.8 ± 0.6 hours - shorter than that reported in the literature for tropical zebu cattle, but this could be partially attributed to the low frequency of oestrous observation periods used in this study. More frequent observations around the time of expected oestrus are advised for future studies as the exact monitoring of the oestrous period holds great potential, especially when controlled mating or AI are contemplated.

The serum progesterone profiles presented concentrations below 1 ng/ml during the first 3 days of the oestrous cycle. These levels started to rise on day 5 and peaked between days 15 to 19 of the cycle at 5.5 to 6.5 ng/ml before declining to very low levels on day 21. A large individual variation in the serum progesterone level was recorded at any given period of the oestrous cycle.

Uterine involution in the Ngaoundere Gudali cows was found to be complete between 45 and 60 days following calving in the majority of the cows. The reproductive tract scores at 60 and 75 days postpartum were highly correlated with the pregnancy rate during the subsequent mating season. This parameter is a good predictor of pregnancy rates if used at the beginning of the mating season. Restricted suckling has a beneficial effect in accelerating the uterine involution and the resumption of postpartum ovarian activity. This practice also shortens the intercalving intervals, although it results in a significant negative effect on calf growth rate and weaning weight. The early weaning of Ngaoundere Gudali calves at 6 months leads to lower weaning weights and lower cow weaner productivity indices, when compared to weaning at 8 months of age. However, the advantages of weaning calves at 6 or 7 months of age should be further investigated as this reduces the intercalving intervals and therefore improves overall cow-calf productivity. Early weaned calves showed post-weaning compensatory growth and identical weights at 12 months to those weaned at 8 months of age were recorded.

## RECOMMENDATIONS

The results of these studies have raised a number of questions that need to be addressed, both at research and extension level. The areas where further investigation is needed include (but not limited to):

- ☞ **The determination of the ideal breeding season**. A discrepancy for the ideal calving season (rainy or dry) has been noted, depending on the aspect being targeted. Although the use of a weaner productivity index has been used and points to a certain period of the year, this ideal calving season needs further investigation on both its length and the months involved. The corresponding mating season should be planned in such a way that both the reproduction of the cow and the well being of the calf are warranted.

- ☞ **The shortening of the breeding season**. The 6 months breeding season currently implemented extends from June to November, leading to a long calving season (from the end of the dry season/onset of the rainy season until the end of the rainy season). The progressive shortening of the breeding and calving seasons has to be evaluated over a few years, until an optimum duration of the breeding season can be determined.

- ☞ **The optimum age at which heifers should be bred** needs to be re-assessed. Years of breed improvement have led to heavier heifers for the same age, and the use of body condition scores in combination with the weight (not necessarily the age) to select the animals for breeding would certainly reduce the age at first calving. It would also be advisable to breed all heifers one month before the older cows are brought to the bull, because primiparous cows take a longer time to resume their ovarian activity.

- **Research on the reproductive characterisation of the Ngaoundere Gudali bull** is long overdue. This is still a virgin area, as virtually everything needs to be explored. The role of the bull fertility on the overall herd fertility, the seasonal variation in the semen and testicular characteristics of bulls at different ages, and libido evaluation need to be assessed. Furthermore, breeding bull evaluation criteria (breeding soundness evaluation) need to be determined, with the setting by the authorities concerned, of minimum standards for qualification at the beginning of every breeding season.

- **Post-weaning stress** was identified in this study, as evidenced by the decrease in bodyweight in calves between the $8^{th}$ and $9^{th}$ month, in the current 8-month weaning system. Alternative management systems aimed at reducing the stress of weaning should be investigated.

- **More on-farm research** is needed, with the traditional farmers' participation, on the weaning of calves on pastures earlier than the present weaning age of 8 months. Earlier weaning at 6 or 7 months of age would be more reasonable, as the calf can at this age already fend for itself. Early weaning would also give the dam the opportunity to be re-bred while reconstituting enough reserves in preparation for the next calf. A large-scale on-farm evaluation is needed before any definitive recommendation can be made on the ideal weaning age of Gudali calves.

- **Serum progesterone profile**: More in-depth studies need to be carried out with a greater number of cows and a higher blood collection frequency to qualify the pattern of the circulating progesterone (and determine the exact time of ovulation) in the Ngaoundere Gudali cows both during the oestrous cycle, and early pregnancy. Influences.

