UTERINE INVOLUTION, OVARIAN ACTIVITY AND BACTERIOLOGICAL STUDIES OF THE POSTPARTUM PERIOD IN INDIGENOUS NIGERIAN CATTLE.

BY

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D.V.M. Ahmadu Bello University, Zaria, 1974

M.S. University of Minnesota, St. Paul, 1979

A

Dissertation

Submitted to the postgraduate school

Ahmadu Bello University

In partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

Department of Veterinary Surgery amd Medicine

Section of Theriogenology

NOVEMBER, 1982

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D E C L A R A T I O N

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of references.



LAWRENCE O. EDUVIE

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ABSTRACT

The effects of suckling, feeding of concentrate supplement, season of calving, parity or age of dam on duration of uterine involution and ovarian activity in the postpartum cow were studied. The effect of suckling on the gross and histological changes in the reproductive organs during the postpartum period and a bacteriological survey of the postpartum uteri of suckled and nonsuckled cows were also undertaken.

Suckling and the season of calving affected the interval from calving to first ovulation significantly (P(.IO). Nonsuckled cows and cows that calved during the dry season ovulated earlier than suckled cows and cows that calved during the rainy season, respectively. Cows that received concentrate supplement had shorter but non-significant postpartum intervals to first follicle, and first ovulation as well as shorter intervals from first follicle to ovulation- Pluriparous cows tended to ovulate earlier than primiparous cows.

Height of ovary associated with the nongravid uterine horn was statistically different (P<.05) for suckled and nonsuckled cows. Breadth of ovary on the side of the nongravid horn and height of ovary associated with the previously gravid horn and nongravid horn were different (P(.05) between postpartum days . Ovary

associated with the previously gravid horn was generally heavier than the contralateral ovary. Nonsuckled cows had more follicles than suckled cows. Cyclic corpora lutea (CL) were detected in four of 12 nonsuckled cows but none of the suckled cows had CL during the first 30 days after calving. The rate of regression of CL of pregnancy during the postpartum period was similar for suckled and nonsuckled cows. Primary and atretic follicles were more prevalent than growing and graafian follicles in the ovaries of both suckled and nonsuckled cows.

There were significant differences in the length, diameter and weight of the uterine horns, uterine body and cervix between postpartum days two, 10, 21 and 30. The diameters of the caruncles near the uterine bifurcation were significantly different between day two and days 10, 21 and 30 postpartum. Uterine horn wall thickness was similar for cows examined at days two and 10, and for those at days 21 and 30 but different between these two periods. Sloughing of caruncular tissue and initiation of caruncular reepithelialization occurred at about day 10 after parturition. Caruncular reepithelialization which occurred from the edges of the caruncles and also from glandular epithelium, was

completed by day 21 postpartum. Epithelium was present in sections of the intercaruncular uterine tissue, the cervix, uterine body and oviducts irrespective of days postpartum. Lymphocytes and plasma cells were commonly found in the lamina propria of the uterine sections from cows in all groups while aggregates of different leucocytes (mainly lymphocytes) were present in some sections. Trophoblastic cells were abserved in a few sections obtained from cows on day two while macrophages and eosinophils were found in some sections obtained from cows on days two and 10.

Postpartum uterine contamination was higher between days 10 and 21 than any other postpartum period, with Staphylococcus aureus being the commonest organism isolated. The partem of uterine contamination during the first month after calving was that of contamination clearing and recontamination as no organism was cons - stently isolated from any animal during this period. Seven out of 24 cows sampled at slaughter and nine of 52 in vivo samplings were positive for bacteria. Suckling had no influence on the rate of uterine contamination which did not interfere with uterine involution.

It is concluded that suckling, level of feeding, season of calving and parity or **age** of daw may delav tne onset of ovarian activity during the postpartum period and thus contribute to a prolonged calving interval and fewer calves per life in the Zebu cows. Delayed uterine involution does not appear to be a problem in Zebu cows.

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I N T R O D U C T I O N

The need to improve the reproductive performance of our indigenous livestock, especially cattle, as a means of increasing livestock production in Nigeria, cannot be over emphasized. Oyenuga (1974) suggested that the daily animal protein intake should reach 27g *per capita* in Nigeria to provide 50% of the *per capita* minimum requirements of protein recommended by the Food and Agricultural Organization (FAO, 1971). This means that the annual calf crop must be increased substantially.

At present research aimed at a genetic up-grading of our indigenous cattle are in progress. However, our knowledge of the reproductive efficiency of these animals remains scanty; despite the recognition that a meaningful genetic improvement cannot be achieved without an efficient reproductive performance. It is important to determine the causes of the low calving rate or low reproductive efficiency of these animals with a view to rectifying them.

An important index of a satisfactory breeding efficiency, is the maintenance of regular calving intervals of a desirable length. This means the animals should conceive when rebred at a suitable interval postpartum. However, available data obtained from surveys (Lamorde and Franti, 1973; Akpokodje and Bolarinwa, 1974;

Oyedipe et al, 1982) on calving intervals of our indigenous cattle, indicate that these intervals are long when compared to those of cattle in temperate countries.

Roberts (1971) noted that the biggest single cause of loss in livestock production is infertility including, amongst other factors anoestrus which Zemjanis (1970) recognized as the most significant cause of infertility in cattle. Postpartum anoestrus resulting from ovarian inactivity, will obviously result in prolonged calving interval and thus low calving rate. It is therefore important to determine the interval between calving and resumption of ovarian activity and the factors affecting this interval in the indigenous cattle.

Another important factor affecting fertility is the involutionary status of the uterus at the time of breeding. The uterus needs to return to the pregravid status for a normal implantation of the fertilized ovum to occur. The objectives of this study are thus:

1. To determine the effects of suckling, nutrition, season of calving and age or parity of dam on the interval between calving and resumption of ovarian activity in White Fulani cows.

2. To study the gross and histological features of ovaries and tracts collected from cows during the postpartum period and the effects of suckling on them.

3. To examine the bacteriological flora of the postpartum uterus.

PART I

REVIEW OF LITERATURE

General

Reports on postpartum ovarian activity vary significantly with breeds of cattle studied as well as amongst the investigators. The reason for these variations could be attributed to the fact that the time after parturition required by individual animals for readjustment of the hormonal balances established to support pregnancy and its subsequent termination, and interval from parturition to reestablishment of normal oestrous cycles vary (Callahan et al., 1971). Furthermore, the interval from parturition to reestablishment of normal cyclical activity in the cow is influenced by a variety of environmental, managemental and genetic factors (Erb et al., 1958a,b; Labhsetwar et al., 1963; Morrow et al., 1966; Marion and Gier, 1968).

Genital rectal palpation or examinantion of reproductive tracts from cows slaughtered postpartum have been used to study the onset of follicular development in the postpartum cow. The reported onset of follicular development varies. While some workers have observed first postpartum follicular development at 16 - 18 days (Hammond, 1927; Casida and Venzke, 1936; Labhsetwar et al., 1964), others reported a mean interval of 33.6 days from parturition to development of the first

follicle (Higaki et al, 1959). On the other hand, Morrow et al, (1966) observed first postpartum follicles as early as five to seven days in dairy cows.

Casida and Venzke (1936) reported a mean of 40.7 days as the interval from calving to the first ovulation from data based on rectal palpations performed at seven days intervals on 50 dairy cows. Hammond (1927) recorded a range of 16 - 21 days interval from parturition to ovulation.

The mean interval from calving to first ovulation for 60 dairy cows palpated rectally every 14 days was 35.0 days, and from calving to first observed oestrus was 60.4 days (Casida and Wisnicky, 1950).

A study of the record of 43 beef cows (Guilbert and McDonald, 1933) showed that 30% of the cows came in heat between 20 and 40 days, another 30% between 40 and 60 days and the remaining 40% between 60 ane 100 days following parturition. The interval from calving to oestrus in both primipara and pluripara Friesian cows was 33 days (Buch et al, 1955). This study involved 322 parturitions and the animals were palpated per rectum with twice daily oestrus checks.

Chapman and Casida (1935) reported that the average time to first oestrus following normal gestation and parturition in dairy cows was 59 days with a standard deviation of 39 days for 179 calvings.

In clinically abnormal cows, that is cows with cystic follicles or retained corpus luteum, the period from parturition to first oestrus was 71 days. They stated that on the avergge in 50% of such cases the interval was less than 61 days, 40% were 61-120 days and the remaining 10% were over 120 days in length.

Lasley and Bogart (1943) reported an average interval of 80.2 days to the first postpartum oestru in Hereford range cows while Warnick (1953) found an interval of 59.6 days in Angus and 58.2 days in Hereford cows on irrigated pastures. In a study of 968 parturitions in 347 cows, Herman and Edmondson (1950) reported an interval of 57 days from calving to the first oestrus.

The average length of time from calving to first oestrus for 472 normal parturitions of 210 cows was 32.1±18.6 days (Olds and Seath, 1953). Analysis of the data indicated that individual cows had a tendency to repeat a similar length of time between calving and first oestrus at successive parturitions. Foote et al, (1960) reported intervals of 38.4 and 58.6 days for calving to first ovulation, and calving to first oestrus, respectively. They studied postpartum physiology using weekly palpations of the genitalia per rectum on a group of 13 (nine fraternal and four identical) pairs of Hereford twins. Menge et al, (1962) found an interval of 18.9 days from parturition to first ovulation and

corpus luteum (CL) formation and 32.4 days from parturition to the first observed oestrus. They concluded from this result that silent oestrus is quite common soon after parturition. The mean interval from parturition to the first silent or standing oestrus and ovulation in normal cows was 15 days (range eight to 38) and 34.4 days (range 10 to 145) for cows with abnormal postpartum periods, such as retained placentae parturient paresis and metritis. The mean interval for both groups was 20.4 days (Morrow et al, 1966). This study involved 203 cows examined by rectal palpations.

Wagner and Hansel (1969) recorded no oestrus or ovulation in Holstein cows slaughtered on day seven or 14 postpartum. They however, observed mean interval of 14 days (10-22 days range) from calving to first oestrus and ovulation in cows slaughtered at 30 days postpartum. All cows in the various slaughter groups were machine-milked twice daily.

There are reports of low calf crop and long calving interval in some cattle indigenous to tropical Africa and India attributable to delayed postpartum resumption of ovarian activity amongst other factors. Rakha et al, (1970) reported mean calving intervals of 379.7±85.8 and 425.7±130±9 days respectively for Angoni and Africander breeds of cattle indigenous to Central Africa.

They observed postpartum heat periods of 79.9±19.2, 66.9±20.9 and 83.3±27.9 days for Angoni, Africander and Hereford breeds, respectively. In another study calving intervals of 412 days have been documented for the Sahiwal breed of cattle in Kenya (Kimenye, 1978), and also 420 days for the Ngada Zebu (Mahadevan and Marples, 1961).

El-Sheikh and Mohammed (1976) conducted a study involving 62 Egyptian buffaloes with 102 calvings to estimate the length of postpartum oestrus interval. They found that the average interval from parturition to first observed heat was 147.37±12.61 days. Among the 102 postpartum heats recorded, 29 (28.43%) were anovulatory while 73 (71.57%) were accompanied by ovulations. Postpartum heats of less than 60 days accompanied by ovulations were observed in only 5% of the buffaloes studied. In the Indian Murrah buffaloes, Rao and Murari (1956), and Bhalla et al, (1967) recorded an average postpartum heat interval of 87.7 and 185 days respectively.

Studies on the postpartum physiology of the Nigerian breeds of cattle have not been carried out. The calving interval for the Bunaji is about 439 days (Oyedipe et al, 1982). In a preliminary study of postpartum uterine involution and resumption of

ovarian activity using rectal palpation and clinical observation, intervals of 21.45±5.4 and 18.5±2.9 days from parturition to first oestrus were observed for Bunaji and Friesian/Bunaji crosses, respectively. It is rather intriguing that in view of the relatively short interval from parturition to oestrus the calving interval is so long for this breed. Thus the factors affecting the postpartum intervals to first oestrus and to first ovulation need to be examined.

Among the factors reported as affecting postpartum ovarian activity are suckling (Clapp, 1937), nutrition (Hammond, 1927; Chapman and Casida, 1937), season (Buch et al, 1955; El-Sheikh and Mohammed, 1976) and age at first calving (Herman and Edmondson, 1950).

Effect of suckling on postpartum ovarian activity

Many investigators have observed a delay in postpartum resumption of ovarian activity as a result of suckling in several species.

In the rat, suckling reduced pituitary, and ovarian weights at 18 days postpartum (Minaguchi and Meites, 1967). They also observed that pituitary luteinizing hormone (LH) content decreased while prolactin content increased.

Greenwald et al.,(1967) observed that follicular atresia and luteolysis occurred at parturition in the hamster. When the suckling stimulus was removed an

immediate resumption of follicular growth occurred. During lactation, pituitary follicle stimulating hormone (FSH) level rose while LH declined; when suckling was stopped FSH declined while LH rose.

An interval of 73-86 days to first oestrus was observed in nursing ewes while nonsuckling ewes came in oestrus at an interval of 55-58 days (Barker and Wiggins, 1964). These results suggested that lactation delayed the onset of postpartum behavioural oestrus in ewes.

Mauleon and Dauzier (1965) found that ewes nursing lambs did not resume cyclic activity as soon after lambing as nonsuckled ewes. Thirty percent of nonsuckled ewes exhibited oestrus by34 days after lambing as compared to 10 percent of the suckled ewes. These authors suggested that stimuli from the lamb inhibited the sexual activity of the ewes rather than lactation per se.

Gould and Whiteman (1973) evaluated postpartum oestrual activity and subsequent reproductive performance of 80 mature early weaned spring-lambing ewes (lambs weaned at 30 days of age) and 77 mature control (lambs weaned at 70 days of age) spring-lambing ewes in two trials. A larger percentage (P(0.05) of the early weaned ewes (91.6 vs 66.7%; 86.3 vs 65.8%) mated postpartum with shorter intervals from lambing to first oestrus (56 vs 65 days; 59 vs 66 days). Also

a larger (P(.10) percentage of early weaned ewes conceived each year (58.3 vs 38.8%; 54.5 vs 29.2%) than control ewes and they did so within shorter intervals (P(.05) from lambing to conception (58 vs 65 days; 62 vs 74 days).

Sharman (1967) presented clinical evidence that lactation delays return to normal menstrual cycles is women. In 14 lactating women and 68 nonlactating women he found that the nonlactating women ovulated at seven weeks or more postpartum but none of the lactating women ovulated before 13 weeks postpartum. He also observed that the first menstrual cycle was frequently anovular regardless of lactation status. In an earlier study, Sharman (1966) observed the incidence of pregnancy during an interval of nine months postpartum in 196 lactating women and 282 nonlactating women. No lactating woman became pregnant while nine of the nonlactating women became pregnant during an interval of four to eight months postpartum.

Clapp (1937) reported that the interval between calving and first oestrus was 69.4 days for cows milked four times a day, 71.8 days for nursing cows, and 46.4 days for cows milked twice daily. Nursing cows showed oestrus 25.4 days later on the average

than the animals milked twice daily. The frequenty of suckling or handling of the teats in milking was believed to be the main cause of the difference in length of interval to first oestrus between cows milked twice daily and those milked four times daily or those suckled.

Wiltbank and Cook (1958) reported a significant difference in the return to normal reproductive cycles in cows with suckling calves when compared to control animals. In their study, milking Shorthorn cows were either allowed to nurse or milked twice daily. The calves did not stay with the cows except when nursing. The interval from parturition to the first ovulation was 53 days for nursed animals and 36 days for control. The intervals to the first observed oestrus were 84 and 54 days for nursed and control animals respectively. Nursed animals also had a significant poorer conception rate; 1.84 services/conception as against 1.54 for controls ($P<0.01$).

Saiduddin et al, (1966) reported that while suckling had no effect on pituitary LH content of 35 primiparous Holstein cows at days 10, 20 or 30 postpartum the LH content on the dgy of parturition was significantly lower than was observed in the postpartum groups. However, using the same group of animals Riesen et al, (1966) observed higher prolactin levels at all postpartum

intervals in the suckled animals than in the nonsuckled.

Saiduddin et al, (1968) determined the effect of suckling on number of follicles, volume of the largest follicle and follicular fluid weight in dairy cattle, on days 1, 10, 20 and 30 postpartum. They reported no differences in any of the ovarian characteristics due to suckling. Their results indicated that there was very little ovarian activity on the day after calving, but considerable activity by day 10 following calving. At day 20 postpartum, one of five cows in the suckled group had a newly formed corpus luteum (CL), while in the nonsuckled group all five cows had CL. From these results it was inferred that the interval from calving to first ovulation is shortened by removal of the calf at birth together with absence of milking compared to suckling. While three to 20 nonsuckled cows came in heat during the first 20 days postpartum, none of the 20 cows in the suckled group came in heat. Between days 21 and 40 after calving, eight of the suckled cows and 13 of the nonsuckled cows came in heat. Average interval from parturition to the first oestrus was 45 days for cows that were suckling and 30 days for nonsuckling cows. All these observations show the interference of suckling with early reproductive activity

in the postpartum cows.

The mean intervals from parturition to first oestrus for five experiments ranged from 53.5 to 93.3 and 17.8 to 30.4 days for suckled and nonsuckled groups of beef cows (Graves et al, 1968). These workers also reported that while suckling produced a decrease in pituitary FSH three days post breeding, both suckling and increased postpartum interval acted to increase pituitary FSH content as observed 15 days after breeding. Neither suckling nor postpartum interval altered pituitary LH activity of cows at three or 15 days after breeding at the first oestrus. Suckling increased follicular fluid weight at day three but had no apparent effect at day 15 postpartum. The same workers also found from their palpations of the postpartum cows that suckling affected the incidence of ovulations without exhibited oestrus. In the nonsuckled cows, 42.4% of the first postpartum ovulations as indicated by the presence of CL, were not preceded by overt oestrus compared to 70.6% in suckled cows. They also observed that suckled cows had a higher percentage of second ovulations that were quiet as compared to nonsuckled cows (50.0% vs 26.1%, respectively). Fertility was higher in the suckled than in nonsuckled group of cows.

Riesen et al.,(1968) studied the relationship between postpartum interval and CL development, pituitary

prolactin activity and uterine involution in dairy cows. They found that while the weight of day six CL formed during the first postpartum oestrous cycle was negatively correlated with interval, it was greater in the suckled than nonsuckled animals. They observed an effect of suckling on the pituitary prolactin activity; the activity of suckled being lower than nonsuckled cows.

Wagner and Hansel (1969) reported that suckling had a detrimental effect on ovarian function in the cow. They found that the interval from parturition to first oestrus and ovulation for nursed cows was 27.5 days compared to twice daily milked cows with an interval of 14 days. The mean diameters of the regressed CL of pregnancy were 8.5 and 9.6mm for milked and nursed cows, respectively, at 30 days postpartum. The ovarian weights were 8.61 and 11.35g for gravid and nongravid and 7.43 and 8.30g for day 30 postpartum milked and nursed cows, respectively. There was no difference in follicle size at day 30 postpartum for both milked and nursing cows.

Oxenreider (1968) shortened the postpartum interval to ovulation significantly by preventing calves from suckling (11±2 vs 55±8 days for nonsuckled and suckled respectively) and oestrus was observed in cows not

suckling calves earlier than those suckling calves (10±3 vs 55±8 days). The difference in time of conception within 100 days after parturition was not statistically significant and pregnancy CL regression was not influenced by suckling.

Short et al., (1972) used second calver Angus cows to study the effect of suckling and mastectomy on bovine postpartum reproduction. They found that the removal of calves from dams at birth shortened the interval from parturition to first oestrus and mastectomy shortened the interval even further. The intervals were 65, 25 and 12 days for suckled, nonsuckled and mastectomised cows, respectively. The interval from calving to first ovulation was the same as that to first oestrus in all cows. Weekly rectal palpation of these animals did not reveal ovulation prior to the expressed oestrus.

While total weaning of calves shortened the interval from parturition to first oestrus, partial weaning did not. Baud and Cummins (1977) allocated 40 heifers suckling their calves to either partial waaning or control group. Calves in the partial group were allowed to suckled for only one hour each day while those in the control group suckled normally. There was no significant difference (P).05) in the

interval from calving to first oestrus between the two groups. Partial weaning however, increased the first service conception rate and reduced the number of services per conception but had no significant effect on the average interval to conception or on the final pregnancy rates achieved after a 9 week period.

In a study of postpartum ovarian function in suckling and nonsuckling beef cows, Radford et al., (1978) reported a detrimental effect of suckling on ovarian function. The mean postpartum interval to first oestrus was 22 days (range 10-33 days) for seven nonsuckled cows while only three of seven cows in the suckled group exhibited oestrus at 58, 80 and 89 days postpartum. Also, mean plasma LH levels were significantly lower in suckling cows than in nonsuckling cows during the first 30 days postpartum possibly due to reduced hypothalamo-pituitary function at this time.

Pimentel et al., (1979) investigated the effect of weaning 90 days after calving on the postpartum anoestrus and pregnancy rate using Devon and Angus beef cows. Calves were separated from their dams at 90 days for the weaned group and at 200 days for the suckling group. They found that the percentage of

pregnant cows was increased by 43.07% by the 90 days weaning, while the frequency of anoestrus in the weaned group was 13.7% compared to a frequency of 60.42% in the suckling group over a period of 100 days postpartum. From the results of thisstudy, it was argued that weaning at three months after calving was too late for the cows to show beneficial effects in order to have a 365-days calving interval.

Kesler et al., (1980) studied the effect of days postpartum on reproductive hormones and ovarian changes in postpartum suckled beef cows and reported intervals of 17.5±2.6 and 36.0±2.2 days from parturition to the first detected ovarian follicle and the first postpartum oestrus, respectively. The number of cows with ovarian follicles increased (P<.01) with days postpartum and follicles were detected in all cows on day 28 postpartum. They also observed an elevation of plasma progesterone about one week prior to the first oestrus in 6 out of 8 cows in the absence of corpora lutea.

Carruthers and Hafs (1980) reported that the average interval from parturition to first ovulation for suckled cows (39.7 days) was almost double the interval for nonsuckled cows (21.2 days).

Effect of nutrition on postpartum ovarian activity

In a review of the factors affecting rebreeding of ewes during the postpartum period, Hunter (1968) noted that the level of nutrition and the condition of the ewes at lambing greatly influenced the ability of the ewes to conceive promptly. Supporting this view, Kirillov (1944) had suggested that the level of nutrition plays a role in the expression of heat after parturition. Similarly, Bezrukov (1957) found that during the first two months postpartum, the ovaries of lactating ewes which were maintained on average or high nutritional levels, contained maturing follicles whereas ewes on lower feeding levels had inactive ovaries.

Smith (1964) examined the effect of grazing alone and of a supplementary ration of 2lb of lucerne hay per ewe daily on oestrus activity after lambing. Lucerne feeding was initiated about two weeks before lambing commenced and continued through lambing until adequate grazing was available. The supplementary lucerne feeding promoted the incidence of oestrus.

Van Niekerk and Mulder (1965) suggested that differences in feeding levels and methods may be the main source of the variation from the postpartum interval to oestrus in a particular breed of sheep, even when lambing occurs at the same time of the year in each instance. They held the opinion that the additional nutritive requirements imposed by lactation, as opposed to the hormonal side effects of lactation played a much greater role in inhibiting the occurrence of postpartum oestrus in lactating ewes than expected.

Finally, the onset of postpartum oestrus and conception was

found to be associated with an increase in the vitamin A level and a decrease in the calcium/phosphorus ratio in the blood serum of ewes and perhaps also with increased sugar intake (Markus, 1956).

On the other hand, Hunter and Lishman (1967) found no significant effect of feeding a supplementary ration of 1lb maize per ewe daily for 25 days after lambing on the postpartum interval to ovulation or oestrus in ewes. Also no significant difference was found between early and late weaned ewes with respect to first postpartum oestrus when on a high plane of nutrition (Wagner and Veenhuizen, 1968; Whiteman et al., 1972).

Thus the reports on the effect of energy intake on postpartum ovarian activity in the ewe indicate variable findings among authors. While some observed an advantage for postpartum supplementary feeding others found no difference. However, there is no report of a negative effect of additional energy intake on postpartum ovarian activity.

In the cow the occurrence of oestrus after calving appears to be significantly influenced by the level of feeding (Wiltbank et al., 1962). Intervals from calving to first oestrus in mature Hereford cows fed different levels of energy pre-and postpartum were 48 days for high-high level group, 43 days for high-low level, 65 days for low-high level and 62 days low-low level of feeding. The conception rates for the various feed level groups were 95,77,95 and 20% for high-high, high-low, low-high and low-low rations, respectively.

Wiltbank et al., (1964) also fed different groups of postpartum beef cows different levels of feed and reported that cows that received 16.5lb total diggestible nutrient (TDN) had a

significantly shorter interval from calving to first oestrus (P(. 01) than those that received 12.5 and 25.0 TDN during the first four to five weeks postpartum and 16.41b thereafter (49 days vs 73 and 77 days).

Dunn et al., (1969) showed that increasing energy intake following calving shortened the interval from calving to oestrus, and pregnancy rate 120 days after calving was directly related to the post-calving energy level. In that study 87% of the cows given high energy level feed (48.2 megcal) after calving were pregnant compared to 72% of those fed a moderate level (27.3 megcal) and 64% of those fed low energy level (14.4 megcal).

The combined effects of lactation and low energy intake on postpartum ovarian activity delayed postpartum follicular growth and ovulation in the cow (Oxenreider and Wagner, 1971). Both energy intake and lactation also affected plasma glucose level which was negatively correlated with postpartum interval to occurrence of a 10mm follicle and ovulation.

In contrast to the findings of most investigators on the effect of energy intake on postpartum reproductive activities in cattle, Carstairs et al., (1980) reported that neither energy nor phosphorus status influenced postpartum reproduction of dairy cows. These workers

subjected groups of heifers to one of four treatments at parturition; (1) high energy, high phosphorus, (2) high energy, low phosphorus (3) low energy, high phosphorus and (4) low energy, low phosphorus and found that the interval from parturition to the first ovulation did not differ between the groups.

