Behaviour of Single-suckled Angus Cattle from Calving to Weaning

A thesis presented in partial fulfilment of
the requirements for the degree of
Master of Agricultural Science
in Animal Science at
Massey University

Victoria Robin Aitken

1978

ABSTRACT

The main objective of this study was the investigation of behaviours which might influence the number and/or weight of calf weaned from single-suckled Angus cows. The behaviour patterns involved were those relevant to parturition, the cow-calf bond and nursing. The effect of such factors as maternal experience, sex, and age of calf and the presence of non-lactating cows were also investigated. In addition, the liveweight of the calves was taken at birth and thereafter at regular intervals throughout the course of the study.

Observations began on average 31 d (range 4 to 65 d) pre-partum and continued until 3 weeks post-weaning, *c.* 33 weeks after the start of the investigation and involved >900 h of field observations.

Eighteen pregnancy-tested Angus cows were involved of which 14 calved. Of these, 5 primiparous and 6 multiparous reared their own calf. Two calves, 1 born from a primigravid and the other born from a multigravid cow, appeared to die as the result of abnormal maternal behaviour. These maternal behaviours resulted in either physical injury to the neonate and/or refusal by the cow to allow the calf to nurse. The latter behaviour was followed by hypothermia in the calf, although adverse weather conditions probably accentuated this heat loss. Two primigravid cows rejected their calves and had to be isolated for up to 5 d and restrained before the cow would accept the calf's presence and nursing activities.

A method of predicting the order and time of calving for each cow was devised. Determination of the calving order was possible in 12 of the 14 cows prior to the birth of the first calf.

The use of 24 physical signs allowed prediction of calving time to within 48 h in all 14 cows. Changes in such behaviours as posture and social activity were associated with calving within the following 3 to 4 h in all except 1 cow. This animal was found to exhibit dystocia, i.e., an extended parturition of >19 h.

On average the physical signs were observed before the behaviours and more cows were recorded for the presence of physical signs than for behavioural signs. However, there was wide variation in the number of signs recorded and the time they were first observed for each of the cows. No single sign could be effectively used for prediction of either calving order or the time of calving, i.e., delivery of the calf.

There was a highly significant difference between the primigravid and multigravid cows in their calving time. The heifers showed a decided tendency to calve during daylight whilst equal numbers of the older cows calved during daylight as during darkness.

The area chosen for calving did not appear to be random. A very highly significant number of cows calved in the same area which provided the parturient cow with visual isolation up to 20 m. The importance of such isolation and subsequent localization to a specific area on the early occurrence of nursing and primary socialization was demonstrated.

Determination of onset and termination of first-stage labour on the basis of either physical or behavioural criteria was only an approximation. Overall, it was more difficult to determine the duration of the various stages of parturition using behaviours than when using physical signs, although there was a tendency for the different behavioural parameters to occur more frequently and/or at greater intensity at specific times during the process.

The effect of experience on maternal behaviour was demonstrated on a number of occasions. For example, with one exception all the primiparous cows showed a significantly shorter duration of maternal grooming of the neonate than did the multiparous cows.

With the exception of 1 multiparous cow, abnormal maternal behaviour was observed only from the primipara. Five of these 6 cows showed some form of agonism on first seeing the neonate. In all except 1 cow this ended several minutes after the cow had investigated the calf.

Other abnormal behaviours such as orientation toward the calf during its teat-seeking activities were recorded only amongst the first calvers and on all occasions resulted in a longer time taken prior to location of the teat by the calf.

On termination of the dam-offspring association at weaning the response from cows and calves was apparent in changes in their behaviour. During the following 7 d the calves showed a very high level of unity in their activities and spatial distribution. As well the form of social interaction changed and became predominantly agonistic. This resulted in rapid establishment of a social rank which appeared to decrease further agonism and instead increased such epimeletic behaviour as grooming.

Despite these changes in behaviour the liveweight of the calves did not significantly change from 11 d pre-weaning until termination of the study 21 d later.

The cows reacted to weaning by increased aggregation, vocalization and walking for up to 9 d post-weaning. These changes were reflected in an apparent decrease in grazing and rumination duration. Fence damage and localized areas of severe pugging was also recorded.

Nursing was investigated for the form and degree of occurrence of both maternal and filial behaviours, including cross- and non-nutritional nursing, as well as the pattern of sucking, i.e., sucking frequency, duration and time spent nursing, and the diurnal and circadian rhythms.

ACKNOWLEDGEMENTS

I wish to acknowledge my appreciation for the encouragement and advice offered to me by my supervisors Mr R.A. Barton, Sheep Husbandry Department and Dr R.J. Holmes, Veterinary Clinical Sciences Department, throughout the course.

The assistance of Mr D.R. Patterson in the collection and recording of liveweight data is also gratefully acknowledged.

I am indebted to Mr P.H. Whitehead, Sheep Farm Supervisor, for his management of the cattle. Mr M.G. Divehall and Mr M.A. Ford were involved in the stock handling and their help is also appreciated.

Gratitude is extended to Mr J.R. Clouston, Central Photographic Unit, and to Mr T.G. Law, Veterinary Faculty Photographer, for their technical advice. I am also grateful for the darkroom facilities made available to me by the Botany and Zoology Department.

Sincere thanks are extended to Mrs L.E. Battye for her French translations and to Mr J.C. Chandler for his German translations.

The financial assistance of the Murray Scholarship and the Helen E. Akers Scholarship is gratefully acknowledged.

The Combined Beef Breeders' Research Committee financially supported some aspects of the study and I express my gratitude for this assistance.

Appreciation is extended to Mrs A.F. Barton for her patient and efficient typing of the thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

INTRODUCTION

There are two main monetary returns from commercial single-suckled beef cattle in New Zealand. These are the weight of calf weaned per 100 cows maintained and, to a lesser extent, the value of the breeding cow when sold at the end of her productive life (Anon., 1972a). A large number of factors have been found to influence the number and weight of calves weaned (cf reviews by Pleasants, 1974; Preston and Willis, 1974). Among these factors mothering ability, largely measured as milk production, has long been recognized as a major contributor (Barton, 1970).

There is another component of mothering ability which has received comparatively little emphasis and that is maternal behaviour. In a recent review on the behavioural problems of farm animals it was stated that: "Maternal behaviour, its triggers and controls is one of the aspects we know least about" (Kiley-Worthington, 1977). Much of the work has involved laboratory animals and primates (review Rheingold, 1963; Rutter, 1972) or field studies of undomesticated ungulates (Lent, 1974).

Studies on the domestic species have concentrated on sheep, goats, pigs and to a lesser extent poultry (reviews by Fraser, 1968; Denenberg and Banks, 1969). A very recent review on the ethology of free-ranging domestic animals noted that much of the available information on maternal behaviour was restricted to sheep (Arnold and Dudzinski, 1978). The need for separate investigations for each of the domestic species was illustrated by the findings of Poindron and Le Neindre (1975) who compared mother-young relationships of sheep and cattle. The two species were found to differ in many behaviours, e.g. nursing and filial identification by the dam. This lack of similarity indicates that extrapolation from one species to another is often not valid.

Filial behaviour is another area in which there is limited information available. Several studies have shown that the behaviour of the young animal influenced subsequent productivity. For example, Cartwright and Carpenter (1961) and Melton *et al.* (1967) demonstrated that the calf's nursing behaviour had a direct effect on milk yield of its dam.

Of the comparatively few studies involving domestic cattle many concentrated on a single aspect of behaviour, for example; parturition (Arthur, 1961; Ewbank, 1963); primary socialization (Hudson and Mullord, 1977); nursing (Hafez and Lineweaver, 1968) and weaning (Nicol, 1977).

Few studies have made long-term investigations on the social interactions of the cow and calf from birth until weaning. Of these most were undertaken under environmental and management conditions dissimilar to those in New Zealand, e.g., American studies (Wagnon, 1963); Australian studies (Rankine and Donaldson, 1968); African studies (Hutchison *et al.*, 1962) and French studies (Le Neindre and Garel, 1977). The environment (physical and social) is a major variable affecting behaviour and as New Zealand is unique extrapolation of results from other countries may not be appropriate.

Many of the studies involved dairy breeds either maintained in total confinement, e.g., Selman *et al.* (1970a and b) or under very intensive stocking, e.g., Donaldson (1970).

To the present only two studies on the behaviour of single-suckled beef cattle farmed in New Zealand are available (Walker, 1962; Nicol and Sharafeldin, 1975). Both provided useful information, with major emphasis on nursing and grazing behaviour. However, owing to the limitations inherent in behavioural field studies, only a small number of animals and few sample periods were involved.

The major aim of the present study was to investigate certain behaviour patterns which might influence the number and weight of calves weaned. Behaviour patterns relevant to parturition, primary socialization and nursing were described and where possible related to calf survival and growth. The effect of maternal experience, i.e., primigravid *versus* multigravid was also investigated. Another area studied was the effect of weaning on subsequent calf behaviour and weight changes.

A method of predicting the time of calving was devised and studied. There is an obvious advantage in being able to predict when cows will calve as this allows advance planning of the grazing management so that a better balance between animal feed requirements and availability of feed can be achieved.

CHAPTER TWO

EXPERIMENTAL DESIGN

1. The Herd

1.1 Composition

The herd consisted of 18 Angus cows, all diagnosed pregnant, from the University's No.3 sheep farm "Tuapaka". In order to study the effects of experience on maternal behaviour, the cows were selected on the basis of previous maternal experience. Half of the herd was multiparous, the remainder had not previously calved. The age difference between the two groups was made as large as possible. The multiparous cows were between 9 and 11 years of age and had all had at least 5 calves. The primigravida consisted of 4 two-year-olds and 5 three-year-olds. Herd composition and maternal performance including the 1977 season, has been summarized in Appendix I.

During the study 14 cows calved, of which 11 reared their own calf. One multiparous cow reared a fostered Friesian bull calf. The 4 dry cows and the 2 whose calves had died were kept with the lactating cows in order to monitor the effects of their presence in a predominantly single-suckled herd.

1.2 Management

The cattle were set-stocked on the observation paddock (Plate 2.1) from the start of the trial (16 July, 1977) until shortly before weaning (2 February, 1978). It was decided to set-stock the animals in order to maintain a relatively constant environment, changes in which might influence behaviour and thereby introduce further random error into the data. This necessitated feeding up to 6 bales of hay per day during calving and the introduction of sheep from late October onwards to utilize excess grass.

Weaning took place on 13 February, 1978 and followed the standard practice used in many commercial herds. The cows and calves were drafted in No.1 sheep farm yards and the cows immediately removed to a paddock *c*. 0.8 km away. This eliminated visual, olfactory and to some extent auditory contact between the calves and their dams. The cattle were thereafter observed daily. Live weight measurements of the calves were obtained daily for the following 11 days and then every second or third day until it was evident that neither behaviour nor weight changes were still being affected by weaning. This occurred on 6 March, 1978 at which time the study was terminated.

2. The Study Area

2.1 Subdivision

The 2 ha paddock was situated on Old West Road, 4 km from the University campus. This location ensured little disturbance for the cattle from either human or stock movements (Plate 2.1).

In order to describe a cow's location within the paddock the area was visually divided into 10 sections of about the same size (Fig. 2.1). The paddock was relatively flat and all, except for 3 small areas, could be seen from any position. Two of these "blind-spots" in T3 and along the northern border of T7 and T4 were fenced off. The third area was a stream bed which divided the paddock. It was not possible to fence this so the observation tower and the caravan (Plate 2.2) were positioned on the northern side of the stream bed in T4 and T1 respectively, so that cattle in the stream bed could be observed.

2.2 Environmental features

The paddock was very exposed to winds, especially easterlies, and there was no shelter available. Drainage was inadequate and the entire paddock became very pugged and waterlogged during the first 3 months of the study. The cattle were moved into the area between gates No.1 and No.3 for several days on 3 occasions so that they were on drier ground.

Reticulated water came mainly from trough No.2 although there was some water available from trough No.1 during the first month of the study.

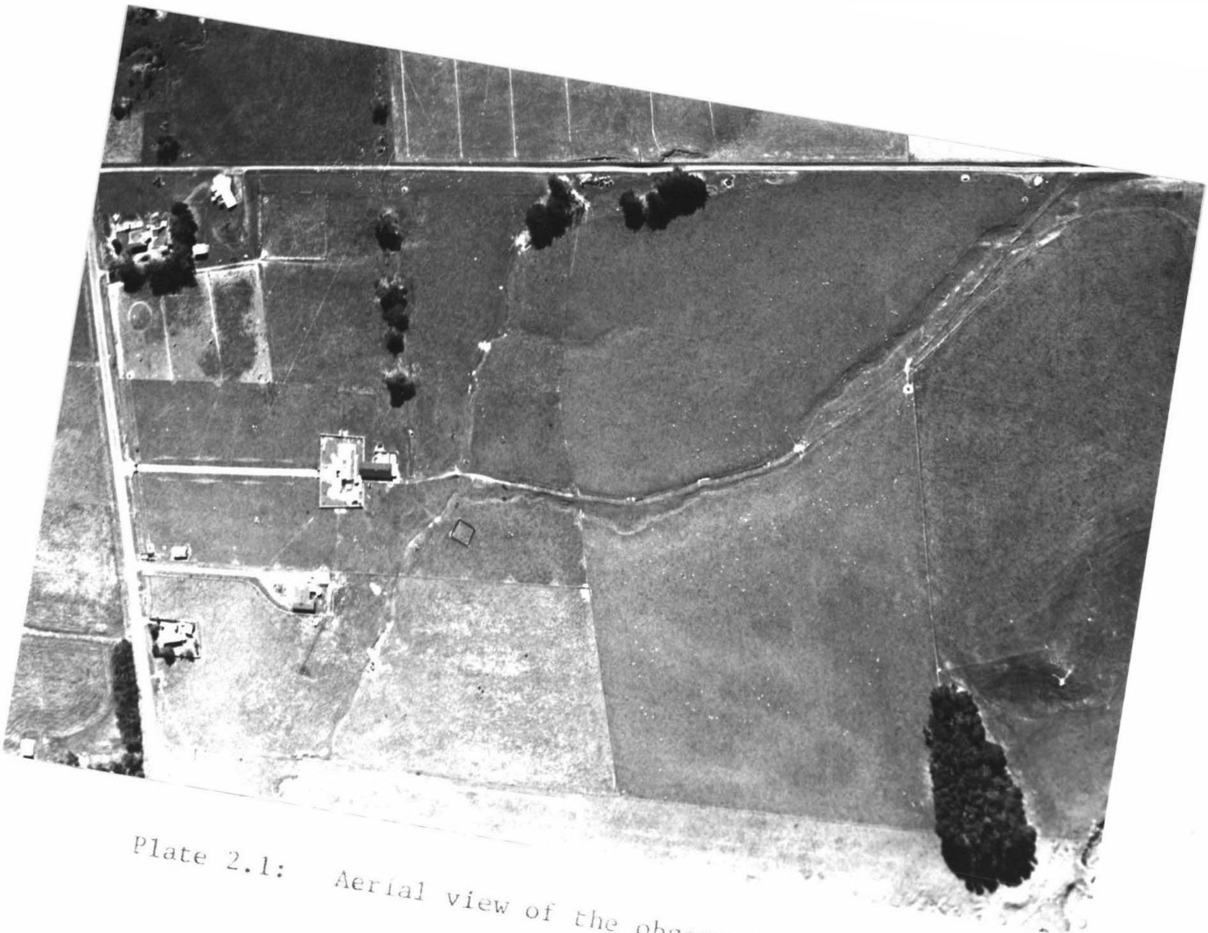


Plate 2.1: Aerial view of the observation paddock

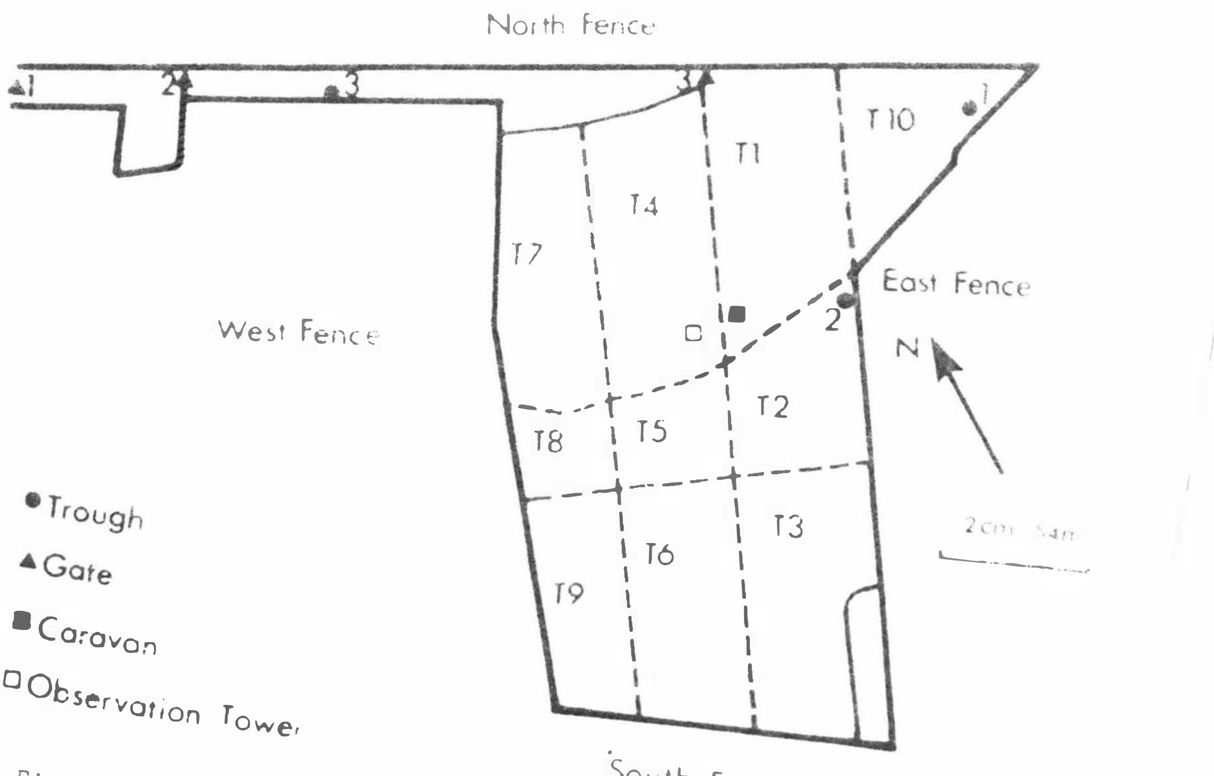


Fig. 2.1: The observation paddock

3. Research Procedures

The experimental design and data analysis followed the principles outlined by Dunbar (1975) although reference was also made to Marler and Hamilton (1968) and Denenberg and Banks (1969).

Dunbar (1975) presented 5 points which were considered prerequisites to any behavioural research project. His points can be summarized as under:

(i) The problem to be investigated has to be defined;

(ii) The kinds of behavioural parameters most appropriate to answering that particular question must be chosen;

(iii) A sampling strategy which will provide an unbiased estimate of these parameters must be chosen;

(iv) A method which is both suitable for recording the data and practicable in the field must be selected.

(v) The most appropriate statistical test(s) for analyzing the data in the form obtained must be chosen.

Decisions made on each of these points posed problems and difficulties. Furthermore, the decision reached at any one of these points placed constraints on the options for other considerations. The choices made for each of these 5 points in the present study were as follows:

3.1 Aim

The aim of the study was to describe certain behaviour patterns observed in single-suckled Angus cattle from pre-partum through to termination of the cow-calf association, that is, weaning, and for a limited time thereafter. In association with this, was the objective of examining the functions of these behaviours, some of the factors found to influence their occurrence and the importance of these behaviours in calf survival and growth.

The behavioural parameters were those relevant to parturition, primary socialization, nursing and weaning. Live weight measurements of the calves were also taken at about monthly intervals pre-weaning and thereafter at regular times.

3.2 Sampling methods

Sampling methods depended on the behaviour being investigated and the type of information required from the particular behaviour. Altmann (1974) regarded behaviour in 2 classes; events and states. Events are instantaneous and are recorded either at the moment of onset of the behaviour, or at some other single defined instant. States have appreciable duration and are recorded while the behaviour is occurring. The choice between these 2 classifications depends on the type of information required. If frequency data are necessary then the behaviour must be regarded as an event. Conversely, if duration information or the time spent in an activity is required then the behaviour must be investigated as a state. In order to determine frequency, sequence of behaviours, duration and time spent in a particular activity it is necessary to record transition times, that is, onset and terminations between exclusive classes of state. For percentage or time involved in a behaviour it is only necessary to sum duration of the state of interest.

3.2.1 *Ad libitum* sampling

Altmann (1974) described 2 methods of collecting behavioural data; *ad-libitum* (or "ad lib") and focal-animal sampling. The former produces records which usually involve the observer recording "as much as he can". In order to do quantitative analysis on such data a number of considerations must be recognized:

(i) The frequency of any 2 classes of behaviour can be compared. That is, the chance that a behaviour will be recorded does not depend upon the class of behaviour being investigated.

(ii) Comparisons can be made across age-sex classes. That is, the likelihood that a behaviour would be observed and recorded does not depend on the sex or age group of the individual concerned.

(iii) Some forms of behaviour may affect the observability of the individual participating in them. For example, parturition often results in the parturient animal secluding itself in an isolated, inaccessible area.

(iv) Whenever more behaviours occur than can be recorded sampling decisions must be made and if the sampling is not systematic the observer's preference becomes involved.

3.2.2 Focal-animal sampling

The alternative method of focal-animal sampling involves the recording of all occurrences of specified behaviours and interactions of the individual or group of individuals during a sample period of known duration.

Of the 2 methods focal-animal sampling is recommended by Altmann (1974) as it offers less bias. However, it was not always possible to use this method because only one observer was available. For example, the 132 possible outcomes from agonistic encounters between the 12 calves necessitated the use of "ad-lib" sampling despite its limitations. These are most evident in the restrictions imposed on analysis. For example, each cell frequency reflects the effect of the animal's choice among partners and the effects, not necessarily conscious, by the observer to boost the frequencies of certain cells. As a consequence it is not possible to directly compare cells or ask such questions as: "Does calf A interact more frequently than calf B or if A interacts is it more likely to do so with B rather than with calf C?" Use of the data collected in the determination of social rank orders based on dominance-submissive relationships has been presented in a socio-metric matrix (Appendix II); a compact method of tabulating data in a contingency table.

Nursing, parturition and primary socialization were studied by the technique described by Altmann(1974) as sequence sampling. This involved recording all the relevant behaviour patterns in the order in which they occurred. The sample period, that is, the interval during which data was collected, began when the sequence commenced and continued until it ended. The main difficulties in this method were the identification of onset and termination of the behaviour(s) and the selection of the behaviour patterns relevant to the activity.

3.2.3 Scan-sampling

Sampling during 24 h periods was described by Altmann(1964) as "scan-sampling" in which the observer recorded all the individual's activity at pre-selected times. This can be used to obtain information from a large number of individuals by observing each in turn. Depending on the sampling interval, the data provide an estimate of behavioural synchrony and the amount or percentage of time individuals devote to various activities. The main limitation is that it cannot be used to determine rates of occurrence or relative frequencies of different behaviours because states, not events, are being recorded.

Continuous monitoring over the 24 h period was not possible due to observer fatigue. Instead sampling occurred at selected times which were chosen on the basis of published studies which have investigated similar behaviours. Hull *et al.* (1960) found a non-significant difference in the data obtained for grazing, idling and ruminating activities when a 60-minute sampling interval was used as opposed to continuous recording. Thus sampling for these behaviours was made every 60 minutes during the 24 h period. However, the use of such large intervals may not be justified when investigating behaviours such as nursing which are characterized by a relatively low frequency and short duration of occurrence. Therefore an interval of 15 minutes was used as it is evident from the literature that this is about the length of an average nursing bout. In order to minimize observer fatigue from these more frequent intervals their use was restricted to the following hours: 1930 to 2000; 2200 to 0100 and 0300 to 0600 as these were found by Hutchison *et al.* (1962) and Walker (1962) to be the times when nursing was most frequent.

3.2.4 Live-weight measurements

Live-weight estimates were always obtained between 0800 and 0900 h on each occasion. This set time was chosen in an attempt to minimize errors due to fluctuations in gut fill. Yates and Larkin (1964) found that this effect could be expressed in a mathematical representation which showed minimum error at 0800 h each day.

3.3 Observations

The 33-week observation period made it impossible for the observer to intensively observe the cattle at all times. Therefore, major emphasis was placed on the 10-week period around calving with an average of 7 h of observations per day. During the 20 weeks of nursing a greater proportion of the observations was spent on the first 12 weeks and the last 4 weeks. This made it easier to monitor changes in the cow-calf association.

During the pre-weaning period daytime observations began between 0630 and 0800 h and continued until night-fall *c*. 1700 to 1900 h. These times were not always rigidly maintained, as they depended on the circumstances. Night-time observations were also undertaken except during the calving season. This was because of the difficulties associated with observing dark coated cattle without prolonged use of artificial light, which was found to disturb the animals. Once calving was completed night-time observations were restricted to the occurrence of a full moon. These sessions formed part of a 24 h observation period used to determine circadian rhythms in grazing, ruminating, idling and nursing.

3.4 Data collection

The behaviours investigated were recorded in note books as they were observed. Provision was also made for recording factors such as weather or the activities of herdmates which might affect the behaviour being monitored.

Extensive use was made of the following photographic equipment; 35 mm single lens reflex cameras (Pentax SP-F and Canon AE-1); 55 mm, 80-200 mm zoom and a 400 mm telephoto lenses. In all except 4 instances (Plates 4.10, 4.16, 5.2 and 5.3) the photographs involved the experimental animals observed in this present study. Determination of duration data involved the use of a Casio quartz electronic stopwatch. Frequency data were compiled using a hand-operated mechanical counter.

Throughout the study climate data were obtained daily from the University campus. A summary of this information has been presented in Appendix III.

Each animal was identified on both sides of the body using a proprietary bleach "Animark", Tasman Vaccine Laboratory (Fig. 2.2). Symbols were used in preference to numerals because they were easier to apply and their identification was more reliable. The bleach needed to be re-applied owing to hair loss as the cattle shed their winter coats. The mature animals were identified by the use of 3 notations. For example, P27-1 refers to a primigravid cow, with the identity number 27, who calved first; M30-12 denotes a multigravid cow, number 30, who was the twelfth to calve. The calves were described in the following way: P34-B denotes a bull calf born to a primigravid cow identity number 34; M24-H was a heifer calf born to the multigravid cow number 24.

3.5 Analysis

In most instances statistical analysis necessitated the use of non-parametric procedures as described by Siegel (1956); Robson (1973); Roscoe (1974) and Meyer (1976) whilst parametric methods were taken from Snedecor and Cochran (1967) and Sokal and Rohlf (1969). Siegel (1956) considered that there were only 2 main limitations associated with the use of non-parametric analysis. First, the power-efficiency of a parametric statistical test is higher when all the assumptions of its statistical model are met and when all the variables are measured in at least an interval scale. However, in the present study most measurements involved the ordinal and nominal scales. Also in many instances the design of the experiment and the data obtained failed to meet the assumptions inherent in a parametric model. Therefore, the advantages of using the higher efficiency tests could not be realized. The second disadvantage of non-parametric analysis is the inability to test interactions in the analysis of variance model, unless special assumptions are made about additivity. It was, therefore, decided to restrict parametric analysis to those instances where the requirements of the test and the assumptions of the statistical model were met by the data.

Plate 2.2: Caravan and observation tower

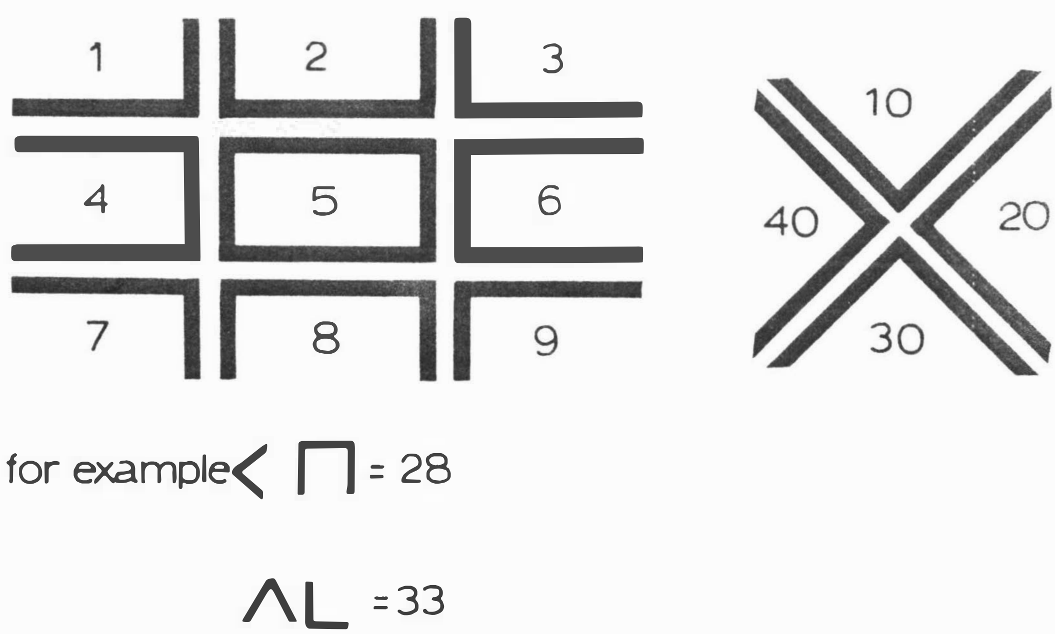


Fig. 2.2: Body markings for cattle identification

CHAPTER THREE

PREDICTION OF CALVING TIME

A. LITERATURE REVIEW

1. Physical Signs

Dufty (1971) studied a number of physical signs in 44 mixed-age Hereford cows and came to the conclusion that although changes did occur during the final stages of pregnancy, variations in the appearance and progression of the signs often limited their usefulness in determining the nearness of parturition. Ewbank (1963) investigated the occurrence and degree of pre-partum slackness of the perineum and vulva, relaxation of the sacro-sciatic ligaments, degree of udder development and the discharge of mucus from the genital tract of 21 Ayrshire cows. In 9 of these animals it was not expected that they would soon calve, but they did so within 2 to 12 h (average 7 h); 6 other cows showed all the signs and yet did not calve within the following 12 h.

1.1 Vagina shape and secretions

Ewbank (1963) considered that classifying the state of the perineum and vulva was the most difficult of all the signs investigated. Wide variation between individual cows in the occurrence and degree of change in these signs was reported by Craig (1937) and Roberts (1971).

Vaginal secretions were also found to vary in time of occurrence and did not increase in the amount or frequency of discharge as parturition approached. Only 8 of the 20 cows were recorded as showing mucus at the last examination pre-partum (Ewbank, 1963). Roberts (1971) recorded the first sign of mucus as early as the seventh month of gestation. Dufty (1971) did report a change in the volume and appearance of vaginal mucus from 7 to 10 d pre-partum. However, it was only possible to predict the time of calving in 4 of the 44 cows using this sign. The value of these results is limited as the criteria, i.e. volume and appearance of mucus on which prediction was based were not provided.

Abusineina (1969) demonstrated that the size and weight of the cervix are added to by each additional pregnancy. When using changes of this structure as criteria for predicting calving time an account must be allowed for this effect of previous calvings.

1.2 Udder size and secretions

All workers who observed udder size and secretions came to the conclusion that, although distension invariably occurred, the time of onset and degree of development were very variable (Craig, 1937; Scholl, 1956; Arthur, 1961; Dufty, 1971; Roberts, 1971). George and Barger (1974) found a range in the onset of udder development of a "few" days to a "few" hours pre-partum. Scholl (1956) and Arthur (1961) first recorded its occurrence 7 d prior to calving. Dufty (1971) found it impossible to use udder shape as a criterion for predicting the onset of parturition in 26 of the 44 cows studied. Obvious udder development was observed in 18 of the 44 cows, but only 9 of these calved in the following 24 h and in one case, calving did not occur for 10 days. This low association between the occurrence of udder development and the onset of labour was shown to be lessened in cases where the udder suddenly became full, to the extent of milk "spurting" from the teats (Arthur, 1961).

Reproductive status of the cow has also been found to influence mammary gland development (Craig, 1937; Scholl, 1956; Dufty, 1971; Roberts, 1971). Primigravid cows appear to have a much earlier onset of udder development than do multiparous cows. Roberts (1971) noted oedema and enlargement by the 4th month of gestation in first-calvers as opposed to 4 to 2 weeks pre-partum in multiparous individuals. Scholl (1956) reported a similar association between maternal status and udder development, but at a much closer time to calving.

The degree of development has also been found to be very variable (Craig, 1937; Scholl, 1956; Arthur, 1961; Roberts, 1971). Extensive development was found to be more common in higher milk producers, especially among young cows. In some instances this was so marked that it interfered with walking and blood circulation, resulting in necrosis of the udder. Occasionally the oedema extended along the abdominal floor or ascended between the hindlegs as high as the vulva (Craig, 1937). In these cows, pre-partum removal of the milk was required (Arthur, 1961). This variation in onset and degree of udder development rendered this method of predicting the time of calving unreliable and its usefulness limited to denoting actual parturition.

Changes in various properties of udder secretions have also been used to predict onset of calving (Arthur, 1961; Dufty, 1971; Roberts, 1971). The secretions were found to change in consistency, clarity and colour as parturition approached. These changes were associated with increases in udder development.

1.3 Pelvic ligament relaxation

Williams (1943); Benesch and Wright (1951); Scholl (1956); Arthur (1961 and 1966); and Roberts (1971) all stated that relaxation of the *sacro-sciatic* ligament was a reliable guide to the nearness of parturition in the cow. Dufty (1971) using this method was able to accurately predict the imminence of calving in 36 of the 44 cows in his study. Dufty considered this was the most efficient method available because the changes were sufficiently distinct to be recognizable in most animals. These changes showed a relatively constant time relationship to the onset of cervical dilation and were least influenced by external factors. A similar conclusion regarding the reliability of the sign was reached by Arthur (1966).

Roberts (1971) reported that in most cows the presence of very relaxed ligaments indicated that parturition would occur within 24 to 48 h. Arthur (1961) found that with complete relaxation, calving would begin within the next 12 h. These differences between reports are possibly due to interpretation of the degree of relaxation.

This relaxation was often associated with a subsiding of the gluteal "muscles" (Craig, 1937) and a "rising" of the tailhead (Scholl, 1956; Roberts, 1971). This elevation was accentuated when the cow arched her back (Dufty, 1971; George and Barger, 1974). Tail elevation and extension from the body were observed to increase slightly within 24 to 36 h pre-partum and reached a maximum during periods of straining associated with labour (Donaldson, 1970; George and Barger, 1974).

Although relaxation of the ligament appears to provide the most reliable sign for determining onset of calving the method was found to have limitations. Dufty (1971) recorded that accurate assessment of the changes in relaxation could be made only by combining external and rectal examinations. Ewbank (1963) substantiated this by showing that, when he used only external palpation, 8 of the 20 cows did not exhibit complete relaxation at the last examination prior to calving, on average 7 h (range 2 to 12 h) later.

Arthur (1961) noted that on rare occasions complete relaxation did not always indicate that parturition would occur in the near future. In such cows the ligaments were found to "tighten up" and a week elapsed before their relaxation prior to parturition

1.4 Body conformation

Little emphasis has been placed on this as a criterion despite its possible value. Craig (1937) found that with approaching parturition the abdomen became more pendulous and the flanks and croup appeared hollow. The spine, especially in the lumbar region, was observed to become more horizontal and in some instances it appeared to slope downward posteriorally.

1.5 Cervical dilation

Determination of cervical dilation requires direct palpation within the vagina and is most commonly described in terms of the number of fingers that can be inserted and the depth to which they penetrate the canal of the cervix. Dufty (1971) found that at the examination prior to calving 16 of the 22 primiparous and 11 of the 22 multiparous cows had closed cervices. In 1966 it was reported by Arthur that direct palpation of the cervix made it possible to identify with certainty first stage labour.

2. Physiological Signs

2.1 Temperature

A number of studies used changes in rectal or vaginal temperature as a method of predicting calving time (review Ewbank, 1963). All reported a common pattern in which body temperature increased and then declined immediately before calving, although the extent of this change and the time period over which it occurred varied. The association between temperature changes and the presence of physical signs was low.

2.2 Heart and respiration rates

Dufty (1971) found little value in the use of either heart rate or respiration rate as signs for predicting onset of parturition. Any changes that did occur were so small as to be masked by diurnal variations. Sharp fluctuations in heart rate were most noticeable in excitable animals and prevented the formation of a baseline from which subsequent trends could be evaluated. Changes in respiration rates appeared to be due mainly to changing environmental conditions. As the most reliable changes in both heart and respiration rates were during the actual process of parturition, their value for predicting time of onset is obviously limited.

3. Behaviour of the Pre-parturient Cow

The occurrence of obvious behavioural changes appear to be limited to the immediate pre-partum period (Fraser, 1968 refer Table 3.1), although these behaviours were not necessarily consistent between cows (George and Barger, 1974).

3.1 Disposition and restlessness

Scholl (1956) described the change in the pre-parturient cow as "a marked transformation from a docile, easily-managed animal into a stubborn, hell-bent-for-election bovine vixen characterized by fussing and fidgeting" (sic). This activity is commonly termed restlessness and often involves walking, up to 6 h a day (Fraser, 1968; Donaldson, 1970; George and Barger, 1974). Although it has been reported that this appeared to have no motivation (George and Barger, 1974) it often was confined to "walking the fence-line" (Donaldson, 1970).

TABLE 3.1: Principal behavioural events at parturition in the domestic cow (Fraser, 1968)

Late gestation	Pre-partum period	Parturition	Post-partum period
Ingestive behaviour may increase. Slower gait.	May separate from herd and seek seclusion (1 day). Anorexia develops. Restlessness begins (several hours). No preparation of calving site.	Bellows. Pain and discomfort expressed in very restless behaviour (alternately lying and rising). Usually recumbent but may stand during expulsion of foetus. Expulsion relatively slow (4 hours)	Usually eats foetal membranes if fresh; sometimes even before uterine separation is complete. Maternal drive develops to a degree and for a duration dependent on the quantity of association with the calf permitted in husbanding.

The various studies differ in the time this restlessness was first recorded. The earliest occurrence was reported by Donaldson (1970) who observed it 14 to 7 d pre-partum whilst Roberts (1971) and Dufty (1972) found that it first occurred within an unspecified number of hours of calving. George and Barger (1974) recorded a variation in onset which ranged from a few days to a few hours pre-partum.

Donaldson (1970) noticed an increase in restlessness from 24 to 36 h pre-partum. Fraser (1968) observed that with time restlessness was superseded by behaviour very similar to the condition of colic.

A change in the cow's posture was recorded, but not described by Donaldson (1970) and Dufty (1972). George and Barger (1974) observed an arching of the back and elevation of the tail which occurred from 3 to 1 h prior to the rupture of the chorio-allantoic membrane.

Restlessness was considered to indicate a build-up of pain (Fraser, 1968). Walser (1965) suggested that this pain served to signal the forthcoming events to the pre-parturient animal.

3.2 Resting and sleep

Donaldson (1970) observed that the proportion of time spent resting, in each 24 h period, decreased 50% to a total of 4 to 5 h in the last 2 weeks of gestation. Each rest period was from 15 to 30 min. long compared to the usual 2 to 4 h duration. Ruckebusch (1975) studied 2 cows and reported a decrease of 50% in both non-rapid eye movement and rapid eye movement sleep during the 24 h period prior to parturition.

3.3 Vocalization

Craig (1939) implied that bellowing in the pre-parturient cow was of fairly frequent occurrence.

3.4 Self grooming

The observations of self grooming by George and Barger (1974) are the only ones to have been reported; the grooming was said to be concentrated around the flank.

3.5 Nutritional activities

Voluntary food intake (VFI) was shown to increase during mid-pregnancy and was observed as a "better appetite" in the pregnant *versus* non-pregnant cow (Snapp and Bull, 1944). This situation was found to reverse during the latter part of gestation (Campling, 1966; Johnson *et al.*, 1966). The rate and onset of this decline in VFI varied from 4 d pre-partum (Marsh *et al.*, 1971) to several hours pre-partum (Scholl, 1956).

Donaldson (1970) observed that ingestion of food and water became sporadic and intermittent during the last 7 d of gestation. Ruckebusch (1975) found that periods of feeding were restricted to the daytime prior to calving, but thereafter feeding also occurred during nightime. However, these observations involved only the 2 d either side of calving and it is therefore not valid to assume that the immediate pre-partum observations were different from earlier gestation periods.

Towards the end of pregnancy rumination time remained approximately constant, but occurred more frequently (Ruckebusch, 1975). A decrease of 50% in rumination time in each 24 h period pre-partum was reported during the last week of gestation by Donaldson (1970).

3.6 Eliminative behaviour

An increase in frequency of both defaecation and urination has been found to occur in the pre-parturient cow especially in the immediate pre-partum period (Fraser, 1968; Donaldson, 1970). Anon. (1972) considered this behaviour was "nature's way of making certain that as much room as possible would be available for the passage of the calf down the vagina".

3.7 Social behaviour

3.7.1 Agonism

By the latter half of the seventh month of gestation, behaviour that involved butting or being butted ceased. Donaldson (1970) suggested two reasons for this change in the pregnant cow's behaviour;

a hard flank attack could be injurious to the foetus and because of her condition the cow would be unable to move as quickly or as easily as previously. The cow would therefore be at a disadvantage in following and avoiding the movements of an opponent. By the second half of the eighth month the pregnant cow no longer interacted in any behaviour that included pushing. This involved active avoidance by the cow of all (physical) agonistic encounters including cows to which she was usually more dominant. This was in contrast to the non-pregnant cow or the cow in the first trimester of gestation who tested the superiority of more dominant individuals and frequently attacked less dominant cows.

3.7.2 Isolation

Craig (1937) and Arthur (1961) reported that unrestrained cows sought isolation prior to calving. They usually preferred concealment in a wood, among bushes or in tall vegetation. Arthur (1961) considered that this represented a carryover from the ancestors of domestic cattle who were very vulnerable to carnivore attack during parturition. Conversely Lynch and Alexander (1973) reported that there did not appear to be any such specific shelter-seeking behaviour at calving.

Donaldson (1970) observed that during the last stages pre-partum the cow stayed at the periphery of the grazing herd. These cows tended to go to water and feeding troughs when there were no other or only a few cows present. Donaldson believed this was part of the cow's active intention to avoid possible agonistic encounters.

Alexander *et al.* (1975) found this isolation was shown from 14 to 7 d pre-partum. Donaldson (1970) and Alexander *et al.* (1975) observed that within the last 2 d pre-partum this tendency to separate from the herd increased. It was characterized by the cow spending a very large proportion of her time in a small, usually secluded area. In the 36 to 24 h pre-partum the cow maintained a flight distance of *c.* 15 m from herdmates and humans. Fraser (1968) reported that this isolation occurred within an hour or two of parturition, but in some cases the cow had simply failed to maintain the grazing movements of the herd.

