GRAZING BEHAVIOUR OBSERVATIONS OF BORAN AND HEREFORD BEEF CATTLE UNDER CONDITIONS EXISTING AT KABETE

By

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D E C L A R A T I O N

I declare that this thesis is my original work and has not been submitted for a degree in any other University.

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This thesis has been submitted for examination with our approval as University Supervisors.

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SUMMARY

Grazing behaviour studies of night-kraaled and free grazed Boran (Bos indicus) and Hereford (Bos taurus) cattle were carried out in a wet season and a dry season. Sixteen cows, 8 Borans and 8 Herefords, were individually observed and their activities recorded while on pasture with reference to grazing time, ruminating time and idle time (walking, drinking and resting). The time animals spent resting, standing, and lying was also examined.

The daily mean grazing time for night kraaled cows in the wet season was 6.05 ± 0.32 hours for Boran cows and 7.6 ± 0.48 hours for the Herefords; and in the dry season the grazing time increased to 8.0 ± 0.19 and 8.37 ± 0.25 hours, for Boran and Hereford cows respectively. The free grazed cows spent a daily mean grazing time in the wet season of 8.17 ± 0.25 hours for Borans and 8.19 ± 0.37 hours for Herefords; and in dry season the time increased to 9.38 ± 0.2 and 8.83 ± 0.09 hours by Boran and Hereford cows respectively. Generally daily grazing was in two peaks, one in the mornings and the other in the afternoons, however, with free grazed cows, a smaller and more variable peak was observed between midnight and 4.00 hours.

Night kraaled Boran and Hereford cows ruminated 14.2 and 12.3 percent of total time at pasture respectively in the wet season. Whereas in dry season ruminating time decreased to 9.6 and 9.5 percent for kraaled Borans and Herefords respectively. For free grazed Boran cows ruminating time was 30 percent of the total time on pasture in wet

season 7.04 hours per day and this increased to 33 percent in dry season (7.68 hours per day). The free grazed Hereford cows ruminated 32 percent of the total time in the wet season (7.52 hours per day); and this rose to 35 percent in the dry season (8.12 hours per day). It was also shown that at least 74 percent of total ruminating time by free grazed cows occurred at night (19.00 hours to 7.00 hours).

There was a significant difference between breeds for lying and standing times ($P< 0.05$). The Herefords took longer standing than the Borans whereas Borans took longer time lying than the Herefords. Resting time was significantly longer in wet season than dry season. For grazing time significant interaction was observed between breed and season ($P< 0.05$); the Herefords grazed longer time than Borans in the wet season and the case was reversed in the dry season. Further interaction was observed between breed and night management ($P< 0.01$); the Herefords grazed longer under kraaled management but shorter time under free grazed management. For ruminating time there was a significant interaction between breed and season ($P< 0.05$).

Idle time, (resting, walking and drinking) was 29.6 and 21.8 percent of time on pasture for night kraaled Boran and Hereford cows respectively in wet season. In dry season, idle time decreased for both kraaled Boran and Hereford cows to 19.3 and 16.00 percent respectively. Free grazed Boran cows in wet season, idled 34.9 percent of the total time on pasture of which 62.6 percent happened at night; in dry season, idle time decreased to 27.9 percent

64.4 percent of it occurred at night. Free grazed Hereford cows idled 32.9 percent of total time on pasture in wet season, and 58.4 percent of it occurred at night; and this decreased to 26.7 percent in dry season, with 62 percent at night.

The time cows spent walking while at pasture showed that Boran cows walked a longer than Herefords. There was no association of walking time with seasonal pasture changes or management practice.

The time cows spent drinking water was longer in dry season than wet season, and Herefords took longer than Borans. The proportion of the time at pasture that night-kraaled cows spent drinking water, ranged between 0.98 to 1.94 percent, whilst free grazed cows were between 0.4 to 0.8 percent.

Night kraaled Boran and Hereford cows grazed 55 percent and 65 percent of total time on pasture respectively, during the wet season. In the dry season the proportions increased to 71.07 percent for Borans and 74 percent for Herefords.

The grazing time/ruminating time ratio was 1.2 and 1.1 for free grazed Borans and Herefords respectively, in both seasons. The ratios for night kraaled cows (during time out of kraals only) were 3.85 and 5.35 for Borans and Herefords respectively in wet season. But during dry season the ratios increased to 7.40 for Borans and 7.42 for Herefords.

CHAPTER I

1. INTRODUCTION

The importance of beef industry productivity cannot be over emphasised. Beef, like other types of meat is an excellent source of protein, vitamins and minerals which are necessary for the growth and health of the human body. The world's meat consumption per caput per day is 24 grammes, 42 percent of which is beef (Josiorowski, 1976). Geometrical increase of population, particulatly in developing countries, is one aspect that underlines the importance of increasing beef productivity programmes so that beef output corresponds with the rising trend of population.

Beef is also ecnomically important both nationally and internationally. Beef is a lucrative export item in a country's foreign exchange earnings and today international trade handles 9 percent of the world's meat production and one half of it is beef (Josiorowski, 1976). For instance, Kenya earned over US$18 million in 1977 as foregin exhcnage through beef sales beyond its borders (Economical Survey, Republic of Kenya, 1977).

Beef production in the tropics is comparatively low and there are several reasons for this. The main reasons are poor nutrition, climatic factors and the gene pool. Indigenous Bos indicus Zebu cattle are genetically poor beef producers in comparison to Bos taurus under improved

management and environment that favour the latter. However, Bos indicus cattle are better beef producers in many tropical conditions, where management and nutrition are not improved. To day efforts are being made to increase beef productivity within the tropical belt partly by introduction of Bos taurus genes into indigenous Bos indicus gene pool and by adopting grazing management practices that favour the Bos taurus and their crosses.

In East Africa, there is a considerable proportion of Bos taurus beef cattle which were introduced in the nineteen twenties (Meyn, 1970). Most of the animals are on commercial ranches and feedlots where they are used for crossbreeding and fattening respectively. Several studies have shown that beef productivity on commercial farms supercedes that of traditional pastoral sectors partly due to the superior performance of Bos taurus breeds over Bos indicus cattle and partly due to management factors (Pratt and Gwynne, 1977). Temperate Bos taurus animals are different from Bos indicus Zebu cattle in several ways. One of the important differences is that the former breed is not adapted to the tropical environment whereas Bos indicus cattle are. Temperate breeds are vulnerable to high tropical temperatures because of their inefficient thermoregulatory systems (Herz and Steinhauf, 1977, personal communication). In a tropical climate especially during sunny times, food intake by Bos taurus is curtailed by involuntary bodily mechanisms to reduce metabolic heat production (Thompson,

Johnson and Breidenstein, 1963). Grazing management practices must, therefore, be designed to graze the Bos taurus cattle during cooler hours to maximise feed intake.

The system of kraaling cattle, or night yarding, when temperatures are lower would not be a good practice to both Bos taurus and to Bos indicus; particularly in dry season (Kyomo, Hutchison and Salehe, 1972). A common abuse of the system is kraaling the animals too early and releasing them too late depending on the convenience of the herdsman. Generally kraaling management practices reduce grazing time resulting in lowered feed intake and subsequently lowered liveweight gains (Joblin, 1961). In heifers this may be reflected by late maturity and thereby protracting subsequent herd generation intervals. The overall result is reduced beef yield per head of cattle.

