SOME ENVIRONMENTAL AND PHYSIOLOGICAL FACTORS AFFECTING FERTILITY RATES IN ARTIFICIALLY INSEMINATED BUNAJI CATTLE HERDS

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DECLARATION

This is to certify that I carried out the work reported in this thesis in the Department of Veterinary Surgery and Medicine, Faculty of Veterinary Medicine and in National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Zaria under the supervision of Professors D. Ogwu and L. O. Eduvie.

The work of other investigators in the areas covered in this thesis is duly acknowledged and refered to appropriately. No part of this thesis has been submitted elsewhere for a degree or diploma.

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CERTIFICATION

This thesis by *Hassan Mohammed Mai* meets the regulations governing the award of Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to:

My family of descend, The "MAI" family

and

The "*Bos indicus*" cattle, the subject of this study.

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ABSTRACT OF THESIS

The objectives of this study were to determine the following:

i) The effect of ambient temperature, humidity and body temperature on fertility rates in Buanji cattle,

ii) The incidence of luteal phase inseminations in Bunaji cows,

iii) The efficiency and significance of some selected methods of estrus detection aids under field conditions.

A total of 524 artificial inseminations in 219 Bunaji cattle were carried out for 2 consecutive years to determine the influence of meteorological variables using the temperature-humidity index (THI) model on conception rate (CR). The effect of body temperature on CR was also evaluated by recording rectal and vaginal temperatures at insemination and approximately 12 hours after in 153 non-suckled Bunaji cows. The mean monthly CRs declined from March to May (37.9%, 26.0% and 19.4%, respectively) which were the hottest months with highest mean monthly THI of 7 5.3, 79.4 and 79.7 and highest mean monthly ambient temperature of 35.8°C, 36.1°C and 35.0°C. The CR appreciated thereafter with decreasing THI. Furthermore, mean monthly CR and mean monthly THI were significantly correlated r= -0.828 (P<0.001). Similarly, the individual daily THI a day following insemination was more closely correlated with CR (r= -0.862; P<0.001) than the other days observed.

In addition, elevation of rectal temperature (RT) approximately 12 hours post AI altered the CR significantly

($P<0.005$). The CR dropped sharply from 48.2% to 7.1% as RT increased from 37.1°C - 39.5°C to 39.6°C - 40.2°C. Thermal stress on spermatozoa, ova, process of fertilization, developing embryo and maternal endocrine system was implicated.

It was concluded that heat stress and elevation of body temperature may adversely affect the reproductive performance of Bunaji cattle particularly in artificially inseminated herds. Serum progesterone concentrations at insemination measured by Radioimmunoassay (RIA) technique revealed that out of the 122 inseminations conducted in 93 Bunaji cows, 16 (13.1%) were luteal phase inseminations (LPI). The post-service interval spanning 4-51 days were observed in relation to the LPI. The CR of the affected animals was very poor, although most of the cows conceived eventually. Management and **"phantom heats"** could contribute to the LPI.

Seventy-two (72) Bunaji cows were synchronized using double injection of prostaglandin F2 alpha ($PGF_{2\&}$ at 13 days interval. The efficiency of some estrus detection aids and ovarian activity were determined by RIA method from blood collected daily starting day of second $PGF_{2\&}$ injection until estrus was observed or continuously for 7 days for **"non-responders"**. At the time of the second injection of $PGF_{2\&}$ estrus detection aids namely. Tail painting, KaMar heat mount detectors and chin-ball mating device (CMD) were applied on the test cows. The efficiency of the detection aids was compared with visual observation of standing estrus and serum progesterone concentration (SPC).

Serum progesterone (P_4) levels recorded 73.6% estrus response rate (ERR) while visual observation registered 61.1%. In relation to the total number of estrus periods observed, unaided visual observation, tail painting, KaMar heat mount detector and CMD respectively recorded 52.2%, 82.6%, 82.6% and 76.8% detection rates accurately. Visual observation of standing estrus alone did not detect 47.8% of the estrus periods. Furthermore, 30.4%, 30.4% and 24.6% of the estrus shown by tail painting, KaMar detectors and CMD respectively, were not observed by visual observation. Twenty-eight (38.9%) cows showed atypical P_4 profile.

The possible reasons for the irregularities of the P_4, the significance and superiority of the heat detection aids, and the magnitude and factors responsible for the false positives and false negatives observed with the detection aids are further highlighted.

It was concluded that estrus detection aids improved the efficiency of estrus detection immensely and tail painting is the most suitable and appropriate aid that justified special emphasis for adoption.

The overall findings in this study indicate that environmental and physiological parameters are detrimental and can pose serious negative effect on the reproductive performance of artificially inseminated Bunaji cattle. Improvement on the management system and animal husbandry practices particularly during the critical period of the dry season is recommended so as to enhance their reproductive efficiency.

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ABBREVIATIONS

ABU	Ahmadu Bello University
AI	Artificial Insemination
AM	Ante meridien
AT	Ambient temperature
BCS	Body condition score
BT	Body temperature
BVD	Bovine viral diarrhoea
°C	Degree centigrade
CL	Corpus luteum
CMD	Chin-ball mating device
CR	Conception rate
DBT	Dry bulb temperature
DP	Dew point
DPC	Diagnostic Product Corporation
DRR	Delayed return rate
E	East
EEM	Early embryonic mortality
ELISA	Enzyme linked immunosorbent assay
ERR	Estrus response rate
°F	Degree Fahrenheit
FAO	Food and Agricultural Organisation
FN	False negative
FP	False positive
FSCR	First service conception rate

FSH	Follicle stimulating hormone
GMT	Greenwich meridian time
GnRH	Gonadotropin releasing hormone
h	hour
IAEA	International Atomic Energy Agency
IAR	Institute for Agricultural Research
IBEVC	Infectious bovine epididymitis and vaginitis complex
IBR	Infectious bovine rhinotracheitis
IFS	International Foundation for Science
ILCA	International Livestock Centre for Africa
IM	Intramuscular
Kg	Kilogram.
KHMD	KaMar heat mount detector
LEM	Late embryonic mortality
LH	Luteinizing hormone
LIBC	Livestock improvement and breeding centre
LPI	Luteal phase insemination
M	Meters
Mg	Miligram
MI	Michigan
Ml	Mililiters
MNT	Minimum ambient temperature
MXT	Maximum ambient temperature
N	North
NAPRI	National Animal Production Research Institute
ng	nanogram

NRR	Non-return rate
NSC	Number of services per conception
P_4	Progesterone
$PGF_{2\alpha}$	Prostaglandin F_2 alpha
PM	Post meridien
PR	Pregnancy rate
PRID	Progesterone-releasing-intravaginal-device
PSPB	Pregnant-specific protein B
r	Correlation coefficient
RBS	Repeat breeder syndrome
RH	Relative humidity
RIA	Radioimmunoassay
rpm	rounds per minute
RT	Rectal temperature
SD	Standard deviation
SI unit	Standard international unit
SPC	Serum progesterone concentration
$T_o(RT_o\&VT_o)$	Rectal and vaginal temperatures at insemination
$T_1(RT_1\&VT_1)$	Rectal and vaginal temperatures 12 hours after insemination
THI	Temperature-humidity index
TN	True negative
TP	True positive
UT	Uterine temperature
VT	Vaginal temperature
WBT	Wet bulb temperature

CHAPTER ONE

INTRODUCTION

Nigeria like all other developing countries of the world is faced with a serious problem of inadequate consumption of protein of animal origin. This problem has been exacerbated by the ever increasing human population without a commensurate increase in food production in general and livestock production in particular.

Cattle and their products which are widely accepted by the generality of the populace play a vital role in the economy and nutrition of Nigerians. However, the productivity and reproductive performance of indigenous tropical cattle is low (Pullan, 1979; Oyedipe *et al.* 1982b). The low productivity is reported as one of the several adaptive features helping to keep these animals in equilibrium with their stressful environment (Tizikara *et al.*, 1985).

The optimal reproductive rate in livestock production is that rate which gives maximal economic profit per breeding female per year, and in the case of cattle, maintaining a calf per cow per year (Pelissier, 1976).

Environmental parameters are known to influence the reproductive performance of livestock (Cavestany *et al.* 1985; Du Preez *et al.* 1994). Recognising the growing concerns about the environment, this study specifically considered the effects of some environmental and physiological factors on fertility rates of artificially inseminated Bunaji cattle.

Notable amongst the factors reported to affect fertility rate of artificially inseminated cattle are thermal stress (Stevenson *et al.*, 1983; Thatcher and Collier, 1986; Du Preez *et al.*, 1991, 1994), high humidity (Scott and Williams, 1962; Gwazdauskas *et al.*, 1973), rainfall (Gwazdauskas *et al.*, 1975; Badinga *et al.*, 1985), photo-period (Peters *et al.* 1980); efficiency of heat detection methods (Williamson *et al.*, 1972a,b; Zakari, 1981; Broadbent *et al.* 1989) and timing of insemination (Fields *et al.*, 1975; Dawuda *et al.* 1987; Voh,Jr. *et al.* 1994b).

In the tropics, prominent thermal effects on fertility are prolonged (Scott and Williams, 1962; Vincent, 1972; Zakari, 1981) and irregular (Rakha and Igboeli, 1971) estrous cycles, reduced signs of estrus (Wolff and Monty, 1974; Thatcher and Collier, 1986), shortened estrus period (Monty and Wolff, 1974; Cavestany *et al.*, 1985), delayed resumption of ovarian activity (Bond and McDowell, 1972; Montgometry *et al.*, 1985), and reduced conception rates and increased embryonic mortality (Ulberg and Burfening, 1967; Fuquay, 1981; Wolfenson *et al.*, 1988). The proportion of cows in which embryonic mortality occurs is believed to be higher in the tropics than it is in the temperate zones (Scott and Williams, 1962).

High environmental temperature is associated with elevated body temperature and reduced conception rate. Zakari (1981) in a study of Zebu cattle reported a reduction in conception rates from 52% at rectal temperature of 38.2°C - 39.1°C to 12% when rectal temperature increased to 39.2°C - 40.0°C. Similarly, Ulberg and

Burfening (1967) observed a decline in pregnancy rates from 61% to 45% as rectal temperature increased by 1°C 12 hours post Artificial Insemination (A.I.). These are in close agreement with findings elsewhere (Badinga *et al.*, 1985; Cavestany *et al.*, 1985; Thatcher and Collier, 1986; Geisert *et al.*, 1988).

The poor fertility rates may be due to the effect of heat stress directly on the ova or spermatozoa (Burfening and Ulberg, 1968) resulting in low fertilization rate (Scott and William, 1962), or on the developing embryo (Alliston and Ulberg, 1961; Alliston *et al.*, 1965), or through maternal endocrine imbalance (Knutson and Allrich, 1988).

It is obvious that for a successful A.I. programme with subsequent high pregnancy rates, accurate estrus detection and correct timing of inseminations are important (Watson and MacDonald, 1984; Voh,Jr. *et al.* 1994b). However, the duration, manifestation and detection of estrus in tropical Zebu cattle particularly during adverse environmental conditions of the dry season make this difficult (Zakari, 1981; Galina *et al.* 1982, Garcia, 1988). In addition, some farmers are unaware that their animals are expressing estrous cycles and it may not be possible to keep a 24-hour surveillance for visual observation of standing heat with the animals. Williamson *et al.* (1972a) and King *et al.* (1976) reported that in properly fed and apparently healthy cows, difficulties in estrus detection may be due to dificiences in herdsmen and management system rather than problems with the cows. About 20% of cows are presented for A.I. when they are not actually in estrus (Appleyard and Cook, 1976; Hoffman *et al.* 1976; King *et al.* 1976). This may result in luteal phase inseminations (Hoffman *et al.* 1976). Similarly, 40-50% of cows in estrus may not be detected by the observer (Esslemont *et al.*, 1985), while 90% of "anestrus" cases is due to failure to observe estrus (Bozworth *et al.*, 1972). Thus, incorrect identification of estrus and failure to detect estrus may contribute to poor reproductive performance in artificially inseminated cattle.

It therefore, becomes necessary to educate and train farmers/herdsmen on estrus detection since there is no substitute for the eye of the skilled observer. More studies need to be conducted in the area of reproductive physiology of indigenous Zebu cattle with particular reference to sexual behaviours. Furthermore, devices that ensure 24-h surveillance such as the heat detection aids should be employed in order to minimize failures and errors in estrus detection, thereby improving the efficiency of reproductive performance of cattle particularly in A.I. herds.

In Nigeria, there is paucity of information on the effect of environmental factors particularly the temperature-humidity index (THI) model, effect of body temperature, incidence of erroneous insemination and efficiency of estrus detection aids on fertility of artificially inseminated Bunaji cattle. It is in view of this that the current study was proposed, the specific objectives of which are to determine:

1. The effect of ambient temperature, humidity and body temperature on fertility rates.
2. The incidence of luteal phase inseminations.
3. The efficiency of some selected methods of estrus detection namely: visual observation for standing estrus, tail painting, KaMar heat mount detectors and vasectomized bull harnessed with a chin-ball mating device.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 REPRODUCTIVE PERFORMANCE AND REPRODUCTIVE PATTERNS IN NIGERIAN CATTLE

2.1.1 REPRODUCTIVE PERFORMANCE

Several parameters have been employed in assessing the reproductive performance of Nigerian cattle. These include: Age at puberty (Oyedipe *et al.*, 1982a,b), age at first calving (Voh,Jr. and Otchere, 1989), calving to first ovulation (Eduvie *et al.*, 1993), calving interval (Zemjanis, 1974; Pullan, 1979; Eduvie and Dawuda, 1986; Voh,Jr. and Otchere, 1989), annual calf crop (Johnson, 1974; Nuru, 1974), pregnancy and calving rates (Zakari, 1981; Pathiraja *et al.*, 1986), first service conception rate (Voh,Jr. *et al.* 1987a), conception rates (Dawuda *et al.*, 1987; Eduvie *et al.*, 1993), interval from calving to conception (Eduvie and Dawuda, 1986), generation interval (Wheat and Broadhurst, 1968); pregnancy index (Akpokodje and Bolarinwa, 1974), non-return rate (Voh,Jr. *et al.*, 1994a), and estrus activity and cyclicity (Zakari, 1981).

Zemjanis (1974) observed the reproductive performance as a single most important factor determining the production efficiency of individual animals as well as entire single herd and the entire livestock industry of a country. It has been reported that the reproductive performance of indigenous Nigerian cattle is low (Lamorde and Weinman, 1972; Akpokodje and Bolarinwa, 1974; Osori, 1976; Oyedipe *et al.*, 1982b). Specifically, Pullan (1979) and

Voh, Jr. and Otchere (1989) demonstrated low reproductive efficiency in Bunaji cattle.

2.1.1.1 Age at Puberty

Is the occurrence of first estrus accompanied by spantaneous ovulation (Jainudeen and Hafez, 1987). Roberts (1971) refered to age at puberty as the age at which the reproductive organs become functional and reproduction may therefore occur. In a study of *Bos indicus* heifers in Australia, Post and Reich (1980) defined puberty as the age at which plasma progesterone levels reach 1.0 ng/ml.

In the bull, puberty is regarded as the presence of spermatozoa in the ejaculate and the ability of the bull to mate and ejaculate 50×10^6 spermatozoa with a minimum of 10% progressive motility (Almquist and Amman, 1976; Lunstra *et al.*, 1978).

The age at puberty is influenced by environmental conditions (Topps, 1977), age and breed of dam (Wiltbank, 1978; Kanuya *et al.* 1993), breed of sire (Hafez, 1987) and body weight as affected by nutrition (Table 3) and other management factors (Oyedipe *et al.*, 1982a; Eduvie *et al.* 1993; Osei *et al.*, 1993).

The time of onset of puberty appears to be a function of body weight than of age (Boyd, 1977; Topps, 1977; McDonald, 1980; Kanuya *et al.* 1993). Under good management conditions, a Bos taurus heifer establishes a regular, cyclical ovarian activity between 7 and 18 months of age and is largely dependent upon the heifer reaching a weight threshhold of 50% and 35% of mature body weight in beef and dairy breeds respectively (Noakes, 1986). In contrast, the Zebu cattle reached upto 60% of adult body weight or even higher at puberty (Mukasa-Mugerwa, 1989).

The local Fulani cattle attained puberty at approximately 36 months of age, 22.3 months in Government farms and 7-8 months in Shika research farm (Lamorde and Weinman, 1972). Knudson and Sohael (1970) observed a longer period of 40.2 months in White Fulani cattle in Vom (Table 1). The results obtained in Shika farm agree with the findings by Noakes (1986). Early attainment of puberty in Shika institutional farm may be as a result of the management system practiced (Oyedipe *et al.*, 1982b). Mukasa-Mugerwa (1989) stated that indigenous heifers attain puberty and breed fairly satisfactorily at one year old. Estimates of age at puberty in *Bos indicus* cattle in the tropics and sub-tropics range between 18-40 months (Table 1).

On the average, Zebu heifers attain puberty 6-12 months later than the temperate breeds (Reynolds *et al.*, 1963; Wiltbank *et al.*, 1969). Mukasa-Mugerwa (1989) reached similar conclusions that puberty in *Bos indicus* heifers occur later than *Bos indicus* and *Bos taurus* cross breds. This observation is in consonance with reports in bulls by Oyedipe *et al.* (1981) who showed that Friesian x Bunaji cross bulls were relatively younger at puberty (15.6±2.7 months) than the pure indigenous Nigerian Bunaji (16.7±0.3 months) and Bokoloji (18.4±0.6 months) bulls.

Delayed puberty could cause serious economic set back to cattle production (Wiltbank, 1978). Early puberty in heifers and bulls which is necessary to increase the efficiency of animal production by enhancing early conception, reducing interval between generations thereby improving their reproductive performance can be achieved by improving the plain of nutrition (Oyedipe *et al.*, 1982a) and the use of exogenous hormones (Komomae *et al.* 1990).

Table 1: Some estimates of age at puberty among *Bos indicus* in the tropics and sub-tropics

Breed	Locations	Estimates (months)	References
Africander	Louisiana(USA)	18.1	Reynolds *et al.* (1963)
Mashona	Central Africa	19	Rakha *et al.* (1970)
Sokoto Gudali	Nigeria	19.0-23.5	Oyedipe et *al.* (1982a)
Brahman	Florida(USA)	19.4	Plasse *et al.* (1968)
Angoni	Central Africa	20	Rakha *et al.* (1970)
Africander	Central Africa	20	Rakha *et al.* (1970)
Brahman	Louisiana(USA)	27.2	Reynolds *et al.* (1963)
Red Sindhi	India	36.7	McDowell *et al.* (1976)
White Fulani	Nigeria	40.2	Knudson & Sohael(1970)

Source: Mukasa-Mugerwa (1989).

2.1.1.2 Age at First Calving

This is the age at which the heifer delivers her first calf. It is influenced by management system and selection (Mukasa-Mugerwa, 1989; Osei *et al.* 1993), nutrition (El-Khidir *et al.* 1979; Oyedipe *et al.* 1982a) and season (Sharma, 1983). However, Oyedipe *et al.* (1982b) reported that season and year of birth had no significant effect on age at first calving.

Wheat and Broadhurst (1968) reported that Bunaji cattle maintained at certain breeding centres in Northern Nigeria averaged 42 months of age at first calving with a range between 33-47 months. This agrees with findings in other Bunaji breeds in Southern Nigeria (Akpokodje and Bolarinwa 1974), in Shika, Northern Nigeria (Oyedipe *et al.* 1982b) and agro-pastoral setting in Northern Nigeria (Voh,Jr. and Otchere 1989). Similar ages at first calving have been reported in a mixed Friesian/Zebu herd in Vom (Knudson and Sohael, 1970) and in mixture of Ndama/West Africa shorthorn and Sanga breeds in Ghana (Osei *et al.* 1993).

Normadic Fulani cattle had their first calf late (Lamorde and Weinman, 1971; Zemjamis, 1974; Nuru and Dennis, 1976; Pullan, 1979). Lamorde and Weinman (1971) further reported age at first calving as late as 84 months in normadic cattle herds while Pullan (1979) observed the age to be 60 months in the same setting (Table 2).

However, Roberts (1971) showed that the temperate breeds of cattle had their first calf earlier, averaging 30 months. Mukasa-Mugerwa (1989) reported 34 months as the average age at first calving in *Bos indicus* x *Bos taurus* crosses in the tropics. For optimal production, a heifer should calf 26-28 months of age (Table 2) (Zemjanis, 1974).

Table 2: Reproductive performance of indigenous cattle in Nigeria

Parameter	Normadic cattle	LIBC* Govt. herds	Optimum performance
Age at first calving	60 months	40 months	26-28 months
Calving interval	17-24 months	16-18 months	13 months
Annual calf crop	40%	60%	85-90%
Calves produced in life-time	$2\frac{1}{2}$	4	8

* Livestock Improvement and Breeding Centre.

Source: Zemjanis (1974).

2.1.1.3 Calving to First Ovulation

The period between calving and resumption of ovarian activity. Parturition is usually followed by a period of ovarian inactivity and sexual queiescence before reproductive cycles recommence.

Farms that were well managed in terms of feeding and disease control had shortest interval from calving to ovulation (Eduvie *et al.*, 1993). Reports on Nigerian cattle indicate that animals calving during the dry season have shorter calving to first ovulation interval than those calving during the wet season (Oyedipe *et al.*, 1982b; Eduvie, 1985b; Dawuda *et al.* 1988). Kassa and Tegegne (1993) reported genotype and body condition score (BCS) affecting this interval in Zebu and Friesian Zebu cross bred cows in Ethiopia. In indigenous Nigerian cattle, mean interval from calving to first follicle was longer for Bokoloji cows than Bunaji cows but the Bokoloji cows ovulated earlier (42.72 days) than the

Bunaji cows (65.85 days) (Eduvie, 1985b). Suggesting effect of breed on the interval from calving to first ovulation.

Suckling is known to interfere with initiation of ovarian activities and thus conception (Eduvie, 1985b; Wettemann *et al.* 1986; Silveira *et al.* 1993). Dawuda *et al.* (1988) reported the first ovulation post calving occurring earlier in cows that had more than two calvings or were over 6 years old (119.5±2.1 days) than those with 1 to 2 calvings or that were 4-6 years old (131.5±7.5 days). Similar observations were reacched by Eduvie (1985b). However, Kassa and Tegegne (1993) reported that parity does not affect this interval.

Calving-to-progesterone rise and/or first ovulation was reported to be 3.7±1.4 months in indigenous beef cattle raised on-farm in Ghana (Osei *et al.*, 1993), 3.4±1.6 months in Tanzanian Mpwapwa breeds (Kanuya *et al.*, 1993) and 3.4±0.9 months in indigenous Zebu and Friesian x Zebu crossbred cows under smallholder management conditions in Ethiopia (Kassa and Tegegne, 1993).

2.1.1.4 **Calving Interval**

This is the time between two successive calvings. It is probably the best index of a cattle herds reproductive efficiency. Calving interval is composed of gestation and "days open" periods. The days open is further subdivided into postpartum anestrus (from calving to first estrus) and service period (first postpartum estrus to conception).

To maintain a calf per cow per year, the "days open" as observed by Peters (1984) shouldn't exceed 85 days. Similar observation was made by Voh,Jr. *et al.* (1987b) in indigenous Nigerian cattle. Determinants that may affect the calving interval include: Season (Oliveira, 1974; Oyedipe *et al.* 1982b; Osei *et al.*, 1993), nutrition (Wheat, 1972; Wheat and Broadhurst, 1972; Pullan, 1979), breed (Oyedipe *et al.*, 1980), age or parity (Oyedipe *et al.* 1982b; Wilson, 1985), suckling effect (Eduvie and Dawuda, 1986) and sex of calf (Plasse *et al.*, 1968).

The mean calving interval of animals calving in the wet season was approximately 82 days longer than that of animals calving in the dry season (Oyedipe *et al.* 1982b). This may be as a result of the availability of crop residue during the dry season (Voh,Jr. and Otchere, 1989).

In Nigeria, calving interval was found to be shorter in well managed Government farms (Wheat and Broadhurst, 1968; Zemjanis, 1974; Pullan, 1979). Interval as short as 12 months was reported in Vom Government farm (Pullan, 1979), 12.73 months in some Government farms in Northern Nigeria (Wheat and Broadhurst, 1968), 14.81 months in Shika farms (Oyedipe *et al.* 1982b) and 15.16 months in Bunaji cattle raised in Southern Nigeria (Akpokodje and Bolarinwa, 1974). Similarly, calving intervals as high as 24 months or more were demonstrated in other herds in Northern Nigeria (Nuru, 1974; Voh,Jr. and Otchere, 1989). The interval was longer in normadic herds compared to Government farms (Pullan, 1979).

The overall calving intervals were 11.87 - 20.75 months and 10.9 - 15.73 months for Bunaji and Friesian x Bunaji crosses in Shika respectively (Oyedipe *et al.* 1980). Furthermore, Eduvie and Dawuda (1986) observed the calving interval for suckled and non-suckled cows as 17.08 and 11.75 months respectively. These confirmed the effects of both breed and suckling on calving interval.

The calving interval following the first parity was longer than the calving intervals during the second to fourth parities. It may increase from the fifth parity (Oyedipe *et al.* 1982b). Similar observations were made in tropical breeds elsewhere (Wilson, 1985; Mukasa-Mugerwa, 1989).

Dams having male calves were reported to have longer calving intervals than those with female calves (Plasse *et al.*, 1968).

2.1.1.5 **Annual Calf Crop**

This is defined as the number of calves produced during the year by cows and heifers of reproductive age expressed as a percentage.

In indigenous herds, Lamorde and Weinman (1972) observed the annual calf crop ranging between 27% and 55%. Similar trend was reported by Nuru (1974). Higher values of 60% in well managed cattle herds in Northern Nigeria and 62.1% in Bunaji herd at Shika research farm were reported by Wheat and Broadhurst (1968) and Johnson (1974) respectively.

Nuru and Dennis (1976) further demonstrated percentage calf crop as highest in Government farms (67%) compared to local Fulani herds (34.2-54.5%).

Akpokodje and Bolarinwa (1974) who defined calf crop as the number of calves produced by each animal reported the average calf crop in Bunaji cattle in Southern Nigeria to be 3.6 calves per cow with a range of 0 to 13 calves. Voh,Jr. and Otchere (1989) observed a lower figure of 2.7 in Agro-pastoral setting in Northern Nigeria. This agrees with result obtained in Zebu cattle in Central Mali (Wilson, 1985). Zemjanis (1974) reported at least 6 to 8 calves per lifetime for optimum performance.

2.1.1.6 Pregnancy and Calving Rates

Pregnancy rate is the number of animals pregnant divided by the number of animals examined or bred or intended to be bred and expressed as a percentage.

The commonest estimate of fertility rate is the percentage of mated or inseminated cows that became pregnant (pregnancy rate) or finally calved (calving rate).

Fertility rates of Zebu cattle are generally low (Rennie *et al*., 1976; Hardin *et al*., 1980; Voh,Jr. *et al*., 1987a), particularly those animals raised under poor management setting (Eduvie *et al*. 1993).

