Studies of Grazing and Nursing Behavior in Angus Crossbred Cattle

by

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(ABSTRACT)

In this experiment, grazing and nursing behavior of approximately 30 cow/calf pairs was examined in two years. Sires of the Polled Hereford x Angus cows had been selected for above (+) or below (-) average expected progeny difference for yearling weight and maternal weaning weight. Calves were sired by Angus bulls of United States (US) or New Zealand (NZ) origin. Observations from dawn to dusk were conducted on five days each year, spaced throughout lactation. All nursing episodes were recorded, and every ten minutes it was noted whether each cow and calf was or was not grazing. Periods of maximum grazing activity were early in the morning and late in the afternoon. The growth genotype of the cow did not affect her grazing time. Calves of maternal (+) cows grazed longer than calves of maternal (-) cows ($P < 0.10$), and their grazing time was not affected by the growth genotype of their dams. In year 1, US-sired calves spent 3% more time grazing than NZ-sired calves; whereas in year 2, NZ-sired calves grazed 4% longer than US-sired calves (interaction $P < .10$). Also in year 1, NZ-sired calves tended to graze during several intervals of time while US-sired calves tended to graze in longer continuous bouts. This tendency was reversed during the second year (interaction $P < .10$). As the grazing season progressed, time spent by calves grazing increased from $< 20\%$ to approximately 60%. Cows with (+) genetic merit for maternal weaning weight were nursed a similar number of times per day as cows with (-) genetic merit. Sire origin likewise did not affect nursing behavior.

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Good behavior	Angus crossbred cattle

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1.0 INTRODUCTION

1.1 Behavioural Sciences as Used in this Work

Compared to other biological sciences, the science of domestic animal behavior is a new subject; and as any novelty would do, it has interested a considerable number of workers. At the beginning of this century, this science was more or less a subdiscipline of psychology whose research workers became very much interested in animals as models for understanding human behaviors, including for example learning ability, aggressiveness, circardian rhythms and sleep.

But ever since, the economic importance of livestock has grown considerably in scope and would predictably increase in consideration of the global food shortage. This development will require a considerable improvement in animal husbandry methods and thus a better understanding of animals to enable better handling, feeding, breeding and management, and thus a greater productivity.

Studying animal behavior for its own sake (and no longer as models therefore victims, for human psychodynamics) constitutes an evolution in the motivation for domestic animal ethology.

It would be worthy to point out that the growing influence of the so-called animal rights activists, which advocate the complete equality between human beings and their fellow animals, has gone a long way beyond their original motivation of fighting cruelty to companion animals. This has increased the concerns of animal producers, who now carry the huge responsability of proving to the consumer how well the "fellows" have been treated. Animal behavioral sciences must therefore deal with understanding every process (physical, environmental, physiological, or human) required for the welfare of domestic animals.

Animal behavioral sciences so coarsly defined encompass several areas of interest. These include:

- *Social behavior*, which deals with aggressiveness, communication, dominance order, territoriality and association.

- *Sexual behavior*, which descibes sexual patterns in animals in relation to hormone secretion and neuro-endocrine stimuli. It would also deal with the effect of experience on successful mating.

- *Maternal behavior*, which deals with the nature and origin of bonds between the dam and the neonate from birth until weaning and the influence of such bonds on the future performance of the individuals. This would include feeding, caring for and keeping the youth out of danger.

- *Learning ability*, which may involve conditional learning such as that of a dog salivating on seeing pieces of meat, or innate intelligence. Animals learn from man as well as they do from other animals, by such means as observing, imitating, rewarding, punishment and habituation.

- *Biological rhythms*, which would be concerned with sleepiness, hibernation, breeding season, seasonal aggressiveness, and idling.

- *Ingestive and excretory behavior*, which focuses on the physiological and environmental variables that determine food intake, the control of intake and abnormal ingestive behavior such as eating unusual food.

- *The relationship between man and animals*, which is a large and very controversial field that deals mainly with legal concerns and animal welfare and could go as far as questioning the very purpose of animal science i.e., slaughtering animals for protein and other products.

- *The inheritance of behavioral traits*, given the fact that at least some behavioral traits display a genetic component (Hohenboken,1986). Behavioral traits are mainly considered quantitative but differ greatly from other quantitative traits by the extent to which they can be influenced by environmental factors. For example it may appear impossible to tell whether a behavior displayed in both a parent and an offspring was learned by the offsping or rather whether the propensity to display that behavior was inherited. Twins and inbred strains have been used to circumvent such difficulties.

These are the main interests of animal behavioral scientists, but the list of course is not exhaustive, and some aspects can hardly be separated from other biological sciences.

1.2 Objectives of this Work

Genetic variability is the raw material for selection and evolution. This experiment was part of a larger study designed to evaluate the impact of divergent selection of sires of cows for growth rate and maternal ability and to evaluate genetic differences in Angus germplasm from New Zealand versus the United States. In each of two years, grazing and nursing behavior of approximately 30 cow/calf pairs was recorded at five times during lactation. The cows were Angus x Hereford crossbreds whose sires had been selected divergently for growth and maternal production, creating four groups. The calves were sired by Angus bulls from New Zealand or the United States.

Differences in grazing behavior might have been expected, because cattle in New Zealand are fed totally on forages while in the United States they receive some forms of supplementation ranging from corn stalks to grain to other concentrate diets to protein supplements. This could have created selection pressure for differences in digestive physiology, feed intake capacity or grazing behavior when both stocks are brought together under similar conditions, as a result of being previously selected under different environments for similar performance objectives.

This experiment was designed to:

1. Describe and characterize cow and calf grazing behavior and nursing behavior across time.

2. Quantify genetic differences among cows and calves in these same behaviors.

2.0 FEEDING BEHAVIOR ON PASTURE

2.1 Measurement Methods

Feed intake in grazing cattle can be expressed as a function of time spent grazing, the number of bites per unit of time and the bite size (Chacon and Stobbs, 1977). Bite size appears to be the most important of these factors (Chacon et al., 1976).

Time spent grazing: This term refers to short periods of walking while selecting suitable grass for eating (Hancock, 1953). Arnold and Dudzinsky (1978) defined grazing as a complex activity that involves searching for and selecting suitable forage, after which it is prehended (grasped) and taken into the the mouth. The forage is then chewed and mixed with saliva, manipulated and formed into a bolus, and then swallowed and ejected with some force into the the anterior rumen.

In this study grazing time will refer essentially to the time involved in searching for and selecting forage, whether or not it is actually consumed. The amount of time spent on grazing may be recorded either manually or mechanically. Manual recording of grazing time is very laborious and requires continuous observation over several hours. Most research observations have been conducted over periods of a few days at most, and the time spent grazing in a given behavioral trial is usually recorded at 10 (Czako et al., 1969) or 15-minute intervals (Gary et al., 1970). Very little work using manual recording went on for more than two consecutive days (Stockadale and King, 1983).

Mechanical recording uses a device called the vibracorder, several types of which are now available (Jones and Cowper, 1975; Hinch et al., 1982). Castle et al. (1950) used infrared devices to allow night observations. Ruckebush and Bueno (1978) used a modified version of the vibracorder to record the time spent by cattle both in grazing and ruminating under field conditions for 24-hour periods in autumn and winter during three consecutive years. These devices work by determining with a mercury switch when the head of the animal is lowered and monitoring jaw movements using a pneumatic system. Chambers et al. (1981) used mercury switches to distinguish between head up and head down activities and a jaw switch to count jaw movements. Coefficients of variation for time spent on grazing usually vary between 5 and 7% for both sheep and cattle (Hodgson, 1982).

Bite size measurements: Esophageal fistulae have been used most commonly to estimate bite size in ruminants (Breen and Hunter, 1976). The technique consists of collecting the total esophoageal masticate in a mesh bag. The number of bites during the collection is recorded and the bite size is calculated by dividing the dry weight of the masticate by the number of bites. A number of devices have been described for ease of collection of the consumed forage (Torrell, 1954; McManus et al., 1962). The fistulation is performed on a site as close as possible to the ventral midline of the neck to avoid forage bypassing the fistula directly to the rumen. An L-shaped cannula made of high density polyethylene is used to stretch the incision. This allows the insertion of the silicone cannula into the lumen of the oesophagus. Before collecting the esophageal masticate, animals are allowed to fast for about one day, as a means to reduce rumen contamination through regurgitation. Rumen contamination of esophageal fistula samples from cattle occurs primarily when collections are made between 10 and 16h (Holechek et al., 1982), which corresponds to the time of the day that cattle normally ruminate (Arnold and Dudzinski, 1978). However bite size is increased by overnight fasting (Chacon and Stobbs, 1977), suggesting that fasting should be kept to a minimum and that sampling during several periods of the day is required for accurate results. Maximum collection of the masticate is assured by occluding the esophagus below the fistula with a foam rubber plug (Stobbs, 1973). Bite sizes have been reported in cattle varying between .18mg OM/kg of live weight (Chacon and Stobbs, 1977) and 3.24mg OM/kg of live weight (Hodgson and Jamieson, 1981). Coefficients of variation are between 16 and 32% for sheep and 7 and 30% for cattle (Hodgson, 1982).

The number of bites per unit of time: This variable, which was first studied by Johnston-Wallace and Kennedy (1944) as an indication of sward condition, is now frequently used in combination with grazing time and bite size to determine forage intake. It is measured either manually or mechanically. When done manually, the amount of time the animal takes to make 20 consecutive bites is recorded, and any records where the animal lifts the head before 20 consecutive bites are discarded. Because it may not always be possible to come very close to the animals without disturbing them, binoculars are often used to monitor jaw movements. In combination with the sounds of the bites, they provide accurate records of rates of bites.

Mechanical bite rate measurement devices that rely solely on jaw movements (Penning, 1983) are inaccurate (Forbes, 1988) because they record true biting movements as well as secondary jaw movements used by the animal to manipulate the forage before and after biting. It has been suggested that mechanical devices for rate of bite measurements should record both head and jaw movements (Chambers et al., 1981). Coefficients of variation of the number of bites per unit of time vary between 8 and 11% in sheep and 4 to 12% in cattle (Hodgson, 1982).

2.2 *Review of Literature*

The design of efficient grazing management systems requires an understanding of the role of each component of the system (Forbes, 1988). Investigating feeding behavior of cattle provides useful information for its own purpose, and is an important step in developing profitable livestock production systems. A knowledge of the feeding cycle in cattle could reduce the amount of labor involved in grazing behavior experiments (Seman et al., 1991), and could also provide some useful information in improving welfare conditions of cattle, such as feeding the animals at a time when they would rather eat than get involved in some other activities if they were left on their own.

When considering behavioral studies on a given species, one major objective would be the design of ethograms (Forbes, 1988), which refer to "catalogues of all behavioral patterns occurring in a species including all vocal patterns". The importance of an ethogram is that it provides standards against which one can measure behavioral deviations.

The grazing behavior of cattle has received considerable attention in the second half of this century (Hancock, 1953; Hafez and Schien, 1962). Lofgreen et al. (1957) compared the grazing behavior of cattle and sheep. They found that the period of grazing was more defined with steers than with sheep. For example, on their second period of observation, some sheep were grazing well into the night while only during one hour were there any steers grazing after dark.

Erlinger et al. (1990) studied grazing behavior in four groups of cattle differing in their genotypes. Treatments were heifers from four size-maturity groups defined by the mature size and the rate of approach to maturity of cow herds from which they originated. They found that the majority of grazing was accomplished during the early morning and evening hours. Their analysis showed a significant effect ($P < .001$) for both period of the day and the genetic background of the animals. The differences among genetic groups were not similar across the hours of the day, resulting in a significant group X period of the day interaction ($P < .001$). They provided no explanation on why one group of cattle (group IV, which were the slowest-maturing heifers) always grazed less during the early morning periods.

In an experiment designed to determine whether grazing behavior was cyclic, Seman et al. (1991) monitored twelve steers grazing endophyte-infected and endophyte-free tall fescue. They recorded whether cattle were standing, lying or eating for each minute for 12h shifts. Grazing time data were investigated by Box-Jenkins time series analysis. Time series functions showed autocorrelations at 24-hours intervals in all treatments, which indicated that grazing patterns of steers were repeated from one day to the next. On this basis, they concluded that labor and time so often exhausted in grazing behavior experiments could potentially be reduced.

Gary et al. (1970) compared four observation intervals (1 min, 15 min, 30 min and 45 min) for grazing time and number of times nursed in Charolais cattle. They found that these four time intervals were not equally sensitive for measuring animal behavior. They then performed an analysis of variance to compare the continuous observation with the 15-minute interval. They concluded that reliable estimates of behavior could be obtained with 15-minute observation intervals of those characters continuous in nature and measurable in duration. These included grazing time, loafing time and total nursing time. The only exception to this was the "erratic" grazing time occurring during darkness. However they mentioned that characters occurring as discrete events and measured in number of occurrences, such as number of nursings, number of defecations and number of urinations, required continuous observation for reliable results. During the course of their work, the number of nursings showed a highly significant difference among cows.

Studies suggest that there is a negative relationship between the length of the day and the amount of time spent on grazing during daylight (Waite et al., 1951). Observations from New Zealand (Hancock, 1950) indicated that cows there spent a greater portion of their time grazing between the morning and the evening milking than in Great Britain. The hypothesis of more intensive grazing during shorter day lengths was supported by the work of Taylor (1951), who found that in December, when the day length was only ten hours compared with 18 hours in July, the grazing periods during daylight were compressed and the period of idling was reduced.

There has been work suggesting some relationship between the quantity and quality of forage and the amount of time spent in grazing, but the results are somewhat conflicting. The contradiction might arise from differences in methods used to assess the pasture. Johnstone-Wallace and Kennedy (1944) found that grazing time was the same when the available feed varied between 280 and 1125 kg per hectare. However, it is now well established that cows graze longer when little forage is available to them (either on a per cow basis or on a per hectare basis) than when the pasture is ample in all respects (Hancock, 1953). Wardrop (1951) found that cows grazing on a ley with short grass grazed more than two hours longer than cows grazing another ley with grass 15-20 cm long.