Effect of season on postpartum ovarian activity

Reports on the effect of season on the interval from parturition to first oestrus are unequivocal. While some studies indicated that the season of the year had an effect on the interval, others indicated no effect. For instance, Chapman and Casida (1937) suggested that this period tended to be longer in spring than in the other seasons of the year. Although, Herman and Edmondson (1950) found no definite trend in the effect of the season on the length of time from calving to first heat, they noted that the average number of days was greater for January, June and August calvings than the other months. But Buch et al., (1955) reported that cows calving during summer tended to come in heat earlier than those calving in the other seasons, whereas those calving during winter had the longest intervals from parturition to first heat. The mean intervals were 32, 28, 32 and 38 days for spring, summer, fall and winter, respectively. Carman (1955) observedthat cows calving in March and those calving

in September had the longest and shortest intervals, respectively, from parturition to first oestrus.

Guilbert and MacDonald (1933) studied the records of 43 beef cows and found no seasonal influence on the interval from parturition to first oestrus. Warnick (1955) reported that the average interval for cows calving during the first half of the calving season was 28.3 days longer for Hereford and 25.5 days longer for Angus than for those that calved during the last half. Also there was a highly significant difference in interval due to years. The average interval for cows was 50.2 days in 1951, 59.8 days in 1952 and 71.2 days in 1953.

Morrow et al., (1966) found no significant influence of season and environment on the interval from parturition to first oestrus and the first to the second oestrus intervals in normal and abnormal cows. The occurrence of corpora lutea was however reported to be significantly higher during February to July than during August to January. The occurrence of cystic corpora lutea was significantly lower during February to July than during August to January (P(0.005).

Sefidbakht and Movassagh (1973) found that the percentage of ewes conceiving among ewes that lambed in fall was higher (P(.001) than that of ewes lambing in spring. The incidence of postpartum ovulation in

fall-lambed ewes was also higher (P(.005) than in spring-lambed ewes (93.7% vs 35.5%). Sefibakht et al., (1977) observed greater number of follicles in spring-lambed ewes as compared to fall-lambed ewes but the percentage of ewes which had ovulated by day 23 after lambing was higher (P(.05) for fall-lambed ewes (80 vs 0%). In the buffalo, El-Sheikh and Mohammed (1976) reported average postpartum heat intervals of 163.03, 158.03, 144.96 and 79 days in autumn, winter, spring and summer, respectively. Though these were statistically nonsignificant, it was obvious that the longest interval was in autumn while the shortest was in summer.

Effect of age and parity on postpartum ovarian activity

Many investigators have observed that age of dam influences postpartum reproductive activity of cows. Hammond and Sanders (1923) found that the interval from parturition to first oestrus in cattle became shorter with age until after the third or fourth calving. Thereafter the interval became longer again with those cows having a sixth, seventh or eigth calving. Tenabe and Salisbury (1946), Herman (1956), Morrison and Erb (1957) and Salisbury and Van Demark (1961) all reported that in the United States fertility of cattle increased up to four years of age, levelled off at six years

of age, then gradually declined. These observations agreed with those reported by Boyd and Reed (1961) who found that the 60 - 90 day non-return rate to first inseminations was 60.5% for heifers, reached a peak of 66.8% at the third gestation and then declined to 51.1% for cows past their eighth gestation.

In a herd study, Hurst (1959) found that 19% of heifers presented for pregnancy diagnosis were not pregnant compared with eight percent of cows. This was interpreted as suggesting a higher rate of post service anoestrus in heifers than in cows. In a review of the effects of age on fertility in female cattle, Dawson (1960) stated that the calf crop for heifers was 15 to 20% lower than for cows. A similar finding in a ranched beef herd was reported by Wiltbank (1966). Earlier on, Casida and Wisnicky (1950) had found that cows more than five years old took a longer time to come in season after calving than younger animals.

Belling (1963) conducted a study on reproductive efficiency of Hereford cows and reported that fertility in beef cattle herds on New Mexico range, reached a maximum at four years of age and remained constant until declining in cows over 10 years of age. In a field study in 14 large dairy herds, Fielden *et al.*, (1973) showed that theincidence of anoestrus due to ovarian inactivity was much greater in first and second calvers

compared with mature cows. Twenty one percent of two-year old cows were examined because they had not been seen in oestrus compared with 18% and 10% for three year-old and older cows, respectively. In contrast to this report Macfarlane and Goodchild (1973) found maximum fertility in maiden heifers. The fertility declined as the age of dam increased; and this decline was noted to be a reflection not only of a falling conception rate but also of an increasing foetal mortality.

Younger buffaloes have been found to come in heat after a significantly longer postpartum interval than older ones (El-Sheikh and Mohammed, 1976). Also differences between primiparous and pluriparous buffaloes in length of postpartum heat intervals were statistically significant. In a study of oestrual activity in lactating ewes, Barker and Wiggins (1964) found no significant difference in postpartum intervals to oestrus between two and three year-old Rambouillet ewes during 1957-58 breeding season, or between the same ewes when they were a year older. The mean postpartum interval for the four year old during the second season was not significantly different from the interval for the same ewes during the previous season. On the other hand, the three year-old in 1958 had

significantly longer postpartum intervals than they had as two year old during the previous season (87.6 compared with 71.8 days, (P(.01). Van Niekerk and Mulder (1965) also did not observe a marked effect of age of ewes on length of postpartum anoestrus, although for two-year, three and four-year old ewes there was a tendency for the interval to postpartum oestrus to vary inversely with age.

It is obvious from the available literature that age and or parity affects postpartum reproductive activity of cattle and sheep; either positively or otherwise. The effect of this factor on the postpartum ovarian activity and thus fertility of our indigenous cattle is not known.

Uterine involution

The significance of uterine involution is in its effect on subsequent fertility. Complete uterine involution is necessary for a cow to conceive readily after parturition (Buch et al., 1955). The influence of delayed uterine involution on subsequent fertility has been investigated by Foote et al., (1960). Conception rates at 60 days postpartum were slightly higher in cows with completely involuted uteri than in cows with incompletely involuted uteri.

Studies on the rate of uterine involution are based either on clinical involution as evidenced by return to normal tone, position and size as determined by rectal palpation in the cow or on gross measurements of weight, diameter and length of uterine horns or histological studies of uterine caruncular changes at slaughter.

On the basis of clinical uterine involution, various values have been given as the intervals from parturition to complete involution: 26.2 days (Casida and Venzke, 1936), 29.2 days (Casida and Wisnicky, 1950), 42 and 50 days (Buch et al., 1955), 43.7 days (Foote et al., 1960), 42.3 days (Menge et al., 1962) and 25 days (Morrow et al.,1966).

Using the results of rectal palpations of 2,338 postpartum genital organs, Tennant et al., (1967) estimated that there were two phases of uterine involution. The rate of involution was rapid and constant from 10 to 25 days postpartum but decreased between 26 and 38 days postpartum. There was no change in mean uterine horn diameter between 40 and 50 days postpartum. They observed increases in mean uterine horn diameter with successive lactations. The investigation of clinical involution in the Bunaji and Friesian/Bunaji cross showed that uterine involution

was complete in 17 days and 16 to 30 days for the Bunaji and crossbreds, respectively (Oyedipe et al., 1980).

Basset (1963) reported that about three quarters of the ovine uterine weight during pregnancy (i.e excluding its contents) was lost during the first week postpartum, and that uterine weight was restored to the level of the nonpregnant uterus by four weeks after parturition.

Nel and Pretorius (1968) killed seven non-lactating Karakul ewes after their first postpartum oestrus (mean, 21.6 days postpartum) and recorded a mean uterine weight of 160.1±52.9 grams compared to 72.1±15.2 grams for nine ewes that did not lamb but were killed after oestrus during the same period. They concluded that, on weight basis, uterine involution occurred in these ewes after 21 days postpartum.

Foote and Call (1969) recorded mean uterine weights of 1, 256, 1, 088, 106 and 96 gm for days 0, 3, 10, 17 and 24 postpartum respectively in lactating ewes and noted that the rate of involution was greatest between days 3 and 10 and thus involution was essentially completed by day 17. The mean uterine weight was 67 gm for day 24 postpartum non-lactating ewes.

Van Wyk et al., (1972b) concluded from the results of the various macroscopic measurements of ovaries and uterus of ewes that uterine involution was complete between 20 and 24 days postpartum. They observed a rapid reduction of the weight of the uterus during the first 8 days (1206g on day 1 to 326g on day 8 postpartum), with the greatest decrease occurring during the first 12 days (151g on day 12). The decline in the volume of the uterus approximated very closely its decrease in weight (1100 to 143ml from day 1 to day 12). Though the recently gravid uterine horns had undergone a maximum reduction in length by the 20th day postpartum (47 to 25.5cm, day 1 to day 20), the diameters had not yet decreased similarly even by the 28th day (5.9 to 2.0cm, day 1 to day 28).

Palmer et al., (1965) observed that macroscopically the uterus of second litter lactating sows declined rapidly in weight (2,724.8±139.3 to 244.0±9.0g) and length (237.2±17.7 to 120.8±10.1cm) from day 1 to day 28 postpartum. It increased in both weight and length during the first four days after weaning at 8 weeks (310 to 502 and 109 to 155cm, respectively). They concluded that the porcine uterus completes involution at between 21 and 28 days after farrowing.

In 57 clinically normal postpartum dairy cows Gier and Marion (1968) observed a reduction in the length of the postpartum uterine horn to half of the size at parturition and to a third by 15 and 30 days postpartum, respectively. Uterine involution was complete by 50 days postpartum. In these animals average uterine weight decreased from 9.0kg at parturition to 1.0kg at 30 days and to 0.75kg at 50 days. Caruncular surface sloughing was complete in 15 days and the area covered again by epithelium at 25 days after parturition. This process (reepithelialization) was complete in 26 to 30 days postpartum in ewes (Uren, 1935).

Tennant and Peddicord (1968) studying the influence of delayed uterine involution and endometritis on bovine fertility, observed a reduction in fertility in cows with uterine horn diameters of two inches or more due to endometritis, at 30 to 50 days postpartum. The mean uterine horn diameter for normal cows 30 to 50 days postpartum was 0.92±0.29 inches compared to 1.0±0.34 inches for cows with endometritis.

Rasbech (1950) reported that uterine involution involved the disappearance of the caruncular stalk through vasoconstriction with subsequent dissolution

of the superficial layer of the uterine canruncle and that the whole process was completed in the cow during the 3rd or 4th week following parturition.

The progressions of the process of the bovine uterine involution based on histological findings have been described in details by Wagner and Hansel (1969) and Archbald et al., (1972). The former observed some exudate on the uterine mucosal surface on day 7 postpartum and reported that necrosis and sloughing of the caruncular surface appeared to begin at a point basal to the maternal crypts. By days 12 to 14 postpartum, the necrotic tissue had sloughed from the surface of the caruncles and regeneration of the epithelium from the edges of the caruncles, was beginning. The uterine mucosal epithelium was re-established in most normal cows within 30 days postpartum.

Gier and Marion (1968) also reported the presence of chorioallantoic cells in the lumen of maternal caruncular crypts at day 2 postpartum. They hypothesized from this observation, that detachment of terminal portions of chorioallantoic villi from maternal crypts probably play a major role in separation of foetal maternal placentae.

The study of Archbald et al., (1972) involved

caruncular and intercaruncular uterine samples obtained from an area at the base of the uterine horn by in vivo serial surgical technique as well as by per-cervical biopsy and at necropsy. On day 1 postpartum, they observed in caruncular sections numerous remnants of chorioallantoic cells in the maternal crypts. These chorioallantoic cell remnants underwent necrosis and mineralization, and were either phagocytized by macrophages or expelled with the lochia. Progressive vascular changes in the medium-sized and smaller arteries of the caruncular compactum were observed during days 1 to 19. These changes consisted of hydropic degeneration of the cytoplasm and pyknosis of the smooth muscle cells of the tunica media and fibrinoid necrosis of the tunica. Concomitant with these vascular changes a progressive necrosis and sloughing of the superficial areas of the caruncles were noticed at about days six to seven postpartum so that by day 15 the stratum compactum was reduced almost to the level of the intercaruncular area.

The sequence of events in the involution of the maternal caruncle was characterised as; degenerative vascular changes leading to peripheral ischemia, resulting in necrosis and subsequent sloughing of

the superficial layers of the caruncle (Archbald et al., 1972). Cuboidal-type epithelial cells with large hyperchromatic nuclei and granular cytoplasm on focal areas of the caruncle, were evident by day 15 and by day 19 the entire caruncular surface was covered by an epithelial layer.

Archbald and his co-workers also reported the presence of both degenerated and regenerated epithelial cells in the intercaruncular epithelium on day 1. While the degenerated cells were confined to the basal areas of the epithelium and were characterized by pyknosis and cytoplasmic vacuolation, the regenerated cells were interppersed amongst the degenerated epithelial cells and were characterized by large, hyperchromatic nuclei and granular cytoplasm. The two processes of epithelial cell degeneration and regeneration continued simultaneously until day 15, at which time no degenerative epithelial cells were observed. They noted that at no time during uterine involution was the intercaruncular area devoid of an epithelial layer. The epithelial cells of the uterine endometrial glands exhibited a pattern of simultaneous degeneration and regeneration similar to that observed in the intercaruncular area. The histological changes reported for the myometrium

consisted of granular degeneration of the sarcoplasm, vacuolation of the muscle cell and atrophy of the nucleus. The initial stages of this process was evident on day three postpartum and the nuclei of the muscle fibres appeared atrophic by day 27. By day 31, the fibres appeared normal and the entire myometrium greatly reduced in size compared to that in the early postpartum period. They did not observe necrosis of the muscle fibres during postpartum myometrial regression.

Van Wyk et al., (1972a) studied the involution of the postpartum uterus of the ewe from three hours after parturition to 28 days later. They found that during the first 12 days postpartum the distal two thirds of the maternal villi liquified in two stages while the remaining hyalinized caruncular tissue detached as plaques between days 16 and 20 leaving a naked caruncular connective tissue to complete involution by 28 days after parturition.

Factors reported to affect bovine uterine involution include parity, season and suckling. Most investigators reported that uterine involution was faster in primipara than in pluripara cows (Casida and Wisnicky, 1950; Foote et al., 1960).

The reported intervals to complete involution were: 18 to 20 days for primipara and 20 to 25 days for pluripara (Rasbech 1950); 42 and 50 days for primipara and pluripara, respectively (Buch et al., 1955); and 34 and 40.6 days for primipara and pluripara respectively (Marion et al., 1968). However, Tennant et al., (1967) found no apparent differences in the rate of uterine involution between cows in the first four lactations.

Buch et al.(1955) reported significant differences in the duration of involution between the four temperate seasons. The mean intervals from normal parturition to complete uterine involution during the winter, spring, summer and autumn seasons were 51, 47, 42 and 44 days, respectively. Marion et al., (1968) found that uterine regression was slower in both primiparous and pluriparous cows during winter and most rapid during spring and summer. Also the length of the interval to complete involution varied much more in the summer and seemed to be associated with ambient temperature. Furthermore, if parturition occurred during extremely hot weather (38^{o}C and higher), heat stress markedly increased the interval from parturition to uterine involution. On the other hand,

Morrow et al., (1966) reported that neither season nor environment significantly affected the rate of uterine involution.

The reported effects of suckling on involution are also contradictory. Riesen et al., (1968) reported that the rate of uterine involution was more rapid for suckled than for nonsuckled dairy cows in one to 10 and 20 to 30 days postpartum periods. Thus uterine involution in the suckled animals was nearly completed by 30 days postpartum or during the first oestrous cycle.

In a similar study in beef cattle, Lauderdale et al., (1968) also found that suckling increased the rate of uterine involution as measured by a decrease in the mass of the three major tissue layers, endometrium, circular and longitudinal muscle layers on day three postpartum pregnant horns. The decrease in myometrial mass resulted from a decrease in cell size; although a significant decline in cell number was not detected. In addition it was also observed that suckling caused a decrease in endometrial glandular mass and lymphocyte counts.

Contrary to the above findings, Oxenreider (1968) did not find a significant difference in the interval from parturition to uterine involution between suckled

(34±3 days) and nonsuckled (32±4 days) beef cows. Similarly, Wagner and Hansel (1969) did not observe a significant effect of suckling on uterine involution In their study, the average diameter of the gravid horn at the bifurcation was 3.9cm in nonsuckled at day 30 postpartum compared to the 4.85cm for suckled cows; and reepithelialization of the caruncle was complete at this time for both suckled and nonsuckled. Moller (1970) also reported that suckling had no influence on the speed of uterine involution

Bacteriology of the postpartum bovine uterus

Bacteriological investigations of the postpartum bovine uterus are scanty. It is generally believed that at parturition the uterus is sterile and that normal involution proceeds aseptically. However, investigations have revealed that the uteri of a number of cows become infected by a number of non-specific bacteria during the puerperium (Rasbech, 1950).

Reports of incidence of infection of clinically normal cows vary. While Clark and Stevenson (1948) reported 0%, Wulf and Dracy (1952) recorded 100% infection. Hartigan (1978) indicated in his review of the role of non-specific uterine infection in the infertility of clinically normal repeat-breeder cows

that majority of reports on the incidence of infection for both fertile and repeat-breeder cows fall within the range of 20 to 40%.

Rasbech (1950) reported that puerperal uterine infections in clinically normal cows occurred with a frequency of 25 to 30% in a herd of 203 cows. The time of sampling was not indicated. Corynebacterium pyogenes in pure culture was the most common (28.3%) bacterium isolated followed by Escherichia coli (26.7%). Staphylococci in pure culture were also demonstrated in 16.7% of the cases. Infection of Group B streptococci in pure culture was demonstrated in two cases too. The presence of the bacterial infections resulted in a purulent lochial discharge which was white or yellowish-white in colour with C.pyogenes infections and greyish-white with E.coli and staphylococcal infections.

Higaki et al.,(1959) (quoted by Morrow et al., 1968) observed that the largest number of bacteria was present in the uterus at one to two weeks postpartum. A direct correlation between the length of the postpartum period and the presence of bacteria was reported by Elliot et al., (1968) who observed that 85% of the uteri between days 0 to 15 postpartum were contaminated with micro-organisms while at 60 days postpartum only 10% of the uteri were infected.

Nunn et al., (1970) investigated the bacterial flora of the genital tract during the postpartum period by assessing the immune response of the genital tract of 118 cows to some of the nonspecific organisms which could commonly be isolated, using homogenates of uterine tissues and mucus. Agglutinating antibodies to Staphylococcus, Corynebacterium pyogenes, Salmonella dublin, Proteus vulgaris and Escherichia coli were found. They detected uteine agglutinins in approximately 80 per cent of the animals 14 to 28 days after calving, whereas only 10 per cent gave a positive response 90 days postpartum.

Griffin and co-workers (1974) obtained uterine swabs in vivo from 12 cows at 30 to 35 days postpartum on two occasions five days apart and isolated coagulase negative Staphylococcus from two cows, and C.pyogenes, enterobacteria, non-haemolytic Streptococci from each of four cows during the first sampling. Isolates from the second sampling were C.pyogenes and non-haemolytic Streptococcus from each of two cows.

Griffin et al., (1974a,b) sampled 93 dairy cows repeatedly throughout the nongravid period and reported that the incidence of infected uterine samples declined from about 100% during the first two weeks postpartum to approximately 30% during the fifth week, and then remained fairly constant thereafter. They

isolated a wide range of bacteria and noted that in individual animals the species often changed because of spontaneous clearance and recontamination.

In this regard Hartigan (1978) expressed the belief that, although puerperal infections are eliminated fairly promptly probably by antibodies, the uterus does not necessarily remain sterile; it is subject to repeated transient invasion by a variety of bacteria present in the posterior reproductive tract.

Bacteriological investigations of the repeat-breeder cow have also been reported. Gunter et al.,(1955) reported that potential pathogens predominated in samples from repeat-breeder or infertile cows, whereas samples from fertile cows contained largely saprophytes. This is contrary to the report by Hartigan et al., (1972) that the frequency and type of infections for repeat breeder cows were similar to those reported for normal fertile cows. These workers examined bacterial swabs from 80 clinically normal repeat breeder dairy cows and isolated bacteria from only 27 cows (34%) with Staphylococcus aureus, Gram-positive bacilli, beta-haemolytic streptococci and microaerophilic streptococci occurring most frequently. C. pyogenes a potential pathogen, was not isolated from any ccw.

There is no concensus of opinion as to whether endometritis is a major cause of infertility in clinically normal repeat breeder cows. While Simon and McNutt (1957) concluded that endometritis was not a major cause of infertility in clinically normal repeat-breeders, Dawson, (1963) and Sagatz and Hardenbrook (1971) diagnosed endometritis in 55 to 80% of infertile cows. C.pyogenes, S.aureus, haemolytic streptococci and haemolytic E.coli have been most commomly implicated as inducing endometritis. However, in a study of repeated bacteriological and histological samples from the uteri of dairy cows (Griffin et al., 1974a,b) only C.pyogenes was found to be consistently associated with endometrial lessions. Other non-specific bacteria made sporadic and transient appearances in the uterine lumen without affecting endometrial histology or subsequent fertility.

Hartigan et al.,(1974) noted that a persistent infection by C.pyogenes caused very severe endometritis, delayed uterine involution, induced anoestrus and caused prolonged infertility or even sterility.

PART II

EFFECTS OF SUCKLING, FEEDING, SEASON OF CALVING, PARITY OR AGE AND BREED ON POSTPARTUM OVARIAN ACTIVITY AND UTERINE INVOLUTION.

INTRODUCTION

A number of factors has been reported to have varying effects on rate of uterine involution and the resumption of postpartum ovarian activity in cattle. Prominent among these factos are nutrition, season, parity and suckling. Different levels of nutrition have been reported to have varied effects on postpartum reproductive activity of the cow. For instance increasing energy intake following calving shortened the interval from calving to oestrus, and the pregancy rate at 120 days postpartum was directly related to the post calving energy level (Dunn et al., 1969). Earlier, it was observed that the level of feeding exerted a significant positive influence on the occurrence of oestrus after parturition (Wiltbank et al., 1962 and 1964). Low energy intake has also been shown to delay postpartum follicular growth and occurrence of ovulation in cattle (Oxenreider and Wagner, 1971). Contrary to the above reports Carstairs and his co-workers (1980) reported that energy status did not influence postpartum reproduction in dairy cows.

Investigations on postpartum ovarian activity and uterine involution in the temperate breeds of cattle indicate a significant effect of season on the interval

from calving to first oestrus and calving to uterine involution. The study by Chapman and Casida (1937) suggested that postpartum intervals to first heat tended to be longer in spring than in the other seasons of the year. Buch et al.(1955) also observed significant variations in bovine postpartum heat and uterine involution intervals between the different seasons. The average intervals from parturition to first heat for calvings in winter, spring, summer and autumn were 38, 32, 28 and 32 days, respectively while the time taken for complete uterine involution were 51, 47, 42 and 44 days for calvings in winter, spring, summer and autumn respectively. In contrast, Guilbert and MacDonald (1933) found no seasonal influence on the interval from parturition to first oestrus in their study of the records of 43 beef cows. Morrow et al., (1966) also did not find a significant influence of season on the interval from calving to first oestrus in experimental normal and abnormal cows.

There are indications that Zebu cattle in general begin reproductive activities later than temperate breeds of cattle(Mahadevan and Marples, 1961; Wheat and Broadhurst, 1968; Wiltbank et al., 1969; Oyedipe et al.,1980).

The influence of age or parity of dam on reproductive activities of cows has also been observed by

a number of investigators. The interval from parturition to first oestrus in cattle was found by Hammond and Sanders, (1923) to become shorter with age until after the third or fourth calving, and longer again with subsequent calvings. The fertility of cattle was reported to increase up to four years of age, levelling off at six years then gradually declining (Tenabe and Salisbury 1946; Herman, 1956; Morrison and Erb, 1957; Salisbury and Van Demark, 1961). Specifically, Boyd and Reed (1961) observed that the 60 - 90 day non-return rate to first inseminations was 60.5% for heifers, reached a peak of 66.8% at the third gestation and then delined to 51.1% for cows past their eighth gestation. Wiltbank (1966) also observed lower conception rates in heifers than in cows in a ranched beef herd. However, Macfarlane and Goodchild (1973) found maximum fertility in maiden heifers with fertility declining as the age of dam increased.

Studies on the effect of suckling on postpartum ovarian activity suggest that suckling interferes with the postpartum reproductive activity of the cow. The intervals to first postpartum oestrus and ovulation were longer for suckled than for nonsuckled cows (Saiduddin et al., 1968; Wagner and Oxenreider, 1971).

Wiltbank and Cook (1958) also observed a significant difference in return to normal reproductive cycles in cows with suckling calves compared to control cows.

While some investigators reported an earlier uterine involution for primiparous than pluriparous cows (Buch et al., 1955; Marion et al., 1968), others found no apparent differences in the rate of involution among cows in the first four lactations (Tennant et al., 1967) or no definite effect generally on the rate of involution (Casida and Wisnicky, 1950). However there are reports of accelerated uterine involution due to suckling (Riesen et al., 1968; Lauderdale et al., 1968) and of no significant difference in therate of involution between suckled and nonsuckled cows (Oxenreider, 1968; Wagner and Hansel, 1969).

It is a practice in institutional cattle farms in Nigeria to wean calves at six months postpartum, while the nomadic cattle farmers controlling over 70% of the cattle population, wean the calves after periods of about one year. Moreover, the only source of nutrients for the nomadic cattle is grazing which in the dry season hardly provides enough nourishment for body maintenance let alone support an efficient reproductive performance. It is evident that these two factors will result in prolonged calving intervals in cows in Nigeria.

However, the effect of a prolonged nursing and inadequate nourishment particularly after calving, on the postpartum reproductive activity and subsequent calving interval of the indigenous cattle has not been investigated.

Recognition of the season for an early resumption of a fertile postpartum ovarian activity, that is, follicular development followed by ovulation, will enhance a planned breeding programme which will ultimately result in a shorter and desirable calving interval for these animals. Also, there is the need to determine the age or parity status for an optimum reproductive efficiency and that for a declining reproductive activity so as to know when to cull the low producing cows to make room for replacements and thus prevent unnecessary expenditure on the maintenance of unproductive cows.

This study was designed to determine the effects of (a) suckling, (b) a supplementary concentrate ration, (c) season of calving (rainy or dry) and (d) age or parity of dam, on postpartum ovarian activity and uterine involution in the Zebu cattle indigenous to Nigeria.