Nuru and Dennis (1976) reported calving rates of 34-55% and 67% in Nigerian cattle raised traditionally and in ranches or government farms respectively. This tended to agree with reports by Voh,Jr. and Otchere (1989) in indigenous Nigerian cattle, and in Zebu cattle in Botswana (Rennie *et al*. 1976) and Ethiopia (Kassa and Tegegne, 1993).

Pregnancy rate in Nigerian Zebu cattle increases with adequate nutrition (Oyedipe *et al*. 1982a; Voh,Jr. *et al*. 1984a; Pathiraja *et al*. 1986). In a study of other tropical breeds, Ward and Taffin (1975) and Buck and Light (1982) supported these findings. Similarly, season (Zakari, 1981; Voh,Jr. *et al*., 1984a) and suckling (Eduvie and Dawuda, 1986) were found to influence pregnancy rates.

2.1.1.7 First Service Conception Rate and Number of Services per Conception

First service conception rate (FSCR) is the number of females that got pregnant after the first service per number of females detected in estrus and bred.

Number of services per conception (NSC) on the other hand indicate the number of inseminations carried out per number of pregnant animals.

In a study of estrus synchronization in indigenous Nigerian cattle, Voh,Jr. *et al*. (1987a) observed FSCR of 46.7% in natural estrus and A.I, and 50.0% in induced estrus and A.I. Similarly, Voh,Jr. (1990) reported pregnancy rates to first service ranging from 40 to 60% for inseminations at spontaneous heat and 25 to 60% for inseminations at synchronized heat.

Pathological conditions such as endometritis in the cow will require significantly more services per conception (2.0 vs 1.6) and lower conception to first service rate (49 vs 62%) (Tennant and Peddicord, 1968).

Number of services per conception will depend largely on the breeding system used, is high in uncontrolled natural breeding and low where hand-mating or A.I is practiced. In an evaluation of fertility to A.I relative to service period in Zebu cattle, Zakari (1981) observed 1.88 NSC. Likewise, Dawuda (1988) reported 1.53 NSC while determining optimum time for A.I. The NSC were 1.0 and 1.1 respectively for Ndama and Sanga breeds raised on-farm in Ghana (Osei *et al.* 1993). In addition, a small herd of Friesian cattle in Ghana recorded NSC ranging from 1-13 with a mean of 3.4 (Kabuga and Alhassan, 1981). Mukasa-Mugerwa (1989) reported that NSC more than 2 is considered poor.

Osman (1972) reported more services per conception in Sudanese indigenous cattle during the rainy season while Tegegne *et al.*(1981) made a contrary observation. Wiltbank and Cook (1958) showed that a larger proportion of milked cows conceived to first service (71% with 1.54 NSC compared to 57% for the nursed cows with 1.84 NSC). Basu *et al.* (1979) observed that NSC increased with increased age at first calving in Indian dairy breeds.

2.1.1.8 Conception Rates (CR)

The total number of females pregnant per the total number of inseminations carried out and expressed as a percentage.

Effect of season, estrus behaviour, time of estrus detection and A.I, presence of mucus at insemination and site of semen deposition on CR were studied (Gwazdauskas *et al.* 1981; Stevenson *et al.* 1983; Dawuda *et al.* 1987; Voh,Jr. *et al.* 1987a).

Dawuda *et al.* (1987) in indigenous Nigerian cattle further reported CR of 67.8% in the rainy season and 58.5% during the dry season. Buck and Light (1982) demonstrated poorest reconception rate with lowest rainfall in Botswanan Zebu cattle. However, these are not in agreement with findings by Wilson (1946), Steinbach and Balogun (1971) and Voh,Jr. and Otchere (1989) who reported high conception rates in hot dry season.

Eduvie *et al.* (1993) recorded zero conception among poorly managed farms and high conceptions upto 100% were obtained in well managed herds in Guinea savanna zone of Nigeria. The overall CR in a herd of postpartum Bunaji cows studied at Shika was found to be 48.8% (Eduvie and Dawuda, 1986). Similarly, Voh,Jr. *et al.* (1987a) recorded 50% CR in a preliminary fertility trial at Shika. Dawuda *et al.* (1987) reported a CR of upto 70% when cows were inseminated 12 hours after onset of estrus.

In other breeds of cattle elsewhere, Hardin *et al.* (1980) reported CR lower than 30% in subtropical commercial *Bos taurus* x *Bos indicus* beef cattle in United States. While Trail *et al.* (1971) in well managed Zebu cows in Uganda and spalding *et al.* (1975) in dairy improvement Friesian herds in U.S.A. reported CR of 79% and 89% respectively.

2.1.1.9 <u>Interval from Calving to Conception</u>

This is the interval between parturition and when the dam is confirmed to have conceived. The period is influenced by season and nutrition (Oyedipe *et al.* 1982b), general management (Eduvie *et al.* 1993), genotype (Kassa and Tegegne, 1993) and suckling effect (Eduvie and Dawuda, 1986). However, there was no significant influence of season of calving observed by Kassa and Tegegne (1993) on the interval to conception in Ethiopian cattle.

Mean intervals from calving to conception as reported in Shika research farm were 7.75 months and 2.42 months for the suckled and non-suckled cows respectively (Eduvie and Dawuda, 1986). The overall mean interval for all the cows in the same study was 4.89 months.

Interval of 5.2±2.8 months was obtained in Tanzanian Mpwapwa cattle (Kanuya *et al.*, 1993) while longer period lasting 5.7±2.2 months was reported by Kassa and Tegegne (1993).

2.1.1.10 Generation Interval

This is the average age of the parents. It is determined by the age at first calving and calving interval. The period is known to affect the rate of genetic improvement.

For Bunaji at Birnin Kudu, Kabomo and Shika, generation intervals were averagely 72, 75 and 72 months respectively (Wheat and Broadhurst, 1968; Wheat *et al.* 1972). Similarly, generation interval of 71.9 months for Sokoto gudali was reported by Wheat and Broadhurst (1972) at Bulassa.

2.1.1.11 Pregnancy Index

Pregnancy index is defined as the average number of days cows become pregnant per year. It has been reported to be 143.4 days in Bunaji cattle kept in Southern environment (Akpokodje and Bolarinwa, 1974).

2.1.1.12 Non-Return Rate (NRR)

Non-return rate is the percentage of animals which after first insemination did not "return to heat" in a time lapse of 30-60 days or 60-90 days (FAO/IAEA, 1985). Furthermore, McDowell *et al.*

(1976) reported that the value of NRR may be derived at 60, 90, 120, 145 or 200 days post mating.

The 60-90 days NRR was about 5-8% lower than the 30-60 days. Good 60-90 days NRR vary between 64% and 72%, however, the number of cattle which eventually calved was about 55% (FAO/IAEA, 1985).

Voh,Jr. *et al.* (1994a) employed the delayed return rate (DRR) method in determining the late embryonic mortality (LEM) rates in indigenous Bunaji cows. Similarly, Kummerfeld *et al.* (1978) studied the incidence of embryonic mortality in dairy cows by a decline in NRR. It is therefore an ideal parameter for estimating the magnitude of embryonic mortality.

2.1.2 REPRODUCTIVE PATTERNS IN NIGERIAN CATTLE

Seasonality of reproductive activity has been reported in Nigerian cattle (Osori, 1976; Zakari, 1981; Voh,Jr. and Otchere, 1989), since plane of nutrition in terms of quality and quantity of pasture in the tropics is determined by the seasonal patterns of rainfall (Topps, 1977; Zakari, 1981) and soil fertility (Wilson, 1946). Seasonal variations in climatological parameters probably contribute to seasonal changes in reproductive efficiency in cattle.

Season is found to exact inlfuence on both the bull and the heifer/cow. Though Kumi-Diaka *et al.* (1981) did not find significant variations in semen characteristics in indigenous bulls, only exotic bulls showed significant seasonal fluctuations. However, Rekwot *et al.* (1987) observed significant effects of season on ejaculate characteristics of indigenous A.I bulls in

Shika. The authors concluded that ejaculate volume, sperm concentration, total sperm count and percentage live-sperm were significantly higher in the rainy season than dry season. Similarly, Sekoni *et al.* (1988) revealed a higher percentage dead sperms in the dry season. It can therefore be deduced that fertility of the bull may be better in the rainy season, hence semen collection and preservation should be recommended during this favourable season.

In indigenous Nigerian heifer/cow, most calvings occur in the early rainy season (Lamorde and Weinman, 1972; Lamorde and Franti, 1973; Osori, 1976). Butterworth (1983) and Osei *et al.* (1993) made similar conclusions in other tropical breeds in Swaziland and Ghana respectively.

However, calving seasons were recorded December to March (dry season) in Northern Nigeria (Voh,Jr. and Otchere, 1989), June to September i.e. dry season in Nyasaland, Tanzania (Wilson, 1946) and April to June, dry to early rainy season in Central Mali (Wilson, 1985).

Observations were made by Osori (1976), Zakari (1981) and Voh,Jr. (1984b) that indigenous cows in Northern Nigeria are seasonal breeders with optimal reproductive efficiency obtained during the rainy and pre-dry seasons when feed is abundant. Voh,Jr. *et al.* (1987b) proposed a breeding plan for Northern Nigeria as follows: start breeding in mid-August to end of September (45 days). Calving will therefore occur mid May to end of June (45 days). This package ensures a calf per cow per year.

The justification for the programme is that during the rainy season, cattle are in good body condition score (BCS), with more developed corpus luteum (CL), longer duration of estrus and more overt estrus signs, thus good fertility rates obtained during A.I. In addition, the calving period coincides with the arrival of the rains so that there will be enough good quality pasture for the survivability of both the dam and her calf.

Similarly, calves born during the wet season were heavier (Johnson and Gambo, 1975), reached puberty and bred earlier (Hauser, 1984; Kanuya *et al.* 1993; Osei *et al.* 1993) than those born in the dry season. Ovarian volume was also larger in wet season-born heifers than dry season-born heifers (Hauser, 1984).

Oyedipe *et al.* (1982b), Eduvie (1985b) and Dawuda *et al* (1988) reported longer calving interval in the rainy season calving. Suggesting that calving in the rainy season, the onset of conception is in the dry season, when condition is unfavourable since they will experience nutritional crisis at postpartum estrus resulting in longer calving interval. This is consistent with the findings by Oliveira (1974) in Brazil and Osei *et al.* (1993) in Ghana. The early ovulation and short calving interval during the dry season calving could be due to changes in temperature or photoperiod since the cows calved in the dry season when nutrition is poor and yet ovulated earlier with shorter calving interval than those calving during the rainy season (Oyedipe *et al.* 1982b; Eduvie, 1985b). Effect of photoperiod on fertility of Keteku cattle breeds in Southern Nigeria was reported by Steinbach and

Balogun (1971).

Conception rate was observed to be higher in the rainy season than the dry season (Wilson, 1985; Dawuda *et al.*, 1987). However, Steinbach and Balogun (1971) demonstrated the CR increasing throughout the dry season and declines before the end of the wet season. They argued that the pasture declines in quality during the latter part of the rainy season. In addition, the negative correlation between annual rainfall and CR may be due to increased disease incidence by internal and external parasites and the possibility that wet years favour the growth of woody bushes at the expense of grass, thus reducing the forage quality (Steinbach and Balogun, 1971).

Several studies showing decreased reproductive performance in the rainy season (summer) with increased ambient temperatures and relative humidities have been reported in the tropical and subtropical climates (Vincent, 1972; Monty and Wolff, 1974; Wolff and Monty, 1974; Thatcher and Collier, 1986; Wolfenson *et al.* 1988). However, Zakari (1981) observed in indigenous breeds, pregnancy rates of inseminated cows highest in the rainy season upto 57%, followed by pre-dry, 28%, dry 21% and the lowest of 18% was recorded during the pre-rainy season. Likewise, Voh,Jr. *et al.* (1984a) noted pregnancy rate of cows inseminated in the rainy season as 56.0%, significantly higher than the pregnancy rate of cattle inseminated in the dry season (32.2%). They attributed the effect on nutrition rather than atmospheric temperature and humidity.

In a study of seasonal effect on estrus and estrous cycle, Zakari (1981) stated that estrus activity was more pronounced and overt in the rainy season (43%) than during the dry (19%), pre-rainy (12%) and pre-dry (25%) seasons. This is in consonance with observations by Rakha and Igboeli (1971) in Zambia, Purbey and Sane (1978) in Indian Dangi cows, Jaster *et al* (1982) in Illinois dairy herd and Voh,Jr. (1984b) in Nigerian Zebu cattle. The duration of the estrous cycle lengthened in the dry season with fewer number of cycles recorded (Zakari, 1981, Voh,Jr. 1984b).

Voh,Jr. *et al.* (1987c) who studied estrus responses in indigenous Nigerian Zebu cows after PGF2& treatment observed that the proportion of cows responding to PGF2& is higher in the rainy season (90%) than the dry season (70%). And the duration of estrus was found to be longer in the rainy (19.2h) than the dry seasons (12.6h). Since the duration and intensity of estrus are affected by season, it is recommended that cows should be bred in the rainy season rather than dry season in order to achieve maximum fertility.

2.2 FACTORS AFFECTING REPRODUCTIVE PERFORMANCE IN CATTLE

2.2.1 THE NOTABLE FACTORS:

Reproductive performance in cattle is affected notably by age, genetic, environmental, disease and nutrition, and other management factors. These variables influence the attainment of puberty and reproductive processes such as ovulation, fertilization, implantation, maintenance of pregnancy and parturition.

2.2.1.1 Age

Puberty is important in achieving optimum reproductive performance in cows (Oyedipe *et al.*, 1982a). Extreme delay in attainment of puberty will have a detrimental effect on breeding efficiency. Arije and Wiltbank (1971) reported that heifers growing faster are likely to attain puberty younger and heavier. Such heifers would have increased lifetime productivity. Meaker *et al.* (1980) concluded that Africander heifers calving first at 2 years produced 0.6 more calves over their productive lifetime than those calving first at 3 years old. Oyedipe *et al.* (1982a) observed the effect of nutrition on onset of puberty in indigenous Nigerian Zebu heifers.

Buck *et al.* (1976) showed that fertility rate increased from 69% in 2.5 year old cows to a maximum of 82% in 6-7 year old cows before declining. Similarly, Kabuga and Alhassan (1981) reported that reproductive performance declines as from 4th lactation in Ghana. Voh,Jr. and Otchere (1989) demonstrated important age of reproduction in indigenous cattle in Northern Nigeria between 4 and 10 years. In most female mammals reproductive capacity rises to a maximum in early maturity and then gradually declines.

The length of calving interval is also influenced by age. de Vaccaro *et al.* (1977) stated that second and third calving intervals were shorter than the first. Oyedipe *et al.* (1982a) observed the same. Similarly, cows which had more than 2 calvings or above 5 years old ovulated earlier postpartum than those with one or two calvings or 3.5 years old (Eduvie, 1985b; Dawuda *et al.*, 1988). It can therefore be deduced that heifers should attain puberty early and breeding programme concentrated at the intermediate ages (productive lifetime) in order to achieve maximum fertility.

2.2.1.2 Genetic

The genetic potential of indigenous cattle is generally low, hence the low productivity of *Bos indicus* breeds in the tropics (Mahadevan and Hitchison, 1964). Mukasa-Mugerwa (1989) suggested that to increase the productivity of the indigenous cattle, they should be crossbred with temperate *Bos taurus* breeds such as Friesian and Hereford. The Hybrid viguour obtained from the crossing may improve those traits of low heritability, such as reproductive performance (Mason, 1966). Similarly, Mahadevan and Hitchison (1964) reported that gene combinations found in 50% crosses between *Bos taurus* and *Bos indicus* were the most productive in Tanzania, and increasing percentages of *Bos taurus* blood caused a decline in the reproductive efficiency of the animals. Similar observations were made in Friesian-Bunaji crosses by Armour *et al.* (1961) and Knudson and Sohael (1970).

In a study of bulls, Rekwot *et al.* (1988) showed that Friesian-Bunaji bulls were heavier with larger scrotal circumference and better semen characteristics than the indigenous Bunaji bulls. In addition, crosses require few services per conception than the Zebus (Tegegne *et al.*, 1981). Therefore, crossing Friesian with indigenous breed through A.I should be encouraged so as to achieve genetic improvement of local livestock.

However, crosses should not exceed 50% *Bos taurus* blood.

The heritability and repeatability estimates for fertility are very low in dairy cattle as in beef, hence selection to improve traits would not be too effective (Lasley, 1978; Bastidas and Verde, 1981; Mukasa-Mugerwa, 1989). Therefore, greatest improvement within a herd would come from proper attention to factors such as nutrition, general management and disease control.

Genotype is known to have significant effect on fertility index (Thorpe and Cruickshank, 1980; Buck and Light, 1982). Similarly, Sengupta (1975) observed Hayana cows with blood groups AA having higher conception rate (67%) and calved earlier (41.2 months) than AB and BB cows with conception rates (47.5% and 51.5%) and age at first calving (44.5 and 44.7 months) respectively.

2.2.1.3 **Environmental Factors**

Since heritabilities of fertility rate in terms of ages at puberty, at first conception and at first calving are generally low (Mukasa-Mugerwa, 1989), it further suggests that these traits are highly influenced by environmental factors.

Some of the physical environmental factors include: maximum and minimum ambient temperatures, relative humidity, rainfall, atmospheric pressure, photoperiod, solar radiation or ultraviolet activity, wind movement, ionization, precipitation, soil fertility and feed supply. Of these, temperature, relative humidity, solar radiation, wind movement and precipitation are the most important climatic elements in livestock production (Tizikara *et al.*, 1985; Yousef, 1985; Du Preez *et al.*, 1992).

The average annual rainfall in Zaria is 1100mm and this spreads from late April to early May to late October (wet season). The mean maximum ambient temperature varies from 27 to 35°C depending on the season while the average relative humidity during the wet season is about 72%, and 21% during the dry cool weather of November to January known as the "harmattan" (Oyedipe *et al.*, 1982b).

High maximum and minimum ambient temperatures and relative humidity are associated with seasonal declines in the reproductive efficiency of domestic cattle (Scott and Williams, 1962; Ingraham *et al.* 1974; Zakari, 1981; Badinga *et al.* 1985; Cavestany *et al.* 1985; Gwazdauskas, 1985; Thatcher and Collier, 1986; Du Preez *et al.*, 1991). Furthermore, Scott and Williams (1962) reported that during the summer in Arizona, lowest breeding efficiency occur in August, when relative humidity increased from 50% in late July to 78% in August. They concluded that relative humidity is the most important factor in lowering breeding efficiency than months with higher temperatures.

Rainfall is another major environmental factor affecting fertility. In cattle, helminthiasis, dermatophilosis (kirchi), lumpy skin disease, foot and mouth disease and ectoparasitism showed remarkable prevalence in the rainy season (Voh,Jr. *et al.*, 1993). Some of these conditions are known to affect reproduction (Ogwu *et al.*, 1981). Similarly, Steinbach and Balogun (1971) observed a decline in fertility towards the end of the wet season for reasons already stated. On the other hand, rainfall poses positive effects on reproductive performance. It provides good quality forage which is a major requirement for the improvement of the reproductive indices. Pregnancy (Zakari, 1981; Voh,Jr. *et al.*, 1984a) and conception (Dawuda *et al.*, 1987) rates were highest in the rainy season.

Photoperiod have been shown to influence fertility (Peters *et al.* 1980; Hansen *et al.* 1982. Tucker, 1982). Maximal sexual activity took place during the time of the year when the increase in daylight period was rapid in the tropics (Wilson, 1946; Steinbach and Balogun, 1971).

2.2.1.4 **Disease**

In addition to the effects of disease on the health status of cattle, reproductive diseases impair reproductive activities thereby reducing productivity of the animals. Common diseases of cattle that were reported in Nigeria include: Brucellosis (Esoruoso, 1974; Chukwu, 1987), Campylobacteriosis (Bawa *et al.*, 1987, 1991) and Trypanosomiasis (Nuru, 1974, Ogwu, 1983).

The prevalence of Brucellosis ranged between 0-100% in Africa (Chukwu, 1987). Upto 60% of breeding heifers in Western Nigeria tested positive for Brucellosis (Esoruoso, 1974). Abortion usually occurs 6-8 months after conception. Other signs include early embryonic mortality, repeat breeder syndrome, still birth, retained placenta, etc.

Campylobacteriosis is transmitted venereally or through A.I. A prevalence of 2.9% was observed in 3 states in Nigeria (Bawa *et al.*, 1991). It is characterized by abortion at any stage of gestation but usually 5-6 months. The disease is also characterized by irregular estrous cycle lengths ranging from 28 to 80 days suggesting embryonic mortality (Bawa *et al*. 1987).

The pathogneumonic feature of bovine Trypanosomiasis is abortion (Ogwu, 1983). Irregular estrous cycles were also noted.

Lesions of Dermatophilosis commonly found around the perineum of heifers and cows obliterate the vulva thereby impairing intromission (Ogwu *et al*. 1981).

Trichomoniasis causes visible abortion 2-4 months, slowing down rate of development of the fetus and pyometra (Osebold, 1977; Arthur *et al*. 1982). The previous authors also reported other bacterial and mycotic diseases of reproductive importance.

The impact of viral diseases such as Infectious Bovine Rhinotracheitis (IBR), Infectious Bovine Epididymitis and Vaginitis Complex (IBEVC), Bovine Viral Diarrhoea (BVD), Fibropapilloma of the genitalia etc. on reproduction have been reported (Roberts, 1971; Harkness *et al*., 1988).

Non-specific bacterial infections may also cause infertility in indigenous cows. Eduvie *et al*. (1984) demonstrated that aerobic and anaerobic bacteria were isolated from the vagina, cervix and uterus of cattle that have conditions such as retained placenta, endometritis, repeat breeder syndrome, etc., as well as from genitalia of normal cows. Some of the organisms are saprophytic and become pathogenic when animal is stressed while others are originally pathogenic.

Tennant and Peddicord (1968) reported in *Bos taurus* cattle that endometritis indicated by pus in the vagina reduces fertility in terms of NSC, conception to first service, calving interval and culling rate. The uterus is observed to be highly resistant to infection during the estrogenic phase but very susceptible during the progesterone dominance (Mukasa-Mugerwa, 1989). This agrees with observations by Roberts (1971). Cystic ovarian disease is common in high yielding dairy cows (Morrow *et al.*, 1969).

Considering the seasonality of some diseases (Steinbach and Balogun, 1971; Voh,Jr. *et al.*, 1993) and their significance on reproduction, effective disease control and prevention programmes should be employed to ensure disease-free cattle, thereby increasing the reproductive efficiency of our livestock industry. Post and Reich (1980) and Eduvie *et al.* (1993) obtained high reproductive index in cattle that were both dewormed and sprayed with acaricide.

2.2.1.5 Nutrition

Nutrition of the growing cattle is the most important factor influencing growth weight, onset of puberty and fertility rates (Table 3) (Oyedipe *et al.* 1982a). Thus, undernutrition increases time taken to reach this growth weight thereby delaying the age at puberty (Joubert, 1954, 1963).

Oyedipe *et al.* (1982a) showed that high protein diet fed to heifers induced rapid growth, early puberty and increased conception rates than those on medium or low protein diets (Table 3). This is consistent with findings by El-Khidir *et al.* (1979) in

Sudan and Voh,Jr. *et al.* (1984a) in Nigeria. Topps (1977) concluded that cows kept without additional feed on extensive grazing conditions which provide low quality forage for a large part of the year are likely to produce a calf in alternate years only.

Buck *et al.* (1976) observed that cows in Botswana weighing less than 300 kg at the beginning of the mating season achieved a 50% calving, the percentage rose to 85% as body weight increased to 430 kg. As from 440 kg fertility decreases because of overweight. The mechanism by which body weight adversely affects fertility in cows is partly due to ceasation of cyclic ovarian activity as a result of depressed gonadotrophic function of the anterior pituitary (Topps, 1977).

Low nutritional level results in shortened estrus and irregular estrous cycles (Joubert, 1954; Rakha and Igboeli, 1971; Zakari, 1981; Voh,Jr. 1984b). Animals on high plane of nutrition such as concentrate ration *ad lib* show higher incidence of estrus than those on roughage ration alone (Buchman-smiths *et al.* 1964). Similarly, Eduvie (1985b) reported that postpartum cows on supplement concentrate had their first follicle and ovulated earlier than those that only grazed.

In a study of 3 intensive breeding schemes in Borno, Northern Nigeria, Pathiraja *et al.* (1986) reported that pregnancy rates of 7.6, 12.5 and 56.3% followed the corresponding values of body condition score (BCS) of 1.5, 1.9 and 2.9 respectively. They further recommended that breeding should be restricted to the rainy season when animals are nutritionally good with a BCS of 3.0 or above.

Similarly, in the dry season, provision of protein supplements improved the fertility of cows on natural grazing (Voh,Jr. *et al.*, 1984a). Topps (1977) suggested segregating herds into the following groups: cows suckling their first calf, other cows from second lactation and above, heifers of mating age and dry cows, and feed them generous, moderate, small and nil amounts of supplement respectively.

Table 3: Age and weight at puberty and conception in Zebu heifers on high, medium and low levels of nutrition

	High[1]	Medium[1]	Low[1]
Age at Puberty (days)	570.4	640.0	702.2*
Weight at Puberty (kg)	207.1	187.1	161.7*
90-day conception rate (%)	58.8	27.8	16.7*
Weight at conception (kg)	240.0	240.2	248.0
Age at conception (days)	624.3	759.0	930.8*

* Differences between treatments significant at P<0.05.

[1] The high, medium and low rations contained 150,100 and 41% of estimated requirements respectively.

Source: Oyedipe *et al.* (1982a).

2.2.2 OTHER FACTORS AFFECTING REPRODUCTIVE PERFORMANCE IN CATTLE

2.2.2.1 Postpartum Anestrus

One of the major causes of poor reproductive performance, notably late calving and long calving intervals in Zebu cattle is the failure of cows to show estrus early postcalving resulting in long postpartum anestrus period lasting longer than 100 days. This failure impedes the possibility of maintaining one calf per cow per year. The long postpartum anestrus period was the most important factor limiting reproductive efficiency in pure bred Zebu cattle (Eduvie and Dawuda, 1986). Garcia (1988) showed that the first ovulation after calving was blocked by free or unrestricted suckling until weaning took place at 8 months postpartum.

Many studies have shown that lactating cows have longer postpartum interval than non-lactating cows (Eduvie, 1985a; Silveira *et al.* 1993; Ducrot *et al.* 1994). Wettemann *et al.* (1978) further observed the interval increasing with high milk production. Furthermore, average length of postpartum period has been found to be longest in nursing cows than those milked twice or four times daily (Clapp, 1937). This is consistent with reports by Wiltbank and Cook (1958). Similarly, Silveira *et al.* (1993) confirmed that maternal-offspring bond prolongs postpartum anestrus and the mere perception by the dam of being suckled is enough to extend the postpartum anovulation.