2.3 Material and Methods

2.3.1 The pasture

The study was conducted from spring through summer of 1988 and 1989 on a 1.3 hectare non-irrigated pasture essentially colonized by orchard grass, bluegrass, tall fescue, red clover and white clover. The pasture was on a gentle slope with a water point at the top corner. There was very little shading opportunity for the animals during both years, yet they occasionally could manage to shade one another. There was adequate forage availability during each observation, but the quantity was less by the end of summer. The pasture was near a low-traffic county road on one side and orchard trees and farm buildings on the other sides (Figure 1). Other pastures were located in the surrounding area, and from time to time the experimental cattle could communicate by mooing with their unselected and unexpected fellows grazing somewhere else.

2.3.2 The animals

During the first year, thirty cow/calf pairs were selected from a group of 89 cows with calves, and thirty four pairs were selected during the second year. Nine cows from the first year were selected again during the second year. The cows were first generation Polled Hereford x Angus crossbreds ranging from four to five years of age for the first year and from four to six years of age for the second year. The Polled Hereford sires of these cows had been divergently selected from the breed association's national sire summary because they were extremes in estimated genetic merit for growth (expected progeny difference or EPD for yearling weight) and estimated genetic merit for maternal weaning weight (Mahrt et al. 1990). Approximately equal numbers of cows in our experiment were from the four possible sire combinations:

- High EPD for both growth and maternal weaning weight.
- High EPD for growth, low EPD for maternal weaning weight.
- Low EPD for growth, high EPD for maternal weaning weight.
- Low EPD for both growth and maternal weaning weight.

The calves were sired either by New Zealand Angus bulls whose semen was imported or by United States Angus bulls whose semen was commercially available through artificial insemination companies. During the first year, five bulls from the United States and four from New Zealand were used. During the second year, four bulls were from the United States and three were from New Zealand. Two of the bulls used as sires for the second year (one from each nationality) had already served during the first year.

2.3.3 Observational methods

Late in the afternoon before each observation day, the cow and calf pairs were separated from the rest of the herd, paint branded with a big letter or symbol applied three times on each side and kept overnight in a pen with water but no feed available. Enamel paint in an aerosol carrier was used. The following day they were released at dawn in the pasture and observed continuously through twilight using binoculars when necessary. The genetic groups of the cattle could not be distinguished by the observers during the observation.

Grazing behavior of each cow and each calf was recorded every ten minutes throughout the day either as 1 (for grazing) or 0 (for not grazing). Each individual recorded as grazing at any check time was assumed to have been grazing during the entire ten minute span. In addition, all nursing episodes were recorded regardless of the time at which they occurred. Very little was done by the two observers to disturb the normal course of the animals' behavior. The observations were conducted five times each year, at intervals of approximately five weeks from spring until the calves were weaned in October (table 1 and 2).

The weight of the calves was recorded at birth, in July and at weaning. Their weight on each behavioral observation day was estimated by interpolation from these data by adding the product of the average daily gain and the number of days since last weighed to their last recorded weight (table 3).

The weather conditions were continuously recorded. Temperature and relative humidity charts for each observation day were obtained from the experiment station, and hour averages were calculated (table 4 to 7). Both variables were used to determine the wet bulb temperature on a chart originating from the Bulletin of the U.S Weather Bureau No. 1071. The results are presented in table 8 and 9. An indicator of the degree of comfort of the cattle, the temperature/humidity index, was calculated using the formula adapted by Ehrenreich and Bjugstad (1966):

Temperature-humidity index = 0.4(dry bulb temperature + wet bulb temperature). The results are presented in figures 2 and 3.

Total hours spent grazing per day was computed as 10 times the number of observation periods in which the individual was recorded as grazing, divided by 60 (tables 1 and 2). Grazing time was also expressed as a percentage of the total duration of each observation period (figures 4 and 5). Since the individuals could spend the same amount of time grazing and still differ with respect to the distribution of their grazing time during the day, additional variables were quantified: the number of grazing episodes, which referred to the number of times in the day each individual grazed continuously for 40 minutes or longer (figures 6 and 7), and the longest amount of time spent grazing without interruption (figures 8 and 9).

2.3.4 Statistical methods

Behavioral data accumulated during both years (1988 and 1989) were subjected to analysis of variance. The behavioral traits that made up the dependent variables were for both cows and calves:

- Time spent on grazing (i.e, the total number of hours spent grazing).
- Percentage of time allowed for grazing during the observation periods.
- Longest continuous grazing bout.
- Number of times the individual grazed for 40 minutes or more.

In addition, the number of nursing episodes was recorded for calves.

The data were analyzed as recorded without further transformation in the dependent variables. For cows, the general model used was:

$$B_{ijklmn} = \mu + M_i + G_j + Y_k + MG_{ij} + MY_{ik} + GY_{jk} + MGY_{ijk} + O_{lk} + cow_{mijk} + e_{ijklmn}$$

where

μ was the overall mean,

M was the maternal genotype (high or low),

G was the dam's growth genotype (high or low),

Y was the year (1 or 2),

O was the obsevation day (1 to 5),

MG was the interaction of M and G defined as above,

MY was the interaction of M and Y,

GY was the interaction of G and Y,

MGY was the interaction of M and G and Y, and

e was the random error and

for calves:

$$B_{ijklmnp} = \mu + M_i + G_j + S_k + Y_l + SY_{kl} + MSY_{ikl} + GSY_{jkl} + O_{ml} + calf_{nijkl} + SO_{kml} + e_{ijklmnp}$$

where

μ was the overall mean,

M was the dam's maternal genotype (high or low),

G was the dam's growth genotype (high or low),

S was the sire of the calves (New Zealand or USA), Y was the year (1 or 2),

O was the observation period (1 to 5),

SY was the interaction between S and Y defined as above,

MSY was the interaction between M and S and Y,

SO was the interaction between S and O,

GSY was the interaction between G and S and Y, and

e was the random error.

All two-factor and three-factor interactions that were not significant as indicated by preliminary analysis were dropped from the model if their presence in the model was not required to accomplish specific experimental objectives. In calves, statistical significance of maternal, growth, sire, year, sire x year, maternal x sire x year, and growth x sire x year effects were tested using the calf within maternal x growth x sire x year mean square as denominator for the F test. The residual mean square was used to test the remaining effects. Similarily in cows, statistical significance of maternal, growth, year, maternal x growth, maternal x year, and growth x year effects were tested using the cow within growth x maternal x year interaction subclass mean square as denominator for F test. The residual mean square was used to test the observation day effect. Coefficients of variation for each behavioral trait were read directly from the analysis.

2.4 *Discussion of the Data*

Meteorological conditions were representative of the seasons; neither extremely severe nor mild conditions were encountered. Some rain occurred that momentarily interfered with grazing activities, but since it was a reflection of real time conditions and all of the individuals were subjected to the same conditions, no adjustments were made to the data (tables 1 and 2).

In cows, maximum grazing times were early in the morning and late in the afternoon, with little grazing activities around noon (figures 4 and 5). This grazing pattern is in agreement with what had been described by other workers (Gary et al., 1970; Arnold and Dudzinski 1978; Seman et al, 1991). To determine whether this pattern was a response to temperature conditions or to variations in daylight intensity would require further investigations to reach reliable conclusions. As a matter of fact, the maximum grazing times corresponded to the periods of minimum daylight intensity as realized by the observers. Since the potential contribution of night grazing was removed by over-night fasting of the animals, it is quite conceivable that they would start grazing heavily as soon as they had the opportunity to do so in the mornings and logically would slow down around noon for rumination and/or rest before they could graze again. This would be somewhat consistent with the findings of Hendricksen and Minson (1980) who reported that cows grazing an annual legume in Great Britain spent 20 to 30% of their total time at night grazing. However, some other works suggest that the night component of the total grazing time is very small (Lofgreen et al., 1957; Kropp et al., 1973)

The comfort index as calculated in this work failed to show any apparent relationship with the grazing time table of cattle (figures 2 and 3), which seemed consistent with the findings of Harker et al. (1961) and Wilson (1961) that indicated that temperature below 30°C could not be related to grazing activities if humidity was low. It is possible if not evident that the skin temperature of cattle or some other measurement of sunlight radiation would be more closely related to their grazing behavior than the ambient temperature, because the latter is taken under the shade while animals in this study were directly exposed to sunlight. This would be consistent with the fact that the temperature-humidity index was originaly conceived for humans, who spend most of their time indoors. The temperature-humidity index would be appropriately used for cattle under shade.

Depending upon the observation day, cows spent 40 to 60% of their overall activities grazing (figure 10), which was very low compared to the 70% reported by Gary et al. (1970). Viewed from the perspective that this experiment was performed in a warmer part of the hemisphere than where their experiment was conducted and that the Charolais breed is more muscular than Angus or Hereford cattle, it would be reasonable to predict that crossbred cattle in this study might graze less, assuming equal bite sizes and biting rates in both breeds. This point of view is in agreement with the work of Stricklin et al. (1976), who found that Charolais x Angus cattle spent 58% of their time grazing while purebred Angus spent only 53% of their time grazing. Also it has been reported that cattle spend less time grazing on fungus-infected fescue pastures than they do on non-infected pastures (Schmidt et al., 1982; Jackson et al., 1984), particularily during hot temperatures (Boling et al., 1989). While the experimental pasture was not dominated by endophyte-infected fescue, the surrounding pastures, where the cows grazed before the experiments began were thought to be infected. A carryover effect might partially explain why cows in this experiment spent less time grazing than other cattle in similar experiments. Tribe (1955) showed that cattle spent more time grazing on high-quality pastures than they did on mediocre pastures. Several other workers have reported grazing time percentage of 40 to 60% in cattle (e.g. Rose-Innes, 1963; Kropp et al., 1973; Hendricksen and Minson, 1980); but their results are not directly comparable to those in this work because their observations were conducted on a 24h basis while only daylight observations were conducted in this work.

The grazing pattern described above (i.e., maximum grazing in the morning and in the evening) remained reasonably consistent over all observation periods in both years, as can be fairly inferred from the graphs (figures 4 and 5). The Seman et al. (1991) study used a model called the Box-Jenkins time analysis which showed that the timing of grazing behavior in cattle was similar from one day to the next, which justifies why daily observations were not necessary in our study, beside the fact that they would not have been feasible. This could have some relevant applications in cattle management, that work such as weighing or parasite treatments, if done between noon and 15h, might have less negative effects on the feed intake of the animals than if they were done at some other times, providing that no compensatory grazing time was allowed. This view assumes that using up ruminating time has less negative effects on cattle performance than disturbing their grazing time. Also an immediate implication of the reduced grazing activities of cattle around noon is the potential of using fewer observers to record behavior than early in the morning or late afternoon.

Differences in the time spent on grazing varied significantly ($P < .01$) across observation periods in cows. For example they grazed a lot longer during the fifth observation (September for the first year and October for the second) than they did in August (figure 10). This may be attributable to variations in day length, but it was also much cooler in September and October during both years than it was in August. Also seasonal variations in forage quality and quantity could influence the time spent on grazing (Hancock, 1953), since forage was less available as the season progressed. The coefficient of variation for the amount of time spent grazing was 14%, which was higher than the the 7% reported by Hodgson (1982), possibly because we purposedly used cattle of different genetic background.

In cows, averages for the longest amount of time spent grazing without interruption varied with the observation and with the year ($P < .0001$), and ranged anywhere between 110 and 260 minutes (figure 8). The coefficient of variation for this trait was 17%. The number of times cows grazed for 40 minutes or more showed observation period effects ($P < .0001$) and was in the range of 2 to 4 (figure 6). The coefficient of variation for this trait was 30%.

In calves, the percentage of their time spent on grazing increased with age (figure 11). During both years, they spent about 17% of their time grazing during the first observation and 60% during the fifth observation, the latter figure being similar to that of their dams. This, of course, was expected because as their weight increased and the milk production of their dams decreased, larger quantities of feed were needed to meet the requirements of the calves. The coefficient of variation was 12%, a value similar to 14% in cows.

The longest average value for the amount of time spent continuously grazing by calves went from about 60 minutes during the first observation to 200 minutes during the fifth observation of the first year and 160 for the fifth observation in the second year (figure 9). Also the number of grazing bouts (number of time a calf grazed continuously for 40 minutes or more) went up from 1 during the first observation to 4 during the fifth observation for both years (figure 7).

During the first year the number of nursings increased sharply from period 1 to period 2, then decreased smoothly as one moved from period 3 to period 5 (figure 12). This is reminiscent of the shape of a typical lactation curve of beef cows which increases steadily after calving, reaches a maximum and then decreases progressively until the end of the lactation period (Gleddie and Berg, 1968). During the second year, the recorded nursing activities did not closely follow this scheme. The number of nursing episodes increased from period 1 to period 2 but to a lesser extent than in the first year. Then nursing activities were similar in the subsequent observations. This was very similar to the data reported by Nicol and Sharafeldin (1975), except that the nursing frequencies are just about half of those in their experiments. If we assume that the differences originated from nocturnal nursings which we did not record, this would imply that just as many nursings take place at night as during day time; but our experiment was not designed to check this hypothesis.