- Throughout these studies, the detrimental effect of the dry season on the productive and reproductive performance of the Ngaoundere Gudali cattle in the Adamawa highlands has been stressed. The issues of **overgrazing**, caused by overstocking, **uncontrolled setting of fires on pastures** and **implementation of pasture preservation** dry season feeding need to be addressed by the administrative and technical authorities through the education of traditional cattle farmers. Without proper feeding of the animals throughout the periods of scarcity, little progress can be achieved in terms of improved growth and calf crop if the animals are not given the opportunity to adequately express their full genetic potential.

# ABSTRACT

## *CERTAIN ASPECTS OF THE REPRODUCTIVE PERFORMANCE OF ZEBU CATTLE IN CAMEROON*

By

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A study divided into two phases was carried out in order to assess the reproductive characteristics of the Ngaoundere Gudali cow of the Adamawa Highlands of Cameroon. In the first part of the study, records from 1966 to 1994 collected at the Wakwa Agricultural Research Centre and Animal Production Station were used to study productive and reproductive traits such as: the gestation length, the postpartum period, the age at first calving and calving intervals. The birth and weaning weights as well as the pre- and post-weaning growth rates of Gudali calves were also evaluated. The second part of the study consisted of a monitoring study conducted between November 2001 and May 2002 on the length of the oestrous cycle, duration of oestrus, the serum progesterone levels during the oestrous cycle, and the effect of two suckling and two weaning regimes on the postpartum ovarian activity of Ngaoundere Gudali cows. The General Linear Models procedures of SAS (1991) were used to statistically analyse the data. Due to the unbalanced nature of the data, Least Squares Means (LSM) were used and, whenever a significant effect was detected, the Tukey-Kramer test was used to evaluate the LSM.

The overall least square mean for gestation length in Gudali cows was recorded as 293.4 ± 0.4 days (N = 697). The sex of the calf significantly ($P<0.05$) affected the

length of gestation, with male calves being carried *in utero* approximately 3 days longer than their female counterparts (294.1 ± 1.2 and 291.1 ± 1.2 days, respectively). Birth weight tended to increase as the gestation period lengthened. The significant effect ($P<0.01$) of the month of service on gestation length could not be explained, as gestation length fluctuated from one year to another. The parity and age of the cow had no significant effect on gestation length.

The mean duration of the open period (from calving to conception) was 267.7 ± 7.4 days, with a range of 24 to 749 days. Approximately 23.2% of the cows conceived within 90 days of calving and a total of 55.6% had conceived by 360 days. The distribution of the open period was bimodal, and could have been influenced by the seasonal availability of feed, or the long (6 months) mating season that allowed cows to calve during the following mating season. The calving to conception interval was significantly ($P<0.001$) affected by the month of calving and parity, but not by the sex of the calf. Cows calving at the end of the dry season/beginning of the rainy season (March and April) had the longest open period (and consequently the longest calving interval), compared to cows calving later (July to September). Cows on their first parity experienced a significantly longer mean postpartum (open) period ($P<0.001$) than older cows (320.7 vs. 200.2 days for first and $5^{th}$ parity cows, respectively). The sex of the calf did not affect the duration of the postpartum period, although this period was on average 5 days longer following the birth of a male than a female calf.

The overall average birth weight was 24.1 ± 2.8 kg (N = 3401), with male calves weighing approximately 1 kg more than their female counterparts (24.6 ± 0.1 and 23.7 ± 0.1 kg, respectively). Calves born during the rainy season were 0.84 kg heavier than those born during the dry season (24.5 ± 0.1 and 23.7 ± 0.2 kg, respectively). No significant effect of parity was recorded on birth weight, although the females calving for the first time tended to have lighter calves than older cows. A year effect on birth weight was detected, but no definite trend towards an increase or a decrease was noted over the years. This year effect was attributed to the large variation in environmental factors (rainfall and nutritive value of the pastures) experienced by the animals.