B. RESULTS AND DISCUSSION

1. Materials and Methods

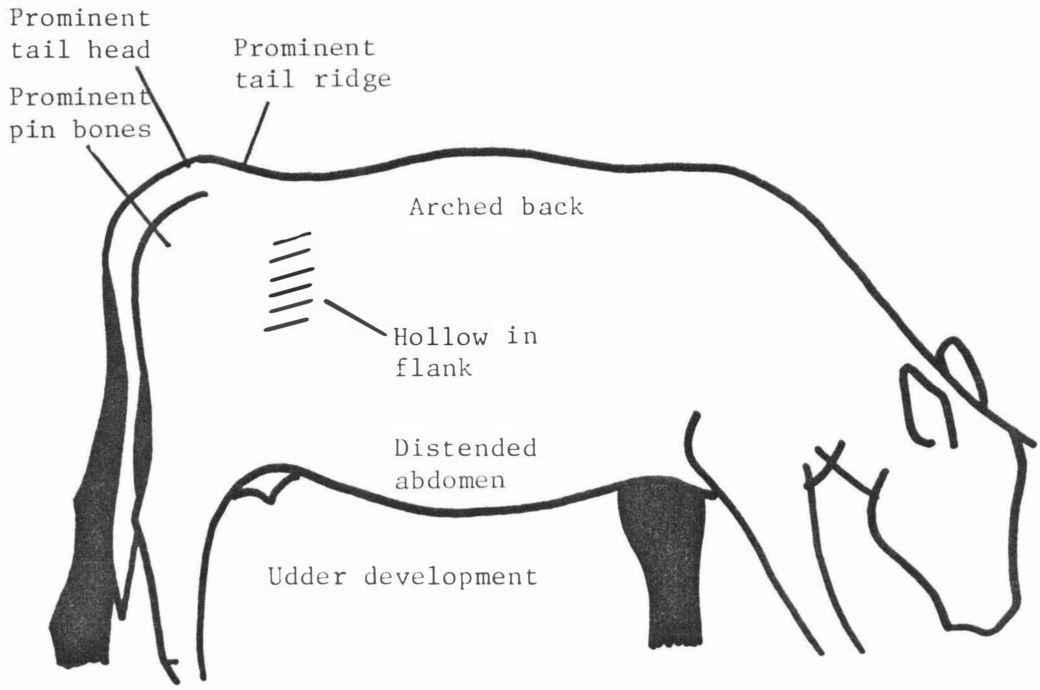
The time of calving was estimated by visual assessment of certain physical and behavioural features. Physiological parameters such as temperature, heartrate and respiration or other signs whose measurement required the use of yards and handling of the stock, such as cervical dilation and udder secretions, were not used.

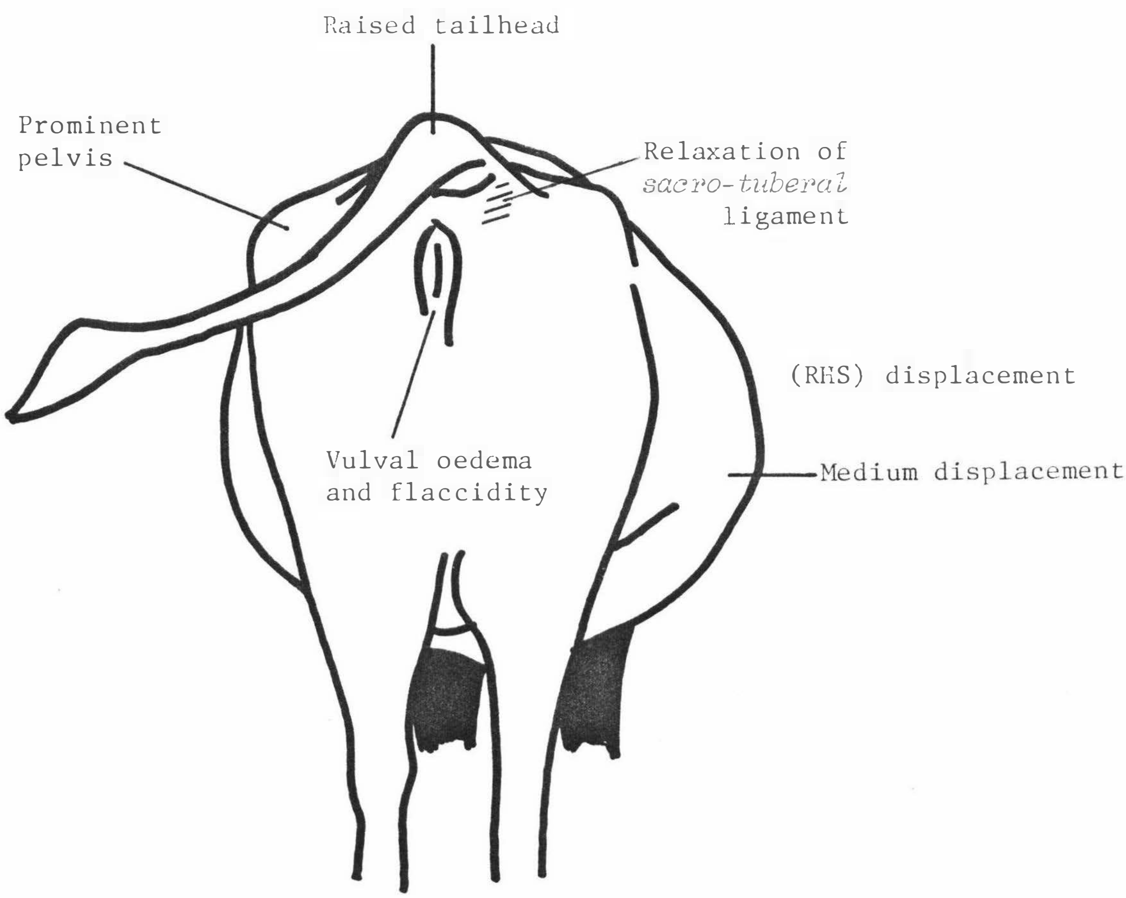
Physical signs were in 4 main categories; labia, udder, pelvic ligaments and body conformation (Fig. 3.1). Each of these was recorded for changes in their appearance and shape. As well, both the udder and labia were visually assessed for oedema. The labia were also assessed for colour changes and the occurrence of mucoid secretions. Changes in the appearance of the labia, udder and pelvic ligaments were independently scored on a scale of 1 to 3. However, this visual assessment was subjective and as it was not possible to obtain quantitative measurements it was decided that use of these data for comparing cows was not justified.

Twenty-four physical signs were used (Appendix IV) as the criteria for each cow. Data collection began on the first day of the study (D/O) 16 July, 1977 and continued twice a day until the cow calved. This occurred on average 31 d (range 4 to 65 d) later. The first recording session was from 0815 to 1015 h and the second was between 1700 and 1800 h, which coincided with the feeding of hay supplements.

Behaviour signs were in 3 categories; gait, posture and social activities; which involved 11 signs (Appendix IV). Because the behaviours could occur at any time during the day a record was made whenever the behaviour was observed. The length of data collection was the same as for the physical signs.

When comparing the pregnant cow in the last week of gestation to the rest of the herd (ROH) it was evident that the frequency of grazing, resting and rumination had increased whilst the duration of each session was less. It was not possible to obtain quantitative data to support these observations so these behaviours were not included as criteria for predicting calving time.


Prominent
tail head
Prominent
tail ridge
Prominent
pin bones
Arched back
Hollow in
flank
Distended
abdomen
Udder development


Raised tailhead
Prominent
pelvis
Relaxation of
sacro-tuberal
ligament
(RHS) displacement
Vulval oedema
and flaccidity
Medium displacement

The data were analysed for each cow on the basis of number of days pre-partum the sign was first detected and the number of signs recorded. This provided information for comparing different signs and cows for the number of signs recorded, within the 2 cow groups, primi- and multigravid. A binomial analysis using χ^2, test of independence was used (Table 3.3).

The number of days from D/O to calving was found to have a very highly significant effect (Anova P<0.001) on the time the physical signs were first observed. This effect of length of observation was also found to differ significantly (Anova P<0.01) between the primigravid and the multigravid cows. Because of these associations it was decided not to compare cows on the basis of their maternal experience for the time the signs were first observed (ref. Table 3.2).

2. Physical Signs

2.1 The labia

Changes in the vulva included relaxation of the tissue, elongation and sometimes tumefaction of the vulva. Frequently the labia became everted which often exposed the vaginal mucosa. This was especially evident when the cow was recumbent (Plate 3.1). In some cows there was a dropping of the labial region relative to the tailhead (Plate 3.2).

Mucus from the vagina was infrequently recorded; 1 of the 6 primigravid and 2 of the 8 multigravid cows. In all these cows its presence was never observed on more than 2 occasions. Furthermore, its occurrence had no apparent relationship to the time of calving. The primigravid cow was recorded for first occurrence of mucus 6 d pre-partum. The 2 multigravida showed the sign 1 d and 24 d pre-partum, respectively.

Although this group of signs was the most frequently observed in both the primigravid and multigravid groups, there was wide variation in the number of cows recorded for each of the signs. The frequency of occurrence appeared to be influenced by maternal status. Of the 9 signs investigated 5 were exhibited by the first calvers *versus* 9 signs amongst the multigravid cows (χ^2, P<0.05, Appendix IV).

TABLE 3.2: Number of signs observed and time (days) from start of observations until calving for each of the cows

Identity No. of cow	Time (days)	No. of Physical Signs	No. of Behavioural Signs
	**	**	
P27-1	4	5	4
P23-2	6	7	0
P31-3	16	8	3
P38-4	17	3	1
P34-5	18	5	2
P35-6	19	3	0
$\bar{x} \pm SD$	13.30 ± 6.56	5.17 ± 2.01	1.66 ± 1.63
Range	4 - 19	3 - 8	0 - 4
M24-7	20	10	0
M32-8	29	12	7
M22-9	31	14	1
M28-10	44	20	5
M21-11	48	17	5
M30-12	59	13	1
M33-13	61	18	4
M36-14	65	6	3
$\bar{x} \pm SD$	44.63 ± 13.66	13.75 ± 4.56	3.25 ± 2.43
Range	20 - 65	6 - 20	0 - 7

** P<0.01 between primigravida and multigravida using Anova, test for significance.

Plate 3.1: Hairloss and everted labia showing vaginal mucosa.

Plate 3.2: Raised tailhead, arched back and prominent pelvic bones.
N.B. Oedema below a flaccid vulva is also evident.

2.2 The udder

Udder development included changes in the shape, degree of distension and enlargement of the mammary gland and teat. These changes were due to oedema and were observed in 5 of the 6 primigravid cows and 2 of the 8 multigravid cows. These figures suggest a parity of cow effect as has been shown by Craig (1937); Scholl (1956); Dufty (1971) and Roberts (1971).

In 4 of the 8 multigravid cows prominent teats were recorded at an average time of 13.0 d (range 1 to 26 d) pre-partum. None of the first calvers were found to exhibit this sign. Irrespective of the occurrence of udder development prior to the onset of calving, by the time first stage labour was in an advanced stage the udder had invariably assumed a tight, shiny appearance with prominent teats. This supports the findings of Arthur (1961) and Dufty (1971).

Unlike Arthur (1971) there was no evidence of milk "spurting" from the teats. Nor was udder oedema so severe that it resulted in visible necrosis or walking difficulties as observed by Craig (1937). These findings suggest that these extreme results of udder development may be restricted to dairy breeds and possibly only to the higher milk yielding individuals.

As the udder changed in appearance it was accompanied by hair loss around the teat and udder region in 50% of the multigravid cows. The extent of hair loss varied markedly amongst these 4 cows and was related to some extent to the time (days, pre-partum) it was first observed.

2.3 Pelvic ligaments

Most studies have referred to the pelvic ligaments as either the *sacro-sciatic* or the *tuber ischii*. In order to minimize confusion when discussing these ligaments it was decided to use the nomenclature proposed by Anon. (1973) as the broad *sacro-tuberal* ligament. In this present study the terms pelvic bone (i.e., the hip) and pin bone have been used to refer to the anotomical structures *tuber coxae* and *tuber ischii*, respectively.

Relaxation of this ligament was reflected in changes in the position of the tailhead and the posterior portion of the spine. To a lesser extent an increase in the prominence of the pelvic and pin bones and a dropping of the labia toward the body were also observed. These signs tended to be more frequently observed in the older cows (Table 3.3).

In two of the four signs related to tail placement there was a significant difference (χ^2, $P<0.02$) between the primigravida and multigravida, for the number of cows recorded. The sign most frequently observed was extension of the tail out from the body. This was recorded in 3 of the 6 primigravida and 4 of the 8 multigravida (Table 3.3).

2.4 Body conformation

Recording and monitoring changes in body conformation involved 6 signs (Appendix IV). Of these displacement of the body profile to the right hand side (RHS) was divided into low, medium and high. These classifications referred to the location of greatest displacement when the cow was viewed from behind (Fig. 3.1).

There was considerable variation in the time of first onset of the 6 signs, but there appeared to be a general pattern. Initially the pelvis and pin bones became increasingly prominent with progressive relaxation of the ligaments around the tail head and vagina. This prominence was more frequent among the multigravid cows 75% *versus* 33% of the primigravid animals (χ^2, $P<0.3$). The other signs in this category occurred in some sort of ordered relationship. The hollow in the flank amongst the older cows often appeared shortly before the abdomen became displaced toward the RHS. At this stage many of the cows were observed to have a marked displacement of the body profile in the low position. These changes in body conformation may have been due to a shift in the position of internal contents because they were much more obvious after the feeding of hay supplements and at the end of a grazing session. A possible explanation is that the increased rumen contents were displacing the uterus and the conceptus toward the RHS. The justification for believing these to be uterine

TABLE 3.3: Frequency of occurrence of the signs according to maternal experience

Category	Sign	Primigravida : Multigravida
A. PHYSICAL SIGNS		
Labia	sunken	2 : 6
	hairloss	0 : 3
Vulva	oedema	5 : 7
	- base	0 : 4 *
	- side	0 : 5 **
	- below	0 : 4 *
	flaccid	3 : 8 *
	red mucosa	2 : 7 *
	mucus	1 : 2
Udder	prominent teats	0 : 4 *
	oedema	5 : 2 *
	hairloss	0 : 4 *
Pelvic ligaments	prominent tailhead	0 : 6 ***
	raised tail	0 : 6 ***
	tail ridge	1 : 3
	extended tail	3 : 4
Body conformation	prominent pelvis	2 : 6
	prominent pin bones	0 : 5 **
	sunken flanks	1 : 5
	distended abdomen	1 : 3
	RHS displacement	3 : 5
	displacement-high	1 : 2
	-medium	0 : 3
	-low	0 : 2
B. BEHAVIOURAL SIGNS		
Gait	slow	1 : 1
	swaying	2 : 1
	jerky	1 : 2
Posture	PSR	1 : 3
	SNP	0 : 2
	leg stamping	2 : 1
	hypernoea	0 : 2
	tail movement	2 : 4
Social	association	0 : 5 **
	flight	0 : 2
	isolation	2 : 5

* significant at 2% level
** significant at 1% level
*** significant at 0.5% level, using χ^2, test of independence

contents is that the rumen is usually located on the LHS and that as parturition approached the displacement of the body profile shifted from the LHS toward the RHS. Except when the displacement was high the primigravid cows were not observed to have any changes in body profile. This suggests that rumen or uterine contents, or both, comprise a larger proportion of body components in the older cow.

3. Behavioural Signs

3.1 Gait

Walking was characterized by slow and deliberate movements. Sometimes the hind leg action was jerky and often the cow swayed from side to side as she moved forward. Usually the head was held at a lower level than normally and the ears were often horizontal to the ground and held out from the side of the head. These features were only exhibited by the pre-parturient cow when walking first started, and were most common after a period of recumbency. Duration of any of these types of gait never exceeded 15 steps.

Only 5 of the 14 pregnant cows were recorded for the sign, 3 primigravida and 2 multigravida (Appendix IV). Of these only 2 cows exhibited more than 1 of the 3 features characteristic of the gait. One primigravid showed 2 features (slow and swaying) whilst 1 multigravid exhibited all 3 (slow, swaying and jerky).

3.2 Posture

Within a fortnight of calving the recumbent cow adopted a modified posture, partial sternal recumbency PSR (Plate 4.1), from the usual normal sternal recumbency NSR (Plate 3.4). PSR was only observed in the pre- and parturient cow. It was characterized by an extension of the limbs, especially the hind legs, from the body so that the cow was less vertically inclined than in NSR. The head was lowered; in the extreme case the muzzle was placed on the ground and the head held perpendicular to the ground. However the position of the head did vary, for example, it was raised during rumination (Plate 3.3).

Plate 3.3: Partial sternal recumbency (PSR) in the pre-parturient ruminating cow
N.B. P31-3 lying behind M28-10 is showing NSR

Plate 3.4: Normal sternal recumbency (NSR)

Sometimes whilst recumbent the cow would exhibit heavy, rapid breathing (hypernoea) which usually increased in intensity and frequency over a 20 s to 10 min. period. This hypernoea was usually terminated by the cow standing up.

Another posture observed with increasing frequency up to and throughout parturition was defined as Standing Non-strain Posture (SNP ref. Chapter 4 B3). The relationship, however, between the occurrence of SNP and onset of parturition was not obvious. For example, one cow (P31-3) exhibited SNP 1 d pre-partum whilst two others (M28-10 and M33-13) exhibited the posture 27 and 23 d pre-partum, respectively.

Whilst standing the cow was sometimes observed to alternately lift each of the hind legs high up under the abdomen. Often this was accompanied by tail movements of varying intensity, but which usually did not exceed several seconds in duration. When these tail movements were the most evident the legs were forcibly lifted and replaced on the ground. This behaviour was defined and recorded as leg stamping.

3.3 Social

Of the 3 social behaviours investigated only 2 were recorded for primigravida. In both instances this involved social isolation. It was first observed on average 5 d (range 4 to 6 d) pre-partum. Amongst the older cows it was first recorded on average 6 d (range 1 to 9 d) pre-partum. Both M21-11 and M36-14 continued this social isolation by maintaining a flight distance (defined as the minimum distance the cow would permit hermates and humans to approach) of at least 6 m.

Withdrawal amongst the primigravid cows resulted in total social isolation, but the multigravid cows tended to associate with lactating cows and their calves. This involved deliberate association with and maintained proximity to lactating cows and/or their calves. This behaviour was therefore defined as association. It is suggested that association might be a premature expression of maternal interest by the pre-parturient cow.

As observations did not begin until on average 31 d (range 4 to 65 d) pre-partum it was not possible to monitor changes in the cow's agonistic behaviour as early in her gestation as did Donaldson (1970). A separate pre- and post-partum social rank for each cow could not be determined because it was not possible to account for the effect of the presence of other cows which had calved and/or were rearing calves at the same time.

Data collection was made twice a day (0800 to 1000 and 1700 to 1830 h) when hay was being fed to the cows. Due to the large amount of data it was decided to make an initial analysis at the end of July and a separate analysis at the end of August. These analyses involved the determination of a social rank based on dominance*-submission relationships of the cow-pairs.

As the data were measured in the ordinal scale and involved repeated measurements from the same animals the non-parametric Wilcoxon test was used to compare the 2 social ranks (Figs 3.2 and 3.3). It was found that the social relationships were not all constant with time. This was substantiated by a significant difference (Wilcoxon, $P<0.02$) between the 2 social ranks. This instability of social rank with time conflicts with the findings of many studies, for example, Dickson *et al.* (1970); Zimmerman-Müller and Zeeb (1970); Barton *et al.* (1974) and Bouissou (1974a, b; 1975). As herd composition, in this present study, did not change it is suggested that 1 or a combination of the following factors might have been responsible for the instability:

(i) The presence of pregnant cows, Beilharz and Mylrea (1963) observed on mixing pregnant and non-pregnant cows that the former animals became more submissive to the latter ones;

(ii) The process of parturition; or the

(iii) Effect of maternal drive, Donaldson (1970) reported that defense of the calf during the first few days post-partum superseded social rank.

---

* Social dominance was defined by Lamb (1976) as: "a relationship where an animal through threat, force or mere presence causes a subordinate animal to yield space."

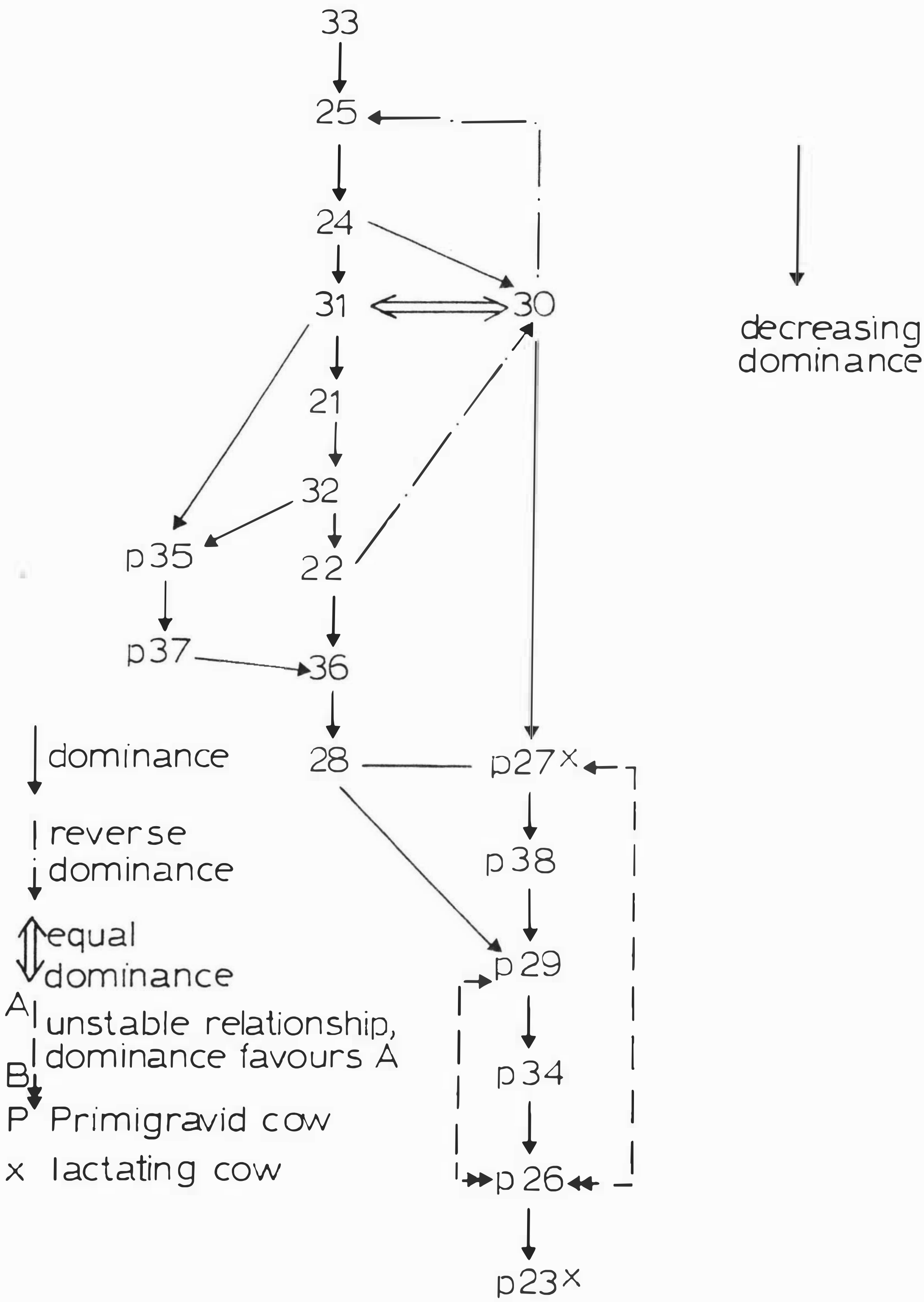


Fig. 3.2: Social dominance relationships amongst the cows (July 16-31 1977)

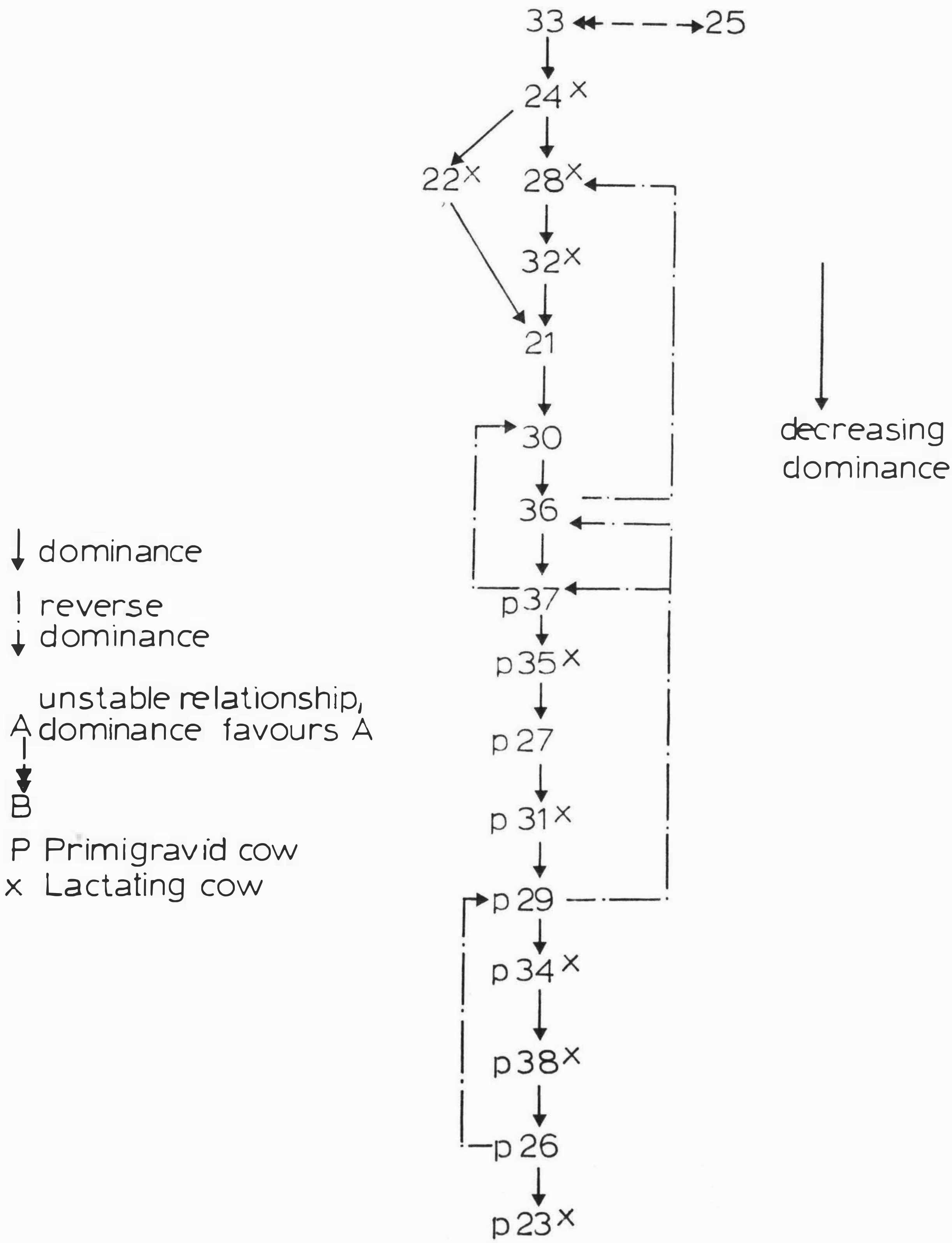


Fig. 3.3: Social dominance relationships amongst the cows (August 1977)

4. Frequency of Occurrence

4.1 Physical signs

There was a highly significant difference (Anova, $P<0.01$) between the primigravid and multigravid cows for the number of physical signs they showed (Table 3.2). Of the 24 physical signs only 13 were recorded for the first calvers *versus* all 24 amongst the older cows. On average 2.4 (range 1 to 5) of the 6 primigravida cows were recorded for each of the 13 signs observed *versus* an average of 4.4 (range 2 to 8) of the 8 multigravid cows. This represented a significant difference (χ^2, $P<0.05$) in 4 of the 24 signs (Table 3.3).

4.2 Behavioural signs

There was a non-significant difference Anova between the 2 groups of cows in the number of behavioural signs recorded (Table 3.2). Of the 11 signs studied 8 were recorded amongst all 11 of the older age group. On average 1.4 (range 1 to 2) of the primigravid cows *versus* an average 2.6 (range 1 to 5) of the multigravid cows were recorded for each of the signs observed. From Table 3.3 it is apparent that only 1 of the 11 signs had a significant level (χ^2, $P<0.05$) of difference between the 2 groups of cows for frequency of cows recorded for each of the signs.

5. Time and Order of Occurrence of the Signs

The average time of first occurrency of each of the 4 physical and 3 behavioural categories has been presented in Table 3.4. From the large standard deviation units associated with the means it is evident that there existed no consistency between the cows for the time and order the signs were first observed.

Comparing the 2 groups of cows on the basis of the average time each of the categories were first recorded it was found that both the physical and behavioural signs differed in the order of their occurrence. This could be due to the wide variation either between individual cows and/or between the cow groups, or it might be a reflection of the low association between the signs in the time of their occurrence.

TABLE 3.4: (a) Average time (days) pre-partum the physical criteria were first observed and the number of cows recorded

	Time $\bar{x} \pm SD$	No. of cows
Primigravida (n = 6)		
Udder	6.4 ± 5.1	3
Body conformation	4.1 ± 2.2	5
Labia	3.2 ± 2.5	5
Pelvic ligaments	2.8 ± 2.4	3
Multigravida (n = 8)		
Labia and vulva	20.8 ± 12.3	8
Body conformation	18.9 ± 11.5	7
Udder	16.6 ± 11.2	6
Pelvic ligaments	13.8 ± 11.2	7

(b) Average time (days) pre-partum the behavioural criteria were first observed and the number of cows recorded

	Time $\bar{x} \pm SD$	No. of cows
Primigravida (n = 6)		
Gait	5.5 ± 4.1	2
Social	5.0 ± 1.4	3
Posture	2.0 ± 1.0	2
Multigravida (n = 8)		
Gait	25.8 ± 5.4	2
Posture	9.9 ± 8.1	5
Social	8.0 ± 5.7	6

6. Discussion

6.1 Prediction of calving order

Prior to the first parturition, a calving order for the 14 pregnant cows was predicted. This order corresponded to the actual calving sequence (Spearman, $P<0.001$) in all except 2 cases. Both these cows (P38-4 and P35-6) were out of sequence by only 1 position.

It was not possible, however, to predict the calving order for all 14 cows using only the signs presented in Appendix IV. It was also necessary to use subjective interpretation of characteristics, shown by the cow, which were not consciously expressed by the observer.

6.2 Prediction of calving time

Monitoring the occurrence and degree of change of the physical signs enabled the observer to predict the time of calving to within 48 h of the onset of parturition in all 14 cows. More accurate prediction of calving time required the detection of certain behaviours. The most reliable of these were social isolation and the increasing frequency of postures characteristic of parturition, e.g. partial sternal recumbency or standing non-strain. These behaviours were followed by calving (i.e. birth of the calf) within 3 to 4 h, in all except one cow (M36-14).

6.3 Reliability of the signs

Initial selection of the signs was based on the studies reviewed. However, some signs were of little or no value because of a lack of occurrence, e.g. milk secretion, or the time the sign was first observed in relation to calving. This latter factor was especially valid for the behavioural signs which were often first detected within hours of the calf's delivery.

Generally both groups of cows showed physical signs earlier than the behaviours, but this difference was not significant within each age group. All 14 cows were recorded for at least 3 of the 4 categories of physical signs, but 2 of the primigravid cows (P23-2 and P35-6) and 1 of the multigravida (M24-7) were not observed to show any of the behavioural signs.

Individual cows vared greatly in the number of signs (Table 3.2) and the time these signs were first observed. This supports the findings of a number of other studies (e.g. Dufty, 1971 and Roberts, 1971). As the observations were restricted to one season the repeatability of the results over successive years is unknown.

In order to obtain useful information from the physical signs it was essential that each cow was studied for the evidence of signs at least once a day. This was necessary because of the wide variation in the time of first occurrence and the rate of subsequent change in each sign for the different cows.

No one sign could be used to predict either calving order or time of calving. On average, the physical signs provided earlier, but less definite prediction than did the behavioural signs. Of the 4 physical categories the labia was the most commonly observed in both age groups. Generally a pattern of decreasing frequency of occurrence of the physical categories amongst the multigravid cows was; labia, pelvic ligaments, body conformation and udder changes. However, this was not absolute as there existed large variation in the frequency of cows exhibiting any particular sign. This variation was even more evident amongst the primigravid cows and made it unwarranted to describe any pattern amongst these cows.

A similar situation amongst the first calvers occurred with respect to the behavioural categories. Amongst the multigravid cows there was a tendency for the 3 behavioural categories to occur in decreasing frequency as social, posture and gait.

In order for a cow's calving time to be accurately predetermined it was necessary for at least 5 physical signs and 3 behavioural signs to be recorded.

CHAPTER FOUR

PARTURITION

A. LITERATURE REVIEW

1. Occurrence

1.1 Termination of pregnancy

Maintenance of pregnancy in cattle is dependent on the continued function of the corpus luteum and regression of this structure is necessary for parturition to occur (Thornburn *et al.*, 1977).

Regression of the corpus luteum was first demonstrated in sheep; Liggins *et al.* (1966) found that maturation of the foetal pituitary-adrenal system was the causal agent leading to the onset of parturition. A number of studies have subsequently indicated that a similar situation exists in the bovine (e.g. Hoffman *et al.*, 1977).

The luteolytic factor responsible for corpus luteum regression has been identified as prostaglandin, which was found to increase from 5 to 7 days pre-partum. These elevated levels were closely related in time with the sharp decline in plasma progesterone concentrations (Fairclough *et al.*, 1975).

In the bovine, oestradiol-17β from the placenta is also involved in the initiation of parturition, particularly in the expulsion of the placenta, and in lactogenesis (Thornburn *et al.*, 1977). A second oestrogen, relaxin, from the corpus luteum has been considered to be important in the relaxation of the cervical canal (Thornburn *et al.*, 1977) by causing relaxation of the pelvic ligaments (Fraser, 1968).

Premature induction of calving by the administration of potent synthetic gluococorticoids after 255 days of gestation was found to be consistently effective (review Gordon, 1977). Practical uses of this technique have been studied by Welch *et al.* (1973). Christiansen and Hansen (1975) also noted the value of the technique, among *Bos taurus* cows mated to the larger *Bos indicus* breeds, in controlling the size of the calf and thus decreasing dystocia and calf death.

An alternative method for terminating pregnancy is the administration of prostaglandins. These are capable of inducing calving during the first months of gestation (Millar, 1974) or during the final month of pregnancy. A disadvantage of the technique is the high incidence of retained placental membranes.

1.2 Circadian rhythm

Slipjer (1958) reported that parturition in ungulates tended to occur during the time of least activity, i.e., during normal resting periods. Arthur (1961) observed that two-thirds of an unspecified number of housed cattle calved between 1800 and 0600 h, when farm staff were usually absent. A similar finding was reported by Fraser (1968). The reason was considered to be a function of light intensity (Arthur, 1961), or as a means of minimizing predation (Fraser, 1968). Whatever the reason it is generally agreed that once the physiological processes of labour have progressed to a certain point, the animal is unlikely to be able to arrest further progress voluntarily.

George and Barger (1974) observed parturitions in 38 multiparous Herefords and recorded that 31 calved between 1200 and 2400 h; and 23 between 0600 and 1800 h.

1.3 Synchronization of calving

Fraser (1968) concluded that timing of parturition appeared in many instances to be so arranged as to limit the vulnerability of the neonate. This is reflected in a peak of calving activity. Kohli and Suri (1960) over 14 years of observations found that although calvings of Hariana cattle in India took place all year round, the highest incidence occurred between January and March. Fraser (1974) reported that in the tropics sexual behaviour was affected by seasonal conditions which could be an explanation for synchrony in the calvings.

Despite the bovine's ability to breed throughout the year, domestication has resulted in the establishment of concentrated calving periods of as short as six weeks in duration.

2. Calving Site

All studies which observed isolation in the pre-parturient cow found that the site eventually became concentrated into a "small" area where the calf was usually born (Arthur, 1961; Fraser, 1968; Donaldson, 1970; Alexander *et al.*, 1975). It appears that selection of the calving site is made prior to first stage labour and is unaffected by subsequent events.

Donaldson (1970) observed that 57 of the 82 cows calved in the same 2.25 m^2 area. This was the corner furthest from the barn. Its topography was such that a recumbent cow could not be seen from the other end of the 0.2 ha enclosure. Twenty of the remaining cows calved within 15 m and on either side of the corner along the fenceline. The near presence of other parturient cows did not appear to affect selection of the calving site.

2.1 Site preparation

Arthur (1961), Fraser (1968), George and Barger (1974) noted that a cow "close" to calving frequently pawed the ground and associated litter. Fraser (1968) observed that on rare occasions the cow pawed loose litter or bedding together as though gathering it into one area.

2.2 Site maintenance

Once the site has been selected, as evidenced by the cow's tendency to remain in the area, the cow was observed to defend the site. This involved butting and driving away any encroaching cows, with the exception of other parturient cows (Donaldson, 1970).

3. Stages of Labour

3.1 Terminology

Parturition is classically divided into three phases. These refer to physical developments and represent the normal situation in monotocous species (Fraser, 1974). However, parturition can also be classified on the basis of behaviour. The relationship between these two was described by Fraser (1968, Ref. Table 4.1). The behavioural phases are less definite than the physical equivalents and extend into the broader periods pre- and post-partum.

The three physical stages have been described as: first stage - dilation of the cervix; second stage - delivery of the foetus and third stage - complete expulsion of the foetal membranes, i.e., placenta (Arthur, 1961; Fraser, 1968). Roberts (1971) also included uterine involution in the third stage of labour.

On reviewing the literature it became apparent that several of the studies were not explicit in distinguishing between the two foetal membrane sacs when referring to passage of the waterbag. Arthur (1961) detected passage of the allantochorion (i.e., the first water bag) in 40% of the cows observed. This suggests that unqualified references to the water bag were related to the amniotic sac or second water bag, which invariably appeared at the vulva at about the same time as the foetus. Arthur (1961) recorded an average of 24 min. (range 0 to 90 min.) between rupture of the two waterbags. Dufty (1972) reported a mean of 1 h 13 min. (range 2 min. to 4 h 39 min.) for the same phenomenon, in 18 cows.

Craig (1937) reported that if the waterbags ruptured early the vaginal mucous membrane and the foetus would be dry. This caused dystocia which endangered survival of the foetus.

3.2 Duration

A number of authors have reported the length of the physical stages of labour and a summary is presented in Table 4.2. As can be seen in the Table there are variations in the values from the different

TABLE 4.1: Physical and behavioural background to parturition (Fraser, 1968)

Phase	Main physical developments	Gross behavioural characteristics	Stage of labour
1	Mounting tone, conductivity and activity of the uterine parts. Building up internal mechanical pressure.	Reduced general activity - resting.	
2	Softening of cervical and vaginal tissue. Dilation of cervical canal.	Pain shown in increasing degrees.	First
3	Great uterine activity - rupture of allantoic and amniotic membranes.	Maximal evidence of pain. Active abdominal straining leading to expulsion of uterine contents. Birth (or dystocia). Expulsion of placenta.	Foetal expulsion Second. Placental expulsion Third.
4	Rapidly decreasing uterine activity. Regression of all tissues comprising the genital tract wall.	Short expulsion phase. Grooming of neonate. First sucking.	

TABLE 4.2: Duration of the physical stages of parturition in the domestic cow

Breed	First stage	Second stage	Third stage	No. of animals	Reference
Dairy	Average 6 h. Range 4 h 28 min. to 8 h 25 min.	Average 69 min.* Range 30 min. to 2 h 50 min.	Average 6 h. Range 2 to 12 h.	Unspecified	Arthur (1961)
Unspecified	Average 4 to 10 h. range 3 h to 2 d.	Usually completed within 1 h.		Unspecified	Fraser (1968)
Unspecified	Average 2 to 6 h. Range 30 min. to 24 min.	Primiparous - less than 3 h. Multiparous - 30 min. to 1 h. Range 30 min. to 3-4 h.	30 min. to 8 h. The heavier the cow the more rapid is the expulsion of the placenta.	Unspecified	Roberts (1971)
Dairy	Primigravida 4 to 6 h. Multigravida 2 to 3 h.	Average - Primigravida 3 to 6 h. Multigravida 2 to 4 h.	70 min. (n = 1)	Unspecified	Anon. (1972)
Hereford		Average 1 h 52 min.+ Range 17 min. to 6 h 31 min.			Dufty (1972)
Hereford		Average 66±8 min.+	Bull calves (n = 17) 12.2±3.6 h. Heifer calves (n = 17) 6.4±1.5 h.	35	George and Barger (1974)

* Interval from rupture of the allantochoronic to delivery of calf.

+ Interval from rupture of the amnion to delivery of calf.

studies. This may be due to the problems involved in determining the time of onset of the stages or alternatively, it might simply reflect large individual cow variation. Arthur (1961) observed that frequently associated with the pain of first stage labour were straining efforts. Although there was a greater tendency for these to occur towards the end of first stage they were recorded as early as 2 h before the allantochorion ruptured.

Anon. (1972) recommended that 12 hours was the limit to considering parturition as being "normal". Craig (1937) found that parturition averaged 1 to 2 h, but that it could range from 15 min. to 2 d without injuring the foetus.

An "extensive" length of parturition has been shown to result in a decrease in the frequency of straining bouts and decline in the number and strength of abdominal contractions (Dufty, 1972).

4. Foetal Delivery

4.1 Presentation

The orientation of the foetus at its delivery is usually described in three aspects; presentation, position, and posture. These include all possible variations in the way the foetus enters the birth canal (Roberts, 1971).

Slipjer (1958) considered that ungulates were normally born in the cephalic presentation with the head lying on the forward stretched forelegs. Studies involving domestic cattle indicated this was the most common presentation. Dufty (1972) found 50 of 52 calves born from primigravid heifers were expelled in anterior presentation. Craig (1937) and Arthur (1966) described delivery of the bovine as occurring most commonly "feet first". George and Barger (1974) recorded all 38 calves observed were delivered in "normal" presentation.

De Snoo (cited by Slipjer, 1958) considered that calves expelled posteriorly often died due to premature onset of breathing which resulted in aspiration of fluids.

Position of the foetus was suggested by Slipjer (1958) to be caused by the distribution of space in the abdominal "canal" and by uterine contractions. Fraser (1976) presented a third factor, namely, foetal righting reflexes, which in cattle were found to occur about a week prior to parturition. A relationship was also described between the occurrence of dystocia and a condition termed "foetal inertia" in which the righting reflex did not occur.