Likewise, investigation on the effects of suckling on resumption of ovarian activity has been reported for indigenous Nigerian cattle. Eduvie (1985b) and Eduvie and Dawuda (1986) observed that suckling interfered with ovarian activities and thus conception during the postpartum anestrus period in Bunaji and Bokoloji cows resulting in prolonged calving interval. Similarly, Voh,Jr. and Otchere (1989) reported that only 15.6% of suckled cows during pre-dry season (crop residue availability) were pregnant in traditional agro-pastoral setting. In the same study, only 1.2% of nursing cows became pregnant under 6 months postpartum.

However, hormonal (Arije and Wiltbank, 1971; Beal, 1993; Voh,Jr. *et al* 1994c) and non-hormonal (Bluntzer *et al.* 1982; Wettemann *et al.*, 1986; Williams *et al.* 1993) treatments may be used in reducing the long postpartum anestrus period.

2.2.2.2 **Estrus detection**

This is one of the most common and useful elements in reproductive management of a cattle herd. A more common cause of poor breeding performance is the inability to detect estrus and have cows remated by 60 to 90 days postpartum (Roberts, 1971; Foote, 1975; Schels *et al.* 1978).

Cows which were previously inseminated and failed to conceive will often pass unnoticed because of inadequate detection of estrus, resulting in long interval between inseminations and consequently, long interval between parturition and conception, and subsequent calving (Olds, 1969; Pullan, 1979; Oyedipe *et al.* 1982b).

In addition to failures of estrus observation and errors in estrus detection (Noakes, 1986), time and frequency of observations (Hall *et al.* 1959; Donaldson, 1968; Esslemont *et al.* 1985) and other management factors (Williamson *et al.* 1972a; King *et al.*, 1976) may also affect efficiency of heat detection.

Hafez (1969) indicated that incidences of 40-60 days cycle are thought to be due to poor estrus detection in which some estrus periods have been missed. This conforms with findings by Zakari (1981) that cycles ranged from 6-54 days for Bunaji and 6-59 days for Bokoloji cows.

Common estrus detection method practiced in Nigeria is the visual observation. In a study of 32 Bunaji heifers for 112 days, Johnson and Gambo (1979) observed none of the heifers in estrus for the possible 5 times, only 9% was observed 4 times whereas 6% did not show any indicative estrus. They suggested that either most of the heifers showed silent estrus or too short cycles and were therefore not observed. In temperate breeds, it has been reported that upto 40-50% of estrus periods are frequently not detected and that 20% of cows are presented for inseminations when they are not really in estrus (Williamson *et al.* 1972a; Barr, 1975; King *et al.*, 1976). Similarly, Salisbury and VanDemark (1961) stated that 40% of the cows returning for service was due to embryonic mortality and 60% poor estrus detection. Zemjanis *et al.* (1969) working in Venezuala and Bozworth *et al.* (1972) in Kansas estimated that 90% of animals thought to be anestrus by farm personnel were actually cycling but not observed in estrus.

Zakari (1981) among Bunaji and Bokoloji cattle in Nigeria reported highest incidence of estrus onset (54%) occurring between 2.00 am and 10.00 am. Similarly, Hurnik *et al.* (1975) found that almost 70% of mounting activity takes place between 2000 and 0600 hours. A figure close to that (63%) was observed by Orihuela *et al.* (1983) in Zebu cattle in Mexico. Observation of cows in the field particularly at night, was the most effective visual method of estrus detection (Williamson *et al.* 1972b). These studies therefore, confirmed that many of the estrus commence in the night and would be undetected by daylight visual observation only. Hence the need for heat detection aids. Cases of suboptimal productivity may therefore be resolved by giving attention to the efficiency of estrus detection rather than conception rates (Ball *et al.* 1983).

Notable factors that may limit efficiency of estrus detection in Zebu cattle include, short and variable duration of estrus (Anderson, 1944, Zakari, 1981; Voh,Jr. *et al.*, 1987c), low intensity of estrus signs (Johnson and Gambo, 1979; Thatcher and Collier, 1986), longer cycle length (Rakha and Igboeli, 1971; Voh,Jr. *et al.* 1987d) and fewer number of mounts per hour (Galina *et al.* 1982; Orihuela *et al.*, 1983).

2.2.2.3 Silent estrus

Morrow *et al.* (1969) and Foote (1975) reported that most cows should have ovulated 2 or 3 times after 60 days postpartum. If by then no signs of estrus have been exhibited, the animal is classified as subestrus or in silent heat due to weak estrus signs and subsequent difficulty in identification of the cycling cow.

Dawuda *et al.* (1989) showed incidence of 29.4% of silent estrus in Bunaji cows whereas Voh,Jr. *et al.* (1994a) demonstrated only 8.2% of silent estrus in the same breed using delayed return rate method. Similarly, Rakha and Igboeli (1971) reported 72.8% silent ovulation occurring immediately before anestrus as a result of low plane of nutrition in Zambian cattle. They further concluded that silent estrus is an intermediate stage between anestrus and ovarian activity.

Furthermore, silent heat was reported to occur in dairy cattle in 77% of first postpartum ovulation, 54% of second and 36% of third ovulations (Roberts, 1971). This tends to agree with results by Hall *et al.* (1959) and Morrow *et al.* (1969) in postpartum cows.

The process of silent estrus is such that adequate pre-ovulatory surge of estrogen stimulate normal release of LH, but is not enough to stimulate estrus behaviour and production of pheromone.

2.2.2.4 Timing of insemination

Optimal reproductive rate in an A.I programme is been hampered by incorrect timing of insemination (McCaughey and Cooper, 1980; Dawuda *et al.*, 1987). For instance, poor detection of estrus is especially crucial in herds where A.I is practiced (Appleyard and Cook, 1976; Garcia, 1988), since conception rate depends directly on timing of insemination (Fields *et al.* 1975; Zakari, 1981; Voh,Jr. *et al.* 1994b).

In a study of inseminations performed in the early, middle and post estrus. Zakari (1981) found conception rates 31, 73 and 63% respectively. Indicating that middle and post estrus are the optimum times for insemination in Nigerian cattle. However, cows seen in heat during the dry and pre-rainy seasons should be inseminated immediately, and re-inseminated if still in heat 12 hours after observation of estrus. When in the rainy or pre-dry seasons, am-pm A.I rule should be upheld for reasons already stated. Similarly, conception rate as high as 70% was recorded by Dawuda *et al.* (1987) when they inseminated cows 12 hours post onset of estrus. This is in agreement with findings by Aschbacher *et al.* (1956), Fields *et al.* (1975) and Robbins *et al.* (1978).

In an evaluation of the progesterone and estradiol 17-β concentrations around insemination. Watson and MacDonald (1984) reported that physiological events around estrus occurred normally and that failure of conception was due to errors in the timing of insemination.

As a result of variation noticed in post-injection interval to onset of standing estrus and its distribution, Voh,Jr. (1984b) reported that a single fixed-time insemination may result in low pregnancy rates and recommended a dual fixed-time A.I at 60 and 72 hours post second PGF2& injection. However, in a more recent study, Voh,Jr. *et al.* (1994b) concluded that following 2 consecutive injections of PGF2& 11 days apart, 60 hours is the optimum time interval for fixed-time A.I for Bunaji cows, and recorded 54.3% conception rate. These are in consonance with observations by King *et al.* (1982) and Orihuela *et al.* (1983).

2.2.2.5 **Non-Fertile inseminations (luteal phase inseminations)**

Non-fertile insemination is responsible for the reduction in herd fertility and reproductive management in cattle.

Progesterone (P4) levels in blood or milk revealed that upto 20% of cows have high (P4) at the time of insemination suggesting that these cows were not actually in estrus before insemination (Hoffman *et al.* 1976; Bulman and Lamming, 1978). Lower number or percentage of cows with high progesterone concentration at A.I. have been reported (Appleyard and Cook, 1976; King *et al.* 1976; Oltner and Edqvist, 1981; Laitinen *et al.*, 1985). Voh,Jr. *et al.* (1994a) demonstrated an overall luteal phase insemination rate of 2.6% in indigenous Bunaji cows.

Errors in detection of heat could result in inseminating animals in diestrus stage of estrous cycle (Appleyard and Cook, 1976; Noakes *et al.* (1986). The estrus cycle length in this case is erratic occurring < 8 days after insemination or between 10 and 16 days (Table 4) (Roche *et al.* 1978; Voh,Jr. *et al.* 1994a). A marked peak of genuinely short estrous cycles, 8-9 days (5.5%) (Voh,Jr. *et al.*, 1994a) and 8-10 days (1.0% to 4.7%) (MacMillan and Watson, 1971) have been reported.

Pregnant and non-pregnant cows in their luteal phases exhibit signs of heat (Guntzler *et al.* 1979; Oltner and Edqvist, 1981). About 3-10% of cows may show estrus while pregnant (Salisbury and VanDemark, 1961; Williamson *et al.* 1972a). The above animals may be inseminated based on the false heat.

Some non-fertile inseminations were accompanied by irregularities in the progesterone profile (Erb *et al.* 1976; Lamming and Bulman, 1976). Ayalon observed cows with abnormal embryos having higher P4 values on the day of estrus, and 3 and 4 days after insemination. However, some cattle conceived though their profiles differ considerably from the "normal" pattern (Bulman and Lamming, 1978).

Successful inseminations are characterised by low progesterone levels. The concentration of progesterone in cows found to be pregnant was below 1.0ng/ml on the day of insemination (Appleyard and Cook, 1976; Laitinen *et al*. 1985; Coppens *et al*. 1987). Cows which failed to conceive were probably in the luteal phase of the estrous cycle (McCaughey and Cooper, 1980; Oltner and Edqvist, 1981). Oyedipe *et al*. (1986) reported that heifers that had progesterone levels of 1.0ng/ml or above at insemination were regarded to be in the luteal phase hence the insemination considered a luteal phase insemination.

2.2.2.6 Application of Reproductive Physiological data from *Bos taurus* to *Bos indicus*

Only sparse information is available on basic reproductive physiology of *Bos indicus* cattle. Hardin *et al*. (1980) confirmed that extrapolation of breeding protocols used in temperate breeds to tropical Zebu cattle and their crosses yielded a fertility rate as low as 30%. In a similar study conducted by Voh,Jr. *et al*. (1987a), pregnancy rate lower than 50% in indigenous Nigeria cattle was obtained. Notable among the reasons adduced for this low fertility rates are application of estrus synchronization protocols and reproductive physiological data from *Bos taurus* that may not necessarily apply to *Bos indicus* (Voh,Jr. *et al*., 1988).

It has been previously stated that Zebu cattle have peculiarities with respect to expression of estrus. It is thought that the timing of events from estrus expression until animal is inseminated has to be reconsidered, as Zebu are observed to have shorter duration of estrus (Voh,Jr., 1984b; Garcia, 1988) thereby limiting the possibility of detecting animals in heat.

The need therefore arose for developing and adopting data for the *Bos indicus* in order to achieve optimum reproductive efficiency in estrus detection, synchronization and A.I, and clinical treatments for reproductive disorders in the tropical breeds. In view of this, Voh,Jr. *et al.* (1987b) studied the double injection systems of PGF2& and reported that 13 days inter-treatment interval has the highest response rate in Bunaji cows as against the commonly practical 11 days. They concluded that 91% of the cows treated using this protocol were in middle diestrus at the time of the second injection.

Investigations on fixed-time A.I in Zebu cattle (Orihuela *et al.* 1983; Voh,Jr. 1984b; Voh,Jr. *et al.*, 1994b) have been previously discussed in this review.

2.2.2.7 **Embryonic Mortality and Repeat Breeder Females**

Embryonic mortality refers to fertility losses during the embryonic period, i.e. the period extending from conception to completion of the stage of differentiation which, in the cow, occurs at approximately 45 days (Committee on Reproductive Nomenclature, 1972).

Results from investigations by Ayalon (1978) and Maurer and Chenault (1983) indicated that early embryonic mortality (EEM) rather than fertilization failure is the major cause of infertility in repeat breeder and control females. This is in line with reports by Wijeratne (1973). The failure of a cow/heifer to conceive at the first insemination may suggest that either fertilization did not take place, even though the cow was in estrus or fertilization did take place, but the embryo failed to survive or the cow was not in heat when served (Wood, 1976).

Diskin and Sreenan (1980), Jaster *et al.* (1982), Oyedipe *et al.* (1986) and Voh,Jr. *et al.* (1994a) found progesterone assay in cattle as useful in monitoring the occurrence of embryonic mortality. In addition, Humblot *et al.* (1988) determined embryonic death by measuring both P4 and pregnant-specific protein B (PSPB) concentrations in peripheral plasma. Furthermore, Diskin and Sreenan (1980), Ayalon (1981) and Gustafsson and Larsson (1985) obtained embryonic losses by slaughter (or surgery) of females at pre-determined intervals to recover fertilized eggs or embryos following insemination.

The major proportion of embryonic losses occur before Day 15 after service (Ayalon, 1978, 1981; Diskin and Sreenan, 1980; Maurer and Chenault, 1983; Almeida and Ayalon, 1984; Almeida *et al.* 1984), therefore the embryo dies too early such that there is no noticeable influence on the length of the estrous cycle despite having being pregnant. Furthermore, Ayalon (1981) reported that critical time for EEM in repeat breeders was found to be soon after the embryo enters the uterus, 6-7 days post service, when the morula is developing into the blastocyst. Whereas in cows with normal fertility, embryonic mortality was not apparent until day 16 post-estrus. Maurer and Chenault (1983) demonstrated that in parous females, embryonic mortality acounted entirely for the reduction in reproductive efficiency with 67% occurring by day 8, the other 33% between days 8 and 16 of gestation. However, intervals occurring 17-24 days (Erb and Holtz, 1958; Roche *et al.* 1978), 16-34 days (Hawk *et al.* 1955) and 25-36 days (Voh,Jr. *et al.* 1994a) (Table 4) indicated embryonic mortality.

While reports demonstrate the time at which embryonic mortality occurs, many authors indicate the extent of embryonic mortality. Bishop (1964) reported a range of 15 to 60% and considered it as a means of eliminating unfit genotype at a low biological cost. Erb and Holtz's (1958), Wijeratne's (1973) and Roche *et al.'s* (1981) estimate of 20.6%, 20.2% and 20-30% respectively were consistent with Bishop's sources. The figures of 14.9%, 15% and 16.2% suggested by Salisbury *et al.* (1952), Boyd *et al* (1969) and Wood (1976) respectively were slightly below these estimates.

Investigations conducted recently on the incidence of late embryonic mortality (LEM) and repeat breeder synchrome (RBS) in artificially inseminated Bunaji cows following estrus synchronization by Voh,Jr. *et al.* (1994a) revealed overall embryonic mortality rate of 27.6% and 12.5% as estimated by delayed return rate and serum progesterone concentration methods respectively. This concurs with findings by some of the authors above.

***Repeat breeder cow*:** is defined as non-pregnant female without morphological or clinical abnormalities which had four or more non-fertile inseminations (Almeida *et al.* 1984, Maurer and Echternkamp, 1985). They constitute a serious cause of economic loss to dairy farmers (Pelissier, 1976). Repeat breeding is associated with low (Maurer and Echternkamp, 1985) or irregular P4 profiles in 23% of cows studied resulting in ovulation failure, fertilization failure or early embryonic loss (Bulman and Lamming, 1978), with total fertility losses twice as high as those in normal cows 5-6 weeks after insemination (Ayalon, 1981).

It has been established that the bovine embryo has to be present in the uterus on day 16 in order to prevent luteolysis and subsequent estrus (Betteridge *et al.*, 1980). However, in repeat breeders which return to estrus at a normal interval after A.I, it seems likely that embryonic death has occured before day 16, or that the embryonic signal was not delivered by the embryo or received by the dam.

Studies on the incidence of RBS was conducted using the delayed return rate method during a 2-year period involving 170 Bunaji cows. Of this number, 26 representing 15.2% were repeat breeders (Voh,Jr. *et al.* 1994a). This finding is on the high side when compared to those of Maurer and Echternkamp (1985) and Hewett (1968) who reported 1.0 to 1.7% in beef cattle and 10% in dairy cows respectively.

It is worthy to note that despite the limitations in the methods used to determine embryonic mortality by Voh,Jr. *et al.*

(1994a), i.e. only LEM occurring between 16-45 days was estimated, yet an overall figure of 27.6% LEM was obtained. Maurer and Echternkamp (1985) showed that higher losses occur 7 or 8 days post insemination, representing EEM. Therefore, if both EEM and LEM were studied, higher embryonic mortality will be recorded, hence very low fertility rate in indigenous cattle herds will be observed.

Table 4: Embryonic mortality rate estimated by delayed return method and comparative distribution of pre-insemination and post-insemination estrous cycle lengths for normal and repeat breeder cows

Cycle length category(days)	Interpretation of cycle	Non-inseminated	Inseminated	Repeat breeder
8-9	Genuinely short cycle	10(5)	23(3.7)	3(1.8)
<8 or 10-16	Luteal insemination	5(2.5)	17(2.7)	4(2.5)
17-24	Normal cycle	170(85)	399(64.0)	91(54.8)
25-36*	Embryonic loss	3(1.5)	133(21.4)	56(33.7)
37-45	No-detected estrus or silent estrus	12(6.0)	51(8.2)	12(7.2)
TOTAL		**200**	**623**	**166**

% in parentheses

* Category representing embryonic loss

Source: Voh,Jr. et al. (1994a).

2.3 EFFECT OF TEMPERATURE AND HUMIDITY ON REPRODUCTIVE PERFORMANCE AND PRODUCTIVITY OF CATTLE

2.3.1 EFFECT OF HIGH AMBIENT TEMPERATURE AND HUMIDITY ON FERTILITY

Average daily ambient temperature is probably the most significant bioclimatic factor in the animal's physical environment that affects conception as a result of thermal stress in artificially inseminated cattle herds (Gwazdauskas *et al.* 1973; Ingraham *et al.*, 1974; Thatcher, 1974; Badinga *et al.* 1985; Cavestany *et al.* 1985; Thatcher and Collier, 1986).

Investigations from natural (Scott and Williams, 1962; Gwazdauskas *et al.*, 1973; Ingraham *et al.* 1974; Wolff and Monty, 1974; Badinga *et al.*, 1985) and controlled (Ulberg and Burfening, 1967; Dunlap and Vincent, 1971; Bond and McDowell, 1972; Wolfenson *et al.* 1988) environments indicate that fertility is negatively related to high ambient temperature and relative humidity.

Thermal stress at insemination and first few days after insemination appeared to be the most critical time on the survival and development of the embryo (Ulberg and Burfening, 1967; Gwazdauskas *et al.* 1973; Thatcher, 1974) with less of the effect of severe heat noted after the cleavaging Zygote had reached the uterus (Ulberg, 1958). Furthermore, high ambient temperature and relative humidity at least 12 days preceding insemination (Ingraham *et al.* 1976; Gwazdauskas, 1985), 2 days prior to insemination (Ingraham *et al.*, 1974), on the day of A.I (Dunlap and Vincent, 1971; Cavestany *et al.*, 1985) and first 4-6 days after insemination

(Wiersma and Scott, 1969; Gwazdauskas *et al.* 1973) influenced conception rate.

Reproductive efficiency is generally lowest in winter at the cooler regions of northern latitudes due to variations in day length (photo-period) rather than temperature (Mercier and Salisbury, 1947; Tucker, 1982). In warm humid climates however, reduced fertility is associated with high temperatures and relative humidity during the summer (Vincent, 1972).

The effect of summer season on fertility of cattle has been reported by Scott *et al.* (1972) who demonstrated lowest fertility ranging between 9 and 15% in August as maximum temperature increases. This tends to agree with reports by Monty and Wolff (1974), Thatcher (1974), Badinga *et al.* 1985 and Cavestany *et al.* (1985).

In a study of controlled environment, Dunlap and Vincent (1971) demonstrated a highly significant difference in conception rate in heifers exposed to 32.2°C, 65% relative humidity for 72 hours post breeding with zero CR as opposed to 48% CR in heifers at 21.1°C, 65% relative humidity for the same 72 hours. This is in line with reports by other researchers (Gutierrez *et al.* 1968; Bond and McDowell, 1972; Scott *et al.* 1972; Wolfenson *et al.* 1988).

From the investigations conducted, heifers were shown to be more fertile and less prone to high ambient temperature than their cow counterparts. Conception rates of lactating cows decreased sharply when maximum air temperature on day after insemination exceeded 30°C. In contrast, CRs for heifers decline only from 35°C

(Badinga *et al.*, 1985). Likewise, effect of climate on Bovine reproduction revealed that heifers had a higher CR of 47% compared with 32% in lactating cows (Thatcher and Collier, 1986). This may be due to inability to maintain normal body temperature under stress because of high rate of internal heat production associated with lactation (Badinga *et al.*, 1985).

Effects of high ambient temperature on reproduction are observed to be only temporary (Scott and Williams, 1962). However, extreme environmental temperature imparts negative influence on estrus and estrous cycle (Rakha and Igboeli, 1971; Thatcher, 1974; Zakari, 1981; Montgometry *et al.* 1985; Thatcher and Collier, 1986), conception rate and embryo survival (Ulberg and Burfening, 1967; Fuquay, 1981; Tucker, 1982; Wolfenson *et al.* 1988). The duration of estrus in cows can be as long as 30 hrs, however, in hot environmental conditions, it can be as short as 6 hours (Thatcher, 1974). These results are in close agreement with findings by Zakari (1981) and Voh,Jr. (1984b) in indigenous Nigerian breeds which is the rationale behind inseminating cow immediately she is in estrus in the dry season.

In the bull, semen quality and fertility were influenced by environmental factors (Kelly and Hurst,, 1963; Rekwot *et al.* 1987; Sekoni *et al.* 1988). Exposure of bulls to temperatures above 30°C impaired spermatogenesis (Casady *et al.* 1953).

2.3.2 EFFECT OF HIGH AMBIENT TEMPERATURE ON PRODUCTIVITY

Elevated environmental temperature decreases the productivity of cattle by reducing feed intake (Tizikara *et al.*, 1985), suppressing growth rate (Fuquay, 1981; Hahn, 1985) and reducing milk yield (McDowell, 1972; Wolff and Monty, 1974; Thatcher and Collier, 1986). The increased heat production from grazing activity, high lignin content in tropical summer forages and reduction in the efficiency of converting feed energy units to production units during heat stress contribute to the crisis militating against cattle production in the tropics and subtropics (McDowell, 1972; Topps, 1977; Buck and Light, 1982).

2.3.3 EFFECT OF HIGH AMBIENT TEMPERATURE AND HUMIDITY ON BODY TEMPERATURE AND SUBSEQUENT FERTILITY

There is a direct relationship between high environmental temperature and elevated body temperature (Dunlap and Vincent, 1971; Wolff and Monty, 1974; Zakari, 1981). Cows with high body temperatures at insemination have lower conception rates than those with normal body temperatures (Ulberg and Burfening, 1967; Turner, 1982; Gwazdauskas, 1985). The decline of conception has been associated with elevated rectal (Monty and Wolff, 1974; Thatcher, 1974; Zakari, 1981; Geisert *et al.*, 1988) and uterine (Gwazdauskas *et al.*, 1973; Thatcher, 1974; Thatcher and Collier, 1986) temperatures.

The thermoneutral Zone for cows is between 0 and 16°C (Bianca, 1970). Cows experience heat stress when ambient temperature rises above 23.8°C at a relative humidity of 80% (Nickerson, 1987). The average rectal temperature in cattle was 38.7°C at ambient temperature of 18-24°C, when ambient temperature increased to 32-35°C, the rectal temperature increased by 1°C in Jersey and 1.4°C in Friesian (Branton *et al.* 1953; Bianca, 1968). Likewise, Wolff and

Monty (1974) observed elevation of body temperature in Friesian cows when air temperature is above 30°C.

In a study of indigenous Zebu cattle, Zakari (1981) reported decline in conception rate from 52% to 12% as rectal temperature increased from 38.2-39.1°C to 39.2-40.0°C. Ulberg and Burfening (1967) further demonstrated a drop in pregnancy rate by 16% as rectal temperature increased by 1°C 12 hours post A.I. These results concur with reports by McDowell (1972), Thatcher (1974) and Gwazdauskas (1985)..

Same effects of high ambient temperature on fertility were observed in Ewes (Dutt, 1959) and Does (Ulberg and Burfening (1967).

2.3.4 EFFECT OF TEMPERATURE-HUMIDITY INDEX (THI) ON PERFORMANCE OF CATTLE

Heat stress is best measured by using the Temperature-Humidity-index (THI) formulae as described by Johnson (1965), Kelly and Bond (1971) and Hahn (1981). A single index which combines all the climatic factors as a measure of stress does not exist (Dupreez *et al.* 1992). Yousef (1985) reported that the THI is the only useful measure of assessing thermal stress. High humidity increases the effect of high temperature, and the maximum and minimum THI accounted for 80% of monthly variation in CR (Ingraham *et al.*, 1974).

The THI values upto 70 are regarded as normal for optimum performance while values above 70 are detrimental to cattle (Anonymous, 1970; Ingraham *et al.* 1974; Yousef, 1985; DuPreez *et al.* 1994). Ingraham *et al.* (1974) reported that the critical THI values are 76 and above.

Furthermore, Anonymous (1970), supported by Hahn (1985) and DuPreez *et al.* (1991) indicated that THI values of 71-78 (alert or stressful level) are considered warning to above critical where cattle exprerience fair amount of heat stress and milk production is affected. In the dangerous category (THI 79-83), the animals experience severe heat stress and their performance is severely affected. All the above adverse effects of dangerous category are present in the emergency category at THI values above 83. Death may easily occur in this category.

DuPreez *et al.* (1991) noted low CR of 36.4% and FSCR of 32.8% in January, when the mean monthly THI value was at its highest 71.9. Similarly, Ingraham *et al.* (1974) found that CR for 191 cows bred with average THI below 66 was 67% as opposed to 21% for 818 cows bred at THI above 76.

2.3.5 POSSIBLE MECHANISMS RESPONSIBLE FOR LOWERED REPRODUCTIVE EFFICIENCY DURING THERMAL STRESS

Means by which climatological factors effect fertility is not fully known. However, several reasons have been adduced to be responsible for poor reproductive performance in adverse weather conditions. Ulberg and Burfening (1967) suggested that many external forces may distrupt the delicate biological balance existing in the reproductive processes. Evidence indicates that a low rate of fertilization (Scott and Williams, 1962) due probably to direct adverse effect on the ova and the sperm when in the female reproductive tract (Burfening and Ulberg, 1968) and a high rate of embryonic mortality (Alliston *et al.*, 1965; Ulberg and

Burfening, 1967) are important in lowering the reproductive efficiency in high temperature conditions. Drost and Thatcher (1987) demonstrated normal fertilization in heat-stressed cattle, incriminating embryonic death fully, in reducing the CR.

The release of reproductive hormones is affected by seasonal periods of hot weather (Thatcher, 1974; Knutson and Allrich, 1988). It is known that increased ambient temperature increases secretion of adrenocorticotropin, which stimulates increased secretion of P4 from the adrenal and a subsequent increase in plasma P4 (Gwazdauskas *et al.*, 1972). Similar trend was observed by Mills *et al.* (1972), Vincent (1972) and Gwazdauskas *et al.* (1973). Conversely, Scott *et al.* (1972), Rosenberg *et al.* (1977) and Wolfenson *et al.* (1988) reported seasonal hyperthermia depressing ovarian function resulting in low plasma P4 and poor reproductive performance. Whereas Biggers *et al.* (1987) observed no effect of heat stress on P4 concentration.