MATERIALS AND METHODS

Animals and treatments

A total of 94 postpartum cows comprising of 79 Bunaji (White Fulani) and 15 Sokoto Gudali cows were used in this study (Appendix 1). Table 1 shows the number of cows per treatment group. At calving the Bunaji cows were randomly alloted to different treatment groups as follows: suckled and nonsuckled; grazing plus concentrate and grazing alone; rainy and dry season; and one to two calving groups (or three to five years old) and more than two calvings (or over five years old). Calves of the cows in the nonsuckled group (15) were weaned at 24 hours postpartum to allow them obtain some colostrum and were bucket fed thereafter.

In the feeding group 36 cows received 3kg of a concentrate ration daily in addition to grazing. The ration was made up of 60% maize and 40% cotton seed cake and was fed to the cows every morning before grazing. The group on grazing alone (58 cows) and the grazing plus concentrate group (36 cows) were intended to simulate traditional and institutional husbandry methods, respectively.

Thirty nine and 55 cows that calved during the dry (October to March) and rainy (April to September) seasons, respectively, were used to determine the effects of these two seasons on the parameters measured in this study. Similarly, 49 cows that had one or two calvings or whose ages were between three and five years old and 43 others which had more than two calvings or were over five years old were used to determine the effect of parity or age on the same parameters.

Examinations

The reproductive tracts and ovaries of all cows in all treatment groups were palpated per rectum (Zemjanis, 1970) beginning a day after calving and at weekly or more frequent intervals thereafter until detection of a well formed cyclic corpus luteum (CL). On detection of a mature follicle, palpations were carried out on alternate days. At palpation the ovarian structures, were recorded and the progress of uterine involution was monitored. Uterine involution was considered complete by a rectum to normal size, tone and position in the pelvis.

All cows were watched for oestrus every morning and during grazing. A cow that stood to be mounted by another cow was regarded as being in oestrus.

The intervals between calving and the detection of the first follicle and occurrence of first ovulation as well as the time taken for complete uterine involution were determined from the palpation data. When an ovulation depression (OVD) was detected, ovulation was estimated to have occurred a day earlier (Zemjanis, 1970). If a corpus haemorrhagicum (CH) was detected without a previous detection of an OVD ovulation was estimated to have occurred two to three days earlier. If a CL was the first ovarian structure to be detected in any cow, the day of oestrus was taken as day zero and ovulation was estimated to have occurred a day after oestrus.

Statistical analysis

The effects of suckling, feeding regime, season, parity and breed on the measured reproductive traits were examined by the least squares analysis of variance (ANOVA) according to Harvey (1960). The parameters examined were as follows: Suckling regime was either suckled or nonsuckled, feeding was either grazing alone or grazing plus concentrate, season was either dry or rainy, parity was either one to two calvings or more than two calvings, and breed was either White Fulani or Sokoto Gudali.

The Statistical model used was as follow:-

$Y_{ijklmn} = \mu + S_i + F_j + M_k + P_l + B_m + e_{ijklmn}$ where:

Y_{ijklmn} = observation on the nth animal of the mth

breed of the 1th parity in the kth season, in the jth feeding regime and the ith suckling regime.

μ = the overall mean.

Si = the effect of the ith suckling treatment (i=1,2)

Fj = the effect of the jth feeding treatment (j=1,2)

Mk = the effect of the kth season (k=1,2)

Pl = the effect of the 1th parity (l=1,2)

Bm = the effect of the mth breed (m=1,2)

eijklmn = random error.

R E S U L T S

All cows in all the treatment groups had normal calvings and with no retained placenta or cystic ovaries.

The ANOVA of treatment effects on the intervals between calving and development of the first palpable follicle and first ovulation as well as the interval for complete uterine involution is presented on Table 2. The means of treatment effects adjusted for independent variables for the parameters measured are shown on Table 3.

Effect of suckling:

The mean intervals from calving to first ovulation for suckled (68.11 days) and nonsuckled (34.11 days) cows were significantly different (P).05(.10). Mean interval postpartum to first detected follicle for nonsuckled cows was less than half of the interval for suckled cows (23.36 vs 52.77 days). However, the difference between the two intervals was not statistically significant. (Note the high standard deviations on Tables 4a,b).

Tables 5 and 6 show the ANOVA and adjusted means, respectively, of intervals from detection of first follicle to occurrence of first ovulation for all treatments. The mean intervals form first follicle to first ovulation for suckled (36.08 days) and nonsuckled (26.86 days) cows were not statistically different. Marked individual cow variations were also manifested for this parameter as indicated by the very high standard deviations of the unadjusted means (Table 7). The interval to completion of uterine involution for the suckled and nonsuckled cows (25.64 vs 25.98 days) were similar.

Effect of feeding:

The level of feeding in this study had no significant effect on the interval postpartum to first follicle and first ovulation (Table 3). However, cows in the grazing plus

concentrate group had their first follicle two days before and also ovulated 18 days earlier than cows in the grazing only group (44.91 vs 47.27 days and 50.87 vs 68.94 days). There was a very significant difference in the interval from first follicle to first ovulation (P(.01) between the two groups (7.44 vs 58.96 days for grazing plus concentrate and grazing only groups, respectively, (Tables 5 and 6). The interval for complete uterine involution for both groups (24.98 vs 26.1 days were not different.

Effect of season:

First postpartum ovulation occurred earlier in cows that calved during the dry season (P(.10) than those that calved in the rainy season (49.7 vs 71.43 days). However, intervals postpartum to first follicle (46.59 days for dry season and 45.86 days for rainy season) and the durations of uterine involution (26.88 vs 24.8 days for dry and rainy seasons, repectively) for both groups were similar. Intervals from first follicle to first ovulation (17.14 vs 42.48 for dry and rainy seasons, respectively, Tables 6 and 7) were different (P(.10) for the two groups.

Effect of parity or age

Parity or age had no significant effect on intervals postpartum to first follicle and first ovulation (Table 2). However, first postpartum ovulation occurred earlier in cows which had more than two calvings or over five years old (50.76 days) than those with one to two calvings or three to five years old (66.78 days). The intervals to first follicle (45.48 vs 46.44 days for cows three to five and over five years respectively) and durations of uterine involution (26.64 vs 24.92 days) were similar for both groups. Mean interval from first follicle to first ovulation for cows with one to two calvings (45.01 days) was longer (P(.05) than that for cows with more than two calvings (12.28 days, Table 6).

Effect of breed

Analysis of variance for breed effect showed that breed had no significant effect on intervals postpartum to first folicle and first ovulation (Table 2). Mean interval postpartum to first follicle for the Sokoto Gudali cows (53.56 days) was however longer than the interval for White Fulani cows (44.91 days) but the interval to first ovulation was shorter for the Sokoto Gudali (42.72 days) than for the White Fulani (65.85 days). Mean interval from first follicle to first ovulation for the White Fulani cows was 43.3 days. Ovulation occurred 34 days before first follicle was recorded for the Sokoto Gudali cows (Table 6). Statistical analysis indicates a very significant difference (P(.01) in the intervals for the two breeds (Table 5). The duration of uterine involution was similar for the two breeds (25.94 and 24.5 days for White Fulani and Sokoto Gudali, respectively).

There were marked individual cow variations in the intervals postpartum to first follicle, to first ovulation and from first follicle to first ovulation in all treatment groups as indicated by the high standard deviations of the unadjusted means shown on Tables 4a, 4b, 4c, and 7. While one of the cows had her first follicle as early as five days another cow had hers as late as 276 days postpartum. Also an early ovulation

occurring at 9 days after calving and late ovulation that occurred 284 days after calving were recorded.

The mean postpartum interval to first follicle for all treatment groups ranged from 23 days for nonsuckled White Fulani cows to 34 days for suckled Sokoto Gudali cows, while the range for postpartum interval to first ovulation was 34 days for nonsuckled White Fulani cows to 71 days for same breed of cows that calved in the rainy season (Table 3). Mean intervals from first follicle to first ovulation ranged from 7 to 59 days (Table 6). Range for duration of uterine involution was from 24 days for Sokoto Gudali to 27 days for White Fulani cows that calved in the dry season (Table 3).

D I S C U S S I O N

Effect of suckling

The results of the present study showed that the average interval postpartum to first follicle for suckled cows (52.77 days) is longer than that observed for the nonsuckled cows (23.36 days) by 29 days. Also, the mean interval from calving to first ovulation is longer for suckled (68.11 days) than for nonsuckled cows (34.11 days) by 34 days. These findings agree with previous reports that indicated longer postpartum intervals to first follicle and first ovulation for suckled cows (Saiduddin et al., 1968; Oxenreider, 1968; Wagner

and Hansel, 1969; Kesler et al., 1980). However, in the present study these differences in the intervals were not statistically very significant because of the small number of animals in each treatment group coupled with the very marked individual variations as indicated by the high standard deviations.

The observed interval of 53 days from calving to first follicle for suckled animals in this study, is much longer than the interval of 16-18 days to first follicle for suckled and milked cows reported by a number of investigators (Callahan et al., 1971; Kesler et al., 1979; Wagner and Oxenreider, 1971). This difference in the results suggests a possible breed and environmental effects. The interval of 23 days for nonsuckled cows in this study, however, agrees fairly well with 16-18 days interval reported by others (Wagner and Oxenreider, 1971).

First postpartum ovulation of 27 to 53 days for suckled and 14 to 36 days for nonsukkled cows have been reported (Wiltbank and Cook, 1958; Wagner and Hansel, 1969; Carruthers and Hafs, 1980). While corresponding intervals observed in this study (68.11 vs 34.11 days) are similar to those reported by Wiltbank and Cook (1958) (53 vs 36 days), they are

higher than those reported by Wagner and Hansel (1969) (27.5 vs 14 days) and by Carruthers and Hafs (1980) (39.7 vs 21.2 days). However, the interval observed in this study agrees very well with the 65 days from calving to first ovulation reported by Short et al., (1972).

The observed interval of 36.0 days from first follicle to ovulation for suckled cows is longer than the interval of 18 days found by Kesler and coworkers (1980). Also, the correpponding interval of 27 days for nonsuckled cows in this study is longer than the three days interval reported by Kesler and coworkers (1979).

Suckling had no effect on the rate of uterine involution in this study (25.64 vs 25.98 days for suckled and nonsuckled, respectively). This finding agrees with those of Oxenreider (1968) and Moller (1970). The intervals are however, shorter than those observed by Oxenreider (1968) (34±3 days for suckled vs 32±4 days for nonsuckled beef cows). On the other hand this finding is in contrast with those of Riesen et al., (1968) and Lauderdale et al., (1968) who reported a more rapid rate of uterine involution for suckled than nonsuckled cows..

The mechanism by which suckling causes delay in postpartum resumption of cyclic activities in the cow

is not well understood. This mechanism could not be determined from this study. However, the detection of first postpartum follicle and occurrence of first ovulation earlier in the nonsuckled cows than in the suckled suggest interference of suckling with the hypothalamopituitary function with regards to the production and release of the gonadotropic hormones, FSH and LH and their effects on the ovaries. In this regard the association of mother and offspring has been reported as inhibiting ovarian activity in the rat (Moltz et al., 1969). Possibly a similar effect could be operating in the cow.

The available data suggests either a dysfunction or hypofunction of the hypothalamus or the pituitary in suckling anoestrus syndrome. This may perhaps be supported by the pituitary LH concentrations observed during the postpartum period, with the plasma level being higher for nonsuckled than suckled cows (Saiduddin and Foote, 1964; Radford et al., 1978; Echternkamp, 1978; Randel et al., 1976; Short et al., 1974).

Wagner and Oxenreider (1972) reported that there was an increased adrenal activity, as indicated by increased adrenal progesterone and cortisol levels, in suckled cows and suggested that this could be exerting a depressing effect on ovarian activity by suppression of hypothalamic production of luteinizing hormone

releasing factor (LRF). Radford et al., (1976) also concluded that the failure of injections of estradiol benzoate to induce LH release in suckled cows at six weeks after parturition but not at 14 weeks was indicative of hypothalamic dysfunction. Furthermore, exogenous gonadotropin releasing hormone (GnRH) induced ovulation in about 50% of anoestrus suckled cows and calf removal 24h prior to the GnRH administration improved the ovulation response (Kesler et al.,1980). On the other hand, Carruthers et al., (1978) concluded that a suckling-induced suppression of serum LH in early postpartum cows, may result from a decreased pituitary response to GnRH and not from reduction in hypothalamic GnRH production or release.

Effect of feeding

The feeding of a supplementary concentrate ration did not significantly influence the intervals from calving to first follicle and to first ovulation in this study. While these findings agree with the findings of Carstairs et al.,(1980) they are at variance to the results of Wiltbank et al., (1962), Dunn et al., (1969 and Oxenreider and Wagner (1971). The observation by Whitmore et al., (1974) that postpartum ovarian activity was more closely related to milk production than

energy intake might explain the non-significant effect of feeding in this study. However, cows that received concentrate supplement had their first follicle and ovulated two and 18 days, respectively earlier on the average than those that only grazed. The interval from detection of first follicle to first ovulation was significantly shorter for the grazing plus concentrate group than for the grazing alone group (7.44 vs 58.96 days). This suggests the influence of nutrition on the rate of postpartum development and maturation of the follicle. The feeding regime had no effect on the rate of uterine involution (24.98 vs 26.11 days for grazing plus concentrate and grazing only groups, respectively). The duration of 24-26 days for completion of uterine involution in this study is consistent with the finding by Casida and Venzke (1936) that about 26 days were required after parturition for the uterus to return to normal position, tone and size. In this regard the indigenous cows compare favourably with exotic breeds of cattle.

Effect of season

The results of this study indicate that White Fulani (Bunaji) cows calving during the dry season ovulate earlier than those calving during the rainy season.

This finding supports that of Oyedipe et al., (1982) who found that Bunaji cows that calved during the dry season had shorter calving intervals than those that calved during the rainy season

This finding suggests an effect of season of calving on postpartum cyclic activities of the White Fulani cow. Similar studies in temperate regions have also indicated seasonal effects on postpartum intervals to first oestrus (Chapman and Casida, 1937; Buch et al., 1955). On the other hand, Guilbert and MacDonald (1933) found no seasonal influence on the interval from parturition to first oestrus based on the records of 43 beef cows.

The observed shorter interval postpartum to first ovulation for cows calving in the dry season at which time the nutrition of the animals is usually poor strongly suggests a climatic influence on postpartum ovulation.

First postpartum follicle was detected at the same interval during the two seasons, but the interval between first follicle and first ovulation was shorter during the dry season than in the rainy season. In effect it can be concluded that resumption of fertile ovarian activities occurs earlier in the dry than in the rainy season. This is in contrast to an earlier

observation of a greater ovarian activity fir the Zebu cow during the rainy and pre-dry seasons (Osori, 1976). The observation that the season of calving had no effect on the duration of uterine involution agrees with the findings of Morrow and co-workers (1966).

Effect of parity or age

In this investigation animals that had had two calvings or less fall into the same category as those aged three to five years while those with more than two calvings fall into the age category of over five years. The results indicate an ealier resumption of ovarian activity in cows which had had more than two calvings or over five years old compared to younger cows. Subsequent follicular development and maturation after first appearance postpartum was also much faster in the older or pluriparous cows than in the younger group as suggested by the significant difference in the interval from first follicle to first ovulation between the two groups. In this regard Belling (1963) had reported that fertility in Hereford beef cattle reached a maximum at four years of age and remained constant until declining in cows over 10 years of age.

Similarly, Fielden et al., (1973) have shown that the incidence of anoestrus due to ovarian inactivity in dairy cows was much greater in first and second calvers than in mature cows. In contrast however, Casida and Wisnicky (1950) observed that cows more than five years old took a longer time to come in season after calving than younger animals. The contrasting reports would suggest a possible breed differences as well as differences in the prevailing environmental conditions under which the various investigations were carried out.

In the present study no difference was found between the two parity or age groups in the rate of uterine involution. This again disagrees with the report of a faster rate of uterine involution in primipara than pluripara cows (Casida and Wisnicky 1950; Foote et al., 1960) and the report of a faster rate in pluripara (Morrow et al., 1966) but agrees with the report by Tennant et al., (1967) who found no apparent differences in the rate of uterine involution between cows during the first four lactations. The observed interval of 24-27 days in the present study is similar to the interval of 20 - 25 days reported for pluripara cows (Rasbech, 1950).

Effect of breed

A comparison of the intervals from calving to first follicle and first ovulation between the White Fulani and Sokoto Gudali breeds of cows revealed no significant difference between the two breeds. However, the observation of first ovulation before detection of first follicle in the Sokoto Gudali cows suggests a possible difference in the sizes of follicle at various stages of development between the two breeds, which made it more difficult to detect by palpation in the Sokoto Gudali than in the White Fulani. The highly significant difference between the two breeds, in the interval from first follicle to first ovulation is an indication of a faster rate of development and maturation of postpartum ovarian follicles in the Sokoto Gudali cows than in the White Fulani cows. In an earlier study Warnick (1955) found no significant breed effect on the interval to postpartum oestrus; the interval for Angus (59.2 days) and Hereford cows (62.7 days) being similar. The result of this study is thus in support of the lack of breed effect. Intervals postpartum to first follicle and first ovulation were however, not compared among the two breeds in Warnick' study.

S U M M A R Y

The individual influence of suckling, feed supplement season of calving, age or parity and breed on postpartum resumption of ovarian activity and uterine involution was studied using 79 White Fulani and 15 Sokoto Gudali cows. Reproductive traits examined were intervals postpartum to first follicle and first ovulation, intervals from first follicle to first ovulation and interval to complete uterine involution. Suckled cows ovulated later (P(.10) than nonsuckled cows. The interval from calving to first follicle and interval to complete uterine involution were not significantly different for suckled and nonsuckled animals. Intervals postpartum to first ovulation and from first follicle to first ovulation were shorter for animals that calved during the dry season (P(.10) than those that calved during the rainy season. Intervals postpartum to first follicle and duration of uterine involution were similar for the two groups.

Feeding of a 3kg per day supplement concentrate ration shortened the interval from first follicle to first ovulation (P(.01) but had no significant effect on either intervals postpartum to first follicle and first ovulation or duration of uterine involution. Cows that had more than two calves tended to ovulate

earlier than those with one to two calvings in the postpartum period. There was no difference in the duration of uterine involution between the two groups. Sokoto Gudali cows ovulated earlier than the White Fulani cows after calving but the rate of uterine involution was similar for the two breeds. It is concluded that suckling, level of feeding, season of calving and parity or age contribute to the prolonged calving intervals of the indigenous cattle by delaying postpartum ovulation.

Table I

Number of animals per group and number of observations per tait

Treatment groups	No. of cows per group	No. of observations per trait* Intervals pp** to detection of first follicle	Intervals pp to first ovulation	Intervals from parturition to completion of uterine involution
BREED				
White Fulani	79	38	68	73
Sokoto Gudali	15	6	14	15
PARITY***				
1-2 calvings	49	28	48	48
More than two calvings	43	16	34	40
SEASON				
Dry	39	14	36	38
Rainy	55	30	46	50
SUCKLING				
Suckled	79	34	67	73
Nonsuckled	15	10	15	15
FEEDING				
Grazing alone	58	22	50	56
Grazing plus concentrate	36	22	32	32

*Traits could not be determined for all cows in each group

**PP = Postpartum

***Parity of 2 cows not known.

Table 2

Least squares analysis of variance of the measured reproductive parameters.

Source of variation	df	Mean squares: Intervals pp to detection of first follicle (days)²	Intervals pp to first ovulation (days)²	Intervals to completion of uterine involution (days)²
Breed	1	289.217	4590.616	17.529
Parity	1	8.197	6108.210	53.104
Season	1	4.619	9146.319*	89.396
Suckling	1	4408.908	8998.180*	0.881
Feeding	1	37.054	3729.623	15.044
+Residual		2238.849	2525.790	40.274

+Numbers of df for residual are as follows: interval pp to first follicle = 38, first ovulation = 76, uterine involution = 82

*P)0.05(0.10

df = degrees of freedom

pp = Postpartum

Table 3

Least squares means (LSM) of the reproductive traits within each variable

Treatments	Intervals (days)pp* to detection of first follicle		Intervals (days)pp to first ovulation		Intervals pp (days) to completion of U. I.**	
	No	LSM	No	LSM	No	LSM
BREED						
White Fulani	38	44.91^{a}	68	65.85^{a}	73	25.94^{a}
Sokoto Gudali	6	53.56^{a}	14	42.72^{a}	15	24.55^{a}
PARITY						
Two calvings or less	28	46.44^{a}	48	69.78^{a}	48	24.92^{a}
More than two calvings	16	45.48^{a}	34	50.76^{a}	40	26.64^{a}
SEASON						
Dry	14	46.59^{a}	36	49.70^{a}	38	26.88^{a}
Rainy	30	45.86^{a}	46	71.45^{b}	50	24.80^{a}
SUCKLING						
Suckled	34	52.77^{a}	67	68.11^{a}	73	25.64^{a}
Nonsuckled	10	25.36^{a}	15	34.11^{b}	15	25.98^{a}
FEEDING						
Grazing alone	22	47.27^{a}	52	68.94^{a}	56	26.11^{a}
Grazing plus concentrate	22	44.91^{a}	32	50.87^{a}	32	24.98^{a}

a.b, means with different superscripts within each treatment group differ significantly (P)o.o5(o.10)

*pp = Postpartum

**U.I = Uterine involution

Table 4a

Unadjusted mean intervals from parturition to detection of first follicle for all treatment groups

Treatment	No. of Animals	Intervals pp* to detection of first follicle (days)	
BREED			
White Fulani	38	43.6±47.4**	(5 - 276)***
Sokoto Gudali	6	61.7±42.2	(17- 137)
PARITY			
Two calvings or less	28	47.6±52.2	(5 - 276)
More than two calvings	16	43.4±36.3	(18-142)
SEASON			
Dry	14	42.3±68.6	(15- 142)
Rainy	30	47.9±33.3	(5 - 276)
SUCKLING			
Suckled	34	53.4±50.6	(18 -276)
Nonsuckled	10	21.1±11.3	(5 - 45)
FEEDING			
Grazing only	22	55.2±57	(15-276)
Grazing plus concentrate	22	37.0±32.1	(5 - 142)

*pp = Postpartum

** = Standard deviation

*** = Range

Table 4b

Unadjusted mean intervals from parturition to occurrence of first ovulation for all treatment groups.

Treatment	No. of Animals	Intervals pp** to occurrence of first ovulation (days)
BREED		
White Fulani	68	61.9±57.1** (9-284)***
Sokoto Gudali	14	61.0±32.9 (20-141)
PARITY		
Two calvings or less	48	67.3±62.1 (9-284)
More than two calvings	32	54.2±39.7 (19-206)
SEASON		
Dry	36	48.7±47.7 (9-284)
Rainy	46	71.5±56.2 (18-216)
SUCKLING		
Suckled	67	69.9±55.8 (19-284)
Nonsuckled	15	24.0±10.4 (9-49)
FEEDING		
Grazing only	52	72.2±59.3 (18-284)
Grazing plus concentrate	32	44.8±37.9 (9-175)

*pp = Postpartum
** = Standard deviation
*** = Range

Table 4c

Unadjusted mean intervals from parturition to completion of uterine involution for all treatment groups.

Treatment	No. of Animals	pp* intervals to completion of uterine involution (days)
BREED		
White Fulani	73	25.9±6.6 (15 - 39)
Sokoto Gudali	15	24.3±4.3 (18 - 34)
PARITY		
Two calvings or less	48	24.8±6.6 (15 - 51)
More than two calvings	40	26.8±5.9 (17 - 36)
SEASON		
Dry	38	26.8±5.7 (20 - 42)
Rainy	50	24.8±6.6 (15 - 51)
SUCKLING		
Suckled	73	25.6±6.3 (15 - 51)
Nonsuckled	15	25.7±6.7 (17 - 39)
FEEDING		
Grazing only	56	25.9±5.7 (17 - 42)
Grazing plus concentrate	32	25.3±7.4 (15 - 51)

*pp = Postpartum
** = Standard deviation
*** = Range

Table 5

Least squares analysis of variance of the intervals from first follicle to first ovulation.

Source of variation	df[+]	Mean squares of interval from first follicle to first ovulation (days)[2]
Breed	1	20651.780***
Parity	1	8852.763**
Season	1	5441.491*
Suckling	1	399.711
Feeding	1	15686.663***
Residual	35	1528.601

[+]df = degrees of freedom

* P (.10

** P (.05

*** P (.01

Table 6

Least squares means (LSM) of interval from first follicle to first ovulation

Treatment	No. of cows	LSM (days)
BREED		
White Fulani	36	43.3^{a}
Sokoto Gudali	5	$*34.34^{b}*$
PARITY		
Two calvings or less	27	45.01^{e}
More than two calvings	14	12.28^{f}
SEASON		
Dry	14	17.14^{c}
Rainy	27	42.48^{d}
SUCKLING		
Suckled	31	36.08^{a}
Nonsuckled	10	26.86^{a}
FEEDING		
Grazing alone	21	58.96^{a}
Grazing plus concentrate	20	7.44^{b}

*Ovulation occurred before first follicle was detected.

ab; cd; ef, means with different superscripts within each treatment group differ significantly ($P < .01$; $P < .10$; $P < .05$).

Table 7

Unadjusted mean intervals from first follicle to first ovulation for all treatment groups.

Treatment	No. of animals	Mean intervals (days) from first follicle to first ovulation
BREED		
White Fulani	36	37.4±51.4 * (2-188) **
Sokoto Gudali	5	7.8±5.8 (4-18)
PARITY		
Two calvings or less	27	39.9±56.7 (2-188)
More than two calvings	14	22.1±27.9 (2-108)
SEASON		
Dry	14	21.2±25.7 (2-63)
Rainy	27	40.4 ±57.0 (2-188)
SUCKLING		
Suckled	31	43.4±52.9 (2-188)
Nonsuckled	10	4.0±9.3 (2-25)
FEEDING		
Grazing only	21	52.7±60.3 (2-188)
Grazing plus concentrate	20	14.1±21.2 (2-73)

* = Standard deviation

** = Range

PART III

OVARIAN ACTIVITY AND CHANGES IN SUCKLED AND NONSUCKLED COWS DURING THE POSTPARTUM PERIOD.

I N T R O D U C T I O N

Moller (1970) examined postpartum ovarian growth pattern along with its structural development. He observed that the ovaries were plastic in texture early in the postpartum period, but possessed greater tonus and showed growth within a fortnight after calving. At the first postpartum examination at calving, 45% of two-and three-year-old cows and 9% of older cows, had ovaries that were less than 15mm along their longest axis. No initial difference existed in the size of the ovaries between milked and suckled cows but differences in the growth pattern became apparent from day 15 postpartum, with continuous suckling suppressing ovarian growth. Wagner and Hansel (1969) recorded 7.43g and 8.61g as weights of the ovaries on the gravid side on day 30 postpartum in nursed and milked cows, respectively. In dairy cows Callahan et al., (1971) observed an increase in size of ovaries between eight and 20 days after calving ($P < .005$) but the changes thereafter through 42 to 60 days were not significant.