Anon. (1972) observed that at some stage during its movement through the cervix the foetus rotated 90^{o} in an anti-clockwise direction which resulted in the foetal head making contact with the top of the cervix. However, Roberts (1971) considered rotation was unnecessary as the foetus was already in the dorso-sacral position by the time it had reached the cervix. Pressure of the foetal head was found to cause further relaxation and dilation of the cervix (Roberts, 1971; Anon., 1972).

Arthur (1961) found that in 80% of the cattle he observed the amnion ruptured as the foetus was being expelled. In the remaining cases the calf was expelled completely enclosed in the amnion.

4.2 Umbilical detachment

Few instances of the umbilicus being compressed in the pelvic region or twisted around the foetal extremities have been recorded. Slipjer (1958) provided two explanations; the relative short length of the umbilicus being only 20 to 30% of the length of the foetus and the stretching taut of the cord during foetal expulsion. The ungulate umbilicus was found to be able to withstand only one-half to one-eighth the weight of the foetus before it ruptured. As the placenta was uncommonly expelled with the calf, the umbilicus usually broke as the foetus passed through the cervix or when the cow stood up (Slipjer, 1958; Arthur, 1961; Fraser, 1968).

Arthur (1966) recorded that the umbilicus ruptured about 13 cm from the calf's abdomen. Slipjer (1958) reported that rupturing occurred either in the umbilical ring or at a distance of 5 to 20 cm from the abdomen. A possible function of the umbilical sphincter influencing detachment was discounted by him.

Haemorrhage following detachment of the umbilicus has rarely been reported. This is apparently due to the contraction of the two umbilical arteries into the body tissues (Craig, 1937). Drainage of blood from the umbilicus was considered by Roberts (1971) to be aided by the dam licking the cord.

5. Behaviour

5.1 Position and posture

Lehrmann (1961) reported a relationship between the posture of the parturient animal and the "manner" in which it established care of its offspring. For example, self-grooming and licking of the emerging foetal membranes and young were often associated with maternal assistance to the emerging foetus. It was suggested that this aspect of behaviour may be of considerable importance in analyzing the development of maternal care.

Slipjer (1958) concluded that the most common, and therefore the normal, position was recumbency. However, Lent (1974) considered the exceptions to be as numerous as the rule and Naaktgeboren (1963) observed bouts of contractions whilst standing and lying.

Donaldson (1970) recorded that in the early periods of parturition, the cow maintained a standing posture, but was seldom stationary. During the same interval Arthur (1961) and Fraser (1968) noticed frequent changes between standing and lying. These changes were interpreted as indicating an attempt by the cow to obtain relief from labour pains. Donaldson (1970) observed that from 6 to 11 h prior to delivery of the foetus the cow was never recumbent. Within the last hour of second stage labour the cow spent more time lying either in a completely lateral posture (Donaldson, 1970) or on her sternum (Craig, 1937).

In 74 of the 82 cows studied by Donaldson (1970) the waterbag was expelled with the cow in a recumbent position. Arthur (1961) observed that for the first part of second stage labour the cow usually stood, but for expulsion of the foetal head and shoulders the cow was fully prone. Craig (1937) believed that such a position occurred only in dystocia.

There is a disagreement between the different studies regarding the position of the cow during final delivery of the foetus. This may be due to differences in the stage of foetal expulsion used as the reference. For example, Arthur (1961) reported cows which stood after expulsion of the foetal shoulders, whilst Craig (1937) and Fraser (1968) indicated that in most cases the cow stood throughout foetal delivery. Conversely, George and Barger (1974) reported that the cow remained recumbent.

During standing contractions a characteristic posture similar to that shown during elimination of urine or faeces was described by Fraser (1968); Donaldson (1970); George and Barger (1974).

5.2 Straining

The strains increase in frequency, intensity and duration within and between the three stages of labour (Craig, 1937; Arthur, 1966; Fraser, 1968, 1974; Anon., 1972). Craig (1937) noted that within each contraction there was a characteristic pattern in the strength of the muscular activity. Initially the intensity was low, but it progressively increased to a maximum which persisted for a time and then gradually subsided.

Rate of cervical dilation, as a result of these contractions, was slower in primigravid cows, in instances where the foetus was in a posterior presentation, or when the uterus inclined too far downward thus causing the cervix to slope up toward the sacrum (Craig, 1937).

Between each bout of contractions, resting periods of varying lengths were observed. Arthur (1966) and Fraser (1968) considered that these rests allowed for the recovery of the foetus and dam and permitted the further preparation of the genital tract.

Expulsion of the placenta was considered by Roberts (1971) to be a complex process involving both mechanical and hormonal factors. Due to peristaltic waves of muscular contractions, beginning at the apex of the uterine horn, the chorion becomes inverted and the allantoic membrane is on the outside of the expelled placenta.

5.3 Vocalization

Craig (1937) described vocalization in the parturient cow as a bellow which first occurred during the restless phase, i.e., first stage labour. Donaldson (1970) noted that it was not until the cow became recumbent that any vocalizations were heard. As parturition progressed vocalizations changed in form and duration and resulted in other cows approaching the parturient cow.

5.4 Placentophagia

Fraser (1968) considered that placentophagia was common in cattle, but that it had become "modified" by domestication. Alexander *et al.* (1975) reported variations to be such that placentophagia was infrequent. George and Barger (1974) observed 14 out of 17 cows to exhibit placentophagia, but the amount consumed was not given. Selman *et al.* (1970a) found that only 2 out of 30 cows did not ingest the placenta.

Roberts (1971) reported that on occasions the cow would commence ingesting the placenta before it was fully expelled.

Craig (1937) recorded choking during consumption of the placenta and Arthur (1961) found that the cow was hindered because she was unable to bite pieces off the membranes.

When rumentomies were made the whole placenta was found intact (Arthur, 1961). A similar finding was reported by Fraser (1968) who considered that consumption did not provide any nutritional advantage but that the behaviour represented maternal adaptation to predation of vulnerable neonates. Placentophagia appeared to be characteristic of certain species which maintained their offspring close to the calving site, for several days post-partum, i.e., hider-type species, ref. Chapter 5:A2.

B. RESULTS AND DISCUSSION

1. Occurrence

1.1 Calving data

The heifers calved on average 13 d (range 4 to 19 d) and the multigravida 45 d (range 20 to 65 d), after the start of the study (Table 4.3).

Of the 18 cows, 14 calved, of which 6 were primigravid (P) and 8 were multigravid (M). Of these 14, there were 3 dead calves (P27-H; M30-B; M36-H) and 2 other calves were rejected by their dams (P31-H; P35-H). One cow (M36-14) had a stillborn calf following a parturition lasting >7 h. The heifer calf born to P27-1 died *c*. 20 h post-partum. Death was due to depletion of energy reserves resulting in hypothermia. From the observations it was apparent that abnormal maternal behaviour was the principal cause. The calf of M30-12 died 18 d post-partum. From the necropsy, behaviour and climate data death appeared to be due to starvation, as the calf was never observed to suckle. The cold, wet conditions present probably accented hypothermia.

1.2 Circadian rhythm

From Table 4.4, 9 of the 14 cows calved during the hours of light, i.e., 0600 to 1800 h. When these data were analysed for maternal status, i.e., primigravid *versus* multigravid, there was a highly significant difference (Binomial, $P<0.01$). Of the multigravid, half calved at night whilst there was a marked tendency for the primigravid to calve during daylight.

This higher number of daylight calvings supports the findings of George and Barger (1974), but conflicts with Arthur (1961). The difference may be a reflection of the management systems in the different studies. This present study and the observations of George and Barger (1974) involved the paddock situation, whilst Arthur (1961) observed housed cattle.

TABLE 4.3: Calving data

Cow identification No.	Maternal status	Calving date (days)[a]	Calving time	Calving site[b]	Calf sex	Calf birthweight (kg)
P27-1	Primigravid	4	1650	T9	H	26.4
P23-2		6	1020	T3	H	24.0
P31-3		16	0915	T5	H	28.1
P38-4		17	**	T6	B	23.6
P34-5		18	1250	T1	B	30.8
P35-6		19	1500	T4	H	27.2
M24-7	Multigravid	20	***	T1	H	27.2
M32-8		29	1027	T2	B	35.4
M22-9		31	***	T4/7*	B	31.7
M28-10		45	0200	T7*	H	24.5
M21-11		48	0700	T10*	H	29.0
M30-12		59	1200	T9	B	N.A.
M33-13		61	***	T10*	H	28.1
M36-14		65	1430	T4/7*	H	N.A.

[a] days after start of observations

[b] Ref. Fig. 4.2

* = Streambed

T = Grid area

** Calving time between 2000 and 0900 h

*** Calving time between 0000 and 0900 h

TABLE 4.4:

a. Proportion of primigravid (P) to multigravid (M) cows calving in sections A, B and C of the observation paddock (ref. Fig. 4.2).

Section	P:M ratio	No. of cows
A	2(33) : 1(13)	3(21)
B	1(17) : 6(75)	7(50)
C	3(50) : 1(13)	4(29)
Total	6(43) : 8(57)	14(100)

b. Proportion of daytime (D) calvings to nighttime calvings (N) in the respective sections.

Section	D : N
A	2(22) : 1(20)
B	4(44) : 3(60)
C	3(33) : 1(20)
Total	9(64) : *5(36)

Numbers in parenthesis refer to percentages

* 3/5 (60%) calved between 0400 and 0800 h

There was no calving activity during the period 1600 to 2000 h (Fig. 4.1). No explanation is readily available, but its occurrence may suggest that cows are able to exert some control over onset of parturition as was proposed by Fraser (1968). However, as only 14 parturitions were involved it is not possible to account for a possible effect of chance on calving time.

1.3 Calving site (ref. Table 4.4)

Calving occurred more frequently in certain areas of the observation paddock (Fig. 4.2). When the OP was divided into 3 sections there was a very highly significant difference (χ^2, test of independence, $P<0.001$) in the area used for calving. Of the 8 multipara 6 calved in section B. Of these, all except one (M32-8) calved in the streambed. This provided visual isolation for the cow for up to 20 m. The only multigravid cow to calve more than 36 m from the stream was M30-12 and her calving site did not appear to be of her own choice. During first stage labour the cow moved towards T1, which was an area devoid of other cattle. However, the rest of the herd followed and soon afterward M30-12 changed her location to T3. Thereafter she did not remain in any area and moved through T3, T6 to calve in T9. This mobility continued post-partum and probably had an effect on subsequent maternal behaviour.

In all except 2 primigravida (P27-1 and P23-2) social isolation by the parturient cow occurred. Usually this became evident during the earlier period of first stage labour, but 3 multigravida (M22-9; M28-10; M21-11) showed the behaviour up to 9 d pre-partum.

As labour progressed the cow localized in an area of *c*. 20 m^2. This was especially evident after rupture of the first water-bag, when the area usually became the calving site. The 3 cows which did not show this localization all had "abnormal" parturitions. The situation relating to M30-12 has already been described. The other cows (P34-5 and M36-14) had extended second stage labours, i.e., dystocia which was reflected in increased mobility (Fig. 4.3) and decreased straining activity in comparison to the other parturient cows. These observations conflict with Arthur (1961); Fraser (1968); Donaldson

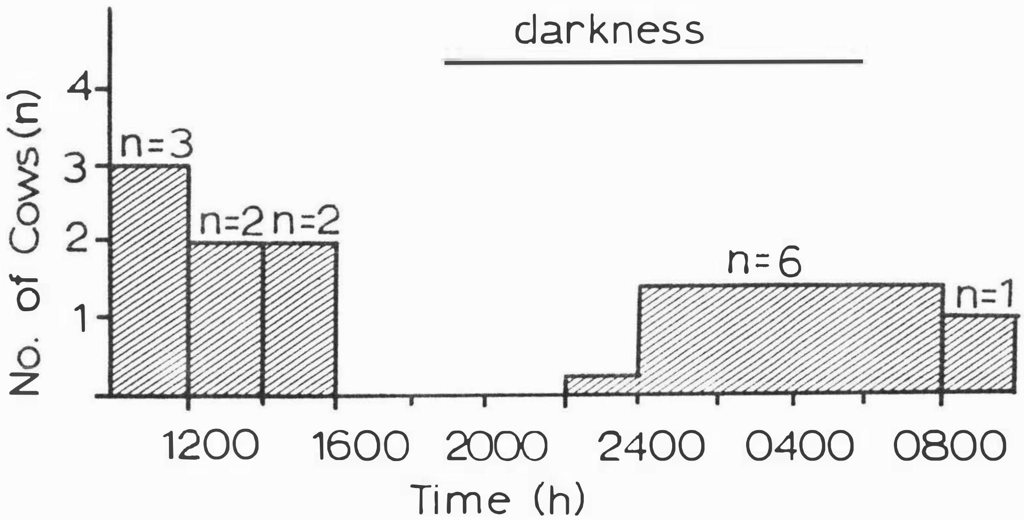


Fig. 4.1: Distribution of calvings over the 24 h period

N.B. The 6 cows which calved during the hours 2200 to 0800 h have been grouped together and averaged over the 10 h period as exact determination of their calving time was not possible.

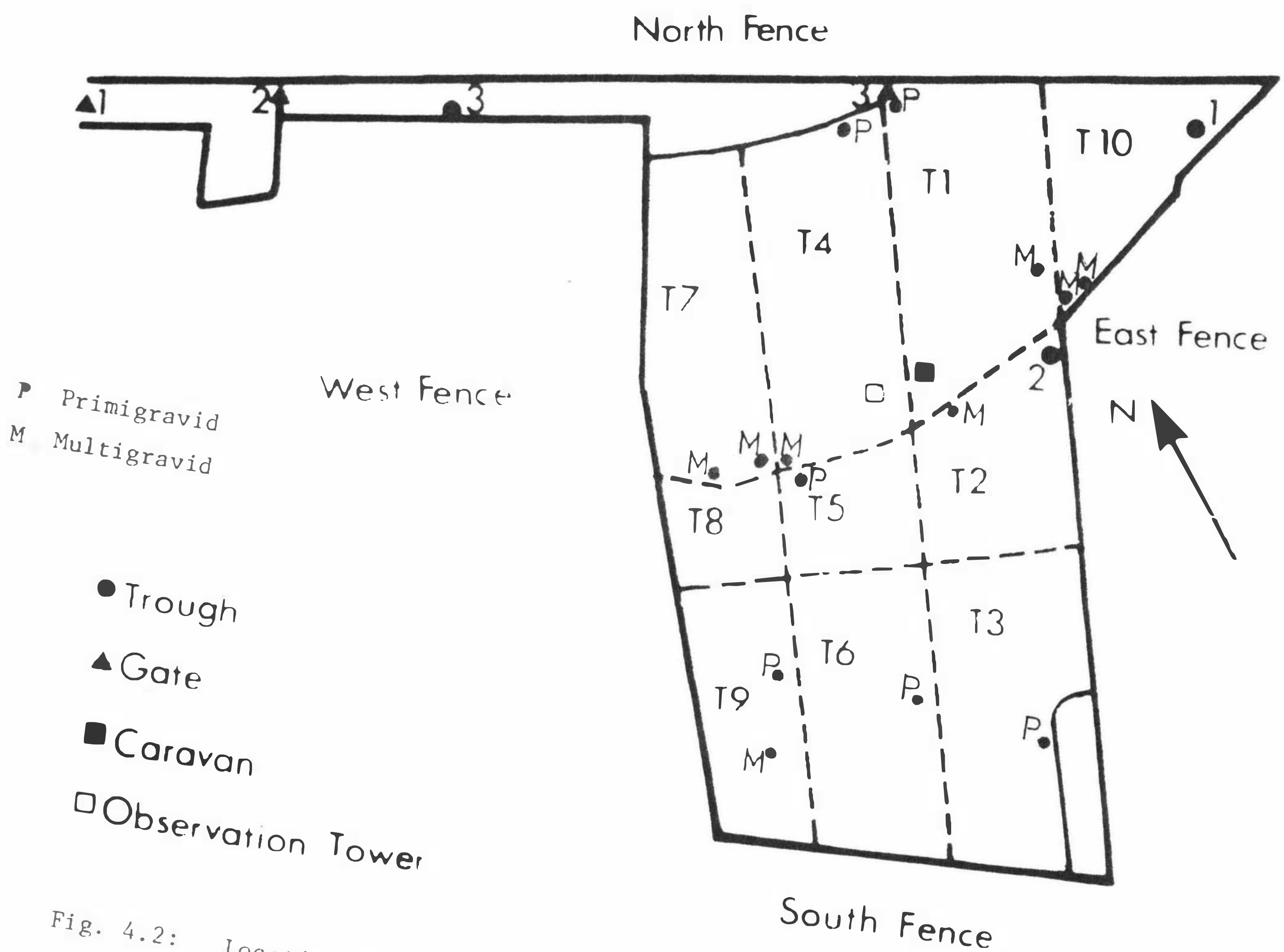
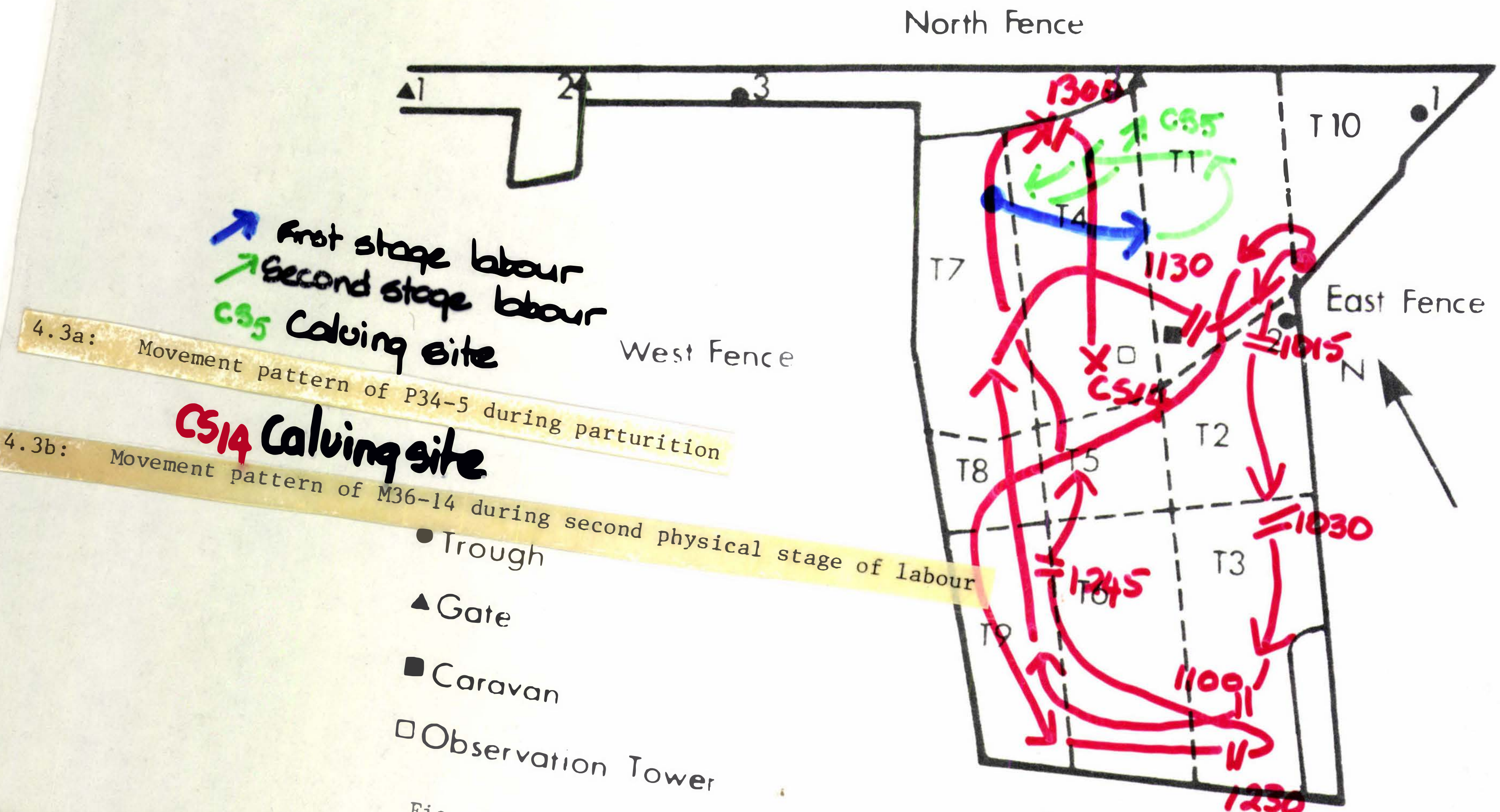


Fig. 4.2: Location of calving sites



4.3a: Movement pattern of P34-5 during parturition

4.3b: Movement pattern of M36-14 during second physical stage of labour

Fig. 4.3: Movement patterns during parturition*

* time presented in S.I. units

(1970) and Alexander *et al.* (1975) all of whom reported that once selection of the calving site was made, during first stage labour, it was unaffected by subsequent events.

Unlike Arthur (1961); Fraser (1968) or George and Barger (1974), there was no evidence of the cow "collecting" litter or grass with which to make a calving bed. Likewise, there was no defence of the calving area recorded in this present study.

2. Stages of Labour

2.1 Terminology

The term parturition is here used to denote the 3 physical stages of labour, ending in expulsion of the placenta. Calving and birth were restricted to describing expulsion of the foetus.

First stage labour is traditionally accepted as ending with dilation of the cervix. This requires internal palpation which was not possible in this study. Also, maximum dilation does not occur until the foetal head and shoulders have passed through the cervix, both of which are recognized as characteristic of second stage labour.

Using cervical dilation as the criteria it was extremely difficult to correctly determine when first stage labour had finished. Therefore it was decided to use either rupture of the allantochorion or the occurrence of specific behaviours as the criteria. Justification for the use of rupture of the allantochorion was based on its close temporal relationship to the end of first stage labour (Arthur, 1966). The behaviours characteristic of this period of parturition included ingestion of grass covered in birth-fluid, localization, isolation and self-grooming. Physical evidence of fluid and mucus over the hind-quarters and tail were also observed.

The criterion for termination of second stage labour was the same as that proposed by Arthur (1961); Fraser (1968); Roberts (1971), i.e., expulsion of the foetus on to the ground.

The delivery of the placenta signified the end of third stage labour. Uterine involution and associated events considered by Roberts (1971) to be part of third stage were not included in this study.

2.2 Duration of physical stages

Exact determination of the onset of first stage was not possible because many of the behaviours used as criteria were observed up to 29 d pre-partum. Accuracy may have been improved if continuous 24 h observations during the last 48 h pre-partum were possible.

Because of the tendency for many of the behaviours to be observed throughout the pre- and parturient period determination of the length of behavioural stages of labour was more difficult to achieve than determination of the duration of the physical stages. However, there was a tendency for certain behaviours to occur more frequently and/or at greater intensity at certain times and these were used as criteria for describing the different behavioural stages of labour (Ref. Chapter 4:B4).

Such behaviours as localization and isolation were observed only from multigravid cows. In these instances it was often associated with periods of increased mobility, each lasting less than 2 min. Other behaviours included an increase in elimination,and frequency of grazing but a decrease in the duration of each bout; adoption of PSR; SNP and SSP (Chapter 4:B3).

A summary of data obtained from 7 cows which were monitored throughout parturition has been presented in Table 4.5. The 2 cows, P34-5 and M36-14, experienced dystocia, i.e., an extended second stage labour. Despite this there was no apparent change in the length of third stage labour in one of these cows. In one of these cows (M36-14) the calf and placenta were delivered simultaneously.

Dystocia in P34-5 was due to a temporary inability of the calf's head to be passed through the vagina. This took over an hour to accomplish *versus* the usual 20 to 30 min. The greatly extended second stage labour in the primigravid cow did not appear to be due to foetal malpresentation as delivery involved "normal" presentation. There was no other explanation available but an internal examination of the cow may have provided some reason for the dystocia.

TABLE 4.5: Duration (min.) of the physical stages of parturition

Cow identification No.	First Stage	Second Stage	Third Stage	Elapsed time between passage of forelegs and birth
P27-1	70	56	250	20
P23-2	69	40	204	5
P31-3	72	60	156	10
P34-5	86	114	160	80
M32-8	60	40	>180	3
M30-12	76	47	200	3
M36-14	>900	270	0	270

All calves were delivered in normal presentation, i.e. cephalic presentation, dorso-sacral position with head dorsal to forward stretched forelegs.

Neonatal death by suffocation following rupture of the umbilicus during foetal delivery was never observed. A probable explanation is that on all occasions the amnion always ruptured prior to passage of the foetal head through the vagina.

3. Behaviour

3.1 Non-straining postures

3.1.1 Partial sternal recumbency (PSR Plate 4.1)

The parturient cow was found to lie down more often on her left side (χ^2, $P<0.10$) than on her right hand side.

PSR became more frequent during the latter part of the first stage labour and throughout second stage labour. During earlier periods and throughout third stage the cow spent a greater proportion of her time standing.

3.1.2 Squat recumbency posture (SRP Plate 4.2)

Squat recumbency posture was an intermediate posture, between lying and standing, in which the forequarters were off the ground while the rest of the body was kept on the ground. SRP was most frequently shown after a period of PSR when it lasted for up to 5 min. It was most frequently observed during the latter part of second stage labour.

3.1.3 Standing non-strain posture (SNP Plate 4.3)

The forelimbs were placed closer together than in normal standing rest posture as exhibited by other cattle. The hindlegs were wider apart and often positioned behind the body. Often the tail was slightly elevated and there was a slight arching of the back. The posture was most often observed just before and during first stage labour.

3.2 Straining postures

3.2.1 Standing strain posture (SSP Plate 4.4 and 4.5)

Standing strain posture was similar, but more exaggerated than the

Plate 4.1: Partial sternal recumbency (PSR) in the parturient cow
N.B. Lowered head, deflected pinnae and developed udder.

Plate 4.2: Squat recumbency posture (SRP)

Plate 4.3: Standing non-strain posture (SNP)

Plate 4.4: Standing strain posture (SSP) - anterior view

normal urination posture (NUP, Plate 4.6 or SNP, Plate 4.3). The front legs were *c*. 15 to 30 cm apart whilst the hindlegs were up to 1.2 m apart. There was also arching of the back and the legs were "drawn-up" under the body. The ears were out and back from the side of the head.

George and Barger (1974) first observed a posture analagous to SSP 1 to 3 h prior to rupture of the first water-bag. In this present study SSP was once recorded as early as 10 d pre-partum, but was most frequently observed within 3 h of rupture of the allantochorionic membrane. As parturition progressed through the first two stages the posture became more frequent and pronounced in form.

3.2.2 Partial lateral recumbency (PLR Plate 4.7)

Whilst straining, the recumbent cow would adopt a more lateral posture than in PSR with the body, except the neck and head, on the ground. It was most evident during the latter part of first stage and throughout second stage labour. Intense straining was characterized by rapid ear, eye and head movements.

3.2.3 Complete lateral recumbency (CLR Plate 4.8)

During CLR the cow was on her side with all legs extended out from the body, i.e., an exaggerated PLR posture. It has been included, in this present study, as a separate posture because Craig (1937) described the same posture as CLR but reported that it was restricted to cows showing dystocia. In this present study, CLR was observed in all cows during the latter period of second stage labour. The posture was also sometimes seen in cows rolling from PLR on to their sides, when it was accompanied with vigorous tail and head movements.

Muscular contractions of the abdomen and uterus were recorded up to 10 d pre-partum. In the earlier period of first stage and throughout third stage labour it appeared that only uterine musculature was involved, as visible movements were restricted to the flank region. At other times during parturition abdominal contractions were also recorded as a sequential motion along the side of the cow at about the midline.

Hypernoea often coincided with straining behaviour. This was most obvious during passage of foetal extremities through the vulva.

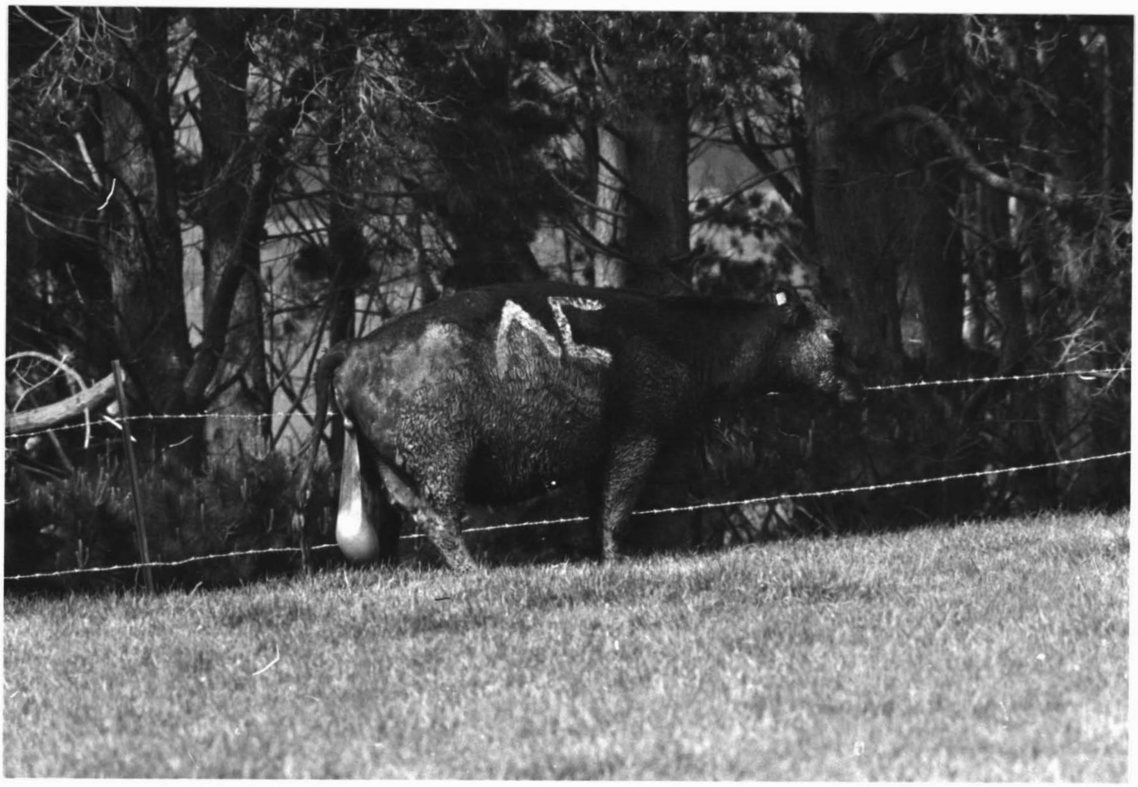


Plate 4.5: Standing strain posture (SSP) - lateral view

Plate 4.6: Normal urination posture (NUP)

Plate 4.7: Partial lateral recumbency (PLR)

Plate 4.8: Complete lateral recumbency (CLR)

Strains usually occurred in a series, within which each successive contraction was of greater duration. An increase in the intensity of straining as evidenced by more frequent postural changes, occurred through the first 2 stages of labour. These observations support the findings of Craig (1937).

During the first stage labour SSP was the most common posture. Thereafter PLR was the most frequently observed straining posture. In all except one multigravid cow, the calves were delivered when the cow was recumbent. Expulsion of foetal head and shoulders involved CLR in all cows.

During the third stage labour most straining activity involved SSP. This was probably influenced by the cow's preoccupation with grooming the calf. Visible movements were rarely observed and when it was it involved no more than 4 contractions each lasting less than 2 sec. Prior to expulsion of the placenta the cow became recumbent for *c*. 30 to 40 min. In the single example of a stillborn calf, the placenta was expelled simultaneously when the cow was recumbent.

3.3 Signs of pain (Plate 4.9)

Although contractions were usually preceded by what appeared to be painful sensations they were also observed independently of any straining activity. These sensations were exhibited as sudden movements by the cow and involved a change in position and/or posture, or some part of the body such as head, ear, eye, tail or leg. An alternative reason for these movements could be that they indicated extreme effort associated with straining. However, this is considered to be the less probable explanation for the following reasons:

(i) The movements occurred prior to visible muscular contractions which are indicative of the most forceful part of straining.

(ii) Movement included parts of the body not involved in straining activity.

(iii) The movements were nearly always accompanied by changes in posture and/or position which were not observed during straining, for example, PSR, SRP and SNP (ref. Chapter 4:B3).

These behaviours were observed in both the recumbent and standing cow, but were restricted to the first two stages of labour.

Movements denoting pain usually occurred immediately prior to

Plate 4.9: Signs of pain showing head and ear movements

Plate 4.10: Self grooming of the udder

straining activity. Movements of the head and ears were the most common signs (e.g., Plate 4.9). Less frequently recorded were leg, tail (Plate 4.14), eye and tongue movements. Sometimes the cow would rock along the longitudinal axis or roll laterally. Vocalizations, described as grunts, were also recorded. Tension in the udder was evident by the hindlegs being lifted up against the gland or by licking of the area (Plate 4.10).

3.4 Semi-erect posture (SEP Plate 4.11)

The parturient cow frequently showed a unique rising posture which was often maintained for up to 20 sec. This was defined as the semi-erect posture which was most common during the latter part of first stage and throughout second stage labour.

3.5 Walking (Plate 4.12)

Walking during parturition was the same as that described in Chapter 3 for the pre-parturient cow.

Initially it had no apparent pattern and the only motive appeared to be as movement to maintain a flight distance of 9 to 15 m from humans and herd mates. This mobility was frequently interrupted by short periods of standing (SNP) and/or ingestion. Throughout second stage labour, walking was relatively brief and rarely exceeded 20 steps. It commonly occurred after straining and was especially evident just prior to expulsion of foetal extremeties. Walking also followed some disturbance due to close proximity of another animal or by sudden noises.

Unless second stage labour was extended for more than 1 h or if there was a persistent disturbance the parturient cow remained within an area of 10 m once first stage was completed. In these cows the area eventually became the calving site.

3.6 Investigation (Plate 4.13)

The cow would slowly move within a 9 m^2 area, keeping her muzzle at ground level. Head movements sometimes included "sweeping" movements plus occasional head jerks, ear movements and licking of the muzzle. Sweeping of the head involved lateral movements from one side to the other. They were made anteriorly and appeared to be directed at a particular area of the ground. During sweeping the head was held less than 5 cm above the ground (Plate 4.13).

Plate 4.11: Semi-erect posture (SEP)

Plate 4.12: Walking
N.B. Eye and pinnae positions

The behaviour was confined to the area and objects, including the cow, over which birth fluids and membranes had been deposited. It was most commonly shown immediately after a straining session. The cow would turn 180° and put her muzzle over the area in which previously the genital region had been located.

3.7 Ingestion (Plate 4.14)

Ingestion principally involved birth fluids and membranes, but also included grass, soil and body hair covered in mucus and other birth by-products. Self-grooming around the flanks, hindlegs and tail was also recorded (Plate 4.10).

Prior to rupture of the first water-bag grazing was evident. However this activity differed from the usual procedure observed in other cattle. The parturient cow tended to intersperse brief grazing periods (1 to 3 bites of grass) with walking, usually less than 6 m. On the commencement of second stage labour, ingestion and associated walking activity became very restricted in area. Two possible explanations for this modified grazing are: a displacement activity or as a positive reinforcement mechanism. The adaptive value of the latter may be to ensure the cow's continued localization in the area.

Another form of ingestive behaviour observed only in the parturient cow was placentophagia (Plate 4.15). This was recorded in 12 of the 14 post-parturient cows. The two exceptions were both primigravida (P27-1 and P23-2).

Placentophagia involved the entire placenta. It began immediately on expulsion and continued until all had been consumed. Contrary to Arthur (1961) there was no evidence of the cow arranging the placenta before ingestion began. During consumption the cow ceased all other activities including maternal grooming of the neonate. In one first-calving cow this preoccupation with the placenta resulted in separation between the cow and neonate and subsequent rejection of nursing attempts.

Three primipara were observed to start ingestion prior to the complete expulsion of the placenta. Two of these cows kicked out at and head-butted the hanging membranes. Both cows showed abnormal maternal behaviour, i.e., agonism and disinterest, which resulted in death of one of the calves and rejection of the other.

Plate 4.13: Investigation of birth fluids

Plate 4.14: Ingestion of birth fluids

It is suggested that placentophagia is a further example of attraction to the birth fluids. This attraction results in maternal acceptance of the calf, e.g., maternal grooming and maintenance of the cow's presence at the calving site during and after calving. This minimized the likelihood of desertion and increased the chances for cow-calf interactions which would aid the success of sucking and primary socialization.

3.8 Rumination

During parturition, rumination ceased and did not recommence until several hours after expulsion of the placenta. Whether this was due to reduced gut content, pain inhibition or an overriding effect of parturition on non-essential activities, it was not possible to determine.

3.9 Elimination

There was an increase in the frequency of both urination and defecation during the early part of first stage labour. Usually successive voiding sessions occurred within minutes. On each occasion the volume was less than that voided by the non-parturient adult cow.

3.10 Vocalization

Three distinct forms of vocalization were recorded; call, grunt and bellow described by Selman *et al.* (1970a). Each was characteristic of a particular time during parturition. The cows varied in the frequency and duration of each of the three forms. Primigravida infrequently vocalized prior to calving, but all reacted to their first sight of the neonate by bellowing. In contrast the multigravida frequently exhibited the "call" vocalization whilst straining, especially during rupture of the allantochorionic membrane and expulsion of foetal head and forelegs. Call vocalization was also made when the cow orientated toward some disturbance such as close proximity of herdmates or barking dogs.

The third form of vocalization, the grunt, was made by several of the multigravida when investigating and ingesting birth fluids. This vocalization was later exhibited when grooming the calf and may have been important as a maternal characteristic learnt by the calf.

Variations in the presentation of these three vocalizations were common. For example, the call was alternated with the grunt as "mmh - moo - mmh" which was repeated without pause 2 to 4 times. It occurred during second stage labour when the cow was walking or showing vigorous movements suggestive of pain.

The bellow was only recorded from first calvers when seeing their calves or by certain of the multipara when showing maternal defence against dogs. It involved a characteristic posture; the head was extended out from the body, the mouth opened and directed either at the calf if primiparous, or at the dogs. The ears were held against the head and lowered from their usual position. The eyes were opened and the chin was extended forward (Plate 4.16).

3.11 Social behaviour

3.11.1 The parturient cow

The first recorded change in social behaviour was isolation. This was observed for all multiparous cows, but involved none of the primigravida. Due to this social isolation opportunity for interaction with other cattle was low and involved only 4 parturient cows. Only if the intruder was of lower social rank and therefore less likely to win the encounter, would agonism result. This agonism was never shown to calves, either in response to their proximity or to their physical contact with the parturient cow.

3.11.2 Other cattle

Bellow vocalization emitted by first-calvers sometimes resulted in herdmates collecting around the parturient cow and exhibiting mounting, head-butting, flehmen and investigatory behaviour. At the first 2 calvings all cattle, irrespective of maternal status or reproductive status, showed such interest. With succeeding parturitions this interest involved only non-lactating primigravida and ceased to occur after the fourth calving.

Plate 4.15: Placentophagia

Plate 4.16: Bellowing by the post-parturient cow

4. Discussion

The occurrence and relationships of the behaviours observed in the parturient cow have been outlined in Fig. 4.4

Each of the straining postures tended to become more frequent as parturition progressed, up to the end of second stage labour. Each of these 3 straining postures tended to be characteristic of certain periods of parturition. Initially SSP was the most common until the end of first stage labour. During the majority of the following stage PLR was the most frequently recorded posture. CLR became more prevalent during expulsion of the foetal forequarters and the thorax, although PLR, and to a lesser extent SSP, were also exhibited. During most of third stage labour all except one primiparous cow remained standing and hence SSP was the only straining posture. From 20 to 60 min. prior to expulsion of the placenta the cows became recumbent and the subsequent posture observed was PLR.

Non-straining sessions varied in duration, but on all occasions they were characterized by quiescence and immobility from the cow. This suggests that they represented either resting periods, allowing recovery of the foetus and cow as postulated by Arthur (1966) and Fraser (1968), and/or that they permitted sufficient time for further dilation of the genital tract.

The group of behaviours traditionally included under the general heading of restlessness included; isolation, walking and heightened reactivity to disturbances. All were characterized by a high degree of activity during which the parturient cow acted independently of the rest of the herd. Restlessness was used as the first conclusive behavioural evidence that parturition had begun.

The most common of these behaviours was walking. A similar conclusion was reached by Fraser (1968); Donaldson (1970) and George and Barger (1974). It involved changes in the gait and speed of movement, but appeared to be unrelated to external conditions such as weather or feed availability and to have no goal. As parturition progressed the cow usually exhibited a characteristic standing posture

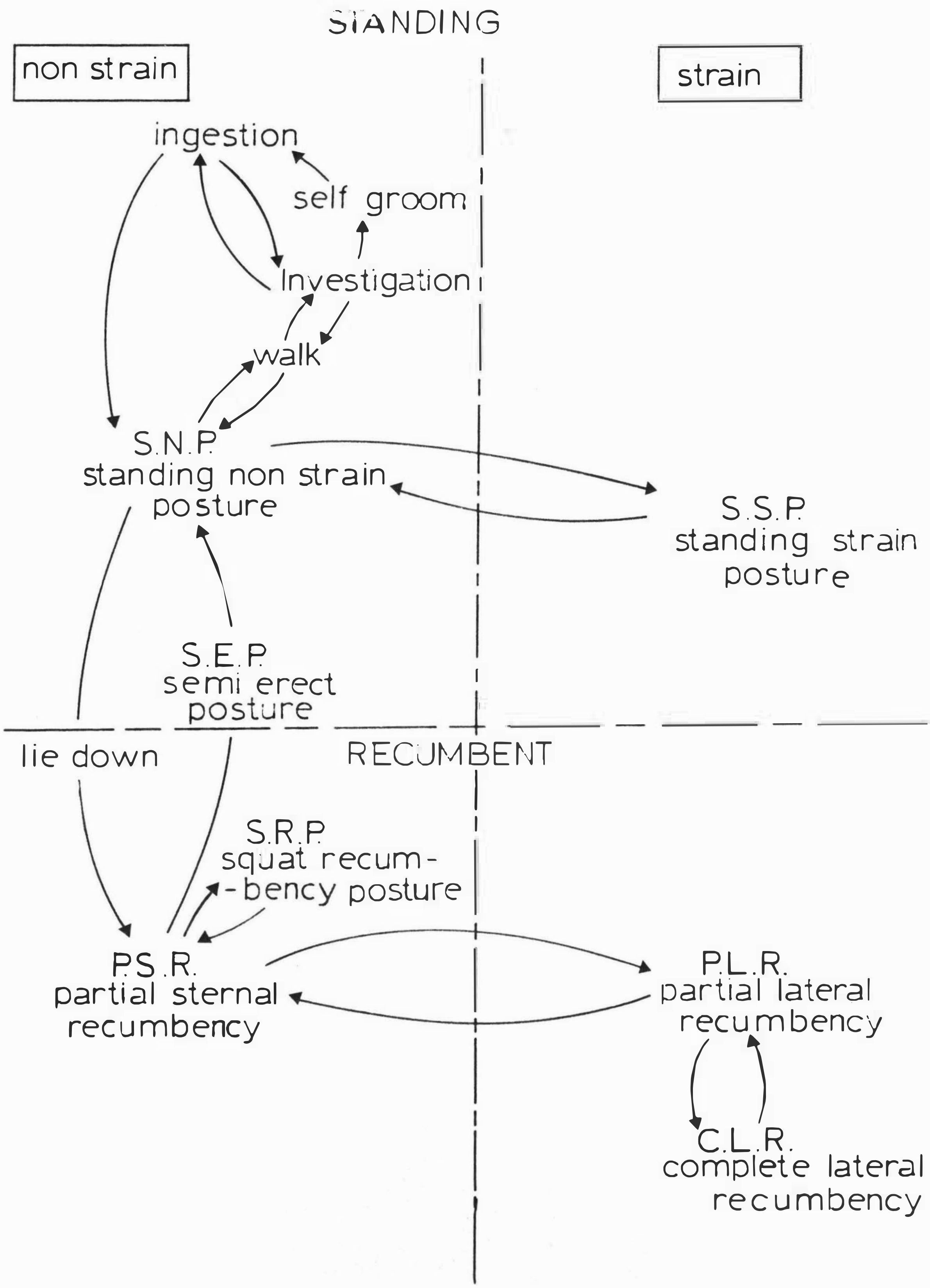


Fig. 4.4: Behaviour sequences during straining and associated periods of parturition

described as SNP. This was gradually succeeded by frequent changes between standing and lying, often intercepted by brief periods of walking. Heightened reactivity from both the physical and social environments increased during the first 2 stages of labour. The cow reacted by turning her head in various directions and orientating her body toward the disturbance. Usually other activities ceased until either the disturbance ended or the cow left the area.