Furthermore, during heat stress, there is decreased secretion of basal as well as pre-ovulatory LH surges (Madan and Johnson, 1973) and lowered estrogen concentrations in plasma due to decreased blood flow induced by elevated temperatures within the reproductive tract thereby affecting ovulation and physiology of the uterus (Gwazdauskas *et al.*, 1973; Ingraham *et al.* 1974). In a related study, Wiersma and Scott (1969) incriminated maternal endocrine imbalance as a result of hot temperatures as responsible for poor CRs and concluded that increase P4 secreted from the adrenal in response of a stressor factor, alter hormonal levels such that the uterus and the embryo become incompatible. This is in consonance with findings by Scott and Williams (1962); Scott *et al.* (1972) and Thatcher (1974).

Alliston and Ulberg (1961) further elucidated that the poor CR is due to thermal stress acting directly on the developing embryo. They subjected ova from sheep to temperatures at 21.1°C and 32.2°C, and found more fertilized ova in the former while in the latter, no evidence of cleavage 48 hours post breeding were noted, suggesting damage or fertilization failure. In addition, Geisert *et al.* (1988) reported that heat stress from days 8 to 16 of gestation in the bovine alters the uterine environment as well as conceptus growth weight and secretory activity.

Evidence indicate that low productivity of the tropical Zebu cattle is one of the adaptive measures to the adverse weather conditions (Tizikara *et al.*, 1985). However, well adapted and continuous exposure of animals to environmental stress results in increase tolerance characterized by minimum loss in body weight and health, high reproductive efficiency, high disease resistance, longevity and low mortality (Gall and Huhn, 1981; Peters *et al.* 1981; Payne, 1990). Herz and Steinhauf (1978) observed in Zebu, more and bigger (480 ml/m^2) sweat glands than other taurine cattle (40 ml/m^2) and this high sweat gland volume is related to high heat tolerance. The coats (Herz and Steinhauf, 1978) as well as skin pigmentation (Warwick and Legates, 1979) seem to provide skin protection against solar radiation in the tropical breeds.

Studies have been conducted in an attempt to improve the fertility of cattle in hot environment. Environmental modifications such as evaporative cooling under shade near breeding time (Scott *et al.*, 1972), air conditioning (Thatcher, 1974), adequate shade and avoidance of overcrowding in the milking area (Cavestany *et al.*, 1985) and housing in an open shade (Wolfenson *et al.*, 1988) showed higher CR than cattle exposed to natural environment. These measures were also coupled with adequate feed supply and readily available drinking water (Hahn, 1981).

2.4 ESTRUS, ESTROUS CYCLE AND ESTRUS DETECTION METHODS

2.4.1 ESTRUS AND ESTROUS CYCLE

The short period-3 to 24 hours (Salisbury and VanDemark, 1961; Zakari, 1981; Voh,Jr. *et al.*, 1987c) in the breeding cycle during which an unrestrained heifer or cow will allow mounting by another is called estrus.

The duration of estrus (9.71±0.6 and 8.59±0.62 hours) and overall estrous cycle lengths (22.87±0.70 and 23.76±0.65 days) for Bunaji and Bokoloji cows respectively were reported by Zakari (1981). Similarly, Voh,Jr. (1984b) reported estrus duration 6-10 hours in the dry season and 11-15 hours during the rainy season. Zakari (1981) further observed a significant negative effect of the dry and pre-rainy seasons on the duration of estrus and estrous cycle lengths in both breeds with gradual shortening and weakening of estrus and lengthening of the cycles. Effects of season on estrus and estrous cycle were reported in other tropical breeds

(Anderson, 1944; Rakha and Igboeli, 1971).

In temperate breeds, Wishart (1972) showed a mean duration of estrus as 14.7±1.6 hours and average cycle length of 22.02±3.5 days. Similarly, Salisbury and Van-Demark (1961) demonstrated 17.8 hours as average estrus period in cows and a shorter duration (15.3 hours) in heifers.

Estrus signs and behaviour pattern have been extensively studied in *Bos taurus* (Williamson *et al.* 1972b; Esslemont *et al.*, 1985) and *Bos indicus* (Zakari, 1981; Orihuela *et al.* 1983; Voh,Jr. 1984b) cattle. Intensity of estrus is based on strength of estrus signs such as amount of mounting, degree of restlessness, nature of vulva and vulvar discharge, etc. There is 90% certainty that the cow that stands solidly to be mounted without walking away is in heat. There is only 30% chance that the cow that mounts another is in heat (Esslemont *et al.*, 1985). This agrees with the findings of Williamson *et al.* (1972b). The key, clear cut single criterion therefore is standing to be mounted. However, Galina *et al.* (1982) reported that Zebu cattle do not allow themselves to be ridden repeatedly. This observation has been confirmed by Orihuela *et al* (1983) in a study of estrus behaviour in Zebu cattle in the tropics. In addition, Johnson and Oni (1986) in Shika, Zaria found that crossbred Friesian x Bunaji bulls mounted crossbred Friesian x Bunaji heifers more than did Bunaji bulls or herdmates.

Zakari (1981) showed that about 90% of cows that stood to be mounted had mucus discharge from the vulvae. The discharge is usually seen 2 days before onset of estrus (Symington and Hale, 1967). Other ancillary periestrual behaviour as reported by Zakari (1981) and Voh,Jr. (1984b) in Bunaji and Bokoloji breeds include licking and rubbing each other, sniffing vagina of another cow, mutual chin resting, pairing, exhibition of flehmen, elevation of tail head, isolation from herdmates, increasing frequency of urination, excessive bellowing, linning up to mount, etc. These are consistent with findings by Hall *et al.* (1959), King *et al.* 1976 and Esslemont *et al.* (1985) in taurine cows.

2.4.2 ESTRUS DETECTION METHODS

To achieve a successful breeding programme particularly in A.I. herds, accurate estrus detection methods should be employed.

The goal of a good estrus detection programme is to identify estrus simply, positively and accurately in all cycling animals and consequently identify non-cycling ones (Foote, 1975).

Detection of estrus in Zebu cattle is difficult due to the level of nutrition, season, frequency and time of observation and variation in the intensity and duration of estrus as already stated. It has also been reported that observations of estrus during the daytime results in missing of about 30% of estrus occurring in the night (Hurnik *et al.*, 1975).

Similarly, difficulties in estrus detection in properly fed and apparently healthy cows may be due to deficiencies in the herdsmen or management system rather than problems with the cow (Williamson *et al.* 1972a; King *et al.*, 1976). This suggests that farmers should be trained in estrus detection.

The methods of heat detection are:

2.4.2.1 Visual observation

2.4.2.2 Visual aid for heat detection

2.4.2.3 Non-Visual observations

2.4.2.4 Teasers

2.4.2.1 Visual observation

Herdsmen should know all signs of estrus or impending estrus since there is no substitute for the eye of the skilled observer who observes cattle for estrus (Foote, 1975). Similarly, for effective visual observation, sufficient time must be taken at least twice a day to catch animals with short estrus period.

Donaldson *et al.* (1968) reported that accurate detection of estrus requires very frequent observations of groups of cows, with or without a bull.

The time and duration of estrus observation varied. Williamson *et al.* (1972a) found that continuous observation was 100% effective in detecting estrus in a dairy herd while casual observation twice daily at milkings by the herdsmen detected only 56% of the same animals. This agrees with findings by Donaldson *et al.* (1968) who detected 100% of 108 estrus periods by continuous observation.

While adopting intermittent estrus observations, increasing the frequency of observation and the time at which observations were made influence the efficiency of estrus detection. Esslemont *et al.* (1985) recommended that in order to improve heat detection among *Bos taurus* cattle, it is useful to watch heat 3 or 4 times a day, leaving not more than 8 hours between visits. Such a system improves heat detection rates to 80%. Similarly, Hall *et al.* (1959) using the 0600 and 1800 h observations as the basis for comparison, found that additional check period at 1200 h increased efficiency by 10%. Fourth observational period at 2400 h increased the efficiency by a further 9.9%. Nevertheless, increasing the frequency of heat observation is labour intensive. Infertility was observed on farms with increased herd sizes without a proportional increase in labour (Zemjanis *et al.*, 1969).

However, not all dairy men are good observers especially of the subtle indications of on-coming estrus. Perera and Abeyratne (1979) stated that an experienced stockman, under the most favourable circumstances, can detect no more than 80% of animals coming into estrus. In addition, Williamson *et al.* (1972b) demonstrated that visual method of estrus detection is only most effective at night time. Barr (1975) and King *et al.* (1976) concluded that about 40-50% of cows in estrus may not be detected by the observer.

These setbacks with regards to estrus detection, prompted the use of a number of methods in form of aids to improve on the efficiency of estrus detection, in addition to proper training and education of herdsmen.

2.4.2.2 **Visual Aids for Heat Detection**

In view of the reasons advanced previously in this review that may limit estrus detection, certain heat detection aids have been developed which in conjunction with visual observation improves the efficiency of estrus detection (Rollinson, 1963; Baker, 1965; King *et al.* 1976; Kerr and McCaughey, 1984; Elmore *et al.*, 1986) with subsequent increase in fertility rate. The key significance of heat detection aid is to provide a potential 24-hour surveillance for heat. The results obtained from the aids as reported by Donaldson (1968) are easy to interprete without being subjected to any laboratory test. For the estrus detection aid to be useful in detecting estrus, it must be reliable, inexpensive, consistently accurate and easy to measure.

There are 6 different estrus detection aids namely:

2.4.2.2.1 Tail painting
2.4.2.2.2 Heat mount detectors
2.4.2.2.3 Closed circuit TV with time-lapsed video
2.4.2.2.4 Chinball mating deviced (CMD)
2.4.2.2.5 Titanium dioxide grease
2.4.2.2.6 Pedometers.

2.4.2.2.1 Tail Painting

Tail painting technique may be suitable for use as a method of estrus detection in many dairy herds. The procedure, type of paint to be used and suitable colours were described by MacMillan and Curnow (1977) and Ball *et al.* (1983).

High response rates were recorded using this aid. Detection rates of 93.3% (Voh,Jr., 1987) and 95.7% (MacMillan and Curnow, 1977) were reported. Lower rates of 73.0% (Elmore *et al.* 1986), 81.5% (Ball *et al.*, 1983) and 88.1% (Kerr and McCaughey, 1984) were also reported using the tail painting technique. In addition, MacMillan and Curnow (1977) and Ball *et al.* (1983) showed that 6%

of 399 cows and 24.6% of 363 possible estrus periods respectively, that were not detected by herdsmen were correctly diagnosed by using tail paint.

The detection rates of the tail painting were accompanied by false positive results, i.e. positive tail painting response occurring in diestrus animals having progesterone levels equal to or greater than 1.0 ng/ml. The false positive values recorded were 4.8% (MacMillan and Curnow, 1977), 7.1% (Ball *et al.* 1983), 26.0% (Elmore *et al.* 1986) aid 30.8% (Kerr and McCaughey, 1984). the above authors attributed the false positve results to, effect of weather on the paint, behaviour of animals approaching heat and in heat, incidence of false or "phantom" heat, anatomical variation within the animals which will influence positioning of the paint, tempering with the tail paint by the test animals etc.

Similarly, tail painting did not detect all the animals in heat, giving false negative result. However, the values were low, 1.0% recorded by both MacMillan and Curnow (1977) and Elmore *et al.* (1986). The false negative may be as a result of great disparity in the body size of the animals and possibly inconsistent sexual behaviour in heifers. Nevertheless, tail painting has been found to be a useful heat detection aid.

2.4.2.2.2 **Heat Mount Detectors**

There are two types- the KaMar heat mount detector (KHMD) and Delta mate master. The devices record that a cow has been mounted with sufficient pressure and duration to indicate that she stood for the mounting. Baker (1965) reported that this pressure from the sternum must be maintained evenly for 4 or 5 seconds to produce a positive colour change (white to red). The most widely used device is the KaMar heat mount detector (KHMD). This pressure sensitive detector fitted to the rump of a cow provides a 24-hour per day continuous check. Detectors are observed at least twice daily to determine if the dye has been expressed (Kiddy, 1979).

Williamson *et al.* (1972a) reported that 100% of 57 cows studied showed positive KHMD over 21 days while only 72% (41 cows) were accompanied by visual observation for standing heat. However, 14 (24.6%) cows showed false positive result or missing KHMD. In a similar trial, 90% of 80 estrus periods observed by Baker (1965) in beef cattle showed red KaMar, 67.5% were examined visually when observations were done daily between 0700 h and 1800 h at 3 hourly intervals for 15 minutes. About 10% of the detectors were either rubbed-off or lost, while 5.5% were false positive as judged by rectal palpation.

The superiority of KHMDs over visual observation for standing heat has also been reported by Boyd and Hignett (1968), Mills *et al.* (1969), Williamson *et al.* (1972b), Schels *et al.* (1978) and Broadbent *et al.* (1989). In addition, the researchers recorded some false positive, false negative and lost detectors during their trials. They concluded that the population density and condition under which the cattle were kept, the conformation of the cows, "phantom" heat and heat during pregnancy, the site for the device on the animal among other factors, may be responsible for the false results and loss of the detectors observed during the studies.

Twenty-five percent of the detectors were lost (Williamson *et al.*, 1972a; Foote, 1975) while 7% of cows in a trial showed estrus during pregnancy (Williamson *et al.* 1972a).

Cows whose detectors fell were replaced but assumed to be an indication of estrus since mounting was responsible for the loosening of the detector (Schels *et al.* 1978).

Occasionally, the interpretation of the KaMar is confusing, some may be half red while some three-quarters red. Anything short of wholly red KHMD should be regarded as negative (Boyd and Hignett, 1968; Williamson *et al.*, 1972a).

2.4.2.2.3 Closed Circuit Television with Time-lapsed Video

This provides a continuous observation for estrus. Video tape recorders may be played for brief periods when estrus checking is not convenient to extend the period of visual observation or played back at convenient times (Foote, 1975).

King *et al.* (1976) observed animals continuously by means of a closed circuit TV system, employing two TV cameras connected through a mixing box with a time-lapsed video recorder. The percentage of cows in which estrus was detected at the first, second and third ovulation was 50%, 94% and 100% as compared to 20%, 44% and 64% respectively in the, casually observed cows by herdsmen. The incidence of detected estrus therefore was higher for cows under continuous observation with the aid of TV at each consecutive estrus.

This system is very efficient and effective but expensive and is mainly of research value.

2.4.2.2.4 Chin-ball Mating Device (CMD)

It consists of a halter with a built-in ball point pen or crayon fitted to the chin of a detector teaser bull (Kiddy, 1979). Foote (1975) used cystic cows as teasers but were variable and unreliable checkers. He further observed surgically prepared bulls or selected active steers with implants better. The bulls stimulate as well as find those cows with weak symptoms of estrus (Kiddy, 1979).

The teaser harnessed with a CMD rolls a band of paint on the back of the cow in heat while disembarking. Interpretation of the marks require some skill because marks are often found on the rump and sides of cows that are not in estrus.

Voh,Jr. (1987) reported 85% accuracy rate of chin-ball mating device while evaluating the efficiency of heat detection aids used in Nigeria. Similarly, in a study of estrus detection aids by Foote (1975), a bull marked 59 out of 115 cows representing 51.3% before the dairyman spotted them while the dairyman recorded 33 cows (28.7%) that the bull did not detect probably due to overwork. Furthermore, 64% of the cows marked by the bull were pregnant as against 45% pregnancy rate of cows observed by the dairyman. Suggesting that the dairyman must have erroneously identified some animals in estrus.

Estrus synchronization programs accompanied by the use of CMD revealed 76%, 14% and 10% of 85 cows as true positive, false positive and false negative respectively (Elmore *et al.*, 1986).

2.4.2.2.5 Titanium Dioxide Grease

Donaldson (1968) observed that smearing of titanium dioxide grease and peanut oil daily on the medial side of the forelimb and sternum of the teaser bull and observation of the cows 4 times a day for marking, proved almost 100% effective under field conditions. This finding is consistent with that of Rollinson (1963) and Mills *et al.* (1969). The latter observed more heat periods detected by teasers with pigmented grease on the brisket (96%) than KaMar patches (76%) or visual observation (66%) in the same study.

2.4.2.2.6 Pedometers

Mechanical pedometers and electronic devices were used for estrus detection in dairy cows (Kiddy, 1977). Holdsworth and Markillie (1982) demonstrated that electronic devices attached to the right hindleg of the cow above the hock are designed to count limb movements in 12 hour periods and read at morning and afternoon milkings. If the number of leg movements is greater than that in the preceding period by a factor of two or three, a signal showed, which is an indication of estrus. Otherwise a green light is illuminated. For mechanical pedometers, a reading double that of the previous day is considered positive.

In evaluating the effect of these devices, Holdsworth and Markillie (1982) reported that both mechanical and electrical pedometers showed large numbers of false positive results. In addition, damage to or loss of pedometers and difficulty in interpretation do occur because of the small size of the dials.

2.4.2.3 Non-visual methods of heat detection

They are as follows:

2.4.2.3.1 Rectal palpation

2.4.2.3.2 Vaginal pH

2.4.2.3.3 Electrical resistance of vaginal mucus at estrus

2.4.2.3.4 Vaginal cytology or epithelia changes

2.4.2.3.5 Changes in vaginal or cervical mucus crystallization pattern.

2.4.2.3.6 Body temperature and vaginal thermal conductance.

2.4.2.3.1 Rectal Palpation

This determines the reproductive status of the animal and when next estrus occurs (Zemjanis *et al.*, 1969). The technique is usually indicated where herdsmen or bulls fail to detect estrus in normal cattle as a result of silent estrus, bull exhaustion or too many cows per bull (Baker, 1965; Symington and Hale, 1967; Williamson *et al.* 1972b). Rectal Palpation is more effective in heifers than old cows because the follicles and corpora lutea could be easily identified on the smooth ovaries of the heifers (Zemjanis, 1970; Mukasa-Mugerwa, 1989).

It has been further reported by Mukasa-Mugerwa (1989) that care has to be taken in examining Zebu cows because their ovaries tend to be smaller than those of *Bos taurus* cows. In addition, rough palpation interfere with uterine tone (Studer, 1975).

The rate of agreement between rectal palpation of ovarian structures and progesterone concentration was 82% and 96% in diagnosing luteal and non-luteal structures, respectively (Garcia, 1988). Rectal palpation is therefore quite efficient in detecting estrus. Williamson *et al.* (1972b) reported that the method found 92.8% (52 out of 56 cows) suitable inseminations at sometime during a three week observation period. Similarly, Baker (1965) in comparison of classical methods of detecting heat found that rectal palpation was most effective with a response rate of 97.5% (78 of 80 estrus periods observed).

2.4.2.3.2 Vaginal pH

It is common in estrus to find the genitalia particularly the cervix and vagina acidic. Schilling and Zust (1968) demonstrated that intravaginal and cervical pH falls at estrus from 6.98 during diestrus to 6.45 at the end of estrus. Similar observation was made by Olds and VanDemark (1957).

2.4.2.3.3 Electrical Resistance of Vaginal Mucus at Estrus

The electrical resistance of the vaginal mucus was lower at estrus than other stages of the estrous cycle (Leidl and Stolla, 1976). The value can be as low as 150 ohms and conception rate when animals were inseminated at this stage was 94% (Stan, 1969). Similarly, Foote *et al.* (1979) studied association between electrical resistance at insemination and pregnancy rate. They concluded that 52% of 58 first service cows inseminated on the basis of low resistance reading became pregnant. In the control group, 86 first service cows were inseminated after been seen in estrus and 49% conceived. This technique can therefore aid in detecting when to inseminate an animal but there is a problem with the insertion of the probe into the vagina and vaginal conductivity

(Foote, 1975; Williamson *et al.* 1972a).

2.4.2.3.4 Vaginal Cytology or Epithelia Changes

Several investigations have been conducted in an attempt to determine the characteristics of the cells of the vagina at various stages of the estrous cycle. Symington and Hale (1967) using Leishman's stain found some variation in the cytology of the vaginal mucus of Zebu heifers during the estrous cycle. This agrees with another report (Hansel, 1959).

2.4.2.3.5 Changes in the Cervical or Vaginal Mucus Crystallization Pattern

Crystallization changes with estrogen level in the blood. Abusineina (1962) observed cervical pattern at estrus as long, thin, wavy or curved with well developed venations, and crystallization occurs in approximately 95% of the film. In addition, vaginal crystallization is similar to cervical, however, only about 50% of the film is covered with crystals and the mucus is semi-clear. Furthermore, Voh,Jr. *et al.* (1987a) demonstrated in Zebu cattle that the ferning pattern of vulvar discharge under the microscope can improve heat detection in conjunction with other techniques. They further reported that "missed inseminations" from the findings of the ferning pattern score can tell animals that can be closely observed for return to estrus. In addition, a relationship exist between mucus fern pattern score and pregnancy rates. Similar changes in cervico-vaginal mucus associated with estrus have been reported (Olds and VanDemark, 1957; Williamson et al. 1972b; Linford, 1974).

2.4.2.3.6 Body Temperature and Vaginal Thermal Conductance

There was a distinct milk temperature rise of 0.3°C and above in a study of association between milk temperature rise and estrus in dairy cattle by Maatje and Rossing (1976). Similarly, Ball *et al.* (1978) in an attempt to determine the best time to inseminate without sole signs of estrus, measured rectal temperatures each morning and milk temperatures morning and evening for fourty days. They concluded that milk temperature rise was at least 0.1°C higher during estrus than before estrus. Furthermore, Lira *et al.* (1975) reported a slight increase in ear canal and rectal temperatures at estrus but not milk temperatures measured once a day on 15 dairy cows.

In a study of vaginal thermal conductance of heifers, Abrams *et al.* (1973) observed that 3 mg of estradiol-17B administered intravenously increases the blood flow to the vagina and also vaginal thermal conductance about 5 hours post injection.

2.4.2.3.7 Hormonal Assay

This technique is more accurate than rectal palpation as reported earlier, but it may not be feasible under field conditions because of the protocols involved. The commonest assays are Radioimmunoassay (RIA) and Enzyme Linked Immunosorbent Assay (ELISA) of the milk or blood samples for hormones such as progesterone, estradiol etc. Smith *et al.* (1975), Peters (1985), Oyedipe *et al.* (1986), Eduvie and Dawuda (1989) indicated hormonal assay as a tool in diagnosing estrus.

2.4.2.3.8 Laparascopy

The ovaries can be examined in-situ to determine estrus using the laparascope. In predicting the stages of the estrous cycle by gross appearance of the functional structures of the ovary, Ireland *et al.* (1980) observed the technique to be accurate in detecting estrus. Similarly, Wishart and Snowball (1973) and Wilson and Ferguson (1984) employed this method to study the ovaries and other internal genital organs.

2.4.2.3.9 Controlled Estrus and Fixed-time A.I

The control of estrus using PGF2& and fixed-time AI at a preset time eliminate the need for continuous observation of animals for signs of estrus (Hardin *et al.* 1980; Olson, 1980; Jaster *et al.* 1982; Voh,Jr. *et al.*, 1987a; Voh,Jr. *et al.* 1994b).

However, some factors influence effectiveness of PGF2& in controlled or induced estrus programmes, such as, incidence of anestrus due to environmental conditions predisposed by undernutrition (Rakha and Igboeli, 1971; Johnson and Gambo, 1979; Zakari, 1981; Voh,Jr. *et al.* 1987d), the reproductive status of the cows in terms of diagnosing functional or non-functional corpus luteum per rectum during the PGF2& treatment (Zemjanis, 1970; Dobson *et al.* 1975; Seguin *et al.* 1978; Smith *et al.* 1984; Voh,Jr. *et al.* 1987d), and abnormal estrous cycle and ovulation without estrus (Thimonier *et al.* 1975; MacMillan and Day, 1982).

2.4.2.4 Teasers

Surgically prepared bulls (Frazer, 1973) which cannot achieve conception (Williamson *et al.*, 1972a) and females treated with hormones (Kiser *et al.* 1977) to induce male-like behaviour may be used for estrus detection. There are 3 major types of teasers, namely: vasectomized or epididectomized bull, pen-o-blocked bull and hormone-treated females.

2.4.2.4.1 Vasectomized or Epididectomized Bull

A portion of the vas deferens is excised. Teasing heifers 3 times a day with vasectomized bull proved a very effective method of estrus detection with 93.1% of estrus recognized as against 90.4% by simple observation and 81.0% when mounted by other cows (Donaldson, 1968). However, the previous author further reported a risk of transmitting venereal diseases with this method.

2.4.2.4.2 Pen-0-Blocked Bull

The procedure for preparation of Pen-0-Blocked bull is described by Kiddy (1979). It is simple to perform, reversible and the bull can be used for estrus observation almost immediately after placing the device, although complications such as swelling and infection have been reported (Foote, 1975). Furthermore, the bull may pass over or under the device to achieve sexual contact when the block is not properly placed. The use of such bulls as stated by Kiddy (1979) resulted in shorter mean estrous cycles and return intervals. In addition, the bulls detected some heat periods that would have been missed by ordinary visual observation (Voh,Jr. 1987).

2.4.2.4.3 Hormone-Treated Females

Treatment and maintenance regimen for estradiol (Hackett and Lin, 1985) and testosterone (Kiser *et al.*, 1977; Hackett and Lin, 1985) required to induce male-like sexual activity and maintain it for sometime in order to mark estrus cows with marking devices have been reported. Hackett and Lin (1985) showed variation in the efficiency of estrus detection ranging from 37% to 70% for the estradiol-treated and 38% to 54% for the testosterone-treated females. However, in the same study, herdsmen observed 94% compared with 51% of estrus periods by the hormone-treated females. Nevertheless, 6% of the cows not detected by herdsmen and assumed to be anestrus were detected by the treated females. Similar observation was made by Kiser *et al.* (1977) and Sawyer and Fulkerson (1981) using androgenised-females alone and concluded that hormone-treated cows with chin-ball mating device were as effective as surgically prepared bulls for detection of estrus. However, both procedures are expensive.

2.4.2.4.4 Other Techniques of Preparing Teaser Bulls

The bulls in this case cannot copulate and transmit venereal diseases but require extensive surgical approach, the methods include: Phalectomy (Frazer, 1973), anchoring penis (Belling, 1961) and deflecting penis (Royes and Bivin, 1973). They reported success with the various methods.

As a rule of thumb, 3 or 4 teasers per 100 cows are adequate (Mukasa-Mugerwa, 1989). The teaser bulls will provide 24-hour surveillance for estrus detection and may even induce estrus (Kiddy, 1979), and identify cows missed by visual observation by herdsmen (Donaldson, 1968). Nevertheless, surgical preparation of the bulls is expensive, they may lose libido and miss some animals, interpretation of marks require skills and device often runs out of marker ink (Foote, 1975).