Saiduddin et al., (1968) observed very little ovarian activity in terms of number of follicles on the day after calving, but increased activity was

observed by day 10 following calving. In that study, the average number of follicles, the total follicular fluid weight as well as the volume of the largest follicle were low at day one compared to the average for days 10, 20 and 30 postpartum. A linear decrease in the number of follicles was observed from day 10 to day 30. Suckling had no effect on the ovarian characteristics.

In the study by Wagner and Hansel (1969) the average size of the largest follicle was reported to increase from 9.6mm, 7 days postpartum to 13.1mm in cows slaughtered 18 to 19 days after the first postpartum oestrus occurring at day 14. They found no difference in follicle size at day 30 postpartum between twice daily milked cows and suckled cows.

Saiduddin et al.,(1968) observed that at day 20 postpartum nonsuckled cows (5/5) had newly formed corpora lutea (CL) while only one of five suckled cows had new CL. At day 30, three of five suckled cows had CL while in the nonsuckled group all five cows had CL. These findings suggest that suckling prolonged the interval from calving to ovulation.

The mean diameters of CL of pregnancy at days 7, 14 and 30 postpartum in cows were reported to be 12.7mm,

9.3mm and 8.5mm respectively (Wagner and Hansel, 1969). The rather big sizes of the CL were attributed to the larger amount of vascular tissue present in these CL compared to the CL of normal oestrous cycle. Histologically the CL of pregnancy at day 7 after parturition showed severe degenerative changes. Atresia of some of the larger follicles, which was characterized by infolding of the granulosa cell layer also occurred (Wagner and Hansel, 1969).

In the White Fulani cow there is very limited information on the ovarian characteristics in the postpartum period. The only information appears to be that of Oyedipe *et al.*, (1980) who studied ovarian structural changes through rectal palpation. A detailed investigation of the gross and histological ovarian changes and the possible effect of suckling on the ovaries in the postpartum White Fulani cow is thus warranted.

The objective of this investigation was to determine the effect of suckling on the gross and microscopic changes occurring in the ovaries and the associated structures during the early postpartum period in White Fulani cows.

MATERIALS AND METHODS

Animals

A total of 24 mature White Fulani cows were used in this study (Appendix 2). The cows were randomly allocated to two equal groups, suckled and nonsuckled, as they calved. Cows in the suckled group were suckled by their calves until slaughter while calves of cows in the nonsuckled group were weaned at 24h after calving. Three cows in each group were slaughtered on days two, 10, 21 and 30 postpartum to obtain their reproductive organs.

Measurements

The length, breadth and height of ovaries associated with both the gravid and nongravid uterine horns were measured after disecting them free of all ligaments, using a measuring tape. The distance between the anterior and posterior poles of the ovary was measured as the length of the ovary while the distance between the medial and lateral surfaces of the ovary and the distance between the attached and free borders of the ovary were measured as breadth and height of the ovary, respectively. The intact ovaries, that is, ovaries with or without ovarian structures, were also weighed

to the nearest gram (gm).

Follicles on each ovary were counted and the diameter of the largest follicle, taken along the longest axis, was measured. The volume of follicular fluid from the largest follicle and the volume of fluid from all follicles were measured using a tuberculin syringe with a 16mm long needle. The weight of follicular fluid from all follicles in each ovary was also determined by subtracting the ovarian weight without the follicular fluid from the weight of the intact ovary.

The corpora lutea (CL) of pregnancy and cyclic CL were dissected from the ovary and their diameters were measured. Each CL was also weighed.

Histological studies

The ovaries and CL were fixed for a minimum of 24hours in Bouins solution (Appedix 3) prepared in the routine manner and sectioned at 6μ before staining with haematoxylin and eosin (Humason, 1967). Serial sections were examined with light microscope and representative parts were photographed.

Statistical analysis

The effects of suckling treatment, days postpartum and treatment by day interactions were examined by an analysis

of variance (ANOVA) procedure (Steel and Torie, 1960). Regression curves for weight and diameter of CL of pregnancy were established using the nth order (quadratic) regression analysis.

RESULTS

Gross morphology of the ovary

Table 1 shows the ANOVA of treatment and days postpartum for ovariandimensions and Table 2 shows the mean ovarian and CL sizes for both suckled and nonsuckled cows. As can be seen ovarian dimensions except the ovarian height associated with the nongravid horn, were similar for both suckled and nonsuckled groups. The breadth of the ovary associated with the nongravid horn as well as the height of the ovary associated with both gravid and nongravid horns were significantly different (P(.05) between days. The weights of the ovaries associated with the previously gravid uterine horn were greater than the contralateral ovaries.

Follicular growth

In general, more follicular development occurred in the ovaries of nonsuckled than in the ovaries of suckled cows (Tables 3 and 4). At day 2 postpartum the ovaries of one out of three nonsuckled cows had follicles (two on ovary on the side of the gravid horn plus four on ovary of nongravid horn) while two of three suckled cows had one follicle each. However by day 10 all three nonsuckled cows had follicles on their ovaries (one had two) while only one suckled cow had follicles on her ovaries (one on ovary on gravid horn and two on ovary on nongravid horn of the same cow). Also while all nonsuckled cows (three) slaughtered on days 21 and 30 had ovaries containing follicles, two of three suckled cows slaughtered on day 21 and one of three cows slaughtered on day 30 had ovaries containing follicles. The number of follicles 5mm or more in diameter for all slaughter days in the suckled and nonsuckled groups of cows are presented on Table 4. The results of measurements for ovarian follicular fluid volume and weight are shown on Table 3.

Ovulation, as indicated by the presence of a newly formed CL, had occurred in two of three

nonsuckled animals slaughtered on days 21 and 30 (Table 4), but none of the cows in the suckled group ovulated by day 30 postpartum.

CL of pregnancy

Table 5 shows the mean diameters and weights of CL of previous pregnancy for the various slaughter days for both suckled and nonsuckled groups, while Figures 1 and 2 show their respective regression curves. On the basis of CL diameters, regression during the first 10 days appeared to be slower than during the subsequent days. On weight basis regression was more rapid during the first 15 days and slowed thereafter. The rate of CL regression was similar for both suckled and nonsuckled cows.

The histological characteristics of the ovaries from suckled cows were similar to those from nonsuckled cows. The pattern of development and atresia of follicles was also not different between postpartum days. Primary and atretic follicles in various stages of degeneration were more prevalent than growing or graafian follicles. Atresia of primary and growing follicles was evidenced first by the oocyte disappearing and then by invasion by fibrous tissue (Plate 1). Plate 2 shows a section of a CL obtained during oestrous cycle, and

sections of CL of pregnancy in different stages of regression in the postpartum period. The sections from the cyclic CL contained normal active luteal cells. The cytoplasm of the luteal cells of the CL of pregnancy obtained from cows slaughtered two days after calving showed evidence of cloudy swelling. The cytoplasm of luteal cells of CL of pregnancy obtained from cows slaughtered at days 10 and 21 postpartum showed evidence of hydropic degeneration while at day 30 there was evidence of cellular vucuolation in the cells. By day 30 cellular necrosis characterised by the presence of nuclei undergoing pyknosis and karyorrhexis was evident. At this time there was also a clear evidence of invasion by fibrous tissue.

DISCUSSION

The result of the ANOVA of treatment effect on the various ovarian dimensions suggests that suckling did not influence the ovarian size *per se* in the White Fulani cow. The observed difference between suckled and nonsuckled cows for ovarian heights on the side of the

nongravid uterine horn was probably due to variation in the size of the animals. The present findings do not support the observation by Callahan et al., (1971) that an increase in size of ovaries occurs between eight and 20 days after calving in dairy cows.

The mean weights for day 30 postpartum ovaries (3.89 and 3.43g for ovaries associated with the previously gravid and nongravid uterine horns) in this study are lower than the 7.43 and 8.30g reported by Wagner and Hansel (1969) for day 30 postpartum in exotic breed of cattle. This difference suggests a breed difference in size of the ovary.

The difference between days with regards to the breadth of ovaries associated with the previously gravid uterine horn and the ovarian height associated with gravid and nongravid horns could be attributed to differences in the rate of development of ovarian structures (follicles and CL) with time after parturition. The net effect of the remnant of the CL of previous pregnancy on the ovaries associated with the gravid horn was reflected in the observation that ovaries from that side were heavier than the ovaries associated with the nongravid horn.

The results of this study show a higher ovarian activity, as indicated by the various follicular

parameters measured (Tables 3 and 4), in the nonsuckled than in suckled White Fulani cows. Suckling has been reported to cause increased follicular fluid weight at day three without any apparent effect at day 15 postpartum (Graves et al., 1968). On the other hand Saiduddin et al., (1966) found no statistical differences in the number of follicles, volume of the largest follicle or total follicular fluid weight between suckled and nonsuckled cows. The mean diameter of the largest follicle (1cm and 1.5cm on ovaries associated with the gravid horn of suckled and nonsuckled cows, respectively) at day 10 postpartum in this study compared favourably with the average of 0.96cm recorded at day seven by Wagner and Hansel (1969).

A third of the nonsuckled cows had ovaries containing newly formed CL by day 30 postpartum compared to none among the suckled cows. This finding is similar to that reported earlier by Saiduddin et al., (1966). The observation of newly formed CL in a percentage of the nonsuckled cows in this study coupled with the findings of Saiduddin et al., (1966) would lead one to suggest that suckling may prolong the interval from calving to ovulation. The mechanism by which this is effective is however not clear.

The regression curves for the CL of previous pregnancy showed that there was no difference in the

rate of regression between suckled and nonsuckled cows. The mean diameter for day 30 CL of pregnancy for both suckled and nonsuckled groups in this study was 0.6cm compared to an average of 0.85cm also for day 30 postpartum cows reported by Wagner and Hansel, (1969). The slight difference may be due to breed differences.

There was also no histological difference between the CL of pregnancy of the two groups. The progressive sequence of events leading to complete regression of the CL was evident in the degenerative changes occurring in the luteal cells. By day two postpartum the cytoplasm of the luteal cells showed evidence of cloudy swelling progressing to hydropic degeneration by days 10 to 21 and severe cellular vacuolation by day 30. At this time the nuclei of the cells had become pyknotic. By day 30 there was fibroplasia leading to complete fibrosis and shrinkage of the luteal tissue resulting in a hard firm structure on the ovary which could be palpated as a hard small firm nodule as indicated by Morrow et al., (1966). But compared to Morrow et al., (1966) it would apear from the present results that this stage is reached later in the postpartum period than the four to seven days suggested by them.

The most significant histological findings in the ovaries from the cows in this study are various

stages of folliculogenesis and follicular atresia; primary and atretic follicles being more abundant than growing or mature follicles. In this regard, Priedkalns, (1981) has shown that more follicles become atretic than attain maturity in the bovine ovary during the early postpartum period. It is evident from the present results that suckling did not appear to affect the early stages of follicular development. Thus it is reasonable to assume that the delaying effect of suckling on postpartum ovulation is probably on follicular maturation and/or ovulation through interference with the production and release of adequate amounts of follicle stimulating hormone (FSH) and luteinizing hormone (LH) from the anterior pituitary.

SUMMARY

Twenty four White Fulani cows alloted randomly at calving into two groups of 12 suckled and 12 nonsuckled animals were used to study the influence of suckling on gross and histological changes in the postpartum ovary and its associated structures. Three cows in each group were slaughtered on days 2, 10, 21 and 30

Table 1 ANOVA of treatment and days after parturition for various ovarian dimensions

Source of variation	df	Mean squares: Length of ovary on side of gravid horn $(cm)^2$	Length of ovary on side of nongravid horn $(cm)^2$	Breadth of ovary on side of gravid horn $(cm)^2$	Breadth of ovary on side of non-gravid horn $(cm)^2$	Height of ovary on side of gravid horn $(cm)^2$	Height of ovary on side of nongravid horn $(cm)^2$	Wt. of ovary on gravid side $(g)^2$	Wt. of ovary on nongravid side
Between treatments	1	.0038	0.481	0.0037	0.1204	0.5704	0.4004*	0.2774	0.8513
Between days	3	1.1387	0.483	0.1415	0.1438*	1.3982*	0.3482*	1.6870	3.1320
Treatment X days	3	1.3743	0.443	0.0104	0.0982	0.6849	0.5404	6.7433	6.6057
Error	16	0.5579	0.226	0.0656	0.0371	0.3288	0.0883	4.4229	2.3258

*P(.05.

df = degree of freedom

Table 2

Mean ovarian dimensions for suckled and nonsuckled cows slaughtered on days 2, 10, 21 and 30 postpartum.

Groups	Days postpartum	No. of cows	Mean length (cm)		Mean breadth (cm)	
			G	NG	G	NG
Suckled	2	3	4.7±0.3*	4.0±0.0	0.8±0.17	0.6±0.1
	10	3	3.8±1.1	3.3±0.76	1.1±0.3	1.03±0.15
	21	3	3.5±1.3	3.3±0.76	1.17±0.29	1.17±0.36
	30	3	3.0±0.5	3.03±0.49	0.83±0.21	0.77±0.05
Nonsuckled	2	3	3.60±0.4	3.33±0.06	0.83±0.15	0.6 ±0.2
	10	3	3.47±0.45	2.63±0.12	1.00±0.20	0.77±0.21
	21	3	3.96±0.55	3.10±0.36	1.17±0.29	0.73±0.25
	30	3	4.10±0.8	3.50±0.50	0.97±0.20	0. 9±0.2

G = Ovary associated with the gravid uterine horn.

NG = Ovary associated with the nongravid uterine horn.

* = Standard-deviation

Table 2 cont'd

Groups	Days postpartum	No. of cows	Mean height (cm)		Mean weight (g)	
			G	NG	G	NG
Suckled	2	3	3.43±1.12	2.3±0.3	5.80±1.25	4.11±0.36
	10	3	1.9 ±0.52	1.77±0.45	3.54±1.7	3.71±0.96
	21	3	1.9 ±0.36	1.80±0.35	5.46±3.32	4.23±2.04
	30	3	2.1 ±0.6	1.83±0.29	3.89±2.23	3.43±1.57
Nonsuckled	2	3	2.2 ±0.4	1.9 ±0.1	5.18±0.58	3.74±1.2
	10	3	1.83±0.23	2.3 ±0.26	4.2 ±1.6	3.78±0.27
	21	3	1.6 ±0.36	1.66±0.28	6.4 ±1.6	2.69±0.74
	30	3	2.5 ±0.5	2.8±0.3	6.78±3.04	6.78±2.98

Table 3 Follicular activity of suckled and nonsuckled cows slaughtered on days 2, 10, 21 and 30 postpartum

Groups	Days Postpartum	No. of cows	Mean nn. of follicles		Mean diameter of largest follicle (cm)		Mean volume (ml) of fluid in largest follicle	
			G	NG	G	NG	G	NG
Suckled	2	3	1	-	0.75±0.35*	-	0.1	-
	10	3	1	2	1.0	0.9	0.25	0.2
	21	3	1	1.5±0.7	0.6	0.65±0.07	0.17	0.37
	30	3	1	1	0.9	0.5	0.3	0.1
Nonsuckled	2	3	2	4	0.7	0.9	0.2	0.15
	10	3	2	1	1.5	0.85±0.07	0.55	0.75
	21	3	1	-	1.15±1.19	-	0.69±0.5	-
	30	3	1	1	0.65±0.07	0.67±0.3	0.18±0.1	0.26±0.09

G = Ovary associated with the gravid uterine horn

NG = Ovary associated with the nongravid uterine horn.

* = Standard deviation

Table 3 cont'd

Groups	Days Postpartum	No. of cows	Mean volume (ml) of fluid in all follicles		Mean weight (g) of fluid from all follicles	
			G	NG	G	NG
Suckled	2	3	0.1	-	0.31±0.28	-
	10	3	0.25	0.2	0.26	0.22
	21	3	0.17	0.25±0.2	0.38	0.35±0.05
	30	3	0.3	0.1	0.44	0.02
Nonsuckled	2	3	0.82	0.85	0.55	1.05
	10	3	0.58	0.75	0.89	1.07
	21	3	0.69±0.5	-	0.98±0.62	-
	30	3	0.18±0.10	0.26±0.09	0.28±0.14	0.41±0.17

Table 4

Follicular and corpus luteal (CL) development in suckled and nonsuckled cows slaughtered at days 2, 10, 21 and 30 postpartum.

	Suckled				Nonsuckled			
Days postpartum	No. of cows	Total no. of follicles	No. of follicles ≥5mm in diameter	Total no. of cyclic CL	No. of cows	Total no. of follicles	No. of follicles ≥5mm in diameter	Total no. of cyclic CL
2	3	2	2	0	3	6	3	0
10	3	3	3	0	3	4	3	0
21	3	4	4	0	3	3	2	2*
30	3	2**	2	0	3	5	4	2

*1 corpus luteum + 1 corpus haemorhagicum (CH)

**Both follicles were on the ovaries associated with the gravid and nongravid uterine horns, respectively, of the same cow.

Table 5

Mean weight and diameter of corpus luteum of pregnancy for suckled and nonsuckled cows slaughtered on days 2, 10, 21 and 30 postpartum.

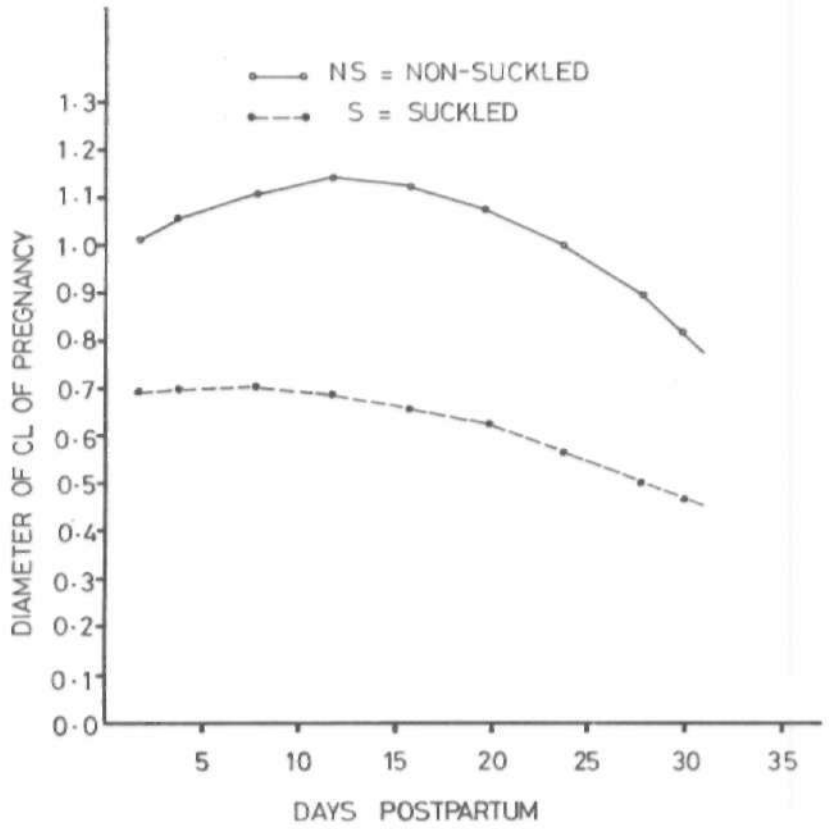
	Suckled			Nonsuckled		
Days postpartum	No. of cows	Mean diameter (cm)	Mean weight (g)	No. of cows	Mean diameter (cm)	Mean weight (g)
2	3	0.67±0.37*	1.76±0.53	3	1.1±0.55	1.62±0.34
10	3	0.8 ±0.28	0.73±0.09	3	0.8±0	0.53±0.09
21	3	0.4 ±0	0.42±0	3	0.5±0	0.84±0
30	2**	0.5 ±0.1	0.45±0.01	2**	0.7±0.4	0.45±0

* = Standard deviation

** = CL of one cow was not measured.

Figure 1

Regression curves of diameter of corpus luteum (CL) of pregnancy for suckled and nonsuckled cows.



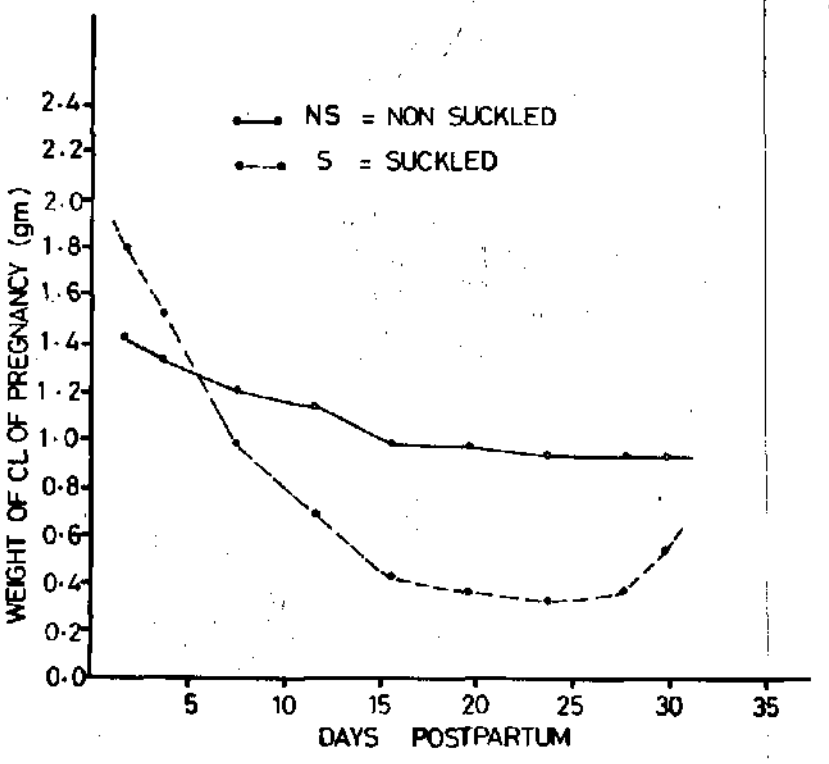
PREDICTION EQUATIONS

NS $\hat{Y} = 0.96 + 0.025x - 0.001x^2 (R^2 = 3\%)$

S $\hat{Y} = 0.69 + 0.003x - 0.0003x^2 (R^2 = 14\%)$

Figure 2

Regression curves of weight of corpus luteum (CL) of pregnancy for suckled and nonsuckled cows.



PREDICTION EQUATIONS

NS $\hat{y}$ = 1·5 − 0·05x + 0·0009x^2 (R^2 = 14·7%)

S $\hat{y}$ = 2·0 − 0·159x + 0·0035x^2 (R^2 = 82%)

Plate I

Photomicrographs of cross sections of ovaries at different stages of follicular development and atresia.

Fig. 1. Photomicrograph of a primary follicle (A) and an atretic follicle (B) (x400)

2. Photomicrograph of a growing follicle (arrow) (x100)

3. Photomicrograph of a graafian follicle (x100)

4. Photomicrograph of an atretic follicle (arrow) (x100).

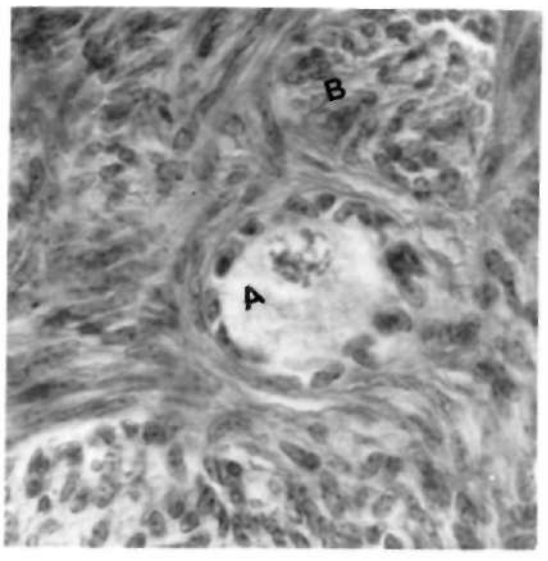


Fig. 1

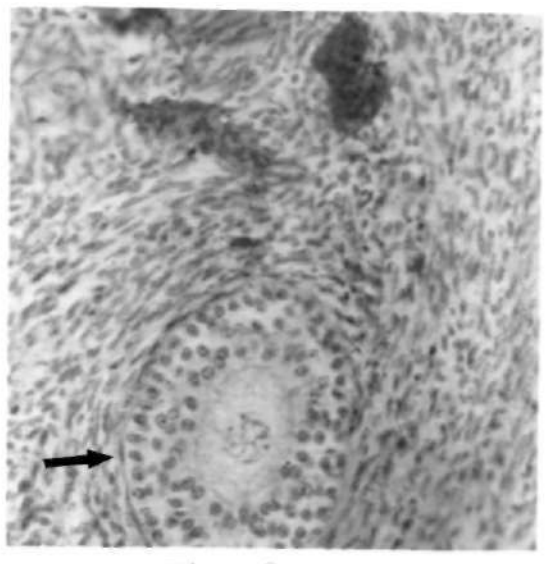


Fig. 2

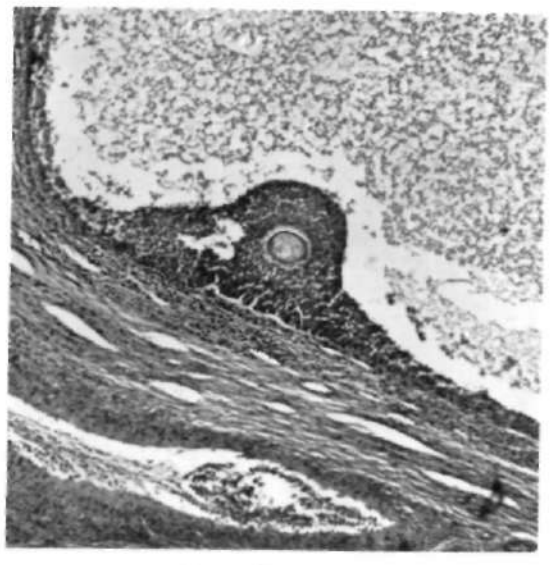


Fig. 3

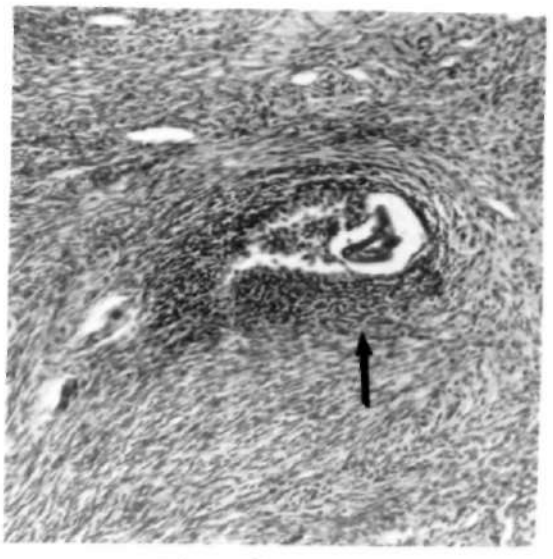


Fig. 4

Plate II

Photomicrographs of sections of cyclic and pregnancy corpora lutea (CL).