CHAPTER FIVE

THE COW-CALF BOND

A. LITERATURE REVIEW

1. The Dam-Offspring Relationship

Two distinct forms of ungulate mother-infant relationship have been described by Walther (1961, 1964, 1965, 1968). These were referred to as the "Ablieger Typ" (lying-out or hider-type) and the "Nachfolger Typ" (follower-type). A diagrammatic representation depicting the ontogenetic differences between the two forms (Fig. 5.1) was presented by Lent (1974). From birth until termination of the relationship the two types (hiders and followers) had similar relationships with the exception of the "hiding period" during which the infant was isolated from all social contact except with its mother. The duration of this period varied greatly between species (range 2 to 120 d), but it was reasonably constant within each species. In domestic cattle, Wagnon (1963) and Yeates and Schmidt (1974) recorded that during the first 2 to 3 d post-partum the calf stayed close to the calving site. When the cow was absent for feeding and drinking the calf remained secluded. On those occasions the cow usually stayed away from the calf the minimum time.

2. Maternal Behaviour

2.1 Importance

In mammals maternal behaviour occupies a central position in the lives of the mother and offspring and in the social organization and preservation of the species. Rheingold (1963) summarized the importance of maternal behaviour with the following statement "for the mother parturition, an event of considerable biological significance, signals maturity and her behaviour is profoundly modified by the presence of the young. For the young the behaviour of the mother is crucial not

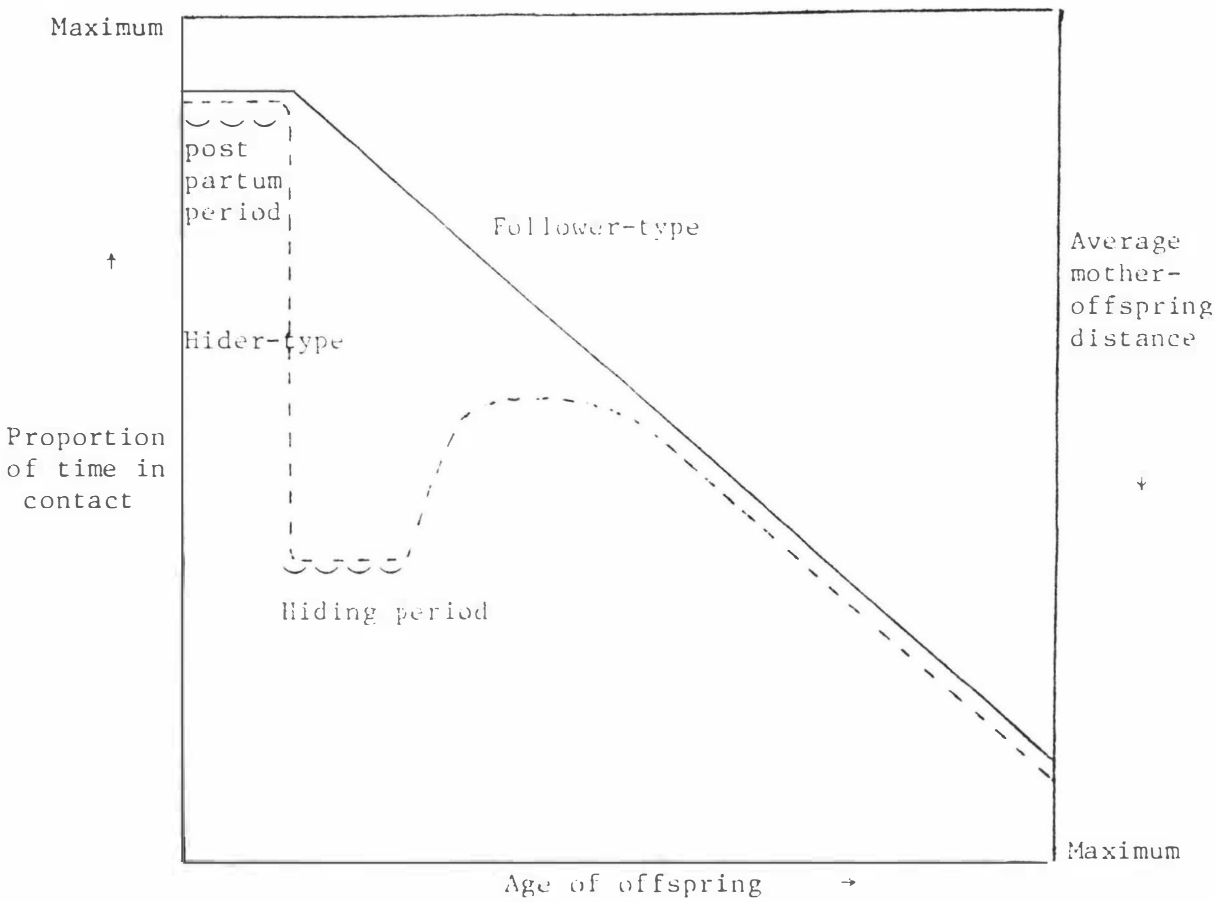


Fig. 5.1 Dam-offspring relationships in the ungulate (Lent, 1974)

only for life itself but for its own subsequent adjustment into the environment into which it is born. In this environment other members of its species are prominent elements; the extent to which it has contact with them and the nature of this contact are mediated by the behaviour of its caretaker".

Care behaviour need not be restricted to the dam, but may also involve surrogates, that is replacement mothers, males and peers of the young animal. Maternal influence on the inheritance of behaviour was extensively studied by Broadhurst (1961), but at that stage there was no data available for domestic cattle.

2.2 Terminology

Hediger (1955) distinguished between "passive" and "active" types of ungulates in relation to the behaviour of the mother during the immediate post-partum period. Lent (1974) observed that this period was characterized by intense reciprocal stimulation between mother and infant and that it varied from 1 to 10 h depending on the species. Passive species were characterized by a low level of maternal interest in the neonate. By contrast active type mothers showed a high degree of maternal attendance in the form of grooming and vocalization.

Two parameters have been used to measure bovine maternal care; distance from and attention displayed toward the calf (Broom, 1977). It was observed that during the 2 to 3 h immediately following birth most cows spent 90% of their time within 2 m of their calves and frequently sniffed and licked the neonate. By the second day the median distance between the two had increased and the cow displayed less attention toward the calf and instead feeding became more frequent.

2.3 Factors affecting maternal behaviour

Herrenkohl and Sachs (1972) considered that maternal behaviour should not be viewed as a single unit as it consists of a variety of behaviour patterns which achieve a common purpose, but are under different kinds of control. This may explain to some extent the changes seen in maternal behaviour as the infant ages. These changes probably reflect the rate and form of behavioural development of the infant.

No single sensory input appears to be the sole requisite for the elicitation of maternal behaviour. Lent (1974) believed that movements, colour and vocalization of the young animal all acted to stimulate maternal responses.

The two most important factors controlling maternal behaviour were considered by Kiley-Worthington (1977) to be the hormonal state of the dam and external stimuli from the offspring. Donaldson (1970) studied dairy cattle and noted that a greater variety of factors such as difficulty of labour, previous maternal experience, human interference, behaviour of the calf and disposition of the mother, influenced maternal behaviour.

2.3.1 Hormonal aspects

Fraser (1968) considered that reproductive behaviour was determined partially by the physio-chemical state of the subject, and in particular, by the endocrine state. Kiley-Worthington (1977) suggested that "something" in the actual process of parturition triggered off maternal behaviour. The justification for this was that cows delivered by caesarian section would often not accept their calves until confined with them for some days in isolation. An alternative reason for this reluctance of the cow to accept her calf born by caesarian section may have been due to the effects of anaesthesia on the expression of maternal behaviour.

2.3.2 Maternal experience

Donaldson *et al.* (1972) observed that cows which were "poor" mothers at their first calving improved at their second, but were still inferior to cows that had taken good care of their first calves.

The effect of experience on maternal behaviour appears to be common throughout domestic species. Hafez (1964) emphasized this difference between primiparous and multiparous cows. He considered that maternal behaviour in the experienced animal was facilitated by the reflexes conditioned during previous lactations; in primiparous cows their behaviour was inhibited by the pain and shock of parturition. Lent

(1974) considered that under normal situations the presence and activity of the ungulate neonate provided visual stimulation which appeared to encourage further maternal behaviour. However, in certain individuals, especially primiparous animals, the offspring appeared to "frighten" the mother and lead to a postponement of all maternal care including nursing.

2.3.3 Social rank

Calhoun (1949) recorded a relationship between a cow's social rank and her maternal ability. Usually the less dominant individuals were the "poorer" mothers. Calhoun believed this association was a reflection of the respective nutritional status of the cows. The theory was that the less dominant animal had the lower food intake. The justification for an association between food intake and maternal ability was not presented.

Donaldson (1970) recorded a positive relationship between social rank and a cow's success in calf stealing.

2.3.4 Rearing method

Donaldson *et al.* (1972) found that cows hand reared in social isolation differed in their mothering ability to those reared in groups. Cows raised together were more vocal, ignored their calves, partially cleaned them and failed to allow nursing. Broom (1977) observed that heifers which had been reared in social isolation for the first eight months of their lives exhibited the same behaviour patterns of sniffing and licking their calves as did group-reared heifers. However, they were less responsive to changes in the activity of the calf and by the first 3 h post-partum were as likely to turn away from the calves as toward them.

Although early experience does influence subsequent behaviour the effect of this experience is not fixed, but has been shown to be dependent on a number of factors such as the age of the animal at the time of the experience and the duration and type of experience (King, 1958).

2.3.5 Management over calving

In one example cited by Kiley-Worthington (1977) mismothering was reported to have caused 25% of the calf deaths which were all due to trampling. This was believed to be due to the "very high" stocking rates imposed over calving. Neither the number of animals nor the stocking rate were specified in the study. Kiley-Worthington (1977) considered that confining together pre-parturient animals leads to the occurrence of over-solicitous behaviour toward any neonate and sometimes results in mismothering.

2.4 Description

2.4.1 Grooming

Numerous functions have been suggested for licking during the post-partum period. It has commonly been viewed as one mode for reciprocal stimulation between mother and offspring. This stimulation was believed to increase neuro-excitability and thus promote motor development in the neonate, thereby increasing its chances of survival. At the same time the mother would receive olfactory and gustatory stimuli which appear to be important in strengthening maternal behaviour in general and in particular the social bond with the offspring. Much experimental evidence to support this theory has been demonstrated in sheep and goats (e.g., Hersher *et al.*, 1963a).

Amongst cattle, maternal licking and muzzling appear to be the principal methods by which the cow grooms and/or stimulates the calf, although Naaktgeboren and Vandendriessche (1962) observed cows to prod the calf with the head.

Another role of licking often considered to be important is its drying action on the neonate's coat thus aiding in its thermoregulation. Although no work is available on cattle, studies involving sheep found that maternal grooming was a relatively inefficient drying mechanism in comparison with evaporation (e.g., Rowley, 1970).

Schneirla (1965) demonstrated that maternal licking orientated the neonate's responses toward the mother, especially during the teat-seeking period. Licking was also found to stimulate urination and defaecation in the offspring (Fraser, 1974).

The only quantitative data available for the duration of maternal grooming of the bovine neonate were provided by Selman *et al.* (1970a, Table 5.1).

TABLE 5.1: The duration of initial, continuous maternal grooming (Selman *et al.*, 1970a).

Dam	No. of animals	Mean (min.)	S.D. (min.)
Beef cows	10	48.3[a]	± 37.1
Dairy heifers	8	11.0[b]	± 8.5
Dairy cows	7	32.9[c]	± 18.5

Note: a, b and c are significantly different (P<0.01) from each other.

Licking was observed to include objects such as straw which had received birth fluids (Selman *et al.*, 1970a). Licking and ingestion of part of the umbilical cord (Donaldson, 1970) and meconium (Selman *et al.*, 1970a) have also been observed.

Licking may be delayed as a result of the cow's slowness in rising after the calf is born (Selman *et al.*, 1970a). This was commonly recorded in cows which had shown dystocia (Donaldson, 1970). The failure of a cow to lick her calf was sometimes found to influence subsequent maternal attention (Selman *et al.*, 1967).

2.4.2 Protection

Donaldson (1970) observed that the cow ceased any protective behaviour during labour and did not resume until she began grooming her calf. This protection appeared to be in defence of the area where the calf was situated and not to the calf itself. Typically the cow would deny access,to herd mates and humans alike, closer than 3 m.

Wagnon (1963) observed instances in which cows actively "hunted" for their calves. The searching was restricted to daylight and in all except one example the calf was close enough to be aware of its dam's vocalization and yet it was never observed to make any response to its dam's activity.

2.4.3 Vocalization

Selman *et al.* (1970a) recorded three distinct sounds from the post-parturient cow. Each occurred in association with a particular form of maternal behaviour at different times post-partum. Donaldson (1970) found an association between a particular form of vocalization described as a bellow and a tendency for her to show rejection of the neonate.

Vocalization from calves occurred much less frequently than from cows and appeared to be restricted to when the calf was frightened. Wagnon (1963) recorded communication between separated cows and calves. Apparently the two animals were informing each other of their respective location.

2.4.4 Nutrition

The most obvious function of maternal behaviour is the provision of nutrients. This has been proved to be of vital importance in the transfer of passive immunity (Mohammed, 1975) and growth rate especially in the earlier stages of the post-natal period (Brumby *et al.*, 1963; Franke *et al.*, 1965). Most behavioural studies have discussed the various components of maternal behaviour related to nutrient transfer in the contexts of teat seeking and nursing.

Another important contribution of the mother is in the development of solid food intake. To date no work is available in domestic cattle, but evidence in the moose indicated that young calves learned by following their mothers and eating the same vegetation that the adults ingested (Edwards, 1976). The close and enduring social relationship between the mother and infant may also affect the calf's future feeding sites. Edwards (1976) found that the transition from nursing to grazing was initiated by the dam's refusal to allow calves access to the udder. Hodgson (1971) using domestic cattle found that withdrawal of access to milk rapidly stimulated solid food intake. It is this relationship which enables weaning of calves at a very early age, i.e., two weeks post-partum.

2.4.5 Abnormal maternal behaviour

Three major types of abnormal maternal behaviour have been described in domestic cattle; failure of maternal drive to appear with parturition (Kiley-Worthington, 1977), rejection of the neonate (Fraser, 1968) and non-acceptance of the calf's teat-seeking activities (Selman *et al.*, 1970a).

Donaldson (1970) distinguished between three distinct forms of rejection of the neonate; delayed acceptor, "walk away" rejection and "violent" rejection. The most outstanding difference between a rejector and a delayed acceptor was that the rejector could easily be driven away from the calf whilst the delayed acceptor would withstand verbal and physical abuse to stand over or stay near her calf. In the "walk away" syndrome no amount of enforced proximity would evoke the mother to exhibit any maternal behaviour to the calf. The more violent form of rejection involved the mother attacking the calf and in one instance this was found to be the direct cause of the calf's death.

Certain unspecified behaviours of the neonate were found to induce agonism from the dam, especially in the case of weak calves (Donaldson, 1970).

Selman *et al.* (1970a) observed a form of maternal rejection which occurred as the calf attempted to teat seek. This rejection consisted either of the cow moving away from, or kicking out at the calf. At some stage during the 8 h post-partum observation period, 15 of the 30 cows rejected teat seeking advances of the calf. In 13 of these the rejection was temporary and was usually restricted to when the calf was extra vigorous in pushing at the udder or when sucking the udder or belly and nibbling the teats. In the remaining 2 cases both calves appeared weak and rejection lasted 5 h and 8 h respectively.

3. Filial Behaviour

In 1970 a comprehensive review on the mammalian parent-offspring relationship was presented by Harper. The conclusion included two points which are of interest to this study. First, a disproportionate amount of emphasis was shown to have been placed on the importance of the parental role in modifying offspring behaviour; the caretaker is also affected by the offspring. Secondly, prior experience with a caretaker is not always essential for the development of the offspring's tendency to display gregariousness, species-typical social responses or exploratory-manipulative behaviour.

In the post-partum period the behaviour of the young ungulate has two main effects: formation of the dam-offspring bond (i.e., primary socialization) and milk ingestion (i.e., sucking).

3.1 Formation of the dam-offspring bond

Moltz (1963) suggested a common factor for all stimuli that had been found to lead to primary socialization; he believed that the process occurred in response to low intensity stimuli. This relationship between the type of stimuli and process of bond formation was substantiated by Schneirla (1959 and 1965) who developed the theory of bi-phasic approach/withdrawal processes by which animals discriminate between stimuli. This involves positive (that is, approach and following) responses toward stimuli of low intensity and negative (that is, withdrawal and fear) responses toward stimuli of high intensity. The relationship between stimuli eliciting the appropriate approach response was presented by Seitz (1940) in the law of heterogenous summation of stimuli (i.e., additive effect of various stimuli). This additive effect of different types of stimuli was demonstrated in cattle by Soffié and Zayan (1977).

The appearance and termination of these infantile behaviour patterns which maintained or prevented contact were believed by Scott (1962) to be one of the timing mechanisms for bond formation. The occurrence of these responses was found to be dependent on the perceptual and motor capabilities of the newborn animal.

3.1.1 Following response (Fo.R)

An alternative term to "following response" is the "heeling" response; these behaviours describe the predisposition of the neonate to relate to, by approaching and/or following, some object. In this present study the term "heeling response" has been used exclusively to refer to calf movements toward a stationary cow. "Following response" has been used to describe the calf's following of its dam in response to her movement away. The Fo.R functions to ensure rapid attachment to some object, which is usually the dam (Fox, 1968). Portmann (1961) considered the Fo.R to be part of the behavioural repertoire of all precocial ungulate infants. Expression of the Fo.R varies between different species (Walther, 1964; 1968) especially between hider and follower types.

Initially the behaviour occurs as a generalized following response (GFR) by which the infant attempts to maintain proximity to some object in its environment. The GFR can be shown to humans and other species. Although the response is initially non-specific, certain conditions are more likely to elicit the behaviour (Walther, 1964; Lent, 1974). For example, the object to which the infant orientates, approaches and then follows should be of an appropriate (i.e., larger than the infant) size and moving away from or tangentially to the infant.

Lent (1974) reported that the GFR was associated with a process which might result in only the mother or mother-object eliciting its appearance. However, under adverse conditions, e.g., presence of a predator, the specific following response (SFR) may be temporarily suppressed and a GFR toward the herd reappears.

In certain species, especially hider-type species, the mother has been observed to inhibit or prevent Fo.R. There have also been cases where the dam induced the response. For example, Wagnon (1963) recorded this in cattle especially when the cow was moving and the calf would not follow.

The exhibition of a Fo.R has often been used as a means of determining whether bond formation has occurred (Manning, 1972; Klopfer, 1974). Sluckin and Salzen (1961) considered that the occurrence of primary socialization resulted in termination of the GFR. Conversely, Lent (1974) believed that the bond formation was partly due to the presence of the SFR, i.e., the GFR was itself responsible for the formation of a SFR.

3.1.2 Prone response (Po.R)

Alternative terms to "prone response" include "freezing", "skulking" or "lying-prone". The Po.R was commonly observed in young hider-type ungulate species (Lent, 1974), and acts as a cut-off mechanism preventing expression of the Fo.R. Waning of the Po.R is associated with the development of a fear response to alarming stimuli.

These behaviours have been described for several cervids and bovids, e.g., white-tailed deer (Carhart, 1946), red deer (Perry, 1952), Caribou (Lent, 1966), domestic goat (Collias, 1956), bison (McHugh, 1958), Grant and Thomson's gazelles (Estes, 1967; Autenrieth and Fichter, 1975).

Under alarm situations mature individuals have been observed to exhibit this behaviour (Lent, 1974). This regression to an infantile behaviour was suggested by Bubenik (1965) to indicate that learning was not involved and that the behaviour was innate.

3.1.3 Fear response (Fr.R)

Fear response is caused by the animal's tendency to avoid the unfamiliar. The occurrence of the response has been found to increase as the animal ages (Fox, 1968).

Two other functions of the fear response have also been reported. Sluckin (1964) believed it to be one of the events leading to termination of primary socialization. Scott (1962) considered that it also had the dual effect of facilitating formation of the mother-young bond and terminating the critical period for primary socialization.

3.2 Milk ingestion

3.2.1 Importance

The time involved prior to milk ingestion is of critical importance in ensuring survival of the newborn animal. Depletion of internal energy reserves by muscular activity and thermogenesis occurs fairly rapidly in the newborn calf, although the rate of heat production through thermogenesis is dependent on environment conditions (Appleman and Owen, 1971; Holmes and Maclean, 1975).

The length of time to the first successful suck has been shown to have a direct effect on calf health (Smith, 1962). The most obvious reason is the need for absorption of adequate concentrations of colostrum-derived globulins. Gay *et al.* (1965) found a high positive relationship between serum concentrations and survival in 4 to 7 d old bull calves. However, uptake is restricted by the efficiency of absorption from the gastrointestinal tract (McDonald, 1975). Hansen and Phillips (1949) and Deutsch and Smith (1957)reported this period to last 24 to 30 h post-partum. Brambell (1970) reported a much shorter period of several hours post-partum. The length of maximum absorption was reported to be influenced by many factors including the specific immunoglobulin under study (review, Mohammed, 1975). Logan *et al.* (1978) demonstrated that there is a delay of *c.* 3 h between a calf obtaining its first feed of colostrum and the appearance of immunoglobulin in the blood. Approximately 5 h is required between the first feed and half maximal blood levels being achieved.

Location of the teat has been found to involve two main components: drive and learning. The term drive is often used in reference to a specific motivation (Hinde, 1970; Manning, 1972). Learning was defined by Thorpe (1963) as "that process which manifests itself by adaptive changes in individual behaviour as a result of experience". Of the six classifications of learning, devised by Thorpe (1963), the one which best fits location of the teat was defined as "trial and error". The activities of the calf which result in the location of the teat were explained by Fraser (1968) by the concept of the "innate releasing mechanism" (IRM). This concept was developed by Tinbergen (1951) and symbolizes the specific relation between a particular stimulus character and a certain response.

Teat seeking activities of most ungulates can be divided into 5 stages; recumbency movements, elevation, ambulation, environmental exploration and udder searching. These were considered by Fraser (1976) to represent 5 of the 7 primary stages which could be recognized in the repertoire of ungulate behaviour during formation of the mother-offspring bond.

3.2.2 Time to stand

Donaldson (1970) found that first standing by the neonatal calf could occur by 20 min. post-partum. Selman *et al.* (1970b) observed that all 30 calves studied were standing by 126 min. after their birth.

Time to stand has been found to be affected by such factors as: position of the cow at the calf's birth, breed effect and maternal status (primigravid *versus* multigravid). Calves, delivered from recumbent cows, were slower to stand than calves born whilst the cow was standing (Donaldson, 1970; Selman *et al.*, 1970b). Beef calves were found to be significantly faster at standing than were dairy calves. Calves of primigravid cows showed greater variation in the time taken to stand. No account was made of factors associated with the primigravida such as duration of labour, calf birth weight or maternal behaviour.

3.2.3 Approach

The calf usually exhibits a very direct movement toward a specific object in its environment (Hafez and Bouissou, 1975). This was described as the result of an innate "drive" (Fraser, 1963) and is characterized by a high level of activity in the newborn calf. The expression of this drive was found to differ between calves (Selman *et al.*, 1970b). Hafez and Lineweaver (1968) observed that twin calves showed weaker "vigour" than singletons, and this difference was reflected in their behaviour during the post-partum period.

The object to which the calf approaches is usually the dam. In certain circumstances, as when the cow was not standing or was not in front of the calf, the approach was made toward some other object, e.g., stall walls (Selman *et al.*, 1970b).

3.2.4 Location of the teat

The initial nursing behaviour exhibited by the neonate was described by Fraser (1963) as the "pushing syndrome". Fraser (1968) believed that expression of this depended on the IRM reacting to sign stimuli.

These stimulating features are usually termed releasers. Lorenz (1935) described a releaser as a feature of a fellow member of the same species to which the subject reacts. A number of different releasers have been recognized in young ungulates. Kingscote (1961, cited Fraser, 1963) believed it to be the shade beneath the dam. Fraser (1963) considered it to be the lower outline of the dam. Rylands (1968) reported that newborn lambs made advances toward a source of heat. Studies in goats and sheep (Hersher *et al.*, 1963a and b) and the horse (Fraser, 1963) indicated that the releaser was the perception of a large object, i.e., a visual factor. To the present there has been no studies made on cattle.

Location of the teat by calves involved licking, muzzling and sucking of protrusions or surfaces (Hafez and Lineweaver, 1968). Fraser (1976) reported that tactile hairs on the muzzle were important in assisting the calf to locate the teat. Calves appear to be able to discriminate between the objects investigated. Hafez and Lineweaver (1968) observed that calves spent more time investigating areas which "felt" like a teat, e.g., placenta, tail or leg covered in blood or mucus as opposed to areas covered in heavy hair.

Fraser (1976) believed that the neonate was myopic. This limited visual competence therefore necessitating the principal use of the muzzle in this exploratory behaviour. This is in disagreement with Lent (1974) who considered that textural aspects were unimportant. Hafez and Lineweaver (1968) found that as the calf aged it tended to rely more on visual factors than on tactile ones. Lent (1974) reported that the role of olfaction, at least in the first few hours after birth, was not important.

The learning element becomes obvious on subsequent movements to the udder. Selman *et al.* (1970b) reported a significant (Anova $P<0.01$) reduction in teat-seeking duration (TSD) after the calves had experienced one sucking experience. However, there is probably a definite limit to this ability to learn. Seligman and Hager (1976) presented evidence from which they postulated a "preparedness dimension" to describe and delineate these limits. It was considered that in any given situation the animal may be in one of three possible states; namely, prepared, unprepared and contraprepared. They were considered to reflect the biological and genetic status of the animal and could be measured in terms of the number of trials needed for the animal to learn.

In the newborn calf a high degree of preparedness to associate the correct behaviours leading to the location of the teat and ingestion of milk is of obvious survival value. Walker (1950) concluded from her observations on calves that unless the teat seeking activities were positively reinforced with milk ingestion then these activities would cease. This suggests that either there exists a sensitive period associated with this learning and/or because of the limited energy resources within the neonate the calf exhausts the supply or is affected by muscular exhaustion.

The area where the calf concentrates its attention was found by Selman *et al.* (1967) to be affected by the shape of the cow's lower outline. Cows which had large and pendulous udders had the xiphoid-auxillary region as the highest part of their ventral surface. Consequently the calf frequently showed teat-seeking around the forelegs of the cow. This influence of dam shape had a significant effect ($P<0.02$) on TSD. A breed effect on dam shape was also reported. Beef cows tended to have less pendulous and smaller udders than did dairy cows.

A tendency for calves to begin sucking the anterior teats was demonstrated by Hafez and Lineweaver (1968) and Selman *et al.* (1970b). This preference was repeated at successive bouts (Walker, 1950).

Teat characteristics such as shape, size and position appear to influence the success (i.e., ability to obtain milk) of the calf's nursing behaviour (e.g., Selman *et al.*, 1967; 1970b). Features such as supernumerary, malformed or malfunctioning teats which may affect the success of nursing have not been investigated.

The various studies vary in the elapsed time prior to the first suck. Walker (1950) and Hafez and Bouissou (1975) reported that it occurred from 2 to 6 h post-partum. Broom (1977) observed that when sucking did occur it was apparent within 3 h of the calf's birth. Conversely, Selman *et al.* (1970b) recorded that 8 of the 20 calves studied did not suck until more than 8 h had elapsed.

A breed effect was reported for TSD (Selman *et al.*, 1970b). The calves of beef cows were significantly faster ($P<0.01$) than dairy calves. This could have been due to the shorter time taken for the beef calves to stand, or the shorter time taken by the beef cows to stand and start grooming the calf, or both.

Features such as calf sex or birthweight have not been studied in relation to the teat-seeking activities of the calf.

4. Primary Socialization

4.1 Introduction

Immediately after birth the neonate begins its social development with primary socialization. Scott (1962) defined primary socialization as "the period in which primary bonds are formed". The term bond was defined by Lorenz (1966) as "an attraction that causes one individual to follow if the partner should move away, or should the partner stay in one place, to stay there too for his sake, or to search for him actively should he disappear".

The first systematic observations of this process involved precocial birds by Spalding in 1872. It was characterized by an early following response toward the first moving object observed by the hatchlings. The phenomenon was first defined by Heinroth (1910) as "prägung" which was given the English translation "imprinting" by Lorenz (1935).

Boch (1960) showed that imprinting occurred in respect of parents, siblings and the physical environment. It has also been found to have a profound effect on later social affiliations, e.g., selection of sexual partners (review, Fox, 1968). Comprehensive studies on imprinting have been provided by Sluckin (1964), Bateson (1966) and Hess (1973), amongst others.

Opinions vary as to whether imprinting as classically studied in precocial birds is the same as the primary socialization observed between the ungulate dam and offspring. Various characteristics such as rapidity of onset of the process and the components of an innate basis plus subsequent learning are common to both processes, but there also exist a number of differences. For example, Lorenz (1935) and Boch (1960) considered that imprinting was fixed, i.e., irreversible, but ungulate studies reviewed by Lent (1974) suggest that this is not the case. Also, imprinting appears to be related solely to the neonate with no positive action required by the mother. Amongst ungulates both mother and offspring have been found to play a crucial role (e.g., Collias, 1956; Review Lent, 1974).

Conversely, Hess (1973) believed that the two processes were the same, because both are characterized by a critical period*, post-partum, of an extremely short duration. Hess also considered that both processes shared the characteristic of not influencing the nature of the behaviour itself, but that they had the function of influencing the object to which the behaviour was directed so that others tended to be excluded. Furthermore, Hess contended that both processes were irreversible as once a bond had been formed no other could be made as easily.

Because of these differences in opinion it was decided to refer to the association between the cow and calf in this thesis as a bond and to restrict the term "imprinting" in reference to precocial bird species.

The formation of the dam-offspring bond to the exclusion of other individuals has been found to be universal among ungulates even in those species which otherwise maintain open social groups (Lent, 1974). Bond formation requires individual recognition and usually occurs fairly soon after birth. It is characterized by certain behaviour patterns exhibited by the dam (e.g., grooming and protection of the neonate) and the offspring (e.g., following and prone responses).

---

* Sluckin (1970) defined critical period as "a certain length of time in ontogeny which is of crucial importance for the development of some characteristic behaviour pattern".

4.2 Concept of "critical" and "sensitive" periods

Both imprinting and the ungulate bond form over a relatively short period of time. Lorenz (1935) called this the "critical" period. The duration of this period was found to be species-specific, but variable between different species (Fraser, 1968). Hudson and Mullord (1977) with 14 multiparous Friesian x Jersey cows found that a 5 min. contact period with a calf immediately post-partum was sufficient for formation of a strong specific bond. If no contact was allowed for periods up to 5 h post-partum the bond did not occur in 50% of the cases.

The belief that bond formation could only occur within a definable and relatively short length of time was first disputed by Scott (1962). He considered that the capacity for such attachment was never lost, although it might occur more slowly outside the period of socialization. This was substantiated by Hersher *et al.* (1963a, b) when observing goats and sheep. It was possible to have nannies and ewes accept young, even those of the other species, when the young were not put with the females until 2 to 12 h post-partum. This extended interval was termed "sensitive" to differentiate it from the "critical" period by Sluckin in 1970.

4.3 Rate of bond formation

Species variation has been found in the rate of bond formation (Fraser, 1968). It appears to be a function of the type of dam-offspring relationship. In hider-type species bond formation occurred over a much longer period than was the case amongst follower-type species (Lent, 1974).

There has also been shown a difference between the dam and offspring in their respective rates. The attachment forms much more rapidly for the mother. In contrast, the behaviour of the young animal remains opportunistic, if the mother is not readily available an alternative will be sought (Lent, 1974). Scott (1962) in his review on primary socialization concluded that there were two principal factors determining rate of bond formation in the neonate. These were the existence of a wide range of stimuli including pain, loneliness and hunger and the degree of emotional arousal exhibited by the young animal.

4.4 Individual recognition

Formation of the bond requires that the participants can recognize and remember the characteristics of each other. The ability to remember individual characteristics was demonstrated in cattle by Hudson and Mullord (1977). The bond was still evident after the cow and calf were separated for 12 h. However, after 24 h separation the cow was unable to recognize the calf although she still showed signs of distress.

Evidence indicating an auditory basis for individual recognition has been reported for several ungulates including cattle (Schloeth, 1958; Tembrock, 1963; Wagnon, 1963; Kiley, 1972). Selman *et al.* (1970a) and Donaldson (1970) recorded different forms of vocalization from the cow and the calf. Each of these calls was always emitted under specific conditions.

Olfaction appears to be important, especially for the mother in the post-partum period (Bareham, 1977). Hess (1973) suggested that olfactory characteristics were learnt during the period of intense licking and muzzling post-partum and that this forms the basis of the first discrimination by the dam between young animals. Rendering the pre-parturient animal anosmic was found to prevent any licking response to birth fluids. However, Poindron and Le Neindre (1975) considered the sense of smell was not of critical importance in the cow's identification of the calf.

Visual recognition is less amenable to experimental manipulation and the information on this aspect of sensory recognition is probably less precise than that available for the other senses. Schloeth (1958) studying wild Camargue cattle observed that visual identification by the calf was based on the perception of specific maternal behaviour patterns. An alternative basis for visual identification could involve physical characteristics of the individual, but this has not been investigated in cattle.

Once the identity of its own young has been established most mothers were observed to play an active role in strengthening and maintaining the bond by rejecting and even "driving" away alien young

(Fraser, 1968). This behaviour has been recorded in cattle (Wagnon, 1963; Ritter and Walser, 1965), and was considered by Hess (1973) to indicate that the success of bond formation was dependent only on the dam with no contribution required from the offspring.

4.5 Manipulation of sensory recognition

The traditional method of fostering calves onto cows involves removal of distinguishing calf odours (Everitt *et al.*, 1968; Kilgour, 1972).

Masking the cow's sense of smell by either smearing her nose with linseed oil (Crowley and Darby, 1970) or by administering a nasal anaesthetic (Kiley, 1976 unpubl. data) has been shown to increase the likelihood of the cow accepting alien calves. Alternatively, it is possible to disguise the odour by covering the calf with the skin of the foster cow's own calf. Although this method is frequently used on New Zealand farms no experimental data regarding success rate are available.

Traditionally fostering involves confining the alien calves with the foster cow in a restricted area until nursing occurs without human involvement. This generally takes about a week and requires a high labour input and access to yards or a small paddock. The technique is not necessarily successful and in some instances a high level of cross-sucking has been reported (e.g., Kilgour, 1972). This cross-sucking was found to result in wide weight gain differences between calves (Everitt *et al.*, 1968).

In 1977 Hudson presented another method of fostering cows and calves. This involved introducing the calves within minutes of the cow calving. On comparing this sytem to the previously described method it was found that all alien calves were accepted within 24 h. The level of cross-sucking was 3% *versus* 30% in "traditionally" fostered calves. This was reflected in a smaller variation in weaning weight amongst the calves fostered by the newer system.

Blindfolding foster cows was shown by Crowley and Darby (1970) to improve the success of fostering. Kiley (1976) found that if foster-calves were substituted for the cow's own calf they would be accepted, but if the cow's calf was not removed then fostering did not occur. Kiley suggested that either the cow could "count" (*sic*) up to 2 or that the facility to make continual comparisons between the calves enabled easy identification of her own calf.

Evidence indicates that cows vary in their tolerance and acceptance of alien calves. Kilgour (1972) recorded up to 8 calves sucking 1 cow whilst another cow would only suckle 1 calf although 4 calves were initially fostered on to her. The dominance (i.e., social rank) of the cow was suggested by Kiley-Worthington (1977) to be important in determining whether alien calves would be accepted.

5. Termination of the Bond

Termination of the bond in non-domesticated populations is a gradual process. It is generally as a result of a successive parturition or puberty in male offspring that complete separation occurs. After parturition the dam and female yearling usually reunite (Lent, 1974). In instances where the dam does not have any offspring the yearling may continue to nurse. Yeates and Schmidt (1975) observed this in cattle and suggested that it was a contributing cause of cross-sucking.

5.1 Weaning

Termination of the maternal-filial bond in undomesticated populations is characterised by a gradual decrease in the tolerance of the dam toward her offspring. Eventually this behaviour results in enforced separation (Lent, 1974). Conversely, domestication is almost invariably associated with an abrupt weaning which signifies the end to any further association between the dam and offspring. This artificially-induced situation may explain the phenomenon termed "weaning stress" which is frequently reported.

This stress has been demonstrated as weight loss and as psychological stress in calves (Young, 1973; Nicol, 1977). However, Christopherson

(1973) after analyzing calf blood samples did not find evidence of psychological stress and suggested that this stress was not of significance in comparison to the effect of nutritional deprivation. However, by 6 to 8 months of age milk intake represents a small proportion of the calf's diet. It is more probable that voluntary food intake, i.e., grazing, is reduced and this is most likely a result of psychological disturbances due to the calf being separated from the cow.

5.1.1 Age at weaning

Bailey and Bishop (1972) demonstrated that the longer calves were permitted to nurse between 4 and 10 months of age the greater was their growth from 4 to 12 months of age. This could be due, in part, to seasonal and/or nutritional effects. For example, Bailey *et al.* (1975) over a 2-year period found that autumn-born calves weaned, at 8 months of age, onto dry pasture gained significantly less weight ($P<0.05$) during the next 2 months than did calves weaned onto a pasture cut for hay or calves which were suckled for a further 2 months. However, this weight difference disappeared when the calves weaned at 8 months were given "good" pasture after weaning.

Christopherson (1973) weaned calves at either 2.5 or at 5-6 months of age. Calves weaned at the younger age had a slightly greater weight loss during the first 3 d post-weaning. Nicol (1977) reported that the heavier calves at weaning had a better post-weaning growth than did lighter calves. This effect could have been compounded by age or sex of calf.

5.1.2 Management

Nicol (1977) compared 2 weaning methods which differed in the type and degree of post-weaning contact between the cows and calves. Differences, between the 2 weaning methods, were recorded as the time the animals took to "settle down" as evidenced by their respective behaviours. Despite this difference the weight changes of the calves in the two groups were similar after the first day post-weaning.

Young (1973) subjected calves to 1 of 3 post-weaning treatments; fasting, crowding and transportation. These were imposed for varying intervals of 1 to 3 d. The post-weaning treatment had relatively little effect on the rate of weight recovery compared with the effect of weaning itself. Duration of the treatment was more important in weight recovery than was the type of treatment. Irrespective of either the type or length of treatment it required 19 to 36 d for the calves to regain their weight at weaning.

B. RESULTS AND DISCUSSION

1. Maternal Behaviour

1.1 Maternal attendance

The term grooming was found to be inappropriate as it implies that the cow concentrated her activity on only the calf. From the observations made in this present study the alternative term maternal attendance is suggested, for the following reasons. Initially the cow was only involved in the ingestion of membranes off the neonate (Plate 5.1). Maternal grooming occurred later as the cow transferred her attention to the calf. Subsequent grooming was frequently interrupted by other activities, such as ingestion of grass covered with blood and mucus and self-grooming by the cow. It was, therefore, extremely difficult to accurately determine the duration of maternal grooming. Instead the following approximation was used: the duration of maternal grooming began with the first licking of the neonate and continued until no such further behaviour was observed. When maternal grooming was interrupted by other activities then the time period over which these occurred was discounted. With one exception (P34-5) all the primiparous cows showed a smaller period of such maternal grooming, average 32 min. (range 0 to 40 min.), than did the multiparous cows, average 105 min. (range 0 to 120 min.).

There were 6 main parts of the calf which received maternal attention (Fig. 5.2). The cow tended to groom particular parts of the calf's body whenever they moved such as the head and perinal region. However, the legs were infrequently groomed despite considerable movement. Initially maternal attention was concentrated on the

Plate 5.1: Maternal ingestion of membranes

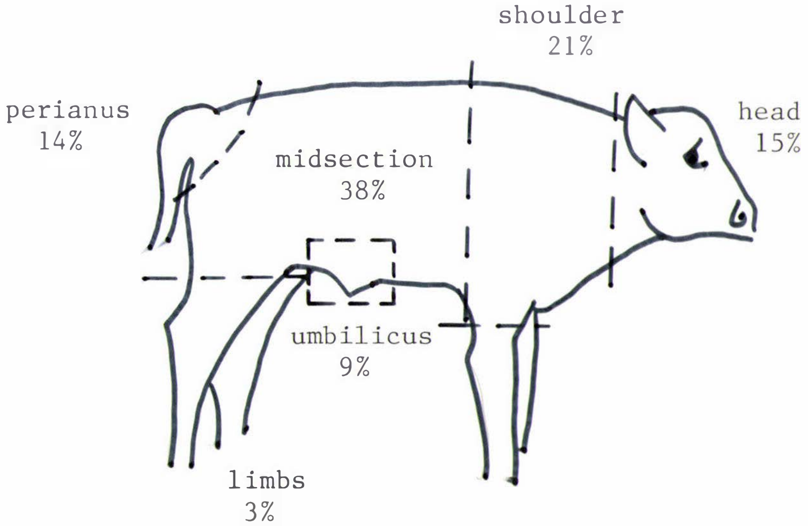


Fig. 5.2: Areas of the calf groomed by the cow
N.B. Values expressed as percentage
of total grooming time

head and abdomen. Once the calf was standing the shoulder and perianal regions were given the most maternal attention.