CHAPTER THREE

THE EFFECT OF AMBIENT TEMPERATURE, HUMIDITY AND BODY TEMPERATURE ON FERTILITY RATES OF ARTIFICIALLY INSEMINATED BUNAJI CATTLE

ABSTRACT

A study of 524 artificial inseminations in 219 Bunaji cattle in a tropical climate was undertaken to determine the influence of meteorological variables, using the Temperature-Humidity index (THI) model, on conception rate (CR). Rectal and vaginal temperatures were recorded at insemination and approximately 12 hours after in 153 non-suckled Bunaji cows so as to evaluate the effect of body temperature on CR.

The mean monthly CRs declined from March to May (37.9%, 26.0% and 19.4% respectively) which were the hottest months with highest mean monthly THI (75.3, 79.4, 79.7) and highest mean monthly ambient temperature (35.8°C, 36.1°C, 35.0°C). The CR appreciated thereafter with decreasing THI. Furthermore, the individual daily THI a day following insemination was more closely correlated with CR ($r = -0.862$; $P<0.001$) than the other days observed. In addition, elevation of rectal temperature approximately 12 hours post insemination altered the CR significantly ($P<0.005$). Conception rate dropped sharply from 48.2% to 7.1% as the rectal temperature increased from 37.1°C - 39.5°C to 39.6°C - 40.2°C. Thermal stress on spermatozoa, ova, process of fertilization and developing embryo was implicated.

It was concluded that stressful environment due to heat is a constraint to efficient reproductive performance in indigenous cattle.

INTRODUCTION

Adverse environmental parameters, such as high ambient temperature and humidity, have been reported to influence the decline in reproductive efficiency of cattle (Gwazdauskas *et al.* 1973; Ingraham *et al.* 1974; Cavestany *el al.* 1985; Thatcher and Collier, 1986). Heat stress has been reported to cause deleterious effects on performance of farm animals (Fuquay, 1981; Gwazdauskas, 1985; Dupreez *et al.* 1991, 1994). Warm months were more closely associated with lower conception rates (CRs) than cool months (Gwazdauskas *et al.* 1975). In addition, the proportion of cows in which embryonic mortality occurs is believed to be much higher in the tropics than it is in the temperate zones (Scott and Williams, 1962). Mean monthly CR decreased from 55% during the months of low temperature and humidity to 10% during months of high temperature and humidity (Ingraham *et al.* 1974). Wolfenson *et al.* (1988) further observed CR to be higher in cooled than non-cooled cows (59% vs 17%).

Thermal stress prior to and post-insemination is detrimental to fertility. For instance, extreme environmental temperature and humidity 2 days preceding AI (Ingraham *et al.* 1974), a day to AI (Gwazdauskas *et al.* 1973, 1975), at AI (Dunlap and Vincent, 1971; Cavestany *et al.* 1985) and a day after (Thatcher, 1974; Zakari, 1981; Badinga *et al.* 1985; Thatcher and Collier, 1986) were inversely related to CR. Similarly, Wiersma and Scott (1969) and Scott *et al.* (1972) showed the first 4-6 days post-AI as the most critical period for thermal stress on reproductive efficiency. This corresponds with the period of passage of the ovum through the oviduct and its implantation. While Ingraham *et al.* (1976) indicated that for optimal CR, heat stress must be minimized at least 12 days prior to AI, Cavestany *et al.* (1985) observed that temperature decreased for 20 days prior to breeding accompanied higher CR. Daily climatological measurements around the time of insemination were ranked by their relative influence on conception (Gwazdauskas *et al.* 1973; Thatcher, 1974; Zakari, 1981; Stevenson *et al.* 1983; Badinga *et al.* 1985).

Ambient temperatures (AT) above 23.8°C and a RH of 80% constitute heat stress in cows (Dale *et al.* 1959; Nickerson, 1987). Hot weather conditions have been reported to delay puberty (Vincent, 1972), decrease CR (Dunlap and Vincent, 1971; Fuquay, 1981; Tucker, 1982; Badinga *et al.* 1985; Wolfenson *et al.* 1988), reduce estrus activity (Hall *et al.* 1959; Gangwar *et al.* 1965; Wolff and Monty, 1974; Thatcher and Collier, 1986), shorten duration of estrus (Monty and Wolff, 1974; Cavestany *et al.* 1985), prolong length of estrous cycle (Gangwar *et al.* 1965; Scott *et al.* 1972; Vincent, 1972), decrease mounting activity (Gwazdauskas *et al.* 1983) delay resumption of ovarian cyclicity (Bond and McDowell, 1972; Montgometry *et al.* 1985), and alter release of reproductive hormones (Mills *et al.* 1972; Madan and Johnson, 1973; Roman-ponce *et al*. 1978; Wolfenson *et al*. 1988). There was also an increase in the incidence of both silent heat (Labhsetwar *et al*. 1963; Thatcher and Collier, 1986) and anestrus (Bond and McDowell, 1972; Wolff and Monty, 1974) associated with hot weather. Severe heat stress has also been reported to cause true anestrus (Gangwar *et al*., 1965).

Extreme environmental temperature is directly proportional to hyperthermia with subsequent reduction in conception rates. As the AT exceeds 30°C, body temperature rises (Wolff and Monty, 1974) and CR drops sharply (Thatcher and Collier, 1986). A 1°C rise in rectal temperature (RT) within 12 hours after insemination decreased pregnancy rate (PR) from 61% to 45% (Ulberg and Burfening, 1967). Similar effects were observed in indigenous Zebu cattle (Zakari, 1981).

The Temperature-Humidity index (THI) is a combination of the significant climatic elements of the environment (Hahn, 1981). It is the most practical means of assessing the exposure of cattle to thermal stress (Yousef, 1985). THI of 70 and less are classified as normal while values above 70 are considered stressful to cattle (Anonymous, 1970). The relationship between THI and reproductive performance has been evaluated (Gwazdauskas *et al*. 1973, 1975; Ingraham *et al*. 1974, 1976; Thatcher, 1974; Dupreez *et al*. 1991, 1992, 1994). Ingraham *et al*. (1974) further indicated that average temperature and humidity accounted for 80% of monthly variation in CR.

There is no documented study on the effects of climatological factors particularly THI on reproductive efficiency of artificially inseminated Bunaji cattle. This study was therefore undertaken to evaluate the relationship between the combined effects of ambient temperature and humidity using the THI values, and body temperature to conception rate in a tropical climate.

MATERIALS AND METHODS

Animals

Five hundred and twenty-four (524) inseminations were performed on 219 Bunaji cattle in 2 selected privately owned and one institutional (National Animal Production Research Institute, Shika, Nigeria) farms around Zaria. The area of the study lies between latitude 11° - 11°30'N, longitude 7° - 7°45'E and on an altitude of 610 to 686m above sea level. The study was for a duration of 2 years, from February 1993 to January 1995.

Only Bunaji heifers of breeding age as well as cows aged 3-9 years that were known to be cycling normally without any history or clinical genital disorder were used. All the animals were in good body condition (BCS equal to or greater than 3; Pullan, 1978). The level of management practices such as animal husbandry, hygiene, disease prevention and control were also good and similar in all the herds that were used. A routine herd health fertility programme on the farms was under the supervision of a veterinarian.

Estrus synchronization

Estrus synchronization was carried out in 102 of the 219 animals using 25mg of prostaglandin F_2 alpha (PGF2&) analogue, Dinoprost tromethamine salt, Lutalyse (R) Upjohn Co. Michigan, MI, administered twice by deep intramuscular injection thirteen days apart (Voh,Jr. *et al*. 1987b, 1994c).

Estrus detection

All the animals were observed for heat at least twice daily from 0800 to 0900 h and 1800 to 1900 h. In addition, a vasectomized bull harnessed with a chin ball mating device (The Great Outdoors Co. Ltd., New Zealand), tail painting (All-weather paintstik (R) IU-60612) and KaMar heat mount detectors (KaMar Inc. Colo.60477) aided in estrus detection. Only cows in standing heat or showing positive heatmount detectors were considered to be in estrus.

Insemination

Two experienced inseminators carried out all the inseminations using the recto-cervical method. Deep frozen semen from one bull packaged in 0.25 French mini-straws and deep frozen in liquid nitrogen at -196°C was used for AI. Out of the 219 cattle (102 synchronized and 117 spontaneous estrus) used, a total of 524 inseminations were conducted. Cows in estrus in the morning were inseminated in the evening of the same day and cows in heat in the evening were inseminated in the morning of the following day (AM-PM AI rule). The site of semen deposition, tone of the uterus and the presence or absence of drooling mucus discharge at the time of insemination were noted.

Record of Climatological Parameters

Meteorological data were obtained at the Agrometeorological station, Department of Meteorological Services, Faculty of

Agriculture, Ahmadu Bello University (A.B.U.), Samaru, Zaria. The daily climatological measurements utilized included maximum temperature (MXT), minimum temperature (MNT), relative humidity (RH) at 0900 and 1500 h, dry bulb temperature (DBT) at 0900 and 1500 h, wet bulb temperature (WBT) at 0900 and 1500 h and dew-point (DP) at 0900 and 1500 h Greenwich Meridian time (GMT). The daily records were obtained for each month of the year throughout the 2-year study period. The distances from the meteorological station to the 3 farms were 7, 26 and 41 km.

Calculation of Temperature-Humidity Index (THI) Values

Due to the interaction of the environmental variables with each other and their effect on fertility, a measure of heat stress called the Temperature-Humidity Index (THI) model which combines the fundamental components of the environment, was adopted. Four different formulae for calculating THI were utilized and compared for their accuracy. The formulae are as follows:

1) $THI = 0.55\ DBT\ (^{\circ}F) + 0.2DP\ (^{\circ}F) + 17.5$ (Johnson, 1965)

2) $THI = 0.4\ [DBT\ (^{\circ}F) + WBT\ (^{\circ}F)] + 15$ (Johnson, 1965)

3) $THI = DBT\ (^{\circ}F) - [0.55 - 0.55\frac{RH\%}{100}]\ [DBT(^{\circ}F) - 58]$ (Kelly and Bond, 1971)

4) $THI = DBT(^{\circ}C) + 0.36\ DP(^{\circ}C) + 41.2$ (Hahn, 1981)

KEY: DBT - Dry bulb temperature
WBT - Wet bulb temperature
DP - Dew point
RH - Relative humidity
°C - Degree centigrade
°F - Degree Fahrenheit.

Using the standard international (SI) unit of measurement, the formular by Hahn (1981) in °C which also happened to be the most recent among the formulae was used in this study. The relationship between THI prior to, at and following insemination and the CRs was determined.

Measurement of body temperature

Rectal temperature (RT) and Vaginal temperature (VT) were obtained using a centigrade clinical thermometer (Smic Co. China °C) over the range of 35-42°C at insemination (T_o) and approximately 12 h post-insemination (T_1) in 153 non-suckled Bunaji cows.

Pregnancy diagnosis

This was performed by rectal palpation 35-40 days post-AI (Zemjanis, 1970).

Statistical analysis

The relationship between THI on the day prior to insemination, the day of insemination and the day following insemination and CR was determined by coefficient of correlation (Snedecor and Cochran, 1974). The same analysis was done in order to determine the influence of mean monthly THI on mean monthly CR. The effect of hyperthermia or elevated body temperature on CR was obtained by chi-square test (Snedecor and Cochran, 1974).

Graphs were used to further illustrate the relationships between the various parameters.

RESULTS

The mean monthly CR decreased from March to May, which were the hotter months with high mean monthly THI. From June, the mean CR started appreciating as the mean THI declined and it remained above 39.2% upto the following February (Table 3.1, Fig. 3.1) indicating an inverse relationship between the CR and THI (Table 3.1, Figs. 3.1, 3.2). Similarly, there was a direct relationship between the mean monthly ambient temperature and mean monthly relative humidity on the THI. As both variables increased, the THI also appreciated while the CR decreased (Table 3.1, Fig. 3.1).

The month of May, which appeared to be the most stressful month due to heat during the 2-year study period, showed the highest mean monthly THI of 79.7 with the lowest mean monthly CR of 19.4% and mean monthly ambient temperature and relative humidity of 35.0°C and 56.1% respectively. In contrast, January had low mean THI of 66.8 and mean CR, ambient temperature and relative humidity of 61.1%, 28.9°C and 23.6%, respectively (Table 3.1, Fig. 3.1).

Correlation coefficient (r) for CR versus the day prior to insemination, at the day of insemination and a day post insemination were ($r = -0.647$; $P<0.001$), ($r = -0.766$; $P<0.001$) and ($r = -0.862$; $P<0.001$) respectively. Test of significance and magnitude of the correlation coefficient revealed that day post insemination was the most significant and critical. Mean monthly CR and mean monthly THI were also significantly correlated $r = -0.828$ ($P<0.001$).

The pattern of THI values obtained in 1993 and 1994 were quite similar (Fig. 3.3). A peak THI was attained in May of both years and the lowest values in January 1993 and December 1994.

The THI using the 4 different formulae were shown graphically in order to ascertain the relationships. Their closeness was illustrated, particularly 1 and 4 (superimposing on each other), and 2 and 3 (Table 3.3, Fig. 3.4).

Considering THI of 76.0 as the critical level (Ingraham *et al.* 1974), and the range of THI values obtained in this study, individual daily THIs were classified and the corresponding CR within each class calculated as follows: THI 70 or less = 68.4%, 71 to 75 = 51.7%, 76 to 80 = 36.4% and 80 and above = 8.2% (Table 3.4). Daily THI during the 2-year study period ranged from 58.0 to 89.2.

An increase in AT resulted in a corresponding increase in both RT and VT (Table 3.5, Figs. 3.5, 3.6). Similarly, there was a significant difference ($X^2 = 21.5$, $P<0.005$) in CR between cows that had an increase in rectal temperature approximately 12 hours post insemination (RT_1) and those that did not. A total of 153 non-suckled Bunaji cows were sampled for RT_o, RT_1, VT_o and VT_1. Out of the 70 cows that showed increased RT_1, 19 (27.1%) conceived while 51 (72.9%) failed to conceive. On the other hand, 55 of the 83 cows (66.3%) that did not show hyperthermia post insemination became pregnant while 28 (33.7%) did not (Table 3.6). The mean (± S.D) for RT_o and RT_1, and VT_o and VT_1 were 39.12±0.68°C and 39.20±0.61°C, and 39.20±0.76°C and 39.37±0.74° respectively.

Furthermore, CR dropped from 48.2% at RT of 37.1-39.5°C to 7.1% as the RT increased from 39.6-40.2°C.

DISCUSSION

The decline in CR observed in the hotter months and the increase in CR in the cooler months in this study are in agreement with reports from elsewhere (Scott *et al.*, 1972; Monty and Wolff, 1974; Thatcher, 1974; Badinga *et al.*, 1985; Cavestany *et al.*, 1985 and Wolfenson *et al.*, 1988). Cavestany *et al.* (1985) showed that temperatures around 33°C were associated with low CR. In addition, Thatcher (1974) noted that cattle breed throughout the year, but at ATs above the critical of 21°C, CRs were depressed. Fuquay (1981) reported thermoneutral zone for cows as 28°C. The practical application of this is that many dairymen reduce or even stop breeding their animals during the hot summer months in order to avoid waste of valuable semen (Wiersma and Scott, 1969; Monty and Wolff, 1974).

Any of the THI formulae could be used due to the closeness of their values (Fig. 3.4). However, THI = DBT (°C) + 0.36 DP(°C) +41.2 (Hahn, 1981) was chosen for reasons already stated. The THI is an index in which environmental determinants are expressed as a measure of stress, it is inversely related to CR (Fig. 3.2). Although February had the lowest THI, the CR was lower than in December. This may be due to the greater number of observations in December (Table 3.1). This pattern of relationship (THI vs CR) is similar to what was obtained by Gwazdauskas *et al.* (1973), Ingraham *et al.* (1974, 1976), Thatcher (1974) and Dupreez *et al.* (1991, 1992, 1994). The negative correlation between mean monthly CR and mean monthly THI was reported by Ingraham *et al.* (1974) and Dupreez *et al.* (1994).

In indigenous cattle, Zakari (1981) reported the pregnancy rate (PR) of animals inseminated during the dry (January to March), pre-rainy (April to May), rainy (June to September) and pre-dry (October to December) seasons as 21, 18, 57 and 28% respectively. The PRs were higher in the rainy and pre-dry seasons which represented the cooler months and very low (18%) during the pre-rainy season i.e. the critical period which constituted the hotter months. Similar observations were made by Osori (1976), Voh,Jr. *et al.* (1984a) and Dawuda *et al.* (1987). The results of the present study tend to agree with the previous findings. Likewise, the estrus activity in this trial followed the same trend in which lower number of animals were inseminated in the hotter months and higher number in the cooler months (Table 3.1). Hurnik *et al.* (1975) observed that estrus usually occurred in the night (cooler period) and it might be easily missed. If it, occurred during the hot day, cattle were inactive resulting in decreased estrus detection and fertility rate (Thatcher and Collier, 1986). Therefore, cows must be observed more often for estrus in the hot season (Gangwar *et al.* 1965; Monty and Wolff, 1974; Zakari, 1981; Voh,Jr. 1984b). The reduced estrus activity lowers metabolic heat production which further reduces body heat load during the thermal stress (Wolff and Monty, 1974; Thatcher and Collier, 1986). This may be beneficial to cattle and therefore a mechanism by which cattle attempt to keep body temperature low.

Most researchers attributed nutritional effect to be responsible for the poor reproductive performance in the dry and pre-rainy seasons. Nutrition was possibly the only predisposing factor in the current study since the cattle maintained a BCS of 3 and above (Pullan, 1978) during the hotter critical months. This satisfies the nutritional needs of the animals for desirable growth and optimal reproductive function. Inspite of the good nutritional status of the animals, their CRs were poor suggesting that heat stress might be a fundamental component responsible for the lowered reproductive function.

Similarly, Gwazdauskas *et al.* (1975) reported greater influence of climatological factors on reproductive performance than nutritional and management factors. In addition, the animals were also cycling normally as examined per rectum (Zemjanis, 1970) prior to commencement of this study. Likewise, AI was conducted throughout the trial which precluded the effect of bull or natural mating. Furthermore, the semen used was from a progeny-tested bull and was well preserved in liquid nitrogen which was regularly evaluated and properly handled during insemination. Thus, all the likely factors that may limit reproductive efficiency were properly taken care of, so that environmental parameters can be evaluated rationally. Thus, thermal stress seems to be the most likely factor for the poor reproductive performance observed during the heat stressful periods.

In contrast to observations by other researchers and also the current study, Voh,Jr. and Otchere (1989) reported higher conceptions in agropastoral herds between March and May which are considered the hottest months. It then declined from early rainy season to low conception during the peak of rains. They attributed their findings to the availability of crop residues in the study area that extends to the end of March. Similarly, in the wet season, low performance observed could be due to consequences of the herdsmen engaging themselves in cropping their farmlands resulting in shorter grazing time for their animals since the cattle are not taken out for grazing early (Bayer and Otchere, 1982; Voh,Jr. and Otchere, 1989). Wilson (1946) studying seasonal effects on reproduction in Zebu cattle in Nyasaland, Tanzania and Steinbach and Balogun (1971) evaluating seasonal variations in the CR of beef cattle in Southern Nigeria made similar observations with those of Voh,Jr. & Otchere (1989).

Individual daily THIs of 70 or less showed a high CR of 68.4% in the current trial. Anonymous (1970), Ingraham *et al.* (1974) and Dupreez *et al.* (1994) reported THI of 70 or less as normal and as the thresthold for normal reproductive performance. Likewise, Yousef (1985) and DuPreez *et al.* (1994) indicated that dairy cattle showed optimal performance, experience no significant heat stress and are not adversely affected by handling within the normal range of THI values of upto 70. However, values above 70 are stressful to cattle which may affect their normal reproductive function. This contrast with the findings in this study in which CR only declined drastically as from THI of 76 (Table 3.4). This implies that Nigerian Bunaji cattle may be more heat tolerant. Furthermore, the range of THI and corresponding CR in this study showed that THI of 75 may be the threshold for optimum reproductive function (Table 3.4). This tends to agree with reports by Ingraham *et al*. (1974) that THI of 76 and above may be the critical THI for the average animal at which physiological responses began to change and only 21% CR was obtained. Similarly, Anonymous (1970) considering the amount of heat stress and performance of the animals categorised THI between 71-78 as alert, 79-83 as danger and above 83 as emergency levels.

Gwazdauskas *et al*. (1973) reported the THI a day post insemination as the most critical followed by the THI on the day of insemination and then the day prior to insemination. The results of the current study are in consonance. Similarly, Thatcher (1974) reported that average ambient temperature day after AI exceeding 30°C was significantly correlated with conception than average ambient temperature the day of insemination. However, Ingraham *et al*. (1974) demonstrated that THI 2 days prior to AI as the most significant. Although THI of only 3 days around the time of insemination were considered in this study and recorded negative influence on conception, it may show the same effect for several subsequent days prior to and post insemination in adverse weather conditions as demonstrated by Wiersma and Scott (1969), Scott *et al*. (1972), Ingraham *et al*. (1976) and Cavestany *et al*. (1985). The effects observed the days pre- and post-insemination due to heat stress are probably as a result of increase (Dunlap and Vincent, 1971; Gwazdauskas *et al.* 1972; Mills *et al.* 1972; Thatcher, 1974) or decrease (Rosenberg *et al.* 1977; Wolfenson *et al.* 1988) in the progesterone levels, decrease in estrogen (Roman-ponce *et al.* 1978) and leutinizing hormones (Madan and Johnson, 1973). Increase progesterone concentration around the time of insemination retards early embryo cleavage (Dickman, 1970). Roman-ponce *et al.* (1978) reported that thermal stress reduced the estradiol-induced increase in uterine blood flow which might increase the uterine temperature (UT) and perhaps negatively affect availability of water, nutrients, electrolytes and hormones to the developing embryo in the uterus.

The association between extreme AT and elevated BT observed in this trial (Table 3.5, Figs. 3.5 & 3.6) is in line with reports by Branton *et al.* (1953), Bianca (1968), Dunlap and Vincent (1971) and Gwazdauskas *et al.* (1973). Bianca (1968) further observed that as from AT of 21.1°C and above, deep BTs began to rise. In addition, Ulberg and Burfening (1967) and Gwazdauskas *et al.* (1973) reported that the deleterious effect of high AT do not occur if body temperatures of the cows do not increase.

In a review of Effects of Climate on Reproduction in Cattle, conception rates of 40 to 80% were recorded with RT of 38.4 to 39.1°C in mild natural environments. The CRs ranged from 10 to 51% and RT 38.7 to 40.1°C in hot conditions (Gwazdauskas, 1985). In indigenous Bunaji and Bokoloji cattle in Nigeria, Zakari (1981) reported a decline in CR from 52% at RT of 38.2 to 39.1°C to 12% at

RT of 39.2 to 40.0°C. These observations agree with findings in this current study in which CR dropped from 48.2% at RT 37.1 to 39.5°C to 7.1% with RT between 39.6 and 40.2°C. The critical RT in Bunaji cattle from this investigation was considered to be 39.5°C.

The overall RTs ranged from 38.6 to 39.9°C. It was higher than value of 38.3 to 39.1°C reported by Bianca (1968) and Gwazdauskas *et al.* (1973), and 38.2-38.6°C observed by Monty and Wolff (1974) in lactating dairy cows in cool weather. However, RTs of 39.3 to 40.5°C (Monty and Wolff, 1974) and 38.7 to 40.1°C (Gwazdauskas, 1985) in hot weather conditions were higher than our findings. The overall VTs (38.5 to 40.0°C) were slightly greater (0.1°C) than the RTs recorded in this study. Gwazdauskas *et al.* (1973) and Wolff and Monty (1974) also found UTs to be higher than RTs.

Failure of some animals with elevated rectal temperature 12 h after insemination to conceive (Table 3.6) concurs with reports by Ulberg and Burfening (1967). Similarly, Thatcher (1974) showed that uterine temperature on the day of AI and approximately a day after AI had great influence on conception. The reduced fertility in such animals may be attributed to high temperature acting directly on the spermatozoa (Bishop, 1964; Ulberg and Burfening, 1967; Burfening and Ulberg, 1968) or ova (Ulberg and Burfening, 1967) prior to fertilization, or on the early developing embryo (Alliston and Ulberg, 1961; Alliston *et al.* 1965; Dunlap and Vincent, 1971). However, some cows (27.1%) (Table 3.6) conceived despite increased in RT 12h post insemination in this trial. Such cows may be heat tolerant and can therefore be considered in selection exercise.

From the current study it was concluded that adverse environmental factors measured in the form of THI and the subsequent increase in body temperature have detrimental effects on fertility of artificially inseminated Bunaji cattle particularly in the hotter months. Furthermore, THI of 75 may be the thresthold for optimum reproductive function, values above which CR declined drastically. Breeding during the heat stressful period may therefore be avoided especially where AI scheme is practised, so that valuable semen is not wasted. It is also recommended that during the same harsh period, animal husbandry and management practices such as feeding high energy and concentrate diets, provision of cool drinking water ad libitum and modification of environment by provision of shade should be encouraged in order to ameliorate the effect of the thermal stress, improve on CR and meet the expected level of production.