Kraaling cattle is an old practice and still exists in the tropics and elsewhere for various reasons. The main function of kraaling is to ensure secutity of the cattle from possible theft and predators; and within the agrarian communities it avoids damage of field crops by cattle at night. Kraaling practice is also influenced by land tenure system as in communal grazing on pieces of land that a community regards unfit for cultivation and settlement. Another reason for night kraaling is lack of capital to fence a ranch. This may oblige a farmer to kraal animals at night and graze them only during day time to avoid crop field encroachment and animal theft.

Understandably, night kraaling, inspite of its disadvantages, will not be abandoned immediately in many developing countries. Therefore, grazing methods may have to be designed, under specific conditions, to include night kraaling of the exotic Bos taurus beef breeds to minimize lowered productivity.

The presence of Bos taurus in East and Central Africa prompts studies on grazing methods conducive to maximum utilization of available pasture by the animals. The deficient information concerning routine grazing methods of Bos taurus cattle and their crosses under tropical environment and pasturage is one of the reasons that such animals fail to express their performance potentials. It is through grazing behavioural studies that information will be available to enable thorough recommendation of meaningful grazing methods that will maximise meat productivity from both Bos indicus and Bos taurus cattle and their crosses.

This study was therefore undertaken to examine the grazing behaviour of kraaled and free grazed Boran cattle, Bos indicus and Hereford cattle, Bos taurus, under conditions existing at Kabete in wet and dry seasons. The conditions are similar to other locations in East Africa of about the same altitude.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction.

The behaviour of cattle on pasture depends on heredity, environmental stimulation and other factors (Hebb, 1953). Among the important environmental factors are temperature, humidity, rainfall and sunlight/darkness. Other factors are pasture equality and quantity, breed differences and general management practices such as kraaling, stocking rates and supplemental feeding.

2.2.1 Environmental factors that affect grazing behaviour

2.2.1.1 Influence of temperature on grazing behaviour

2.2.1.1.1 Influence of temperature on grazing time

Bonsma, Schaltz and Badenhorst (1940) in South Africa, showed that Hereford cattle in sunny conditions with temperatures of 39^{o}C reduced daytime grazing to 79 percent of 7.9 hours average grazing time whilst Brahmans reduced to 89 percent of 8.5 hours average grazing time.

Hughes and Reid (1951) observed Hereford cattle at Stratford-on-Avon in the UK, in summer and spring. The animals grazed a range of time between 6 to 8 hours per day

(24 hours) during summer days when air temperatures maximised 28-30°C and increased to a range between 6.5 to 9 hours per day in spring when temperature was recorded to a maximum of 15-19°C.

However, some workers have found no association between grazing time and temperatures. Hancock (1954) at Ruakura in New Zealand found no relationship between temperatures and grazing time such that longest grazing time occurred equally on hottest days and cool days. Maximum temperatures on hotter days rose to 28°C but only 23°C on cooler days. Lampkin, Quarterman and Kidner (1958) concluded from their results that temperature is one of the weather factors that has least influence over cattle grazing time on high altitude locations in the tropics. Later, Lampkin and Quarterman (1962) showed no difference in time steers spent grazing from 7.00 hours to 19.00 hours between a cooler high altitude tropical location with maximum temperature of 19°C and a tropical location where temperature maximised 38°C. Holder (1960) observing lactating dairy cows in New South Wales reported a similar result that there was no change of grazing time in summer when maximum temperature was 30°C and autumn when maximum temperature was 21°C. Mugerwa, Christensen and Ochetim (1973) working in Uganda with lactating Bos taurus dairy cows showed no change in average grazing time with seasonal environmental variations. Maximum and minimum temperatures in dry season

were 28.3°C and 16.9°C respectively as compared to cooler wet season of maximum temperatures of 26.0°C and minimum of 15.5°C. However, probably the difference in temperatures between dry and wet season was so narrow so as to have influenced any difference in grazing time.

Observations of indigenous Zebu cattle in the tropics have shown that there is little influence by rising environmental temperatures on time of daylight grazing. Smith (1959) in Zambia reported that temperatures had no influence upon Zebu cattle grazing time from 6.00 to 20.00 hours. In cool months when maximum temperatures were 21.9°C, grazing time for the overstocked group of cattle averaged 8.3 hours per day between 6.00 to 20.00 hours local time and 7.9 hours for the liniently stocked. In hot dry months when maximum temperatures varied between 26.1°C to 36.6°C, the overstocked cattle grazed 9.8 hours while the other group spent an average of 8.6 hours grazing. Lampkin and Quarterman (1962) reported similar results when studying Boran Zebu steers at Muguga, a high altitude cooler location; and at Mariakani, a hot location near the coast of Indian Ocean. At the cooler location, Muguga, daily maximum and minimum temperatures were 19.5°C and 9.4°C respectively. While on a tropical hot dry location, Mariakani, daily maximum temperature was 38.0°C and minimum was 19.0°C. Steers grazing from 7.05 to 19.00 hours showed no difference in grazing time within the two locations.

2.2.1.1.2 Influence of temperature on grazing distribution and intensity

The grazing time distribution pattern and intensity has been shown, however, to be affected by rising environmental temperatures (Lampkin et al., 1962; Goldson, 1963; Kyomo, Hutchson and Salehe, 1972). Both Bos taurus and Bos indicus tend to intensify grazing in the morning and late afternoon at the times when temperatures are relatively lower. Lampkin et al. (1962) reported relatively more intensive grazing by both Zebu and Bos indicus x Bos taurus steers between 6.00 to 9.00 hours and 16.00 to 20.00 hours in a hotter environment and an extra grazing peak at night was discernible. At a cooler location Muguga, Kenya, intensive grazing by both breeds was noticed between 7.00 to 10.00 hours in the morning and 13.00 to 15.00 hours in the afternoon.

2.2.1.1.3 Influence of temperature on idle time

The infleunce of temperature on idle time has been variably expressed by different investigators. In this context idle time refers to time cows spent lying resting, standing resting, walking and drinking. Lampkin et al. (1958) noticed that under higher environmental temperatures Bos indicus x Bos taurus steers spent more time lying and resting. Hughes and Reid (1951) classified idling time as standing, lying down, walking and rumination time. The two workers noted that Bos taurus idle time took an average

of 9.3 hours out of 24 hour period on pasture. The longest idle time of 10.7 hours occurred during mid-summer when environmental temperatures maximised 30°C. Kropp, Holloway, Stephens and Knori, Morrison and Totusek (1973) demonstrated that idle time in summer was more than in winter.

Goldson (1963) reported that dairy cows at Kitale, Kenya, during dry season with clear and hot days (maximum temperature 31.0°C), idled average of 7.7 hours (32% of total time on pasture) out of 24 hours on pasture. Idling (lying resting, standing resting, drinking and walking) mainly occurred at night. This suggests that inspite of maximum temperatures which normally occur during day time, idling takes more time at night when temperatures are normally minimum (Mugerwa, et al., 1973).

Wilson (1961) observing indigeous East African Shorthorn Zebu heifers reported that idle time (standing and lying without engaging in any activity) increased with rising seasonal temperatures. The heifers, idled 7.2 hours per day (24 hours) in wet/dry transitional cool season and 8.7 hours per day in dry hot season. It was further shown that heifers spent shorter time lying per day in wet/dry cool transitional season than in dry hot season. The explanation was that higher temperatures and the greater number of hours of direct sunlight caused an increased heat burden on the grazing heifers resulting in a longer time spent idling in lying position. Under cool conditions, however, Zebu

steers have also been shown to stand and rest longer time as a sign of discomfort (Lampkin et al., 1958).