Licking of the perianal area was sometimes associated with elimination by the nursing calf. The umbilicus was more frequently groomed by certain of the cows after the calf had nursed, but it was also observed when the calf was recumbent.

1.2 Protection

Contrary to the findings of Donaldson (1970) the cows in this present study were never observed to show protective behaviour to the calving site (i.e., agonism to prevent access to or continued proximity by other animals, including dogs and humans). However, 2 of the primiparous cows (P27-1 and P35-6) showed protective behaviour against herdmates in defence of the neonate.

The presence of dogs within 270 m of the calves invariably resulted in specific cows (P23-2; M24-7; M33-13) showing a characteristic protective behaviour (Plates 5.2 and 5.3). The cow would face the stimulus and stretch her head and neck forward with the nose at ground level. The head and ears were periodically shaken whilst the eyes were fully opened and the pupils dilated. The forelegs often pawed the ground and disturbed ground litter and dust. Usually these actions were accompanied by snorting and vigorous tail movements. The behaviour signalled the intention of the cow and nearly always resulted in the withdrawal of the intruder from the vicinity.

Guarding behaviour as described by Wagnon (1963) and Yeates and Schmidt (1974) was frequently observed (Plate 5.4). It was not possible to determine any consistent order in the cows' presence at the calf-pool The term "calf-pool" was used to describe a group composed of 3 or more calves and with at least 1 lactating cow in attendance or remaining within 20 m of the calves. Only certain of the lactating cows showed the behaviour which did not appear to be related to maternal status. It is suggested that the term guarding be discontinued or qualified as neither the occurrence of the calf-pool (Plate 5.5) nor the presence of cows with the calves occurred as a means of protecting the calves. When potential danger existed all the dams would go to the calf-pool and on making

Plate 5.2: Maternal defence posture - anterior view

Plate 5.3: Maternal defence posture - lateral view

Plate 5.4: Maternal guarding of the calf

Plate 5.5: The calf pool and attendant cows

contact with their calf disperse so as to maximize distance between themselves and the danger, i.e., movement by individual cow-calf pairs away from the danger rather than collective defense by the cows of all the calves was observed. Also there was not always a cow in close attendance at all times. However, this study involved a 2 ha area with ready access to water and no real threat from predation hence the situation is not the same as that involved in the studies of Wagnon (1963); Rankine and Donaldson (1968) and Yeates and Schmidt (1974).

The calf-pool was most often composed of calves between 4 d and 4 months of age. The calf-pool resulted from the cattle collecting together in a defined area. Throughout the observations only a limited number of areas were used of which 2 were much more frequently chosen. By the time the calf's grazing time accounted for 30 to 40% of the adult cattle's values the calf tended to remain with the herd. Thereafter the calf-pool and associated cows was only observed during darkness when the herd was resting and inactive. This suggests that the existence of the calf-pool was related to development of solid food intake and/or physical maturity of the calves rather than as a means of providing protection for the calves.

As the calf-pool did not occur as a means of protecting the calves it is suggested that its existance was an illustration of the high degree of group cohesion evident amongst the cattle. This was also observed during grazing when the cows all remained within an area of less than 0.5 acre.

1.3 Orientation

Successful location of the teat by the calf required that the cow face towards the calf and then maintain a stationary position. These maternal behaviours have all been considered as orientation and their relationship to the calf's T-SA have been presented in Fig. 5.3.

Instead of showing orientation some primiparous cows retreated or turned the hindquarters away from the approaching calf. Both these abnormal behaviours appeared to express deliberate movements by the cow to maintain visual contact with the calf. An alternative explanation could be that the cow attempted to maintain personal space. However, in the author's opinion this is the least likely explanation as the cow continually showed maternal attention toward the calf, e.g. grooming and investigation. These activities are not considered defensive and would

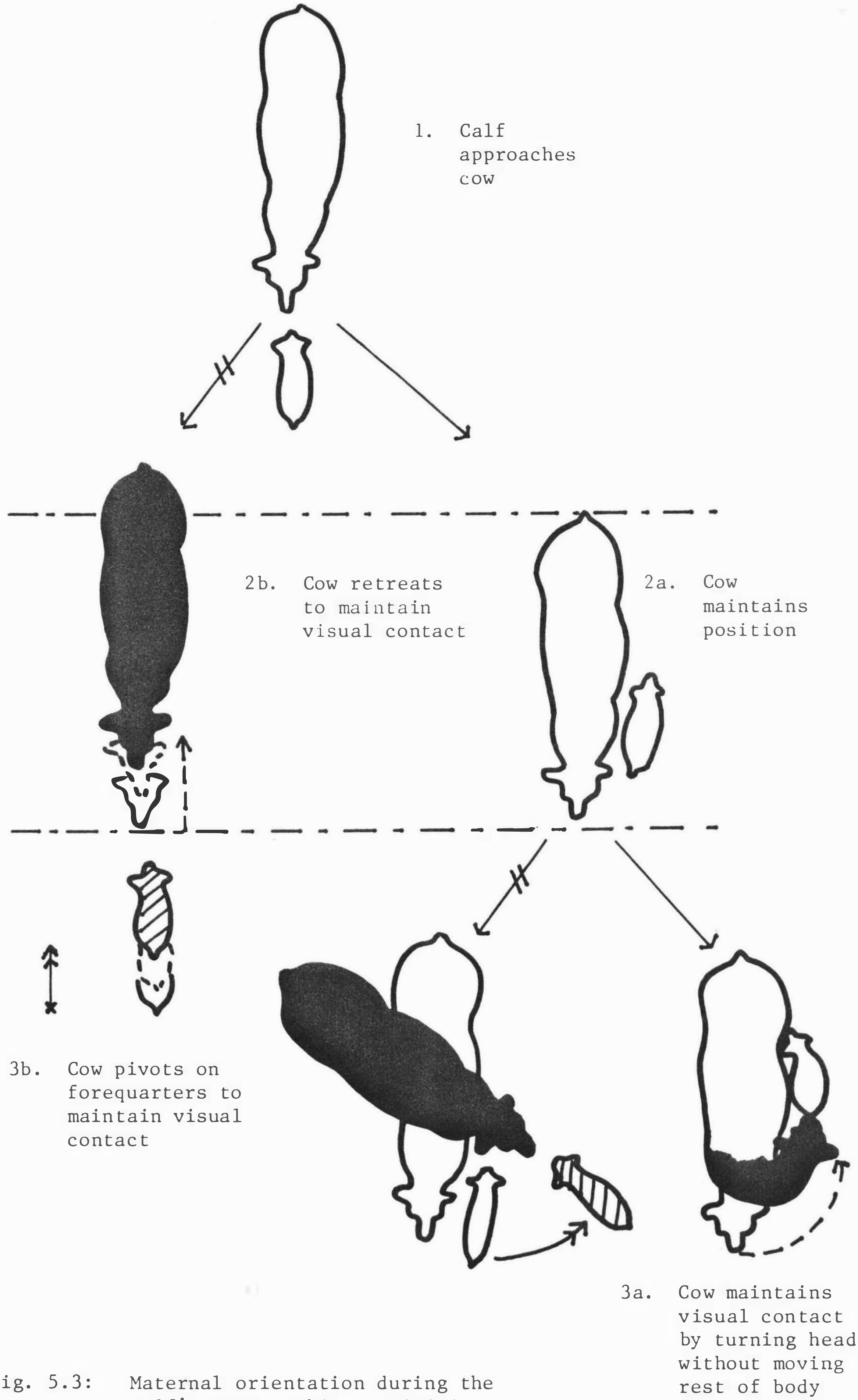


Fig. 5.3: Maternal orientation during the calf's teat-seeking activities

therefore not aid an attempt to maintain personal space. The multiparous cows maintained visual and tactile contact with the calf by turning only the head toward the offspring. This provided opportunity for maternal grooming and investigation of the perianal region.

Certain of the multiparous cows were observed to show movements which shifted the calf toward the udder region and directed it into a position suitable for sucking. These activities usually involved the cow muzzling and licking the perianal area of the calf. Less commonly recorded were positional movements of the hindquarters toward the calf or abduction of the ipsilateral hindleg.

1.4 Abnormal maternal behaviour

Failure of maternal drive at parturition as described by Kiley-Worthington (1977) was not recorded in this present study. However, maintenance of maternal behaviour did require continued stimulation from the calf. This appeared to be more than just visual stimulation. For example, one calf (P35-H) became physically separated, but did not lose visual contact, from its dam. After several hours the cow left the area and on the following day refused to accept the T-SA of her calf.

Rejection of the neonate involved either the dam displaying agonism toward the calf or non-acceptance of the calf's teat-seeking activities (T-SA). Both forms of rejection were not due to a complete failure of maternal drive as, unlike herdmates, the dam was not disinterested in the calf but showed deliberate reactions to its behaviour and presence.

With the exception of one multiparous cow (M30-12) abnormal maternal behaviour was only observed in primiparous cows. Five of the 6 first-calvers showed some form of abnormal maternal behaviour on first seeing the neonate. Usually this involved bellowing and head-pushing directed toward the calf. In all except 1 cow (P27-1) this agonism ended within several minutes of birth after the cow had investigated the calf.

The multigravid cow, M30-12, denied the calf access to the teat in refusing to exhibit maternal orientation and she repeatedly elicited following response from the calf.

2. Calf Behaviour

2.1 Movement

Prior to its final expulsion from the vulva the calf occasionally exhibited head and mouth movements. These were usually accompanied by the release of mucus and fluid from the mouth and sneezing.

All the calves were expelled from the cow into a lateral prone position (Plate 5.6). Subsequent movements appeared to be initiated by maternal contact as was also observed by Donaldson (1970). However, this contact was not essential, for example, 1 heifer calf (P31-H) attempted to stand although her dam remained recumbent for 17 min. following calving.

Within 2 min. of birth all calves except one M30-B performed various movements which rotated them onto the sternum. Thereafter they orientated toward the nearest cow (Plate 5.7), which was not necessarily the dam. Sometimes this orientation was accompanied by mouth movements which could be described as lip-smacking. Similar behaviour was also observed in bison by Marjoribanks-Egerton (1962) and in cattle by Kirchschofer (1963).

Elevation involved lifting either the shoulders (Plate 5.8) or the rump (Plate 5.9). This was followed by an extension of the legs. This "half-up" posture described by Selman *et al.* (1970b) was very frequently recorded prior to the calf standing. (The criterion for standing was taken as the maintenance of an erect stance for at least 1 min.). On average there were 8 (range 2 to 18) unsuccessful attempts made before first standing was achieved (Table 5.2). All the calves, except 1 (M30-B) attempted to stand within 10 min. of birth. The exception was the only calf born from a standing cow and the calf remained motionless for more than 5 min. in spite of maternal grooming and vocalization. Despite this initial inactivity the calf stood much earlier (Anova $P<0.02$) than did the other calves (ref. Table 5.2).

2.2 Ambulation

The first movement of the neonate was not the same as walking in the more balanced and co-ordinated adult, therefore it was decided to use instead the term proposed by Fraser (1976) as ambulation.

Unsteadiness was a prominent feature of this movement which was probably exaggerated by walking on the foetal digital pads.

Plate 5.6: Lateral prone position of the neonate

Plate 5.7: Filial orientation toward the dam

Plate 5.8: Neonatal elevation with the shoulders
N.B. Maternal interest and position relative
to neonate.

Plate 5.9: Neonatal elevation with the rump

TABLE 5.2: The time taken and the number of attempts made before standing by the calf

Identity No. of calf	First attempt to stand (min.)	No. of attempts	First standing (min.)
P27-H	2	8	*
P23-H	4	2	46
P31-H	9	2	35
P34-B	8	6	48
M32-B	9	6	43
M30-B[a]	17	18	26

* All attempts to stand ceased by 35 min. post-partum.

[a] Significant difference (Anova, $P<0.02$) between M30-B and the other calves was found.

2.3 Location of the teat

Location of the teat included a variety of behaviour collectively referred to as teat-seeking activities (T-SA). Once the calf made physical contact with the cow it investigated the cow's body. This involved use of the muzzle and tongue whilst contact was maintained by the calf's poll and head, at about the level of the cow's ventral surface. The poll was pressed against the cow and the muzzle rotated upward with the neck extended. This produced an upward force which directed the investigatory activities to the highest part of the cow's lower abdomen.

2.3.1 Areas investigated

There were 5 main parts investigated and their respective proportion of total teat-seeking time has been presented in Fig. 5.4. The calf tended to change its attention to different parts as its T-SA progressed. Maternal orientation and position relative to the calf's location tended to result in the calf making initial contact around the forelegs. The T-SA were then directed to the abdomen adjacent to the cow's limbs. Thereafter, the calf spent proportionally more time investigating around the hindlegs until the udder was located. This pattern conflicts with Lent (1974) who reported a tendency for the neonate to investigate specific parts in a random method.

There was a significant (χ^2, $P<0.02$) tendency for calves to suck from anterior teats. The main reason was that in 97% of the observations the calf located the teat whilst in the reverse-parallel nursing position, i.e., facing in the opposite direction to the cow. There was no tendency for the calves to nurse from one particular side of the cow's udder.

2.3.2 Teat-seeking duration (TSD)

TSD was fairly consistent between 3 of the 6 calves born from primiparous cows and 6 of the 8 calves born from the older cows. Amongst these 9 calves TSD averaged 22 min. (range 15 to 40 min.). In these animals sucking occurred on average 80 min. (range 60 to 150 min.) post-partum. Of the other 5 calves 2 died (P27-H; M36-H) and 3 were unable to suck due to abnormal maternal behaviour (P31-H; P35-H; M30-B).

A possible effect of learning was reflected in a significant (χ^2, $P<0.01$) decrease in TSD between the first and subsequent sucking bouts.

The length of observations on which this data was based averaged 302 min. (range 210 to 600 min.). By the second day after calving there was no further change in teat-seeking duration. This supports the findings of Walker (1950) and suggests that there does exist a limit to learning.

2.3.3 Releasing factors

No single releasing factor was found to be responsible for the location of the udder. Instead there appeared to be a sequence of stimuli which progressively directed the calf to the teat. The principal stimulus was visual perception of the cow, but the possible contribution of physical contact cannot be ignored.

Even before standing, the calf was observed to orientate toward the cow. This orientation and approach appeared to be stimulated by the close proximity of the cow. When standing, the calf approached the cow (Plate 5.10) apparently in response to the larger size of the cow. (Approach was also made toward humans and other cattle provided they were not recumbent and therefore providing a smaller visual area.)

After physical contact was established the calf advanced down the side of the cow along the longitudinal axis (Fig. 5.5). This continued until further progress was prevented by contact with one of the cow's legs, i.e., the normal axis (Fig. 5.5). This obstruction tended to direct the calf's head into the angle made by the junction of the cow's leg and lower abdomen, i.e., lateral axis (Fig. 5.5 and Plate 5.11). If the calf was at the rear of the cow this usually resulted in location of the udder. Thereafter the calf concentrated its activities on and around the udder. This site preference suggests that some factor such as the surface of the mammary gland, as was postulated by Hafez and Lineweaver (1968), or the temperature of the udder, as was the opinion of Rylands (1968), may be involved.

If the calf was at the forequarters of the cow, maternal grooming usually resulted in the calf moving under the neck and then progressing toward the rear of the cow.

Plate 5.10: Filial approach toward the dam

Plate 5.11: Pressing syndrome posture

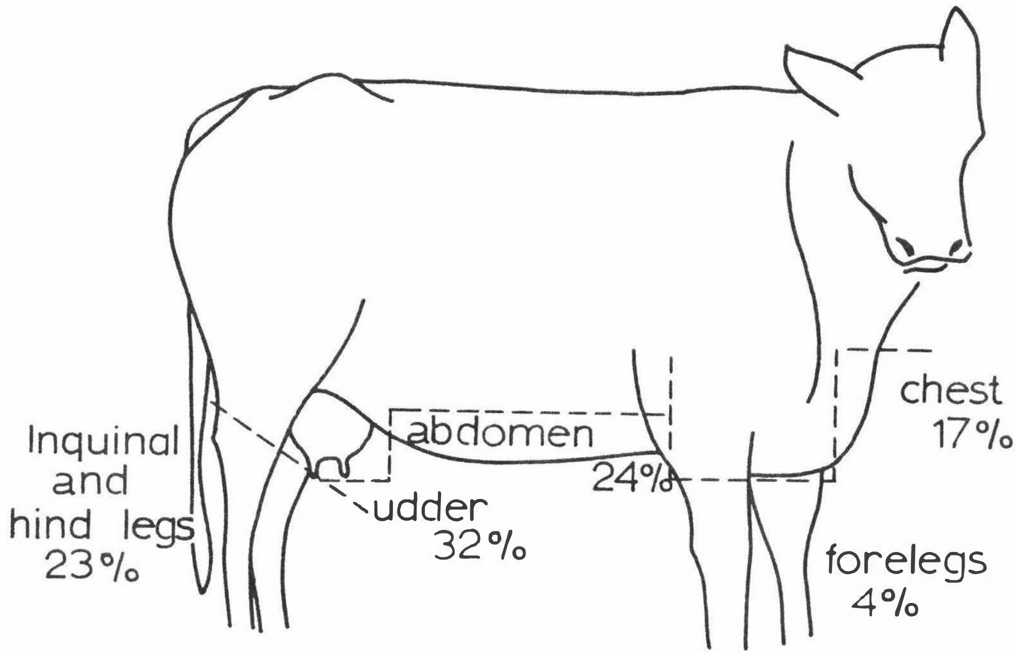


Fig. 5.4: Areas of the cow investigated by the calf

N.B. Values expressed as percentages of TSD for 6 calves

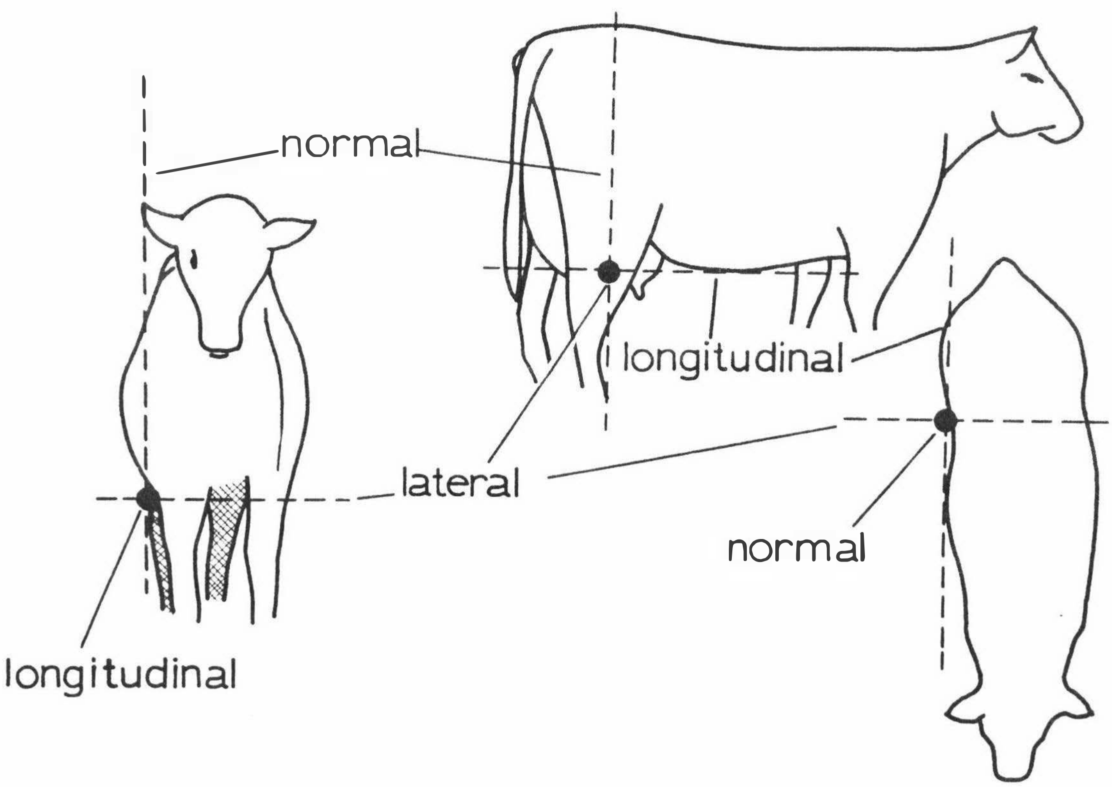


Fig. 5.5: Axes* relevant to location of the udder

* Axes have not been drawn through centre of gravity

2.3.4 Factors affecting teat-seeking activities

The calf's success in locating the teat, as measured by teat-seeking duration, depended on a number of factors. The neonate's ability to remain standing was a reflection of its balance and co-ordination. By the 3rd h post-partum there was little further improvement in these abilities. In the instances in which sucking had not occurred within 2 h of birth, the calf usually ceased further T-SA. This could be due either to fatigue or the lack of positive reinforcement which would result in further activity by the calf.

The calf's behaviour was also important in locating the teat. The neonate attempted to maintain physical contact with the dam at all times. On reaching the end of the cow's body the calf would immediately turn until it reached the other side when it would continue along the longitudinal axis.

Neither calf sex (5 males and 8 females) nor birth weight, average 28, (range 24 to 32 kg) were found to significantly effect the time elapsed prior to first suck post-partum. However, only 13 calves were involved and this low number may not necessarily represent the true situation.

Shape of the cow's lower abdomen appeared to affect the calf's T-SA in one case (M30-12). In this cow the udder was the lowest part of the cow's ventral outline, i.e., below the junction of the axis and the calf spent 80% of the total time spent teat-seeking around the hindlegs at a level above the udder. The calf was never observed to suck and died 8 d later.

The area of the calf groomed by the cow was also important in determining TSD. If the cow persisted in facing the calf the neonate was unable to progress toward the cow's hindquarters. However, if the cow stood still and turned her head to groom the perianal region then the calf was directed toward the udder region. Continued presence of the calf at this area appeared to be stimulated by maternal grooming at the calf's perianal region.

2.4 Filial responses

2.4.1 Following response (Fo.R)

In this present study a distinction was made between approach behaviour (i.e., movement towards a specific stationary object) and following behaviour (i.e., movement in pursuit of a moving object). Other studies reviewed considered these behaviours to be expressions of a single response which differed only in their spatial consequences. Whilst this may be correct the distinction was considered justified because approach behaviour in this present study involved movement by only 1 animal whilst the Fo.R was elicited by the cow showing "walk-away" behaviour (Plate 5.12) which resulted in the appropriate response by the calf (Plate 5.13), i.e., Fo.R involved movements by 2 animals in the same direction.

Initially the Fo.R was non-specific, but by the time the calf had sucked, usually within 2 h of its birth, the calf would only show the response to its dam. Subsequent generalized responses toward non-specific cattle, as described by Lent (1974), were only recorded when the herd was being mustered.

2.4.2 Prone response (Po.R)

The Po.R resulted when the recumbent calf was approached and physical contact was made by humans or cattle other than the dam (Plate 5.14). As a result of this contact the calf would extend its head and neck along the ground. The ears were held against the head and the eyes opened. Usually the limbs were flexed against the body. All these movements served to minimize the calf's body profile (Plate 5.15).

An alternative posture in which the young animal turns the head and neck along the side of the body has been recorded in several species, e.g., Gazelles (Walther, 1968) and Pronghorns (Autenrieth and Fichter, 1974). However, in this present study, this posture was not considered to be indicative of Po.R for a number of reasons. The posture was initially recorded at later ages than was the Po.R (*c.* 14 d *versus* 3 d, post-partum) and was also often shown by the adult cattle. Also, the posture was never exhibited in response to the presence of contact

Plate 5.12: Elicitation of the following response
N.B. Cow showing "walk-away" behaviour
cf Plate 5.9.

Plate 5.13: The following response (Fo.R)

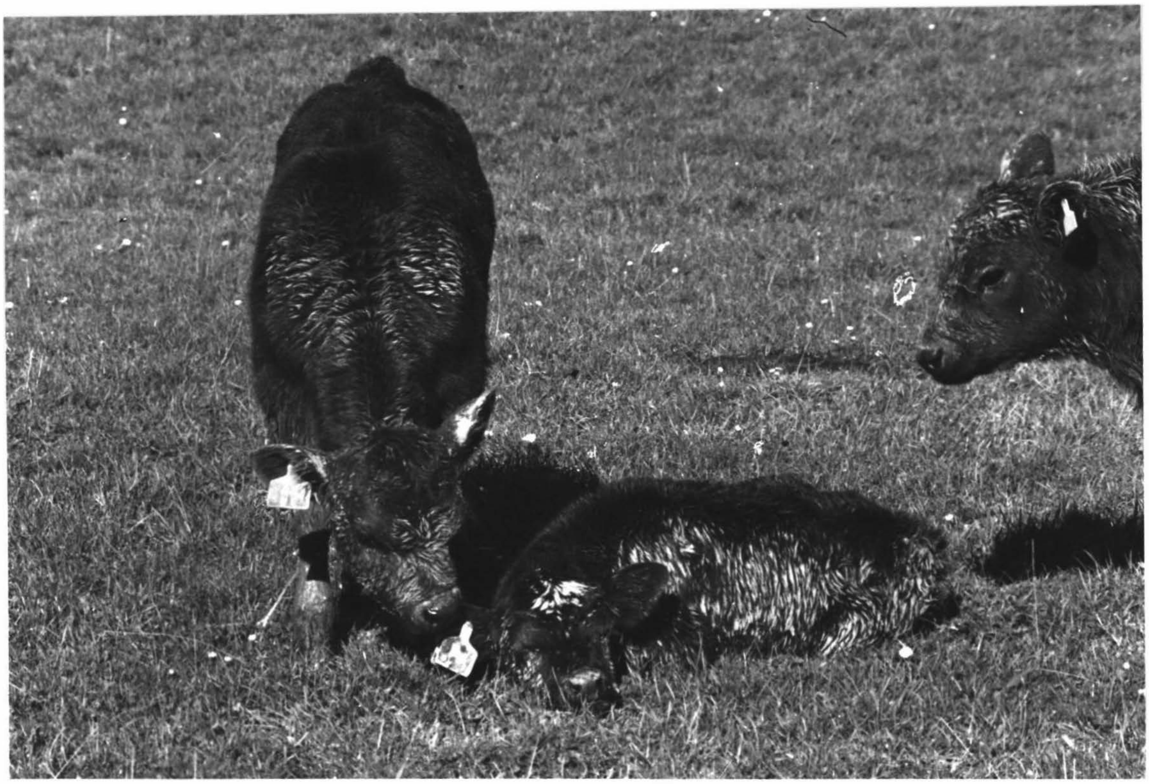


Plate 5.14: Elicitation of the prone response
N.B. Investigatory behaviour of the standing calf

Plate 5.15: The prone response (Po.R)

of humans or herdmates. Also, Ruckebusch (1975) described an analogous posture in cattle which he considered to be indicative of rapid eye movement sleep.

2.4.3 Fear response (Fr.R)

The Fr.R differed from the Po.R in that it was not characterised by tonic immobility; nor was there any change in posture. The behaviour was shown by all cattle irrespective of age unlike Po.R which was only exhibited by calves.

Fo.R could also be differentiated from the usual response shown by a cattle beast on reacting to some stimuli. The Fr.R always involved an abrupt cessation of the animals activities such as self-grooming, sleeping or rumination. Instead an increase in arousal was exhibited. The degree of arousal was related to the intensity of the stimulus, e.g., if the intruder approached closer than 3 m the calf would stand and retreat; however if the intruder stopped *c.* 10-15 m distance the calf would simply maintain visual and/or olfactory contact by rotating its head.

2.4.4 Occurrence of the responses

These 3 responses were expressed by the calf in response to particular behaviours of another and have been presented in Fig. 5.6. The dam on initiating a contact period with the calf would approach to *c.* 8 m and then stand and wait for the calf to make physical contact (Plate 5.16). In most instances, the cow would wait for *c.* 3 min. and if there was no response from the calf she would either vocalize and/or approach towards the calf. Physical contact by the dam invariably consisted of grooming and vocalization (Plate 5.17) which would result in nursing. Alternatively, the cow would elicit Fo.R by showing "walk-away" behaviour.

Intruders differed in their approach and contact behaviour from the dams. Contact was invariably investigatory and was made whilst the calf was still recumbent, i.e., calling-out was never observed. On all occasions the calf reacted by adopting the Po.R.

3. Interrelationship of Maternal and Filial Behaviours

The spectrum of interactions between the cow and its calf in the immediate post-partum period has been outlined in Fig. 5.7. Initial and subsequent movements by the recumbent calf were stimulated by the

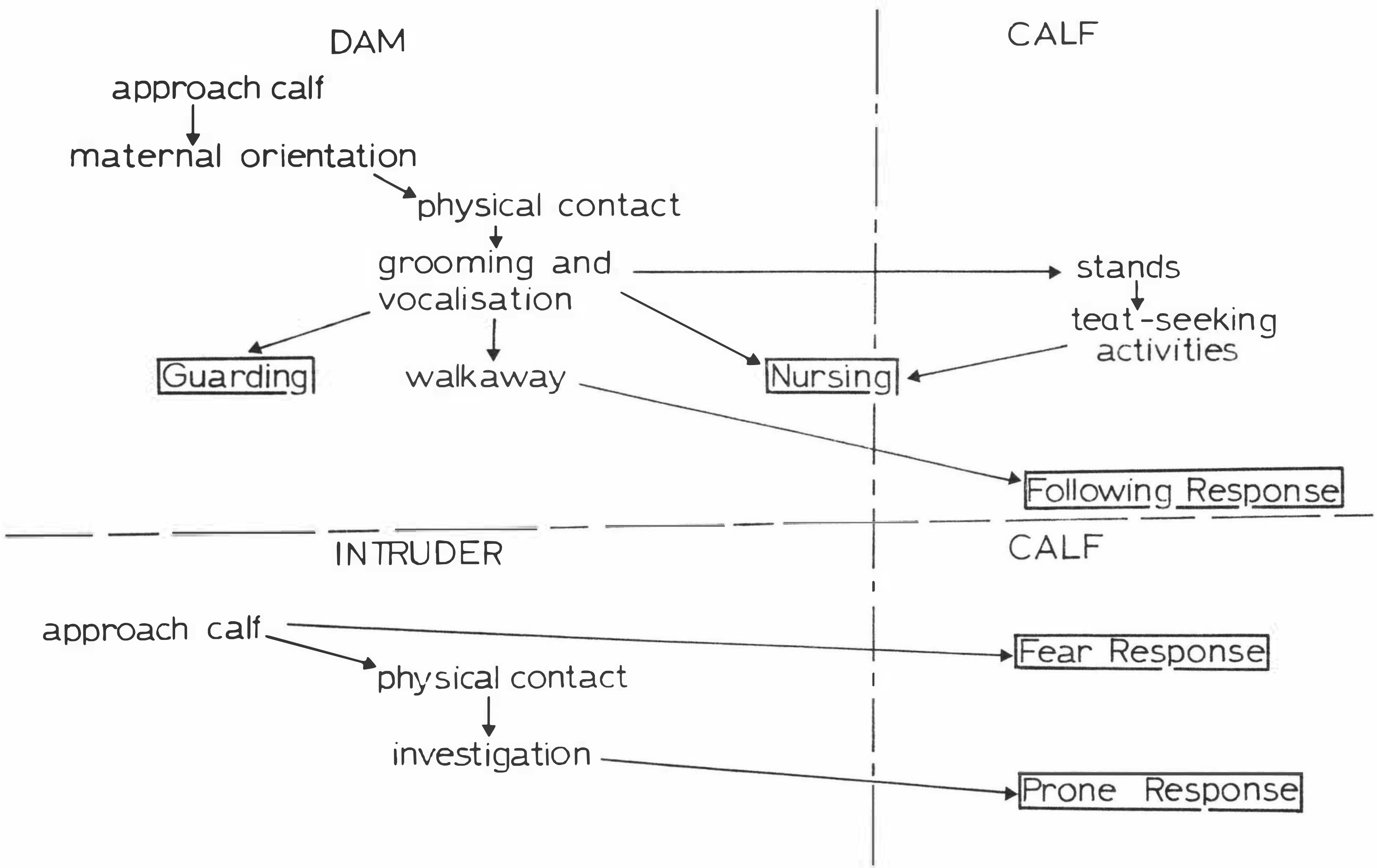


Fig. 5.6: Behaviour sequences following initiation of a contact period with a recumbent calf

Plate 5.16: Maternal orientation toward the calf

Plate 5.17: Maternal contact with the calf
N.B. Grooming behaviour of the cow
cf Plate 5.12.

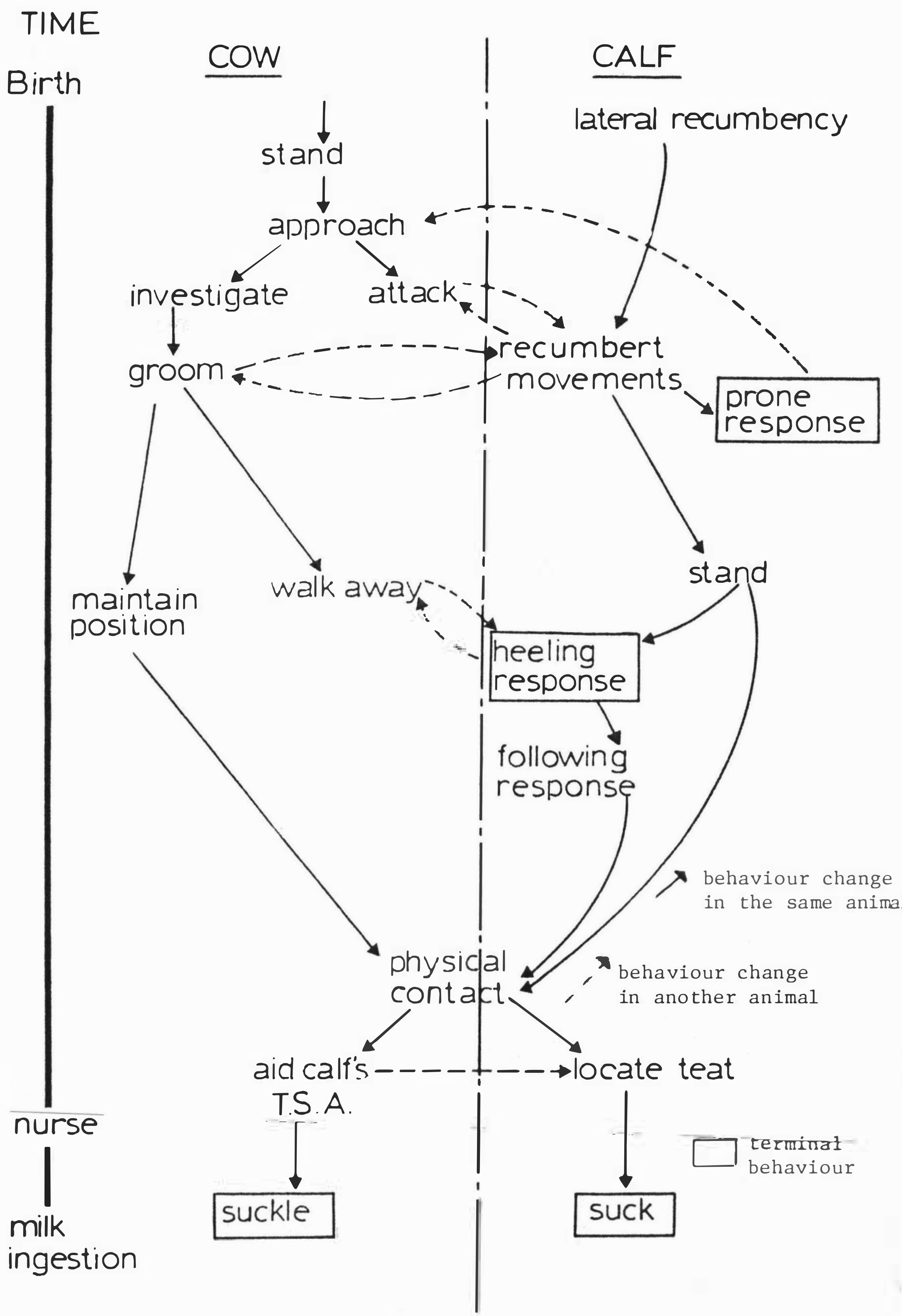


Fig. 5.7: Behavioural interactions between cow and calf during the immediate post-partum period

form and intensity of maternal behaviour. On standing, the cow approached the recumbent calf and then showed one of two mutually exclusive behaviours; investigation or attack. If the normal maternal behaviour occurred, i.e., investigation, the cow would then groom the calf; alternatively the cow would attack the calf. This latter behaviour was associated with a characteristic vocalization very similar to the sexual bellowing of a bull.

The maternal behaviour and the calf's response stimulated each other by a process commonly described as "feed-back" (Hinde, 1970; Manning, 1972). Initially the feedback was positive, but with time the calf would stand in response to maternal grooming or would exhibit Po.R if the dam was attacking it. The Po.R appeared to appease the cow as further agonism would cease. After the calf had maintained immobility for *c*. 5 min. the cow would investigate and then groom the calf, thereafter normal maternal behaviours would usually be expressed. However, 2 cows (P27-1 and M30-12) continued to show abnormal behaviours. The multigravid cow repeatedly elicited Fo.R and nursing was never observed. In the other example cessation of maternal attack resulted in the calf moving and this invariably stimulated the cow to attack. Eventually the calf associated its movement with maternal attack and thereafter maintained Po.R indefinitely. The cow then concentrated her attention on self-grooming and placentophagia and no further contact between the cow and calf was observed. The calf died the following day, when a post-mortem examination was made. The calf was extensively bruised, although no fractures or excessive haemorrhages were found.

The relationship between maternal status and the occurrence of abnormal maternal behaviour has already been discussed. The association described suggests that maternal ability is not entirely instinctive, i.e., innate, but that there is a learnt component involved. It would be worthwhile to repeat calving observations of the same cows over several years in order to study the possible effects of maternal experience.

It was also evident that cows varied widely between each other in the intensity, i.e. duration and degree of expression, and the form of maternal behaviour shown. Determination of the repeatability of this variation between individual cows would require observations to be made over successive years. Such information might allow for some determination of the genetic component of maternal behaviour.

4. Weaning

4.1 Changes in behaviour

The 6 non-lactating cows (N-L) were kept in yards adjacent to the weaned calves for the first 3 d post-weaning. The proximity of these cows was reflected in the behaviour of the calves. Whilst the cows were in the yards the calves camped and grazed within 75 m. During the first 7 d post-weaning the calves showed a very high level of unity and cohesion in their activities and spatial distribution (Plate 5.18). They remained within 18 m of each other and at any one time at least 80% showed the same behaviour, e.g., grazing, rumination, resting, and walking.

On removal of the N-L cows the calves showed heightened reactivity to sudden noises or presence of other animals. Their social behaviour also changed. Previously the most common form of social interaction was play, but now agonistic interactions became increasingly obvious. This was associated with the formation of a social rank (Fig. 5.8). This increase in agonism, in the absence of adult cattle, could be due to the removal of a regulating influence. The calves may have feared reprisals from the older cattle. Alternatively, the increase in agonism may have been a reflection of psychological stress due to weaning or it might be due to factors such as calf age, or the composition of the group.

Social rank was rapidly established and by 6 d, post-weaning, the frequency and severity of agonism had declined. The decline in agonism was evident when comparing the frequency with which such interactions were observed on successive days post-weaning. This agonism was replaced by an increase in grooming behaviour. The calves most frequently groomed were the most dominant, i.e., had the highest social rank. This suggests that grooming was, to some extent, an appeasement behaviour by the more submissive calves. The justification for describing this as appeasement behaviour was supported by the type of behaviours observed. For example, P23-H on approaching M33-H exhibited head-butt intention movements. M33-H responded by grooming P23-H. This action by the submissive calf resulted in P23-H showing no further aggressive behaviour.

The dams reacted to loss of contact with the calves by an apparent increase in activity, e.g., vocalization and walking. During the first 5 d post-partum the cows congregated in the corner of the paddock closest to the calves (Plate 5.19). This aggregation resulted in an apparent decrease in grazing and ruminating time over this period.

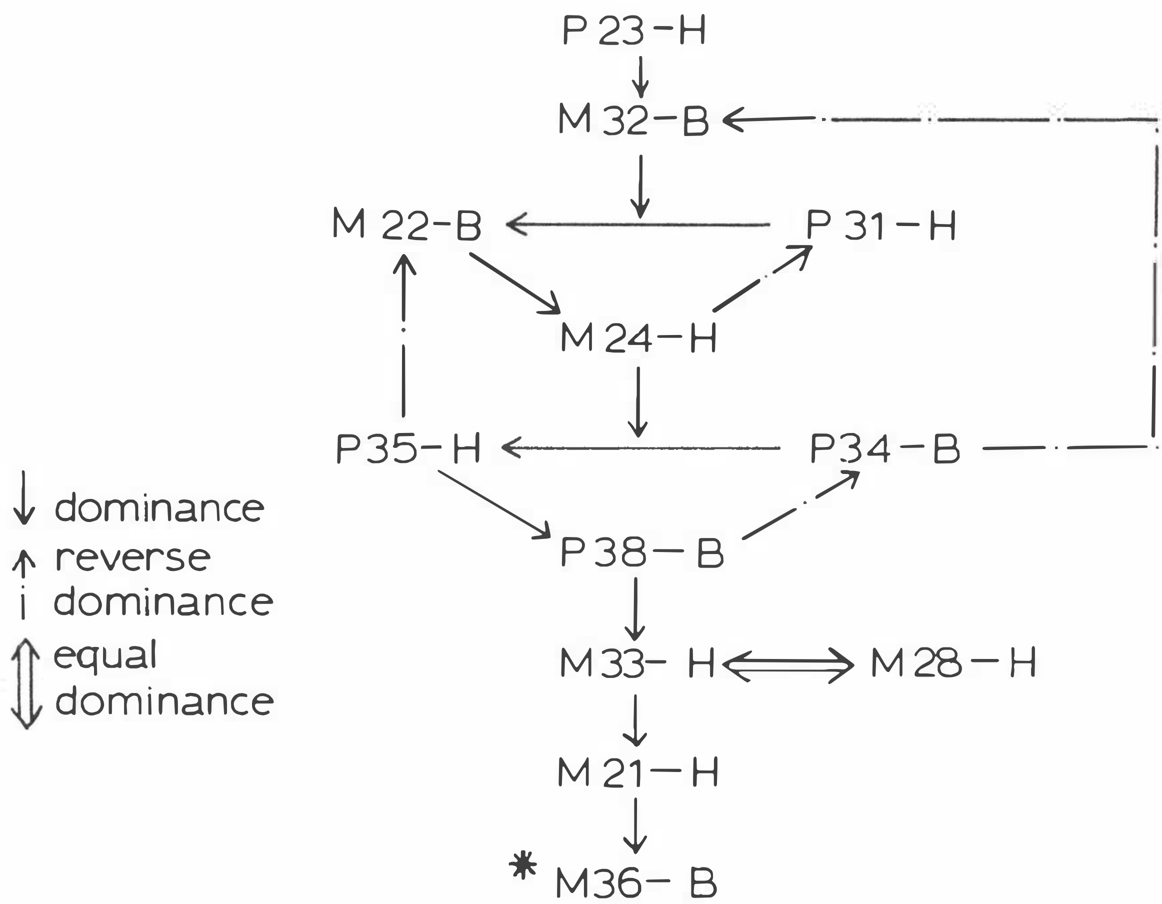


Fig. 5.8: Social dominance relationships amongst the weaned calves

Plate 5.18: Group cohesion showing leadership-followship behaviour

Plate 5.19: Aggregation of the cows following weaning

This also resulted in damage to the fences and pugging of the ground. By the 9th day there was no apparent indication that their separation from their calves at weaning was still influencing their behaviour.