Fig. 1. Photomicrograph of a section of a cyclic CL showing normal luteal cells (arrow)(x400)

2. Photomicrograph of a section of a CL of pregnancy at day 2 postpartum showing luteal cells undergoing cloudy swelling (arrow) (x400).

3. Photomicrograph of a section of a CL of pregnancy at day 10 postpartum showing luteal cells undergoing hydropic degeneration (arrow) (x400).

4. Photomicrograph of a section of a CL of pregnancy at day 21 postpartum showing luteal cells also undergoing hydropic degeneration (arrow) (x400).

5. Photomicrograph of a section of a CL of pregnancy at day 30 postpartum showing cytoplasmic vacuolation of luteal cells (arrow) and fibroplasia (F).

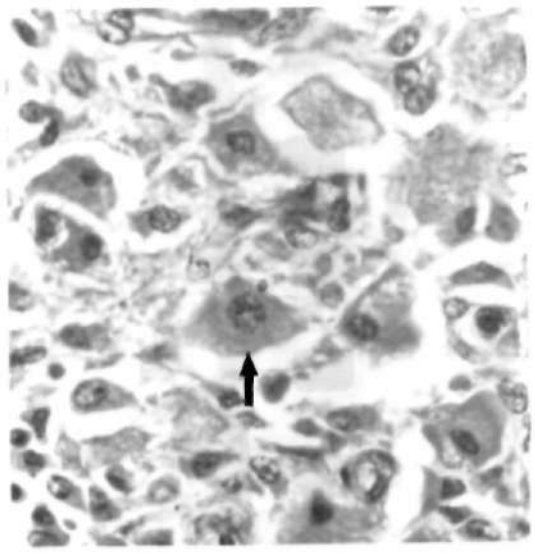


Fig. 1

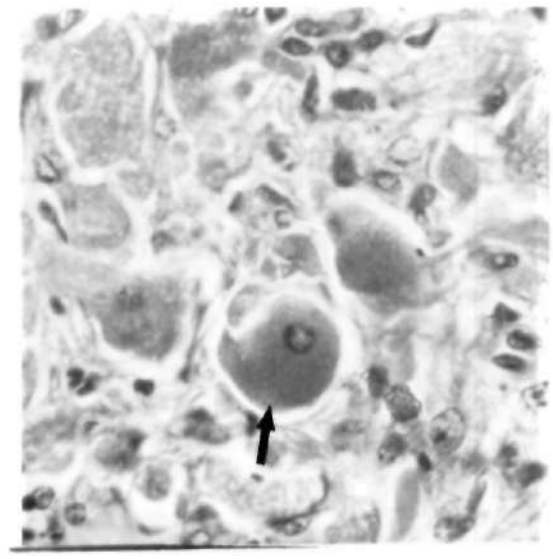


Fig. 2

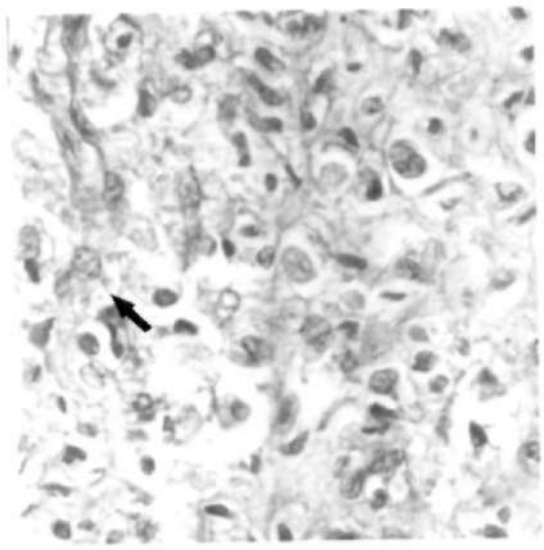


Fig. 4

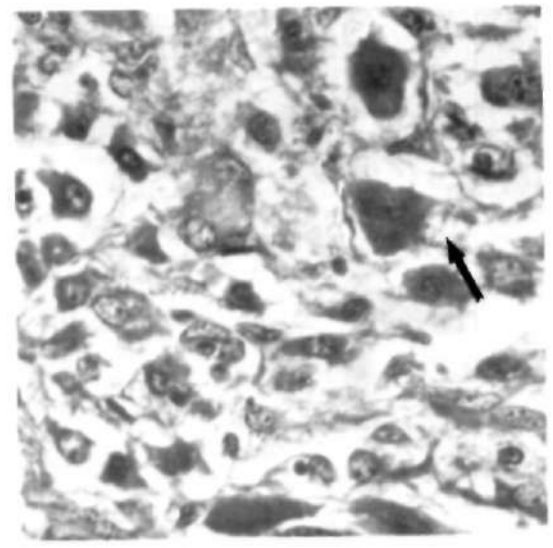


Fig. 3

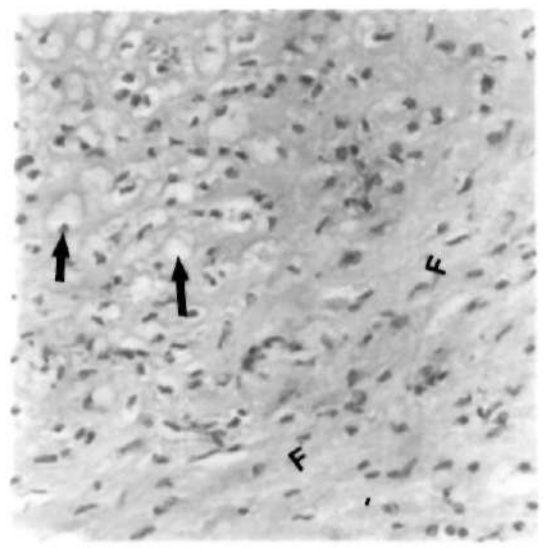


Fig. 5

PART IV

GROSS AND HISTOLOGICAL CHANGES IN THE REPRODUCTIVE TRACT OF SUCKLED AND NONSUCKLED POSTPARTUM COWS.

I N T R O D U C T I O N

Uterine involution is necessary for a cow to conceive readily after parturition (Buch et al., 1955). Conception rates 60 days postpartum have been shown to be higher in cows having completely involuted uteri than in cows with incompletely involuted uteri (Foote et al., 1960).

Studies involving gross measurements of the uterus indicated that uterine involution was complete by 50 days after parturition in dairy cows (Gier and Marion, 1968). The stages of involution described in these studies included a rapid decrease in the dimensions of the postgravid horn during the first few days after parturition. The length of the post-gravid horn decreased to half its size at parturition by 15 days and to a third by 30 days after parturition; concurrently there was a decrease in weight of the uterus from an average of 9.0kg at calving to 1.0kg at 30 days and to 0.75kg at 50 days.

The uterine size at the time of breeding is essential for optimum conception rates. In a study by Tennant and Peddicord (1968) the mean uterine horn diameter of normal cows at 30 - 50 days postpartum was 0.92±0.29 inches. Cows that had uterine horn

diameters of two inches or more at 30 - 50 days after calving had poor fertility.

Histological studies of the postpartum uterus have been carried out, especially with regards to caruncular reepithelialization after parturition. The findings of Rasbech (1950) and Gier and Marion (1968) indicate that caruncular epithelium was replaced between days 20 and 25 after parturition while Wagner and Hansel (1969) observed completed caruncular reepithelialization at day 30 postpartum. In a later study, Archbald et al., (1972) observed foci of cuboidal type epithelial cells with large, hyperchromatic nuclei and granular cytoplasm in the caruncle by day 15, the entire caruncular surface being covered by an epithelial layer by day 19.

In part II of the present study it was observed that uterine involution in the indigenous cattle, as determined by rectal palpation, was complete within 24 to 27 days after calving and that suckling had no effect on this interval. Although Wagner and Hensel (1969) also reported that the presence of calves did not alter the rate of uterine involution significantly, they found a slight difference in the average diameter of the gravid horn at the bifurcation at day 30 postpartum between nursing cows and milked cows; 4.83cm for nursing cows compared to 3.94cm for milked cows. Similar studies

regarding the gross anatomical and histological changes of the involuting uterus in the indigenous Nigerian cattle have not been carried out.

The objectives of this study were thus (a) to describe the macroscopic and microscopic changes that occur in the reproductive tract of suckled and nonsuckled White Fulani cows during the postpartum period; and (b) to determine if any, the effect of suckling on these parameters.

MATERIALS AND METHODS

Animals

The animals used for this study were the same as those described in Part III (Appendix 2).

Measurements

At the laboratory, each tract was trimed to remove all ligaments. The length of each uterine horn from the external bifurcation, that is the site where both horns

are externally connected by the intercornual ligament, to the uterotubal junction was measured using a measuring tape. The length of each uterine horn from the internal (after dissection) junction of the uterine horns and the uterine body (site of internal bifurcation) to the uterotubal junction was also measured. The diameter of each horn at the external bifurcation was measured and each horn was then weighed after severing at the internal bifurcation. Subsequently, an incision was made into each horn as close to the external bifurcation as possible and the thickness of the wall was measured from serosa to endometrium. The diamenter of the caruncle close to the external bifurcation was also measured.

The oviducts were dissected free from the mesosalpinx, resected from the uterotubal to tubo-fimbrial junction, weighed and their lengths determined.

The cervix and uterine body were also weighed and their diameters were measured. The distance from the external to the internal os was taken as the length of the cervix while the distance from the internal os of the cervix to the site of the internal bifurcation of the uterus was measured as the length of the uterine body.

Histological samples

Uterine samples for histological studies were taken from the dorsal surface of the uterus close to the external bifurcation. Portions of caruncle plus uterine wall, inter-caruncular wall and caruncle only, were obtained from each uterine horn. Sections of the internal os, external os and mid-cervix were collected from the cervix and sections of the uterine body were taken at a point midway between the internal bifurcation of the uterus and the internal os of the cervix. All samples including the entire oviduct were fixed in buffered 10% formalin. Later the tissues were trimmed processed in a routine histological procedure, sectioned at 6μ (microns) and stained with haematoxylin and eosin (Humason, 1967). Histological findings in all tissues were compared between suckled and nonsuckled cows and between days.

Statistical analysis

The effects of treatment, day after calving, and treatment by day interaction on the various parameters measured were tested by an analysis of variance (ANOVA) procedure (Steel and Torie, 1960). Because suckling treatment had no significant effect on any of the parameters, data for both groups (i.e suckled and nonsuckled) were combined and the least significant difference (L.S.D) (Steel and Torie, 1960) method

of analysis was used to determine the differences between days (Table 2). The nth order (quadratic) regression analysis was used to determined the regression curves for the uterine measurements for each of the treatments.

RESULTS

Gross observation

Plate 1 shows examples of the gross appearance of the tracts for the various slaughter days. Day 2 tracts were generally large organs containing bloody lochia. Big caruncles with prominent "stalks" and crypts were characteristic of these tracts. Petechial haemorrhage was common on the surfaces of these caruncles. By day 10 the caruncle and stalks had reduced in size but petechiae and crypts were still visible. These tracts usually contained more bloody lochia than day two tracts. By day 21 to 30 the stalk had retracted and the caruncle had become only a smooth elevation on the surface of the uterine mucosa.

Gross measurements

The ANOVA of treatment and days postpartum for various uterine parameters are presented on Table 1. Suckling had no significant effect on any of the measured uterine parameters determined. Table 2 shows the combined means

of all measured parameters for the different days postpartum for both suckled and nonsuckled cows, while Tables 3, 4 and 5 show the means for the various days for both groups. There were significant differences (P(.05; P(.01; P(.001, Table 1) between days after calving for all uterine parameters, but not for length or weight of oviduct.

The means of all the measured uterine parameters for day two were different from those for days 10, 21 and 30 and means for day 10 were different from those for days 21 and 30 (Table 2). The mean length of the uterine horn for day 10 cows (48.65cm measured from internal bifurcation) was different from that for day 21 (28.49cm) animals and very di different from that of day 30 (27.58cm). Mean length of cervix for day 10 cows (12.73cm) was much different from the mean for day 21 (7.65cm) which was different from that for day 30 (11.22cm) cows. Mean uterine horn lengths for days 21 and 30 (28.49 vs 27.58cm) were similar. The thickness of the wall of the uterine horns for days 2 and 10 (1.15cm vs 1.0cm for gravid horns) cows were similar but different from that of days 21 (.72cm) and 30 (.72cm) which had similar wall thickness.

The mean diameters of the uterine horn, uterine body and cervix for day 2 animals were different from those for days 10, 21 and 30 cows, while those of day 10 were different from those of days 21 and 30. Mean uterine horn diameters for days 21 and 30 were similar but the uterine body had a bigger diameter on day 30 than on

day 21. The diameters of the caruncles at the uterine bifurcation were similar for days 10, 21 and 30 cows but different for day 2 cows.

The day 2 uterine horn, uterine body and cervix were much heavier than those of day 10, 21 and 30 Table 2). While the mean weights of the day 10 uterine horn and cervix were different from those of days 21 and 30 the mean weights for these two days were similar. Mean weight of the uterine body for days 10 and 21 were not different; weights for days 21 and 30 were also not different but those for days 10 and 30 were different. The nongravid horn was generally smaller both in size and weight than the gravid horn in all animals.

Figures 1 - 4 show the regression curves of some of the measured uterine horn parameters. The rate of uterine involution as indicated by the decline in the measured parameters, was much faster during the first 10 - 15 days postpartum than the subsequent days. Grossly, involution was complete by day 20 - 25 as there were no or very little differences between the lengths, diameters and weight of the uterine horns from days 20 to 25. By day 30 the lengths, diameters and weights of the uterine horns of some of the cows had increased due to resumption of cyclic activities.

Histological features

Histologically there were no apparent differences between the tracts of suckled and nonsuckled cows. A summary of the histological findings is presented on Table 6. On day two postpartum, maternal crypts were visible in a thick disintergrating mass of caruncular tissue (Plate II Fig.1). The lamina propria appeared rather disorganized. By day 10, the caruncular tissue had reduced in size and sloughing of the tissue was evident. Concurrent with sloughing, epithelial regeneration had commenced (Plate II, Fig.2). Regeneration of epithelium occurred from the edges of the caruncles as well as from glandular epithelium (Plate II, figures 3 and 4). By day 21 and after caruncular reepithelialization was complete.

Epithelium was present in sections of intercaruncular tissues, the cervix, uterine body and oviducts of all cows regardless of days postpartum.

Trophoblastic cells were found in sections from two cows while macrophages and eosinophils were present in sections from days two and 10 animals. Lymphocytes and plasma cells were a common feature in the lamina propria of sections from all groups of animals. A few neutrophils were present in sections from days two and 10 postpartum cows. Foci of leucocytes were present in some sections (Plate III). Glandular development was more prominent in the postpartum days 21 and 30 cows

than days two and 10. The complete reepithelialization and glandular development observed at 21 days postpartum suggest complete involution by day 21 postpartum

Based only on cursory examination it would appear that muscle fibres in the sections decreased in size with days postpartum until day 21. No difference between fibres was apparent in sections obtained on days 21 and 30. Blood vessel luminal patency and haemorhage were a common feature in all sections.

DISCUSSION

The analysis of variance of the effect of treatment on the various uterine measurements indicated that suckling had no significant effect on gross and microscopic features of uterine involution. While this finding is in agreement with the findings of Oxenreider (1968) and Wagner and Hansel (1969) it is contrary to the observations of Lauderdale et al., (1968) who reported a faster involution rate in suckled than nonsuckled beef cattle.

On the basis of gross changes recorded in this study, uterine involution would appear to be completed by 20 to 25 days after parturition while histological evidence of caruncular

reepithelialization confirms that uterine involution is completed by 21 days. Thus these findings as well as the duration of 24 to 27 days for clinical involution found in Part II of this study, clearly indicate that the uterus of the postpartum White Fulani (Bunaji) cow is completely involuted within 30 days after calving. This duration, though shorter, is within the 50 day duration reported by Gier and Marion (1968). These animals can thus be bred successfully within the first 60 days of calving so long as they come in oestrus.

In contrast to the treatment effect on the measured parameters, the analysis of variance indicated significant differences between days with the measurements decreasing with days (Table 2). The progressive decreases observed for the various parameters, agree with the changes observed by Gier and Marion (1968) in the uteri of clinically normal postpar m dairy cows. The lack of significant differences between the uteri of days 21 and 30 postpartum animals further confirms the return of the uterus to normal pregravid status by about 21 days after calving.

The mean day 30 gravid uterine horn diameter of 4.02cm for suckled and nonsuckled cows observed in this study compares favourably with the 4.36m average for suckled and nonsuckled cows reported by Wagner and Hansel (1959). However, the average day 30 gravid horn weights of 166.6g for nonsuckled and suckled are lower than those reported by the same workers (306g vs 314g) suggesting possible breed differences.

Based on the report by Tennant and Peddicord (1968) these animals should have fairly normal conception rates. There were no differences in the length or weight of the oviducts between postpartum days. This would suggest that little or no physiological and or anatomical changes occur in the oviducts of pregnant and postpartum cows.

The regression curves for uterine horn length, diameter and weight indicated increases of these parameters at 30 days compared to 21 days postpartum especially for nonsuckled animals (Figures 1,2 and 4). This was obviously due to hormonal effects as some of these animals had resumed cyclic ovarian activities at this time.

The histological features of tissue sections from suckled and nonsuckled cows were also similar. The time of 21 days for complete caruncular reepithelialization found in this study is similar to the 19 days reported by Rasbech (1950) but shorter than the 30 days reported by Wagner and Hansel (1969). The commencement of epithelial regeneration at 10 days postpartum observed in this study is close to the 12 to 14 days observed by these workers. The increased lochial discharge observed 10 days postpartum indicates that caruncular sloughing took place around this time

while the presence of new epithelium also at this time suggests a concurrence of both activities. Along with epithelial regeneration is an increased muscular contraction as indicated by the sharp decline in the measured parameters during the first 10 postpartum days. Thus the combined effects of the two processes of muscular contraction and epithelial regeneration eventually returned the uterus to the pregravid status.

The significante of the rather common leucocytic infiltration of the lamina propria could not be determined from this study. However it might be associated with the necrotic process and eventual sloughing of the caruncular tissue. The presence of macrophages in sections from days two and 10 and not in sections from days 21 and 30 would indicate a phagocytic function as the necrotic process and sloughing which calls for removal of dead cells, occurred during the early period of involution. The presence of leucocytic foci in some sections probably suggests some mild chronic non-specific uterine infection. Similar findings have been reported by others (Gier and Marion, 1968; Wagner and Hansel, 1966).

The lack of effect of suckling on uterine involution regression, even though suckling delayed ovarian

activities as observed in part II of this study, is an indication that uterine involutionary process may not be influenced by ovarian steroid hormones. Casida and Wisnicky (1950) reported that administration of 20mg of diethystilbestrol within 9 hours after parturition failed to affect length of involution interval. Also subcutaneous inoculations of cows with 0.05mg of 17β-estradiol on alternate days beginning 3 days after parturition and continuing until uterine involution was complete did not significantly influence rate of uterine regression (Marion et al., 1968). Reports on the influence of progestins on duration of uterine involution vary. Foote and Hunter (1964) observed that the uterine regression interval in beef cows was significantly shortered by once-a-day injections of 50mg of progesterone given on day 12 through day 23 after calving. However, Fosgate et al., (1962) found that 22 injections of 100mg of 17-alpha-hydroxy progesterone-n-proate administered on alternate days beginning the day of calving significantly increased the regression interval. On the other hand, Marion, et al., (1968) reported that while treatment with medroxy progesterone-n-ca-proate given on alternative days from three to five days postpartum had no influence, daily treatment with 30mg of progesterone from three

to five days post calving resulted in a highly significant increase ($P<.01$) in length of uterine regression interval.

SUMMARY

A study of the effect of suckling on the postpartum uterine involutionary changes in the White Fulani cow was undertaken using 24 mature animals. The animals were alloted into two groups of 12 suckled and 12 nonsuckled cows. Three animals from each group were slaughtered on postpartum days 2, 10, 21 and 30 respectively. Gross measurements of the tracts were made and portions of the tracts for histological studies were taken for sectioning and staining with hematoxylin and eosin. Suckling did not influence the rate of uterine regression. There were significant differences between the postpartum days for all measured uterine parameters except length and weight of the oviducts. The nongravid uterine horns were generally smaller than the gravid horns in all animals regardless of treatment or postpartum day.

Based on gross measurements uterine involution was complete by 20 to 25 days postpartum. Histologically sloughing of caruncular tissue and initiation of carucular reepithelialization occurred at about day 10 after calving. The histological features of the tracts from suckled and nonsuckled cows were also similar. Caruncular reepithelialization which occurred from the edges of the caruncles as well as from glandular epithelium, was complete by 21 days after parturition. Full glandular development also occurred by day 21. It is concluddd that the delaying effect of suckling on ovarian and cyclic activities of the postpartum White Fulani cow may not be an important factor in the uterine involutionary process. Prolonged calving interval in the White Fulani cattle cannot be attributed to poor uterine involution.

Table 1 ANOVA of treatment and days after parturition for uterine parameters.

Source of variation	df +	Mean squares: Length from internal bifurcation to utero-tubal junction (cm)²		Length from external bifurcation to utero-tubal junction (cm)²		Length of oviducts from uterotubal junction to tubo-fimbrial junction	
		Gravid horn	Nongravid horn	Gravid horn	Nongravid horn	Gravid horn	Nongravid horn
Between treatments	1	52.5	75.26	35.3	1.04	0.004	15.68
Between days	3	1723.12***	454.43**	986.99***	186.56***	26.75	16.33
Treatment X days	3	70.96	6.04	46.08	22.71	10.103	0.90
Error	1f	90.59	50.96	73.34	20.70	22.83	9.37

** P(.01

*** P(.001

df+ = degrees of freedom

Table 1 cont'd

Source of variation	df	Mean squares		
		Length of cervix $(cm)^2$	Wall thickness $(cm)^2$	
			Gravid horn	Nongravid horn
Between treatments	1	15.84	0.02	0.004
Between days	3	36.56**	0.75***	0.095**
Treatment X days	3	12.29	0.017	0.024
Error	16	5.03	0.04	0.014

** = P<.01

*** = P<.001

Table 1 cont'd

Source of variation	df	Mean squares					
		Diameter $(cm)^2$					
		Gravid horn	Nongravid horn	Uterine body	Cervix	Caruncles near uterine bifurcation	
						Gravid horn	Nongravid horn
Between treaments	1	1.4504	2.16	3.375	.0038	0.18	.0208
Between days	3	184.5171***	37.84***	147.472***	31.636***	9.74***	6.467***
Treatment X days	3	6.5782	3.06	2.236	2.152	0.54	0.0887
Error	16	3.5025	0.83	0.927	1.539	0.368	0.2006

*** P<.001

Table 1 cont'd

Source of variation	df	Mean squares			
		Weight $(g)^2$			
		Gravid horn	Nongravid horn	Oviduct of gravid horn	Oviduct of nongravid horn
Between treatments	1	72435	50050	0.059	0.0384
Between days	3	4331258***	396177***	0.162	0.119
Treatment X days	3	68769	76439	0.035	0.0303
Error	16	28378	31343	0.081	0.0497

*** P<.001

Table 1 cont'd

Source of variation	df	Means squares: Weight (g)[2]	
		Uterine body	Cervix
Between treatment	1	8331.7107	1902
Between days	3	81227.427***	285954***
Treatment X days	3	2883	17637
Error	16	6603.8006	14453

*** P(.001

Table 2

LSD for means of treatment and days after parturition for various slaughter days.

	No. of cows	Length (cm) from internal bifurcation to uterotubal junction		Length (cm) from external bifurcation to uterotubal junction	
		Gravid horn	Nongravid horn	Gravid horn	Nongravid horn
Treatment					
Non suckled	12	43.33[a]	34.05[a]	27.87[a]	19.43[a]
Suckled	12	40.2[a]	30.49[a]	25.44[a]	18.95[a]
Days					
2	6	62.34[b]	43.67[b]	43.67[b]	25.59[b]
10	6	48.65[c]	34.35[c]	29.07[c]	21.68[b]
21	6	28.49[d]	26.65[cd]	19.15[cd]	16.40[bc]
30	6	27.58[d]	24.42[d]	14.74[d]	13.09[c]

a,b,c,d, means with different superscripts within each column for treatment and days, are significantly different (P<.05).

LSD = Least significant difference.