2.5 Figures and Tables

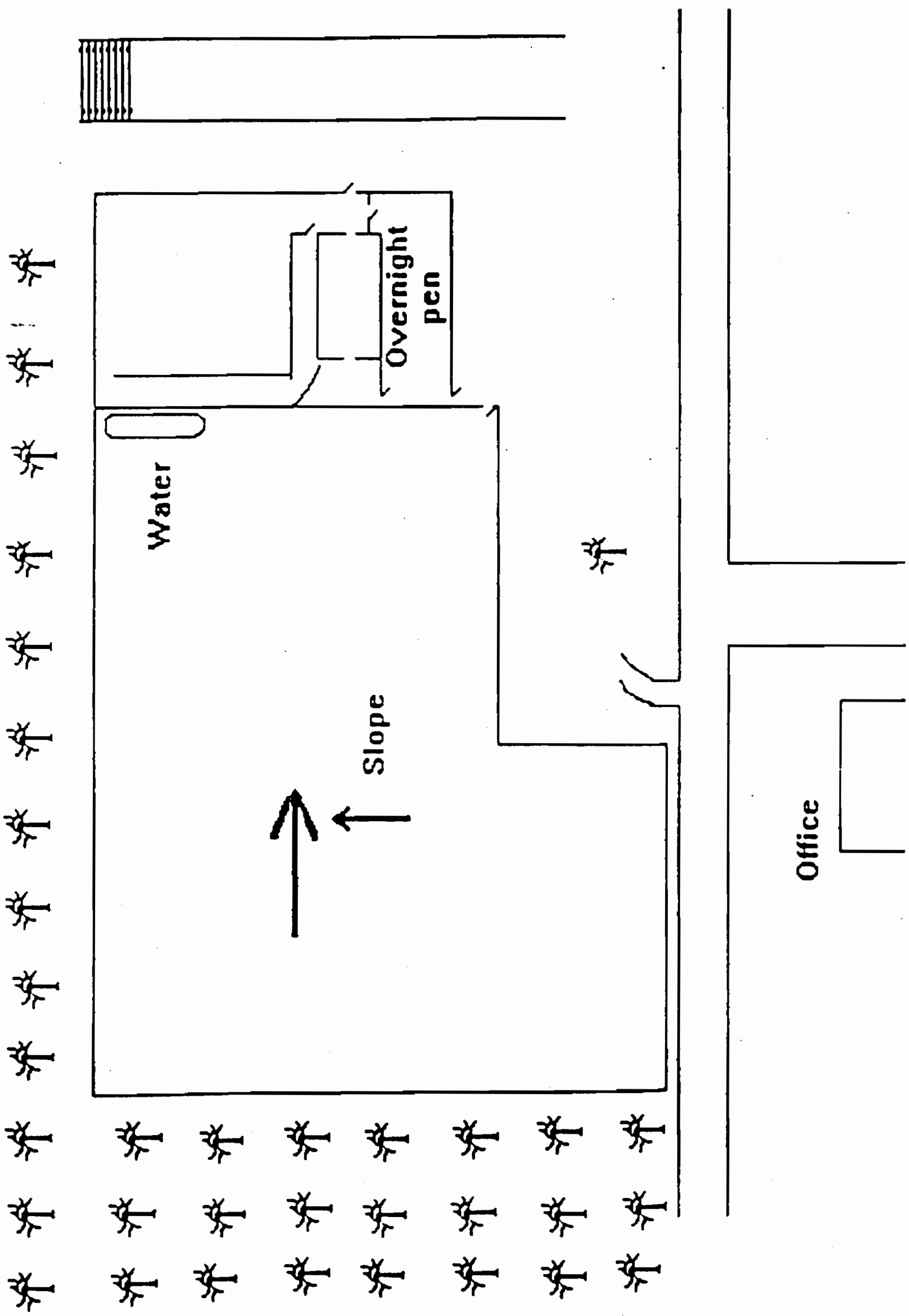

Figure 1. Diagram of the pasture.

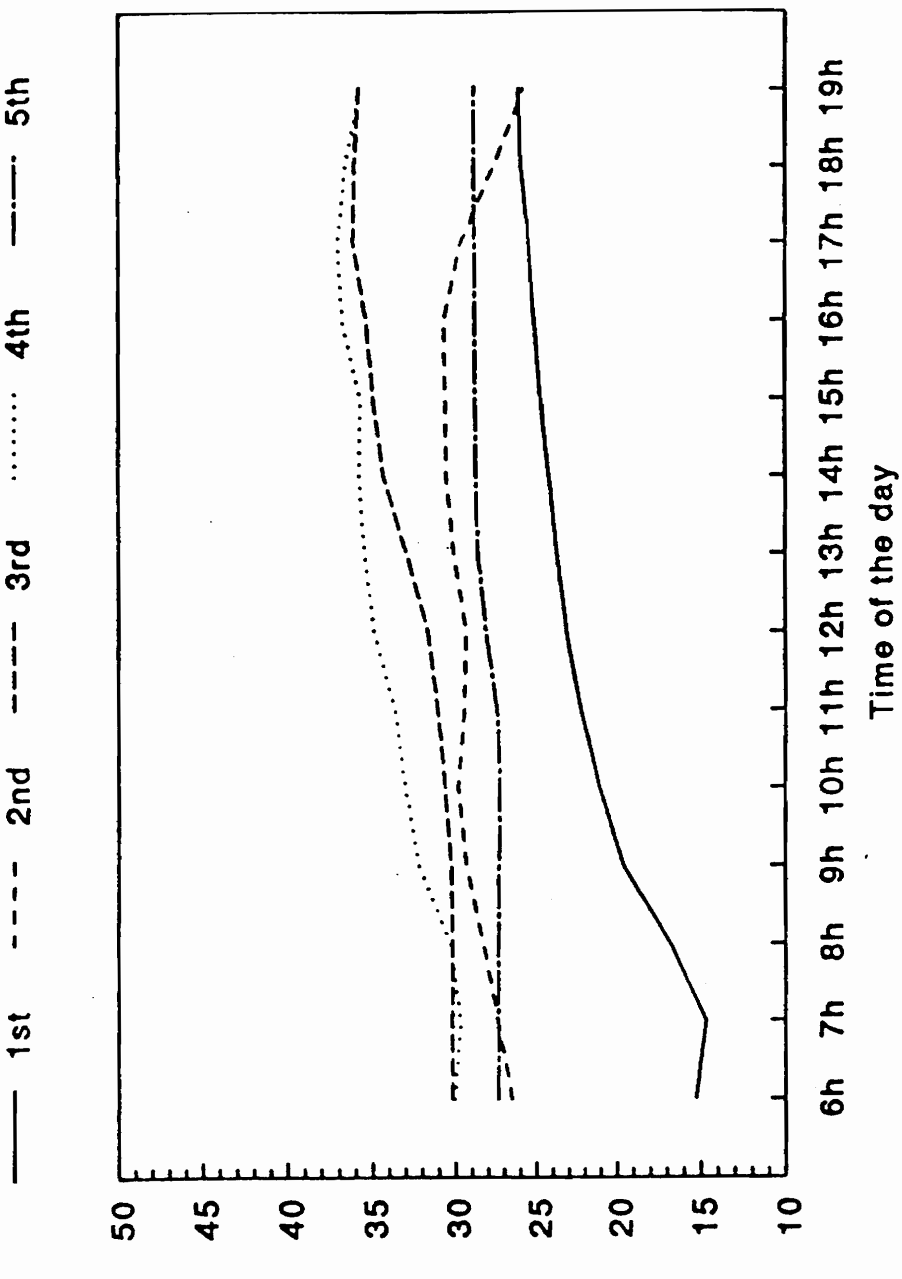

Figure 2. Comfort index for each observation period in year 1

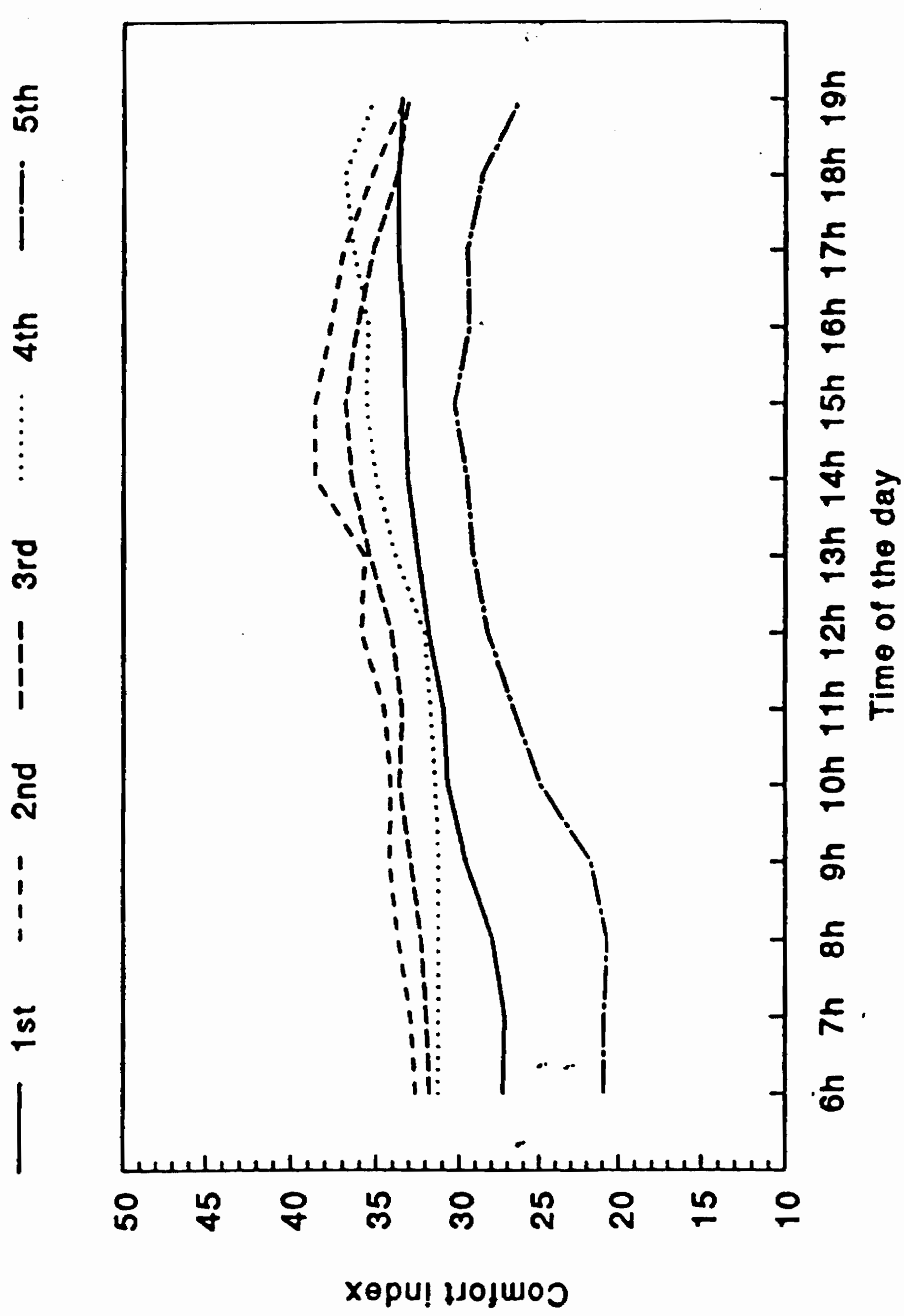

Figure 3. Comfort index for each observation period in year 2

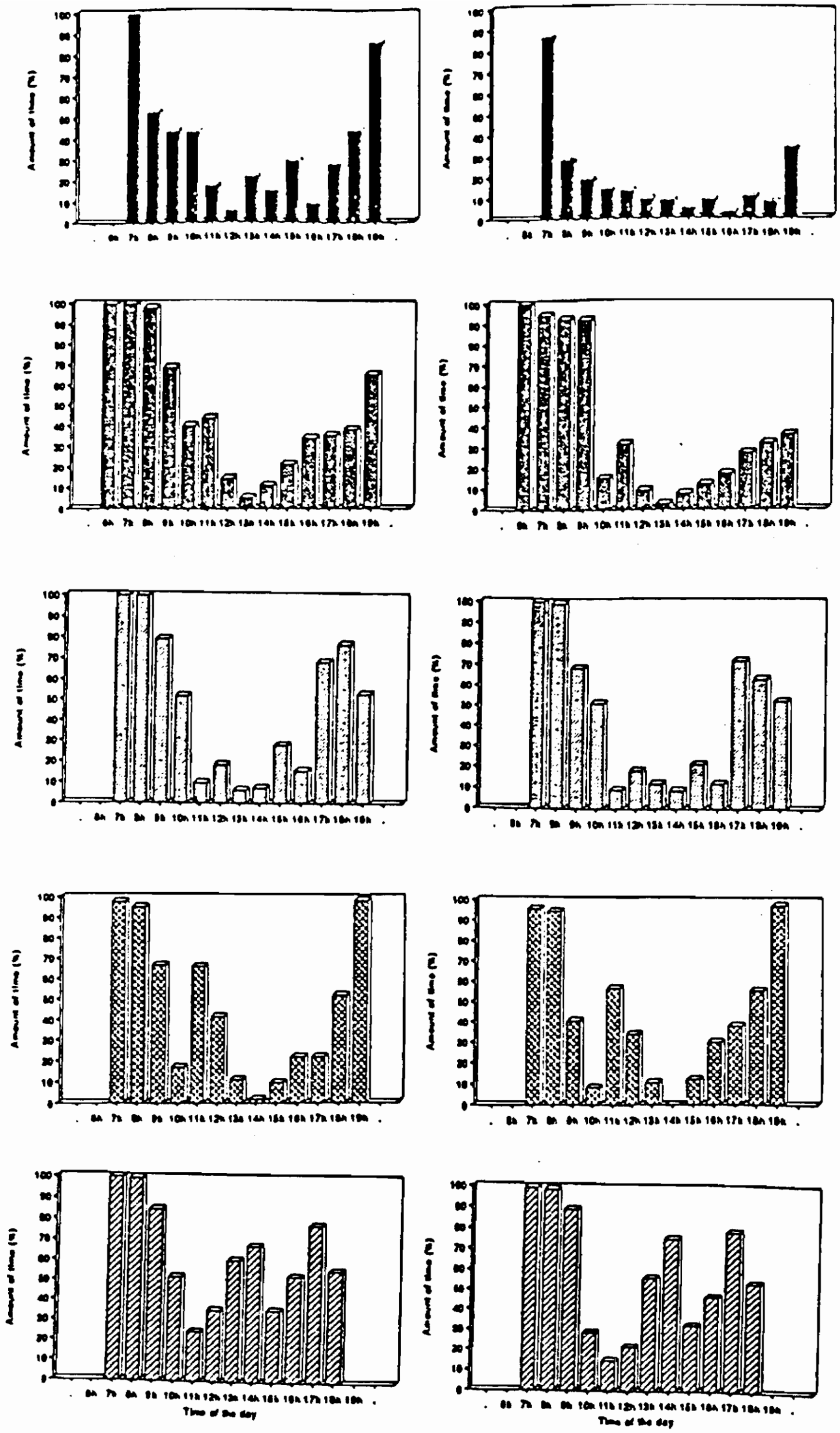

Figure 4. Percentage of time spent on grazing by cows (left) and calves (right) in year 1 according to time of the day from observation period 1 (top) to observation period 5 (bottom)