Table 3.1: Meteorological data, the resultant THI, the corresponding CR and the number of observations in 219 Bunaji cattle during the study period

Month	Mean monthly ambient temperature (°C)	Mean monthly relative humidity(%)	Mean monthly THI	Mean monthly CR (%)	Number of observations (n)
FEB. 1993/94	31.7	17.3	63.3	51.6	40
MAR. 1993/94	35.8	26.2	75.3	37.9	27
APR. 1993/94	36.1	40.5	79.4	26.0	33
MAY 1993/94	35.0	56.1	79.7	19.4	29
JUN. 1993/94	31.3	63.1	77.6	32.9	41
JUL. 1993/94	29.2	70.9	76.5	46.9	49
AUG. 1993/94	27.9	76.7	73.9	60.3	55
SEP. 1993/94	29.7	73.0	75.7	49.7	46
OCT. 1993/94	31.8	70.2	76.1	39.2	38
NOV. 1993/94	31.9	35.4	72.9	57.1	57
DEC. 1993/94	28.0	29.7	67.3	64.3	66
JAN. 1994/95	28.9	23.6	66.8	61.1	43
TOTAL					524

Table 3.2 The mean monthly THI values for 1993 and 1994

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JULY	AUG.	SEP	OCT	NOV	DEC.
Mean THI (1993)	63.3	69.9	75.1	79.3	79.5	77.9	77.2	74.8	76.9	76.2	73.2	69.0
Mean THI (1994)	67.7	66.7	75.5	79.4	79.8	77.3	75.8	73.1	74.4	76.0	72.6	65.5

Table 3.3: Comparison of the mean monthly THI values using the 4 different formulae adopted in this study

FORMULAE FOR THI	FEB. 1993/94	MAR. 1993/94	APR. 1993/94	MAY 1993/94	JUN. 1993/94	JUL. 1993/94	AUG. 1993/94	SEP. 1993/94	OCT. 1993/94	NOV. 1993/94	DEC. 1993/94	JAN. 1994/95
$THI=0.55DBT(^{\circ}F)+0.2DP(^{\circ}F)+17.5$ Johnson (1965)-(1)	68.35	75.29	79.33	79.62	77.62	76.55	74.00	75.69	76.08	72.93	67.32	66.87
$THI=0.4[DBT(^{\circ}F)+WBT(^{\circ}F)]+15$ Johnson (1965)-(2)	70.91	76.05	80.30	80.42	78.36	77.13	74.88	76.48	76.95	73.29	68.86	68.60
$THI=DBT(^{\circ}F)-[0.55-0.55\frac{RH(\%)}{100}][DBT(^{\circ}F)-58]$ Kelly and Bond (1971)-(3)	70.98	76.08	79.96	80.63	78.79	77.40	75.05	76.80	77.24	73.51	69.04	68.82
$THI=DBT(^{\circ}C)+0.36DP(^{\circ}C)+41.2$ Hahn (1981)-(4)	68.33	75.30	79.35	79.65	77.61	76.53	73.94	75.66	76.12	72.89	67.27	66.82

Table 3.4 Classification of daily THI values into various categories

THI	CR (%)
70 or less	68.4
71 - 75	51.7
76 - 80	36.4
>80	8.2

THI - Temperature-humidity index

CR - Conception rate

Table 3.5: Changes in the Rectal and Vaginal temperatures of 153 non-suckled Bunaji cows at insemination associated with increased ambient temperature

AMBIENT TEMPERATURE (°C)	RECTAL TEMPERATURE (°C) (MEAN±S.D)	VAGINAL TEMPERATURE (°C) (MEAN±S.D)	NUMBER OF OBSERVATIONS (n)
23	37.55±0.64	37.75±0.55	22
24	-	-	-
25	38.25±0.53	38.23±0.54	14
26	38.45±0.07	38.75±0.05	22
27	38.41±0.47	38.52±0.50	23
28	38.37±0.32	38.60±0.36	11
29	38.66±0.45	38.81±0.46	12
30	38.79±0.19	38.96±0.34	11
31	38.85±0.34	38.97±0.36	6
32	39.30±0.14	39.46±0.40	9
33	39.62±0.32	39.80±0.20	4
34	39.40±0.50	39.37±0.45	3
35	39.69±0.30	39.65±0.28	7
36	39.65±0.15	39.79±0.35	4
37	39.85±0.19	39.94±0.17	3
38	39.97±0.37	40.06±0.18	2
MEAN	**39.12±0.68**	**39.20±0.76**	**TOTAL 153**

Table 3.6: **Relationship between mean monthly CR and increase or no increase in rectal temperature (°C) approximately 12h post-A.I recorded from 153 non-suckled Bunaji cows**

	PREGNANT	**NOT PREGNANT**	**TOTAL**
Increase in Rectal Temperature 12 h post-A.I	19(27.1)	51(72.9)	70
No increase in Rectal temperature 12h post-A.I	55(66.3)	28(33.7)	83
TOTAL	**74**	**79**	**153**

% in parentheses

X^2 = 21.5 ($P<0.005$).

FIG. (3.1): THE INTERACTION OF MEAN VALUES OF MONTHLY CLIMATIC CONDITIONS, MONTHLY TEMPERATURE-HUMIDITY INDEX (THI) AND MONTHLY CONCEPTION RATE (CR) DURING THE STUDY.

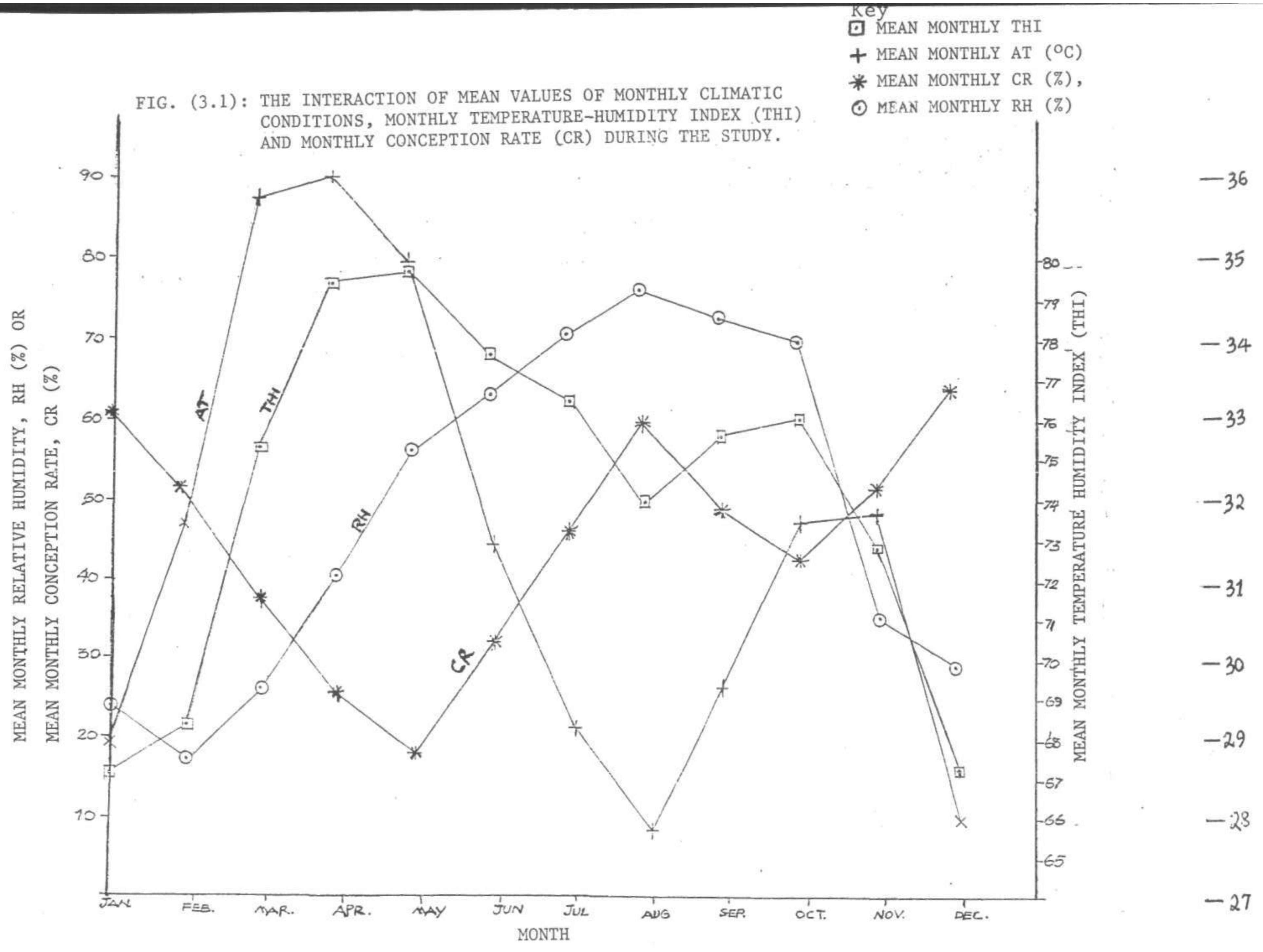
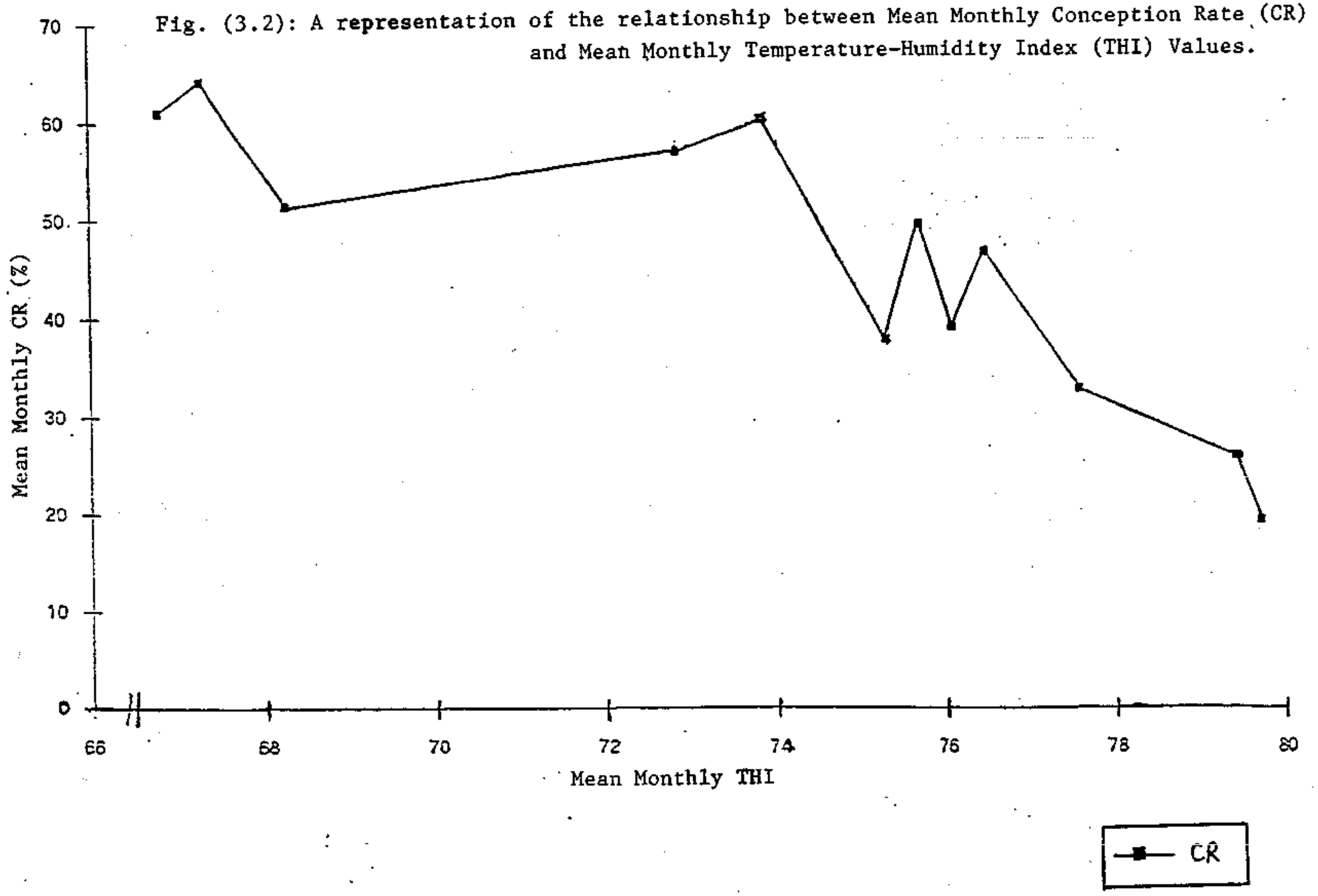


Fig. (3.2): A **representation** of the relationship between Mean Monthly Conception Rate (CR) and Mean Monthly Temperature-Humidity Index (THI) Values.



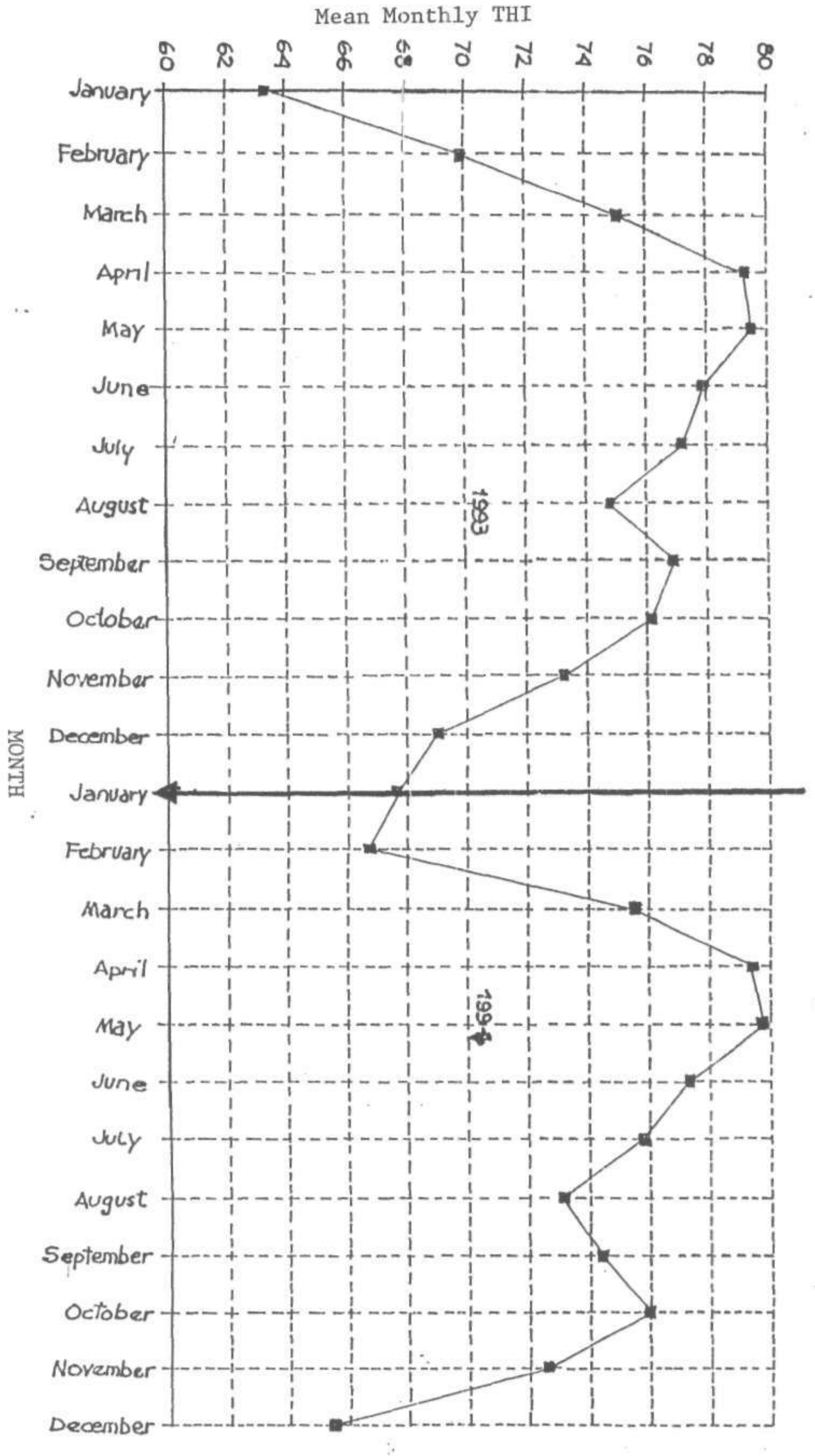
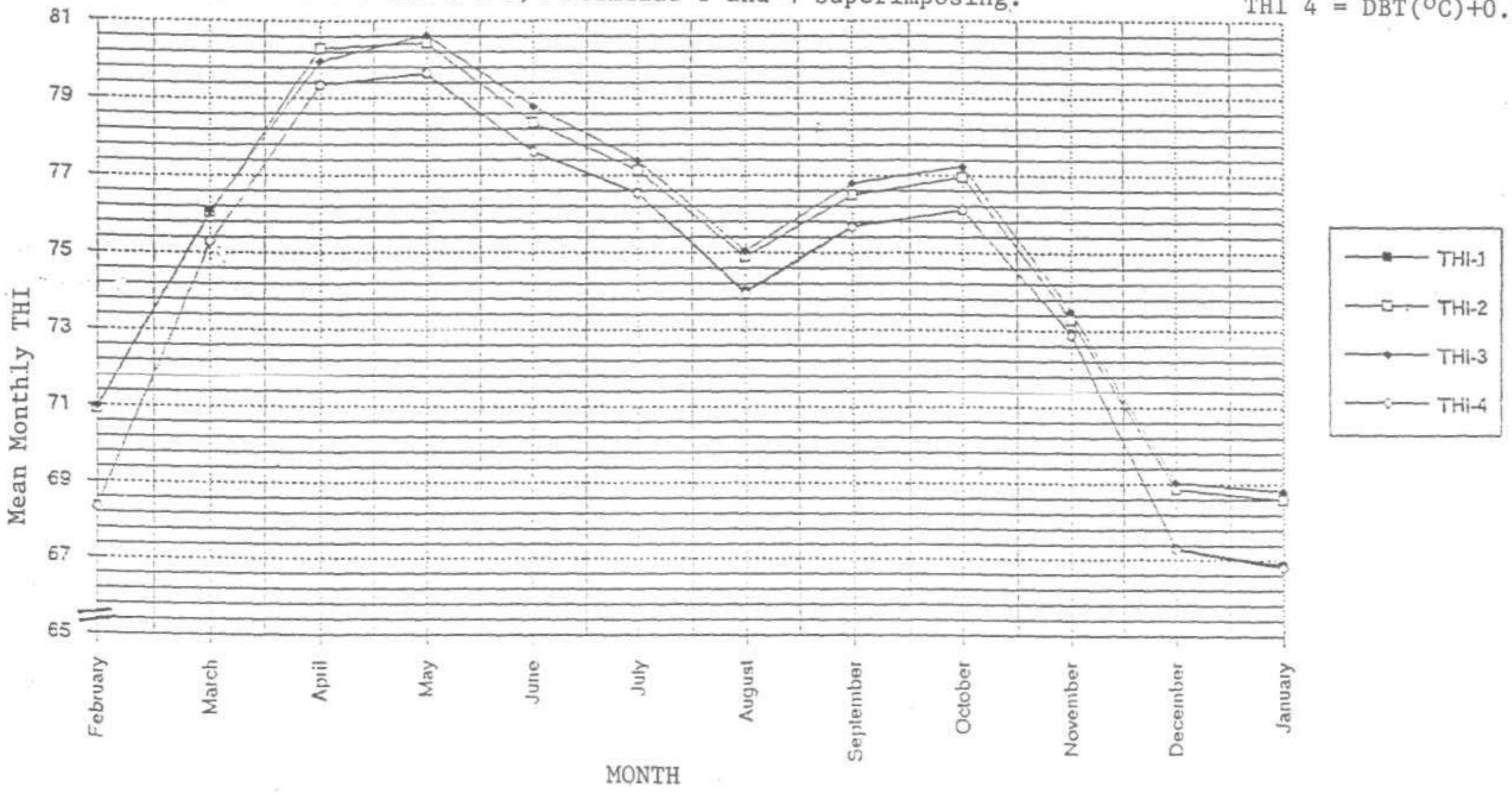


Fig. (3.3) Association of the Temperature-Humidity index (THI) Recorded in 1993 and 1994

Fig. (3.4) The Relationship of the Four Different Formulae for the 2-year study period.
(Note 1 & 4 and 2 & 3): Formulae 1 and 4 superimposing.



THI 1 = $0.55DBT(^{o}F)+0.2DP(^{o}F)+17.5$ Johnson(1965)

THI 2 = $0.4((DBT(_{o}F)+WBT(^{o}F))+15$ Johnson (1965)

THI 3 = $DBT(^{o}F)-[0.55.0.55\frac{RH\%}{100}](DBT(^{o}F)-58)$ Kell Bond (1971)

THI 4 = $DBT(^{o}C)+0.36DP(^{o}C)+41.2$ Hahn (1981)

Fig. (3.5) **The Ambient Temperature Effects on the** Rectal Temperature of 153 non-suckled Bunaji Cows

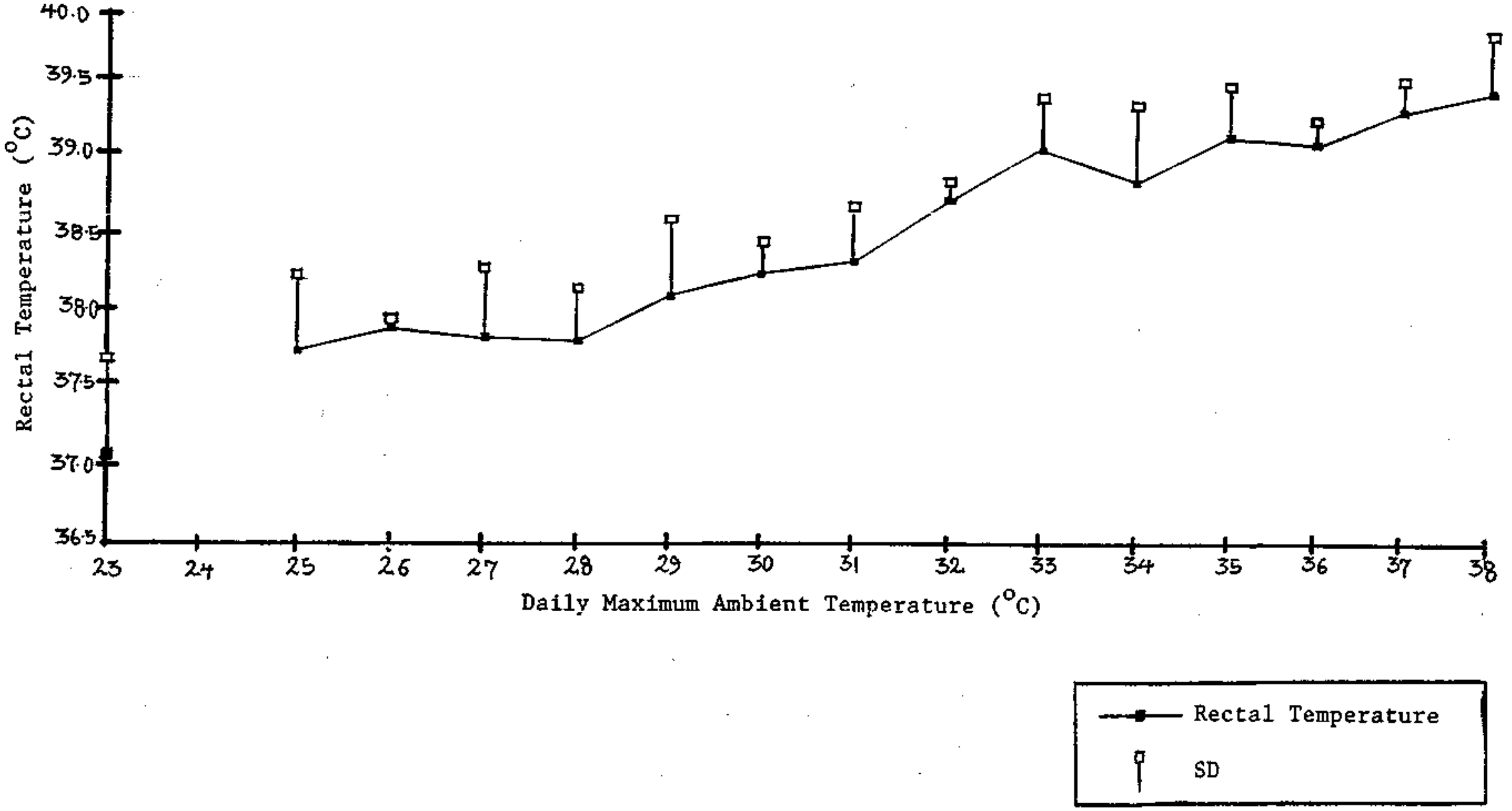
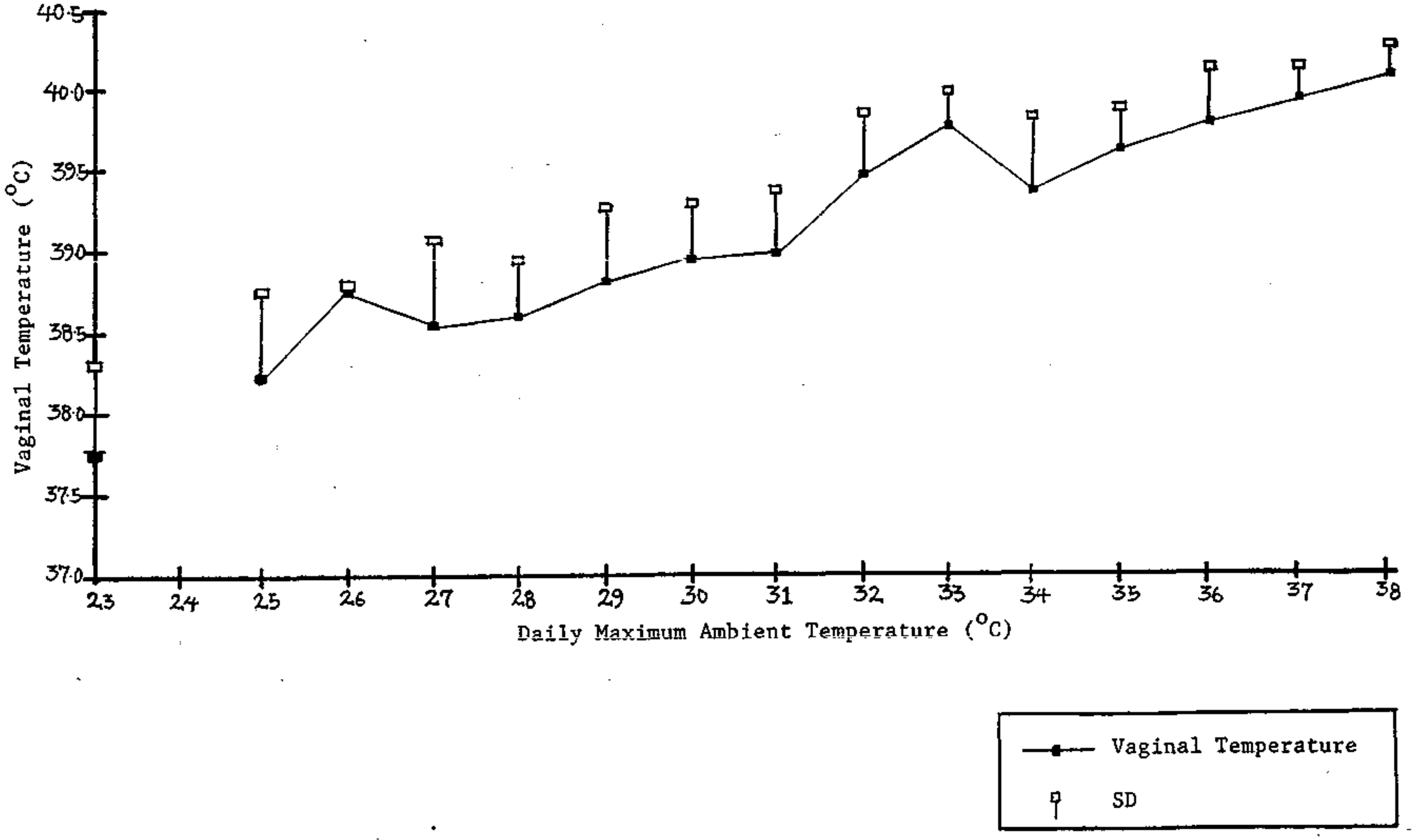


Fig. (3.6): The Ambient Temperature Effects on the Vaginal Temperature of 153 non-suckled Bunaji Cows



CHAPTER FOUR

THE INCIDENCE OF LUTEAL PHASE INSEMINATIONS IN INDIGENOUS BUNAJI COWS

ABSTRACT

Peripheral serum progesterone concentrations (SPC) at insemination determined by a solid phase non-extraction Radioimmunoassay (RIA) method showed that out of 122 inseminations carried out in 93 Bunaji cows, 16 (13.1%) were luteal phase inseminations (LPI). Variations in the post-service interval ranged between 4 and 51 days during the study. The conception rate (CR) of the affected animals was very poor, although most of the cows conceived eventually. The estrus detection rate (69.9%) and overall fertility rate (47.5% CR) were considerably low. Seasonal effects and poor estrus detection were attributed to the poor reproductive performance. Some of the factors that are likely to be responsible for LPI include management and **'phantom heats"**.