Table 2 cont'd

Treatment	No. of cows	Length (cm) of oviduct		Length (cm) of cervix	Wall thickness (cm)	
		Gravid horn	Nongravid horn		Gravid horn	Nongravid horn
Nonsuckled	12	23.96[a]	23.29[a]	12.12[a]	0.90[a]	0.66[a]
Suckled	12	23.96[a]	21.70[a]	10.49[a]	0.89[a]	0.63[a]
Days						
2	6	25.33[b]	24.49[b]	13.67[b]	1.15[b]	0.77[b]
10	6	22.25[b]	20.55[c]	12.73[b]	1.00[b]	0.73[b]
21	6	20.15[b]	22.90[bc]	7.65[c]	0.72[c]	0.58[c]
30	6	22.10[b]	22.05[bc]	11.22[d]	0.72[c]	0.50[c]

Table 2 cont'd

	No. of cows	Diameter of gravid horn (cm)	Diameter of nongravid horn (cm)	Diameter of uterine body	Diameter of cervix (cm)	Diameter of caruncle near uterine bifurcation (cm)	
						Gravid horn	Nongravid horn
Treatment							
Nonsuckled	12	8.72[a]	5.50[a]	9.47[a]	8.85[a]	1.82[a]	1.25[a]
Suckled	12	9.20[a]	6.09[a]	10.19[a]	8.90[a]	1.64[a]	1.19[a]
Days							
2	6	16.17[b]	8.59[b]	16.0[b]	12.07[b]	3.55[b]	2.77[b]
10	6	10.44[c]	7.25[c]	11.65[c]	9.00[c]	1.60[c]	0.89[c]
21	6	5.23[d]	3.90[d]	6.25[d]	7.15[d]	1.12[cd]	0.62[c]
30	6	4.02[d]	3.45[d]	10.84[c]	7.29[d]	0.65[d]	0.62[c]

Table 2 cont'd

	No. of cows	Weight of gravid horn horn (g)	Weight of nongravid horn (g)	Weight of oviduct on gravid horn (g)	Weight of oviduct on nongravid horn (g)	Weight of uterine body (g)	Weight of cervix (g)
Treatment							
Nonsuckled	12	694.97[a]	322.89[a]	0.80[a]	0.76[a]	107.40[a]	397.93[a]
Suckled	12	804.84[a]	355.69[a]	0.70[a]	0.67[a]	144.89[a]	415.45[a]
Days							
2	6	1960.03[b]	782.81[b]	0.80[b]	0.94[b]	283.78[b]	696.15[b]
10	6	722.60[c]	330.65[c]	0.77[b]	0.70[b]	142.70[c]	454.55[c]
21	6	180.10[d]	129.30[d]	0.92[b]	0.70[b]	53.45[cd]	247.30[d]
30	6	136.89[d]	114.39[d]	0.63[b]	0.63[b]	25.12[c]	228.76[d]

Table 3

Mean uterine dimensions for suckled and nonsuckled cows slaughtered on days 2, 10, 21 and 30 postpartum.

Groups	Days postpartum	No. of cows	Length (cm) from internal bifurcation to uterotubal junction		Length (cm) from external bifurcation to uterotubal junction		Length of uterine body
			Gravid horn	Nongravid horn	Gravid horn	Nongravid horn	
Nonsuckled	2	3	67.5±19.9*	46.17±12.8	41.0±17.7	23.0±3.1	4.33±0.8
	10	3	45.3±3.5	36. 2± 4.6	31.3±4.0	22.7±5.5	5.20±1.8
	21	3	30.67±1.04	27.0±1.0	23.0±5.3	17.0±4.0	3.83±0.29
	30	3	29.83±6. 5	26.83±11.0	16.17±5.2	15.0±6.9	2.2 ±0.3
Suckled	2	3	57.17±15.0	41.17±5.3	46.33±12.7	28.17±6.5	8.0±3.0
	10	3	52.0±6.24	32.5 ±5.4	26.83± 4.6	20,66±0.6	6.10±0.52
	21	3	26.3±5. 0	26.3±6.0	15. 3±4.4	15.8±4.3	4.5±0.76
	30	3	25.33±3.69	22.0±2.18	13. 3±0.26	11.17±1.60	2.63±0.64

* = Standard deviation

Table 3 cont'd

Groups	Days postpartum	No. of cows	Length (cm) of cervix	Diameter of gravid horn (cm)	Diameter of nongravid horn (cm)	Diameter of uterine body (cm)	Diameter of cervix (cm)
Nonsuckled	2	3	13.67±0.6	16.0±3.3	8.17±0.6	15.5±1.3	11.3±2.0
	10	3	12.80±1.3	8.7±1.2	6.00±0.	10.5±0.5	9.0±1.0
	21	3	8.50±1.3	5.66±0.57	4.0±0.5	6.2±0.2	7.1±0.2
	30	3	13.60±4.77	4.53±0.92	3.83±1.04	5.67±1.15	8.0±1.7
Suckled	2	3	13.67±2.5	16.33±3.1	9.0±1.7	16.5±1.5	12.83±1.3
	10	3	12.66±0.6	12.17±2.3	8.5±1.3	12.8±0.76	9.00±1.3
	21	3	6.80±1.8	4.80±0.3	3.8±0.3	6.3±0.8	7.20±0.8
	30	3	8.83±0.76	3.50±0.5	3.07±0.40	5.17±0.76	6.57±0.51

Table 3 cont'd

Groups	Days postpartum	No. of cows	Weight of gravid horn (g)	Weight of nongravid horn (g)	Weight of uterine body (g)	Weight of cervix (g)
Nonsuckled	2	3	1888.89±121.9	685.55±84.9	268.61±203.2	631.9±88.2
	10	3	522.5±81.7	325.8±103.1	92.2±43.1	458.4±73.7
	21	3	201.9±20.3	145.3±8.3	46.9±22.2	211.3±36.9
	30	3	166.6±68.5	134.9±60.72	22.8±3.4	290.1±21.2
Suckled	2	3	2031.17±400.4	880.06±351.6	298.95±72.2	760.39±217.6
	10	3	922.7±194.2	335.5±71.0	193.2±60.9	450.7±107.3
	21	3	158.3±41.6	113.3±27.5	60.0±13.2	283.3±205.2
	30	3	107.18±24.86	93.88±10.07	27.41±9.02	167.41±4.3

Table 3 cont'd

Groups	Days postpartum	No. of cows	Wall thickness (cm) Gravid horn	Nongravid horn
Nonsuckled	2	3	1.07±0.1	0.83±0.2
	10	3	1.06±0.1	0.8±0
	21	3	0.73±0.25	0.53±0.15
	30	3	0.73±0.3	0.47±0.06
Suckled	2	3	1.23±0.3	0.7 ±0.2
	10	3	0.93±0.05	0.66±0.05
	21	3	0.7 ±0.2	0.63±0.2
	30	3	0.7 ±0.17	0.53±0.05

Table 4

Mean diameter of caruncles near the uterine bifurcation in gravid and nongravid uterine horns of suckled and nonsuckled cows slaughtered on days 2, 10, 21 and 30 postpartum.

	Suckled			Nonsuckled		
Days Postpartum	No. of cows	Mean diameter of caruncle (cm)		No. of cows	Mean diameter of caruncle (cm)	
		Gravid horn	Nongravid horn		Gravid horn	Nongravid horn
2	3	3.13±0.23*	2.7±0.82	3	3.96±0.9	2.83±0.76
10	3	1.83±0.28	0.77±0.15	3	1.37±0.98	1.0 ±0.45
21	3	0.87±0.15	0.53±0.2	3	1.37±0.9	0.7 ±0.2
30	3	0.73±0.77	0.77±0.12	3	0.57±0.15	0.47±0.15

* = Standard deviation

Table 5

Mean lengths and weights of oviducts of suckled and nonsuckled cows slaughtered on days 2, 10, 21 and 30 postpartum.

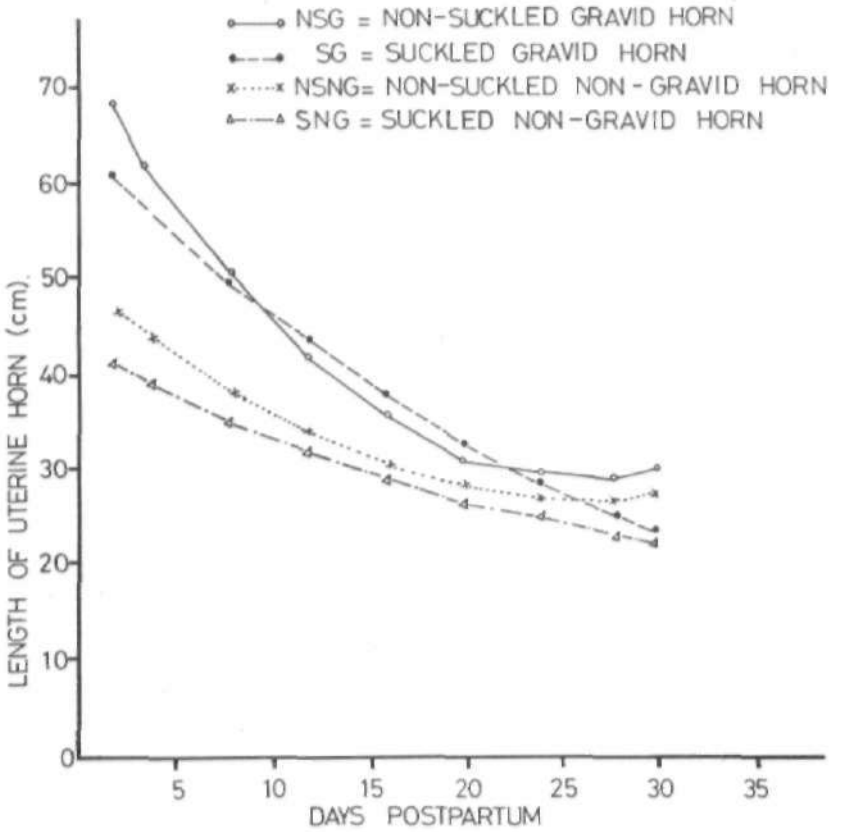
Days postpartum	No. of cows	Mean length (cm) of oviduct		Mean weight (g) of oviduct	
		Gravid horn	Nongravid horn	Gravid horn	Nongravid horn
Suckled					
2	3	23.83±4.65*	23.3±2.3	0.72±0.4	0.83±0.22
10	3	22.2±3.57	19.7±5.05	0.63±0.15	0.57±0.2
21	3	27.8±8.9	22.0±1.8	0.97±0.55	0.8±0.3
30	3	22.0±2.6	21.8±3.25	0.48±0.2	0.48±0.19
Nonsuckled					
2	3	26.83±2.36	25.67±1.76	0.87±0.08	0.85±0.09
10	3	22.3±6.0	21.4±3.9	0.9±0.1	0.83±0.25
21	3	24.5±2.2	23.8±1.0	0.87±.0.3	0.77±0.29
30	3	22.2±4.04	22.3±3.3	0.57±0.12	0.58±0.11

* = Standard deviation

Table 6 Some histological features of the uterine sections of cows slaughtered on days 2,10,21 and 30 after calving.

Microscopic features	Days postpartum			
	2	10	21	30
Maternal crypts	+++	+	-	-
Caruncular epithelium	Absent	Incomplete	Complete	Complete
Intercaruncular epithelium	Complete	Complete	Complete	Complete
Cellular Infiltration:				
Trophoblastic cells	+	-	-	-
Lymphocytes	+++	+++	+++	++
Plasma cells	++*	++	++	++
Macrophages	+	+	-	-
Neutrophils	++	+	+	-
Eosinophils	++	+	-	-
Glandular development	+	++	++++	+ +++
Size of muscle fibres	+++	++	+	+

*One cow in this group had a massive invasion of plasma cells.



PREDICTION EQUATIONS

$$\text{NSG } \hat{Y} = 74{\cdot}1 - 3{\cdot}5x + 6{\cdot}8x^2 \; (R^2 = 75{\cdot}4\%)$$

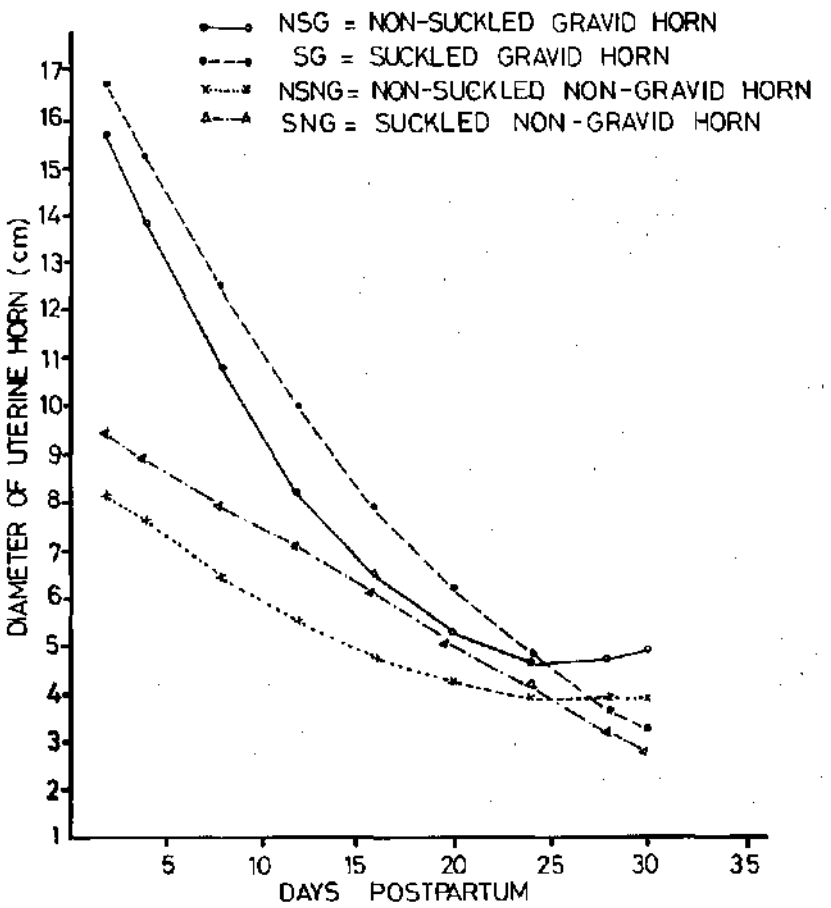
$$\text{SG } \hat{Y} = 64{\cdot}1 - 1{\cdot}98x + 2{\cdot}1x^2 \; (R^2 = 76{\cdot}0\%)$$

$$\text{NSNG } \hat{Y} = 49{\cdot}7 - 1{\cdot}7x + 3{\cdot}2x^2 \; (R^2 = 55{\cdot}0\%)$$

$$\text{SNG } \hat{Y} = 43{\cdot}1 - 1{\cdot}14x + 1{\cdot}5x^2 \; (R^2 = 75{\cdot}5\%)$$

Figure 2

Regression curves of diameter of uterine horns of suckled and nonsuckled cows.



PREDICTION EQUATIONS

$$\text{NSG } \hat{Y} = 17\cdot6 - 1\cdot0x + 1\cdot9x^2 (R^2 = 88\cdot5\%)$$

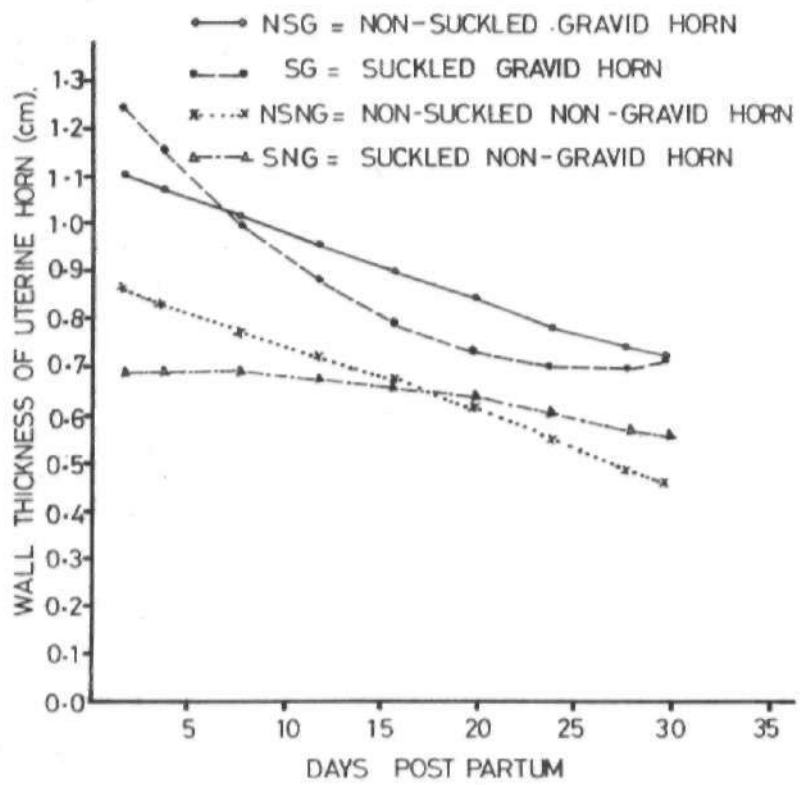
$$\text{SG } \hat{Y} = 18\cdot3 - 0\cdot8x + 1\cdot0x^2 (R^2 = 90\cdot1\%)$$

$$\text{NSNG } \hat{Y} = 8\cdot9 - 0\cdot4x + 6\cdot6x^2 (R^2 = 91\cdot6\%)$$

$$\text{SNG } \hat{Y} = 9\cdot9 - 0\cdot3x + 3\cdot3x^2 (R^2 = 82\cdot1\%)$$

Figure 3

Regression curves of wall thickness of uterine horns of suckled and nonsuckled cows.



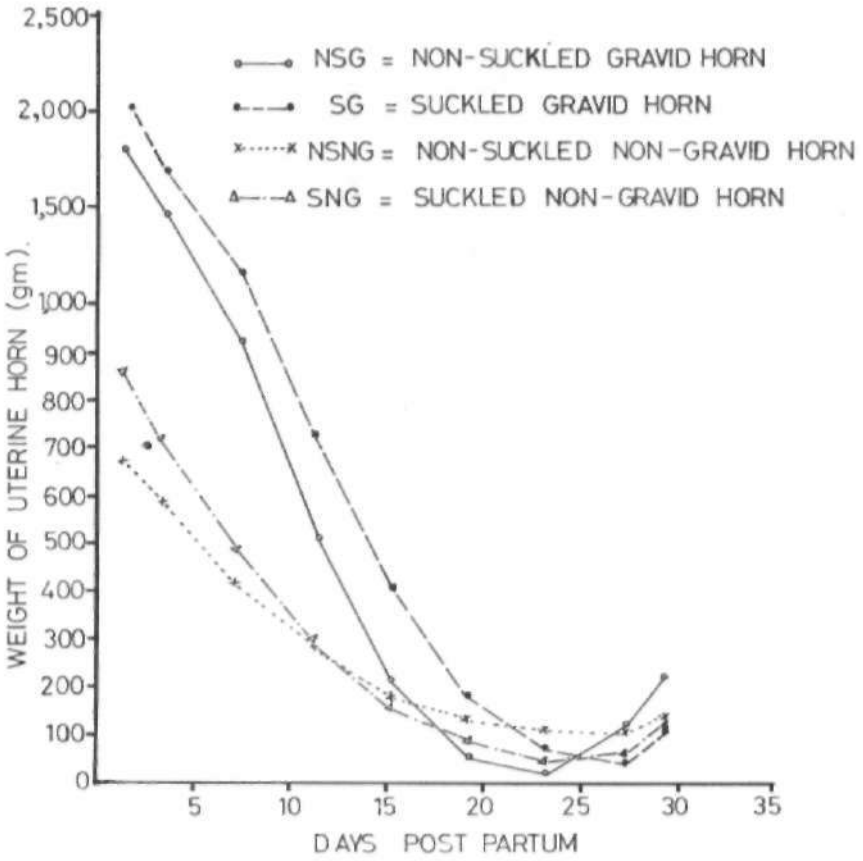
PREDICTION EQUATIONS

NSG $\hat{Y} = 1.13 - 0.016x + 7.8x^2 (R^2 = 40\%)$

SG $\hat{Y} = 1.33 - 0.05x + 0.0009x^2 (R^2 = 67.7\%)$

NSNG $\hat{Y} = 0.88 - 0.013x - 0.000035x^2 (R^2 = 70.7\%)$

SNG $\hat{Y} = 0.69 + 0.00048 - 0.00018x^2 (R^2 = 27.2\%)$



PREDICTION EQUATIONS

NSG $\hat{Y} = 2175{\cdot}2 - 188{\cdot}5x + 4{\cdot}1x^2 (R^2 = 95{\cdot}6\%)$

SG $\hat{Y} = 2366{\cdot}3 - 177x + 3{\cdot}4x^2 (R^2 = 94{\cdot}7\%)$

NSNG $\hat{Y} = 642{\cdot}6 - 42{\cdot}4x + 0{\cdot}9x^2 (R^2 = 92{\cdot}7\%)$

SNG $\hat{Y} = 1013{\cdot}2 - 79{\cdot}6x + 1{\cdot}6x^2 (R^2 = 81{\cdot}3\%)$

Plate 1

Photographs of gross appearance of uterus for various slaughter days.

Fig. 1. Uterus at day 2 postpartum. Note large size of the organ and big caruncles (arrow).

2. Uterus at day 10 postpartum. Note decreased size of the organ and caruncles as well as the presence of a bloody lochia (arrow). The blood apparently originated from the exposed blood vessels of the caruncles following the dissolution and sloughing of the superficial caruncular tissue.

3. Uterus at day 21 postpartum. Caruncular surfaces are now smooth (arrow).

4. Uterus at day 30 postpartum. Mucosal surface appears clean and caruncles (arrow) appear as smooth elevations on the mucosal surface.

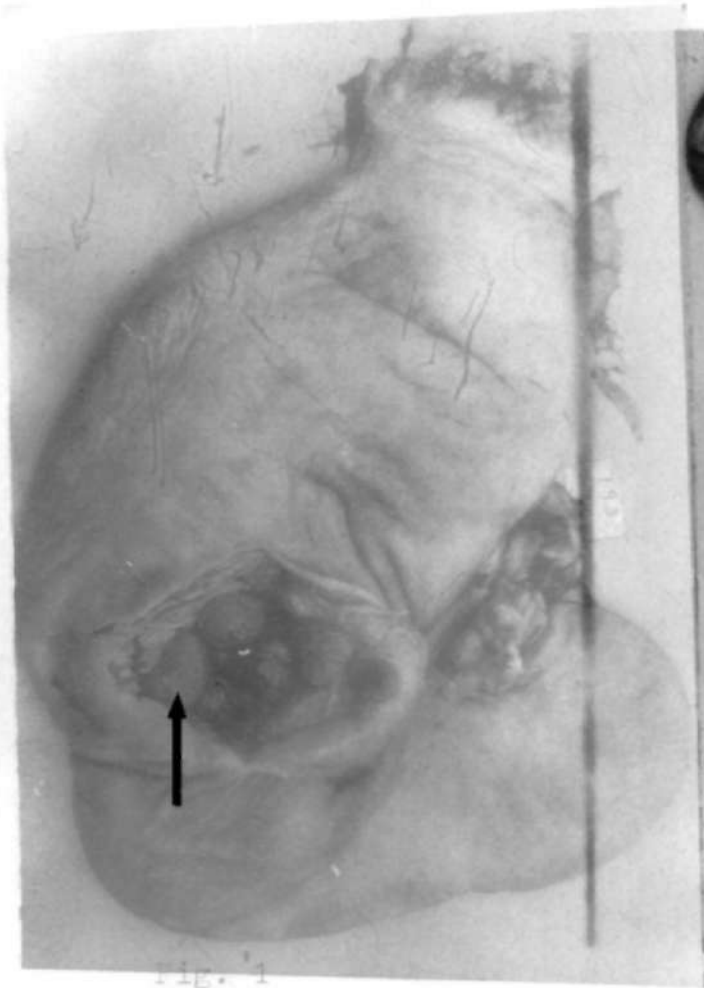


Fig. 1



Fig. 2



Fig. 3



Fig. 4

Plate II

Histological features of the uterus.

Fig. 1. Photomicrograph of a cross section of a caruncle at day 2 postpartum showing maternal crypts (arrow) in a mass of caruncular tissue (x100).

2. Photomicrograph of a cross section of a caruncle at day 10 postpartum showing concurrent sloughing (arrow) and regeneration of caruncular epithelium (arrow) (x200).

3. Photomicrograph of a cross section of a caruncle showing caruncular epithelial regeneration from the edge of the caruncle (arrow) (x200).

4. Photomicrograph of a cross section of a caruncle showing caruncular epithelial regeneration from glandular epithelium (arrow) (x100).

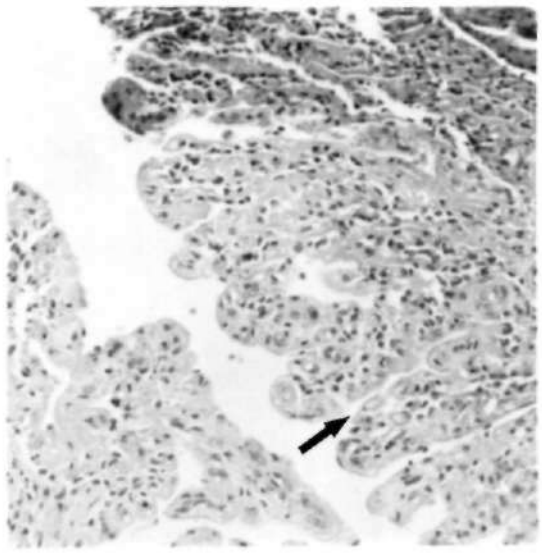


Fig. 1

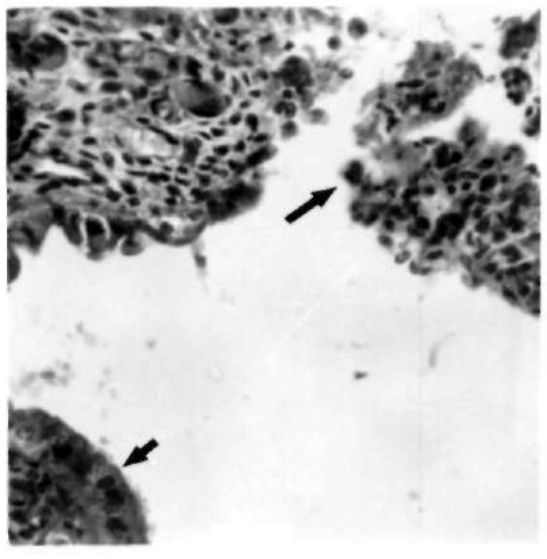


Fig. 2

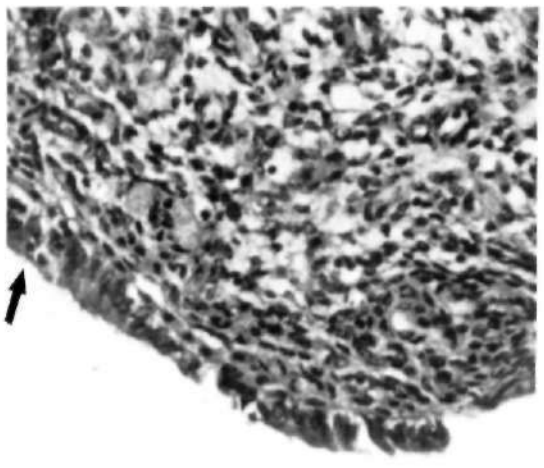


Fig. 3



Fig. 4

Plate III

Cell types of the uterine sections

Fig. 1. Photomicrograph of a focus of leucocytes (mainly lymphocytes) in the lamina propria of a uterine section obtained from a day 10 postpartum cow (x200).