2.2.1.1.4 Influence of temperature on watering activity

Apart from other factors, watering behaviour of cattle is influenced by environmental temperatures. The higher the temperatures the more time animals spend drinking water (Lampkin et al., 1962; Horrocks and Phillips, 1961; Wigg and Owen, 1973). Bos taurus lactating cows under tropical environment have been found to spend between 0.1 to 0.5 percent of total time on pasture on drinking water. This varies between 2 to 7.2 minutes over 24 hours on pasture (Goldson, 1963; Musangi, 1965; and Mugerwa et al., 1973).

Wilson (1961) reported that although time cattle spend drinking water, in wet/dry transitional cool season and dry hot season was equal, yet quantity of water intake in the two seasons was not equal. The estimate of water quantity intake per Zebu heifer per day was 8.5 litres in wet/dry transitional season and 17 litres in dry hot season. The time taken watering by each heifer per day in each season was 6 minutes. Equal frequency (number of drinks per heifer) of watering in cool and hot environment by Zebu steers was also demonstrated by Lampkin et al. (1962). The frequency

was 2.4 but water intake was shown to increase from 10 litres in a cool environment to 18.9 litres per day in a hot environment.

2.2.1.2 Influence of sunlight/darkness on grazing behaviour

2.2.1.2.1 Influence of sunlight/darkness on grazing times and pattern

Giobel and Lindbom (1933) in Sweden observed that dairy cows' 50 percent of grazing time occured at night whilst the other 50 percent during the day. Johnstone-Wallace and Kennedy (1944) upon observing a single beef cow at Cornell University farm in the USA, found that 60 percent of the 7.5 hours total daily grazing time was accomplished during day time and 40 percent at night.

Hughes et al., (1951) reported that Hereford steers at Statford-on-Avon in United Kingdom exhibited a marked periodicity of herd grazing during daytime. It was observed that two major grazing peaks occurred each day throughout each season during the year. The first peak of intensive grazing started shortly before or after sunrise and lasted 2 to 3 hours. Another peak commenced in late afternoon or early evening which extended to shortly after sunset. Between the two primary grazing peaks 2 to 3 secondary well defined peaks, which varied from one observation to another, existed. It was also noted that 100 percent

grazing was during daylight in mid summer partly because of extended day light to 18.83 hours. In autum there was a tendency for cattle to graze at midnight which was calculated as 14 percent of the total daily grazing. The total grazing time was 32 percent of the 24 hours total time steers were on pasture.

Other studies from Kenya, Muguga, in a high altitude tropical climate have shown that in cooler months, grazing between 7.05 to 19.00 hours by grade steers make up 91 percent of the total daily grazing (Lampkin et al., 1958). Grazing was observed to start at 7.00 hours (one hour after dawn) and the animals grazed intensively for approximately 2 hours before they rested. The second peak occurred at 13 hours and was steady but not as intensive as the one in the morning. The afternoon grazing ended abruptly when darkness fell. Night grazing was usually sporadic mainly by individual steers. The total time steers were occupied grazing was 30.5 percent of the 24 hours total time the steers were on pasture.

Bos taurus cattle under tropical climatic conditions have shown grazing patterns, in many ways, similar to those demonstrated by the same type of animals in temperate climate. Goldson (1963), during dry season at Kitale, Kenya, observed that lactating Jersey cows grazed 68.2 percent of the 8 hours total grazing time per day between 7.00 to 19.00 hours. The remaining 31.8 percent occurred between 19.00 to 7.00 hours. Three grazing peaks were noticed, two after each milking in the morning

and afternoon, at 9.00 to 10.00 hours and 18.00 to 20.00 hours respectively. A third peak was noticed at night between 1.00 hours to 4.00 hours.

Mugerwa et al. (1975) found that dry and lactating Friesian cows' grazing time at night in dry and wet seasons ranged between 30.9 to 46.2 percent of the total grazing time. The daily grazing times were 7.5 to 8.5 hours depending on lactation stage of the cows. In general cows showed two grazing peaks, one between 10.00 hours and 12.00 hours and another between 18.00 hours and 20.00 hours in both dry and wet season during the year. Grazing in the dark after 20.00 hours was sporadic and averaged 10 to 15 minutes per hour. The difference of grazing patterns and distribution between Goldson (1963) and Mugerwa et al. (1973) observations is the absence of a third grazing peak in the results of the latter which pressumably diffused between 18.00 to 20.00 hours grazing time.

Towards end of a dry season in Uganda, Musangi (1965) reported Friesian steers taking 76 percent of effective grazing during time between 6.00 to 18.00 hours. The total grazing time was 39.4 percent of the 24 hours total time steers were on pasture. Little night grazing was observed and consisted of only 14 percent of 9 hours daily total grazing time. There were two grazing peaks, one at 10.00 to 13.00 hours and the other at 17.00 to 18.00 hours.

Indigenous Zebu cattle grazing time distribution during day and at night under tropical conditions have been reported by several workers (Lampkin et al., 1958; Smith, 1959, 1961; Wilson, 1961; Hutchison, et al. 1962). In Zambia, Smith (1959) observed that during dry season 33 percent of total grazing time of 13.2 hours per day occurred at night between 20.00 to 6.00 hours and in wet season only 8 percent of the 8.4 hours daily grazing time took place at night. The grazing time pattern and distribution was fixed. There were 2 peak periods of intensive grazing each day. One in the morning at dawn extending to about 11.00 hours followed by a rest. Similar peak was reported by Lampkin et al. (1962). The afternoon grazing peak commended at 13.00 hours and extended to 1 hour after sunset (about 18.00 hours). Night grazing was however, not regular. It usually occurred between mid night and 4.00 hours (Lampkin et al., 1962 and Kyomo et al., 1972).

Wilson (1961) in Uganda observed Zebu heifers and reported that the mean percentage of total grazing during the hours of darkness was 22.5 percent in the wet/dry cool transitional period and 25.2 percent in the dry season. Wilson (1961) showed that the daily grazing time in dry/ wet transitional season was 36 percent of total time heifers were on pasture and 32.5 percent during the dry season. The grazing peaks in wet season were similar to those demonstrated by Smith (1958) and Lampkin et al. (1962) but in dry season, afternoon grazing peak was subdivided into two seperate parts. One part starting around midday and lasted for 2 to 3 hours and the second part commenced at about 16.00

hours continuing until after sunset. Night grazing occurred between midnight and 4.00 hours as shown by other workers (Lampkin et al., 1962; Smith, 1958 and Kyomo et al., 1972).

2.2.1.2.2 Influence of sunlight/darkness on ruminating time and pattern

It is generally accepted that rumination occurs mostly during night hours. Wilson (1961) reported that 63 to 76 percent of the total 7 hours daily ruminating time took place at night. Goldson (1963) noted 67 percent of the 6.5 hours total ruminating time taking place at night while Hutchison et al., (1962) reported 70 percent of the 8 to 9 hours daily annual average (Lampkin et al. 1958). Goldson and McAllister (1974) who compared rumination time in sheep left in light for 12 hours and then caged in a total darkness for the same period also found that rumination is greatest in period of darkness.

2.2.1.2.3 Influence of sunlight/darkness on idle time

Cattle mainly idle at night (Lampkin et al., 1958, 1961; Goldson, 1963; Musangi, 1965; Mugerwa et al., 1973). Cattle are known to be normally inactive at night and usually do little walking (Hughes et al., 1951) but spend most of the time lying whilst ruminating and resting alternatingly (Lampkin et al., 1958; Hancock, 1953).