The average weaning weight of Ngaoundere Gudali calves was recorded as 149.4 ± 1.4 kg (N = 1827), with male calves weighing 6.1% more than the female calves at weaning (157.0 ± 2.8 and 148.0 ± 2.7 kg, respectively). There was a 20.4% weaning weight advantage of dry season born calves over those born during the rainy season (166.6 ± 4.5 and 138.4 ± 1.9 kg, respectively), despite the fact that the former were born significantly lighter. There was also a significant ($P<0.001$) year effect on weaning weight, with no evident trend over the years. This could be due to the variation in environmental conditions (inconsistent rains, total rainfall, heat stress, solar radiation, seasonal availability of forages, etc). No significant effect of parity/age of the cow on the weaning weight was detected, but age at weaning was found to be a very important determinant of the weaning weight. The earlier the calves were weaned, the lower their weaning weight, but the higher their adjusted weaning weight to an age of 205 days. The season at which the calves were weaned did not significantly affect their weaning weight, despite the apparent advantage that dry season born calves had over their rainy season born counterparts. A weaner productivity index was used in order to determine the best calving season. This index showed that cows calving in the dry season had significantly ($P<0.001$) higher indexes than those calving during the rainy season (113.1 ± 2.0 and 95.0 ± 1.5 kg, respectively). This index also differed with the sex of the calves (107.7 ± 1.6 and 100.4 ± 1.4 kg for male and female calves, respectively) and the month of birth. These results indicate that the best 3 months for calving span from November to January, with a corresponding mating season between February and April. Pre-weaning weights (1, 3 and 6 months of age) were significantly ($P<0.001$) influenced by the month, season, year of birth, and by the sex of the calf. The sex of the calf, month and year of birth but not season of birth significantly ($P<0.05$) affected average daily gain of Ngaoundere Gudali calves. The mean ADG were 1.1 ± 0.4, 0.8 ± 0.2, and 0.7 ± 0.1 kg/day from birth to 1, 3 and 6 months of age, respectively. Male calves consistently grew faster than their female counterparts at these 3 pre-weaning stages. Post-weaning weight and growth rate were significantly affected by the sex of the calf for the period considered (from 9 to 36 months of age), with bull calves retaining a higher growth rate. However, all calves experienced negative growth rates between the ages of 8 and 9 months (weaning took place at 8 months ± 2 weeks), due to either the stress of weaning or due to the new environment to which the weaners were moved. Season of birth no more significantly affected post-weaning weight and ADG from the age of 18 months. Interestingly, the study showed that the Ngaoundere Gudali heifers reach bodyweights of 222 and 281 kg at 24 and 30 months, respectively, meaning that an earlier age at first breeding could be contemplated.

The average length of the oestrous cycle of the Ngaoundere Gudali cow was 21.8 ± 0.5 days, ranging from 15 to 35 days. Most oestrous cycles (67.9%) had a length comprised of between 18 and 22 days, while 18.5% lasted between 23 and 28 days. The oestrous cycles were significantly ($P<0.05$) longer during the dry season (24.1 ± 0.7 days), compared to the rainy season (20.6 ± 0.5 days). Historical data from the AI herd showed that out of 1504 services performed at natural oestrus during a 9-year observation period, only 28.9% of the oestrous manifestations were detected during the dry season (November to March) and early rainy season (April and May), compared to 71.1% from June to October. The seasonal peak occurrence of oestrus correlated well with the seasonal concentration of births in the herds to suggest that oestrous manifestation in the Ngaoundere Gudali cow is more readily expressed during the rainy season. The most consistent sign of oestrus was the acceptance of the female in oestrus to be mounted by a teaser bull or another female, for an oestrous period that averaged 9.8 ± 0.6 hours (range of 5 to 13 hours). However, it was suspected that in this study, due to the low duration and long intervals between observations, the onset and termination of some oestrous periods could have been missed. Thus the shorter duration of the oestrus recorded. Serum progesterone concentrations were at the lowest (0.4 ng/ml) between days 1 and 3 of the oestrus cycle, before rising from day 5 to reach peak values (5.5 to 6.5 ng/ml) between days 15 and 19. These serum progesterone levels declined rapidly thereafter to reach very low levels by the day of oestrus. Uterine involution was completed in Ngaoundere Gudali cows by 45 to 60 days after calving, earlier in a larger proportion of cows with calves under restricted suckling (RS) management, than in the unrestricted suckling (US) group. 26.3% of the cows in the RS group and 0% of the US group were in oestrus within 75 days postpartum. Between 75 and 90 days postpartum, 84.2 and 15.8% had been observed in oestrus and mated in the respective groups. The mean postpartum interval from calving to first oestrus was significantly ($P<0.05$) shorter in the RS (83.4 ± 5.1 days), compared to the US group (126.4 ± 5.1 days). The intercalving period was estimated at 397.9 ± 5.0 days,