The results of the study confirmed the incidence of luteal phase inseminations in Bunaji cattle and may contribute to the low conception rates observed in artificial insemination programmes.

INTRODUCTION

In order to achieve optimum reproductive performance particularly in an artificial insemination (AI) programme, correct timing of insemination is essential (Robbins *et al.* 1978; Watson and MacDonald, 1984; Voh,Jr. *et al.* 1994b). High conception rates (CRs) will occur only when cattle are inseminated at the appropriate time in relation to ovulation (Aschbacher *et al.* 1956; Fields *et al.* 1975; Foote, 1975; Zakari, 1981; Dawuda *et al.* 1987). A significant number of cows are presented for insemination at a stage of the estrous cycle incompatible with good CR (Mylrea, 1962; Williamson *et al.* 1972a; King *et al.* 1976). Inseminations in the luteal phase resulted in failure of conception (Erb *et al.* 1976; McCaughey and Cooper, 1980; Oltner and Edqvist, 1981).

Fertile inseminations were observed with basal progesterone (P4) levels. Values below 1.0ng/ml (Jaster *et al.* 1982; Coppens *et al.* 1987) and less than 0.5ng/ml (Appleyard and Cook, 1976; McCaughey and Cooper, 1980) were demonstrated in successful inseminations. Oyedipe *et al.* (1986) reported that serum P4 level equal to or greater than 1.0ng/ml is indicative of luteal activity in Bunaji cows.

Hoffman *et al.* (1976) observed the incidence of luteal phase inseminations (LPI) to be 22% in 260 cows studied. Bulman and Lamming (1978) also reported a figure of 20%, while Cavestany and Foote (1985) found 11% of 427 cows having high levels of P4 at insemination. Lower rates have also been reported. Appleyard and

Cook (1976) showed only 6 cows (4.3%) had luteal activity at the time of insemination out of 141 cows examined. Similar results were obtained by McCaughey and Cooper (1980), Oltner and Edqvist (1981) and Laitinen *et al*. (1985).

Incorrect identification and failure to detect estrus in which cows in heat are not being observed and then incorrectly identified at some stage in the subsequent diestrus may result in luteal phase insemination (Hoffman *et al*., 1976; Cavestany and Foote, 1985; Noakes, 1986). Apart from actual errors in diagnosis of estrus, inadequately marked cows could be inseminated through mistaken identity (Foote, 1975; Appleyard and Cook, 1976), or because of a breakdown in communication between farm staff and inseminator (Appleyard and Cook, 1976). An estimated 10% error in cow identification has been reported (Esslemont, 1973).

Furthermore, pregnant and cyclic diestrus cows sometimes manifest estrus (Williamson *et al*. 1972a; Bulman and Lamming, 1978; Ball *et al*. 1983; Peters, 1985) and such cows could be erroneously inseminated during the luteal phase.

There is a paucity of information on the extent to which Bunaji cows are inseminated when they are not in estrus. This study was aimed at determining the incidence as well as the significance of luteal phase insemination on conception rates in artificially inseminated Bunaji cows.

MATERIALS AND METHODS

Ninety-three (93) normally cycling Bunaji cows aged between 5 and 9 years belonging to the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Zaria, Nigeria, were used during the study period.

The animals grazed sown and unsown pastures and crop residues, in addition to supplementary feeding of concentrates in the dry season. Likewise, all cows had free access to water and mineral salt lick. Body condition was determined as described by Pullan (1978).

Where estrus synchronization was employed, two intramuscular (IM) injections of 25mg PGF2& (Lutalyse(R) Upjohn Co.) at 13 days interval were given (Voh,Jr. *et al.* 1987b, 1994c). Visual estrus detection for 1h was carried out two times a day at 0800 and 1800 h. Other estrus detection aids, namely, tail-painting, KaMar heat mount detectors and vasectomized bull harnessed with a chin-ball mating device were applied at the time of second PGF2& injection. Both natural and induced estrus were studied. Cows exhibiting heat were immediately recorded in pocket note books by herdsmen. Records from herdsmen were collated into log books.

Inseminations were carried out by an experienced inseminator approximately 12 hours following estrus using the recto-cervical method with deep frozen semen stored in liquid nitrogen at-196°C. Animals that failed to conceive were re-inseminated as they showed heat.

Blood samples were collected via the jugular vein on the day of AI and day 21 post-insemination for analysis of progesterone. Serum which was obtained by centrifugation of the blood samples at 3000rpm for 15 minutes, was deep frozen at -20°C until assayed. Solid phase non-extraction I^{125}-RIA technique (Diagnostic product corporation DPC, California 90045) was used to determine serum progesterone concentration. Serum progesterone level at AI confirmed LPI. Cows with Progesterone levels greater than or equal to 1.0ng/ml were in the luteal phase hence the insemination considered a LPI.

Pregnancy was determined by progesterone level at day 21 after insemination. In addition, pregnancy diagnosis in all animals that did not return to estrus was confirmed by rectal palpation 35-40 days later by recognising the fetal membranes as the **"fetal membrane slip"** and occasionally palpating the amniotic vesicle (Zemjanis, 1970; Voh,Jr. *et al.*, 1994d).

RESULTS

A total of one hundred and twenty-two (122) inseminations were carried out during the study using 93 Bunaji cows, out of which 65 (69.9%) exhibited estrus (Table 4.1).

From the serum progesterone levels, 16(13.1%) of the total inseminations were conducted during luteal phase (Table 4.1).

The interval from one estrus to another estrus exhibited or incorrectly identified during the luteal phase (LPI) ranged from 29 to 36 days. Those serviced in the luteal phase returned to estrus between 4 and 15 days period. However, cows that failed to conceive in the same group, inspite of detection of estrus and AI manifested estrus 22 to 51 days later. Eleven of the affected cows eventually conceived before the end of the experiment. One cow was observed to have conceived to the luteal phase insemination (LPI).

DISCUSSION

The results revealed the occurence of LPI in Bunaji cattle. The incidence of LPI of 13.1% obtained in this study tended to agree with those of Hoffman *et al.* (1976), Bulman and Lamming (1978) and Cavestany and Foote (1985) who reported 15-22%, 20% and 11% respectively using milk progesterone levels. It is also in consonance with the assertion by Williamson *et al.* (1972a), Appleyard and Cook (1976) and King *et al.* (1976) that 10-22% of cows are presented for insemination when they are not really in estrus.

However, the finding is at variance with the 4.0% (Oltner and Edqvist, 1981), 4.3% (Appleyard and Cook, 1976) and 4.6% (Laitinen *et al.* 1985) reported earlier. Except Appleyard and Cook (1976) who used plasma, the other two authors used milk P4.

The overall LPI rate of 2.6% observed by Voh,Jr. *et al.* (1994a) in Bunaji cows is much lower than our findings in the same breed. This could be due to the method of determining luteal phase insemination in the 2 studies.

The service interval of 29 to 36 days recorded may very well mean that one estrus was missed and the cow erroneously identified as being in estrus. This range conforms with 25 to 35 days observed by Noakes (1986). Roche *et al.* (1978) in temperate breeds in Ireland and Voh,Jr. *et al.* (1994a) in tropical breeds in Nigeria reported cows not in estrus at the time of insemination returning less than 8 days or between 11 and 16 days. It agrees with this finding in which insemination at the luteal phase and next estrus spanned 4 to 15 days. Laitinen *et al.* (1985) reported that re-insemination within 4 days was considered to be performed at the same estrus. Furthermore, Bulman and Lamming (1978) showed that short intervals of <18 days occur in LPI and cows inseminated during midcycle exhibited service intervals of 8-12 days, which is also consistent with our result. However, MacMillan and Watson (1971), Roche *et al.* (1978) and Voh,Jr. *et al.* (1994a) indicated that 8 to 9 days post AI represent genuine short cycles.

Intervals between estrus of 22 to 51 days observed in this study indicate failure to detect estrus. Similar trends were observed in previous studies (Erb and Holtz 1958; Noakes, 1986; Dawuda *et al.* 1989).

The cows inseminated during the luteal phase and returning to estrus 8-12 days thereafter in this study may imply that they manifested "phantom heat" during the luteal phase as a result of secondary estradiol peak due probably to increased follicular activity of midcycle follicles (Smith *et al.* 1975; Ball *et al.* 1983). The service interval observed is also in agreement with reports by Bulman and Lamming (1978). Result of estradiol assay at A.I is needed in order to confirm more reliably this assertion. In addition, pregnant (Salisbury and VanDemark, 1961; Williamson *et al.* 1972a; Bulman and Lamming, 1978) as well as non-pregnant cyclic cows in luteal phase of the estrous cycle (Glencross *et al.* 1973; Smith *et al.* 1975; Ball *et al.* 1983; Peters, 1985) have been reported to exhibit estrus.

Other reasons advanced as responsible for LPI include mistaken identity and incorrect recordings as a result of poor identification of the animals (Foote, 1975; Appleyard and Cook, 1976; Ball *et al.* 1983). It is worthy to note that the breeding protocol practiced in which cows observed in estrus in the morning are not inseminated immediately but delayed until evening and vice versa may also contribute to incorrect identification and hence insemination of animals which may be in luteal phase.

All the affected cows in the current investigation had progesterone values >1.0 ng/ml at insemination indicating luteal activity (Oyedipe *et al.* 1986). None of them conceived at that level of P4 which agrees with reports by McCaughey and Cooper (1980), Jaster *et al.* (1982) and Coppens *et al.* (1987). However, one cow unusually conceived when her P4 level was 1.88 ng/ml. This is in contrast with reports by Erb *et al.* (1976) and Oltner and Edqvist (1981). Nevertheless, it is in line with findings by Appleyard and Cook (1976) and Bulman and Lamming (1978) who noted conception with atypical progesterone profile. The 78.6% conception rate (11 of 14) of the affected animals before the termination of this study conforms reasonably with Bulman and Lamming (1978) who showed 3 out of 4 such cows eventually conceived.

There is no significant difference between PGF2&-induced and natural luteohysis and P4 Profile (Dobson *et al*. 1975; Adeyemo and Heath, 1980; Oyedipe *et al* 1986; Voh,Jr. *et al* 1987d), and fertility rates (King *et al*. 1982; Voh,Jr. *et al*. 1987a). The estrus detection rate in the current study therefore combined both PGF2&-induced and natural estrus responses. The estrus detection rate was low (69.9%), so also was the conception rate (47.5%) obtained (Table 4.1) compared to figures of 89.1% estrus response rate (ERR) and 58.6% conception rate (Voh,Jr. *et al*. 1994c) using the same breed, synchronization regime and AI protocol. Low estrus and fertility rates were attributed to poor heat detection (Zakari, 1981; Garcia, 1988; Dawuda *et al*. 1989), and seasonal or environmental or nutritional effects (Rakha and Igboeli, 1971; Zakari, 1981; Pathiraja *et al*. 1986; Voh,Jr. *et al*. 1987d) among other factors. In this study, estrus detection, particularly in animals that did not have estrus detection aids was low, although they were maintained at the desired nutritional level through out the trial. Therefore, season or adverse weather conditions and to some extent efficiency in estrus detection may be the contributory factors to the poor estrus detection and subsequent low conception rate. Voh,Jr. *et al*. (1994c) concluded that variable results in terms of estrus response and fertility rates are to be exprected even under the most controlled conditions.

The serum progesterone concentrations and service intervals indicate that management errors in heat detection on the part of the herdsmen/observers as well as **"phantom heats"** may be responsible for the LPI.

In conclusion, this study confirmed the existance of luteal phase insemination in Bunaji cows and may contribute to the long interval between estrus, long service to conception and subsequent calving intervals experienced in Nigerian cattle thereby limiting their reproductive efficiency. There is therefore, a need to improve on estrus detection by proper training and careful observation of estrus by herdsmen, adequately record the identity of any estrus cow as they are observed, adopt a routine and well-organised post-partum herd health fertility programme and most importantly employ heat detection aids to enhance estrus detection.

Table 4.1: Estrus detection and overall fertility data of 93 Bunaji cows during the study

Total number of animals	Number detected in estrus	% in estrus (estrus detection rate)	Number of inseminations	Incidence of LPI	Number of cows pregnant	% conception rate (CR)	Number of cows conceiving to 1st service	% first service conception rate (FSCR)	Number of services per conception (NSC)
93	65	69.9	122	16(13.1%)	58	47.5	27	41.4	2.10

Cows showing P_4 level greater than 1.0ng/ml at insemination were considered in luteal phase.

CHAPTER FIVE

THE EFFICIENCY AND SIGNIFICANCE OF SOME SELECTED METHODS OF ESTRUS DETECTION AIDS IN BUNAJI COWS UNDER FIELD CONDITIONS

ABSTRACT

The objectives of this study was to determine the efficiency as well as the significance of some estrus detection aids in Bunaji cows.

A total of seventy-two (72) Bunaji cows were synchronized using double injection of PGF2& 13 days apart. Blood samples to determine ovarian activity and accuracy of estrus detection aids by Radioimmunoassay were collected daily from the day of second PGF2& injection until estrus was observed or continuously for 7 days for **"non-responders"**. At the time of the second injection, estrus detection aids namely: Tail painting, KaMar heat mount detectors and chin-ball mating device (CMD) were applied and assessed. The efficiency of the several visual aids in relation to visual observation of standing estrus and serum progesterone concentration is reported.

The estrus response rate was 73.6% as indicated by serum P_4 levels. Visual observation registered 61.1% estrus response rate (ERR). Based on the total number of estrus observed, unaided visual observation, tail painting, KaMar and CMD respectively recorded 52.2%, 82.6%, 82.6% and 76.8% detection rates accurately. Visual observation of standing heat alone did not detect 47.8% of the estrus. Similarly, 30.4%, 30.4% and 24.6% of estrus periods recorded by tail painting, KaMar detectors and CMD respectively were undetected by visual observation of estrus. A total of 28(38.9%) cows showed abnormalities of the progesterone (P4) profile. The serum progesterone concentration (SPC) was the most efficient method of estrus detection and is 12.5% more accurate than the other methods adopted. The possible reasons for irregularities of P4 and subsequent low estrus response rate even with the SPC, the significance and superiority of the heat detection aids, and the magnitude and factors responsible for false positives and negatives are further highlighted.

These investigations showed that undemonstrable estrus from animals that were hitherto regarded as **"anestrus"** by visual observation of standing heat due to short estrus periods or night heats were detected by the heat detection aids. The study further revealed that tail painting and KaMar detectors were the most effective visual aids but the former is more convenient and economical, and can therefore be adopted by farmers/herdsmen to improve on the efficiency of estrus detection.

INTRODUCTION

Accurate detection of estrus is an important component of a successful breeding programme (Foote, 1975; Appleyard and Cook, 1976; Kiser *et al.* 1977; Ball *et al.* 1983; Elmore *et al.* 1986), since insemination at other times of the cycle results in reduced conception rates (McCaughey and Cooper, 1980; Watson and MacDonald, 1984; Dawuda *et al.* 1987).

Long service intervals (Olds, 1969; Hafez, 1969; Zakari, 1981; Garcia, 1988) and intervals between parturition and conception (Morrow *et al.* 1969; Schels et *al.* 1975; Dawuda et *al.* 1989) may be attributed to inadequate detection of estrus resulting in long calving intervals (Williamson *et al.* 1972a; Pullan, 1979; Oyedipe *et al.* 1982b).

Although efficient estrus detection is a significant factor in AI (Ball *et al.* 1983), 40-50% of estrus periods are frequently undetected (Williamson *et al.* 1972a; Barr, 1975; King *et al.* 1976; Esslemont *et al.*, 1985), and 90% of cows assumed to be acyclic by herdsmen are probably having regular estrous cycles (Zemjanis et *al.* 1969; Bozworth *et al.* 1972).

Furthermore, accurate detection of estrus is usually difficult in Zebu cattle under tropical conditions (Rakha and Igboeli, 1971; Zakari, 1981) due to the short and variable duration of estrus (Anderson, 1944; Johnson and Gambo, 1979; Zakari, 1981; Voh,Jr. *et al.*, 1987c), weak expression of estrus signs (Voh,Jr. 1984b; Garcia, 1988) and fewer number of mounts per hour (Galina *et al.* 1982; Orihuela *et al.* 1983; Johnson and Oni, 1986). The duration of estrus can be as short as 1.3 h (Anderson, 1944) and 3.1±0.2 h (Johnson and Gambo, 1979) in Zebu cattle. Therefore twice daily observations of estrus in the mornings and evenings that is commonly practised in Nigeria may not be adequate to detect a high proportion of cows in estrus particularly in the dry season when the duration of estrus could be shorter.

In addition, estrus activity is greatest in the night (Hall *et al*. 1959; Williamson *et al.* 1972b; Hurnik *et al*. 1975; Zakari, 1981; Orihuela *et al*. 1983). Hurnik *et al*. (1975) further reported that 70% of mounting activity occur in the night and may be missed unless all cows are inspected through the night. Estrus can therefore begin at anytime of the day and be of varying length (Donaldson *et al*. 1968).

It has been reported that there is no substitute for the eye of the skilled observer for heat detection (Foote, 1975), however, the most experienced stockman under the most favourable conditions, can detect no more than 80% of cows coming into estrus (Perera and Abeyratne, 1979). It is therefore, certain that visual observation of estrus is not a perfect method of selecting cows in estrus (Williamson, *et al*. 1972a,b). Moreso, it is literally impossible to keep a close and continuous watch on these animals all day.

To circumvent some of these constraints, several heat detection aids have been developed in order to maintain a potential 24-hour surveillance (Foote, 1975), so as to improve on the efficiency of estrus detection (Ball *et al*. 1983). Such aids should be simple, reliable, accurate, consistent, inexpensive and easy to interprete (Boyd and Hignett, 1968; Donaldson, 1968; Donaldson *et al*. 1968; Foote, 1975). Some of the heat detection aids include: Tail painting (MacMillan and Curnow, 1977; Ball *et al*. 1983; Kerr and McCaughey, 1984), KaMar heat mount detectors (Baker, 1965; Boyd and Hignett, 1968; Williamson *et al*. 1972b; Schels *et al*. 1978), closed circuit TV with time-lapsed video (King *et al.* 1976), chin-ball mating device (Kiddy, 1979; Elmore *et al.* 1986; Voh,Jr. 1987), titanium dioxide grease smears (Rollinson, 1963; Donaldson, 1968; Mills *et al.* 1969), mechanical and electrical pedometers (Holdsworth and Markillie, 1982), and use of teasers such as a vasectomized bull (Elmore *et al.* 1986), Pen-0-blocked bull (Kiddy, 1979) and hormone-treated females (Hackett and Lin, 1985).

Variable results on the efficiency of estrus detection using these aids have been reported. Most of them are superior to visual observation (Baker, 1965; Mills *et al.* 1969; Williamson *et al.* 1972a; Ball *et al.* 1983; Kerr and McCaughey, 1984; Elmore *et al.* 1986; Voh,Jr. 1987). Some yielded 100% detection rate (Rollinson, 1963; Donaldson *et al.* 1968; King *et al.* 1976). However, these aids while reliable, are not without drawbacks (Donaldson, 1968; Foote, 1975; Schels *et al.* 1978; Kerr and McCaughey, 1984; Elmore *et al.* 1986).

Other techniques that have been tried to avoid the frequent observation necessary with all visual methods, include, rectal palpation (Baker, 1965; Williamson *et al.* 1972b; Garcia, 1988), hormonal assay (Peters, 1985; Oyedipe *et al.* 1986; Eduvie and Dawuda, 1989) and laparatomy (Ireland *et al.* 1980). Likewise, changes in vaginal pH (Schilling and Zust, 1968); electrical resistance of vaginal mucus (Stan, 1969; Leidl and Stolla, 1976),vaginal cytology (Symington and Hale, 1967), vaginal and cervical mucus crystallization pattern (Linford, 1974; Voh,Jr. *et al.* 1987a) and variations in body temperature and vaginal thermal conductance (Lira *et al.* 1975; Maatje and Rossing, 1976) have been used for estrus detection. Most of these methods are not practicable for routine detection of estrus (Foote, 1975).

Considering the significance of estrus detection particularly in AI programmes in tropical Zebu cattle, any step aimed at accurate detection of estrus will be a worthy venture. However, studies on the efficiency of several methods of estrus detection aids in Bunaji cattle in Nigeria are scanty.

The objective of this study therefore, was to evaluate the efficiency and significance of some techniques of estrus detection, such as, visual observation for standing heat, tail painting, KaMar heat mount detector and vasectomized bull harnessed with a chin-ball mating device, in Bunaji cows so that adequate comparison can be made, and the best method recommended for adoption. The accuracy of the different estrus detection aids and actual functioning of the ovaries will be determined by using the progesterone profile as the reference method for evaluating the heat detection aids.

MATERIALS AND METHODS

Animals

The study was conducted at the National Animal Production Research Institute, Shika, Ahmadu Bello'University, Zaria, Nigeria. During the study, 72 Bunaji cows aged between 5 and 9 years were used. Cows with good body condition score i.e. equal to or greater than 3 (Pullan, 1978) were selected and used. The animals were on free range, grazing sown pastures during the day and at night they were kept in paddocks or pens. Concentrate mixture and hay were given during the critical period of the dry season. Water and mineral salt lick were provided ad lib.

Only animals that showed at least one estrus within a pre-experimental period of one month were selected. In addition, rectal palpation of the internal genitalia was carried out to determine the ovarian activity of the cows (Zemjanis, 1970). All the 72 cows were applied with tail painting and KaMar detectors concurrently. A total of 92 observations each from tail painting and KaMar were recorded during the study. While a CMD was fitted to a vasectomized bull.

Estrus synchronization and application of heat detection aids

All the selected cows were synchronized with 25mg PGF2& (Dinoprost tromethamine salt) administered twice 13 days apart by deep IM injection. Those that were in the follicular phase of the cycle at the time of the second dose ,were not injected but were observed for heat along with the other animals.

On the day of the second PGF2& injection, the various estrus detection aids were applied as follows:

Tail painting

Livestock marker (All-weather paintstik [R], Lake chemical Co., 250 N. Washtenaw Ave., Chicago, Ill.60612) was used to make a strip of 18-20cm long and 5-6cm wide running posteriorly from midsacrum to the 2nd coccygeal vertebrae in all the testcows. The position of the strip varied if pelvic structure of a particular cow prevented the paint strip from being rubbed by the brisket of a mounting cow or bull (MacMillan and Curnow, 1977).

Appropriate colours for visibility depending on the coat-colour of the cows were used. The strip was applied liberally, first against the direction of the hair for thorough mixing with the hair and then posteriorly along the direction of the hair in order to obtain a smooth solid plaque as described by Kerr and McCaughey (1984). Tail painting was re-applied in cows that failed to conceive and were treated once more with PGF2&.

Rubbing off of the strip was considered a positive sign of estrus.

KaMar heat Mount detectors (KaMar)

KaMar heat mount detector (KaMar Inc. Steamboat Springs Colo. 60477) is a pressure sensitive device fitted to the sacral region of the test cows by an adhesive. It is oval in shape 11x15cm to which is attached a plastic dome 8x1.5cm in size. Inside the dome is a plastic tube containing a red dye. An even and sustained pressure from mounting expresses the dye which changes from white to red indicating heat. A fresh KaMar was used in cows that were re-synchronized.

Chin-ball mating device (CMD)

A Chin-ball mating device (CMD) was applied to a vasectomized bull. The CMD is an adjustable preformed halter (Great Outdoors Co. Ltd, New Zealand) with a built-in freely rotating exposed ball pen bearing marker unit worn on the chin of the vasectomized bull, making sure that the movement of the jaws were not restricted.

Streaks of marking fluid running parallel to the vertebrae due to bull dragging its chin along the back of the cow when dismounting was regarded as positive for heat. Accidental marks were differentiated from positive chin-ball marks. The ink lasted for the 7 days that observation was made. Colours of marking fluid were varied.

Estrus detection/insemination

The experimental cows with tail paint and KaMar heat mount detectors were made to run continuously with the vasectomized bull harnessed with a chin-ball mating device, during grazing and in their paddocks at night for estrus detection.

Visual observation for behavioural estrus was done twice daily at 0800 and 1800 h for periods of 1 h each. Observation for behavioural estrus was independent of the heat detection aids. Time of onset of estrus was noted.

Similarly, cows that showed red Kamar or rubbed-off tail paint or streaks of chin-ball mating device were regarded as in estrus and therefore inseminated accordingly using the AM-PM AI rule. Site of semen deposition, tone of the uterus and the presence or absence of drooling mucus discharge at the time of insemination were noted. Estrus observation continued for 7 days from the day of the second PGF2& injection and application of aids in the category that did not show heat. All the animals observed in estrus during grazing were recorded.

The estrus response rate (ERR) was calculated as the number of animals detected in estrus per total number of animals used in the trial and expressed as a percentage.

Blood sample collection

Samples were taken via jugular vein puncture daily from the day of second PGF2& administration until estrus or continuously until day 7 for cows that failed to manifest estrus. The blood samples were allowed to clot and centrifuged at 3000rpm for 15 minutes, serum was decanted and deep frozen at -20°C until analysed for P4 in order to determine the accuracy of heat detection.

Radioimmunoassay of serum P4

Serum progesterone concentrations were determined using a solid phase I^{125} Radioimmunoassay non-extraction technique (DPC, Los Angeles, CA 90045).

RESULTS

Fourty-four (61.1%) cows manifested estrus as indicated by both standing estrus and visual heat detection aids. This was also confirmed by SPC. Fifty three cows (73.6%) exhibited estrus as shown by P4 concentrations (Table 5.1). Twenty five (34.7%), 47(65.3%), 47(65.3%) and 51 (70.8%) cows responded to visual observation, tail painting, KaMar and CMD respectively (Table 5.1). With 4(5.6%), 3(4.2%), 3(4.2%) and 7(9.2%) of the total animals by visual observation, tail painting, KaMar and CMD respectively been false positive i.e. they exhibited estrus while the progesterone (P4) levels indicated that they were not in heat (Table 5.3). The P4 profiles also indicated that 69 estrus events occurred during the study.