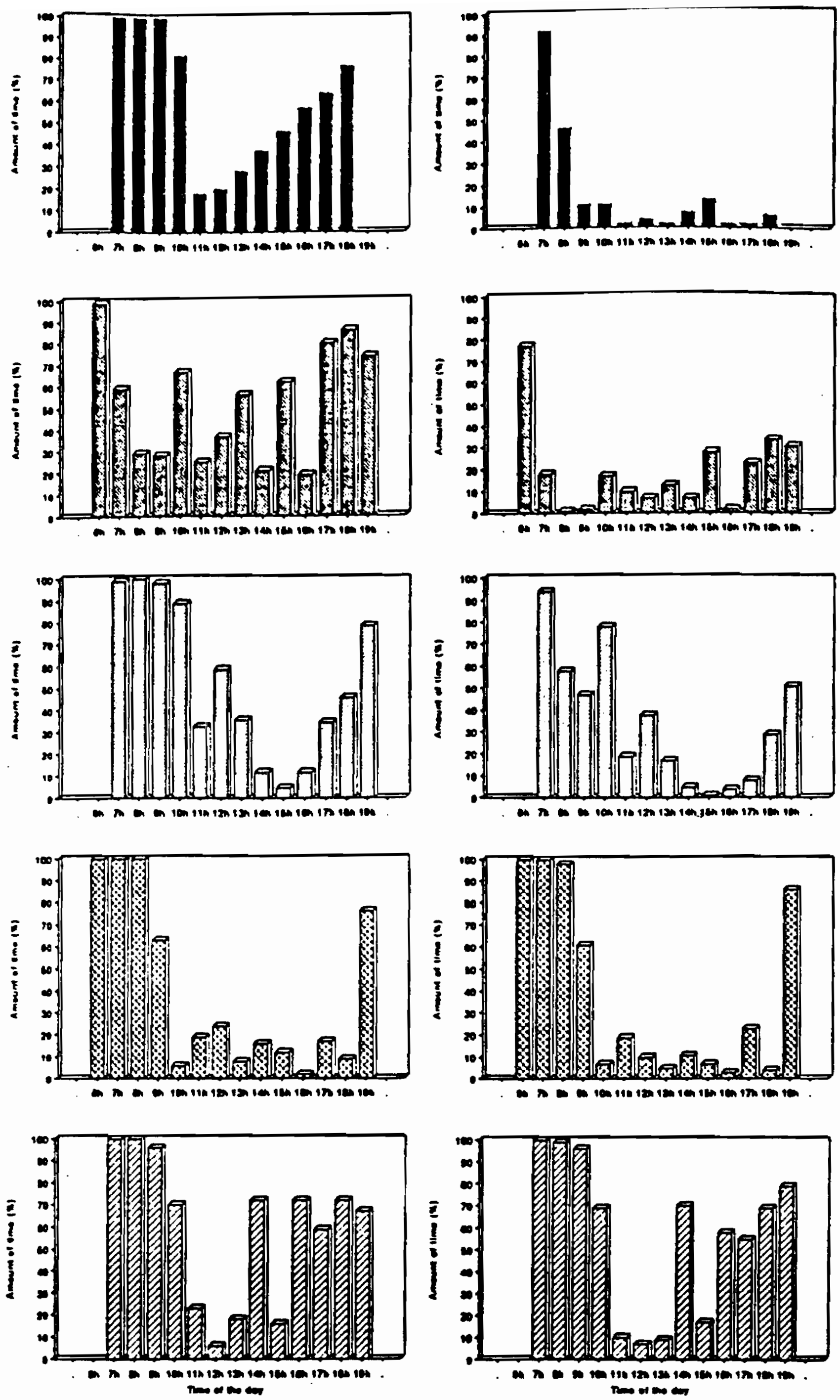

Figure 5. Percentage of time spent on grazing by cows (left) and calves (right) in year 2 according to time of the day from observation period 1 (top) to observation period 5 (bottom)

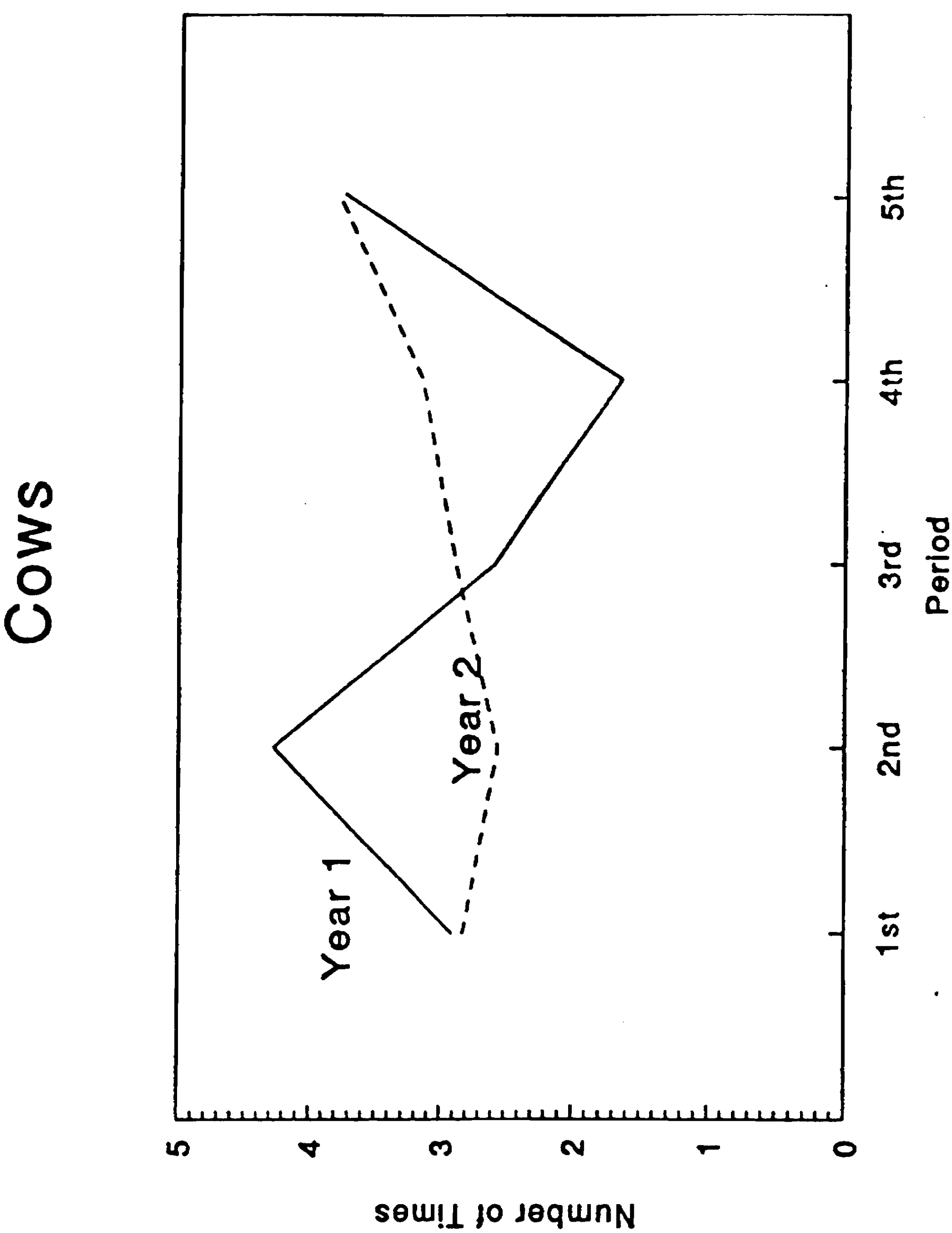

Figure 6. Average number of grazing episodes of 40 minutes or more for cows.

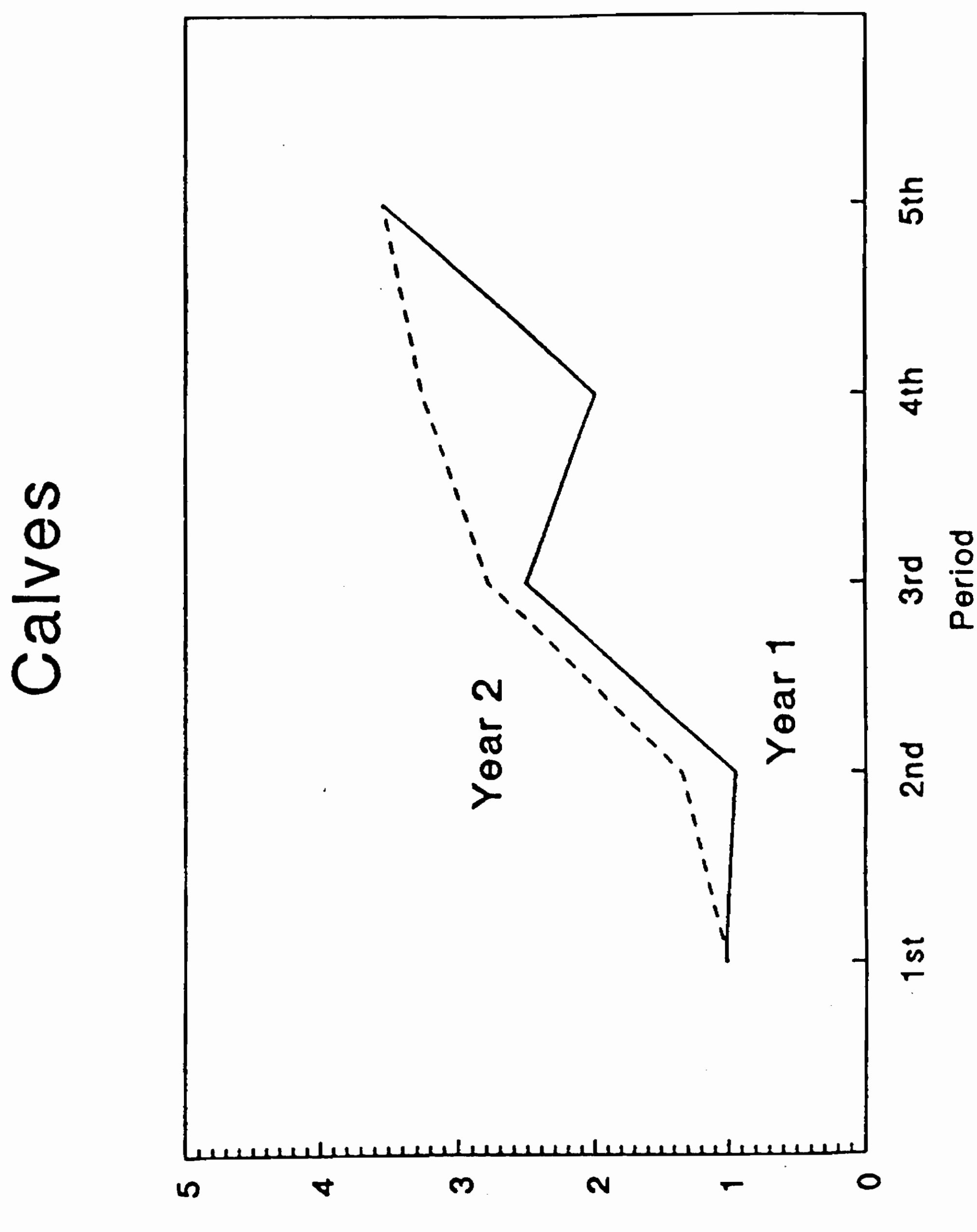

Figure 7. Average number of grazing episodes of 40 minutes or more for calves

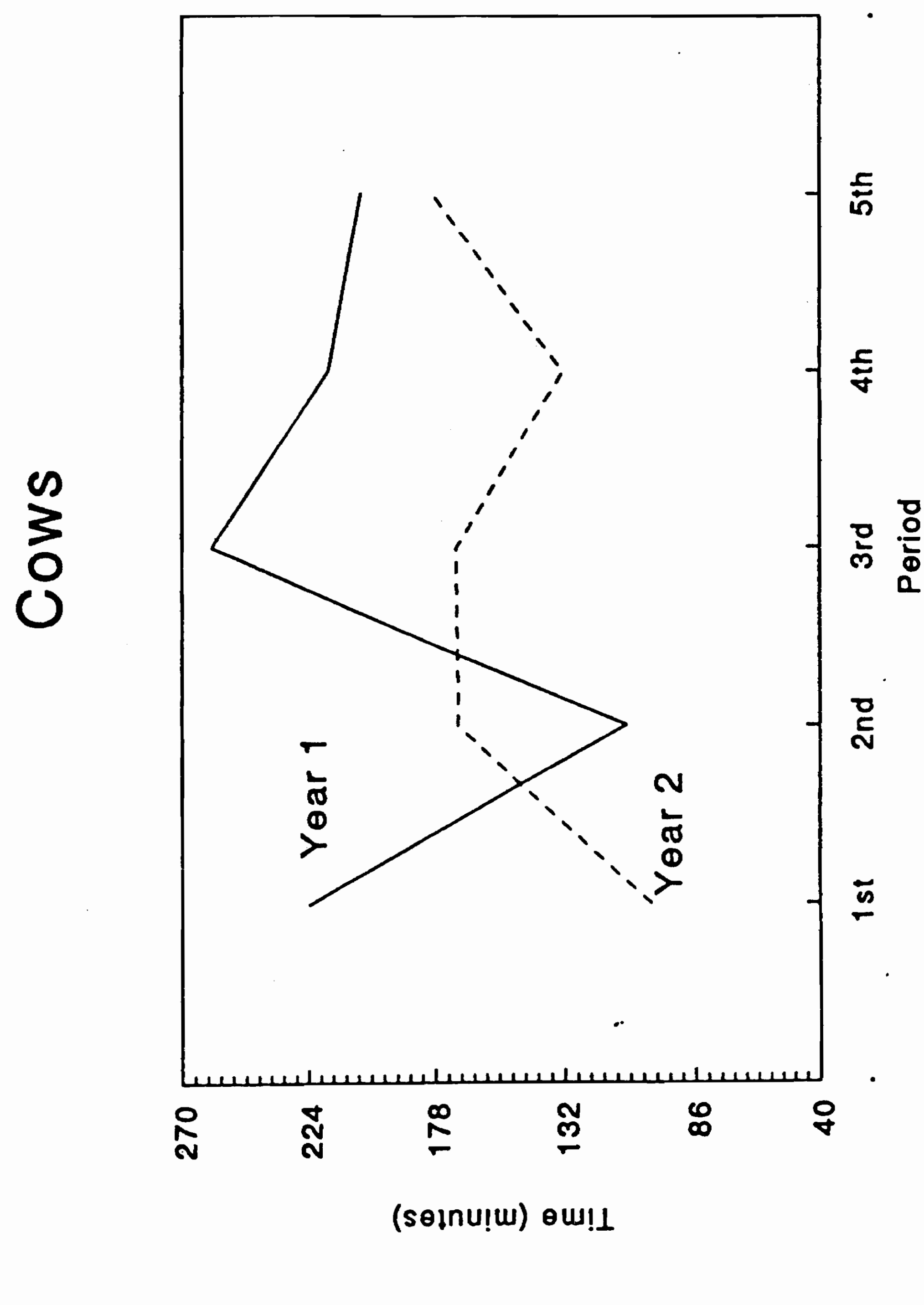

Figure 8. Average longest continuous grazing bouts for cows.