significantly ($P<0.01$) longer in cows that were suckled ad libitum ($419.4 \pm 6.5$ days), than in cows in the RS group ($376.4 \pm 3.2$ days). A high correlation was found between the reproductive tract score at 60 and 75 days postpartum ($r = 0.6$) and the conception rate of the cows. The overall mean weaning weight was $114.8 \pm 2.7$ kg for all the calves - significantly ($P<0.05$) higher for the US than for the RS regimes (134.1 vs. 95.3 kg, respectively). This indicates that restricted suckling had slowed calf growth and decreased weaning weight. Pre-weaning growth rate was significantly higher in the US than in the RS group. Calves that were in the US group and weaned at 8 months were 34.9, 28.7 and 71.1 kg heavier than the RS calves weaned at 8 months, US and RS calves weaned at 6 months, respectively. Post-weaning growth rate to 12 months of age was significantly different ($P<0.01$) for the two weaning regimes and it was found that early weaned calves grew faster (176 g/day) than those weaned at 8 months (123.8 g/day) - revealing some compensatory growth from weaning up to a yearling age. The level of serum IgG in 35 newborn Gudali calves (72 hours following birth) recorded a mean concentration of $7.8 \pm 0.5$ g/l (range of 0.04 to 12.7 g/l), far below the levels quoted in the literature at 24 to 48 hours following birth. These values point either to a low concentration of IgG in the colostrum of Ngaoundere Gudali dams, leading to an insufficient intake by the calves, or to a limited absorption of the ingested colostrum.

Overall, the present series of studies have contributed to the characterization of the most important aspects of the Ngaoundere Gudali reproductive and productive parameters. In general, the results obtained are indicative of low reproductive performances that seem to be linked to the seasonal availability of feed, which in turn depends on the seasonal and annual variations in rainfall. Certain management practices with a potential to improve the reproductive efficiency of the cows were identified (shorter breeding season, restricted suckling, early weaning, etc). An improvement in the reproductive efficiency of Ngaoundere Gudali cows would contribute to improve the overall productivity of the traditional cattle production systems in the Adamawa Highlands of Cameroon.

Key words: Age at first calving – Birth weight – Calving interval - Cattle – Gestation length – Gudali zebu - Oestrus cycle – Postpartum period – Suckling – Weaning.

# OPSOMMING

## *SEKERE REPRODUKSIE PRESTASIE ASPEKTE VAN ZEBU BEESTE IN KAMEROEN*

deur

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'n Studie wat opgedeel is in twee fases is uitgevoer om die reproduktiewe eienskappe van Ngaoundere Gudali koeie van die Adamana Hooglande van Kameroen te evalueer. In die eerste deel is rekords van 1966 tot 1994 wat by die Wakwa Landbou Navorsingsetrum en Diereproduksiestasie aangeteken is, gebruik om die volgende produktiewe en reproduktiewe eienskappe in die ras te evalueer: dragtigheidsperiode, die postpartum periode, ouderdom by eerste kalwing en interkalfperiodes. Die geboorte en speengewigte, sowel as die voor- en naspeense groeitempo van Gudali kalwers is ook geëvalueer. Die tweede deel van die studie het ingesluit 'n studie tussen November 2001 en Mei 2002 om die lengte van die estrussiklus, die lengte van die estrusperiode, serum progesteroon-konsentrasies tydens die estrussiklus en die effek van twee soog en twee speenbehandelings op die postpartum eierstok aktiwiteit van Ngaoudere Gudali koeie te monitor. Die "General Linear Models" prosedures van SAS (1991) is gebruik om data statisties te verwerk. As gevolg van die ongebalanseerde geaardheid van die data is kleinste kwadraat van gemiddeldes (LSM) gebruik (i.p.v. gemiddeldes) en wanneer 'n betekenisvolle verskil waargeneem is, is die Tukey-Kramer toets gebruik om die LSM te evalueer.