2.2.1.2.4 Influence of sunlight/darkness on Watering activity

Cattle rarely drink water at night (Lampkin et al., 1958, 1961; Smith, 1959; Wilson, 1961). Smith (1959) reported cattle drinking water at night only 2 nights out of 22. Lampkin et al. (1962) noticed only one occassion that cattle took some water at night, Wilson (1961) reported that heifer cows did not drink water at night.

2.3.2 Influence of pasture quality and quantity on grazing behaviour

2.3.2.1. Influence of pasture quality and quantity on grazing time

Grazing time is described as time an animal spends in the act of eating herbage including short periods of walking while selecting grass on pasture field (Chambers, 1959). Wagon, Albaugh and Hart (1960) described it as time animals will spend gathering daily herbage substenance on a grazing field.

Alkenson, Shaw and Cave (1942) reported that cows spend 30 percent more grazing time on poorer pastures than those on better pasturesin terms of quality and quantity. However, Johnstone-Wallace et al. (1944) showed that grazing time was not related to pasture quality or quantity. They showed that beef cows spent 7 to 8 hours grazing per day and

as grazing progressed better pasture was progressively selected thus forage quality deteriorated and quantity decreased but time spent grazing by cows did not change. Hughes, et al. (1951) used three 2 year old Hereford bullocks and observed that steers grazed for 7.9 hours out of 24 hours of the day but as pasture quality and quantity fell,grazing time per day increased. Lofgreen, Meyer and Hull (1957) demonstrated a similar trend with Bos taurus steers on pastures of higher total digestible nutrients. They reported that steers on a pasture of comparably more TDN (Total Digestible Nutrients) spent less grazing time than steers on a pasture of comparably less TDN. On comparably more TDN steers grazed 6.1 hours per day compared to 7.9 hours on pasture of comparably less TDN.

Dairy Bos taurus cattle have also been shown to increase grazing time on relatively poorer quality and relatively lesser quantity pastures. Hancock (1953) studied habits of Bos taurus dairy cows and reported that on mixed pastures, cattle spend relatively longer grazing time because they spend time selecting prefferable pasture. It has been further demonstrated that grazing time reduces where pasture is in abundant quantity and quality is excellent but extends when pasture is abundant but of mixed quality.(Hancock, 1953).

Lampkin et al. (1958) in a high altitude subtropical climate - Muguga - Kenya showed that Bos taurus steers

increased time of grazing with deterioration of quality and dwindling quantity of pasture. The steers spent an average of 6.5 hours per day (24 hours) on good pasture but when pasture was relatively poorer, steers grazed 8 to 9 hours per day thus extending grazing time by 23 to 38 percent.

In the tropics, changes of season are closely associated with pasture quality and quantity and as such grazing time has been reported to alter with such changes (Harker, Rollinson, Taylor, Gourlay and Nunn, 1961). However, Mugerwa et al. (1973) observing Friesian dry and lactating cows in Uganda did not find seasonal variations effects on grazing time per day.

Several studies, carried out in East Africa and elsewhere in the tropics concerning grazing time of Zebu (Bos indicus) cattle, have shown that grazing time increases with poorer quality and limited quantity of pasture. Harker et al. (1956) in Uganda studied habits of ten adult cows for four periods of 48 hours each in different months of the year. He showed that free grazing cows throughout day and night increased their grazing time during dry season when pasture quantity was lower and quality poorer. In June, when there was relatively good quantity of herbage, cows grazed an average of 9.7 hours per day (24 hours) whilst in mid January, towards end of dry season, when pasture was limited and stemmy, cows grazed for an average of 10.4 hours per day. Lampkin et al. (1958) at Muguga, Kenya

observed Zebu steers on three different types of pasture for a period of 11 hours continuously each day. The first type of pasture consisted of Star grass of reasonable quantity but very stemmy. The second type was rather sparse Star grass and the third was good quantity of leafy Kikuyu grass making a uniform sward of about 100 mm high. On the first and second fields where pasture was comparably of inferior quality and quantity than that of the third type, the steers grazed for 8.9 hours (81.2 percent of the 11 hours on pasture). The grazing time on the third pasture was 6.7 hours (60.5 percent of the 11 hours on pasture). Probably decreased time of grazing on better pasture was attributed to availability of good quality and unlimited herbage inducing little selective grazing amongst the steers (Lampkin et al. 1958).

It was also shown by Smith (1959) that grazing time of Zebu cattle varied seasonally depending on pasture quality and quantity. Cattle grazed average of 8 hours per day (24 hours) during rainy season when grass was abundant and spent maximum of 14 hours in scarce and coarse grass during dry season.

Harker et al. (1961) made specific descriptions of pasture fields where Zebu steers were observed for their grazing behaviour. On pasture described good but of limited quantity (1620 to 2250 kg/ha DM yield) Zebu cattle took 8.3 hours grazing time out of 24 hours. On poorer quality but unlimited quantity (7200 to 7650 kg/ha/DM)

the animals spent 9.1 hours grazing per day. The steers spent longer time, 10.0 hours, grazing on poorer quality and abundant quantity (6300 to 5850 kg/ha DM). Shortest time of 6.5 hours was spent by steers which were on the pasture described as good quality but poor quantity (1620 kg/ha DM).

2.3.2.2. Influence of pasture quality and quantity on ruminating time

Ruminating is the second important time taking activity by cattle on pasture (Kropp et al., 1973). Rumination is closely related to feeding. It has been shown that fasting decreases rumination sharply in sheep but refeeding produced a rapid initiation of rumination (Welch and Smith, 1968).

Rumination has been found to relate to type of food ingested. Feeds of higher digestibility have been demonstrated to cause shorter times of rumination in cattle and sheep (Lofgreen et al., 1957). Gordon (1958) showed that diets of concentrates only reduced time of rumination but diet which include roughages such as hay increase ruminating time. However, no relationship existed between quantity of hay fed and the time of ruminating.

Ruminating is also shown as an activity influenced by inherited factors apart from feeds (Hancock, 1960; Toyotaro, 1973).

Hughes et al. (1951) showed that ruminating times of Hereford steers varied between 5.9 to 9.4 hours per day (24 hours). They failed to correlate ruminating time with any one particular factor and suggested that factors include age of the animal, dental condition and food.

Hancock (1954) observed that dairy cows took between 5.5 to 8.5 hours per day (24 hours) ruminating and singled out pasture quality and quantity as the major factor affecting rumination time. When grass was abundant and excellent quality, rumination time was shown to range between 5.5 to 5.9 hours per day. On good quality and abundant quantity of grass, time spent ruminating per day was 6.2 hours. On a mixed coarse pasture rumination time lengthened to 8.5 hours per day. In short, rumination time, was longer when cows grazed upon grass of higher crude fibre and increased dry matter intake was accompanied by increased time of rumination. Lofgreen et al. (1957) showed similar results that ruminating time by Hereford steers was 4.4 to 7.7 hours per day depending on quality of pasture in terms of total digestibility of nutrients.

In East Africa,it has been shown by various workers that ruminating time is directly affected by quality and quantity of grass animals graze. The more fibrous grass is, the longer the time of rumination (Hutchison et al., 1962).

Harker et al. (1956) reported that rumination of the free grazing Zebu cattle was 1 hour more than those which were restricted at night in a kraal. It was postulated that the practice of night kraaling restricted quantity of food intake. Therefore, ruminating substrate in the rumen was limited and consequently ruminating time was short. Ruminating time of the animals ranged between 6 to 8 hours per day (24 hours).