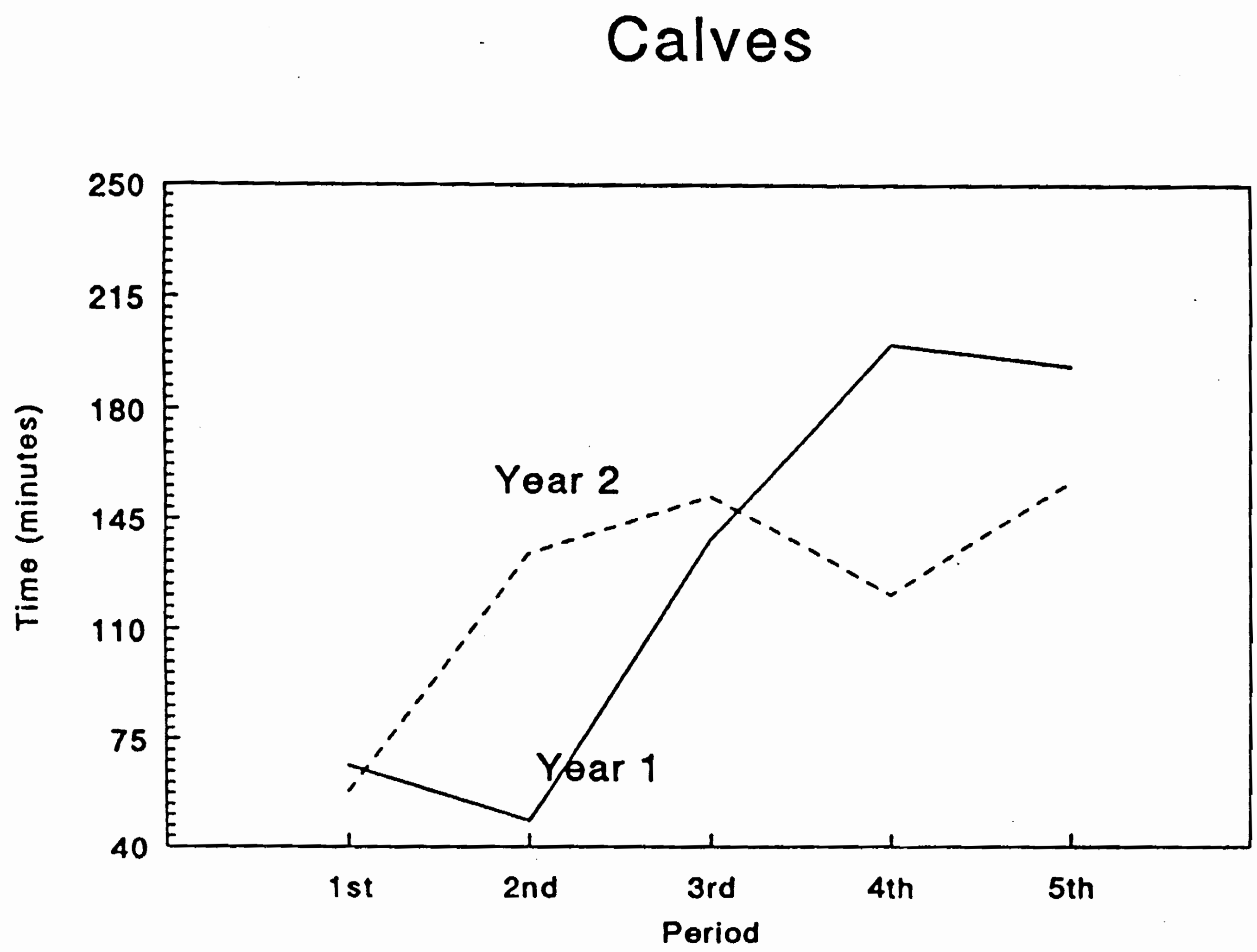

Figure 9. Average longest continuous grazing bouts for calves

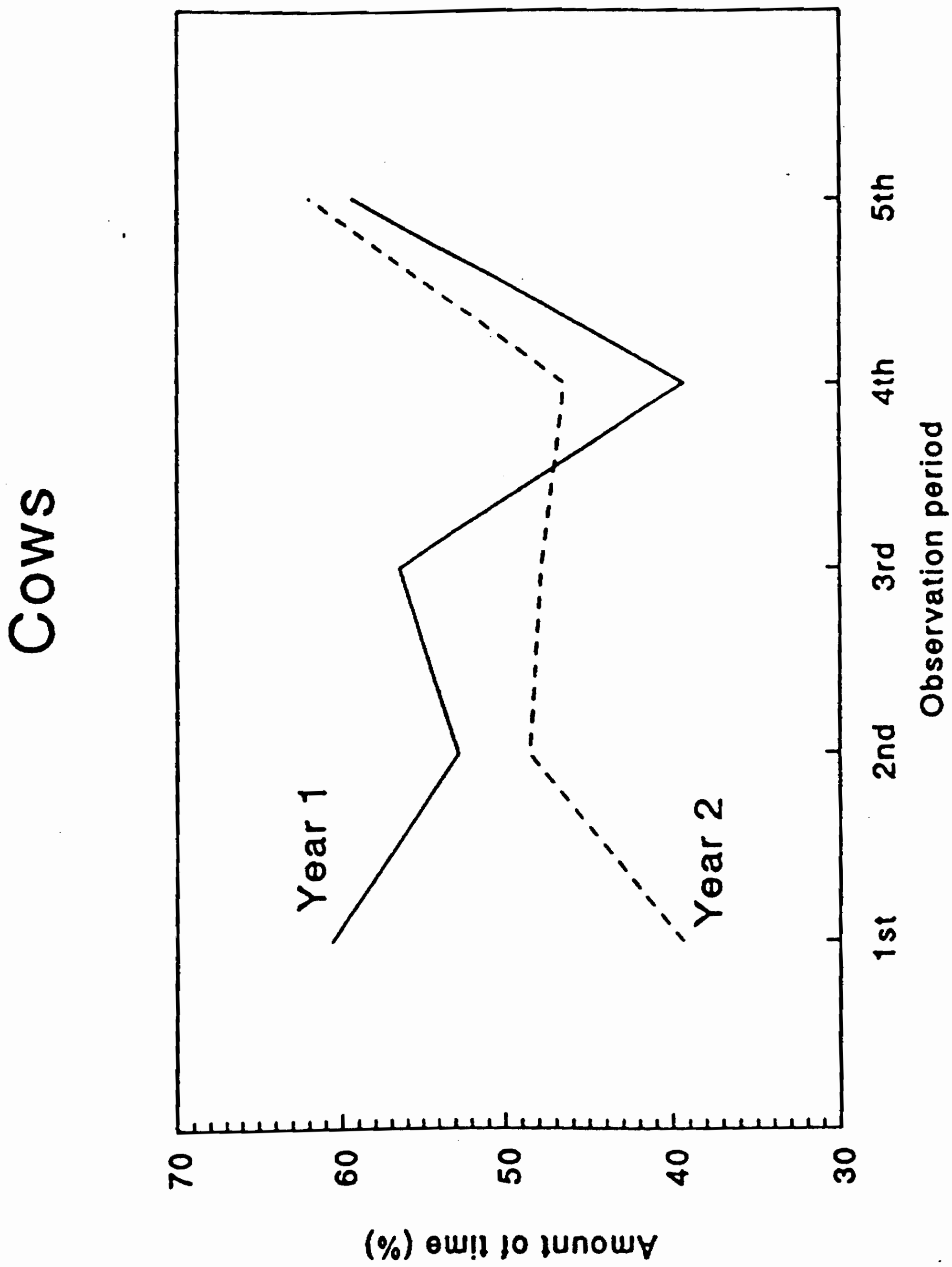

Figure 10. Average time (%) spent grazing by cows according to period and year.

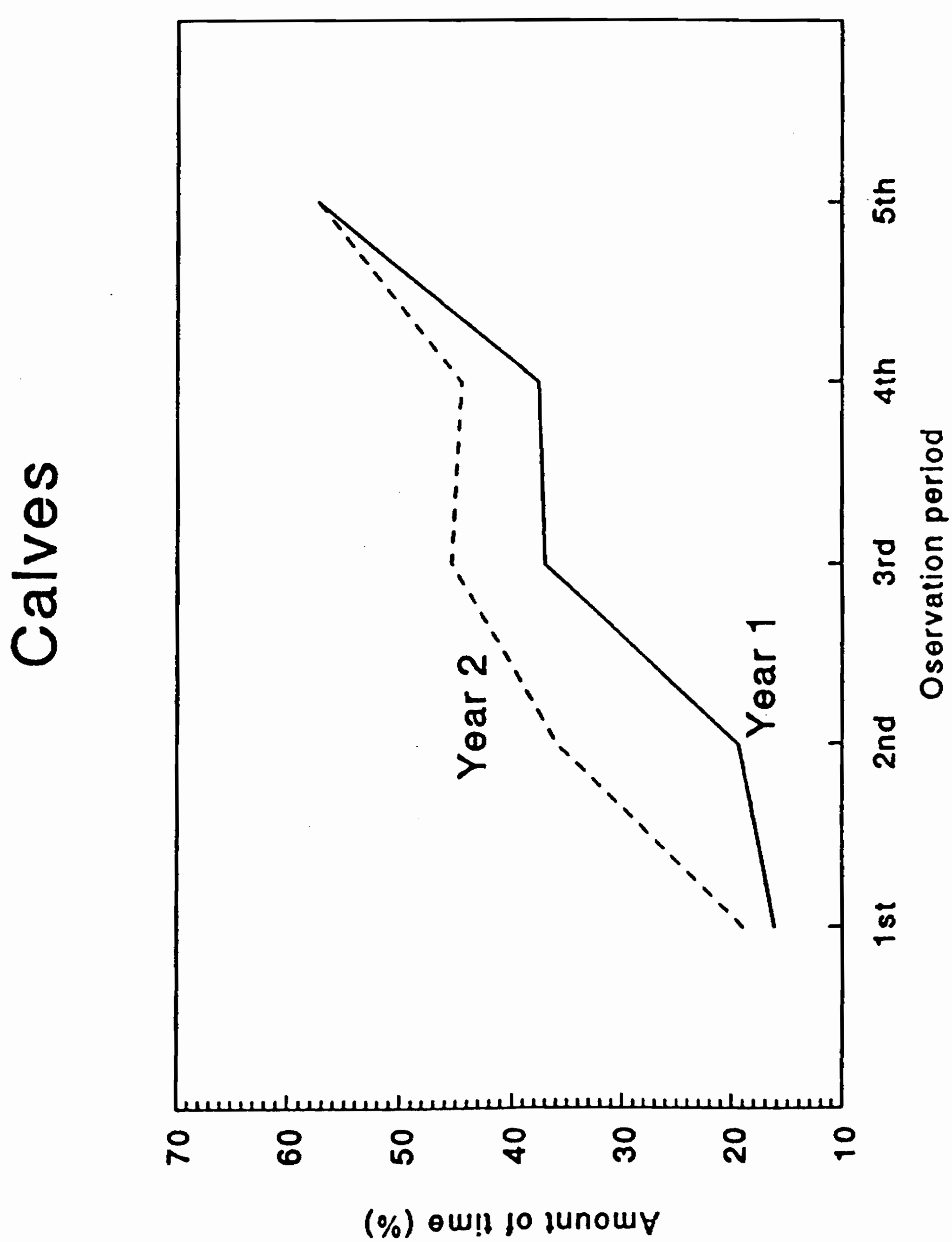

Figure 11. Average time (%) spent grazing by calves according to period and year.