Die algehele LSM vir die dragtigheidsperiode in Gudali koeie was 293.4 ± 0.4 dae (N = 697). Die geslag van die kalf het hierdie periode betekenisvol (P<0.05) beïnvloed, met bulkalwers wat 3 dae langer in utero gehuisves word as die verskalwers (294.1 ± 1.2 en 291.1 ± 1.2 dae respektiewelik). Geboorte-gewig het geneig om te verhoog soos die dragtigheidsperiode langer geword het. Die betekenisvolle (P<0.01) effek van maand van dekking op die dragtigheidsperiode kon nie verklaar word nie, aangesien die dragtigheidsperiode gevarieer het van jaar tot jaar. Die pariteit en ouderdom van die koei het geen effek op die dragtigheidsperiode gehad nie. Die gemiddelde duur van die oop periode (kalwing tot konsepsie) was 267.7 ± 7.4 dae met 'n verspreiding van 24 tot 749 dae. Nagenoeg 23.2% van die koeie het gevat binne 90 dae na kalwing en 'n totaal van 55.6% het gevat by 360 dae. Die verspreiding van die oop periode was bi-modulêr, en kon beïnvloed word deur die seisoenale beskikbaarheid van voedsel, of die lang (6 maande) dekseisoen wat koeie toegelaat het om te kalf tydens die volgende dekseisoen. Die kalwing tot konsepsie interval was betekenisvol (P<0.001) geaffekteer deur die maand van kalwing en pariteit, maar nie deur die geslag van die kalf nie. Koeie wat gekalf het teen die einde van die droë seisoen/begin van die reënseisoen (Maart en April) het die langste oop periode getoon (en gevolglik die langste interkalfperiode) vergeleke met koeie wat later kalf (Julie tot September). Koeie wat vir die eerste keer kalf het 'n betekenisvol (P<0.001) langer postpartum (oop periode) periode getoon, vergeleke met ouer koeie (320.7 dae vs 200.2 dae vir eerste en vyfde pariteit koeie, respektiewelik). Die geslag van die kalf het nie die duur van die post-partum periode beïnvloed nie, alhoewel hierdie periode gemiddeld 5 dae langer was vir bul- vergeleke met verskalwers.

Die gemiddelde geboortegewig was 24.1 ± 2.8 kg (N = 3401) met die bulkalwers wat ongeveer 1 kg meer weeg as die verskalwers (24.6 ± 0.1 en 27.7 ± 0.1 kg respektiewelik). Kalwers gebore tydens die reënseisoen was 0.84 kg swaarder as daardie gebore tydens die droë seisoen (24.5 ± 0.1 en 23.7 ± 0.2 kg), respektiewelik). Geen effek van pariteit op geboortegewig is waargeneem, alhoewel die verse wat vir die eerste keer kalf, geneig het om ligter kalwers te hê, vergeleke met ouer koeie. 'n Jaareffek op geboortegewig is waargeneem, maar geen definitiewe neiging (toename of afname) is waargeneem oor die jare nie. Die jaareffek is toegeskryf aan die groot variasie in omgewingsfaktore (reënval en voedingswaardes van die weidings) ondervind deur die diere.