4.2 Changes in calf liveweight

The average liveweight of the 11 Angus calves is plotted in Fig. 5.9. Regression analysis of liveweight data taken at certain times before, at, and after weaning was also made (Table 5.3 a and b). In both analyses a non-significant difference in calf liveweight over time was found. This suggests that weaning did not significantly depress calf weight.

Allowing the calves some contact with N-L cows may provide a partial explanation for these results. Alternatively, the shortage of pasture over the month preceding weaning may have depressed milk production to such an extent that by weaning the contribution of milk to the calves diet was relatively unimportant. Determination of the milk available to the calves would require measuring milk production which was not undertaken in this present study. The effects of calf age at weaning and the degree of separation between the cows and calves may also have had an effect on subsequent events.

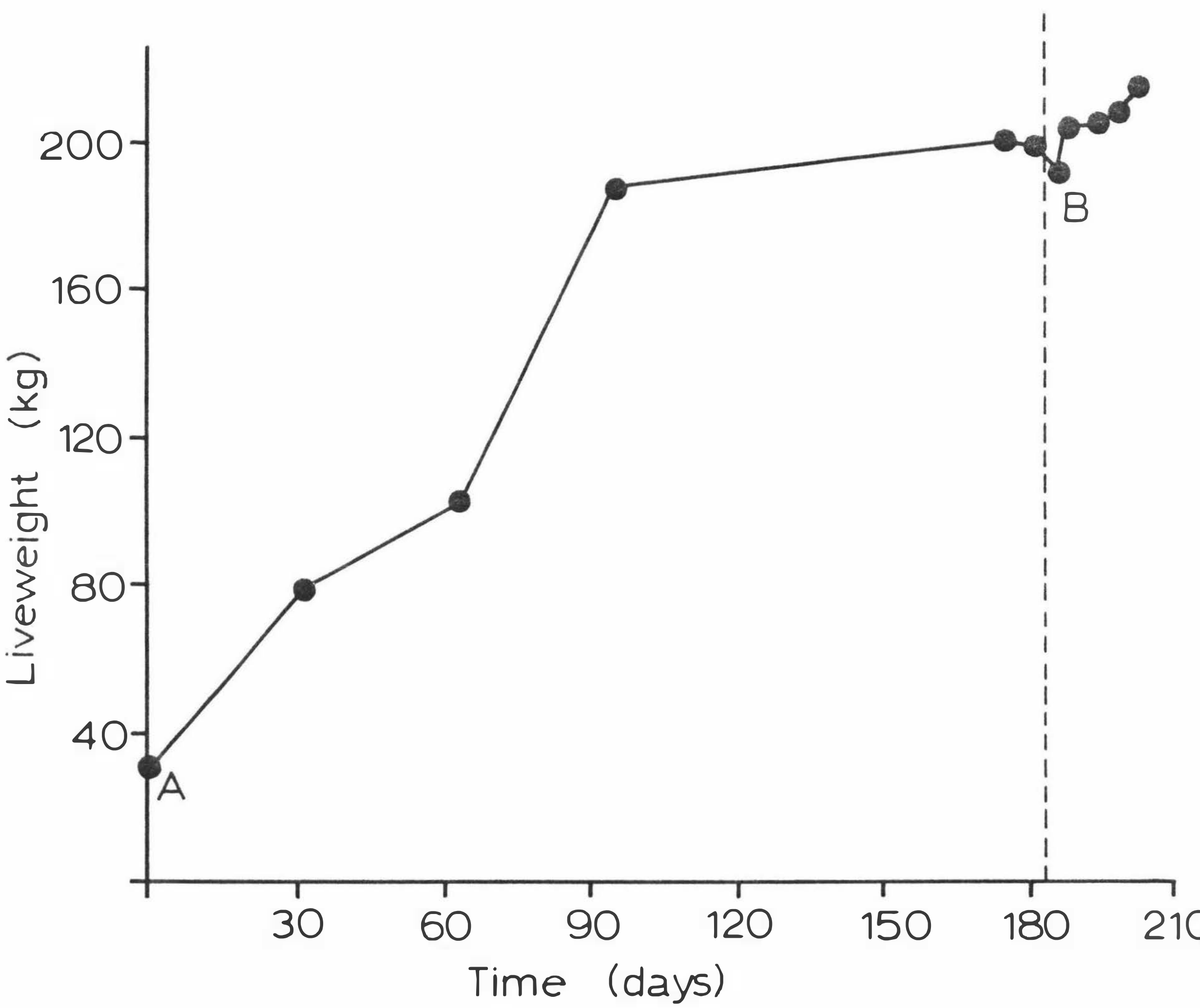


Fig. 5.9: Changes in average calf liveweight with time*

* These data exclude the values of the Friesian bull calf reared by M36-14

A = Mean calving day

B = Weaning day

TABLE 5.3: (a) Regression analysis of the liveweight data for the 11 Angus calves for 11 d pre-weaning, weaning and 3 d post-weaning

Source	S.S.	df	MSS	F
Regression	253.405	1	253.405	0.543 NS
Error	8864.35	19	466.545	

(b) Regression analysis for liveweight data obtained 11 d pre-weaning, at weaning and 21 d post-weaning

Source	S.S.	df	MSS	F
Regression	1695.67	1	1695.67	3.982 NS
Error	11923.5	28	425.838	

CHAPTER SIX

NURSING

A. LITERATURE REVIEW

1. Mechanism of Sucking

1.1 The sucking response

The sucking response complete with its accompanying orientation movements is one of the earliest complex behaviour patterns exhibited by newborn mammalian species (Ross *et al.*, 1957). Baliassnikowa and Model (1931-32) described the sucking response as a chain reflex compounded of search and orientation reflexes accompanied by sucking and swallowing acts.

Wolff (1958) found that mammalian sucking behaviour could be divided into 2 categories; nutritive mode and non-nutritive mode, according to temporal organization. Among most of the species investigated there existed wide variation in the mean sucking rate of the 2 modes. In calves there was no real difference recorded between the categories.

Adler *et al.* (1958) considered that sucking had 2 functions; the provision of nutritional and emotional requirements for the young animal. Conversely, Fraser (1963) considered that these requirements resulted in 2 distinct behaviours, described as the "pushing syndrome" and "head-pressing", respectively. This is supported by Walther (1964) who observed a distinct form of sucking only recorded in response to some disturbance.

Walker (1950) described the instinctive tendency of calves to suck at udder height as opposed to feeding from a bucket on the ground. This reluctance may be due not only to the level the milk is positioned at relative to the calf's head, but also that ingestion from a teat is different from the mechanism involved in drinking from a container.

1.2 Pulsation rate

Martjugin (1944) recorded the pulsation rate in suckled calves between 3 and 105 days of age and found a variation of 2 to 36 during any one sucking period. The number of pulsations per minute averaged 91 and ranged between 62 and 114. Hafez (1961) cited by Hafez and Bouissou (1975), obtained an average of 74 pulsations per minute (range 57 to 102). Pulsation rate was found to decrease toward the end of each sucking period and as the calf grew older (Martjugin, 1944 and Hafez, 1961 cited by Hafez and Bouisson, 1975).

1.3 Milk removal

Hafez (1964) described the process of sucking as a series of events timed by hormonal and humoral factors. Sucking was divided into 2 phases. The first was considered to last less than 1 min. and was characterized by restless activity in the calf as it stimulated the udder. This stimulation resulted in the occurrence of the milk-ejection reflex (Fraser, 1968), commonly termed milk "let-down". With the let-down of milk, second phase of sucking began and was characterized by relative immobility by the calf (Hafez, 1964). After a few minutes the intramammary pressure decreased as a combined result of withdrawal of milk and relaxation of the myoepithelium in the mammary gland. As this occurred a more active state, similar to that exhibited during first phase sucking, was resumed by the calf (Cross, 1961).

Martjugin (1944) distinguished between two distinct aspects of milk ingestion, sucking and swallowing, which were reflected in pressure changes in the mouth. A wide variation in these pressures between the 5 calves was recorded. The number of pulsations during sucking varied at different times and between calves, but remained fairly constant for each calf at any one time.

2. Behaviour

2.1 Approach and initiation

Initiation of nursing sessions by the dam has been shown by the "calling-out" of the offspring. It was frequently observed in hider-type species (Lent, 1974). Schuller (1957) reported on a 2 mth old domestic calf which continued to react to maternal vocalization by udder searching, even though it had been handreared. Long distance vocal exchanges preceding nursing were observed by Schloeth (1958; 1961) in feral cattle. Wagnon (1963) recorded that in 17% of an unspecified number of observations, the calf responded to maternal vocalization. Similar results were reported by Nicol and Sharfeldin (1975).

Lent (1974) described a particular behaviour exhibited by young ungulates as "heading-off". This involved the young animal standing in front of its mother in order to stop her forward movement, thereby allowing nursing to occur.

Various workers (e.g., Walker, 1962; Wagnon, 1963; Kilgour, 1972; Nicol and Sharafeldin, 1975) have observed that cow-calf pairs tended to nurse at the same time. This could be explained by the concept of "social facilitation" defined by Crowford (1939) as "behaviour showing increments in the frequency or intensity of responses already learnt by the individual". It is frequently used to refer to an increase in a particular activity as a result of the performer being with other animals (e.g., Kiley-Worthington, 1977).

Not all approaches necessarily result in nursing. Wagnon (1963) reported 9 out of 144 instances when the cow denied sucking and 4 out of the same 144 cases where the calf did not suck, although it investigated around the udder. Lent (1966) observed that when Caribou cows were disturbed they would adopt a characteristic stance and they then would not permit nursing.

2.2 Position

This term has been used to describe the orientation of the nursing calf to the cow. From the literature it appears that there are 3 main positions (Le Neindre and Garel, 1977), although within these, there was found to be large variation. The nursing positions differed in the amount of physical contact between the cow and the calf. Selman *et al.* (1970b) and Lent (1974) considered that the variation in nursing position increased as the offspring grew older.

One of the positions described as reverse-parallel, in which the 2 animals face in opposite directions, was found by Lent (1974) to permit the dam access to the perianal and back regions of the offspring. There is evidence in goats presented by Blauvelt (1955) which suggests that the grooming activities of the nanny induces the kid to adopt this nursing position.

The second major position involves the offspring standing at right angles to its dam. This position minimizes the amount of physical contact between the participants or opportunity for maternal grooming. Hafez and Bouissou (1975) found that in cattle this was the least frequently observed position. This suggests that the cow and calf purposely maintain physical contact with each other and thus nursing may be providing for some psychological requirements of the animals.

The third main position involves the calf nursing from the rear of the cow, usually between her legs although Lent (1974) considered this position to be more characteristic of follower-type species. In cattle its occurrence was found to be infrequent and when it was observed it was usually only maintained for a short time before the calf changed to some other position (Selman *et al.*, 1967; 1970b).

The nursing position observed in ungulate mothers was described by Hediger (1955) as the "abdominal leg angle". Fraser (1968) found that in monotocous species the posture of the nursing dam was typically that of an "upright open stance". Hafez and Bouissou (1975) in their review of the literature considered that there was little evidence to show that cattle varied from this posture.

Other stances such as sucking by the offspring while standing on the carpal joints or whilst the dam was recumbent have been described in a number of ungulate species (review Lent, 1974), but not in domestic cattle.

2.3 Teat preference

The term preference is used to denote the calf's selection of side and quarter of the udder from which it sucks. Selman *et al.* (1967;

1970b), with calves less than 12 h old, observed that the calves tended to return to the same side of the cow each time they nursed. Fraser (1974) and Hafez and Bouissou (1975) observed that calves were able to reach all teats without changing their position. There was no evidence to suggest that the calves showed a particular preference for any teat. A similar conclusion was reached by Martjuggin (1944) who found that calves between 3 and 105 d of age selected teats at random. On average 46.2% of total sucking time (TST) involved the anterior teats and 53.8% from posterior teats. Hafez and Lineweaver (1968) observed that calves aged up to 6 weeks showed no preference and selected the teat closest to themselves.

2.4 Activity of the nursing cow

Wagnon (1963) recorded that during 41% of the nursing observations the cow was standing at ease, sometimes grooming her calf, in 34% of the cases rumination occurred and in the remaining 25% the cow was ingesting water, grass or supplements.

Maternal grooming was considered by Lent (1966) to be important in Caribou. A statistically significant association between maternal licking and nursing was reported. Lent suggested this indicated a facilitative and/or stimulatory function of maternal grooming toward nursing behaviour.

2.5 Posture of the calf

Posture is used in this thesis to describe the nursing stance of the calf. Hafez and Lineweaver (1968) distinguished between 2 distinct postures on the basis to which the calf lowered its shoulders relative to its normal height. This lowering of the shoulders was believed to facilitate more vigorous sucking while the associated spreading of the forelegs increased the stability of the calf. This posture apparently aided sucking by making bunting more forceful and allowing "better" access to all 4 teats. It was observed that weaker and younger calves were less likely to adopt the lower of the 2 postures described.

Selman *et al.* (1967) observed that the head and neck of the nursing calf were bent; apparently this allowed sucking to occur as "easily as possible", but no justification for this statement was given. A possible explanation could be taken from the observations of Hafez and Bouissou (1975) who noted that as the young calf increased in size it tended to exhibit a downward curving of the back and neck. This resulted in directing the head upward so that the mouth connected with the teat at the "correct" orientation.

Bunting describes the activity of the nursing calf as it makes forceful contact with the udder. Lent (1974) considered it to be a universal behaviour pattern of ungulates. In cattle bunting has been described as a prod, strike and butt. Hafez and Lineweaver (1968) observed that bunting was more forceful when the calf adopted a low nursing posture, presumably because the direction of the force was upward into the udder. Bunting is often considered to aid in milk let-down by physical stimulation of the udder (e.g., Fraser, 1974; Hafez and Bouissou, 1975). Alternatively, bunting may indicate frustration due to the calf's inability to obtain milk.

Lent (1974) found that bunting generally became more forceful as the animal grew older. Sometimes the bunting was so vigorous that it caused the dam to move or it actually propelled her forward. Walther (1965), in his observations on gazelles, found that the 2 animals often pivoted as the offspring continued to bunt. Walther described this behaviour as "saügkreisen" (circle-nurse). Among a number of ungulate species Lent (1974) noted that as a result of being bunted the dam would present a threat posture and in some instances strike out at or bite her offspring. Lent postulated that this agonism might play a role in weaning.

Tail movements were found to be less obvious in calves than in other domestic species such as lambs (Hafez and Lineweaver, 1968). Hafez and Bouissou (1975) reported that "peaceful" (*sic*) sucking was often accompanied by tail movements of the calf. Vigorous tail-wagging was observed by Selman *et al.* (1967; 1970b) to occur only when the calf was not being satisfied in its demands, for example, whilst teat-seeking or after emptying the quarter or udder of its available milk.

2.6 Termination of nursing

Wagnon (1963) found that in 81% of the cases the calf was responsible for ending the nursing session. In those instances in which the cow terminated nursing, it was usually due to her walking away or lying down. On 6% of these latter occasions there was no further nursing activities shown by the calf; in the remaining observations the calf returned to nurse after 1 to 2 min.

Lent (1974) reported an increase in the frequency of terminations by the dam as the offspring aged. He believed this represented an increase in agonism by the dam which was part of a general trend, resulting eventually in weaning.

3. Abnormal Nursing

3.1 Non-nutritional nursing (NNS)

Reference to this as a distinct mode has already been made under the sucking response. Hafez and Lineweaver (1968) noted a negative relationship between sucking duration (SD) of individual calves and the occurrence of NNS. There is a commonly held belief that calves removed from their dams some time after birth and thereafter reared by bucket show a higher frequency and intensity of NNS than do single-suckled or teat-reared calves (e.g., Harker and Rollinson, cited by Hafez and Lineweaver, 1968).

Wood *et al.* (1967) presented a survey of 955 English and Welsh dairy herds and found that only 13.8% of the herds exhibited NNS, but within these herds up to 30% of the calves were affected. The behaviour was rarely observed in adult cattle and was less frequent in herds of mixed breeds. The most important causal agent identified was the method of rearing. Suckled calves showed the least inclination whilst those bucket-reared with milk substitutes were affected nearly twice as much.

The areas selected for NNS have been found to include the sheath, scrotum, udder and ears. Frequency of NNS averaged 176 and ranged between 78 and 337 per 24 h. The occurrence of NNS was found to cause a marked reduction in dry matter consumption and depressed weight gains (Hafez and Lineweaver, 1968). A relationship between diet composition and NNS of hair was reported by Wiltbank *et al.*, 1965).

3.2 Cross-nursing

The term "cross-nursing" or "milk robbing" is used to describe the nursing activities of a calf not the offspring of the cow. In some cases 2 or more calves may nurse 1 cow. The term is also used to describe the instance in which cows and other adult cattle nurse one another.

Nicol and Sharafeldin(1975) noticed that the absence of cross-nursing among the single-suckled cattle studied was due to the cows preventing it rather than the absence of attempts by calves to cross-nurse. Kilgour (1972) found a high incidence in calves fostered on to cows. The occurrence of cross-nursing was considered to be the result of the cows inability to discriminate between the calves. This lack of recognition was thought to be due to fostering after the critical period for the cow-calf bond formation had elapsed (Kilgour, pers. comm.). Kilgour (1972) considered cross-nursing might be an important mechanism for the transfer of disease between cows. Espmark (1971) observed that nursing was susceptible to social facilitation which stimulated the occurrence of cross-nursing.

4. Pattern of Sucking

In general, bovidae are characterised by low sucking frequency, i.e., number of sucking bouts/24 h and long sucking duration, i.e., number of minutes spent sucking for each session of sucking. These features were considered by Lent (1974) to be typical of hider-type species.

All frequency and duration values in this report refer to 24 h periods unless otherwise qualified.

4.1 Sucking frequency (SF)

From Table 6.1 it was calculated that SF averaged 5.2 per day over the entire nursing period although values as high as 11 were reported by Hafez and Lineweaver (1968). These high frequencies were believed to

TABLE 6.1: The relationship between age and breed of the calf and nursing behaviour

Breed	No. of calves	Age of calves (days)	Sucking frequency (per 24 h)	Sucking duration (min.)	Total sucking time (min.)	Reference
		1	5-8			Walker (1950)
		14 & older	3-5			
Hereford	8 or 9	120	4.1	11.4	48	Peterson and Woolfolk (1955)
		180	3.2	9.0	29	
Angus	21 or 27	30	4.6 ± 1.4	8.4	38.8 ± 18.4	Drewry *et al.* (1959)
		90	4.8 ± 1.3	11.6	55.9 ± 14.8	
		180	3.0 ± 0.8	10.2	30.7 ± 9.4	
Angus	9	Av. 93 (16 to 163)	4.0 (3.0 to 5.0)	10.0 (7.0 to 12.5)	40.0	Walker (1962)
Hereford	13	188	6.7 (5.4 to 8.0)	9.2 ± 0.5 (7.8 to 10.9)	60.3 (45.1 to 64.7)	Wagnon (1963)
Hereford		25 (7 to 42)	5.0 (3.0 to 11.0)	8.9 (7.8 to 10.0)	44.5 (37.0 to 57.0)	Hafez and Lineweaver (1968)
Hereford	12	42 (7 to 84)	2.89 (2.3 to 3.9)	8.55 (6.3 to 13.2)	23.7 (16.0 to 27.0)	Ewbank (1969)
Hereford	42				47.6	Schake and Riggs (1969)
Angus	24	7	5.6	6	30 to 35	Nicol and Sharfeldin (1975)
AA x HH		24 to 120	3.0	10 to 11		
AA x SS		24 to 120				
Charolais x Salens	5	39.5 ± 24.1	6.0 ± 3.0	11.0 ± 3.1	62.6 ± 18.1	Le Neindre and Petit (1975)

AA x HH = Angus x Hereford cross
AA x SS = Angus x Shorthorn cross

to be a result of the low milk production of the Hereford cows, although no milk production data were presented. The value of 4 is an average figure, in fact SF was not constant, but was found to vary as a result of a number of factors including breed, sex, age of calf, number of siblings, milk production and milk let-down (Walker, 1950, 1962; Peterson and Woolfolk, 1955; Wagnon, 1963; Le Neindre and Petit, 1975; Nicol and Shafeldin, 1975). Further consideration of these factors has been given in Chapter 6:A6 (Factors affecting nursing behaviour). Walker (1962) found that most calves studied nursed 4 times or more in every 24 h period (Refer Table 6.2).

TABLE 6.2: Percentage of cow-calf pairs nursing at either 3, 4, 5, 6, or greater times per day (Walker, 1962)

Percentage cow-calf pairs (n = 195)	SF per 24
38	4
22	3
24	5
13	6 or more

4.2 Sucking duration (SD)

Schloeth (1961) in his study of feral cattle found that the population was characterized by "long" SD. There was no quantitative support given for this statement and it is therefore impossible to determine from the study what effects domestication might exert on this aspect of bovine behaviour.

McHugh (1958) working with Bison calves reported SD to be 8 to 19 min. SD in domestic cattle is similar and has a usual range of 8.6 to 11.5 min. (Refer Table 6.1). SD changes as the calf ages, but there does not appear to be a consistent trend between the various studies (Peterson and Woolfolk, 1955; Hutchison *et al.*, 1962; Ewbank, 1969; Le Neindre and Petit, 1975).

The length of interval between successive nursing bouts does not appear to be a factor influencing SD. Schake and Riggs (1969) allowed nursing twice a day at 0800 and 1630 h. The average time required for morning and evening nursings was 14.8 and 15.3 min. respectively, despite the fact that the length of separation between nursing was 8 h during the day and 16 h during night-time. Hutchison *et al.* (1962) obtained a mean duration of 9.2 min. for each nursing session. The only factor which significantly affected this was the individual cow-calf combination which showed very highly significant differences ($P<0.001$) between mean duration of sucking time.

4.3 Total sucking time (TST)

TST has been used in this thesis as the total time spent sucking/24 h, i.e., TST = SF x SD. Selman *et al.* (1970b) recorded that mean TST over the first 8 h post-partum averaged 16.7 ± 9.2 min. Walker (1950) determined TST by separating the cow and calf allowing the calf access to the cow 6 times per day for the first 4 days after parturition. TST ranged from 9 to 14 min. and averaged 11 min. This is lower than the values reported by Hafez and Lineweaver (1968) in calves aged 1 to 41 days, when TST ranged from 16 to 27 min. and averaged nearly 24 min. over the entire period. Wagnon (1963) recorded TST as 49 min. and Hafez and Bouissou (1975) concluded that TST ranged from 37 to 57 min. The increase in TST in the last 2 studies examined could be explained by the existence of another nursing period during the hours of darkness.

Ewbank (1969) observed an increase in TST from birth to 42 days post-partum, thereafter it declined until termination of the study at approximately 96 days post-partum. This change in TST was reflected in a decrease in both SF and SD. However, Nicol and Sharafeldin (1975) found that TST from dawn to dusk remained relatively constant from birth to 120 days post-partum, although there were changes recorded in SF and SD. These changes tended to cancel each other out so that TST remained unchanged.

5. Circadiam Rhythm

Lent (1974) reported the occurrence of distinct patterns in nursing activity in many ungulate species, the tendency being most prounounced in hider-type species.

There are differences in the literature regarding the proportion of nursing periods that occur during daylight *versus* darkness. Peterson and Woolfolk (1955) and Ewbank (1969) found that usually there were the same number of sessions during the day as during the night. Conversely Cartwright and Carpenter (1961), Walker (1962), Hafez and Lineweaver (1968) all came to the conclusion that there were fewer nursing bouts during darkness. This is substantiated by Schake and Riggs (1969) who found that the interval between nursing sessions was nearly twice as long during darkness as it was during daylight. Le Neindre and Petit (1975) recorded the ratio of nocturnal nursing periods to total number of nursing periods to vary between 16.3 to 50% between the legal hours of sunset to sunrise. However, when night time was restricted to the hours of darkness the ratio only ranged from 4.1 to 29.4%. Drewry *et al.* (1959) noticed that unless disturbed the sucking of calves during the night was negligible. Walker (1950) believed this was because the calves became aware with increasing darkness that it was a "time for sleeping" and only when the hours of darkness exceeded 5 did they nurse. This is supported by Kilgour (1972) who observed that from the onset of darkness (*c.* 2000 h) the majority of calves became recumbent, usually in close proximity to their dams.

Wagnon (1963) observed that nursing occurred throughout the 24 h, but that it was most frequent between 0500 and 0600 h with lesser periods of activity after midday, around dusk and about midnight. Hutchison *et al.* (1962), Hafez and Lineweaver (1968), Ewbank (1969) also recorded nursing at all hours particularly with young calves.

Hafez and Lineweaver (1968) found a large variation between individual calves in the time they nursed. They considered that this was a reflection of physiological changes in the digestion and rate of growth of these animals. Weaver and Tomanek (1951) suggested this variation was due to the occurrence of nursing when the calf was hungry or when the cow felt discomfort. Lampkin and Lampkin (1960) observed a similar lack of consistency in the time of nursing between individuals. Conversely, Cory (1927), Peterson and Woolfolk (1955) reported a high level of regularity and consistency in the circadian rhythm. Cory (1927) concluded that calves sucked 3 times a day; morning, noon and night for periods of 10 to 15 min. each. Nicol and Sharafeldin (1975) reported a similar pattern in calves less than 100 days old. Walker

(1962) found that the most regular sucking time was around daybreak (0400 to 0600 h) during which all cow-calf pairs nursed. The next period of nursing was between 0900 to 1200 h, with the peak occurring from 1100 to 1200 h. During the afternoon and early evening there was no clear period of activity. This was apparently due to the tendency for cow-calf pairs which nursed 4 or more times a day to nurse at some stage during this period. The next regular nursing period was between 2200 and 0100 h. Hutchison *et al.* (1962) was able to identify 5 distinct periods during which nursing occurred. A similar lack of regularity during part of the 24 h period as Walker (1962) recorded, was found by Hutchison *et al.* (1962), but it tended to occur between late evening and around midnight.

Le Neindre and Petit (1975) observed nursing at all hours but 80 to 100% of the calves nursed during the 3 h around dawn. At pasture the nursing cycles were found to coincide with the grazing cycles of the herd (Petit, 1972; Le Neindre and Petit, 1975). Peterson and Woolfolk (1955) found that the time of maximum nursing coincided with the beginning and end of rest periods. Kilgour (1972) fostered either 3 or 4 calves on to dairy cows and these were observed to exhibit a very obvious nursing rhythm with 3 definite peaks of circadian activity per 24 h.

6. Factors Influencing Nursing Behaviour

6.1 Breed

Hutchison *et al.* (1962) using Zebu cattle (*Bos indicus*) found they had higher SF values than those reported in *B. taurus* populations. One month old Zebu calves averaged SF of 9.5 per day but by the 6 month of age this had decreased to 5.6 per day. The possible effect of other variables such as nutrition and management was not discussed. Cartwright and Carpenter (1961) reported an average diurnal SF and TST which was greater for Brahman-Hereford calves (SF = 3.5, TST = 28.7 min.) In the same study no apparent breed effect for the time of day at which nursing occurred was found.

Within domesticated breeds of *B. taurus* there also exist differences, especially between "dairy" and "beef" breeds. This may be due to the greater milk production of the dairy breeds or it might be a reflection of calf appetite. Walker (1962) observed that Hereford x Angus heifers nursed their calves more frequently (4.5 *versus* 4.0), but for a shorter time (9.0 *versus* 10 min.) than did Angus heifers. This might be a result of hybrid vigour, but in the same study Angus x Jersey heifers had a shorter SD (8.0 *versus* 9.0 *versus* 10.0 min.) than either the Hereford x Angus or Angus cattle. This suggests that breed *per se* is more important than heterosis. Hafez and Lineweaver (1968) reported a significant effect ($P<0.01$) for breed between Holstein and Hereford calves for SF. There was no significant difference for SD between the 2 breeds. A breed effect for TST when calves were fed a standard volume of 700 ml of milk by nursette was recorded. Holstein calves spent 22 to 42 min. whilst Herefords spent 16 to 28 min. per day sucking. These breed effects were found to be related to differences in body weight, with body weight being a function of dry matter consumption and growth rate. Nicol and Sharafeldin (1975) noted that Friesian x Angus calves sucked more often (3.83 *versus* 3.37) and for a marginally longer SD (9.98 *versus* 9.69 min.), resulting in a significantly ($P<0.05$) greater TST (35.6 *versus* 30.9 min.) than Angus calves. An explanation given by the authors was that, as a result of heterosis, milk production was stimulated and this permitted a higher growth rate in the crossbred calves.

6.2 Sex of calf

Cartwright and Carpenter (1961) and Melton *et al.* (1967) reported that male calves had a higher SF than female calves. However, Rugh and Wilson (1971); Le Neindre and Petit (1975) and Nicol and Sharafeldin (1975) found no real difference in the sucking behaviour of heifer and bull calves of the same age.

6.3 Age of calf

Walker (1950) observed that newborn calves sucked 5 to 8 times per day, but that this declined to 3 to 5 times from 2 weeks onwards. Hutchison *et al.* (1962) found that SD remained fairly constant within the 5 calves studies, but SF showed a very highly significant ($P<0.001$)

decrease with age from about 11 times per day to about 5 times per day at 6 months of age.

This decline in SF related to calf age has a limit. Nicol and Sharafeldin (1975) noted a decrease until 24 d post-partum, thereafter it remained constant until the end of the observational period (120 d post-partum). Le Neindre and Petit (1975) recorded a decrease in SF which showed the largest decline in the first 2 months. Wagnon (1963) noticed the greatest drop in SF occurred in calves 3 months and older. There has been only one report which has found an increase of SF with time and this involved calves 6 weeks and younger (Hafez and Lineweaver, 1968).

The decrease in SF appears to be associated with a corresponding increase in SD such that TST remains relatively constant (Nicol and Sharafeldin, (1975). However, Wagnon (1963) found TST of calves 76 d or younger to be greater than the TST of calves 76 to 180 d of age. Hutchison *et al.* (1962) reported a very highly significant negative relationship between TST and calf age. Le Neindre and Petit (1975) found that young calves which were housed, but allowed *ad lib.* access to cows increased their TST as they aged and this resulted in a milk production increase. However, in older calves run as a single-suckled herd on pastures neither calf age nor milk production significantly influenced either SD nor TST.

Hutchinson *et al.* (1962) noticed that after the first month there was little variation in mean TST per night, although the time spent sucking by day continued to decrease significantly through the remaining 5 months. Also the calves, as a group, reacted similarly to changes from month to month during their daytime sucking, but reacted individually with regard to their night time sucking.

Nicol and Sharafeldin (1975) found that in calves greater than 100 d of age there was no longer any obvious pattern in nursing. It was suggested that this might be due to the increase in grazing time in the calves which showed a very marked three peaked pattern by 100 d post-partum. However, Peterson and Woolfolk (1955) studied a group of 4 month-old-calves and again 2 months later. A very distinct pattern was observed at both ages. Each calf nursed 4 times a day at about 6 hourly intervals. Walker (1962) observed that intervals between successive nursing sessions increased as the season progressed.

6.4 Development of solid food intake

Nicol and Sharafeldin (1975) related an age effect to increased grazing time in older calves.

Changes in nursing behaviour with time could be due to either an increase in calf age and/or an increase in solid food intake associated with an increase in calf age. The respective effects of these 2 variables can only be assumed until experimentation is performed which can account for independent changes in each of the factors.

Nursing rhythms are also influenced by the relative proportions of TST which occur during the night *versus* the day. Le Neindre and Petit (1975) found night-time nursing decreased as the calf aged, but as grazing time increased nocturnal nursing reappeared and its time of occurrence was apparently associated with the grazing cycle.

6.5 Number of siblings

Studies involving twins *versus* singletons in cattle have found SF in twins to be greater (Hafex and Lineweaver, 1968). There are 2 possible explanations for this difference; there may be social facilitation within twin pairs; and/or because twins tend to nurse at the same time, available milk may be inadequate for the combined demands of the calves, therefore more frequent sucking may result as a means of fulfilling these requirements.

6.6 Method of feeding

Hafez and Lineweaver (1968) studied the differences in nursing behaviour of single-suckled calves and those fed by nursette. SF in nursette-fed calves was as high as 55 times a day. The reason for these levels was considered to be due to the very dilute milk replacer used. TST for Hereford calves reared on the nursette was 16 to 28 min. per 24 hours as opposed to 37 to 57 min. in single-suckled calves. This indicated that either suckled calves spent a large proportion of TST not extracting milk or that the milk flow rate was slower. This could be due to inefficient stimulation of the udder; poor extraction of milk; or that some of the time involved in nursing is unrelated to nutritional needs of the calf, i.e., it provides some psychological need of the cow and the calf.

Swanson (1956) used identical twin pairs and estimated that calves sucking their mothers drank more milk than those which were bucket-reared.

Wise *et al.* (1940) showed that the nipple system in contrast to bucket-rearing stimulated salivation and retarded the rate of consumption resulting not only in more saliva per unit of milk, but also in more mixing of the milk and saliva in the mouth.

6.7 Milk let-down

The removal of milk from the udder involves mechanical withdrawal and a positive milk-ejection process (Fraser, 1968). Milk let-down requires initial activation and time for the causal agent oxytocin to circulate before reaching the mammary gland. Findlay (1971) in his review on the relationship between behaviour and lactation gave a number of examples illustrating this association,

Milk-ejection was shown by Cross (1961) to be inhibited by various "stress" factors. This appears to be due mainly to the effects of adrenalin (Kon and Cowie, 1961). There have been 4 distinct mechanisms reported by which adrenalin acts in this context (Cowie *et al.*, 1971; Grosvenor and Mera, 1974).

6.8 Milk production and composition

Drewry *et al.* (1959), from the size and form of the correlation between weight of milk required per unit of liveweight gain, indicated that initially the heavier and older calves sucking lower-producing dams sucked more frequently and spent more time sucking. However, by 6 months of age calves sucking the heavier-producing dams tended to suck more frequently and spent more time nursing. Le Neindre and Petit (1975) found that at the same age, single-suckled calves run at pasture, had the same SF and SD irrespective of milk production. This was not the case reported by Nicol and Sharafeldin (1975) who subjected 1 group of cows to a low plane of nutrition for the first 40 d of lactation. Calves from dams in this low plane intake group had a 75% greater grazing time than other calves. This difference just failed to reach significance at the 5% level, but the authors considered that it suggested that the calves were able to compensate to some degree for low milk production by increasing their grazing time. However, there was no difference between the times of nursing behaviour.

Hafez and Lineweaver (1968) noted that differences in TST between single-suckled and nursette-reared calves was due to differences in the milk composition, particularly in the percentage of total solids. Increasing this component resulted in a decrease in TST and an increase in dry matter consumption. This change was reflected in a faster growth rate.

B. RESULTS AND DISCUSSION

1. Description

1.1 Approach and initiation

Of the 334 relevant observations 85% of the initiations were due to the calf responding to approach and orientation by the dam and was described as calling-out (ref. Fig. 5.6). Of the remaining 15% all resulted from the calf approaching the dam of which 11% occurred whilst the cow was feeding hay supplements and 4% whilst the cow was grazing. These figures contrast with the findings of Wagnon (1963) in which in 83% of the observations the calf initiated nursing by approaching the cow. Whether the calf approached the cow due to maternal presence or behaviour was not discussed.

Heading-off as described by Lent (1974) was recorded in 3 of the calves and nearly always occurred after 3 weeks of age. Of these calves 2 were born from primigravida heifers (P31-3; P35-6) both of which initially had to be restrained in order for nursing to occur. The remaining calf was born from a multigravid cow (M21-11) and heading-off behaviour ceased after 40 d, post-partum.

Throughout the study there was a strong tendency for nursing to involve several cow-calf pairs at about the same time. The number of such pairs averaged 5, but ranged from 2 to 10; in 86% (n = 244) of the instances in which initiation of a nursing session resulted from a cow moving to the calf-pool other cows showed the same behaviour within the following 10 min. Thus it may be inaccurate to state that the tendency for more than 1 cow-calf pair to nurse at the same time was due to social facilitation as defined by Crowford (1939) (ref. Chapter 6A:1). Instead it could have been indicative of the high degree of synchronization of the activities of the herd. As it was impractical to isolate cow-calf pairs it was not possible to show that nursing activity increased because calves were together in a group.

Except when the cow and calf were disturbed all contact periods resulting from "calling-out" led to nursing. In those instances in which the pair were disturbed the cow would elicit Fo.R until the pair had moved *c*. 9 m away from the disturbance at which time nursing would usually occur.

It might be that nursing reinforced the bond between the participants as nearly all contact periods following a period of separation resulted in nursing. Also, nursing allowed for an intensive period of mutual stimulation by grooming and vocalization, etc. for both cow and calf which frequently continued after nursing had ceased.

1.2 Position

Four main calf nursing positions were studied and a summary of their respective proportion of occurrence has been presented in Table 6.3. The most common position was the reverse-parallel (Plate 6.1) in which the body of the calf was parallel to but facing in the opposite direction to the cow. The next most frequently observed position was described as variable angle (Plate 6.2) in which the calf faced in the opposite direction to the cow, but there was less physical contact between the animals than occurred in reverse-parallel position. In the extreme case the calf was positioned at right angles to the cow (Plate 6.3), but this was only recorded in 11.7% of the 334 observations. The fourth main nursing position involved the calf standing behind the cow (Plate 6.4). As is apparent from Table 6.3 rear nursing was most frequently observed in 2 calves (P31-H and P35-H); in the other calves rear nursing never exceeded 2% of the observations recorded in each instance.

TABLE 6.3: Proportion of nursing positions recorded for individual calves*

Identification No. of calf	Reverse-parallel	Variable angle	Right angle	Rear	Total No. of observations
P23-H	78.4	16.2	5.4	0	37
P31-H	9.8	11.8	41.2	37.3	51
P38-B	58.1	27.9	9.3	4.7	43
P34-B	67.3	25.0	3.9	3.8	52
P35-H	22.2	3.7	14.8	59.8	27
M24-H	50.0	40.5	9.5	0	42
M32-B	75.0	15.0	5.0	5.0	20
M22-B	64.5	29.0	3.2	3.3	31
M28-H	83.3	8.3	0	8.3	12
M21-H	75.0	25.0	0	0	8
M33-H	50.0	0	0	5.0	4
M36-B	43.0	28.6	0	28.6	7
Total	54(177)	22(72)	11.7(39)	14(46)	334

Numbers in parenthesis represent number of observations

* Values expressed as percentage of total observations

Plate 6.1: The reverse-parallel nursing position

Plate 6.2: The variable angle nursing position

Plate 6.3: The right angle nursing position

Plate 6.4: The rear nursing position

The 2 calves (P31-H and P35-H) had not been initially accepted by their mothers and throughout the nursing period initiation of nursing was more frequently (Binomial, $P<0.01$) made by these calves than their dams. This contrasts with the situation observed in the other 10 cow-calf pairs.

Nursing whilst the cow was recumbent was observed on 8 occasions (Plate 6.5). It involved 3 cow-calf pairs and was most frequently observed in the same pair (P34-5). In all instances recumbent nursing was a continuation of a nursing bout which had been interrupted by the cow lying down. If the calf was nursing on the right hand side the cow would lie down on that same side, presumably to obscure the teat. The cow often hindered the calf's nursing by drawing her legs up under the body and rolling to a more vertical posture.

1.3 Teat preference

There was no apparent preference for one side of the udder. Of the 329 observations 162 and 167 involved the left and right hand sides, respectively (Table 6.4).

During the first 14 d post-partum the calves tended to suck from a single teat on each occasion. This did not appear to be due to an inability of the calf to reach other teats or to a lack of knowledge of the presence and location of the other teats. Instead it appeared to be due to the calf's appetite and/or ability to continue sucking long enough to remove all milk from the quarter being suckled. With age the calves used all the teats, to varying degrees, during each nursing period. This indicates that there was an increase in calf appetite, vigor, and/or a decrease in the milk available from each of the quarters with time.

There was a very highly significant tendency (Binomial, $P<0.001$) for each nursing period to commence with an anterior teat, usually on the same side of the udder as the calf was located. A total of 264 observations were found on the initial preference for the anterior and posterior teats. Of these 156 involved an anterior teat whilst 108 began on a posterior teat. The sequence and frequency with which specific teats were used varied between calves, but was reasonably consistent for each calf at successive sessions. This suggests that calves may learn and remember to use only those teats from which milk is most readily available.

TABLE 6.4: The preference of individual calves for the left and right hand side of the udder

Identification No. of calf	Left hand side	Right hand side	Total No. of Observations
P23-H	29	2	57
P31-H	20	28	48
P38-B	16	24	40
P34-B	29	26	55
P35-H	2	5	7
M24-H	24	21	45
M32-B	14	5	19
M22-B	17	14	31
M28-H	4	8	12
M21-H	2	6	8
M33-H	1	1	2
M36-B	4	1	5
Total	162	167	329

TABLE 6.5: Activities of the nursing cow*

Activity	Frequency of occurrence	Proportion of time
Grooming calf	57	39
Grazing	10	8
Rumination	15	34
Others	18	19

* Values expressed as percentage of totals

Total No. observations = 329

The sucking of supernumerary teats was most frequently observed in the 2 calves, which often nursed from behind the cow (P31-H; P35-H). Of the 12 lactating cows 8 had more than 4 teats. In all except 1 these extra teats were on the posterior quarters above the teat proper. Nursing from these supernumerary teats frequently resulted in the cow kicking out at or moving away from the calf, thereby terminating nursing. It was not possible to determine whether these teats were functional or not.

1.4 Activity of the nursing cow

There were 3 main activities shown by the nursing cow and their respective frequency of occurrence and proportion of time has been summarized in Table 6.5. The cow's behaviour often changed during each nursing session and between different observations. Of these activities certain of the cows consistently exhibited the same behaviour. For example 2 primigravid cows (P31-3; P35-6) frequently grazed whilst nursing and consequently spent much less time showing maternal interest in the calf.