2. Photomicrograph of a uterine section showing plasma cells (P) and lymphocytes (L) in the lamina propria (x400).

3. Photomicrograph of a uterine section obtained from a day 2 postpartum cow showing a trophoblastic giant cell (arrow) in the lamina propria (x400).

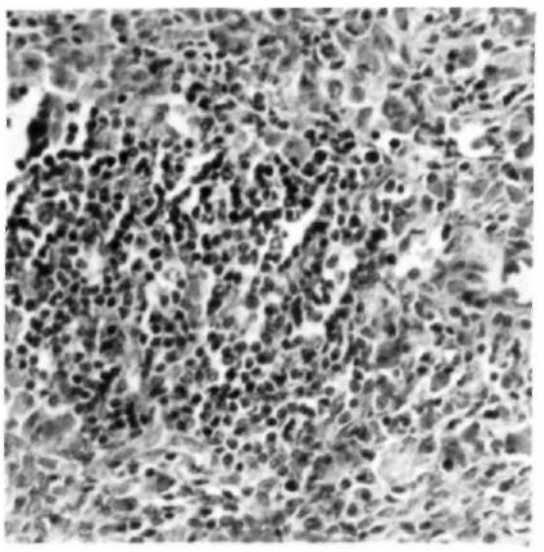


Fig. 1

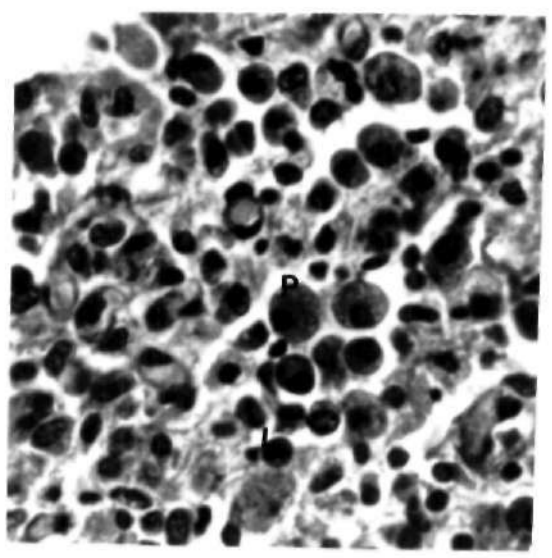


Fig. 2

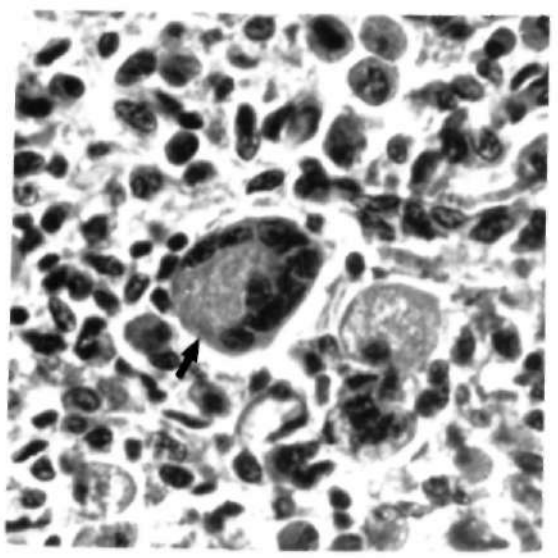


Fig. 3

PART V

BACTERIOLOGICAL INVESTIGATION OF THE POSTPARTUM UTERUS: RELATIONSHIP TO INVOLUTION AND HISTOPATHOLOGICAL FINDINGS.

INTRODUCTION

Normal uterine involution is believed to proceed aseptically. However, a number of cows have been found to be infected by different types of bacteria especially during the early postpartum period (Rasbech 1950). Postpartum uterine infections have been classified as specific or nonspecific. Prominent among organisms causing specific uterine infections are Brucella sp., trichomonas and Vibrio sp. (Campylobacter) (Roberts, 1971) while staphylococci , streptococci, corynebacteria, Escherichia coli and unclassified gram-negative rods have been identified as the usual causes of nonspecific infections (Sagatz and Hardenbrook, 1971).

It is obvious that reproductive tract infections can play a significant role in fertility, either through a direct damage to gametes or deleterious effect on the developing embryo. Endometritis may impair implantation.

Incidence of 25-30% puerperal uterine infection in clinically normal cows was reported by Rasbech (1950). Higaki et al., (1959) observed that the largest number of bacteria was present in the uterus at one to two weeks postpartum. Elliot et al., (1968) found that at 0 to 15 days postpartum 85% of the uteri they sampled

were contaminated with microorganisms while at 60 days only 10% of the uteri were infected. Griffin et al., (1974a&b) also noted a decline in the incidence of infected uterine samples from about 100% during the first two weeks postpartum to approximately 30% during the fifth week with the level of infection remaining fairly constant thereafter.

Perry (1960) noted that while nonspecific bacterial infections may cause both acute and chronic endometritis the latter is more commonly observed. Corynebacterium pyogenes has been associated with severe endometritis (Hartigan et al., 1972). During the first sampling of 12 postpartum cows two days postpartum Griffin et al., (1974) isolated coagulase negative Staphylococcus from two cows, while C. pyogenes, enterobacteria and non-haemolytic Streptococci were isolated from each of four cows. Isolates from the second sampling were C. pyogenes and non-haemolytic Streptococcus from each of two cows.

With regards to uterine involution Boyd (1925) observed that a mild uterine infection often delayed normal involution by seven to 10 days. Also, Hartigan et al., (1974) observed that, while a transient infection by C. pyogenes during the puerperal period reduced the probability of a successful first service

persistence of the infections caused very severe endometritis, delayed involution, induced anoestrus and caused prolonged infertility or even sterility.

Gier et al., (1962) undertook a histological study of the postpartum bovine uterus and reported that during the first 15 days neutrophils occumulated in the sloughing placental mass and to a lesser extent, in the stratum compactum. The caruncular stratum compactum contained numerous histiocytes while lymphocytes were extremely numerous in the endometrium of infected uteri and moderate in most uteri found bacteriologically sterile. In the uteri infected with pyogenic bacteria a good number of neutrophils persisted beyond 30 days' While monocytes occurred irregularly with bacterial infections, mast cells and eosinophils were irregularly present not correlated with bacterial infection or stage postpartum.

The influence of puerperal uterine infection by nonspecific bacterial organisms on the involutionary process of the postpartum uterus of the Nigerian indigenous cows has not been studied. Furthermore the effect of the stress due to suckling on the resistance of the postpartum cow to puerperal infection is also not known.

This study was thus designed to determine the aerobic and anaerobic bacterial flora of the postpartum uterus of suckled and nonsuckled White Fulani cows

with a view to determining the relationship between bacteriological findings and the rate of uterine involution.

MATERIALS AND METHODS

Animals.

The 24 White Fulani cows described in part III of this study were used for this bacteriological investigation. Samples for culture were collected from eighteen of these cows at slaughter at the rate of six cows (three suckled and three nonsuckled) on days two, 10 and 21 after parturition. The remaining six cows (three suckled and three nonsuckled) were used for in vivo sample collection starting from day one after calving until the 30th day when they were slaughtered and sampled.

Sample collection at slaughter

The animals were slaughtered at the Meat Laboratory of the Department of Animal Science of the University.

At slaughter, the reproductive tract was removed and samples were taken immediately. Each uterine horn was sterilized with tincture of iodine and then cut open close to the external bifurcation with a sterile scalpel blade to obtain swabs from the uterine lumen. The swabs were immediately inoculated on four plates each of blood agar and chocolate agar and two MacConkey agar plates. Two plates of blood agar, chocolate agar and MacConkey agar were incubated after streaking, aerobically at 37°C while two plates each of blood and chocolate agar were also incubated anaerobically. Plates were incubated for 24 hours in the first instance and were reincubated for another 24 hours when no growth was observed.

When distinct colonies were observed, they were transferred to differential media for isolation and identification procedures of bacteria according to routine standard procedures (Carter 1973; King, 1972).

Direct smears of swabs as well as smears of colonies were also made on slides and stained with Gram stain for bacterial examination.

In vivo sampling technique

a) Instrument for sampling

A biopsy instrument made of stainless steel (Figure 1).

was used to obtain bacteriological samples from the uterus. The instrument consisted of (a) A 59cm long outertube sealed at one end but open at the other end. About 1cm from the sealed end there is a 1.5x0.5cm rectangular opening. (b) An inner solid rod 56cm long with a 5cm long cutting end piece screwed on it. The rod had a 7cm long and 1cm thick handle with which it could be moved in and out of the outer tube to close or open the rectangular opening on the outer tube.

(b) Sampling procedure

The biopsy instrument and a vaginal speculum were wrapped in brown paper after thorough washing and steam sterilized before use. The vulva and the surrounding area were thoroughly washed with soap and water and dried with clean dry towel. The lips of the vulva were parted and the speculum was carefully introduced into the vagina to expose the external os of the cervix. With the rectangular opening of the outer tube closed, the sampling instrument was introduced through the speculum into the cervix and then into the uterine horn. The inner rod was then pulled back a little to open the outer tube which was then used to scoop the uterine mucosa, after which the inner rod was pushed in to close the opening before withdrawal of the instrument. Sterile swabs were then used to obtain the material in the cavity

of the sampling instrument to innoculate blood, chocolate and MacConkey agar plates. Bacterial culture and isolation procedures were as described for samples collected at slaughter.

Samples were obtained from each cow at about 24 hours after calving, and then at twice weekly intervals until they were slaughtered at30. days postpartum.

Histopathology

Portions of the uterine wall as well as caruncles were taken for histopathological study as earlier described in part IV.

Statistical analysis

A 2-sample t-test (unpaired) was used to compare the rates of uterine contamination for suckled and nonsuckled groups of cows sampled at slaughter. The frequency of uterine contamination for suckled and nonsuckled cows sampled *in vivo* was also compared.

RESULTS

The bacterial organisms isolated from the uteri of suckled and nonsuckled cows slaughtered on the indicated postpartum days are shown on Table 1.

It is evident from the results that suckling had no significant influence (P).05) on the rate of postpartum uterine contamination. All cows slaughtered two days after calving were free of uterine contamination. However three of six cows slaughtered on days 10 and 21 (Table 1) yielded bacteria on culture of uterine samples and one of six cows had a contaminated uterus at day 30 after parturition. Staphylococcus aureus was the commonest organism isolated. Two nonsuckled cows slaughtered on day 10 yielded S. aureus and Klebsiella sp; and S. aureus and beta haemolytic Streptococcus respectively in uterine cultures. The incidence of bacterial isolation for all animals was 29.2% (7/24).

The culture results of repeated in vivo sampling of six postpartum cows during the first 30 days are presented on Table 2. There was no difference in the rate of uterine contamination between suckled and nonsuckled cows and the frequency of bacterial isolation for individual cows (Table 3) was also not significantly different (P)0.05) for suckled and nonsuckled animals. The incidence of bacterial isolation from all sampling

for all cows in the two groups was 17.3% (9/52).

Most of the bacterial isolations were made during the first two weeks after parturition with S. aureus being the commonest organism isolated. All but one of the cows had sterile uteri on the first postpartum day. Culture of uterine sample from one cow yielded Klebsiella sp. and Escherichia coli on day four. No organism was consistently isolated from an animal throughout the sampling period. The findings from the in vivo samples taken just before slaughter agreed with those observed at slaughter but for one cow from which S. aureus was isolated in vivo but not at slaughter.

Table 4 shows cows that had uterine leucocytic foci and or bacterial isolates, while Figure 3 shows the prevalence of these foci with days postpartum. On day two postpartum only one of six cows had scattered foci of leucocytes (mainly lymphocytes) in the stratum compactum while on day 10, two cows had the foci. Four and five cows had these foci on days 21 and 30, respectively. On the whole, 12 of 24 cows had these foci. However, bacteria were isolated from only three of the 12 animals with leucocytic foci, two on day 21 and one on day 10 . On the other hand four cows from which bacteria were isolated, did not have leucocytic foci, while eight cows

neither had foci nor bacteria isolates. The presence of leucocytic foci or bacteria did not affect the rate of uterine involution.

DISCUSSION

The report of 25 - 30% incidence of puerperal uterine infections by Rasbech (1950) and the observation by Boyd (1925) that a mild uterine infection was capable of delaying normal involution by seven to 10 days, are pointers to the possible detrimental effects of uterine infections on fertility. However, there is no general agreement as to whether or not nonspecific uterine infections are of importance in bovine infertility. The failure in this study to isolate any bacteria during the first two days after calving tends to support the belief that the uterus is sterile at parturition only to become infected as involution proceeds (Rasbech, 1950).

In the present study, the incidence of uterine contamination for both suckled and nonsuckled cows

sampled on different days post calving was 29.2%. This falls within the range of 20 to 40% reported by Hartigan (1978) for both fertile and repeat-breeder cows. The incidence of 17.3% based on repeated in vivo sampling is also quite close to Hartigan's. However, both disagree with the reports of 0% and 100% by Clark and Stenvenson (1948) and Wulf and Dracy (1952), respectively.

The pattern of contamination observed in this study indicates a rise between day 10 and 21 postpartum followed by a decline thereafter. This rise coincided with the beginning of massive sloughing of caruncular tissue along with increased dischage of bloody lochia (Part IV) which probably created a good opportunity for bacteria to migrate from the vagina through the apparently open cervix to the uterus. Ultimately as involution approached completion due to uterine and cervical contractions, the cervix became less patent or closed resulting in a restriction of uterine invasion by bacteria. While Higaki et al., (1959) noted that the largest number of bacteria was present in the uterus at one to two weeks postpartum, Elliot et al., (1968) reported the existence of a direct correlation between the length of the postpartum period and the presence of bacteria.

Eighty-five per cent of the uteri sampled by Elliot et al., (1968) were infected by microorganisms at 0 to 15 days after calving while only 10% were infected at 60 days postpartum. Similarly in a study involving repeated sampling of 93 dairy cows the incidence of infected uterine samples was shown to decline from about 100% during the first two weeks postpartum to approximately 30% during the fifth week (Griffin et al.,(1974a,b).

The repeated in vivo sampling in this study revealed that no organism was consistently isolated from a cow throughout the sampling period. This clearly suggests a pattern of uterine contamination, clearing and reconta-mination by the same or different organisms. A similar pattern was reported by Griffin et al., (1974a,b) who observed also a change in type of bacteria isolated from indidual cows repeatedly sampled during the postpartum period. On the other hand Hartigan (1978) reported a repeated transient uterine invasion by a variety of bacteria from the posterior reproductive tract.

Histological examination of sections of uteri of cows used in this study revealed that the number of cows having leucocytic foci in the stratum compactum increased with days postpartum. Only three of the 12 cows showing

these foci yielded bacteria on culture, two on day 21 and one on day 10. None of the five day 30 cows showing the foci was positive for bacteria. While the presence of these foci is an indication of infection at one time or the other, failure to isolate bacteria in the uteri showing these foci suggested that the infection was either chronic or a low grade type or cleared.

The finding of the leucocytic foci in this study is similar to the report by Elliot et al., (1968) of the presence of organized lymphocytic nodules within infected uterine stratum compactum postpartum and in many bacteriologically negative uteri 10 to 50 days after parturition. Also Sagartz et al., (1971) reported a higher prevalence of histopathological lesions in the endometrium (90%) than the percentage yield of bacterial isolates (61.9%). Similarly Hartigan et al., (1972) found no direct correlation between endometritis and uterine infection with nonspecific bacteria. They diagnosed endometritis in 11 (41%) of 27 infected uteri and in 23 of non-infected uteri.

The presence of bacteria in some samples without corresponding leucocytic foci or any other histological evidence of infection is an indication that bacteria may be found in the uterine mucosa or fluid without

necessarily invading the endometrium.

The results of this study leads us to conclude that suckling had no influence on the rate of uterine contamination by nonspecific bacteria and the presence of bacteria did not interfere with the normal involutionary process. This finding does not support Boyd's report (1925) that a mild chronic uterine infection often delayed normal involution.

It can therefore be inferred from these findings that puerperal uterine contamination by nonspecific bacteria are not of a significant importance as far as uterine involution in the White Fulani cows is concerned and that the stress due to suckling has no influence on the level of uterine contamination by bacteria.

SUMMARY

A bacteriological investigation of the postpartum uterus of suckled and nonsuckled White Fulani cows was undertaken to determine the type of flora, the effect of suckling on the flora and the influence of the flora on uterine involution. Uterine swabs were taken from six cows (three suckled and three nonsuckled per slaughter day) at slaughter on days two, 10, 21 and 30 postpartum,

respectively for bacteria isolation and identification. Six (three suckled and three nonsuckled) of the cows slaughtered on day 30 were repeatedly sampled *in vivo* beginning from day one after calving and twice weekly until slaughter. Suckling did not affect the incidence of uterine contamination by bacteria. Uterine contamination was highest between days 10 and 21 postpartum with *Staphylococcus aureus* being the commonest organism isolated. The incidence of contamination from repeated sampling was 17.3% for all suckled and nonsuckled cows. There was no consistent isolation of one type of bacterial organism from a cow throughout the sampling period. Foci of leucocytes (mainly lymphocytes) were found in uterine sections in an increasing order with days postpartum. Bacteria were isolated from only 25% of the uteri that had the leucocytic foci. Uterine involution was normal and complete by 21 days or within 30 days of calving. It is concluded that suckling did not influence postpartum uterine contamination and puerperal uterine contamination by nonspecific bacteria did not interfere with the normal process and duration of uterine involution and thus may not be a serious factor in subsequent implantation of a conceptus.

Table 1

Bacteria isolated from cultures of uterine samples obtained from suckled and nonsuckled cows slaughtered on days 2, 10, 21 and 30 postpartum.

Group	Cow number	Days postpartum			
		2	10	21	30
Suckled	1	NG	*Pseudomonas auruginosa*	*Lactobacillus* sp	NG
	2	NG	NG	*Mima polymorpha*	NG
	3	NG	NG	NG	NG
Nonsuckled	1	NG	*Staphylococcus aureus* *Klebsiella* sp	NG	NG
	2	NG	*S. aureus* *Beta haemolytic Streptococcus*	NG	*S. aureus*
	3		NG	*S. aureus*	NG

NG = No growth

Table 2 Bacteria isolated from the uteri of suckled and nonsuckled cows repeatedly sampled *in vivo* from day 1 to day 30 postpartum

Groups	Days postpartum								
Suckled cows	1	4	7	11	15	19	23	27	30
707	NG*	NG	*Staphylococcus aureus*	NG	NG	NG	NG	NG	NG
1208	NG	NG	NG	NG	NG	NG	NG	NG	NG
376	NG	NG	*Escherichia coli*	*S. aureus*	NG	NG	NG	NG	*S. aureus*
Nonsuckled cows									
1575	*S. aureus*	NG	*Mima polymorpha*	NG	NG	NG	NG	NG	NG
988	-**	*Klebsiella sp* *E. coli*	NG	*Beta haemolytic Streptococcus*	NG	NG	NG	NG	*S. aureus*
1470	-**	NG	NG	NG	NG	NG	NG	NG	NG

*NG = No growth

** = Cows were not sampled

Table 3

Frequency of bacterial isolation for suckled and nonsuckled cows as determined by *in vivo* sampling.

Suckled			Nonsuckled		
Cows	No. of times sampled	No. of times bacteria were isolated	Cows	No. of times sampled	No. of times bacteria were isolated
707	9	1	1575	9	2
1208	9	0	988	8*	3**
376	9	3	1470	8*	0
Total	27	4	Total	25	5

*Cows were not sampled on day 1

**One sample yielded two bacterial organisms on culture.

Table 4 Number of animals showing leucocytic foci in the stratum compactum and those from which bacteria were isolated.

Groups	Days postpartum					
	2			10		
	Cow	Leucocytic foci	Bacteriological culture	Cow	Leucocytic foci	Bacteriological culture
Suckled	791	-	-	1289	-	+(Peudomonas) (auruginosa)
	792	-	-	2	-	-
	1495	-	-	1110	+	-
Non-suckled	193	-	-	1264	-	+(S. aureus Klebsiella sp)
	1483	-	-	1139	+	+(S. aureus Beta haemolytic Streptococcus)
	717	+	-	1098	-	-

\- = Negative for foci bacteria

\+ = Positive for foci or bacteria.

Table 4 Cont'd

Groups	Days postpartum					
	21			30		
	Cow No.	Leucocytic foci	Bacteriological culture	Cow No.	Leucocytic foci	Bacteriological culture
Suckled	892	-	+(*Lactobacillus* sp)	707	+	-
	2218	+	+(*Mima polymorpha*)	1208	+	-
	573	+	-	376	+	-
Nonsuckled	488	+	-	1575	+	-
	1487	-	-	988	-	+(*S.aureus*)
	1158	+	+(*S.aureus*)	1470	+	-

- = Negative for foci or bacteria

+ = Positive for foci or bacteria.

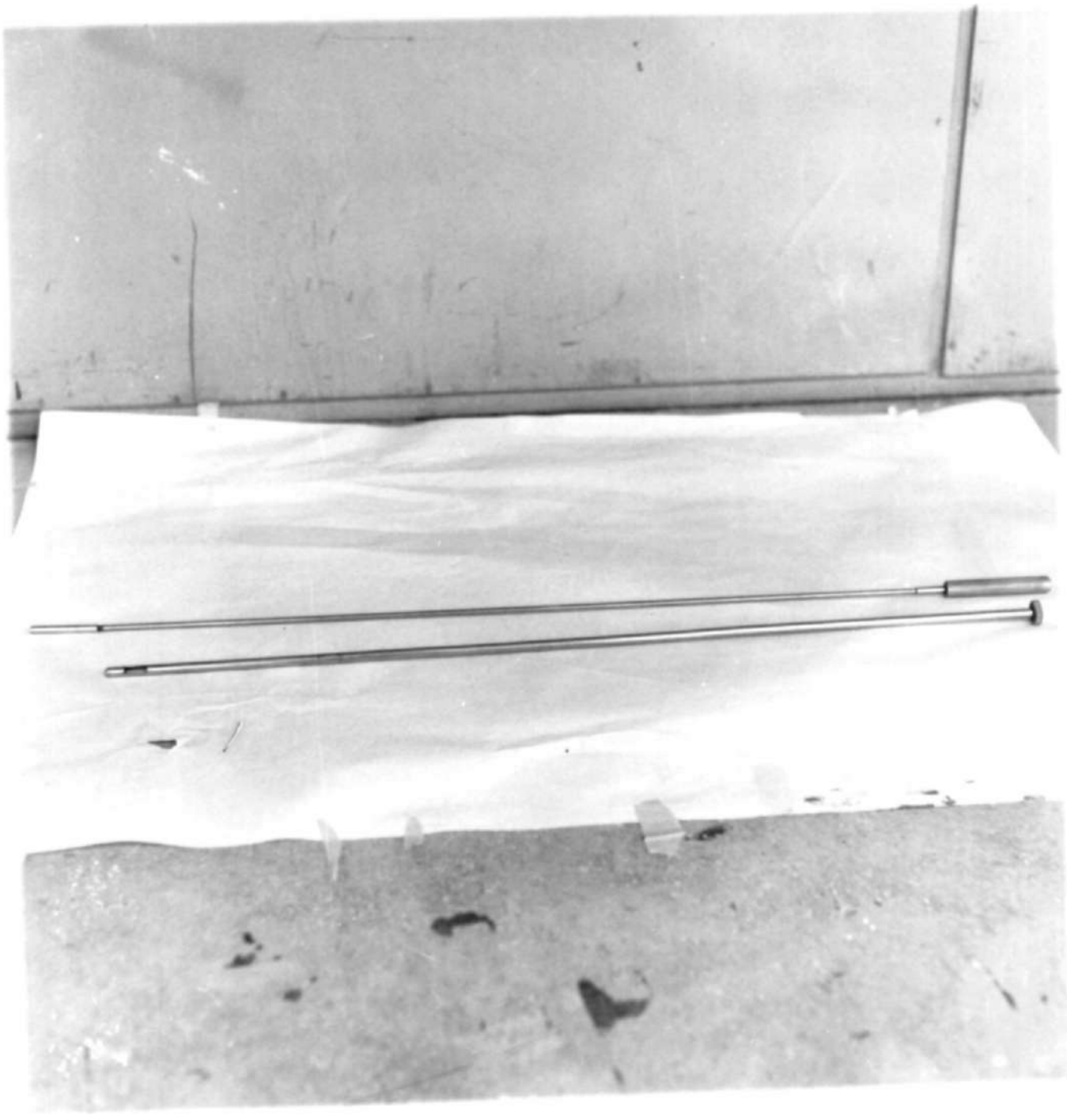
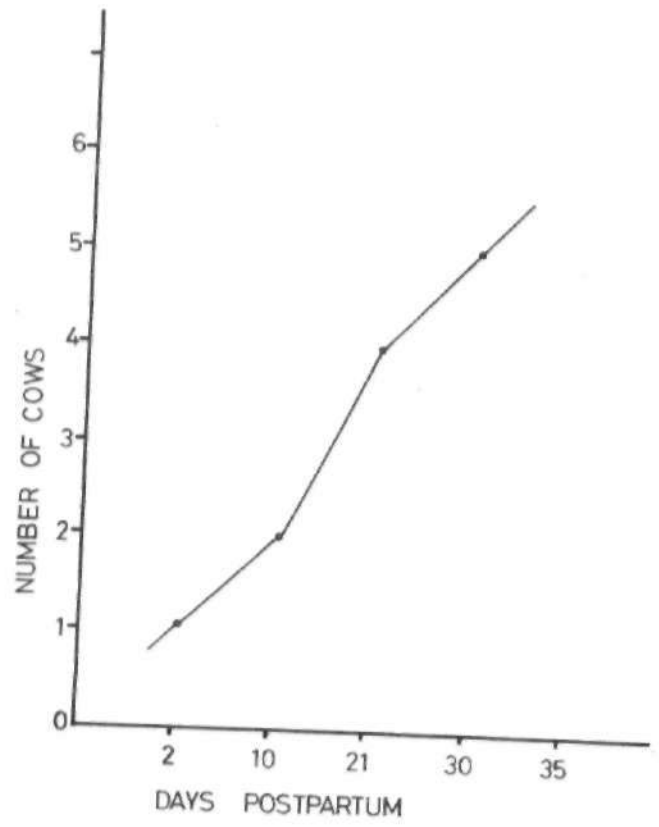


Figure 1

Photograph of the instrument used for *in vivo* collection of uterine samples for culture.