Wilson (1961) in Uganda found a different association of rumination by Zebu cattle with the deterioration of pasture quality and quantity. In a wet/dry transitional season when quantity and quality of grass were relatively better, ruminating time was 7 hours per day (24 hours) and in dry season when sward was drying and yellowing and quantity reducing, the heifers ruminated only 6.5 hours, less than they did in wet/dry transitional period. The explanation was that grazing time in dry season increased such that it reduced time of rumination.

2.3.2.3 Influence of pasture quality and quantity on Walking activity

Walking is an important aspect of animal behaviour especially in arid areas where cattle have to look for water and more soft herbage (Cory, 1927 cited by Wagnon et al. 1960). Hutchison et al. (1962) observed that free choice walking by Zebu heifers increased principally during dry

season when grazing pasture was scarce. However, Wilson (1961) found that walking by Zebu heifers was fairly constant on pasture throughout the year. There was no difference of time spent walking between dry season when pasture was coarse and scarcier and in wet/dry transitional season when pasture was relatively abundant. The time spent walking was 1.6 hours per day (24 hours).

2.3.2.4 Influence of pasture quality and quantity on watering activity

Watering behaviour of cattle may be influenced by type of feed and quality. Lofgreen et al., (1957) reported that Hereford steers spent 0.2 hours per day (24 hours) on drinking water on abundant alfalfa pasture but spent average of 0.1 hours on scant alfalfa pasture. At times when pasture is wet by rain water or dew cattle tend to reduce drinking water habit because partly or all the water intake requirement is met from the wet grass. In a coarse drier pasture animals tend to spend more time on watering (Horrock et al., 1961 and Wigg et al., 1973).

2.3.2.5 Influence of pasture quality and quantity on grazing time/ruminating time GT/RT ratio

Grazing time/ruminating time ratio (GT/RT) reflects a relationship between time of grazing and time of ruminating. Quality and quantity of pasture is one of the important factors affecting grazing time and rumination time subsequently would affect grazing time/ruminating time ratio.

Hughes et al. (1951) found GT/RT ratio ranging between 0.8 to 1.1 by Hereford Bos taurus steers on temperate pasture. As pasture quality and quantity deteriorated and lessened respectively, GT/RT ratio increased. The finding inferred that the steers were spending longer time grazing with deterioration of pasture quality in effort to select better quality grass and sufficient quantity in a scanty coarsier pasturage. Lofgreen et al. (1957) demonstrated a linear relationship and positive correlation between eating time (ET) and RT ratio to total digestible nutrients (TDN) percentage. The lesser the ET/RT ratio the lesser the TDN. The ratio found on alfalfa pasture was 1.18. This ratio implied that cud chewing in dairy cows correlated with low moisture and high fibre in the herbage being consumed. Similar findings were observed by Hutchison et al. (1962) in lactating Zebu cows. Wilson (1961) in Uganda with Zebu heifers, reported an opposite trend. The GT/RT ratio increased with the deterioration of pasture in dry season. Mugerwa et al. (1973) who observed a similar trend in Bos taurus lactating and dry cows suggested that on tropical pasture, cows spend longer grazing time because of extensive selectivity and this is accompanied by reduced time for rumination. In such cases GT:RT ratio will be high because the animals require a much longer time to attain that level of reticulo-rumen fill necessary to inhibit feeding and spark off rumination.

2.4.3 Breed heat tolerance differences and their influence on grazing behaviour

2.4.3.1 Comparison of heat tolerance mechanisms between Bos indicus and Bos taurus cattle

Several investigations have shown that Bos indicus cattle are more adpated to hot environment than the Bos taurus cattle. Walter (1960) reported that Bos indicus cattle have a thinner skin thickness and averaged 5.86 mm compared to Bos taurus whose skin thickness was 6.02 mm. The thinness of Bos indicus skin was demonstrated to correlate with superiority of heat tolerance over Bos taurus. The combination of thinner skin thickness and larger surface area, as a result of the dewlap in Bos indicus cattle, provide a means of dissipating excessive body heat through radiation, convection and conduction to the surrounding.

Cattle breeds differ in their ability to sweat and that high sweat gland volume is related to high heat tolerance (Steinhauf, 1977, Personal communication). Evaporation of sweat has been shown to be associated with lowering skin temperatures (Taneja, 1959). Taneja (1960) also showed that Bos indicus cattle have more sweat glands than Bos taurus cattle especially on the shoulder area and that the storage capacity of sweat glands is about 40 ml per m^2 in Bos taurus breeds compared with 480 ml per m^2 in Bos indicus cattle.

The coats of breeds of cattle are closely related to heat tolerance (Bonsma, 1949; MucMullum, Wodzika, Lee Fohrman, 1955; Taneja, 1959; Bianca, 1959). Bos indicus cattle have a smooth hairy coat and the hair is straight which facilitates cutaneous evaporation readily. The hair emerges from the better developed sweat and sebaceous glands as compared to those of Bos taurus. The sebaceous glands secrete more sebum that prevents the drying of superficial layers of the skin and may afford some advantages in reflecting solar radiation (Bonsma, 1949). The coat of Bos taurus has two types of hair, medullated and non medulated. The non medullated is coat's inner thin curly hair which forms a mat on the skin and retains heat from the body. It is for this reason that the animals have difficulties to dispose of excessive heat effectively through radiation and evaporation in hot environment (Taneja, 1959 and 1960).

2.4.3.2 Influence of breed on grazing time

The influence of breed upon grazing time have been reported by few workers. Lampkin et al. (1958) compared grazing habits of Bos taurus steers under high altitude tropical climate at Muguga, Kenya. Outside mean daily temperatures were not exceeding 20.0°C, both Bos indicus and Bos taurus steers grazed an average time of 7.1 hours per day (24 hours). In a warmer month, December when maximum daily temperature was 23.0°C, it was also found that there was no difference in grazing time per day even when they grazed on three different types of pastures. Lampkin

et al. (1962) compared the same steers under hot dry climate at Mariakani, Kenya, where maximum temperatures were exceeding 35°C, and there was also no difference in grazing time between the two breeds.

However, Musangi (1965) comparing Friesian steers Bos taurus and Nganda Bos indicus steers in Uganda found different average grazing time per day between the two breeds. The maximum and minimum temperatures during observation were 28.0°C and 16.1°C respectively. Friesian steers (average liveweight of 309 kg) grazed 9.4 hours per day whilst Nganda steers (average weight 239 kg) grazed for 7.4 hours. The pasture dry matter, crude fibre and crude protein percentages were 29.4, 36.1, and 8.6 percent respectively. It is probable that Friesian cattle, being bigger and heavier than Nganda, grazed longer time to ensure sufficient feed intake for nutritional maintenance requirements.

2.4.3.3. Influence of breed on ruminating time

Reports on the influences of breeds on cattle ruminating time indicated that there are differences between breeds when cattle graze tropical stemmy grass normally available in the tropics during dry seasons. Lampkin et al. (1958) showed no rumination time differences between Bos taurus and Bos indicus steers grazing a mixture of star grass and red Oat grass whose quantity was adequate throughout the trial period. Kropp, et al. (1973) also found no

breed effects between Hereford, Holstein and Hereford x Holstein, upon mean yearly ruminating time. Furthermore, no general pattern for effect across seasons was noticed.

However, Lampkin et al. (1962) at Mariakani, Kenya a location with hotter and drier climate with stemmy pasture, found significant differences in ruminating time between Bos indicus and Bos taurus steers. The Bos taurus steers ruminated longer time than Bos indicus steers. They concluded that the Bos taurus cattle are probably not used to more tropical coarse grass. That opinion is supported by the work of Phillips (1961) who demonstrated that Zebu steers digested 3 percent more of the organic matter of low quality hay than did Hereford steers. It was also found that fermentation rates were higher in Zebu steers and it was suggested that greater saliva production by Zebu during rumination could account for these differences. Rumination enables remastication and reinsalivation of food (Church, 1975). It also increases food surface area for action by bacteria and enzymes during digestion (Gordon, 1958), it is reasonable therefore, to associate rumination time with feed digestibility and fermentation.