Of the 4 categories of behaviour investigated grooming of the calf was the most frequently observed and involved a greater proportion of nursing time than the other activities. This maternal grooming was sometimes concentrated on specific areas of the calf's anatomy such as the perianal region when it was frequently observed to result in urination and/or defecation by the calf (Plate 6.6). Those cows which consistently groomed their calves were less likely (Anova, $P<0.02$) to terminate nursing than were those cows which most frequently grazed or showed some other non-maternal behaviour.

The values in this present study are similar to those reported by Wagnon (1963) with the exception of grazing activity. The lower values found in this present study may reflect the fact that nursing most frequently occurred between successive grazing cycles, and most often immediately following a period of grazing, than at any other time.

Plate 6.5: Nursing from a recumbent cow

Plate 6.6: Stimulation of urination by the cow

1.5 <u>Posture</u> (Plate 6.7 and 6.8)

Both postures described by Hafez and Lineweaver (1968) were observed in this present study, but no apparent relationship between posture and calf age was found.

Bunting usually involved the muzzle of the calf (Plate 6.9 and 6.10) although sometimes the calf's poll was used to bunt the udder. Bunting was most frequently observed following 5 to 10 min. of sucking and often resulted in a different teat being sucked. This supports the findings of the reviews made by Fraser (1974) and Hafez and Bouissou (1975) who considered that bunting aided milk let-down. There was a positive but non-significant relationship between calf age and the frequency of bunting. The most obvious increase in bunting occurred between the first and second 6 weeks post-partum (No. buntings = 156 of which 87 were recorded in the second 6 week period).

1.6 <u>Termination of nursing</u>

Termination of nursing by the calf occurred in 87% of the 334 observations (Table 6.6). This value is comparable to the 81% value reported by Wagnon (1963). Contrary to the opinion of Lent (1974) the cows in this present study rarely terminated nursing or any other contact period with their calves by agonism. Only 2 cows were observed to show such behaviour over an extended period and both were primigravida (P31-3; P35-6). This agonism most often involved kicking out at the calf, although when the calf persisted in nursing the cow would head-butt the calf. During the first 10 d following parturition all of the primigravida were observed to try to prevent and/or terminate nursing. This behaviour varied in both its frequency and persistency between the different cows. It usually involved the cow moving forward or abducting the appropriate hindleg so that the teat was obscured. After this period of maternal rejection these cows appeared to become more tolerant of their calves' nursing activities, as they less frequently tried to prevent or terminate nursing. A possible explanation might be that pain in the udder and/or maternal inexperience were responsible for the initial terminations by the cow.

There was no evidence available to suggest that maternal agonism resulting in termination of nursing increased in frequency or severity as the calf aged as was reported by Lent (1974). Under domestic

Plate 6.7: Calf nursing posture

Plate 6.8: Milk ingestion using the tongue and lips

Plate 6.9: Bunting - physical stimulation of the udder
N.B. Higher head posture of calf and tail movement of the cow

Plate 6.10: Bunting - resumption of sucking

TABLE 6.6: Activities causing termination of nursing*

Activity	Calf (%)	Cow (%)
Lie down	13	4
Grazing	16	13
Head contact	42	43
Walk away	21	17
Others	8	23
Proportion (%)	87	13

* values expressed as a percentage of total observations

Total No. observations = 329

situations calves are rarely weaned later than 8 mth of age and perhaps at this age calves are not forceful enough to evoke maternal agonism. Alternatively, cows may be less aggressive toward their offspring than are dams of other ungulate species.

There were 4 major activities recorded which resulted in termination of nursing (Table 6.6). Termination of nursing by the cow was usually temporary; within 2 min. the calf would often return to nurse. This persistency by the calf became more evident as the calf grew older. Initially the cow was responsible for terminating nursing, but from *c.* 14 d, post-partum, cessation of nursing was most frequently due to the calf changing its activity. This was probably due to the calf's increased tenacity to nurse despite attempts by the cow to terminate nursing and in the case of the primigravida increased tolerance toward the calf's nursing, with time.

2. Abnormal Nursing

2.1 Non-nutritional nursing (NNS)

Of the total 415 nursing observations only 12 involved sucking of objects other than the teat. (Excluded from these values are the instances during the exploratory teat-seeking activities of the neonate.)

Specific objects were found to be most often used by the calves. These included ear-tags of other calves (Plate 6.11); body hair of other herdmembers (Plate 6.12) and to a lesser extent, electric fence standards, baling twine and plastic. Unlike Hafez and Lineweaver (1968) no relationship was found between SD and NNS. All observations of NNS involved calf ages of between 8 and 34 d, post-partum. On every occasion NNS appeared to result from the calf's exploratory behaviour when it was investigating a novel object in its immediate environment.

2.2 Cross-nursing

Cross-nursing was only observed on 4 occasions when it involved 2 primigravida cows (P31-3; P34-5). On all occasions the cow's own calf had begun sucking and was positioned laterally to its dam. The alien

Plate 6.11: Non-nutritional nursing of an eartag

Plate 6.12: Non-nutritional nursing of body hair

Plate 6.13: Cross-nursing by an alien cow

Plate 6.14: Cross-nursing by an alien calf

calf or cow nursed either from behind the cow (Plate 6.13) or on the distant side of the cow's calf (Plate 6.14).

Nursing involving only an alien cow-calf pair always resulted in the two terminating contact as soon as she had identified the calf, usually within a minute of the commencement of nursing. This form of cross-nursing invariably involved calves less than 7 d old which had been unable to nurse from their own dams owing to abnormal maternal behaviour.

3. Pattern of Nursing

3.1 Terminology

A distinction was made between the terms of sucking and nursing. A sucking bout was considered to exist when the calf had the teat in its mouth; whilst nursing was used to describe the more general situation when the calf was engaged in activities characteristic of nursing, for example, T-SA and bunting. The nursing term was also used when it was impossible to determine where the teat was in relation to the calf's mouth. During darkness audible sounds indicative of milk ingestion were used as the criteria for determining the occurrence of sucking.

Sucking frequency (SF) was used in reference to the number of sucking bouts separated from successive observations by at least 10 min. In calves less than 3 weeks of age up to 7 sucking bouts were often observed, but when they were separated by less than 10 min. they were recorded as the same SF. The relationship between calf age and the existence of successive short sucking bouts was probably due to calf fatigue or temporary loss of contact with the teat as a result of the cow shifting her position. It is unlikely to be due to insufficient milk availability as milk yield is around maximum during the first weeks post-partum.

Sucking duration (SD) was measured to the nearest min. and included the time during which the teat was in the calf's mouth when ingestion of milk may not be occurring, for example, stimulation of the udder prior to milk let-down.

Due to observer fatigue only 6 24 h continuous periods of observations were made. On each occasion the observations began at 0600 h and continued until the following 0600 h. The remainder of the observations were divided throughout the day and night. Each fortnight this data was combined to obtain the circadian pattern.

3.2 Sucking frequency (SF)

Over the 20 weeks of the study SF averaged 5.2 per 24 h period with a range of 4 to 6, and this value was very consistent between calves of a comparative age. During the 3 to 18 weeks post-partum period SF remained reasonably stable (Fig. 6.1), but averaged only 3.2 (range 0 to 6) during the first 24 h following calving. It then increased to a maximum 6.4 by *c*. 3rd day and thereafter decreased to 5.2 by an average 12 d (range 7 to 21 d) post-partum. During the last 2 weeks pre-weaning SF declined slightly which was probably due to depressed milk yield resulting from a very short amount of feed being available. An alternative explanation is that by *c*. 5 months of age the contribution of milk to the calf's diet may have decreased to such an extent that fewer sucking bouts were required. This decrease in SF with increasing age of calf is in agreement with all studies reviewed with the exception of Hafez and Lineweaver (1968) who reported the opposite situation.

3.3 Sucking duration (SD)

During the first 2 weeks SD increased from an initial value of 3 min. (range 42 s to 5.4 min.) to 10.2 min. (range 6.8 to 12.2 min.). This was accompanied by a decrease in the time spent nursing (TSN). As the calf aged it spent proportionally more of the time involved in nursing activities in milk ingestion, i.e., sucking. There were 2 reasons which appeared to be responsible for this; an increase in the calf's nursing vigour and an improvement in its co-ordination and appetite. As well, in the case of all the primiparous cows and one multiparous cow (M30-12) abnormal maternal behaviour was found to decrease SD and increase TSN during the early post-partum period. In all calves SD did not differ significantly from the average 10.2 min. during the remaining 18 weeks prior to weaning.

As was also reported by Schake and Riggs (1969) the length of interval between successive nursing bouts was found to have no effect on either SD or TSN for any sucking session.

Of the 7 factors known to influence nursing behaviour which were discussed in the literature review only 3; namely, breed, calf sex and age, could be investigated in this present study.

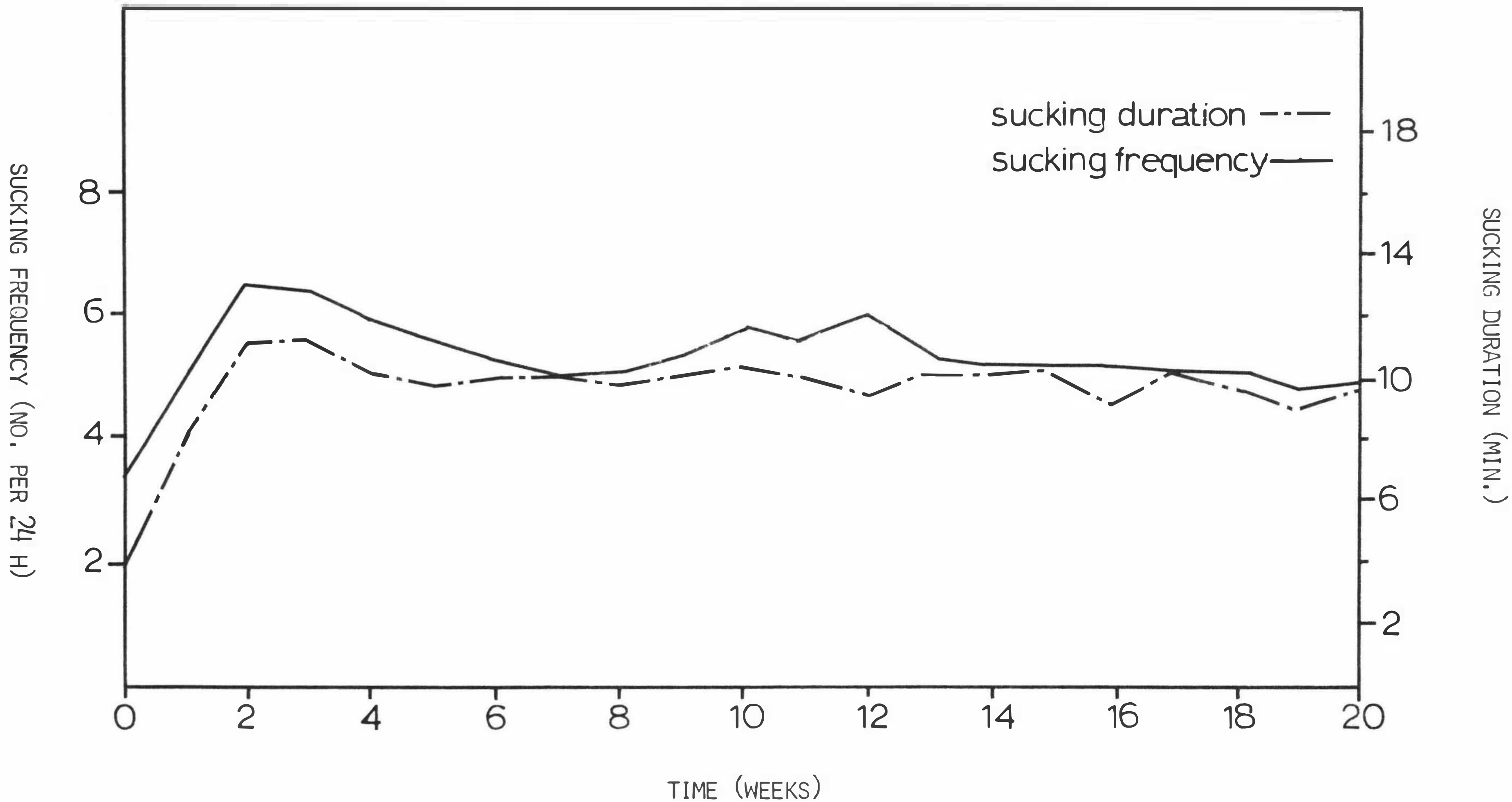


Fig. 6.1: Pattern of sucking over the 20 week nursing period

Walker (1962) and Nicol and Sharafeldin (1975) both recorded lower SF values for Angus calves than was found in the present study (4.0 and 3.37, respectively). However, the average SD value of 10.2 min. in this present study is in agreement with the values reported by Walker (1962) and Nicol and Sharafeldin (1975) for Angus cattle (10.0 and 9.69 min., respectively) for SD.

Sex of calf had no significant effect in this present study on any of the variables; SF; SD; TST or TSA. This result supports the conclusions of Rugh and Wilson (1971); Le Neindre and Petit (1975) and Nicol and Sharfeldin (1975), but conflicts with the results of Cartwright and Carpenter (1961) and Melton *et al.* (1967) who found that male calves sucked more frequently than did female calves.

3.4 Total sucking time (TST)

TST averaged 52.44 min. per 24 h period over the 20 weeks of observation. This is within the range of values reported by the studies reviewed (ref. Table 6.2). Due to the changes in SF and SD over the first 3 weeks post-partum, TST likewise changed as shown in Fig. 6.1.

The maternal status of the cow had a significant (Anova, $P<0.01$) effect on SD and hence on TST during the first month. This effect was due, in certain of the cows, to maternal rejection of the calf's nursing behaviour. However, a more apparent reason for this maternal effect was a drop in body condition of the heifers due to insufficient feed availability. This drop in body condition was presumably reflected in low milk yields as was evident by the time spent by the calves of these cows prior to sucking in such behaviours as bunting and changing the teat used.

4. Circadian Rhythm

Throughout the study nursing was observed at all times throughout the 24 h period (ref. Fig. 6.2) as was also observed by Hutchison *et al.* (1962); Wagnon (1963); Hafez and Lineweaver (1968); Ewbank (1969) and Le Neindre and Petit (1975).

Despite the occurrence of nursing at all times there was a tendency for nursing to be more evident during 4 periods. The most apparent of these extended from 0400 to 0600 h, i.e., *c.* dawn; to a lesser extent increased nursing activity was also recorded between the times of 0800 to 1200 h; 1400 to 1700 h and from 2100 to 2400 h.

Taking into account the variation in the time of dawn and dusk over the 20 week period the same number of peaks of nursing activity were recorded during daylight as for darkness. This substantiates the findings of Peterson and Woolfolk (1955) and Ewbank (1969), but is in disagreement with the opinions of Cartwright and Carpenter (1961); Walker (1962) and Hafez and Lineweaver (1968) who all reported fewer nursing bouts during darkness.

When all the data from the 20 week observation were combined and expressed as the percentage of cow-calf pairs observed, it was possible to obtain the circadian rhythm which is presented in Fig. 6.2. However, when the data were analysed on the basis of the number of observations for different periods over the 20 weeks it was apparent that wide variations existed in the time at which nursing was recorded (Fig. 6.3).

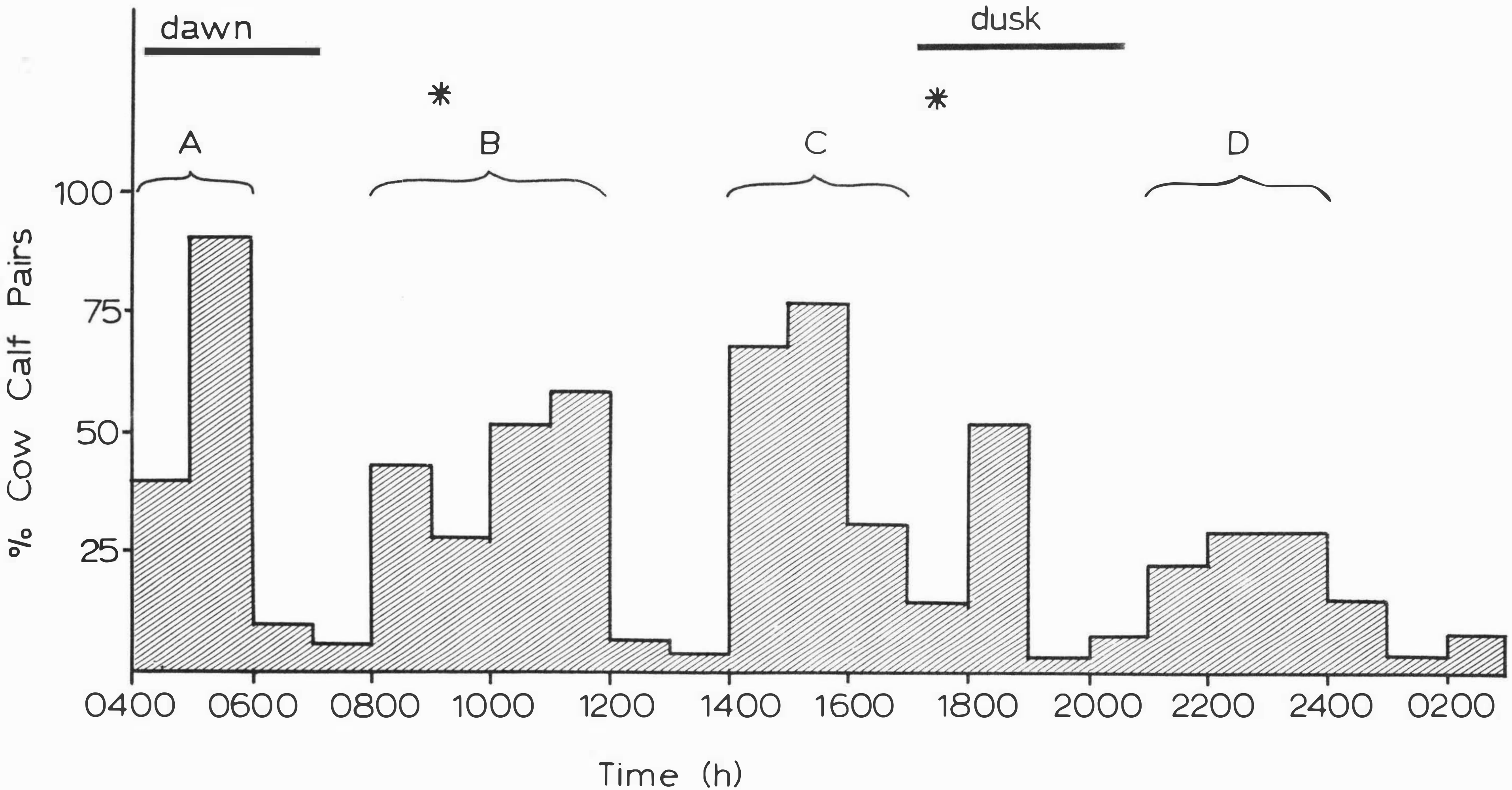


Fig. 6.2: Circadian nursing rhythm

* Time hay supplement was made available every day during the first 10 weeks

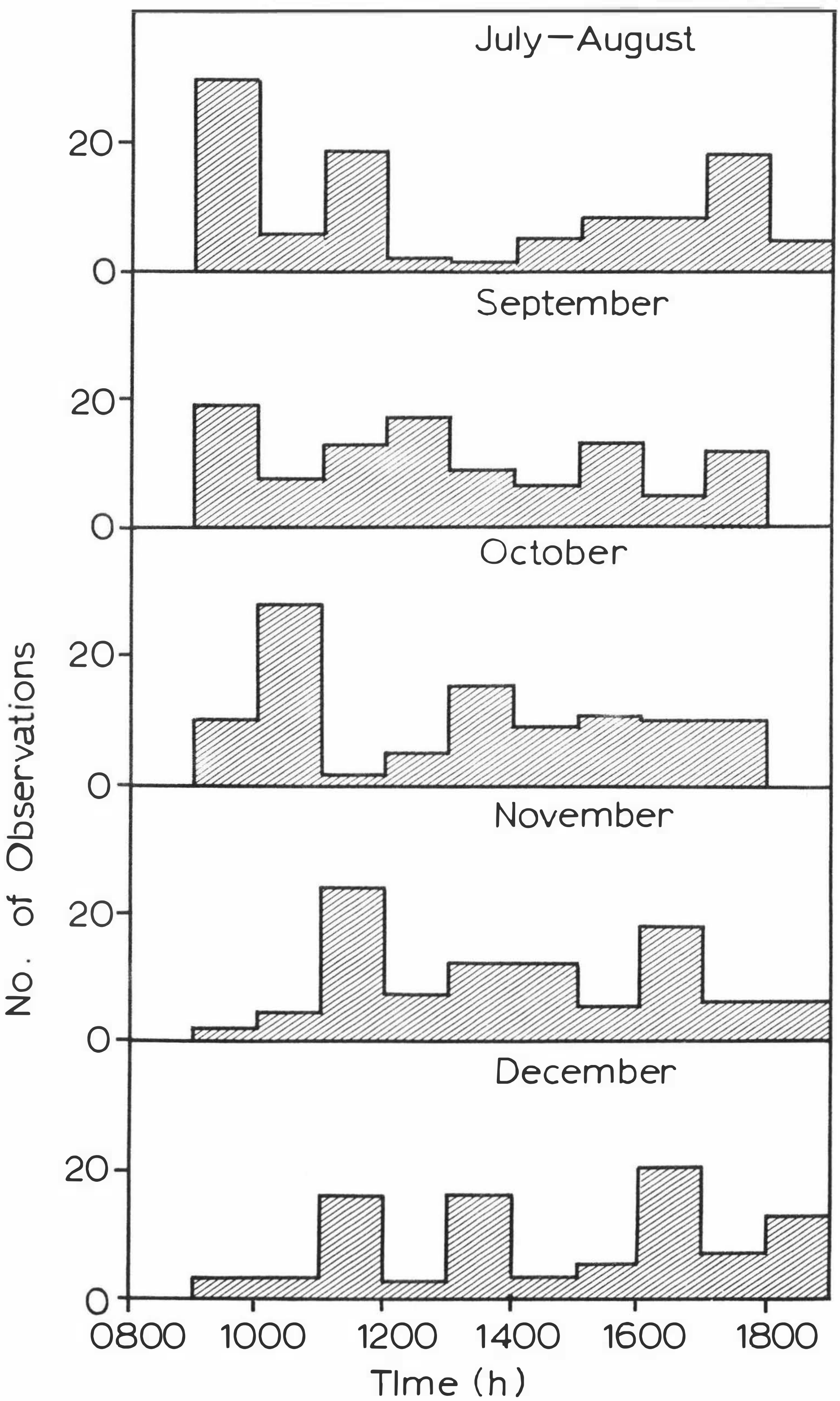


Fig. 6.3: Changes in the diurnal nursing rhythm with time

CHAPTER SEVEN

CONCLUSIONS

A. GENERAL DISCUSSION

1. Prediction of Calving-time

Despite the accuracy in predicting calving order and calving time using visual assessment of 24 physical and 11 behavioural signs there did exist a number of limitations. For example, it was necessary to make a daily inspection of each of the cows for the various signs. This could be made at specified times of the day for the physical signs, but a similar restriction could not be applied to the behavioural observations. Instead behavioural data needed to be collected throughout each day if complete and accurate records were to be obtained. The need for regular data collection was especially evident during the last 48 h preceding parturition. However, the calving season lasted for 65 d and it was not possible to undertake detailed observations for this length of time. It is considered that this lack of detailed observations may help to explain the relatively low number of cows recorded for each of the behavioural signs in comparison with the number of physical signs observed.

Due to the wide variation between individual cows, for the number of signs and time they were first recorded, it was not possible to determine either calving order or calving time by comparing cows. Instead it was necessary to individually identify the cows and to compare the data of each cow over successive days and use this as the basis for her independent prediction.

Another effect of these wide variations was that it was not possible to use any one sign as the sole criterion for prediction; at least 5 physical signs and 3 behavioural signs needed to be recorded for each cow to achieve an accurate prediction.

A possible effect of maternal experience on the occurrence of signs was demonstrated by a highly significant difference in the number of physical signs recorded by the 2 cow groups (primigravid *versus* multigravid). In contrast, there was no statistically significant difference in the number of behavioural signs recorded on the basis of maternal experience.

Other possible explanations for these results could be the existence of different control mechanisms operating for the 2 types of signs or inaccuracies in data collection. As the study was made in one season only it was not possible to determine which of these was the most important contributing factor. At least two relationships between maternal status and certain parturient behaviours were found in the present study. First, there was a definite tendency for the primigravid heifers to calve during daylight which represented a significant difference from the multigravida who showed no such propensity. Secondly, 75% of the multigravid cows calved in the same area of the paddock whilst the heifers calved at random locations. The extent to which these behaviours reflected maternal experience obtained from previous calvings cannot be determined until subsequent calvings involving the same animals are studied. As only 14 cows (6 primigravid and 8 multigravid) were involved the results obtained may be due to chance effects and may not represent a true association between maternal status and behaviour.

2. Maternal Behaviour

2.1 Placentophagia

The single most important parturient behaviour recorded was considered by the observer to be the pre-occupation by the parturient cow to ingest the placental tissues and fluids. The reasons for this opinion are outlined in the following 3 paragraphs.

The most commonly expounded theory for this ingestion is as an adaptive method to minimize predation. For 2 main reasons this explanation is not acceptable to the present author. First, expulsion of the placenta occurred *c.* 120 min. (range 46 to 360+) following the calf's birth by which time the calf was mobile and less vulnerable to predation. Secondly, cattle have been domesticated for a number of centuries and as a consequence of this the threat of predation has been greatly reduced. If ingestion functions solely as a protective mechanism it is surprising that it is still evident to such a high degree.

It is the opinion of the author that the following is a reasonable alternative explanation for placentophagia in a species which at all other times is herbivorous. Placentophagia was invariably shown following rupture of the allanto-chorionic membrane and continued, except for 2 primiparous, until completion of placentophagia. It is suggested that this ingestion aids the cow in the formation of a bond with the neonate by providing a chemical basis for discriminatory identification of her calf. It is believed that the cow initially becomes attracted to these chemicals prior to the calf's birth. This fixation localizes her to the calving site. After the birth the cow remains in the area due to the presence of birth by-products and not initially at least, to the neonate. As the cow removes the material off the calf she changes her attention to grooming the calf. At first this interest is due to ingestion of membranes which cover the calf, but later by association, physical contact is progressively made with the calf.

Although it appeared that the birth by-products were responsible for providing positive reinforcement and ensuring continued maternal ingestion, neonatal movements and/or vocalizations may have also been important. The principal sensory basis for maternal acceptance of and subsequent attachment to the neonate appeared to be olfactory. This is supported by the studies reviewed which found that removing olfactory communication or manipulation of the calf's smell affected formation of the bond. In this present study, with the exception of 1 cow, maternal acceptance of the neonate by primigravid heifers occurred after the cow had investigated the neonate by smelling. A possible contribution of gustatory sensory perception may also be involved.

2.2 Active *versus* passive mother-type

Using the criteria presented by Hediger (1955) for distinguishing between passive and active types of ungulate mothers, it was evident from this present study that the domestic cow could be included in the latter category. This was demonstrated by the rapidity with which the cow established contact and showed maternal behaviour toward the neonate following its birth. This involvement by the cow in the ingestion of birth by-products and subsequent maternal grooming was shown by all the cows, including the 3 primigravid and 1 multigravid, which initially rejected or attacked their calves.

Active interest of the dam in the calf was not restricted to the immediate post-partum period. During nursing and other contact periods a large proportion of the time involved maternal grooming. The degree of these maternal behaviours varied between the cows, but tended to be characteristic of individual animals.

3. Filial Behaviour

3.1 Hider *versus* follower offspring-type

On the basis of the observations collected during the course of this work it was not possible to unequivocally categorize domestic cattle as representing either a hider or a follower type species as described by Walther (1961, 1964, 1965, 1968). Instead the cattle showed characteristics of both types without demonstrating the complete behavioural repertoire of either type. For example, a modified hiding period was shown, but to a less developed extent, than that described by the species reviewed by Lent (1974).

Taking into account the topography and restricted area available in which the cattle were grazed the location of the hiding site did not appear to provide protection by camouflage, seclusion or inaccessibility. Also, in contrast to the typical hider-type species, the periods of contact between the cow and calf were not restricted to nursing. Instead the cow tended to spend nearly all her resting and rumination periods alongside the calf.

Choice of the site was not the sole prerogative of the calf, as is the case in hider-type species, although on some occasions the calf moved to areas inaccessible to the cow. It was nearly always due to the cow eliciting following response, a behaviour considered to be characteristic of follower-type species, that the cow and calf would move to a "hiding site".

In common with hider-type species the cow would not approach and make contact with her infant at its hiding site. Instead they showed a behaviour which has been described in Chapter 5 as "calling out".

Duration of the "hiding phase" varied between the different cow-calf pairs and appeared to be due principally to the existence of a calf pool. This was demonstrated by the tendency for the hiding phase to decrease, to a minimum of *c*. 20 h, with successive calvings and for the cow and calf to unite with other calves at the calf pool at which a few other cows may be present. However, as the latter calvings all involved multigravid cows this tendency might have been due to some extent to the cow's maternal status.

It is the opinion of this observer that instead of a true hiding period the cattle demonstrated a behaviour described by Lent (1974) as maternal isolation. This involved the peri-parturient animal seeking and maintaining isolation for sometime following calving.

3.2 Filial response

The occurrence and subsequent changes in filial responses did appear to be related to the timing of primary socialization. The presence of general and specific following responses were recorded. The latter of these responses appeared to be a consequence of bond formation as was the opinion of Manning (1972) and Klopfer (1974), but this idea is in conflict with the opinion of Lent (1974). This difference in opinion is an example of the discrepancy between the results of the different studies reviewed for many of the behaviours investigated and it serves to justify the need for continued investigations to try to account for these differences of opinion.

3.3 Nursing

Nursing behaviour was more representative of hider-type species than of follower-type species, e.g., a relatively long sucking duration (average 10.2 min.) in comparison to low sucking frequency values (average 5.2) plus a low occurrence of deviant nursing postures such as rear-nursing were recorded (14% of 334 observations).

The principal feature which became apparent from the observations of nursing behaviour was the lack of consistency in the pattern of sucking recorded at different times through the study period. This inconsistency is not substantiated by other studies reviewed in Chapter 6.

The only possible explanation for this feature of the study is the low number of calves (n = 12) combined with the large difference in their ages (average 34 d; range 1 to 59 d). If this is the reason then future studies should undertake investigations on larger numbers of animals and/or limit the age range of the experimental animals.

B. RECOMMENDATIONS

1. Data Collection

Throughout the study it was evident from the large standard deviation units that there existed wide variation between the animals despite the fact that only 14 cows or 11 cow-calf pairs were involved. These variations were especially evident when attempting to predict calving order and calving time. In order to determine the extent, and hence the importance, of these individual cow differences more data collection and analysis, using the maximum number of animals possible, are required.

As the study was restricted to one calving season no estimation of the repeatibility of the results for individual cows could be obtained. Likewise, it was not possible to determine the effect of year or environmental (social and physical) features on the results obtained.

Determination of these would necessitate data collection over a number of years preferably using the same animals. Maintaining a constant composition of the experimental animals would be of particular value in accounting for the effect of experience on maternal behaviour. If repeatibility of maternal behaviour is high and therefore maternal experience is of relatively low importance in influencing the cow's behaviour it might be a justified management policy to select breeding cows on the basis of their primiparous performance.

As was shown in Chapter 6:B6 prediction of the calving order required some subjective interpretation of characteristics of which quantitative assessment was not possible. It is suggested that there existed some contribution of the "skill of stockmanship" in predicting this calving order. These skills could be defined as the ability to intuitively assess a situation on the basis of the cow's "demeanour". Hence, it is recommended that emphasis be placed on developing objective descriptions and measurements of these skills whenever future experimentation in this area is undertaken.

This study involved only Angus cattle run under set-stocked pasture conditions. If it is considered necessary to obtain a more complete ethogram (i.e., behavioural repertoire) of single-suckled cattle it would be advisable to also study other breeds under a variety of management and environmental conditions.

A major, but unavoidable limitation of the present study was the availability of only 1 observer. This was aggravated by the length of the study *c*. 33 weeks. Due principally to observer fatigue 24 h continuous periods of data collection were infrequently obtained.

As the cattle were unrestrained, night-time observations with limited lighting facilities were found to decrease the ease and accuracy of data collection. However, as the project was designed to simulate as near as possible a commercial farming situation confinement of the cattle to improve observational techniques might have detracted from the value of the study.

2. Stock Management

An increasing prevalent feature in many herds including this study is the calving of the primigravida before the older cows. The justification for such a policy is that it provides a means of decreasing the effects of lactational anoestrus by increasing the time between calving and mating for the following calving season. Another advantage of this calving policy is better utilization of feed supplies in order to maximize milk production of the primigravid cows.

In this study the calving pattern of the 2 cow groups resulted in a significant difference between the 2 groups of cows in their respective number of observation days prior to calving. This restricted the analysis to the frequency of signs indicative of calving recorded and excluded the use of the time (days, pre-partum) the signs were first observed.

Maintaining primiparous cows, whose calves had died *c*. calving, with the herd could have been responsible for some of the abnormal maternal behaviour observed in some cows. The effect of these non-lactating primiparous cows was due to their interest in the post-parturient cow and her calf. When the interference occurred it resulted in rejection and desertion of the calf by its dam (ref. Chapter 4:B3). With successive calvings in this study it was evident that there was progressively less interference and correspondingly less abnormal maternal behaviour. There are 2 possibilities presented to explain these results. First, due to the decline in interest from herdmates the post-parturient cow was less likely to be forced to simultaneously express epimeletic maternal behaviour toward her calf and protective or agonistic responses toward herdmates. Hence, the cow would be less likely to show agonism toward the calf if there was no need for this response to occur because of the lack of interference from other cattle. Secondly, the primigravid cows which calved toward the end of the season may have learnt the correct response, i.e., maternal grooming, by exposure to the presence of a neonate at other calvings prior to their own. Hence, the presence of their offspring would not be a novel stimuli which due to its uniqueness might elicit an agonistic response from the dam. It was observed that most interference involved primiparous cows. Furthermore, both this interference and abnormal maternal behaviour decreased with successive calvings. These findings suggest that the recommendation be made that multigravida be calved ahead of the primigravida. This might decrease both unwanted behaviours, because the maternally experienced older cows are more successful in denying alien cows access to their calves. Also, the additional "exposure" to calvings available to the primigravid might provide them with learning opportunities.

Another obvious effect of the management method used was the age of the calves at weaning and the subsequent degree of contact permitted between the cows and calves. Estimation of the importance of such factors would require their manipulation. This would either necessitate extending observations over several years or using larger numbers of experimental animals at the same time. The latter alternative would require additional labour and possibly greater yard and weighing facilities, but all the data could be collected from 1 season which would greatly decrease the time involved in such a study.

3. Future Objectives

The possible value of the by-products of birth in the formation of the bond by the cow with the neonate has already been discussed (Chapter 7:A). In order to obtain experimental evidence to support or refute the theory proposed there, a number of approaches could be investigated. For example; analysis of the components of the birth fluids and membranes throughout parturition. It might be possible that certain of these compounds could aid in preparing the cow for the calf's birth and the appropriate subsequent maternal responses. Determination of the relevant compounds and their role would require the identification of the chemicals in them. Then application of individual and/or combinations of these chemicals to cows in different physiological states, e.g., pregnant, parturient, lactating cows or application to a heifer which has never been pregnant could be made. After application of these compounds observations of subsequent changes in the cow's behaviour should be monitored and recorded. The presence and form of any such changes might clarify the existence of such a role of these compounds.

An alternative approach would be to restrain the parturient cow in order to deny her access to fluids and membranes from the initiation of parturition. The calf could be presented after being cleaned of all membranes. Alternatively, the cow could be allowed access to the calf without human interference. Monitoring of the resulting maternal and filial behaviours might allow for the determination of the contribution of the birth fluids and membranes in their expression.

The second area requiring investigation is the relative value of the releasers responsible for teat seeking behaviour and the associated maternal behaviours. Knowledge of these might aid an understanding of how to obtain successful fostering of alien cow-calf pairs with minimum human or resource involvement. The ability of a cow to rear more than 1 calf may become of increasing importance as the economics of farming the traditional form of single-suckled beef herds declines. Alternative policies could involve the use of breeds, or combinations of breeds, which provide milk excess to the requirements of 1 calf, e.g., Friesian or Simmental breeds and this potential should be utilized.

It was not possible to investigate all features inherent in a single-suckled beef herd such as the possible effects of oestrus on maternal and/or filial behaviours. Likewise, the relationship between behaviour and productivity is an area which requires much more attention. The majority of the literature reviewed concentrated on the relationship between nursing behaviour and calf liveweight gains. However, it appears that behaviour has more extensive repercussions than this. For example, in this present study, a definite relationship between maternal and filial behaviours and calf survival were found (ref. Chapter 5B). Unfortunately it was not possible to monitor the influence of behaviour on subsequent production except at weaning. Hence, although it is apparent that behaviour does affect the number of calves weaned it was not possible to determine the effects of behaviour on other production parameters such as milk production, live weight gains in the cow and calf or the time to first oestrus. It is therefore suggested that future studies are designed to investigate for such associations.

REFERENCES

Abusineina, M.E. (1969): Effect of parity and pregnancy on the dimensions and weight of the cervix uteri of cattle. *Br. Vet. J., 125:* 12-20.

Adler, J., Linn, L. and Moore, A.U. (1958): "Pushing" in cattle: its relation to instinctive grasping in humans. *Anim. Behav., 6:* 85-6.

Alexander, G., Signoret, J.P. and Hafez, E.S.E. (1975): Sexual and maternal behaviour, pp 222-56. *In: Reproduction in Farm Animals*, Ed. Hafez, E.S.E., Publ. Lea and Febiger, Philadelphia, 480 pp.

Altmann, J. (1974): Observational study of behaviour: Sampling methods. *Anim. Behav., 48:* 227-67.

Anon. (1972): Natural birth, pp 13-22. *In: Calving the Cow and Care of the Calf.* Publ. Farming Press Ltd, Fenton House, Warfedale Rd, Ipswich, Suffolk, 164 pp.

Anon. (1972a): *In: Beef Cattle Improvement.* Ed. Clifford, H.J. and McDonald, M.F. Publ. N.Z. Soc. Anim. Prod., Occ. Publ. No.1, 32 pp.

Anon. (1973): *In: Nomina Anatomica Veterinaria.* Second edition. Publ. International Committee on Veterinary Anatomical Nomenclature, 218 pp.

Appleman, R.D. and Owen, F.G. (1971): Relationship of the environment, including nutrition, to calf health. A review. *Trans. Am. Soc. Agric. Eng., 14:* 1083-91.

Arnold, G.W. and Dudzinski, M.L. (1978): *In: Ethology of Free-ranging Domestic Animals.* Publ. Elsevier, Amsterdam, 198 pp.

Arthur, G.H. (1961): Some observations on the behaviour of parturient farm animals with particular reference to cattle. *Vet. Rec., 12:* 75-84.

Arthur, G.H. (1966): Recent advances in bovine obstetrics. *Vet. Rec., 79:* 630-40.

Autenreith, R.E. and Fichter, E. (1975): On the behaviour and socialization of Pronghorn fawns. *Wildlife Monog., No.42,* pp 111.

Bailey, P.J. and Bishop, A.H. (1972): The effect of age at weaning and post-weaning stocking rate on the growth of autumn born calves. *Aust. J. Expt. Agric. Anim. Husb., 12:* 579-83.

Bailey, P.J., Halls, M.A. and Bishop, A.H. (1975): Effect of weaning age and post-weaning nutrition on the growth of calves and the liveweight of their dams. *Aust. J. Expt. Agric. Anim. Husb., 15:* 581-86.

N.B. Zeir. fur Tier. = Zeitschrift fur Tierpsychologie.

Baliassnikowa, N.J. and Model, M.M. (1931-32): Zur neurologie des Saügens. (On the neurology of the mammal). *Zsch. f. Kinderforsch., 39:* 1-16.

Bareham, J. (1977): Development of mother-infant relationships in ungulates. *Br. Vet. J., 133:* 190 (Abst.) *Proc. Soc. Vet. Ethol.* (1975).

Barton, R.A. (1970): The yield and composition of milk of suckled beef cows and their relation to calf live weight gain, pp 130-41. *In: New Zealand Beef Production, Processing and Marketing.* Ed. Campbell, A.G. Publ. N.Z. Inst. Agric. Sci., Wellington, 683 pp.

Barton, E.P., Donaldson, S.L., Ross. M. and Albright, J.L. (1974): Social rank and social index as related to age, body weight and milk production in dairy cows. *Proc. Indiana Acad. Sci., 83:* 473-7.

Bateson, P.P.G. (1966): The characteristics and context of imprinting. *Biol. Rev., 41:* 177-220.

Beilharz, R.G. and Mylrea, P.J. (1963): Effect of pregnancy on dominance rating of dairy heifers. *Anim. Behav., 11:* 528.

Benesch, F. and Wright, J.C. (1951): Parturition, pp 122-36. *In: Veterinary Obstetrics.* Publ. Baillière, Tindall and Cox, London, 549 pp.

Bielański, A (1977): Foetal behaviour and the possibility of its detection in farm animals. *Appl. Anim. Ethol., 3:* 379-90.

Bijou, S.W., Peterson, R.F. and Ault, M.H. (1968): A method to integrate descriptive and experimental field studies at the level of data and empirical concepts. *J. Appl. Beh. Anol., 1:* 175-91.

Boch, J. (1960): Tierärzt und Moderne Verhaltensforschung. (The veterinarian in modern research in behaviour.) *Tierärzh. Umsch., 15:* 11-14.

Bouissou, M.F. (1974a): Établissement des relations de dominance-soumission chez les bovins domestiques. I. Nature et evolution des interactions sociales. (Establishment of dominance-submissive relations in domestic cattle. I. Type and evolution of these social interactions.) *Ann. Biol. anim. Biochim. Biophys., 14:* 383-410.

Bouissou, M.F. (1974b): Établissement des relations de dominance-soumission chez les bovins domestiques. II. Rapidite et mode d'etablissement. (Establishment of dominance-submissive relations in domestic cattle. II. Rapidity and method of establishment.) *Ann. Biol. anim. Biochim. Biophys., 14:* 757-68.

Bouissou, M.F. (1975): Établissement des relations de dominance-soumission chez les bovins domestique. III. Role de l'experience sociale. (Establishment of dominance-submissive relations in domestic cattle. III. Social experience.) *Zeit. fur. Tier., 38:* 419-35.

Brambell, F.W.R. (1970): Transmission of immunity in the ruminants, pp 201-27. *In: The Transmission of Passive Immunity from Mother to Young.* Publ. North Holland Co., Amsterdam, 385 pp.