Figure 2

Prevalence of leucocytic foci with days postpartum.


NUMBER OF COWS
0
1
2
3
4
5
6
2
10
21
30
35
DAYS POSTPARTUM

PART VI

GENERAL DISCUSSION

GENERAL DISCUSSION

The work reported in this thesis was designed primarily to investigate the role of specific factors such as suckling, supplementary concentrate feeding, season of calving and parity or age of dam, in the prolonged calving interval and the subsequent low calving rate of our indigenous Zebu cattle. To achieve this objective, the effects of these factors on postpartum ovarian activity and uterine involution were determined. The overall result shows that all the factors contribute to the prolonged calving interval by either delaying follicular development or ovulation. The duration of uterine involution was not affected by any of the factors and thus may not play any role in the prolonged calving interval.

In part II of this study the average postpartum intervals to first follicle and first ovulation were found to be longer by 29 and 34 days, respectively for suckled than nonsuckled cows. Also the results of the investigation in part III showed that more follicular development occurred in the ovaries of nonsuckled than suckled cows. While a total of four out of 12 nonsuckled cows had cyclic CL none of the 12 suckled cows had a CL as late as 30 days after calving. Similar results have

been reported for the exotic breeds of cattle by a number of investigators (Wiltbank and Cook, 1958 ; Wagner and Hansel, 1969; Kesler et al., 1980).

The feeding of a supplementary concentrate ration had no statistically significant effect on postpartum ovarian activity. However, the postpartum intervals to first follicle and first ovulation were shorter for nonsuckled than suckled cows. The lack of statistical significance between the two groups was apparently because of the wide individual cow variations. The differences in the mean postpartum intervals to first follicle and first ovulation between the two groups were as high as 18 and 37 days, respectively. The delay of ovarian activity by these days will obviously contribute to an extended duration of postpartum anoestrus and subsequent calving interval, the lack of statistical significance not withstanding. The detrimental effects of a postpartum low energy intake on follicular growth, ovulation and pregnancy rate have been observed (Dunn et al., 1969; Oxenreider and Wagner, 1971).

Cows that calved during the dry season ovulated earlier than those that calved in the wet season. This finding confirmed an earlier observation (Oyedipe et al., 1982) that White Fulani cows that calved during dry season had shorter calving intervals than those that

calved during the rainy season. This shows that postpartum interval to ovulation is a good determining factor in a subseuent calving interval; the shorter the interval to ovulation the shorter the postpartum breeding time and the shorter the subsequent calving interval. As speculated earlier, the observed higher rate of ovulation postpartum in the dry than in the rainy season may be an indication of a climatic influence on ovulation and that this influence may even be higher than that of nutrition since the animals receive a better nutrition in the rainy than dry season.

Cows that had more than two calvings or pluriparous cows (cows over five years old) generally tended to resume ovarian activities after calving, earlier than those with one or two calvings. This is an indication that fertility in these animals increases with parity or age. The report of an earlier study (Oyedipe et al., 1982) supports this finding. In that study it was found that the mean calving interval for heifers with one calving was 470.5 days compared to a mean interval of 431.9 days for cows with seven calvings. Further investigation to determine the age for optimum fertility in these cows is necessary so as to know when to cull the non-productive animals. Belling (1963) observed that fertility in Hereford beef cattle reached a maximum at four years

of age remaining constant thereafter until 10 years when it declined. Also, a higher incidence of anoestrus due to ovarian inactivity in first and second calvers compared to mature cows has been reported (Fielden et al., 1973).

The effect of all the factors considered in this study, on conception rates in the White Fulani cattle needs to be investigated. The levels of the reproductive hormones especially in the postpartum period should be determined inorder to elucidate the mechanism by which these factors delay ovarian activities.

Uterine involution as determined by either clinical measurement through rectal palpation, gross measurements, or histological changes, is complete between 20 and 27 days after parturition in the White Fulani cattle. This means that the uteri of these animals are ready for implantation of fertilized eggs anytime from 30 days postpartum which falls conveniently within the 60 days post calving breeding time recommended to achieve a 365 day calving interval. None of the factors considered in this study had any effect on the duration of involution. Though the rate of puerperal uterine infection by nonspecific bacteria was fairly higher in the nonsuckled than suckled cows there was also no difference in the rate and duration of complete involution.

From the results of this study, two general conclusions can be drawn.

1. All the factors considered in this study cause a delay in return to normal fertile ovarian activities after parturition and thus contributing to a prolonged calving interval resulting in a subsequent low calving rate of the White Fulani cattle.
2. Uterine involution is obviously not a deterring factor in an early postpartum successful breeding of the indigenous cattle since these animals have completely involuted uteri within 30 days of calving.

In view of these results, it is recommended that inorder to achieve a desirable calving rate by shortening the calving interval, the animals must be weaned early, provided with good nutrition which should include concentrate supplementation during the dry season, and bred during the dry season.

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APPENDIX 1

INTERVALS FROM CALVING TO DETECTION OF FIRST FOLLICLE, TO FIRST OVULATION, FROM FIRST FOLLICLE TO FIRST OVULATION AND TO COMPLETION OF UTERINE INVOLUTION FOR INDIVIDUAL COWS USED IN PART II.

Table 1

Table 1

Intervals from calving to detection of first folicle, to first ovulation, from first follicle to first ovulation and to completion of uterine involution.

Tag No.	Interval pp* to detection of first follicle (days)	Interval pp* to first ovulation (days)	Interval from first follicle to first ovulation (days)	Interval pp* to completion of uterine involution (days)
1199	81	154	73	15
1162	37	53	16	15
1435	53	60	7	51
1466	ND**	20	ND	27
1151	ND	32	ND	ND
1196	18	28	10	23
1470	18	24	6	21
1467	33	96	63	21
887	ND	60	ND	ND
728	18	ND	ND	ND
792	ND	37	ND	21
272	ND	42	ND	25
874	ND	47	ND	33
707	ND	ND	ND	20
585	ND	ND	ND	25

*pp = Postpartum

**ND : Not determinable

Table 1 Cont'd

Tag. No.	Interval pp* to detection of first follicle (days)	Interval pp* to first ovulation (days)	Interval from first follicle to first ovulation (days)	Interval pp* to completion of uterine involution (days)
577	49	ND**	ND	25
785	ND	58	ND	30
713	94	98	4	25
576	142	175	ND	33
793	21	48	27	23
1381	5	9	4	29
1431	9	11	2	20
1184	20	24	4	30
1248	ND	17	ND	36
1289	14	23	9	25
1139	ND	11	ND	21
791	20	22	2	21
717	ND	30	ND	25
1141	45	32	13	17
892	ND	20	ND	22
749	ND	31	ND	22
592	31	33	2	30
608	24	27	3	32
1158	24	49	25	39

pp* = Postpartum

ND** = Not determinable

Table 1 Cont'd

Tag No.	Interval pp* to detection of first follicle (days)	Interval pp* to first ovulation (days)	Interval from first follicle to first ovulation (days)	Interval pp* to completion of uterine involution (days)
680	19	21	2	17
153	15	50	35	23
31	23	103	80	26
214	276	284	8	28
200	41	89	48	34
47	46	66	20	23
89	55	216	161	23
192	24	212	188	25
202	41	215	174	17
194	46	162	116	18
77	48	77	29	28
890	24	26	2	31
116	28	49	21	27
92	22	60	38	26
101	38	58	20	37
886	19	38	19	19
126	98	206	108	21
196	ND	44	ND**	21

*pp = Postpartum

**ND = Not determinable

Table 1 Cont'd

Tag No.	Interval pp* to detection of first follicle (days)	Interval pp* to first ovulation (days)	Interval from first follicle to first ovulation (days)	Interval pp* to completion of uterine involution (days)
222	ND**	34	ND	34
164	ND	30	27	37
203	ND	32	ND	29
195	ND	29	ND	24
73	ND	82	ND	18
146	NL	27	ND	19
144	ND	18	ND	24
130	ND	25	ND	23
105	ND	29	ND	29
117	ND	57	ND	42
122	ND	60	ND	34
136	ND	38	ND	26
851	ND	ND	ND	33
17	ND	ND	ND	29
118	ND	ND	ND	32
743	ND	80	ND	24
570	ND	70	ND	34
223	ND	67	ND	24
573	ND	53	ND	36

*pp = Postpartum

**ND = Not determinable

Table 1 Cont'd

Tag No.	Interval pp* to detection of first follicle (days)	Interval pp* to first ovulation (days)	Interval from first follicle to first ovulation (days)	Interval pp* to completion of uterine involution (days)
787	ND **	37	ND	36
567	ND	46	ND	23
767	ND	ND	ND	17
921	ND	ND	ND	21
174	ND	22	ND	26
23	ND	88	ND	21
138	ND	19	ND	23
1098	39	41	2	23
1323	ND	70	ND	23
1362	ND	64	ND	23
1321	17	35	18	23
612	ND	20	ND	25
376	ND	27	ND	29
627	ND	42	ND	34
1345	59	65	6	20
1314	ND	85	ND	30

*pp = Postpartum

**ND = Not determinable

Table 1 Cont'd

Tag No.	Interval pp* to detection of first follicle (days)	Interval pp* to first ovulation (days)	Interval from first folicle to first ovulation (days)	Interval pp to completion of uterine involution (days)
1319	ND**	35	ND	22
614	68	ND	ND	18
1325	ND	70	ND	27
1363	62	68	6	21
1315	ND	100	ND	22
1348	137	141	4	27
1337	27	32	5	21

*pp = Postpartum

**ND = Not determinable

APPPENDIX 2

DATA FOR INDIVIDUAL COWS USED IN PARTS III, IV AND V.

Tables 2 to 8

Table 2

Weight, age and parity of cows

Tag No.	Age (years)	Weight(kg)	No. of calvings
793	9	288	NR*
1483	5	324	2
717	9	NR	NR
791	8	NR	5
792	9	NR	NR
1495	6	366	3
1264	5	300	NR
1139	6	330	2
1098	7	320	4
1289	5	NR	NR
2	14	385	11
1110	6	400	NR
488	10	NR	NR
1487	5	NR	NR
1158	6	346	3
892	8	NR	NR
2218	6	NR	NR
573	10	NR	5
1575	5	NR	NR
988	8	460	3
1470	5	352	2

*NR = No record

Table 2 Cont'd

Tag No.	Age (years)	Weight(kg)	No. of calvings
707	9	310	NR*
1208	6	330	3
376	10	NR	NR

*NR = No record

Table 3

Ovarian weights and dimensions for suckled cows

Days postpartum	Tag No.	Ovary associated with the gravid uterine horn				Ovary associated with the nongravid uterine horn			
		L	B	H	W	L	B	H	W
2	791	4.5	0.7	3.0	8.23	4.0	0.5	2.5	4.52
	792	5.0	1.0	2.6	5.88	4.0	0.7	2.0	3.84
	1495	4.5	0.7	4.8	6.30	4.0	0.6	2.3	3.97
10	1289	2.9	1.4	1.5	4.28	2.5	1.0	1.3	2.78
	2	3.5	0.8	1.7	4.86	3.5	0.9	1.8	3.65
	1110	5.0	1.0	2.5	7.49	4.0	1.2	2.2	4.70
21	892	4.0	1.0	2.0	6.00	4.0	1.0	2.0	5.0
	2218	2.0	1.0	1.5	1.89	2.5	1.0	1.4	1.92
	573	4.5	1.5	2.2	8.48	3.5	1.5	2.0	5.78
30	707	2.5	1.0	1.7	2.41	2.7	0.8	1.5	2.50
	1208	3.0	0.6	1.8	2.81	2.8	0.8	2.0	2.54
	376	3.5	0.9	2.8	6.47	3.6	0.8	2.0	5.24

L = Length of ovary in cm
B = Breadth of ovary in cm
H = Height of ovary in cm
W = Weight of ovary in gm.

Table 4

Ovarian weights and dimensions for nonsuckled cows

Days postpartum	Tag No.	Ovary associated with the gravid uterine horn				Ovary associated with the nongravid uterine horn			
		L	B	H	W	L	B	H	W
2	793	3.5	0.7	1.9	5.30	3.4	0.6	1.8	3.53
	483	3.3	0.8	2.7	4.54	3.3	0.4	2.0	2.67
	717	4.0	1.0	2.0	5.70	3.3	0.8	2.0	5.02
10	1139	3.9	1.2	2.0	3.86	2.7	0.6	2.0	3.55
	1264	3.5	1.0	2.0	5.94	2.5	1.0	2.5	4.08
	1098	3.0	0.8	1.5	2.79	2.7	0.7	2.4	3.71
21	488	3.4	1.0	1.3	7.83	3.0	0.7	1.5	2.56
	1487	4.0	1.0	2.0	4.63	3.5	1.0	2.0	3.48
	1158	4.5	1.5	1.5	6.74	2.8	0.5	1.5	2.02
30	1575	3.6	0.9	2.0	3.74	3.0	1.0	2.7	3.76
	988	3.8	0.8	2.9	6.79	3.5	0.7	2.6	6.86
	1470	5.0	1.2	2.5	9.82	4.0	1.0	3.1	9.72

L = Length of ovary in cm
B = Breadth of ovary in cm
H = Height of ovary in cm
W = Weight of ovary in gm.

Table 5

Follicular activity, diameters and weights of CL* of pregnancy and CL development for suckled cows

Days Post-partum	Tag No.	No. of follicles		Diameter of largest follicle (cm)		Volume of fluid in largest follicle (ml)		Volume of fluid in all follicle. (ml.)		Weigh: of fluid (g) from all follicles	
		G*	NG***	G	NG	G	NG	G	NG	G	NG
2	791	1	-	1.0	-	0.1	-	0.1	-	0.5	-
	792	1	-	0.5	-	0.1	-	0.1	-	0.11	-
	1495	-	-	-	-	-	-	-	-		
10	1289	1	2	1.0	0.9	0.25	0.20	0.25	0.20	0.26	0.22
	2	-	-	-	-	-	-	-	-	-	-
	1110	-	-	-	-	-	-	-	-	-	-
21	892	-	-	-	-	-	-	-	-	-	-
	2218	-	2	-	0.7	-	0.37	-	0.39	-	0.39
	573	1	1	0.6	0.6	0.17	0.10	0.17	0.10	0.38	0.31
30	707	1	1	0.9	0.5	0.3	0.1	0.3	0.1	0.44	0.02
	1208	-	-	-	-	-	-	-	-	-	-
	376	-	-	-	-	-	-	-	-	-	-

*CL = Corpus luteum

**G = Ovary associated with gravid uterine horn.

**NG = Ovary associated with nongravid uterine horn.

Table 5 Cont'd

Days postpartum	Tag No.	Diameter of CL* of pregnancy (cm)	Weight of CL of pregnancy (gm)	No. of newly formed CL	
				G**	NG***
2	791	0.5	1.71	-	-
	792	0.4	1.26	-	-
	1495	1.1	2.32	-	-
10	1289	1.0	0.79	-	-
	2	0.6	0.66	-	-
	1110	-	-	-	-
21	892	0.4	0.42	-	-
	2218	-	-	-	-
	573	-	-	-	-
30	707	-	-	-	-
	1208	0.4	0.44	-	-
	376	0.6	0.45	-	-

*CL = Corpus luteum
**G = Ovary associated with gravid uterine horn
***NG = Ovary associated with nongravid uterine horn

Table 6

Follicular activity, diameters and weights of C[illegible] of pregnancy and CL development for nonsuckled cows

Days post-partum	Tag No.	No. of follicles		Diameter of largest follicle (cm)		Volume of fluid from largest follicle (ml)		Volume of fluid from all follicles (ml)		Weight of fluid from all follicles (g)	
		G*	NG**	G	NG	G	NG	G	NG	G	NG
2	793	-	-	-	-	-	-	-	-	-	-
	1483	-	-	-	-	-	-	-	-	-	-
	717	2	5-6	0.7	0.9	0.2	0.15	0.82	0.85	0.55	1.05
10	1139	-	1	-	0.8	-	-	-	-	-	-
	1264	2	-	1.5	-	0.55	-	0.58	-	0.89	-
	1098	-	1	-	0.9	-	0.75	-	0.75	-	1.07
21	488	1	-	0.24	-	0.9	-	0.9	-	1.1	-
	1487	1	-	0.7	-	0.12	-	0.12	-	0.31	-
	1158	1	-	2.5	-	1.05	-	1.05	-	1.54	-
30	1575	1	1	0.6	0.4	0.1	0.15	0.1	0.15	0.18	0.22
	988	1	1	0.7	0.6	0.25	0.3	0.25	0.3	0.38	0.44
	1470	-	1	[illegible]	1.0	[illegible]	0.33	-	0.33	-	0.56

*G = Ovary associated with gravid uterine horn;

**NG = Ovary associated with nongravid uterine horn

Table 6 Cont'd

Days postpartum	Tag No.	Diameter of CL of pregnancy (cm)	Weight of CL of pregnancy (gm)	No of newly formed CL	
				G	NG
2	793	0.5	1.83	-	-
	1483	1.2	1.22	-	-
	717	1.6	1.80	-	-
10	1139*	-	-	-	-
	1264	0.8	0.6	-	-
	1098	0.8	0.46	-	-
21	488	2.2	2.1	1	-
	1487*	-	-	1	-
	1158	0.5	0.84	-	-
30	1575*	-	-	-	-
	988	1.0	0.45	-	1
	1470	0.4	1.24		1

*CL of pregnancy for these cows were accidentally destroyed.

Table 7

Uterine dimensions and weights for suckled cows

Days post-partum	Tag No.	Length from internal bifurcation (cm)		Length from external bifurcation (cm)		Length of Oviducts (cm)	
		Gravid horn	Nongravid horn	Gravid horn	Nongravid horn	Gravid horn	Nongravid horn
2	791	68.0	47.0	61.0	35.5	22.5	22.5
	792	63.5	36.5	38.0	23.5	29.0	25.9
	1495	42.0	40.0	40.0	26.0	20.0	21.5
10	1289	50.0	31.0	29.0	21.0	18.2	16.5
	2	47.0	28.0	30.0	22.0	25.0	17.0
	1110	59.0	38.0	21.5	20.0	23.5	25.5
21	892	31.0	32.0	16.5	17.5	38.0	24.0
	2218	21.0	20.0	10.5	11.0	24.0	20.5
	573	27.0	27.0	19.0	19.0	21.5	21.5
30	707	22.5	19.5	13.4	10.5	21.0	21.9
	1208	24.0	23.5	13.5	13.0	20.0	18.5
	376	29.5	23.0	13.0	10.0	25.0	25.0

Table 7 Cont'd

Days Post-partum	Tag No.	Length of uterine body (cm)	Length of cervix (cm)	Wall thickness of gravid horn (cm)	Wall thickness of nongravid horn (cm)	Diameter of gravid horn (cm)	Diameter of nongravid horn (cm
2	791	9.5	16.0	1.5	0.8	19.0	10.0
	792	4.5	11.0	1.0	0.5	13.0	7.0
	1495	10.0	14.0	1.2	0.8	17.0	10.0
10	1289	6.5	13.0	0.9	0.7	12.0	10.0
	2	7.0	12.0	1.0	0.7	14.5	7.5
	1110	5.5	13.0	0.9	0.6	10.0	8.0
21	892	4.5	7.0	0.7	0.6	5.0	4.0
	2218	5.0	5.0	0.5	0.5	4.5	3.5
	573	3.5	8.5	0.9	0.8	5.0	4.0
30	707	1.9	9.5	0.5	0.5	3.0	2.7
	1208	3.0	9.0	0.8	0.6	3.5	3.5
	376	3.0	8.0	0.8	0.5	4.0	3.0

Table 7 Cont'd

Days Postpartum	Tag No.	Diameter of body (cm)	Diameter of cervix (cm)	Diameter of caruncle near bifurcation (cm)		Weight of gravid horn (g)	Weight of Nongravid horn (g)
				Gravid horn	Non-gravid horn		
2	791	18.0	14.0	3.4	2.5	2302.12	832.44
	792	16.5	11.5	3.0	2.0	1571.22	554.73
	1495	15.0	13.0	3.0	3.6	2220.16	1253.01
10	1289	13.0	8.0	1.5	0.6	1088.0	410.0
	2	12.0	10.5	2.0	0.8	971.3	268.6
	1110	13.5	8.5	2.0	0.9	708.8	328.0
21	892	7.0	8.0	0.7	0.4	205.0	140.0
	2218	5.5	6.5	1.0	0.4	125.0	85.0
	573	6.5	7.0	0.9	0.8	145.0	115.0
30	707	4.5	6.7	0.8	0.7	82.25	83.63
	1208	5.0	6.0	0.6	0.7	107.31	103.77
	376	6.0	7.0	0.8	0.9	131.98	94.25

Table 7 Cont'd

Days Postpartum	Tag No.	Weight of oviduct of gravid horn (g)	Weight of oviduct of nongravid horn (g)	Weight of body (g)	Weight of cervix (g)
2	791	0.57	0.65	365.79	825.21
	792	1.19	1.08	222.41	517.73
	1495	0.41	0.77	308.65	938.24
10	1289	0.50	0.40	195.0	330.0
	2	0.60	0.50	253.2	535.2
	1110	0.80	0.80	131.5	436.9
21	892	1.60	1.20	75.0	505.0
	2218	0.70	0.60	50.0	100.0
	573	0.60	0.60	55.0	245.0
30	707	0.54	0.41	19.54	172.36
	1208	0.26	0.33	25.44	165.36
	376	0.65	0.69	37.26	164.50

Table 8

Uterine dimensions and weights for nonsuckled cows

Days Post-partum	Tag No.	Length from internal bifurcation (cm)		Length from external bifurcation (cm)		Length of oviducts (cm)	
		Gravid horn	Nongravid horn	Gravid horn	Nongravid horn	Gravid horn	Nongravid horn
2	793	44.5	31.5	21.0	19.5	29.5	27.5
	1483	78.0	55.0	47.5	24.0	25.0	24.0
	717	80.0	52.0	54.5	25.5	26.0	25.5
10	1264	49.0	41.5	35.0	28.0	16.5	17.2
	1139	42.0	33.0	27.0	23.0	22.0	22.0
	1098	45.0	34.0	32.0	17.5	28.5	25.0
21	488	31.0	27.0	27.0	21.0	25.5	25.0
	1487	29.5	26.0	17.0	13.0	22.0	23.0
	1158	31.5	28.0	25.0	17.0	26.0	23.5
30	1575	23.0	19.0	12.0	11.0	21.5	19.0
	988	36.0	39.5	22.0	23.0	26.5	25.5
	1470	30.5	22.0	14.5	11.0	18.5	22.5

Table 8 Cont'd

Days Post-partum	Tag No.	Length of uterine body (cm)	Length of cervix (cm)	Wall thickness of gravid horn (cm)	Wall thickness of nongravid horn (cm)	Diameter of gravid horn (cm)	Diameter of nongravid horn (cm)
2	793	4.5	13.0	1.0	0.8	19.5	8.5
	1483	5.0	14.0	1.0	0.7	13.0	7.5
	717	3.5	14.0	1.2	1.0	15.5	8.5
10	1264	5.0	11.5	1.2	0.8	8.0	6.0
	1139	3.5	13.0	1.0	0.8	10.0	6.0
	1098	7.0	14.0	1.0	0.8	9.0	6.0
21	488	4.0	9.0	0.5	0.4	6.0	3.5
	1487	4.0	9.5	0.7	0.5	5.0	4.0
	1158	3.5	7.0	1.0	0.7	6.0	4.5
30	1575	2.0	11.0	0.4	0.4	4.0	3.0
	988	2.5	10.5	0.8	0.5	5.6	5.0
	1470	2.0	19.0	1.0	0.5	4.0	3.5

Table 8 Cont'd

Days Post-partum	Tag No.	Diameter of body (cm)	Diameter of cervix (cm)	Diameter of caruncle near bifurcation (cm)		Weight of gravid horn (g)	Weight of nongravid horn (g)
				Gravid horn	Non-gravid horn		
2	793	16.0	11.0	5.0	3.5	1982.0	610.9
	1483	14.0	9.5	3.4	3.0	1933.84	777.91
	717	16.5	13.5	3.5	2.0	1750.33	667.85
10	1264	11.0	8.0	2.5	1.5	510.9	441.8
	1139	10.0	9.0	0.8	0.6	506.9	291.2
	1098	10.5	10.0	0.8	0.9	449.7	244.3
21	488	6.0	7.0	2.5	0.6	207.0	139.0
	1487	6.5	7.4	0.7	0.9	179.5	142.2
	1158	6.0	7.0	0.9	0.6	219.1	154.7
30	1575	5.0	7.0	0.6	0.6	104.3	88.7
	988	7.0	10.0	0.4	0.3	240.0	203.7
	1470	5.0	7.0	0.7	0.5	155.5	112.4

Table 8 Cont'd

Days Postpartum	Tag No.	Weight of oviduct of gravid horn (g)	Weight of oviduct of nongravid horn (g)	Weight of uterine body (g)	Weight of cervix (g)
2	793	0.94	0.78	469.54	733.40
	1483	0.88	0.83	63.21	588.03
	717	0.79	0.95	273.07	574.27
10	1264	0.90	1.10	62.40	380.10
	1139	1.00	0.80	72.50	468.60
	1098	0.80	0.60	141.70	526.50
21	488	0.70	0.60	72.00	237.00
	1487	0.70	0.60	39.10	227.90
	1158	1.20	1.10	29.70	169.00
30	1575	0.43	0.47	19.70	269.00
	988	0.60	0.57	22.30	311.40
	1470	0.67	0.69	26.40	290.00

APPENDIX 3

COMPOSITION OF BOIUN'S SOLUTION

Boiun's solution

1.	Picric acid, saturated aqeous solution	750ml
2.	37 - 40% formalin	250ml
3.	Glacial acetic acid	50ml