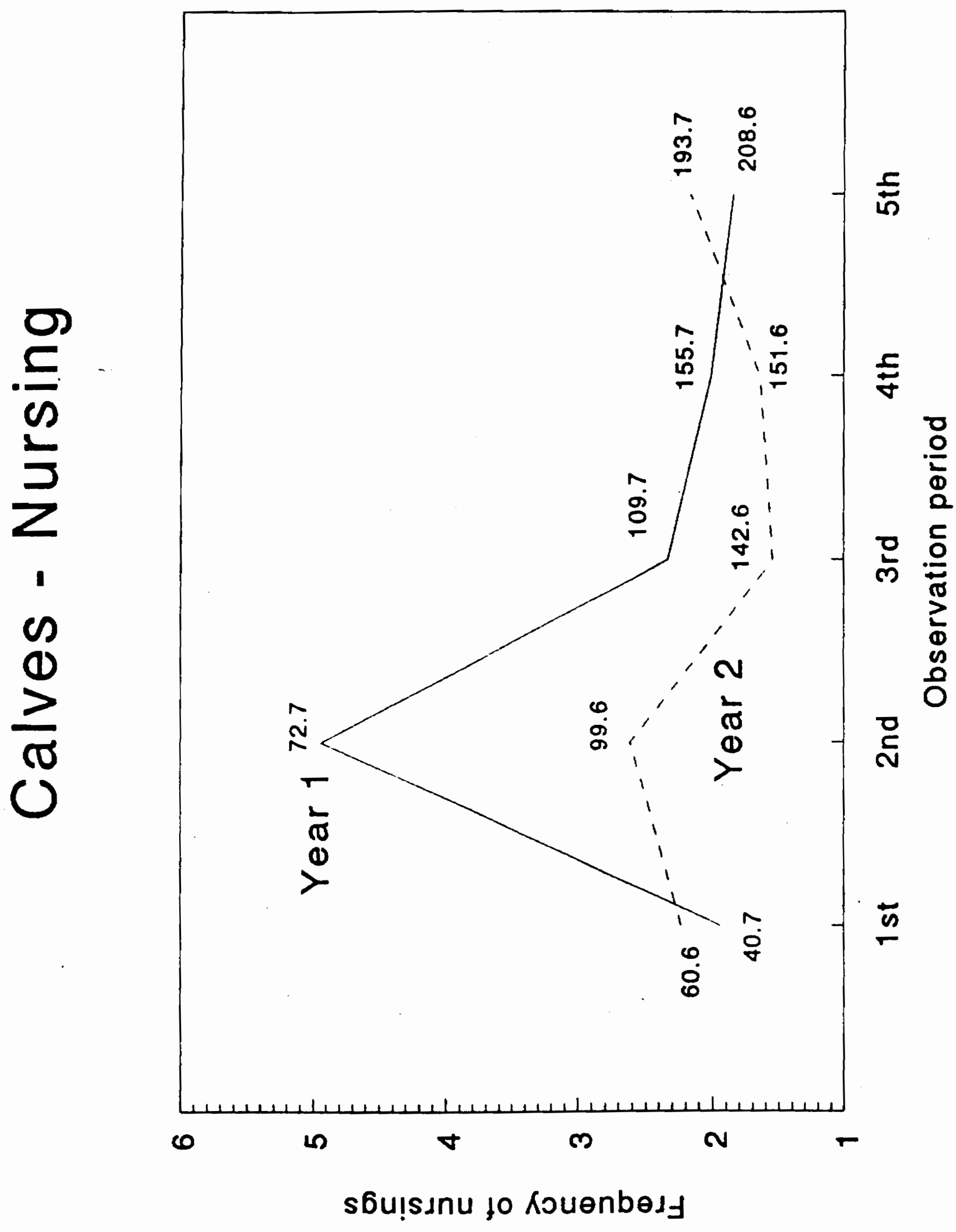

Figure 12. Frequency of nursing episodes according to year and observation periods. The average ages (days) for each observation period are marked on the curves

Table 1. Weather conditions on each observation day and time spent grazing by cows in year 1 (1988)

Observation day	Date	Daily high °C	Daily low °C	Precipitation mm	Time spent grazing (hour) Cows	Calves
1	April 17	17.8	-2.3	0	7.3	2.0
2	May 19	21.1	13.9	23.7	7.4	2.8
3	June 25	29.5	14.5	0	7.9	5.2
4	August 10	31.2	19.4	0	5.6	5.3
5	September 17	17.2	15.6	0	7.8	7.4

Table 2. Weather conditions on each observation day and time spent grazing by cows in year 2 (1989)

Observation		Daily high	Daily low	Precipitation	Time spent grazing (hour)	
day	Date	°C	°C	mm	Cows	Calves
1	June 3	25.1	21.7	0	5.2	2.5
2	July 12	31.6	21.7	0	6.8	5.1
3	August 24	29.3	17.3	0	6.3	5.9
4	September 21	27.7	21.7	5.6	6.1	5.8
5	October 29	21.0	7.5	0	7.5	6.8

Table 3. Estimated weight (kg) of the calves for each observation period and their age (days) at observation period 1

Calf ID	Year	Observation 1	Observation 2	Observation 3	Observation 4	Observation 5	Age (days)
813	1	71.3	92.1	116.2	142.9	160.1	47
823	1	82.6	114.3	150.6	195.1	229.5	47
824	1	68.1	94.8	126.1	165.6	200.0	37
825	1	69.0	96.2	127.9	161.0	178.3	39
826	1	71.7	93.5	119.3	147.4	164.7	43
829	1	77.6	103.0	132.0	163.3	180.5	49
831	1	57.6	81.2	108.4	145.2	179.6	31
834	1	83.9	113.4	147.9	190.5	225.0	46
839	1	77.6	101.6	128.8	158.8	176.0	47
846	1	74.9	102.1	132.9	165.6	182.8	42
847	1	57.6	84.9	116.6	156.5	191.0	29
849	1	74.4	98.0	124.8	154.2	171.5	46
850	1	61.7	85.8	113.0	142.9	160.1	35
851	1	65.8	88.9	115.7	145.2	162.4	47
852	1	57.2	83.0	113.4	145.2	162.4	28
853	1	48.6	72.2	99.4	129.3	146.5	27
854	1	78.1	107.5	141.5	176.9	194.2	44
855	1	66.7	88.9	114.8	149.7	184.2	49
859	1	69.9	98.5	131.1	172.4	206.9	37
860	1	77.1	109.2	146.1	190.5	225.0	37
862	1	68.5	98.5	132.5	167.8	185.1	41
865	1	65.8	90.3	118.9	156.5	191.0	47
866	1	67.6	96.6	130.7	156.5	191.0	38
867	1	70.3	99.8	134.3	170.1	187.4	29
868	1	84.4	113.9	148.3	190.5	225.0	46
871	1	75.3	104.4	137.5	172.4	189.6	36
872	1	87.1	115.2	147.4	188.3	222.7	45
878	1	79.9	105.7	135.7	167.8	185.1	50
879	1	78.1	103.9	133.8	165.6	182.8	43
882	1	81.7	114.3	152.0	197.3	231.8	39
822	2	100.7	129.8	155.2	159.2	203.7	88
826	2	100.7	129.8	155.2	159.2	201.4	73
831	2	117.5	152.0	190.1	198.2	237.2	91
833	2	106.6	136.6	162.9	166.9	201.4	91
834	2	123.0	159.7	189.2	193.2	224.1	88
840	2	114.8	147.9	175.6	179.6	217.3	93
843	2	84.4	110.7	134.7	138.8	169.7	71
848	2	108.9	138.4	164.2	168.3	187.8	90
849	2	95.3	122.0	146.1	150.2	183.3	86
850	2	121.6	156.5	195.1	203.2	241.8	95

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862	2	118.4	152.0	190.1	198.2	239.5	90
868	2	133.4	173.3	215.0	223.2	257.6	85
869	2	123.9	165.6	208.2	216.4	255.4	81
870	2	122.5	160.6	191.4	195.5	224.1	85
872	2	60.8	83.0	115.2	123.4	157.9	42
873	2	93.5	134.3	166.5	170.6	199.1	51
875	2	86.2	118.9	146.1	150.2	183.3	60
878	2	99.4	129.3	155.2	159.2	199.1	87
881	2	98.9	128.8	155.2	159.2	199.1	77
883	2	75.8	100.3	133.4	141.5	176.0	61
885	2	107.1	137.9	164.2	168.3	208.2	84
892	2	92.1	125.2	152.9	157.0	192.3	70
893	2	72.2	90.3	109.8	113.9	158.3	76
894	2	100.7	135.7	174.2	182.4	216.8	64
896	2	92.6	115.2	137.0	141.1	165.1	89
899	2	96.2	126.6	162.9	171.0	207.8	68
909	2	103.9	132.0	157.4	161.5	205.9	90
910	2	101.2	135.7	174.2	182.4	216.8	74
912	2	101.6	129.8	155.2	159.2	199.1	90
913	2	74.0	90.8	109.8	113.9	144.7	86
915	2	88.9	112.1	134.7	138.8	174.2	92
917	2	106.2	137.5	174.2	182.4	221.4	90
918	2	126.6	162.4	191.4	195.5	221.8	93
923	2	91.7	122.0	148.3	152.4	190.1	71
926	2	89.4	113.9	137.0	141.1	185.5	88

Table 4. Ambient hourly temperatures for each observation day (year 1)

Date and	Hour and temperature (°C)														
observations	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
April 17, 1988 1st observation	1.1	.8	3.9	7.8	9.8	11.7	13.1	14.2	15.3	16.2	16.8	17.5	17.8	17.5	16.4
May 19, 1988 2nd observation	14.7	15.6	17.5	18.8	19.1	18.8	18.8	19.7	20.8	21.1	21.1	19.7	16.4	13.9	13.1
June 25, 1988 3rd observation	20.0	20.0	20.0	20.3	21.1	22.2	23.6	25.6	27.2	27.8	27.8	28.3	27.8	26.7	25.6
August 10, 1988 4th observation	19.4	19.4	20.6	23.1	25.0	26.7	28.3	29.4	30.0	29.7	30.0	29.7	28.6	27.2	26.1
September 17, 1988 5th observation	15.6	15.6	15.6	15.6	15.6	15.8	16.7	17.2	17.2	17.2	17.2	17.2	17.2	17.2	16.9

Table 5. Ambient hourly temperatures for each observation day (year 2)

Date and observations	Hour and temperature (°C)														
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
June 3, 1989 1st observation	15.6	15.6	16.9	19.4	21.1	21.7	22.8	23.9	24.4	24.4	24.7	25.0	24.7	24.2	23.3
July 12, 1989 2nd observation	23.3	23.6	24.7	25.6	25.8	26.7	28.3	30.0	30.8	30.5	29.9	27.8	25.6	23.3	22.8
August 24, 1989 3rd observation	21.7	21.9	22.5	23.6	24.7	25.6	26.7	28.1	28.9	28.3	26.9	25.3	23.9	23.1	22.2
September 21, 1989 4th observation	20.6	20.6	20.6	20.6	20.8	21.7	23.1	25.3	26.9	27.5	27.2	27.2	27.5	25.3	23.1
October 29, 1989 5th observation	7.5	7.5	7.5	9.7	14.2	16.7	19.2	20.6	21.1	21.4	20.8	19.7	17.2	15.0	13.1

Table 6. Relative humidity for each observation day (year 1)

Date and	Hour and relative humidity (%)														
observations	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
April 17, 1988 1st observation	73	58	52	49	44	39	37	35	33	31	29	28	32	38	38
May 19, 1988 2nd observation	98	98	91	84	87	88	87	85	78	73	72	78	87	91	92
June 25, 1988 3rd observation	84	84	84	82	76	66	60	58	59	62	68	74	79	88	91
August 10, 1988 4th observation	91	82	78	74	63	54	55	52	50	54	63	72	77	81	85
September 17, 1988 5th observation	99	99	99	97	95	95	96	96	97	98	98	98	99	99	99

Table 7. Relative humidity for each for each hour during the observation periods (year 2)

Date and observations	Hour and relative humidity (%)														
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
June 3, 1989 1st observation	98	96	88	80	78	75	73	72	72	73	74	76	78	82	85
July 12, 1989 2nd observation	89	82	81	78	74	71	72	77	83	83	88	95	95	96	97
August 24, 1989 3rd observation	97	91	86	82	77	69	63	67	73	83	92	94	95	96	96
September 21, 1989 4th observation	99	99	99	99	99	89	76	73	74	75	76	93	95	96	97
October 29, 1989 5th observation	99	99	89	74	68	62	57	54	54	57	65	74	77	83	90

Table 8. Estimated hourly wet bulb temperatures for each observation day (year 1)

Date and	Hour and wet bulb temperature (°C)														
observations	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
April 17, 1988 1st observation	-0.5	-1.6	0.5	3.7	5.4	6.3	7.2	7.5	7.7	8.1	8.2	8.5	9.4	10.0	8.7
May 19, 1988 2nd observation	14.5	15.4	16.4	16.8	17.8	17.1	16.8	17.9	17.9	17.8	18.0	16.8	14.9	12.9	12.2
June 25, 1988 3rd observation	17.9	18.0	17.9	17.9	17.9	17.8	18.0	19.3	21.0	22.0	23.0	24.5	24.8	25.2	24.0
August 10, 1988 4th observation	18.1	17.2	17.7	20.0	20.0	19.9	21.4	21.7	21.9	22.0	24.4	25.3	25.3	24.5	24.1
September 17, 1988 5th observation	15.3	15.3	15.3	15.2	15.0	15.1	16.0	16.7	17.0	17.1	17.1	17.2	17.2	17.0	16.8

Table 9. Estimated hourly wet bulb temperatures for each observation day (year 2)

Date and	Hour and wet bulb temperature (°C)														
observations	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
June 3, 1989 1st observation	15.2	14.9	15.5	17.1	18.1	18.2	19.2	20.0	20.8	21.1	21.2	21.6	21.8	21.9	21.5
July 12, 1989 2nd observation	20.7	21.2	22.0	22.5	22.0	22.2	23.9	26.8	28.2	27.8	27.9	27.1	25.0	22.5	22.1
August 24 1989 3rd observation	20.8	20.5	20.7	21.2	21.8	20.9	21.0	23.0	24.8	26.2	26.0	25.1	22.9	22.1	21.5
September 21 1989 4th observation	20.1	20.1	20.1	20.1	20.2	20.2	19.7	21.8	23.1	24.0	24.0	26.2	27.0	25.1	22.2
October 29, 1989 5th observation	7.3	7.3	6.8	7.2	10.8	12.5	14.0	14.8	15.2	16.8	15.2	16.5	14.8	13.2	12.0

3.0 GENETIC ANALYSIS

3.1 Review of Literature

When considering behavioral studies in farm animals, genetics should be of special importance. In fact, domestication occurs as a result of man's selection in wild species (whether consciously or not) for behavioral characters such as docility, learning ability and adaptation to the ever-changing modern environment.

Whether behaviors of domesticated species evolved as a result of direct selection or as logical consequences of correlated responses to selection on other desirable traits is subject to speculations. Price (1984) hypothesized that changes in behavior accompanying domestication could occur in response to shifts in thresholds of stimulation. If the thresholds were raised above the normal level of stimulation, a behavior would not be frequently observed and its loss would result from this change. But the fact is that, in cattle at least, there are still too many undesirable behavioral characters whose elimination would certainly benefit livestock production. For example, in a study conducted by Tulloh (1961), Hereford and Angus cattle had better temperament scores than

Shorthorns, and animals with bad temperament scores had lower body weight than those with good temperament scores.