Broadhurst, P.L. (1961): Analysis of maternal effects in the inheritance of behaviour. *Anim. Behav., 9:* 129-41.

Broom, D.M. (1977): Mother-young interactions in dairy cattle. *Br. Vet. J., 133:* 195 (Abst.). Proc. Soc. Vet. Ethol. (1975).

Broom, D.M. (1978): The development of social behaviour in calves. *Appl. Anim. Ethol., 4:* 285 (Abst.). Proc. Soc. Vet. Ethol. (1977).

Brumby, P.J., Walker, D.K. and Gallagher, R.M. (1963): Factors associated with growth in beef cattle. *N.Z. J. Agr. Res., 6:* 526-37.

Bubenik, A.B. (1965): Beitrag zur Geburtskunde und den mutter-kind Beziehungen des Reh- und Rotwildes. (Contribution to the science of obstetrics and on the mother-child relations of roe deer and red deer.) *Zeit. Säug., 30:* 65-228.

Calhoun, J.B. (1949): A method for self control of population growth among mammals living in the wild. *Sci. N.Y., 109:* 333-5.

Campling, R.C. (1966): A preliminary study of the effect of pregnancy and of lactation on the voluntary intake of food by cows. *Br. J. Nutr., 20:* 25-39.

Cannon, W.B. (1953): *In: Bodily changes in pain, hunger, fear and rage.* Publ. Brandford Co., Boston, 405 pp.

Carhart, A.H. (1946): *In: Hunting North American Deer.* Publ. The Macmillan Co., New York, N.Y., 232 pp.

Cartwright, T.C. and Carpenter, J.A. (1961): Effect of nursing habits on calf weights. *J. Anim. Sci., 20:* 904 (Abst.).

Christiansen, I.J. and Hansen, L.H. (1975): Dexamethasone induced parturition in cattle. *Br. Vet. J., 130:* 221-9.

Christopherson, R.J. (1973): Some observations on weaning stress in beef calves. *U. of A. Feeders Day,* University of Alberta, pp 48-9.

Collias, N.E. (1956): The analysis of socialization in sheep and goats. *Ecol., 37:* 228-39.

Cory, V.L. (1927): Activities of livestock on the range. *Texas Agr. Exp. Sta. Bull., 367:* 1-47.

Cowie, A.T. and Tindall, J.S. (1971): Milk removal, pp 185-222. *In: The Physiology of Lactation.* Publ. Arnold, London, 392 pp.

Craig, J.F. (1937): Normal parturition, pp 176-213. *In: Fleming's Veterinary Obstetrics.* Publ. Ballière, Tindall and Co., London, 552 pp.

Cross, B.A. (1961): Neural control of lactation, pp 229-77. *In: Milk: the Mammary Gland and its secretion.* Ed. Kon, S.K. and Cowie, A.T., Vol. 1. Publ. Acad. Press, London, 515 pp.

Crowford, M.P. (1939): The social psychology of the vertebrates. *Psychol. Bull., 36:* 407-46.

Crowley, J.P. and Darby, T.E. (1970): Observations on the fostering of calves for multiple suckling systems. *Br. Vet. J., 126:* 658-64.

Denenberg, V.H. and Banks, E.M. (1969): Techniques of measurement and evaluation, pp 192-233. *In: The Behaviour of Domestic Animals.* Ed. Hafez, E.S.E. Publ. Ballière, Tindall and Cassell, London, Second edition, 647 pp.

Deutsch, H.F. and Smith, V.R. (1957): Intestinal permeability to protein in the newborn. *Amer. J. Physiol., 191:* 271-6.

Dewsbury, D.A. (1978): Experience and behavioural ontogeny, pp 132-53. *In: Comparative Animal Behaviour.* Publ. McGraw-Hill Book Co., 451 pp.

Dickson, D.P., Barr, G.R., Johnson, L.P. and Wieckert, D.A. (1970): Social dominance and temperament of Holstein cows. *J. Dairy Sci., 53:* 904-7.

Donaldson, S.L. (1970): Maternal behaviour in dairy cattle (Appendix A). *In:* Ph.D. thesis *The effects of early feeding and rearing experiences on social, maternal and milking parlour behaviour in dairy cattle.* Purdue, U.S.A.

Donaldson, S.L., Albright, J.L. and Black, W.C. (1972): Primary social relationships and cattle behaviour. *Proc. Indiana Acad. Sci., 81:* 345-51.

Drewry, K.J., Brown, C.J. and Honea, R.S. (1959): Relationships among factors associated with mothering ability in beef cattle. *J. Anim. Sci., 18:* 938-46.

Dufty, J.H. (1971): Determination of the onset of parturition in Hereford cattle. *Aust. Vet. J., 47:* 77-82.

Dufty, J.H. (1972): Clinical studies on bovine parturition. *Aust. Vet. J., 48:* 1-9.

Dufty, J.H. (1974): Clinical studies on bovine parturition - Fetal aspects. *Aust. Vet. J., 49:* 177-81.

Dunbar, R.I.M. (1975): Some aspects of research design and their implications in the observational study of behaviour. *Behav., LVIII:* 78-98.

Dwyer, D.D. (1961): Activities and grazing preferences of cows with calves in Northern Osage County, Oklahoma. Bull. Okla. Agric. Exp. Sta., Bull. 588, 61 pp.

Edwards. J. (1976): Learning to eat by following the mother in Moose calves. *Am. Midl. Nat., 96:* 229-32.

Espmark, Y. (1971): Mother-young relationship and ontogeny of behaviour in Reindeer. *Zeit. fur. Tierp., 29:* 42-81.

Estes, R.D. (1967): The comparative behaviour of Grants and Thomson's gazelles. *J. Mammal., 48:* 189-209.

Everitt, G.C., Phillips, D.S.M. and Whiteman, D.P. (1968): Suckling: the effects on the cow and calf. *Proc. Ruakura Fm. Conf.,* pp 158-75.

Ewbank, R. (1963): Predicting the time of parturition in the normal cow. *Vet. Rec., 75:* 367-71.

Ewbank, R. (1969): The frequency and duration of the nursing periods in single-suckled Hereford beef cows. *Brit. Vet. J., 125:* IX (short communication).

Fairclough, R.J., Hunter, J.T. and Welch, R.A.S. (1975): Peripheral plasma progesterone and uteroovarian prostaglandin F concentration in the cow around parturition. *Prostag., 9:* 901-14.

Findlay, A.L.R. (1971): Neural and behavioural interactions with lactation, pp 75-93. *In: Lactation.* Ed. Falconer, I.R. Publ. Butterworths, London, 467 pp.

Fox, M.W. (Ed.) (1968): *In: Abnormal Behaviour in Animals.* Publ. W.B. Saunders Co., Philadelphia, 563 pp.

Franke, D.E., England, N.C. and Hendry, J.E. (1965): Effect of breed of dam and breed of sire on birth weight of beef calves. *J. Anim. Sci., 24:* 281 (Abst.).

Fraser, A.F. (1963): The significance of the "pushing" syndrome. *Anim. Behav., 11:* 51-2.

Fraser, A.F. (1968) *In: Reproductive Behaviour of Ungulates.* Publ. Acad. Press, London, 202 pp.

Fraser, A.F. (1974): *In: Farm Animal Behaviour.* Publ. Baillière, Tindall and Co., London, 183 pp.

Fraser. A.F. (1976): The neonatal bond. *Appl. Anim. Ethol., 2:* 193-6.

Fraser, D., Ritchie, J.S.D. and Fraser, A.F. (1975): The term "stress" in a veterinary context. *Br. Vet. J., 131:* 653-61.

Gay, C.C., Anderson, N., Fisher, E.W. and McEwan, A.D. (1965): Gamma globulin levels and neonatal mortality in market calves. *Vet. Rec., 77:* 148-9.

George, J.M. and Barger, I.A. (1974): Observations of bovine parturition. *Proc. Aust. Soc. Anim. Prod., 10:* 314-7.

Gordon, I. (1977): Controlled breeding in cattle. Part 2. Pregnancy testing, control of calving, reduction of the calving interval, induction of twinning, breeding at younger ages and future developments. *Anim. Brd. Abst., 44:* 451-60.

Grosvenor, C.E. and Mera, F. (i974): Neural and hormonal control of milk secretion and milk ejection, pp 227-68. *In: Lactation - The Mammary Gland, Development and Maintenance.* Vol.1. Ed. Larson, B. and Smith, V.F. Publ. Acad. Press, New York, 516 pp.

Hafez, E.S.E. (1964): Some physiological and behavioural responses of the neonate. *Cornell Vet., 54:* 545-60.

Hafez, E.S.E. (1970): Physiology of behaviour, pp 1052-81. *In: Duke's Physiology of Domestic Animals.* Ed. Swenson, M.J. Publ. Cornell Univ. Press, Ithaca, 1463 pp.

Hafez, E.S.E. and Bouissou, M.F. (1975): The behaviour of cattle, pp 203-45. *In: The Behaviour of Domestic Animals.* Ed. Hafez, E.S.E. Second ed. Publ. Baillière, Tindall and Co., London, 532 pp.

Hafez, E.S.E. and Lineweaver, J.A. (1968): Suckling behaviour in natural and artificially fed neonate calves. *Zeit. fur. Tier., 25:* 189-98.

Hansen, R.G. and Phillips, P.H. (1947): Studies on proteins from bovine colostrum. I. Electrophoretic studies on the blood serum proteins of colostrum-free calves and of calves fed colostrum of various ages. *J. Biol. Chem., 171:* 223-7.

Harper, L.V. (1970): Ontogenetic and phylogenetic functions of the parent-offspring relationship in mammals. *Adv. Study Behav., 3:* 75-117.

Harte, J.F. and Crowley, J.P. (1968): The early weaning of suckled calves from beef heifers. *World Rev. Anim. Prod., IV:* 55-8.

Hediger, H. (1955): *In: Studies of the Psychology and Behaviour of Animals in Zoos and Circuses.* Pub. Butterworths, London, 166 pp.

Heinroth, O. (1910): Beitrage zur Biologie namentlich Ethologie und Physiologie der Anatiden. (Contributions on the biology, particularly the ethology and physiology of anatiden.) *5th International Ornithol. Kongress, Verh., 5:* 589-702.

Herrenkohl, L.R. and Sachs, B.D. (1972): Sensory regulation of maternal behaviour in mammals. *Physiol. and Behav., 9:* 689-92.

Hersher, L., Richmond, J.B. and Moore, A.U. (1963a): Maternal behaviour in sheep and goats, pp 293-32. *In: Maternal Behaviour in Mammals.* Ed. Rheingold, H.L. Publ. Wiley, New York, 349 pp.

Hersher, L., Richmond, J.B. and Moore, A.U. (1963b): Modifability of the critical period for the development of maternal behaviour in sheep and goats. *Behav., 20:* 311-320.

Hess, E.H. (1958): "Imprinting" in animals. *Am. Sci., 198:* 81-90.

Hess, E.H. (1959): The relationship between imprinting and motivation, pp 421-83. *In: Nebraska Symposium on motivation.* Ed. Jones, M.R. Publ. Nebraska Univ. Press, 243 pp.

Hess, E.H. (1962): Imprinting and the critical period concept, pp 254-264. *In: Roots of Behaviour.* Ed. Bliss, E.L. Publ. Harper and Bros, New York, 339 pp.

Hess, E.H. (1973): *In: Imprinting: Early Experience and the Development of Psychobiology of Attachment.* Publ. Van Nostrand Reinhold Co., New York, 472 pp.

Hinde, R.A. (1970): *In: Animal Behaviour. A synthesis of ethology and comparative ecology.* Publ. McGraw-Hill Inc., London, 876 pp.

Hodgson, J. (1971). The development of solid food intake in calves. I. The effect of previous experience of solid food, and the physical form of the diet, on the development of solid food intake after weaning. *Anim. Prod., 13:* 15-24.

Hoffman, B., Wagner, W.C., Rattenberger, E. and Schmidt, J. (1977): Endocrine relationships during late gestation and parturition in the cow, pp 107-26. *In: The Fetus and Birth.* Publ. Ciba Fd., Elsevier, New York, 481 pp.

Holmes, C.W. and McLean, N.A. (1975): Effects of air temperature and air movement on the heat produced by young Friesian and Jersey calves, with some measurements of the effects of artificial rain. *N.Z. J. Agric. Res., 18:* 277-84.

Hudson, S.J. (1977): Multiple fostering of calves onto nurse cows at birth. *Appl. Anim. Ethol., 3:* 57-63.

Hudson, S.J. and Mullord, M.M. (1977): Investigations of maternal bonding in dairy cattle. *Appl. Anim. Ethol., 3:* 271-6.

Hull, J.L., Lofgreen, G.P. and Meyer, J.H. (1960): Continuous *versus* intermittent observations in behaviour studies with grazing cattle. *J. Anim. Sci., 19:* 1204-7.

Husband, A.J., Brandon, M.R. and Lascelles, A.K. (1972): Absorbtion and endogenous production of immunoglobulin in calves. *Aust. J. Expt. Biol. Med. Sci., 50:* 491-8.

Hutchison, H.G., Woof, R., Mabon, R.M., Salehe, I. and Robb, J.M. (1962): A study of the habits of Zebu cattle in Tanganyika. *J. agric. Sci., Camb., 59:* 301-17.

Johnson, W.L., Trimberger, G.W., Wright, M.J., Van Vleck, L.D. and Henderson, C.R. (1966): Voluntary intake of forage by Holstein cows as influenced by lactation, gestation, body weight and frequency of feeding. *J. Dairy Sci., 49:* 856-64.

Kiley, M. (1972): The vocalizations of ungulates. *Zeit. fur Tier., 31:* 171-222.

Kiley-Worthington, M. (1977): *In: Behavioural Problems of Farm Animals.* Publ. Oriel Press Ltd, Northumberland, 134 pp.

Kilgour, R. (1972): Some observations on the suckling activity of calves on nurse cows. *Proc. N.Z. Soc. Anim. Prod., 32:* 132-6.

King, D.L. (1966): A review and interpretation of some aspects of the infant-mother relationship in mammals and birds. *Psychol. Bull., 65:* 143-55.

King, J.A. (1958): Parameters relevant to determining the effect of early experience upon the adult behaviour of animals. *Psychol. Bull., 55:* 46-58.

Kirchshofer, R. (1963): Das Verhalten der Giraffen-gazelle, Elenantilopenn und des Flachtland Tapir bei der Geburt einige Bemerkungen zur Vermehrungsrate und Generation enfolge dieser Arten im Frankfurter. (The behaviour of the gerenuk, of the antelope and of the lowland tapir at birth, and a few observations on the rate of increase and breeding success of these breeds in Frankfurt.) *Zeit. fur Tier., 20:* 143-59.

Klopfer, P.H. (1964): Parameters of imprinting. *Am. Nat., 98:* 175-82.

Klopfer, P.H. (1971): Mother love: What turns it on? *Am. Sci., 59:* 404-7.

Klopfer, P.H. (1974): *In: An Introduction to Animal Behaviour: Ethology's first century.* Second ed. Ed. McElroy, W.D. and Swanson, C.P. Publ. Prentice-Hall, 275 pp.

Kohli, M.L. and Suri, K.R. (1960): Breeding season in Hariana cattle. *Indian J. Vet. Sci., 30:* 219-23.

Kon, S.K. and Cowie, A.T. (Eds.) (1961): *In: Milk: The Mammary Gland and its Secretions, Vol.I.* Publ. Acad. Press, London, 515 pp.

Lamb, R.C. (1976): Relationship between cow behaviour patterns and management systems to reduce stress. *J. Dairy Sci., 59:* 1630-6.

Lampkin, K. and Lampkin, G.H. (1960): Studies on the production of beef from Zebu cattle in East Africa. 2: Milk production in suckled cows and its effect on calf growth. *J. Agric. Sci., 55:* 233-40.

Leech, F.B. (1976): Some biological factors affecting survival, with particular reference to farm animals. *Brit. Vet. J., 32:* 335-45.

Lehrman, D.S. (1961): Hormonal regulation of parental behaviour in birds and infra-human mammals, pp 1268-1382. *In: Sex and Internal Secretions.* Ed. Young, W.C. Publ. Williams & Wilkins, Baltimore, 1609 pp.

Le Neindre, P. and Petit, M. (1975): Nombre de tétées et temps de pâturage des veaux dams les troupeaux de vaches allaitantes. (Number of suckling periods and grazing time of calves in a herd of nursing cows.) *Ann. Zootech., 24:* 553-8.

Le Neindre, P. and Garel, J.P. (1976): Existence d'une période sensible pour l'establissement du compartement matérial de la vache après la mire bais. (Existence of a lengthy period post-partum during which maternal behaviour of the cow occurs.) *Biol. Behav., 1:* 217-21.

Le Neindre, P. and Garel, J.P. (1977): Étude des relations mère-jeune chez les bovins domestiques: Comparision des liasons existant entre la mère et des ceaux légitimes ou adoptés. (A study of the mother-young relations in domestic cattle: A comparison of the mother calf relationship with true and adopted calves.) *Biol. Behav., 2:* 39-49.

Lent, P.C. (1966): Calving and related social behaviour in the barren-ground Caribou. *Zeit. fur tier., 23:* 702-56.

Lent, P.C. (1974): Moehter infant relationships in ungulates, pp 14-55. *In: The Behaviour of Ungulates and its Relation to Management.* Publ. IUCN, Morges, 940 pp.

Liggins, G.C., Holm, L.W. and Kennedy, P.C. (1966): Prolonged pregnancy following surgical lesions of foetal lamb pituitary. *J. Repr. Fert., 12:* 419 (Abst.).

Logan, E.F., McMurray, C.H., O'Neill, D.G.O., McParland, P.J. and McRoy, F.J. (1978): Absorbtion of colostral immunoglobulins by the neonatal calf. *Br. Vet. J., 134:* 258-62.

Lorenz, K. (1935): Der Humpan in der Umwelt des Vogels. (The companion in the environment of the bird.) *J. Ornith., 83:* 137-214.

Lorenz, K. (1966): *In: On Aggression.* Publ. Harcourt, Brace and World Inc., New York, 273 pp.

Lynch, J.J. and Alexander, G. (1973): Animal behaviour and the pastoral industries, pp 371-400. *In: The Pastoral Industries of Australia.* Ed. Alexander, G. and Williams, O.B. Publ. Sydney Univ. Press, Sydney, 567 pp.

Manning, A. (1972): *In: An Introduction to Animal Behaviour.* Second ed. Publ. Arnold, London, 294 pp.

Marjoribanks-Egerton, P. (1962): *The cow-calf relationship and rutting behaviour in the American bison.* Master's thesis, Univ. Alberta, Edmonton, 155 pp.

Marler, P. and Hamilton, W.J. III (1968): Descriptions in space and time, pp 711-42. *In: Mechanisms of Animal Behaviour.* Publ. John Wiley and Sons Inc., New York, 771 pp.

Marsh, R., Curran, M.K. and Campling, R.C. (1971): The voluntary intake of roughages by pregnant and by lactating cows. *Anim. Prod., 13:* 107-16.

Martjuggin, D.D. (1944): Izučenieakta sosanijau teljat Soobščenie 1-e Soobščenie 2-e. (A study of the art of suckling in calves Parts I and II.) *Anim. Brd. Abst.,* (1946) *14:* 18.

McCoy, G.L., Reneau, J.K., Hunter, A.G. and Williams, J.B. (1970): The effect of diet and time on blood serum protein in new born calf. *J. Dairy Sci., 53:* 358-62.

McDonald, L.E. (1975): Pregnancy and parturition, pp 424-44. *In: Veterinary Endocrinology and Reproduction.* Second edition. Publ. Lea and Febiger, Philad., 493 pp.

McHugh, T.C. (1958): Social behaviour of the American buffalo (Bison bison bison). *Zoo., 43:* 1-40.

Melton, R.A., Riggs, J.K., Nelson, L.A. and Cartwright, T.C. (1967): Milk production and calf gains of Angus, Charolais and Hereford cows. *J. Anim. Sci., 26:* 804-9.

Meyer, M.E. (1976): *In: A Statistical Analysis of Behaviour.* Publ. Charles A. Jones, Wadsworth Publ. Co. Ltd, California, 107 pp.

Millar, P.G. (1974): Methods for early termination of pregnancy in the cow. *Vet. Rec., 94:* 626.

Mohammed, B. (1975): *A study of some of the factors affecting the transfer of immunoglogulins from cows to cows.* Master of Agricultural Science Thesis, Massey University, 120 pp.

Moltz, H. (1963): Imprinting: An epigenetic approach. *Psychol. Rev., 70:* 123-38.

Naaktgeboren, C. (1963): Untersuchungen uber die Geburt der Saugetiere. (Investigations on birth in the mammal.) *Bijdr. tot de Dierk., 32:* 1-50.

Naaktgeboren, C. and Vandendriessche, W. (1962): Beiträge zur Vergleichende Geburtskunde, I. (Contributions to comparative obstetrics.) *Zeit. Säuget., 27:* 83-110.

Nicol, A.M. (1977): Beef calf weaning methods. *N.Z. J. Agric., 134:* 17-18.

Nicol, A.M. and Sharafeldin M.A. (1975): Observations on the behaviour of single-suckled calves from birth to 120 days. *Proc. N.Z. Soc. Anim. Prod., 35:* 221-30.

Perry, R. (1952): *In: The Watcher and the Red Deer* Publ. Scient. Book Club, London, 188 pp.

Peterson, R.A. and Woolfolk, E.J. (1955): Behaviour of Hereford cows and calves on short grass range. *J. Range Mgmt., 8:* 51-7.

Petit, M. (1972): Emploi du temps des troubeaux de vaches-mères et de leurs veaux sur les pâturages d'altitude de l'aubrac. (Use of time by herds of lactating cows and their calves on high pastures in Aubrac.) *Ann. Zootech., 21:* 5-27.

Pleasants, A.B. (1974): *The wintering and calving of Angus beef cows on a sawdust pad.* Master of Agricultural Science Thesis, Massey University, 169 pp.

Poindron, P. and Le Neindre, P. (1975): Comparasion des relations mère-jeure observées lors de la tétée chez la brebis (*Ovis aries*) et chez la vache (*Bos taurus*). (Comparative study in the ewe and the cow of the behavioural interactions between the mother and young at suckling.) *Ann. Biol. anim. Bioch. Bioph., 15:* 495-501.

Portmann, A. (1961): *In: Animals are Social Beings.* Publ. Viking Press, New York, 249 pp.

Preston, T.R. and Willis, M.B. (1974): *In: Intensive Beef Production.* Second edition. Publ. Pergamon Press Ltd, Oxford, 567 pp.

Rankine, G. and Donaldson, L.E. (1968): Animal behaviour and calf mortalities in a North Queensland breeding herd. *Proc. Aust. Soc. Anim. Prod., 8:* 138-42.

Reinhardt, V., Mutiso, F.M. and Reinhardt, A. (1978): Social behaviour and social relationships between female and male prepubertal bovine calves *(Bos indicus)*. *Appl. Anim. Ethol., 4:* 43-54.

Rheingold, H.L. (Ed.) (1963): *In: Maternal Behaviour in Mammals.* Publ. Wiley and Sons, New York, 349 pp.

Ritter, H.C. and Walser, K. (1965): Über das saugverhalten de kalber in multerkukherden unter besonderer ferücksichtigung der entergesundheit der mutter kuke. (On the sucking behaviour of calves in the mother's placenta with special consideration of the health of the mother's placenta.) *Bayer Landw. Fb., 42:* 324-8.

Roberts, S.J. (1971): Parturition, pp 201-26. *In: Veterinary Obstetrics and Genital Diseases.* Publ. by author, Ithaca, New York, 776 pp.

Robson, C. (1973): *In: Experiment, Design and Statistics in Psychology.* Publ. Penguin Educ., 174 pp.

Roscoe, J.T. (1975): *In: Fundamental Research Statistics for the Behavioural Sciences.* Publ. Holt, Rinehart and Winston Inc., New York, 483 pp.

Ross, R., Fisher, A.E. and King, D. (1957): Sucking behaviour: A review of the literature. *J. Genet. Psychol., 91:* 63-81.

Rowley, I. (1970): Lamb predation in Australia: Incidence, predisposing conditions and the identification of wounds. *CSIRO Wildl. Res., 15:* 79-122.

Ruckebusch, Y. (1975): Feeding and sleep patterns of cows prior to and post parturition. *Appl. Anim. Ethol., 1:* 283-92.

Rugh, M.C. and Wilson, L.L. (1971): Cow body size and calf sex on certain behavioural traits in Angus-Hereford cows and their progeny. *J. Anim. Sci., 32:* 727-31.

Rutter, M. (1972): *In: Maternal Deprivations Reassessed.* Ed. Foss, B.M. Publ. Penguin Modern Psychology, 175 pp.

Rylands, J.M. (1967): Sucking in the lamb and calf. *Vet. Rec., 81:* 698.

Schein, M.W. and Fohrman, M.H. (1955): Social dominance relationships in a herd of dairy cattle. *Brit. J. Anim. Behav., 3:* 45-55.

Schake, L.M. and Riggs, J.K. (1969): Activities of lactating beef cows in confinement. *J. Anim. Sci., 28:* 568-72.

Schloeth, R. (1958): Über die Mutter-kind Beziehungen beim halbwilden Camargue Rind. (A study of the mother-offspring relationship in feral Camargue cattle.) *Säugetierk Mitt., 6:* 145-50.

Schloeth, R. (1961): Das sozialleben des Camargue-rindes. Qualitative und quantitative Untersuchungen uber die sozialen Bezlehungen-insbesandere die soziale Rangordung - des halbwilden französischen kampfrindes. (The social life of Camargues cattle Qualitative and quantitative investigations on the social relations, - in particular social rank order - of half-wild French fighting cattle.) *Zeit. fur Tier., 18:* 579-627.

Schmisseur, W.E., Albright, J.L., Dillon, W.M., Kehrberg, E.W. and Morris, W.H.M. (1966): Animal behaviour responses to loose and free stall housing. *J. Dairy Sci., 49:* 102-4.

Schneirla, T.C. (1959): An evolutionary and developmental theory of bi-phasic processes underlying approach and withdrawal, pp 1-42. *In: Current Theory and Research on Motivation,* Vol.7. Ed. Jones, M.R. Publ. Univ. Nebraska Press, Nebraska, 243 pp.

Schneirla, T.C. (1965): Aspects of stimulation and organization in approach-withdrawal processes underlying vertebrate behavioural development. *Adv. Study Behav., 1:* 1-74.

Scholl, M. (1956): Calving signs you can use. *Hoards Dairyman,* Dec. 10, p 1188.

Schuller, L. (1957): Zur Euter-suche junger Huftiere. (Teat-seeking activities of young hoofed animals.) *Saügetierk Mitt., 5:* 170.

Scott, J.P. (1962): Critical periods in behavioural development. *Sci., 138:* 949-58.

Seitz, A. (1940): Die Paarbildung bei einigen Cichliden. (Mating in a few Cichlidea.) *Zeit. fur Tierp., 4:* 40-84.

Seligman, M. and Hager, J. (1976): Ready, steady, learn. (The Sauce Bearnise Syndrome.) *Psych. Today, 2:* 44-8.

Selman, I.E., Fisher, E.W. and McEwen, A.D. (1967): Observations of the early postpartum behaviour of cattle. *Proc. Soc. Vet. Ethol., 1:* 7-8.

Selman, I.E., McEwan, A.D. and Fisher, E.W. (1970a): Studies on natural suckling in cattle during the first eight hours post-partum. I. Behavioural studies (dams). *Anim. Behav., 18:* 276-83.

Selman, I.E., McEwan, A.D. and Fisher, E.W. (1970b): Studies on natural suckling in cattle during the first eight hours post-partum. II. Behavioural studies (calves). *Anim. Behav., 18:* 284-9.

Siegel, S. (1956): *In: Nonparametric Statistics for the Behavioural Sciences.* Publ. McGraw-Hill, New York, 312 pp.

Slipjer, G.J. (1958): Birth in ungulates. *Mammal, 22:* 104-6.

Sluckin, W. (1964): *In: Imprinting and Early Learning.* Publ. Spottiswoode, Ballantyne and Co. Ltd, London, 147 pp.

Sluckin, W. (1970): *In: Early Learning in Man and Animal.* Publ. Allen and Unwin, London, 147 pp.

Sluckin, W. and Salzen, E.A. (1961): Imprinting and perceptual learning. *Quart. J. Expt. Psych., 13:* 65-77.

Smith, H.V. (1962): Observations of the aetiology of neonatal diarrhoea (scours) in calves. *J. Path. Bact., 84:* 147-68.

Snapp, R.R. and Bull, S. (1944): Effect of pregnancy on quality of beef. *Ill. agric. exp. Sta. Bull.,* No.508: 431-51.

Snedecor, G.W. and Cochran, W.G. (1967): *In: Statistical Methods.* Sixth edition. Publ. Iowa State Univ. Press, Ames, Iowa, 593 pp.

Soffié, M. and Zayan, R. (1977): Responsiveness to "social" releasers in cattle. I. A study of the differential and additive effects of visual and sound stimuli, with special reference to the law of heterogeneous summation. *Behav. Process., 2:* 75-97.

Sokal, R.R. and Rohlf, F.J. (1969): *In: Biometry.* Publ. W.H. Freeman and Co., San Fransisco, 776 pp.

Spalding, D. (1872): Instinct with original observations on young animals. Reprinted. *Brit. J. Animal. Behav., 2:* 2-11.

Swanson, E.W. (1956): The effect of nursing calves on milk production of identical twin heifers. *J. Dairy Sci., 39:* 73-80.

Tembrock, G. (1963): Acoustic behaviour of mammals, pp 751-86. *In: Acoustic Behaviour of Animals.* Ed. Busnel, R.G. Publ. Elsevier, Amsterdam, 933 pp.

Thornburn, G.D., Challis, J.R. and Currie, W.B. (1977): Control of parturition in domestic animals. *Biol. Repr., 16:* 18-27.

Thorpe, W.H. (1963): *In: Learning and Instinct in Animals.* Publ. Methuen, London, 558 pp.

Tinbergen, N. (1951): *In: The Study of Instinct.* Publ. Clarendon Press, Oxford, 228 pp.

Wagnon, K.A. (1963): Behaviour of beef cows on a California range. *Calif. Agric. Expt. Sta. Bull.,* No.799, 56 pp.

Walker, D.M. (1950): Observations on behaviour in young calves. *Bull. Anim. Behav., 8:* 5-10.

Walker, D.E.K. (1962): Suckling and grazing behaviour of beef heifers and calves. *N.Z. Agr. Res., 5:* 331-8.

Walser, K. (1965): Über den geburtsschmerg bei tieren. (On birth pains in animals.) *Tierärzh. Wschr., 78:* 321-4.

Walther, F. (1961): Einige Verhaltensbeobachtungen ain Bergwil des Georg von Opel Friegehes. (A few observations of behaviour in the mountain wild of Georg von Opel's open-air enclosure.) *Tierforsch.,* (1960-61): 53-9.

Walther, F. (1964): Verhaltensstudien an der Galtung Tragelaphus de Blainville (1816) in Gefangenschaft unter besonderer Berücksichtung des sozialverhaltens. (Studies of behaviour in the genus Tragelaphus de Blainville (1816) in captivity, with special regard to social behaviour.) *Zeit. fur Tier., 21*(4): 393-467.

Walther, F. (1965): Verhaltensstudien an der Grantsgazelle (*Gazelle granti* Brooke, 1872) im Ngorongoro-krater. (Studies of behaviour in the Grants gazelle (*Gazelle granti* Brooke, 1872)). *Zeit. fur Tier., 22*(2): 167-208.

Walther, F. (1968): *In: Verhalten der Gazellen.* (Behaviour of gazelles.) Die Neue Brehm Bücherei, No.373. Publ. Wittenberg Lutherstadt: A Ziemsen Vertag, 144 pp.

Weaver, J.E. and Tomanek, G.W. (1951): Ecological studies in a mid-western range: the vegetation and effects of cattle on its composition and distribution. *Nebr. Conserv. Bull.* No.31, 82 pp.

Welch, R.A.S., Newling, P. and Anderson, D. (1973): Induction of parturition in cattle with corticosteroids: an analysis of field trials. *N.Z. Vet. J., 21:* 103-8.

Wickler, W. (1976): The ethological analysis of attachment. *Zeit. fur Tierp., 42:* 12-28.

Williams, W.L. (1943): *In: Veterinary Obstetrics.* Publ. Ballière, Tindall and Co., London, 482 pp.

Wiltbank, J.N., Bond, J. and Warwick, E.J. (1965): Influence of total feed and protein intake on reproductive performance of the beef female through second calving. *U.S.D.A. Tech. Bull.* No.1314, Washington DC, 41 pp.

Wise, G.H., Miller, P.G. and Anderson, G.W. (1940): Changes observed in milk "sham-fed" to dairy calves. *J. Dairy Sci., 23:* 997-1011.

Wolff, P.H. (1968): Sucking patterns of infant mammals. *Brain Behav. Evol., 1:* 354-67.

Wood, P.D.P., Smith, G.F. and Lisle, M.F. (1967): A survey of intersucking dairy cattle in herds in England and Wales. *Vet. Rec., 81:* 396-7.

Yates, R.J. and Larkin, P.J. (1964): Minimal error weight measurement in cattle experiments. *East Afr. Agric. and Forest J., 30:* 263-4.

Yeates, N.T.M. and Schmidt, P.J. (1974): Maternal and Reproductive Behaviour, pp 154-64. *In: Beef Cattle Production.* Publ. Butterworths Ltd, 323 pp.

Young, B.A. (1973): Weaning and post-weaning stresses on beef calves. *U. of A. fd Day,* Univ. of Alberta, pp 46-8.

Zimmerman-Müller, M. and Zeeb, K. (1970): Sozialstruktur und Alchuität bei Milchkühen. (Social structure and social activity in lactating cows.) *Tierz., 9:* 251-3.

APPENDIX I

Maternal Performance

Cow identification No.	Year of birth	No. of matings	No. of calves born	No. of calves weaned	No. of calf deaths
25	1966	9	8	8	0
21	1967	8	8	7	1
24	1967	8	7	7	0
28	1967	8	8	8	0
30	1967	8	8	6	2
33	1967	8	7	7	0
22	1968	7	7	7	0
32	1968	7	5	4	1
36	1968	7	6	5*	2
27	1974	1	1	0	1
29	1974	1	0	0	NA
31	1974	1	1	1	0
35	1974	1	1	1	0
37	1974	1	0	0	NA
23	1975	1	1	1	0
26	1975	1	0	0	NA
34	1975	1	1	1	0
38	1975	1	1	1	0

* Calf stillborn in 1977, cow reared a fostered Friesian bull calf.

APPENDIX II

Socio-metric matrix showing dominance-submissive relationships between calf pairs

Calf Identity No.	23-H	31-H	38-B	34-B	35-H	24-H	32-B	22-B	28-H	21-H	33-H	FR-B	Row Total
P 23-H		1	4	2	5	3	1	2	3	2	4	2	29
P 31-H	0		2	5	5	0	0	(1)2	1		1	5	21
P 38-B	0	0		1	0		0	0			1		2
P 34-B	0	0	0		1	0	2	0		2	1	1	7
P 35-H	0	0	5	0		0	0	4		3	12	2	26
M 24-H	0	2		1	4		0	0	1	2	4	9	23
M 32-B	0	2	2	0	4	3		1		1	1	2	16
M 22-B	0	0	1	3	0	2	0			1		(1)1	8
M 28-H	0	0				0				2		2	4
M 21-H	0			0	0	0	0	0	0			11	11
M 33-H	0	0	0	0	0	0	0					6	6
FR-B	0	0		0	0	0	0	0	0	0	0		0
Column Total	0	5	14	12	19	8	3	9	5	13	24	41	153

The winners of each agonistic encounter are represented by the rows and the losers by the columns. The cell entries are the frequency of the dyadic interactions. Numbers in parenthesis represent encounters which had indecisive outcomes. Blank cells indicate that no interaction was observed between the calves involved.

Example: $\frac{\text{P23-H}}{\text{P38-B}} = \frac{4}{0}$ There were 4 encounters recorded of which P23-H won 4 and P38-B lost 4, i.e. 0 wins.

APPENDIX III

Climatological Data. Monthly July 1977 - March 1978 inclusive
Soil Science Department, Massey University

Month	Mean Air Temp ^{o}C	Maximum Temp ^{o}C	Minimum Temp ^{o}C	Mean Rainfall mm	R.H. p.c.	Mean Sunshine h.	Mean Anemometer Run km
July	8.8 (5.3-12.2)	12.1 (8.3-17.5)	5.4 (-0.3-10.4)	2.6 (0.0-12.1)	88 (74-98)	3.5 (0.0- 8.1)	180.2 (57.9-383.0)
August	9.9 (4.0-13.0)	13.0 (9.2-15.5)	6.4 (-1.4-11.1)	1.7 (0.0-11.3)	83 (66-99)	3.5 (0.0- 9.2)	212.4 (0.0 -469.9)
September	8.6 (3.9-13.2)	12.4 (9.0-17.0)	4.8 (-1.3-12.4)	3.6 (0.0-21.5)	80 (61-94)	3.4 (0.0-10.8)	239.8 (0.0 -745.1)
October	11.7 (7.5-14.7)	15.3 (11.5-20.0)	7.9 (0.9-11.9)	1.5 (0.0-11.8)	74 (57-91)	5.3 (0.0-11.7)	346.0 (104.6-770.9)
November	13.3 (8.6-18.1)	17.3 (13.1-22.6)	9.2 (0.5-14.6)	2.6 (0.0-18.3)	72 (59-97)	6.2 (0.0-13.3)	302.5 (130.3-642.1)
December	14.8 (11.5-18.0)	19.1 (14.1-22.7)	10.5 (5.5-15.5)	3.0 (0.0-19.1)	73 (50-94)	6.1 (0.0-13.4)	294.4 (154.5-569.7)
January	17.5 (11.5-22.9)	22.7 (17.7-28.5)	12.2 (5.1-17.2)	0.3 (0.0- 7.3)	76 (66-90)	7.7 (0.4-13.8)	308.9 (125.6-537.5)
February	19.5 (17.3-22.7)	25.0 (19.9-28.6)	14.1 (5.2-19.2)	0.3 (0.0- 1.3)	74 (61-91)	8.9 (0.0-13.3)	305.7 (151.2-474.7)
March	17.4 (12.2-22.4)	23.0 (17.6-27.3)	11.9 (5.0-17.4)	0.5 (0.0- 4.4)	68 (54-95)	6.1 (0.0-11.3)	263.9 (123.9-449.1)

Note: Numbers represent total daily values. Numbers in parenthesis represent range.

APPENDIX IV

Time (days, pre-partum) the physical and behavioural signs were first recorded

Category	Sign	Primigravida 27-1	23-2	31-3	38-4	34-5	35-6	Range (days)	No. of cows	Multigravida 24-7	32-8	22-9	28-10	21-11	30-12	33-13	36-14	Range (days)	No. of cows
Calving day		4	6	16	17	18	19			20	29	31	44	48	59	61	65		
A. PHYSICAL SIGNS																			
Labia	sunken	-	-	6	-	-	1	1-6	2	-	12	10	13	28	39	41	-	10-41	6
	hairloss	-	-	-	-	-	-	N.A.	0	-	-	-	10	-	39	32	-	10-39	3
	oedema	-	5	6	1	6	1	1-6	5	13	9	10	18	16	38	41	-	9-41	7
	- base	-	-	-	-	-	-	N.A.	0	-	-	10	23	-	-	41	41	10-41	4
	- side	-	-	-	-	-	-	N.A.	0	7	-	10	23	-	-	33	15	7-33	5
	- below	-	-	-	-	-	-	N.A.	0	5	-	-	23	-	-	33	35	5-35	4
	flaccid	-	1	-	1	6	-	1-6	3	6	11	12	24	41	32	26	35	6-41	8
	red mucosa	-	1	-	1	-	-	1	2	6	11	8	11	13	21	-	35	6-35	7
	mucus	-	6	-	-	-	-	6	1	-	24	-	1	-	-	-	-	1-24	2
Udder	prominent teats	-	-	-	-	-	-	N.A.	0	-	-	1	11	14	26	-	-	1-26	4
	oedema	3	6	15	-	6	2	2-15	5	-	11	10	-	-	-	-	-	10-11	2
	hairloss	-	-	-	-	-	-	N.A.	0	-	-	-	11	17	24	-	41	11-41	4
Pelvic ligaments	prominent tailhead	-	-	-	-	-	-	N.A.	0	7	9	-	15	18	30	33	-	7-33	6
	raised tail	-	-	-	-	-	-	N.A.	0	7	-	8	2	2	30	33	-	2-33	6
	tail ridge	-	-	6	-	-	-	6	1	5	-	-	23	4	-	-	-	4-23	3
	extended tail	3	1	1	-	-	-	1-3	3	-	5	-	4	-	21	6	-	5-21	4
Body conformation	prominent pelvis	3	-	6	-	-	-	3-6	2	-	8	9	14	26	21	33	-	8-33	6
	prominent pin bones	-	-	-	-	-	-	N.A.	0	-	11	12	9	-	21	23	-	9-23	5
	sunken flanks	-	-	7	-	-	-	7	1	6	-	4	2	13	-	35	-	2-35	5
	distended abdomen	3	-	-	-	-	-	3	1	-	-	13	33	31	-	-	-	13-33	3
	RHS displacement	3	-	7	-	2	-	2-7	3	-	12	28	27	31	-	41	-	12-41	5
	displacement-high	-	-	-	-	2	-	2	1	-	-	-	-	3	-	9	-	3-9	2
	-medium	-	-	-	-	-	-	N.A.	0	-	9	-	-	15	-	28	-	9-28	3
	-low	-	-	-	-	-	-	N.A.	0	-	-	-	-	18	-	41	-	18-41	2
B. BEHAVIOUR SIGNS																			
Gait	slow	-	-	-	-	9	-	9	1	-	19	-	-	-	-	-	-	19	1
	swaying	-	-	1	-	9	-	1-9	2	-	24	-	-	-	-	-	-	24	1
	jerky	3	-	-	-	-	-	3	1	-	29	-	-	-	-	-	31	29-31	2
Posture	PSR	3	-	-	-	-	-	3	1	-	5	-	1	-	-	11	-	1-11	3
	SNP	-	-	-	-	-	-	N.A.	0	-	-	-	27	-	-	23	-	23-27	2
	leg stamping	2	-	1	-	-	-	1-2	2	-	-	-	-	5	-	-	-	5	1
	hypernoea	-	-	-	-	-	-	N.A.	0	-	-	-	1	-	5	-	-	1-5	2
	tail movement	3	-	1	-	-	-	1-3	2	-	4	-	9	10	-	9	-	4-10	4
Social	association	-	-	-	-	-	-	N.A.	0	-	5	-	1	9	-	9	22	1-22	5
	flight	-	-	-	-	-	-	N.A.	0	-	-	-	-	9	-	-	13	9-13	2
	isolation	-	-	4	6	-	-	4-6	2	-	5	1	4	9	-	9	-	1-9	5