Various authors after studying either Bos taurus or Bos indicus cattle breeds in temperate or tropical conditions have reported different ruminating time values as outlined in Table 1.

TABLE 1: Ruminating time as a percentage of total time on pasture as reported by various other authors.

Year	Author	Breed	Climate	Percentage of total time on pasture
1944	Johnstone-Wallace et al.	Bos taurus	Temperate	29-30
1951	Hughes et al.	"	"	24-39
1953	Hancock	"	"	22-35
1957	Lofgreen et al.	"	"	17-35
1958	Lampkin et al.	"	"	28-32
1962	Lampkin et al.	"	Tropical	34
1963	Goldson	"	"	27
1973	Mugerwa et al.	"	"	29
1956	Harker et al.	Bos indicus	"	26-34
1962	Lampkin et al.	"	"	29
1961	Wilson	"	"	27-29
1962	Hutchison et al.	"	"	31-39

2.4.3.4 Influence of breed on idle time

Breed influences in idling time, that is time cattle spend without either grazing or ruminating, have been reported under extreme weather conditions. Lampkin et al. (1958) showed significant difference between Bos taurus and Bos indicus steers in the length of time the two groups idled throughout the night. The Zebus stood longer time 2.6 hours per night (19.05 to 7.00 hours) compared to 1.9 hours by Bos indicus. It was suggested that the prevailing temperatures were below those that Zebus were properly adapted to. Lampkin et al. (1958) suggested that the reaction of cattle to cold was standing rather than lying. It was also found that when it rained Bos indicus idled for a longer period than Bos taurus. Under hot environment maximum temperarure 38^{o}C Lampkin et al. (1962) showed that Bos taurus spend more time lying than Bos indicus, and Bos indicus stood longer time than Bos taurus. Musangi (1965) found that Friesian steers stood for a longer time than Nganda steers when daily highest and lowest temperatures recorded were 28.5 and 16.1^{o}C respectively.

2.4.3.5 Influence of breed on walking activity

Breed is also known to influence time cattle spend walking on pasture. Under high temperatures, Bos taurus walking abilities fall below those by Bos indicus. Bonsma, (1949) showed that at temperatures of 34^{o}C Bos taurus Hereford cattle did not walk more than 10 kilometers; whilst Africander Zebu cattle walked comfortably a distance

of more than 26 kilometers. Bertha (1975) has indicated that Zebu cattle walk longer than Bos taurus cattle on pasture because they search for the most tasty herbage.

2.4.3.6 Influence of breed on watering activity

Watering activity is highly influenced by breed. Bos taurus cattle intake of water is more than that of Bos indicus as shown by many workers (Lampkin et al., 1958, 1961; Horrocks and Phillips, 1961; Wigg et al., 1973). Lampkin et al. (1962) showed a frequency of watering (number of drinks per animal) of 2.8 and 2.4 for Bos taurus and Bos indicus respectively. Cattle have, however, been shown to go for water in the morning and afternoon irrespective of breed (Lampkin et al., 1958, 1961; Smith, 1959 and Wilson, 1961).

2.5.4 Influence of night kraaling on grazing behaviour

2.5.4.1 Influence of night kraaling on grazing time and pattern

Harker et al. (1956) reported that night paddocking reduced grazing time of adult Zebu cattle particularly in dry season. In times of adequate pasture there was no difference of grazing time between free grazed cattle and the night paddocked ones. Kyomo et al. (1972) in Tanzania also reported that Zebu heifers grazed as much as 2 hours at night during dry season. In rainy season, when pasture was plenty, little night grazing lasting less than

30 minutes per night was observed. It has generally been shown that under milder climatic conditions kraaling cattle at night is not important but in areas and conditions of grass shortage, kraaling cattle at night limits grazing time (Joblin, 1961; Harker, 1956).

Smith (1961) found that Zebu cattle kraaled from 18.00 hours to 7.00 hours grazed average of 8.9 hours per day annually while free grazed cattle grazed average of 10.8 hours per day. However, there was no significant difference of liveweight gains between free grazed cattle and the night kraaled cattle at any period of the year. He showed that severely kraaled (from 16.00 to 9.00 hours) reduced liveweights during dry season when veld was deficient in quality and quantity but there were no differences in liveweights during rains when grass was abundant.

Kyomo et al. (1972); Wigg et al. (1973) have shown that cattle that are free grazed at night attain more liveweight gains annually than those that are kraaled.

Kraaling cattle at night has been shown to change day grazing intensity pattern. Smith (1961) compared the free grazed and night kraaled Zebu cattle. The kraaled cattle during pasturing, grazed more or less continuously. Only in wet season did the animals stop grazing and rested. The cattle kraaled from 18.00 to 7.00 hours grazed average

time of 8.6 hours per day; between 7.00 to 18.00 hours when they were out of kraals and the free grazed cattle grazed 7.6 hours during the same period. Probably, kraaled cattle attempted to overcome limited grazing time by grazing intensively and by postponing ruminating and resting until they had been kraaled in the evening. (Smith, 1961). Similar observations have been reported with Bos taurus cattle (Lampkin et al., 1958).

CHAPTER 3

3. MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Location

The two experimental observations were conducted at the University of Nairobi Field Station Kabete, Kenya. Kabete is 1^{o} South of the equator on an altitude of 1830 m above sea level. The soil is Kikuyu red loam and there are two rainfall maxima. The long rainy season starts from March and ends in July and in 1978 it measured 617 mm. Short rains normally commence in October and stop in December. An amount of 325 mm fell during short rains in 1978. Total rainfall during 1978 was 942 mm.

A meteorological station is situated 200 metres south of the experimental site. Meteorological observations including temperatures, solar radiation and wind were regularly observed and recorded as shown in appendix I.

3.1.2 Pasture/Paddocks

The total area of the grazing field was 6.25 hectares, and was enclosed by a 5 strung barbed wire. Earlier, in 1973, the field was planted with sunflower and the following year in 1974, Sorghum almum was shown and drilled with calcium ammonium nitrate at the rate of 20 kg N per hectare. Weeds were controlled by application of 2-4 D herbicide

(2, 4 - dichlorophenoxyacentic). After establishment of the ley, two other experiments using grazing steers were conducted on the field. However, since mid 1975, the plot remained idle except for occassional grazing by dry beef cows and weaned calves.

Before the start of the experiment, the field was divided into four equal portions, each with an area of about 1.5 hectares. Two barbed wire kraals, measuring approximately 25 square metres each were constructed attached to each of the two opposite long sides of the field. The kraals had completely no grass in them and had gates to both two adjacent partitional fields to enable cows grazing on the adjacent partitional field to be penned together in the same kraal at night. Each partitional field had gates to the two neighbouring partitions flanking it to facilitate rotation of cow groups from one partitional field to the other.

At the time of the first trial in December, 1978, after three weeks of moderate to heavy rainfall, the pasture was green and ranging between 1 metre high to prostrate ground grass runners. The cover was not uniform and the pasture composition was mixed but dominated by star grass (Cynodon nlenifuensis Vanderyst) as shown in Table 2. Weed plants like Conyza sumatrensis (Retz.) Solanum incanum L., (sodom apples) and Bidens pilosa L. were also growing but not to an important extent.