Also during the course of domestication, many changes have occurred in the desirable direction, but many other changes that are not desrirable to man have occurred. This was evidenced in research reported by Murphy et al. (1980), where dairy breeds were significantly more approachable than beef breeds. In that same experiment, *Bos taurus* cattle were significantly more approachable than *Bos indicus* cattle. Raising beef cattle for milk did not improve their approachability, nor did raising dairy breeds for meat reduce their approachability.

3.1.1 An overview of the inheritance of grazing behavior traits in cattle

Erlinger et al. (1990) remarked that cattle of different genetic growth patterns had different grazing behavior patterns and therefore concluded that cattle could be selected for desirable grazing traits. Czako (1974) documented differences in lying time and feeding time in five groups of Simmental cattle descending from five different bulls. He speculated that it would have been desirable had the five groups reacted the same way with regard to their lying and feeding time to adapt to an industrial system of production.

One classic study in the genetics of grazing behavior is that of the six sets of monozygotic twin dairy cows, who showed similar behavior for time spent grazing per day within sets while differences between sets were very large (Hancock, 1950).

Lampkin and Quarterman (1962) compared Zebu and Grade cattle in two locations under favorable tropical conditions. Grades spent considerable more time lying down and ruminating than Zebu cattle. They associated these differences to differences in digestive efficiency. As they moved from one location to the other, the total grazing time remained the same in both breeds. However, the pattern changed from intermittent daytime grazing to two periods of intensive grazing at dawn and at dusk, with an increase in the time spent grazing at night. In both locations grades consumed twice as much water as Zebu steers.

Erlinger et al. (1990) observed large and consistent differences in the total grazing time in four different groups of cattle differentiated by mature size. The contrast of the largest heifers versus the heifers from groups smaller in mature size was significant during all but one of their six data collections. The largest heifers grazed 70.7 min/d longer than the small but rapidly maturing group. In this same experiment, with the exception of the group II versus group III comparison (groups intermediate in mature size), bite size increased with mature size. Based on these observations, they concluded that differences in ingestive behavior were associated with genetic growth patterns in cattle.

In a behavioral study of Charolais and Zebu cattle, Cunha et al. (1963) used 5 Charolais, 10 Charolais x Zebu crossbred and 4 Zebu cattle aged from 3 to 8 years. They found that the time spent grazing and walking increased significantly with the percentage of Charolais inheritance, while the time spent lying down decreased. The above mentioned work may be contrasted with the investigations of Yates and Larkin (1965) who found no differences in grazing behavior between beef cattle and dairy cattle. Also, Havstad et al. (1986) studied the grazing behavior of four breed combinations of cattle (Hereford, Aberdeen Angus x Hereford 50-50, Simmental x Hereford 50-50, and Simmental x Hereford 75-25). They found no differences among stocks with respect to the amount of time spent grazing. The amount of time cows spent grazing increased with milk yield and decreased as the age of the calves increased. Hereford and Simmental x Hereford 75-25 cows with steer progeny grazed considerably longer than those with heifer calves.

Nursing and drinking behavior have been studied in several works. Nicol and Sharafeldin (1975) studied the effects of breed group on suckling beef calves. They observed a group of 24 calves sired by either a Friesian or Angus bull and nursing Angus purebred or Angus crossbred dams. Friesian x Angus calves nursed more often and for a longer duration per episode than Angus calves. Another study (Walker, 1962) involved 9 Angus, 10 Hereford x Angus and 3 Angus x Jersey heifers mated to Angus bulls. Calves of Hereford x Angus heifers nursed their dams more frequently than calves of Angus heifers, but for a shorter amount of time. Calves from the Hereford x Angus dams also nursed more frequently than calves of Angus x Jersey heifers and for an even shorter time. Selman et al. (1970) studied the nursing behavior of cattle within 8 hr after calving. Beef cattle appeared to be better mothers than dairy cows. The calves of the beef cows were standing well before those of dairy cows, and of the 23 calves that nursed within the 8-hr period, the beef calves nursed in a mean time of 82 min versus 262 min for the dairy calves. Within that period of time, the number of nursing episodes varied from 0 to 4.

Mendoza-Ordones et al. (1988) analyzed the time required to drink one liter of liquid, the number of gulps per second and the amount of liquid consumed per gulp in five German breeds of cattle. Differences between breeds were not significant, but there were significant differences between herds in the time required to drink one liter of liquid. The heritabilities of the three drinking traits were 0.43, 0.68 and 0.52, and the correlation between body weight and the drinking traits were -0.61, -0.71 and 0.74, respectively. The investigators concluded that selection for growth in calves was possible on the basis of drinking behavior. In another investigation, Balaine et al. (1975) noted significant differences between genetic groups of cattle for the time required to drink one liter of milk.

3.1.2 Problems in designing and interpreting behavioral genetics experiments in cattle

In a review paper relevant to experimental design for behavioral characters, Hafez (1961) pointed out that both management and social behavior produce environmental effects that may be confounded with genetic responses and that selection could be used to influence behavioral trends associated with economic traits.

3.1.2.1 Learning and previous experience

The excellent work presented by Hancock (1950) on the behavior of monozygotic cattle twins has since been challenged by several other works. For example, Petersen (1957) studied several behavioral traits on pasture, using eight pairs of twins. In dominance order ranking, twins of a pair appeared to be equal in rank. No matter whether they were monozygotic or dizygotic, each pair tended to walk together and to behave similarly on pasture. This suggested that the monozygotic twin cattle in Hancock's experiments showed how much they could learn from each other and how well they could display what they learned more than they illustrated genetic effects on grazing behavior.

Van Putten (1969) examined several behavior traits on monozygotic, dizygotic and artificial (unrelated calves born within a short time of each other) twins. The results of his investigations showed no differences between the sets of twins indicating that behavior in his study was predominantly controlled by the environment.

In another experiment that was designed to study patterns of behavior between unrelated single-born calves reared together as pairs, Ewbank (1967) observed four pairs of monozygotic twins, one pair of dizygotic twins and eight pairs of artificial twins. After two years of observations, members of each pair on pasture tended to be close to each other, regardless of their type of twinship. This behavior, the association of pair mates at pasture, was attributed more to the method of rearing the set of twins than the genetic make up of the animals involved. Hohenboken (1987) postulated that the possibility to generate identical twins by embryo manipulation and to tranfer them to different recipient cows provides a powerful tool for reaseach in behavioral genetics free from any common environmental complications either prenatal or postnatal, such as those involved when considering naturally occurring identical twins.

3.1.2.2 Social facilitation interferences

Social facilitation refers to an increase of a behavioral activity under the influence of the sight or the sound or any other stimuli coming from other individuals engaged in the same activity. An example of this change in behavior was shown in the work of Bailey et al. (1974) where steers receiving a supplement of oat grain grazed for a shorter period than steers that received no supplement. When groups of steers were mixed together, grazing time of the nonsupplemented group of steers was considerably reduced by the presence of the group that received oat grain supplement. While these groups were presumbly from the same genetic background, a similar scenario is conceivable, where the difference between the groups may be of genetic rather than nutritional origin. That is what seemed to appear in the investigations of Oldenbroek and Jansen (1979). In their work, three breeds of cows were divided into two groups for each breed and the influence of a subgroup of one breed on the behavior of another breed was investigated. The results of their investigations suggested that the presence of one breed could influence the grazing behavior of another breed of cattle.

3.1.2.3 What is heritable and how heritable is it?

The genetic component of a behavior may be hidden by the way results of an otherwise excellent investigation are interpreted. For example, Wilson (1961), in a study involving East African Zebu cattle, indicated that their grazing behavior differed from that of the other breeds and crosses studied in respect to the diurnal pattern rather than the total time spent in each behavioral category. Should he have concentrated solely on his original objective which was the study of the total time of behavioral activities, he would have concluded that the breeds were similar in behavior, thus missing the differences in patterns which turned out to be more important than the investigated hypothesis.

In another experiment (Moran, 1970), 3/4Brahman-1/4 Shorthorn and purebred Hereford steers were grazed together on an improved pasture. After seven periods of observation of their grazing behavior, the similarity of their grazing time was striking; yet when using the ruminating time/grazing time ratio as an indicator for digestive efficiency, the superority of the Brahman crossbreds over the Herefords in this respect increased with the quality of the pasture.

In an experiment designed to clarify differences in the grazing patterns of free-grazing Jerseys and Friesians, Brumby (1959) observed a mixed group of cattle at four periods throughout their lactation. He was able to show that when the fat-corrected milk (FCM) production of the two breeds was the same, there was no "clear-cut" difference between them in grazing time. The grazing time required per unit of pasture intake was greater in the Jerseys than in the Friesians, whereas the feed intake per unit FCM was greater in the Friesians than in Jerseys.

Investigations have been conducted on grazing activities of 16 Jersey cows with high breeding index and 16 with low breeding index (Arave and Kilgour, 1982). There were no differences between groups in grazing, lying or standing time or drinking frequency early or in the middle of lactation. Cows with high breeding index grazed longer late in the lactation period. In that same experiment, indoor feeding trials showed that the high breeding index groups always consumed more food. The investigators speculated that even when there was no difference in total grazing time between groups, it is possible that cows with high breeding index grazed and drank more in equivalent time periods, which indoor trials suggested, but they surrender their hypothesis to further investigations.

Behavioral characters are often studied as if they are quantitative. Even though this is often justified, such traits sometimes are more qualitative than quantitative. Scott and Fuller (1965) found that attempts to restrain Cocker Spaniel puppies resulted in little struggling while similar attempts on Basenji puppies resulted in much struggling. The first generation of hybrids behaved like the Basenji, and back-crosses indicated that a single dominant gene controlled this behavior. To come back to cattle, Serban et al. (1979) found that within the Romanian Brown breed, polled animals were more docile than horned individuals. They designed a breeding program to take advantage of the findings. Also differences in grazing time have been reported in groups of cattle differing in coat color (Bennie, 1956; Stricklin et al., 1976)

3.2 *Material and Methods*

For both years (1988 and 1989) cows and calves were the same as described in the previous section, and so was the analysis of variance. The dependent variables investigated for both cows and calves were total grazing time, percentage of time spent grazing, number of grazing episodes, longest grazing episode and in addition for calves, the number of nursing episodes. Least square methods were used to analyze the data using the General Linear Model procedure (Statistical Analysis System, SAS, 1982).

In cows, intraclass correlations among repeated measures for the percentage of time spent grazing and the longest grazing episode across observation periods were estimated using the ratio of the variance among cows to the total variance. The repeatability of the number of grazing bouts was not investigated because the duration of the observation was not the same for each period.

Since the amount of time spent grazing of calves was almost equal to that of their dams during the fifth periods of observation (58% in calves compared to 60% in cows for the first year and 58% in calves compared to 62% in cows for the second year), this variable (i.e., the amount of time spent grazing during the fifth observation) was used to compute preliminary estimates of the heritability of this behavior, by regressing the records of calves on those of their dams. This approach to heritability estimation is subject to an important reservation, since a low heritability could simply connote a low genetic correlation between the two traits, grazing behavior at 7 months of age and grazing behavior at an adult age. On the other hand, a high estimated heritability could simply reflect the ability of calves to mimic their dams. Nevertheless, this attempt represents a first order approach to the calculation of grazing time heritability. A more consistent approach would rely on further investigations, and would include time spent grazing for these same calves at a mature age and would, of course, involve a much larger number of observations. The heritabilities of other behavioral traits were also estimated bearing these same reservations in mind.

3.3 Discussion of the Data

The analyses of variance of the dependent variables investigated (grazing time, number of grazing episodes, longest grazing episode in cows and calves and, in addition, nursing frequency in calves) are presented in table 10 through table 16. A P value of 0.1 or less for each source of variation was considered significant. This was because as the experiment progressed, it was noticed that the cattle had some tendency to perform all of their activities together, which most certainly could mask some individual variations. Hence actual genetic differences among genotypes could be underestimated.

Averaged over both observation years, cows from sires above average for maternal weaning weight EPD spent a similar amount of time grazing as cows from below average sires (table 10). This result was not expected since extra forage would be required to support their superiority in milk production. However further analysis showed no differences in nursing frequencies in calves from both genetic groups of cows, suggesting that some calves consumed less milk than what was potentially available to them. This could provide some explanation to this similarity in grazing time. Cows above average for growth spent the same amount of time grazing as cows below average (table 17). This conflicts with the results of Erlinger et al. (1990), who documented differences in grazing time in groups of cattle differing in growth patterns. The apparent differences could be explained by the fact that they they used heifers in their investigation while this study compared mature cows, whose requirements for growth would be minimal, if not comparable. There were significant differences among individuals within the same genotypic groups ($P < .01$) with respect to grazing time (table 10).

The average longest grazing episodes were similar among all cow genotypes, about 176 min averaged over both years. It is not obvious whether these results illustrate similarities of behavior between genotypes or rather the possibility that some groups of cattle might have been stimulated to graze longer (or shorter) than they would otherwise have done, influenced by the presence of cows of other genotypes. For this same behavior, there was a significant dam growth genotype x year interaction ($P = .05$); the explanation of that interaction was not at all evident.

Growth (+) cows had more grazing episodes than growth (-) cows, on a two-year average basis, but the difference was not statistically significant. The least squares means for this behavior together with that of other behaviors investigated are presented in table 17.

Calves of maternal (+) cows spent significantly more time grazing (38% of their time as compared to 36%) than calves of maternal (-) cows ($P < 0.01$). This difference, which was not observed in their dams, suggests that for this behavior at least, genetic differences are more expressed at an earlier age than when the animals get older.