Die gemiddelde speengewig van Ngaoundere Gudali kalwers is vasgestel as 149.4 ± 1.4 kg (N = 1827), met bulkalwers wat 6.1% meer weeg as die verskalwers (157.0 ± 2.8 en 148.0 ± 2.7 kg respektiewelik). Daar was 'n 20.4% speengewig voordeel van die kalwers gebore in die droë seisoen, vergeleke met daardie gebore in die nat seisoen (166.6 ± 4.5 en 138.4 ± 1.9 kg respektiewelik), alhoewel die kalwers gebore in die droë seisoen effens ligter was. Daar was ook 'n betekenisvolle ($P<0.001$) jaareffek op speengewig met geen ooglopende tendens oor die jare. Dit kan wees a.g.v. die variasie in omgewingsfaktore (nie konstante reënval, totale reënval, hitte stres, sonstraling, seisoenale beskikbaarheid van voere, ens.). Geen betekenisvolle effek van pariteit/ouderdom van die koeie op speengewig is waargeneem nie, maar ouderdom met speen het speengewig definitief beinvloed. Hoe vroeër die kalwers gespeen is, hoe ligter was hul speengewigte – maar hoe hoër was hul 205 dae aangepaste speengewig. Die seisoen wanneer die kalwers gespeen is, het nie hul speengewig betekenisvol beinvloed nie, nieteenstaande die kaarblyklike voordeel van droë seisoen kalwers oor die reënseisoen kalwers. 'n Speen produktiwiteitsindeks is gebruik om die beste kalfseisoen vas te stel. Hierdie indeks het gewys dat koeie wat in die droë seisoen kalf, betekenisvol ($P<0.001$) hoër indekse gehad het as koeie wat in die reënseisoen kalf (113.1 ± 2.0 en 95.0 ± 1.5 kg respektiewelik). Hierdie indeks het ook verskil met geslag van die kalf (107.7 ± 1.6 en 100.4 ± 1.4 kg vir bul- en verskalwers respektiewelik) en die maand van geboorte. Hierdie resultate wys daarop dat die beste 3 maande vir kalwing tussen November en Januarie strek, met 'n ooreenstemmende dekseisoen tussen Februarie en April. Voorspeense gewigte (1, 3 en 6 maande ouderdom) was betekenisvol ($P<0.001$) beïnvloed deur maand, seisoen, jaar van geboorte en geslag van die kalf. Die geslag van die kalf, maand en jaar van geboorte en nie die seisoen nie, het die gemiddelde daaglikse toename in Ngaoundere Gudali kalwers betekenisvol beïnvloed. Die GDT was 1.1 ± 0.4, 0.8 ± 0.2 en 0.7 ± 0.1 kg/dag vir geboorte tot 1, 3 en 6 maande ouderdom respektiewelik. Bulkalwers het konstant vinniger gegroei as verskalwers by die 3 voorspeense stadia. Naspeense gewig en groeitempo was betekenisvol beïnvloed deur die geslag van die kalf vir die periode 9 tot 36 maande ouderdom, met bulkalwers wat 'n hoër groeitempo handhaaf. Alle kalwers het 'n negatiewe groeitempo ondervind tussen 8 en 9 maande ouderdom (speen het plaasgevind op 8 maande ± 2 weke) a.g.v. die stres van speen of a.g.v. die nuwe omgewing waarin die speenkalwers geplaas is. Seisoen van geboorte het nie meer die naspeense gewig en GDT vanaf 18 maande ouderdom beïnvloed nie. Die studie het gewys dat Ngaoundere Gudali verse liggaamsgewigte van 222 en 281 kg op 24 en 30 maande respektiewelik bereik, menende dat 'n vroeër ouderdom by dekking moontlik is.

Die gemiddelde lengte van die estrussiklus van die Ngaoundere Gudali koei was 21.8 ± 0.5 dae, met 'n verspreiding van 15 tot 35 dae. Meeste estrussiklusse (67.9%) het 'n lengte van 18 tot 22 dae getoon, terwyl 18.5% geduur het tussen 23 en 28 dae. Die estrussiklusse was betekenisvol ($P<0.05$) langer tydens die droë seisoen (24.1 ± 0.7 dae), vergeleke met die reënseisoen (20.6 ± 0.5 dae). Historiese data van die KI kudde dui daarop dat uit die 1504 dekkings uitgevoer by natuurlike estrus tydens 'n 9 jaar periode, slegs 28.9% van die estrus manifestasies waargeneem is tydens die droë seisoen (November tot Maart) en vroeë reënseisoen (April tot Mei), vergeleke met 71.1% vanaf Junie tot Oktober. Die seisoenale piek van estrus voorkoms was goed gekorreleerd met die seisoenale voorkoms van geboortes in die kuddes om voor te stel dat estrus manifestasie in die Ngaoundere Gudali koeie meer geredelik plaasgevind het tydens die reënseisoen. Die mees algemene teken van estrus was die aanvaarding van die vroulike dier in estrus om gedek te word deur 'n koggelbul of ander koei, vir 'n periode wat gemiddeld 9.8 ± 0.6 uur (5 tot 13 uur) geduur het. Dit is vermoed in die studie dat die korte duur en lang intervalle tussen observasies aan die begin en die einde van estrusperiodes nie waargeneem is nie. Dus is 'n korter lengte van estrus genoteer. Serum progesteroon konsentrasies was op hul laagste vlak (0.4 ng/ml) tussen dae 1 en 3 van die estrussiklus en het vanaf dag 5 toegeneem om piekvlakke (5.5 tot 6.5 ng/ml) te bereik tussen dae 15 en 19 van die siklus. Hierdie serum progesteroon konsentrasies het daarna vinnig gedaal om baie lae vlakke by estrus te bereik.