The second trial was performed in March, 1979, two weeks after rains had stopped. Grass was visually dry and generally looked mature. Star grass (Cynodon nlemfuensis Vanderyst) remained dominant. There was occassional out of season rains, towards end of the trial. Grass height ranged from three quarters of a metre to ground runners and bare ground. Weed plants, mainly Conyza sumatrensis (Retz) and Solanum incanum (L), were more conspicuous than in the first trial of December 1978.

TABLE 2: Composition of the field pasture as assessed in December, 1978.

	Percent composition in the field
Cynodon nlemfuensis Venderyst (Star grass)	40
Sporobolus fimbriatus Nees	20
Sporobolus agrostoides Chiov	15
Paspalum scrobiculatum L.	10
Sporobolus pyramidalis Beauv	5
Trifolium semipilosum Fres (Kenya white clover)	3
Eragrotis tenuifolia (A. Rich.) Steud. (Love grass)	2
Themeda triandra Forsk (Red Oats)	2
Chloris gayana (Rhodes grass)	1
Miscellaneous	2

3.1.3 Cattle

3.1.3.1 Boran (Bos indicus)

The 8 Boran cows used in the experiment are the Kenyan Boran improved type chosen at random from the Faculty of Agriculture herd, University of Nairobi. The cows were born at Muguga Research farm 15 kilometres from Kabete and were brought to Kabete at the time they were heifers. Particulars of the cows are given in Tables 3 and 4.

3.1.3.2 Hereford (Bos taurus)

The 8 Hereford cows used in the experiment were purchased from various farms in Trans Nzoia, Kenya and had been at Kabete University farm for at least one year. The cows were therefore born and reared in an environment close or similar to the prevailing Kabete environment. Details of the Hereford cows used in this experiment are given in Tables 3 and 4.

3.1.3.3 Age of the cows used in the experiment

Boran cows were all born in 1975. The Hereford cows' dates of birth ranged between 1971 to 1977. Therefore, there were variations of age between the breeds and within the Hereford breeds.

The age variation, in the short time of study, was assumed to make negligible influences on the grazing behaviour of the cows during the trials.

TABLE 3: Particulars of the cows used in the experiment

Breed	Cow No.	Date of birth	Weight (kg)
Boran	B1	1975	374
"	B2	"	402
"	B3	"	358
"	B4	"	413
"	B5	"	478
"	B6	"	362
"	B7	"	412
"	B8	"	372
Hereford	H1	1973	516
"	H2	1977	320
"	H3	?	438
"	H4	1971	512
"	H5	1973	666
"	H6	1971	556
"	H7	1972	474
"	H8	1972	580

All cows were mated in November 1978.

TABLE 4: Average initial weights (kg) of cows for various treatments.

Boran Kraaled		Boran Free Grazed		Hereford Kraaled		Hereford free grazed	
Cow No.	Weight (kg)	Cow No.	Weight (kg)	Cow No.	Weight (kg)	Cow No.	Weight (kg)
B1	374	B5	478	H1	516	H5	666
B2	402	B6	362	H2	320	H6	556
B3	358	B7	412	H3	438	H7	474
B4	412	B8	372	H4	512	H8	580
Average weight	386.5		406.0		446.5		560.0

3.2 EXPERIMENTAL METHODS

3.2.1 Treatment/grouping

The experiment was a 2^3 factorial in which the treatments were breed (*Bos indicus* and *Bos taurus*), seasons (dry and wet) and night management (night kraaled and free grazed). Parameters studied were grazing time, ruminating time, standing time, lying time and resting time.

Four cows grouped at random, consisting of two Borans (*Bos indicus*) and two Hereford (*Bos taurus*), were chosen for kraaling at night, ie. from 19.00 to 7.00 hours East African time. Another group of four cattle also consisting of 2 Borans and 2 Herefords was allowed to remain on pasture and freely grazed day and night. Each group was replicated twice; hence making four cows of each breed to be either kraaled or free grazed throughout the experiments. It has been shown that average observations of at least four animals give more accurate results in recording techniques (Rollinson, Harker and Taylor, 1956).

Every cow was given an experimental number which was written in broad letters using enamel paint, on both sides of each animal. All kraaled cows were given numbers from B1 to B4 and H1 to H4 respectively. The rest which were allowed free grazing were numbered B5 to B8 and H5 to H8. Detail of the grouping is shown in Table 5.

TABLE 5: The grouping arrangement of cows for wet and dry season observations

	Allowed to graze 12 hours only		Allowed to Freely graze	
	Boran	Hereford	Boran	Hereford
Replicate I	B1	H1	B5	H5
	B2	H2	B6	H6
Replicate II	B3	H3	B7	H7
	B4	H4	B8	H8

3.2.2 Parameters studied and procedure

The observations of grazing behaviour of sixteen cows (8 Hereford and 8 Borans) were carried out in two seasons, namely, wet and dry season to record time each cow spent on various behavioural activities. The animals were watched continuously for 12 days in each season. However, there were four days disturbance in dry season. Other interruptions included short times when cows were sent for dipping or repainting of their experimental numbers. This occured in both seasons. Activities of animals during interruption times were not recorded at all and the time was excluded from the total time animals were observed.

Each cow was observed and recorded on time it grazed, ruminated and idled. Idling included resting standing, resting lying, walking and drinking.

Grazing was recorded when a cow was eating grass whilst walking or standing. Rumination was recorded when a cow was observed chewing the cud. If rumination was done in standing or lying positions, recording was done accordingly. Resting was deduced when a cow stood or lay down without doing any other activity. Licking or sniffing of one another was assumed as resting. Walking was recorded when a cow moved for no apparent determined purpose. Drinking was when a cow dipped its mouth into the water and observe lower jaw characteristic movements that cattle make when drinking water.

Wet season trial started from 5th December and ended on 16th December 1978 inclusive. Dry season observations were done from 10th March 1979 to 26th March, 1979 inclusive but 19th, 20th, 21st and 22nd of March were excluded due to unexpected heavy rains. Observations started at 7.00 hours each day. The kraaled cows were penned at 19.00 hours and remained in the kraal until 7.00 hours in the morning next day. However, the cows were released 15 minutes prior to start of recording to let the animals settle. The penned cows activities were not recorded while they were in the kraals but free grazed cows were continuously recorded. Before the beginning of observations in each season the

animals were acclimatised to the experimental procedure for a period of 3 days.

Minerals in form of salt licks and clean fresh water were available to all cows at all the times of the trials.

There were a total of 8 observers/recorders who worked on 12-hour shifts. A single shift comprised of two people. All the recordings were put on a special form designed for the purpose. Each observer recorded eight cows during day shifts and four at night because penned cows were not recorded upon when in kraals. To ensure alertness of observers, each was allowed twelve hours rest after day shift and twenty-four hours after working during the night. At night, observers used strong beam torches to enable them see the cows clearly. However, lighting torches was kept to a minimum as much as possible to avoid undue disturbances to the cows.

Each cow was given a chance to graze at any part of the pasture field. Experimental groups were rotated throughout the partitional fields every other day of observation but observations were made fifteen minutes after the rotation to make sure that the animals settled down.

3.2.3 Species composition, quality, quantity and digestibility assessments of pasture

Species composition was assessed only once for both trials but quantity, quality and digestibility were monitored each week during the two trials.

In assessing species composition, quantity and quality, a half square metre quadrant was thrown at random twelve times in the field and plants species were counted within each quadrant to find the proportion of each grass species. The proportion of each species of grass from all quadrants was averaged to obtain a meaningful estimate of the proportion of plant species for the whole field.