Atypical progesterone profiles were observed. Based on the daily bleeding for 7 days, sixteen cows (22.2%) were found to be anestrus (Table 5.2). Mean serum progesterone concentrations (± standard deviation) at the time of the second injection of PGF2& as indicated in Fig. 5.1 was 1.6±1.10 ng/ml. Luteolysis occurred following the second $PGF_{2\&}$ injection but there was no appreciable increase in P4 uptil day 7 (0.20±0.15 ng/ml) which marked the end of the blood collection exercise. In the second category, 9(12.5%) cows (Table 5.2) exhibited silent heat. The SPC was 2.60±1.81 ng/ml, following administration of PGF2&, luteolysis ensued about 48 hours after injection, the P4 declined to estrual level (0.37±0.26 ng/ml and 0.40±0.20 ng/ml by days 3 and 4 respectively). However, estrus was not observed and the SPC started to appreciate as from day 5 reaching 1.84±0.23 ng/ml on day 7 of sampling (Fig. 5.2). In the last category in which 3 cows, representing 4.2% of the total cows (Table 5.2) showed abnormal luteolysis, the P4 concentration dropped from 2.79±0.39 ng/ml on the day of second PGF2& injection to 1.41±0.71 ng/ml on the third day. Thereafter, the P4 level remained elevated upto the end of the bleeding exercise (Fig. 5.3). Therefore, a total of 28 (38.9%) cows revealed abnormalities in the progesterone profiles (Table 5.2).

Out of the 72 cows studied, 9(12.5%) in heat were neither identified by visual observation nor by any of the heat detection aids as shown by the hormonal assay (silent heat) giving a false negative (FN) result (Table 5.3).

Visual observation:

Based on the visual observation of standing estrus alone without any aid, only 36 (52.2%) of the 69 observations were detected (Table 5.4).

Tailpainting and KaMar:

Tail painting identified 57 (82.6%) out of the total observations, therefore, 30.4% of heat periods passed unnoticed by visual observation of standing estrus when compared with this method (Table 5.4). Similar result was obtained with the KaMar. None of the 92 fitted KaMar detectors was lost during the trial.

Chin-ball mating device (CMD):

For the CMD, 53 (76.8%) heat periods were detected, thus 24.6% of the estrus would have been missed if visual observation had not been accompanied by CMD.

These results were termed true positive (TP) since they agreed with serum P4 values (Table 5.4).

The serum P4 indicated that some 19 observations were actually not in heat, of this, 15 (78.9%), 16 (84.2%), 16 (84.2%) and 12 (63.2%) of the observations by standing estrus, tail painting, KaMar and CMD respectively agreed with the serum P4 levels i.e. true negative (TN) (Table 5.4).

DISCUSSION

This study indicated that the serum progesterone concentration (SPC) was the most efficient method of estrus detection (Table 5.1). The SPC was 12.5% more accurate in detecting estrus than visual aids. However, the estrus response rates determined by the various methods were low (Table 5.1). This is because of the number of cows that were hitherto cycling at the beginning of the experiment but showed silent estrus or became anestrus in the course of the study (Table 5.2, Figs. 5.1, 5.2 & 5.3). The same trend was observed in indigenous Zebu cows following PGF2&-induced (Voh,Jr. *et al.* 1987d) and naturally occurring (Johnson and Gambo, 1979; Zakari, 1981) estrus.

Other reasons put forward for synchronization failures using PGF2& include: limitations associated with the morphology of CL per rectum (Zemjanis, 1970), administration of the luteolytic agent to such animals without fully functional corpus luteum (CL) (Seguin *et al.* 1978), failure of a significant number of heifers to respond to the second PGF2& (Smith *et al.* 1984) and cows with long follicular phase (MacMillan and Day, 1982).

The irregular or abnormal or partial luteolysis observed in this trial (Fig. 5.3) is in line with earlier reports by Edqvist *et al.* (1975), Baishya *et al.* (1980) and Voh,Jr. *et al.* (1987d). Competitive inhibition of PGF2& by a luteotrophic factor-luteinizing hormone (Donaldson *et al.* 1964) or suboptimal dose of PGF2& (King *et al.* 1982) have been reported to be responsible for this aberration. However, the former may be implicated in this case since the recommended dose of PGF2& was administered.

Amongst the various methods of estrus detection aids tried, tail painting and KaMar heat mount detectors were the most accurate with 82.6% accuracy rate each (Table 5.4). Similar results using tail painting were shown by Ball *et al.* (1983), Kerr and McCaughey (1984) and Elmore *et al.* (1986) who reported 81.5%, 88.1% and 73.0% respectively. Higher values of 93.3% (Voh,Jr. 1987) and 95.7% (MacMillan and Curnow, 1977) were reported. The difference in the results obtained by the previous workers and our findings may be due to the variation in assessing the accuracy of the heat detection aids. With regards to KaMar detectors, Baker (1965), Mills *et al.* (1969), Schels *et al.* (1978) and Broadbent *et al.* (1989) recorded 90%, 76%, 77% and 86% detection rates respectively, which tended to agree with our results.

Three cows (4.2%) showed both rubbed-off tail paint and red KaMar while the P4 concentration revealed that the animals were not in estrus (Table 5.3). Likewise, 4(5.6%) cows including the 3 above, erroneously showed standing estrus with respect to progesterone assay (Table 5.3). These FP values agree with observations made by MacMillan and Curnow (1977) and Ball *et al.* (1983) with tail painting, Baker (1965) and Williamson *et al.* (1972a) with KaMar, and Baker (1965) and Ball *et al.* (1983) by visual observation of standing estrus. However, in an evaluation of tail painting technique, Kerr and McCaughey (1984) and Elmore *et al.* (1986) reported higher FP figures of 30.8% and 26.0% respectively.

Some of the reasons adduced for false positives have included: licking of the aids (Foote, 1975; Kerr and McCaughey, 1984), shedding of winter coats (MacMillan and Curnow, 1977), accidental rubbing (Baker, 1965; Foote, 1975), Pen conditions or confinements

(Donaldson, 1968), overcrowding (Williamson *et al.* 1972a), **"phantom"** heats (Ball *et al.* 1983), cows in heat mounting other cows (Baker, 1965), increased reactions when heifers are simultenously in heat (Hurnik *et al.* 1975), and anatomical conformation of the cows in terms of size and body condition which will influence the positioning of the paint strip (MacMillan and Curnow, 1977) and KaMar detectors (Baker, 1965).

Considering the condition under which the animals in this study were kept i.e. they were not confined nor overcrowded, the total number of cows studied with few selected and synchronized at a time, the number and distribution of false positive - 3 cows showing all the FP standing estrus, tail painting and Kamar, we ruled out most of the factors advanced by the various workers. It is probable therefore, that **"phantom"** heats and behavioural patterns of animals in estrus contributed more to the FP result obtained. Furthermore, the low false positive result is in consonance with reports by Baker (1965) that only cows in true heat will stand long enough to trigger the detectors. Similarly, Kerr and McCaughey (1984) observed that several mounts are required to remove the paint.

The accuracy rates of tail painting and KaMar were equal (Table 5.4) and virtually every animal that showed rubbed-off tail paint had red KaMar. This may imply that sustained pressure from mounting and standing solidly to the mount triggered both aids positively and simultenously.

KaMar detectors remained attached satisfactorily to the cows and out of the 92 KaMars used, none was lost throughout the study as opposed to Boyd and Hignett (1968), Williamson *et al.* (1972a) and Foote (1975) who reported about 25% KaMar losses. The previous authors used the KaMar detectors for a long time, upto 104 days (Boyd and Hignett, 1968). In this study the heat mount detectors were observed for only 7 days period, and a new one fitted at the next synchronization.

The efficiency of CMD in this study (Table 5.4) concurs very well with observations by Elmore *et al.* (1986). However, it is lower (76.8 vs 85.0%) than reports by (Voh,Jr. 1987). The accuracy of the CMD was not determined by the latter, and this may be responsible for the higher values recorded. The highest incidence of FP (9.2%) in this study was obtained with CMD method of heat detection particularly towards the end of the 7-day daily bleeding. This may be as a result of misinterpretation of the chin ball marks on the rump, sides and back.

Considering standing estrus alone, 47.8% of the cases of estrus would have been missed (Table 5.4) which is consistent with observations by Williamson *et al.* (1972a), Barr (1975), King *et al.* (1976) and Esslemount *et al.* (1985) who reported that 40-50% of estrus passed unnoticed.

Tail painting, KaMar and CMD were 30.4%, 30.4% and 24.6% respectively superior to visual observation (Table 5.4), implying that these percentages of cows would not have been observed if estrus detection was based only on standing estrus. Some slight differences were noted with regards to the superiority when compared with other workers (Baker, 1965; Mills *et al.* 1969; Williamson *et al.* 1972a,b; MacMillan and Curnow, 1977; Schels *et al.* 1978; Ball *et al.* 1983; Kerr and McCaughey, 1984). The extent of FP and FN contributed to these differences.

Since we have already precluded the tubular genitalia and the ovaries of the experimental cows prior to the commencement of the exercise i.e. no clinically detectable pathological conditions of the genital tract was noticed, and the higher detection rates observed using heat detection aids, we can safely conclude that the **"anestrus"** recorded in this study was as a result of subestrus or failure to observe behavioural estrus rather than true anestrus due to inactive ovaries. This concurs with reports by Hall *et al.* (1959), Williamson *et al.* (1972a), King *et al.* (1976) and Schels *et al.* (1978) that anestrus is a consequence of management practices than physiological dysfunction. The heat detection aids therefore have the advantage of detecting cows that were regarded as **"anestrus"** by herdsmen due to short estrus periods or night heats. In addition, the results from the aids are unequivocal and do not depend on interpretation of any chemical or histological test (Donaldson, 1968). If subestrus ovulations can be detected, then valuable breeding time will be saved and reproductive efficiency increased (Williamson *et al.* 1972a).

From the accuracy rates recorded by the various techniques, besides the progesterone assay which is expensive and impracticable, for routine use in the field in Nigeria, requiring facilities and reagents, it is evident that both tail painting and KaMar are equally efficient and of practical value. They can be adopted for Bunaji cows. However, KaMar in comparison with tail painting is more expensive and not readily available (Schels *et al.* 1978). While tail painting on the other hand is cost effective, more convenient and easy to interprete (MacMillan and Curnow, 1977; Ball *et al.* 1983; Kerr and McCaughey, 1984) giving it an added advantage over KaMar.

It was concluded from this study therefore that tail painting appeared the most useful and provided accurate estrus detection, simple, economically justified and suitable enough for farmers/herdsmen to adopt. This will improve the efficiency of estrus detection in AI schemes in Bunaji cattle such that short estrus periods or night heats can be detected particularly in the dry season.

Table 5.1: **Estrus response as recorded by visual aids, standing estrus and serum progesterone concentrations (SPC) in 72 Bunaji cows**

Observations	No. of animals in Estrus	% of animals in Estrus
Visual aids and SPC	44	61.1%
Visual aids only		
KaMar (including 3 FP)	47	65.3%
Tail painting (including 3 FP)	47	65.3%
CMD (including 7 FP)	51	70.8%
Standing estrus and SPC	21	29.2%
Standing estrus only (including 4 FP)	25	34.7%
SPC only (including silent heat)	53	73.6%
Silent heat only	9	12.5%

Table 5.2: Atypical serum P4 profiles during the trial

Ovarian activity	**No. of cows**
Anestrus	16(22.2%)
Silent heat	9(12.5%)
Abnormal or partial luteolysis	3(4.2%)
TOTAL	**28(38.9%)**

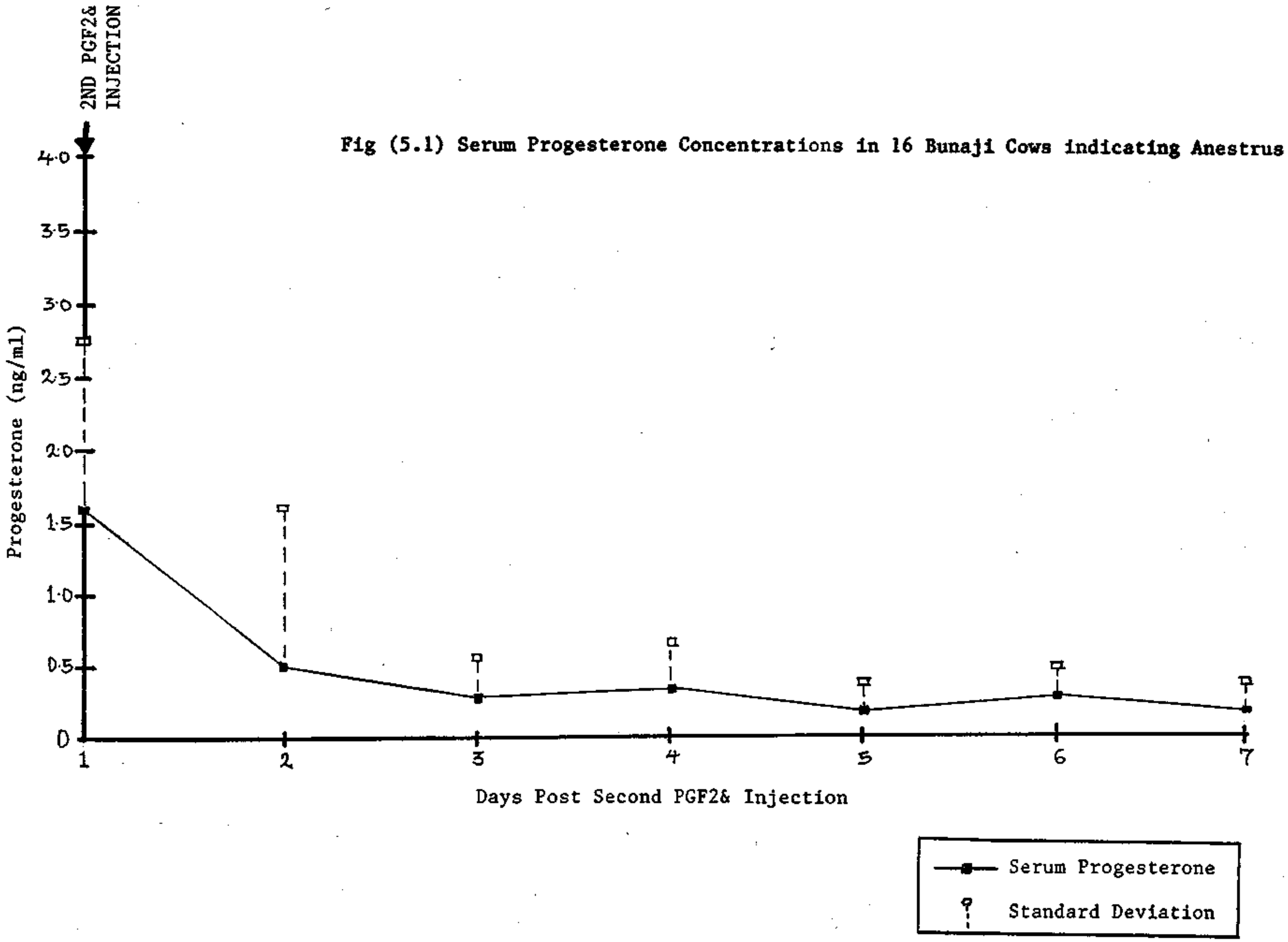
Table 5.3: **Incorrect identification of estrus i.e. false positive (FP) and failure to detect estrus i.e. false negative (FN) in relation to the total number of cows synchronized**

Behavioural estrus and Detection aids	**FP**	**FN**
Standing estrus	4(5.6%)	9(12.5%)
Tail painting	3(4.2%)	9(12.5%)
KaMar detectors	3(4.2%)	9(12.5%)
Chin-ball mating device	7(9.2%)	9(12.5%)

Table 5.4: Comparison of the accuracy of the various aids in relation to the 69 estrus periods i.e. true positives (TP) and 19 true negatives (TN) as indicated by the serum progesterone concentration (SPC)

Methods of estrus detection	**TP (Agreed)**	**TN (Agreed)**
Standing estrus	36(52.2%)	15(78.9%)
Tail painting	57(82.6%)	16(84.2%)
KaMar detectors	57(82.6%)	16(84.2%)
Chin-ball mating device	53(76.8%)	12(63.2%)

Fig (5.1) Serum Progesterone Concentrations in 16 Bunaji Cows indicating Anestrus



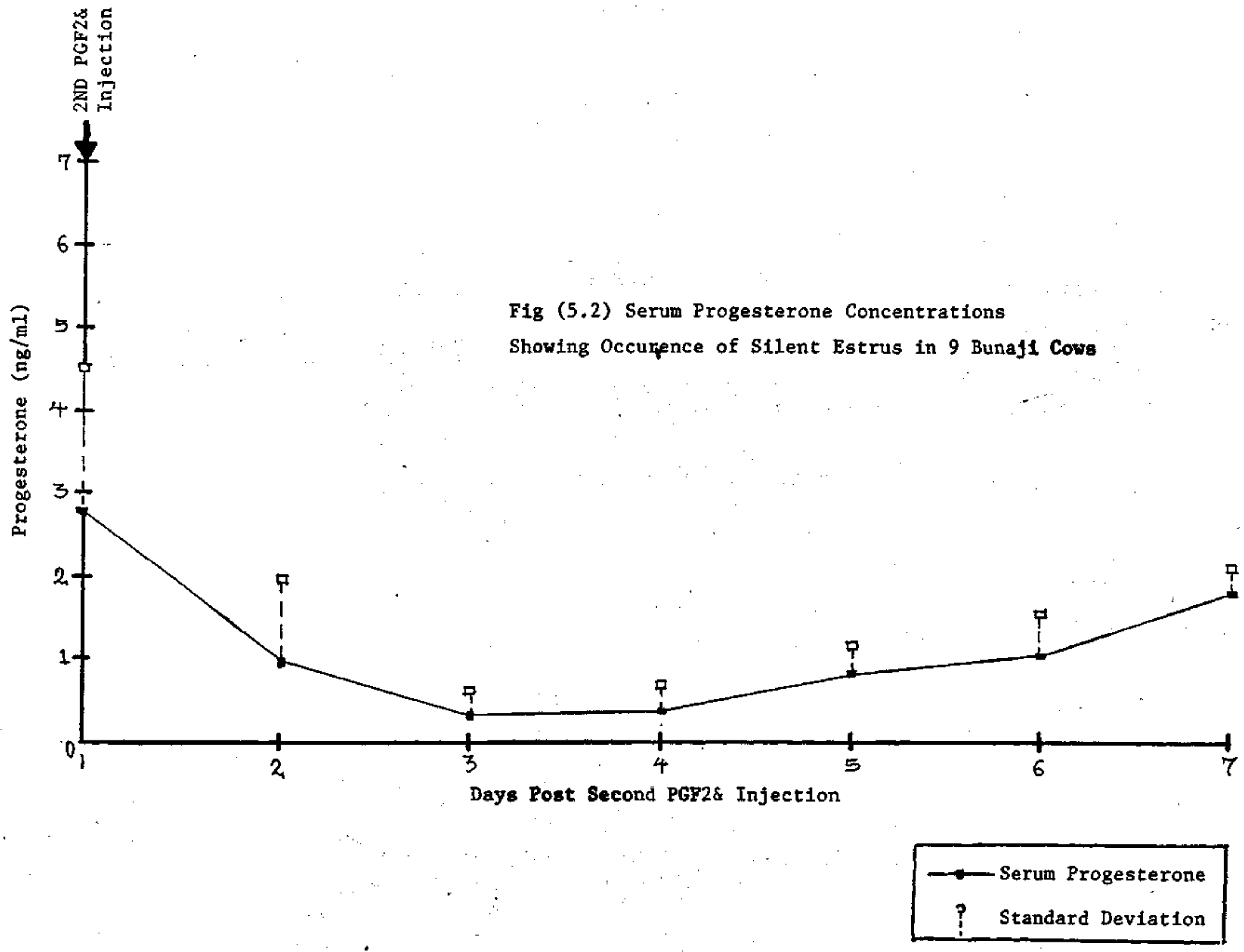


Fig (5.2) Serum Progesterone Concentrations
Showing Occurence of Silent Estrus in 9 Bunaji **Cows**

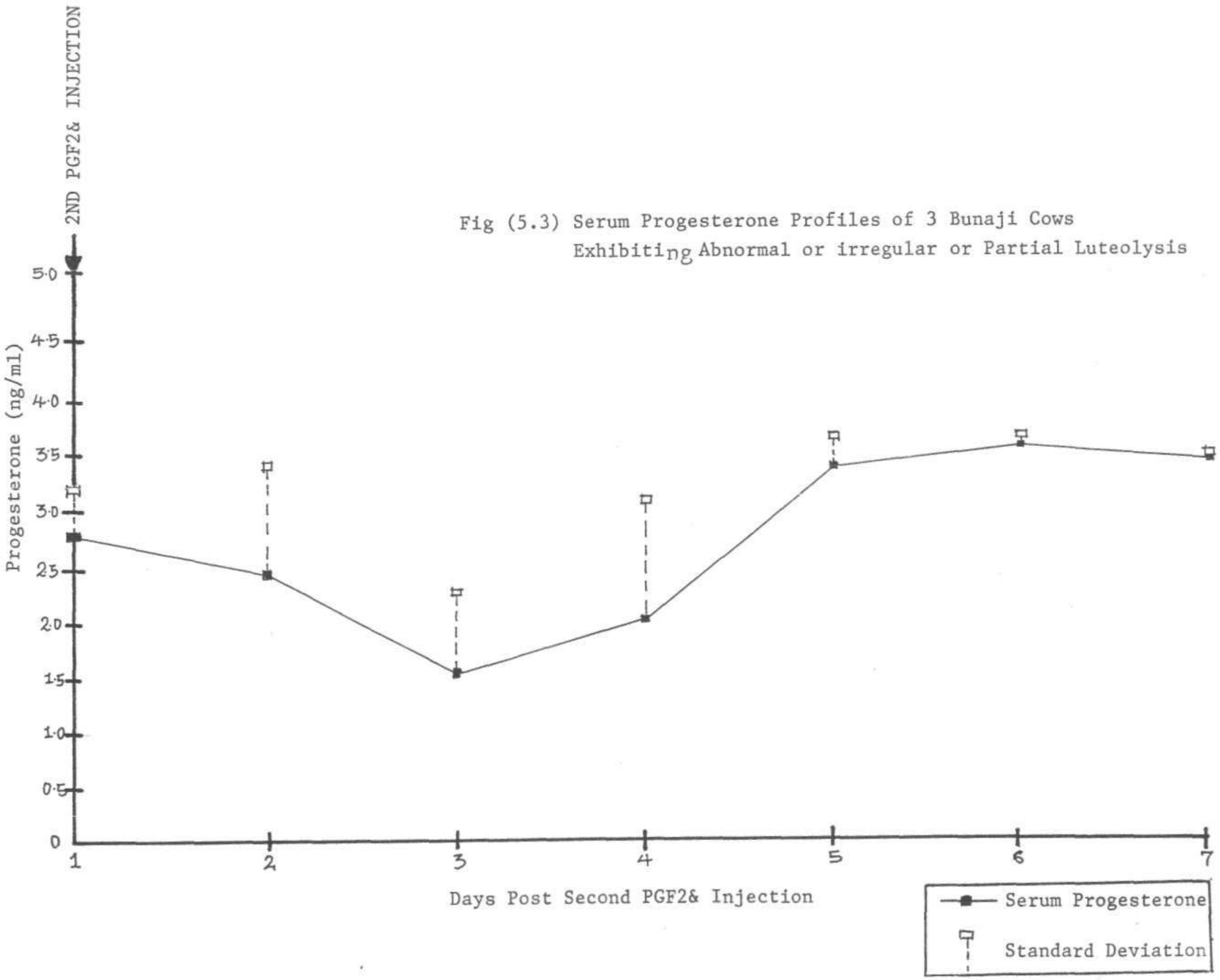


Fig (5.3) Serum Progesterone Profiles of 3 Bunaji Cows Exhibiting Abnormal or irregular or Partial Luteolysis

CHAPTER SIX

GENERAL DISCUSSION

Investigation on the effect of some environmental factors using the temperature-humidity index (THI) model as well as physiological factors on fertility rates of artificially inseminated Bunaji cattle around Zaria was evaluated.

It was observed that THI which is the most practical means of assessing the exposure of cattle to thermal stress was inversely proportional to conception rate (CR). The hotter months of March, April and May with highest THI, recorded correspondingly low CR. All the factors that may contribute to poor reproductive performance during the study such as nutrition, effect of the cow and the bull or natural mating, and quality, preservation and handling of the semen during AI, etc. were circumvented. Thus, the conditions that are likely to limit the reproductive efficiency were properly taken care of so that environmental parameters can be evaluated rationally. Inspite of all these, the CRs were poor suggesting that adverse climatological factors such as heat stress might be a fundamental component responsible for the lowered reproductive function rather than nutritional or management factors. The economic implication of this finding is that insemination of cattle during the hot months may result in waste of valuable semen. Hence, breeding programmes should be restricted to cool months of the rainy season and pre-dry season as much as possible. Furthermore, improving the level of nutrition, provision of water ad lib, avoiding adverse handling of cattle, provision of shades and wetting of animals are recommended during the heat stressful periods of the dry season in order to cushion the effect of the extreme environmental factors.

Individual daily THIs of 70 or less showed highest CRs. However, THI of 76 and above recorded low CR. Therefore, THI of 75 may be the threshold for optimum reproductive function.

It was found that extreme ambient temperature (AT) elevated body temperature with resultant decrease in CR of Bunaji cattle in this trial. The deleterious effect might not have occurred if body temperature of the cow did not increase. The CR decreased drastically with increase in rectal temperature. Similarly, increased rectal temperature 12 hours after insemination negatively influenced CR of cows in the current study. The factors responsible for the reduced fertility in the cattle studied are complicated but may be attributed to high temperature acting directly on the spermatozoa or ova prior to fertilization, on the early embryo cleavage or even a consequence of maternal endocrine imbalance.

This study confirmed the incidence of luteal phase insemination (LPI) in Bunaji cows and it may be responsible for the poor reproductive performance in indigenous cattle. All the affected animals had P4 levels greater than 1.0 ng/ml at insemination indicating luteal activity. Errors in the diagnosis of estrus as well as **"phantom heats"** probably influenced this phenomenum. The finding emphasises a need to improve on estrus detection by training farmers/herdsmen and employing estrus detection aids to complement visual observation of standing heat.

It was revealed from this study that a great number of estrus periods would have been passed unnoticed by herdsmen if visual observation of standing estrus had not been accompanied by heat detection aids. This problem is exacerbated during the dry season when estrus activity is reduced and its duration shortened. The heat detection aids therefore, have the advantage of detecting cows that were hitherto regarded as **"anestrus"** by herdsmen. The practical value of this finding is that estrus detection aids should be used particularly during the dry season in order to improve on the efficiency of estrus detection. Infact, it is recommended that apparent acyclicity problem should be defined using the heat detection aids so that analysis of the form of infertility is obtained before instituting therapy.

Amongst the various techniques of estrus detection aids tried during this study, tail painting was found to be the cheapest and most convenient, as well as accurate. It can therefore be recommended for farmers/herdsmen.

In conclusion, based on results obtained from this study, environmental factors, elevation of body temperature, luteal phase insemination and poor estrus detection may contribute to the poor reproductive performance observed in artificial insemination programmes in Nigerian Bunaji cattle.

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