The grazing time averaged over both observation years was similar in calves from growth (+) dams as in calves from growth (-) dams. The least squares means for this variable as well as those of other behaviors investigated in calves are presented in table 18. This was surprising as one would expect calves with high growth potential to spend more time grazing than calves with low growth potential, especially at the exponential phases of their growth curve. One interesting explanation of this surprising result comes from the work of Kropp et al. (1973) in which grazing time was not highly related to forage intake in cattle. In their studies, grazing time remained remarkably similar among breeds while forage intakes were considerably different. Hancock (1953) explained that even though there was some relationship between grazing time and feed requirement, individual differences in feed intake per unit of time and day-to-day variations in this trait were large enough to obscure such a relationship. He suggested that a large number of cattle observed several times at frequent intervals was necessary to clarify relationships between grazing time and feed requirements.

Also, as already mentioned in cows, calves tended to graze together with the herd, and as they grew older, this tendency became more and more observable. This behavioral component (not particularly studied in this work), often referred to as social facilitation could, with little doubt, mask genetic differences in grazing time. Therefore, the leftover differences analyzed in this work might not have detected relationships between growth pattern and grazing time. For more reliable results, future work on grazing behavior in cattle should observe different breeds on different (but similar) pastures before mixing them together.

In year 1, United States (US)-sired calves spent 3% more time grazing than New Zealand (NZ)-sired calves; whereas in year 2, NZ-sired calves grazed 4% more than US-sired calves (interaction, $P = .08$). This interaction is pictured in figure 13. It is possible that in one of the years, the weather and the pasture conditions could have better simulated the situation in New Zealand where sires of one group of calves originated. This interaction might also have been generated by differences in sampling in the sets of bulls from the United States and from New Zealand during both years.

The number of grazing episodes of 40 minutes or longer duration averaged over both years was the same in each genetic comparison of calves and was about 2.2. However, there was a significant sire origin x year interaction as it can be inferred from figure 13. Calves from US sires had an average of 2.2 grazing episodes in year 1, while NZ-sired calves had 1.9; in year 2 NZ-sired calves had an average of 2.5 lengthy grazing episodes, whereas US-sired calves had 2.3. The parallelism of this behavior with the time spent grazing, which showed a similar interaction, suggests that these traits are highly correlated and that grazing by several bouts as compared to long continuous grazing periods was a better strategy to graze more than the average. This means that groups of calves that had the largest number of lengthy grazing episodes always spent more time grazing than the other groups. Therefore it may be concluded that grazing by several bouts was more advantageous to the calves than grazing by long continuous bouts.

The average longest continuous grazing episode was 130 min in US-sired calves and 123 min in NZ-sired calves. In consideration of the the above mentioned analysis, it can be concluded that NZ-sired calves had a better grazing strategy than US-sired calves when it came to depending essentially on pasture resources.

Cows with (+) genetic merit for maternal weaning weight were nursed a similar number of times as cows with (-) merit. Also cows above average for growth were nursed a similar number of times as cows below average for growth. The sire origin of the calves likewise did not affect their nursing behavior. It would have been desirable to measure the duration of each nursing episode before concluding that nursing behavior is not influenced by genetic effects in this experiment.

The repeatability of grazing time was 5%. The heritabilities for grazing time, number of grazing episodes and longest continuous grazing episode were 0 ±20%, 0 ±2% and 20 ±22%, respectively. These numbers are very low compared to those described in other works (example, Mendoza-Ordones et al., 1988). This may simply indicate a low correlation between the traits as expressed in calves and those expressed in their dams.

3.4 Figures and Tables

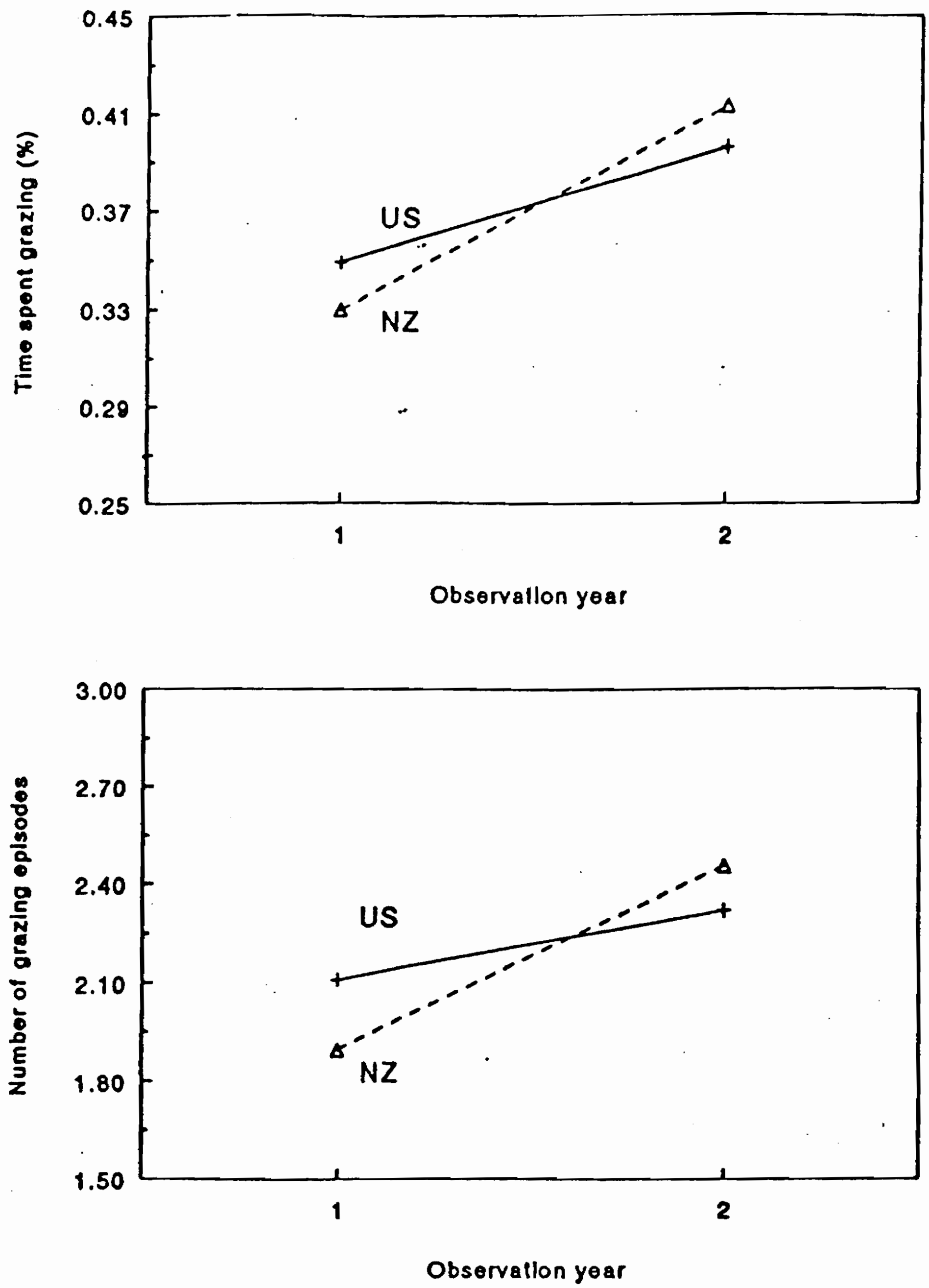

Figure 13. Grazing time (top) and number of grazing episodes of greater than or equal to 40 minutes duration (bottom) according to sire origin and year.

Table 10. Analysis of variance of the time spent grazing by cows

Source of variation	D.F	Mean square	F value	P value
Growth	1	.0211	2.2	.14
Maternal	1	.0029	.3	.58
Year	1	.1746	18.6	< .01
Growth x Maternal	1	.0070	.7	.39
Growth x Year	1	.0052	.5	.46
Maternal x Year	1	.0002	.0	.88
G x M x Y	1	.0052	.5	.46
Cow/(G x M x Y)	56	.0094	2.1	< .01
Observation/Year	8	.2287	51.7	< .01
Residual	248	.0044		

Table 11. Analysis of variance of the longest grazing episode of cows

Source of variation	D.F	Mean square	F value	P value
Growth	1	345	.3	.58
Maternal	1	5	.0	.95
Year	1	201,827	177.6	< .01
Growth x Maternal	1	29	.0	.87
Growth x Year	1	4764	4.2	.05
Maternal x Year	1	370	.3	.57
G x M x Y	1	538	.5	.49
Cow/(G x M x Y)	56	1136	1.3	.08
Observation/Year	8	66,213	76.8	< .01
Residual	248	862		

Table 12. Analysis of variance of the number of grazing episodes[1] of cows

Source of variation	D.F	Mean square	F value	P value
Growth	1	2.005	1.6	.21
Maternal	1	.023	.0	.89
Year	1	.189	.1	.70
Growth x Maternal	1	.616	.5	.48
Growth x Year	1	1.986	1.6	.21
Maternal x Year	1	.024	.0	.89
G x M x Y	1	.006	.0	.94
Cow/(G x M x Y)	56	1.241	1.2	.21
Observation/Year	8	19.526	18.4	<.01
Residual	248	1.062		

[1]Number of grazing episodes greater than or equal to 40 minutes duration

Table 13. Analysis of variance of the time spent grazing by calves

Source of variation	D.F	Mean square	F value	P value
Growth	1	.000	.0	.88
Maternal	1	.016	3.7	.06
Sire Nationality	1	.001	.1	.72
Year	1	.374	85.0	< .01
Sire x Year	1	.014	3.3	.08
Growth x Sire x Year	3	.005	1.2	.32
Maternal x Sire x Year	3	.003	.6	.58
Calve/(G x M x S x Y)	53	.004	2.0	< .01
Observation/Year	8	.740	332.1	< .01
Sire x Observation/Year	8	.004	1.7	.11
Residual	239	.002		

Table 14. Analysis of variance of the longest grazing episode of calves

Source of variation	D.F	Mean square	F value	P value
Growth	1	3	.0	.96
Maternal	1	1,303	1.1	.30
Sire Nationality	1	3,412	2.9	.10
Year	1	2726	2.3	.14
Sire x Year	1	34	.0	.87
Growth x Sire x Year	3	1,344	1.1	.35
Maternal x Sire x Year	3	281	.2	.87
Calve/(G x M x S x Y)	53	1,191	1.4	.05
Observation/Year	8	101,969	119.9	< .01
Sire x Observation/Year	8	396	.5	.88
Residual	239	850		

Table 15. Analysis of variance of the number of grazing episodes[1] of calves

Source of variation	D.F	Mean square	F value	P value
Growth	1	.15	.2	.65
Maternal	1	1.15	1.5	.22
Sire Nationality	1	.17	.2	.63
Year	1	13.82	18.4	< .01
Sire x Year	1	2.16	2.9	.10
Growth x Sire x Year	3	.74	1.0	.40
Maternal x Sire x Year	3	.92	1.2	.30
Calve/(G x M x S x Y)	53	.75	1.2	.13
Observation/Year	8	37.54	62.7	< .01
Sire x Observation/Year	8	.38	.6	.75
Residual	239	.60		

[1]Number of grazing episodes greater than or equal to 40 minutes duration

Table 16. Analysis of variance of the number of nursing episodes of calves

Source of variation	D.F	Mean square	F value	P value
Growth	1	4.07	2.4	.13
Maternal	1	.02	.0	.92
Sire Nationality	1	1.27	.8	.39
Year	1	23.63	14.1	< .01
Sire x Year	1	.00	.0	.99
Growth x Sire x Year	3	1.24	.7	.53
Maternal x Sire x Year	3	2.15	1.3	.29
Calve/(G x M x S x Y)	53	1.68	1.5	.02
Observation/Year	8	27.23	24.5	< .01
Sire x Observation/Year	8	1.54	1.4	.20
Residual	239	1.11		

Table 17. Least squares means and standard errors of the behavioral traits investigated in cows

Genotype	Time spent grazing (%)	Longest grazing episode (min)	Number of grazing episodes[1]
Maternal (+)	51.6 ±0.55	176.6 ±2.4	3.15 ±0.09
Maternal (-)	51.0 ±0.54	176.8 ±2.4	3.13 ±0.08
Growth (+)	52.1 ±0.56	175.7 ±2.5	3.23 ±0.09
Growth (-)	50.4 ±0.53	177.8 ±2.3	3.06 ±0.08

[1] Number of grazing episodes greater than or equal to 40 minutes duration

Table 18. Least squares means and standard errors of the behavioral traits investigated in calves

Genotype	Time spent grazing (%)	Longest grazing episode (min)	Number of grazing episodes[1]	Number of nursing episodes
US	36.8 ±0.4	130.3 ±2	2.22 ±0.07	2.28 ±0.09
NZ	37.1 ±0.4	123.6 ±2	2.18 ±0.07	2.37 ±0.09
Maternal (+)	37.7 ±0.4	129.0 ±2	2.26 ±0.07	2.32 ±0.09
Maternal (-)	36.2 ±0.4	124.9 ±2	2.13 ±0.07	2.33 ±0.09
Growth (+)	37.0 ±0.4	127.1 ±3	2.21 ±0.07	2.21 ±0.09
Growth (-)	36.9 ±0.4	126.8 ±2	2.18 ±0.06	2.44 ±0.09

[1] Number of grazing episodes greater than or equal to 40 minutes duration

4.0 SUMMARY AND CONCLUSIONS

- Cows grazed intensively in the morning, rested or grazed sporadically between noon and 15:00 and resumed intensive grazing by the end of the afternoon.
- The grazing pattern in cattle was not related to temperature or to the calculated comfort index.
- The grazing time varied considerably with observations and years in cows and calves.
- Cows spent 40 to 60% of their time grazing.
- The averages for longest grazing episode varied between 110 and 260 minutes, and the average number of grazing episodes equal to or greater than 40 minutes duration was about 2 to 3 in cows.
- Grazing time in calves increased with their age, and was similar to that of their dams by 7 months of age.
- The number of nursings increased at the beginning of the lactation period and decreased thereafter.

- Differences in genetic groups were observed with respect to the behavioral traits studied but were thought to have been underestimated, in consideration of group facilitation effects. The maternal genotype had the most noticeable effects on grazing behavior, while the effects of the growth genotype and sire origin were subject to interpretation.

- There were more differences among calf genetic groups than cow groups.

- Grazing behavioral traits were lowly heritable, but it was thought that low heritability estimations might have been a reflection of low genetic correlation between grazing behavioral traits in calves and those observed in their dams, or insufficient data.

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