Baarmoeder involusie in Ngaoundere Goudali koeie was volledig 45 tot 60 dae na kalwing. Involusie was vroeër voltooi in 'n groter gedeelte van die koeie onder beperkte soogbestuur (RS), vergeleke met die onbeperkte soog (US) groep. 26.3% van die koeie in die RS groep en geen in die US groep was in estrus binne 75 dae postpartum. Tussen 75 en 90 dae postpartum was 84.2 en 15.8% van die respektiewe groepe in estrus geïdentifiseer en gedek. Die gemiddelde postpartum interval vanaf kalwing tot eerste estrus was betekenisvol (P<0.05) korter in die RS (83.4 ± 5.1 dae), vergeleke met die US groep (126.4 ± 5.1 dae). Die interkalwingsperiode was vasgestel as 397.9 ± 5.0 dae, betekenisvol (P<0.01) langer in koeie wat vrylik gesoog is (419.4 ± 6.5 dae) as in die RS groep (376.4 ± 3.2 dae). 'n Hoë korrelasie is gevind tussen die geslagskanaaltelling by 60 en 75 dae postpartum (r = 0.6) en die konsepsiesyfer van die koei.

Die gemiddelde speengewig was 114.8 ± 3.7 kg vir alle kalwers – nie betekenisvol verskillend tussen die twee soogbehandelings (115.1 vs 114.7 kg vir die US en RS groepe respektiewelik). Dit wys daarop dat beperkte soog geen betekenisvolle negatiewe effek op kalfgroei en speengewig het nie. Voorspeense groeitempo was betekenisvol hoër in die US as die RS groep. Kalwers in die US groep en gespeen op 8 maande was 5.4, 31.4 en 26.7 kg swaarder as die RS kalwers gespeen op 8 maande en die US en RS kalwers op 6 maande respektiewelik. Naspeense groeitempo tot 12 maande ouderdom was betekenisvol (P<0.01) verskillend vir die 2 speenbehandelings en is dit gevind dat vroeg gespeende kalwers vinniger gegroei (176 g/dag) het as daardie wat op 8 maande gespeen is (123.8 g/dag) – wat dui op kompensatoriese groei vanaf speen tot jaar ouderdom. Die vlak van serum IgG in pasgebore kalwers (± 72 uur na geboorte) in 35 Gudali kalwers was 7.8 ± 0.5 g/l (verspreiding van 0.04 tot 12.7 g/l) – baie laer as waardes aangegee in die literatuur, 24 tot 48 uur na geboorte. Waardes dui of op 'n lae konsentrasie IgG in die kolostrum van Ngaoundire Gudali koeie wat lei tot onvoldoende inname deur die kalwers, of tot 'n beperkte absorpsie van die ingeneemde kolostrum.

Oor die algemeen dra die studie by tot die karakterisasie van die mees belangrikste reproduktiewe en produktiewe parameters in die Ngaoundere Gudali koei. Die resultate gekry dui op lae reproduksie prestasies wat moontlik gekoppel is aan die seisoenale beskikbaarheid van voer, wat op sy beurt afhanklik is van die seisoenale en jaarlikse variasie in reënval. Sekere bestuurspraktyke met 'n potensiaal om reproduktiewe doeltreffendheid in die koeie te verhoog is geïdentifiseer (korter teelseisoen, beperkte soog, vroeë speen, ens.). 'n Verbetering in die reproduksie doeltreffendheid van die Ngaoundere Gudali koei sal bydra om die algehele produktiwiteit van die tradisionele beesproduksie sisteme in die Adamawa Hooglande van Kameroen, te verhoog.

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