Pasture quantity and quality were estimated from grass samples obtained from 24 quadrants. The grass was cut to ground level within each quadrant. The samples were bulked and weighed then sent for drying in an oven at $60^{o}C$ for 24 hours. The dried samples were subsequently weighed and dry matter yield was estimated. Aliquot samples were obtained at random for proximate and acid detergent lignin analyses.

Pasture dry matter digestibility among Boran kraaled, Hereford kraaled, Boran free grazed and Hereford free grazed was evaluated by the use of lignin content in pasture and faecal samples of a corresponding week. The faecal samples were bulked according to groups of cows as indicated above. Apparent dry matter digestibility coefficients

calculated using formula of Crampton and Harris (1960); which states that: Apparent digestion coefficient (%)

$$= 100 - \left(100 \times \frac{\%\ \text{internal indicator in feed}}{\%\ \text{internal indicator in faeces}} \times \frac{\%\ \text{nutrient in faeces}}{\%\ \text{nutrient in feed}}\right)$$

3.2.4 Data and statistical analysis

The data in terms of time cows spent on various activities from the two observational trials was compiled. Comparisons on specified activity were made between wet and dry seasons, between Bos taurus and Bos indicus breeds and between night kraaling and free grazed managements. Since rumination, total standing, total lying and total resting times were not recorded at night in kraaled cows, it was regarded unrealistic to compare kraaled and free grazed cows. However, grazing being a major activity which cattle do during daytime, comparisons were made within and between night kraaled and free grazed animals.

Factorial analyses of variance were carried out on the average time each animal spent performing a specified activity per day. For grazing time, the analysis was a 2 x 2 x 2 factorial where factor effects of breed, season and night grazing management and their interactions were tested of their significance after computing necessary sums of squares. The analyses of variance for rumination time, standing time, lying time, and resting time were performed as 2 x 2 factorial where breed and season factors

were examined. Paired t tests were performed to compare means of time cows spent ruminating, lying, standing and resting between breeds, and between seasons. Comparisons of grazing time were done between breeds, between seasons and between night managements (night-kraaled and free grazed).

CHAPTER 4

4. RESULTS

4.1 The pasture quality

The chemical analyses of pasture composition deteriorated from the wet season to the dry season. The pasture grass was more fibrous and contained lower values of crude protein and moisture in the dry season than in the wet season. Lignin content in the dry season was almost double the value of the wet season. The deterioration of the dry season pasture was also reflected by its lower apparent dry matter digestibility by all the cows, as shown in Table 7.

4.2 The daily times for the various grazing activities

Comparison of the overall daily times for various activities for the breeds, seasons and night management practices (Table 8) showed that activities taking longer time in the dry season were grazing, ruminating and lying. The Hereford breed cows showed longer time per day than the Boran breed cows in grazing, ruminating, standing and resting. The free grazed cows showed longer grazing times than the kraaled cows.

Means of grazing time per day of the Boran cows and the Hereford cows in the dry and the wet season under kraaled and free grazed night management can be compared in Table 9. The grazing times ranged between 6.05 to 9.38 hours. Kraaling and the dry season induced longer grazing times.

Table 6: Pasture chemical composition and dry matter (DM) yield.

	Season	
	Wet	Dry
Pasture Dry matter (DM)		
D.M. Yield (kg/ha)	2010	2750
D.M. percentage	17.13	29.12
Chemical analysis (on DM basis)		
Moisture %	9.02	6.66
Ether extracts %	4.57	3.39
Protein %	15.26	10.39
Nitrogen free extracts %	34.15	38.49
Crude fibre %	27.31	31.08
Ash %	9.69	9.99
Lignin %	4.99	7.66

Table 7: The digestibility of pasture Dry Matter (DM) among different groups of cows in wet and dry season.

Period		D.M. digestibility of pasture (%)			
Season	Week	Boran kraaled	Hereford kraaled	Boran free graze	Herefore free grazed
Wet	I	59.9	59.5	60.1	58.2
	II	59.0	58.9	57.0	56.0
Dry	I	56.5	55.0	55.7	56.6
	II	54.9	54.0	55.7	54.9

Table 8: Means ± standard errors of the time (hours per day) spent on each grazing activity for each season, breed and night grazing management.

Activity	Season		Breed		Night management	
	Wet	Dry	Boran	Hereford	Kraaled	Free grazed
Grazing	7.40 ± 0.28	8.64 ± 0.23	8.00 ± 0.32	8.24 ± 0.17	7.58 ± 0.24	8.65 ± 0.17
Ruminating	7.28 ± 0.13	7.92 ± 0.14	6.56 ± 0.83	7.82 ± 0.20	-	-
Standing[a]	5.77 ± 0.37	4.95 ± 0.32	4.78 ± 0.23	5.94 ± 0.37	-	-
Lying[b]	8.86 ± 0.87	8.95 ± 0.65	9.32 ± 0.20	8.48 ± 0.31	-	-
Resting[c]	7.29 ± 0.23	5.82 ± 0.19	6.51 ± 0.39	6.63 ± 0.18	-	-

[a]Standing time = Resting standing time plus ruminating standing time.

[b]Lying time = Resting lying time plus ruminating lying time.

[c]Resting time = Standing resting time plus lying resting time.

Table 9: Mean grazing time (hours per day) for each season, within breeds and night management practices.

Kraaled				Free grazed			
Boran		Hereford		Boran		Hereford	
Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
8.00	6.05	8.37	7.59	9.38	8.17	8.83	8.19

Table 10: Mean times (hours per day) of free grazed cows for ruminating, standing, lying and resting within breeds and seasons.

Activity	Wet season		Dry season	
	Boran	Hereford	Boran	Hereford
Ruminating	7.04	7.52	7.68	8.12
Standing[a]	5.24	6.26	4.28	5.62
Lying[b]	9.37	8.35	9.28	8.61
Resting[c]	7.50	7.09	5.54	6.12

Note: [a]Standing time = Resting standing time plus ruminating standing time.

[b]Lying time = Resting lying time plus ruminating lying time.

[c]Resting time = Standing resting time plus lying resting time.

The various activities, namely, ruminating standing, lying and resting for the free grazed cows are compared between breeds and between seasons in Table 10. Ruminating time per day ranged between 7.04 to 8.12 hours depending on the season and on the breed. Standing time ranged between 4.28 to 6.26 hours per day and were lower in the dry season than the wet season- and also lower for the Boran cows than the Hereford cows. Lying time varied between 8.35 to 9.37 hours per day and the resting daily time was between 5.54 to 7.50 hours.

4.3 The analysis of variation of the various grazing activities

Resting was shown to take significantly longer in the wet season than in the dry season. For standing and lying significant differences were observed between the breeds. The times in Table 8 reflect that Boran cows spent longer in a lying position and the Hereford cows were standing longer than the Boran cows.

There were interactions for grazing time between season and breed, and also between breed and night management. The grazing times given in Table 8 describe the interactions. Both breeds increased daily grazing time in the dry season. However, the Hereford cows grazed longer in the wet season than the Boran cows, but in the dry season, the case was reversed, and Boran grazed longer time.

Table 11: The analysis of variance of the time (hours) cows spent on each activity during each period.

Source	Grazing		Ruminating		Standing		Lying		Resting	
	DF	MS x 10^3	DF	MS x 10^3	DF	MS x 10^3	DF	MS x 10^3	DF	MS x 10^3
Season	1	10580**	1	1460**	1	2660	1	290	1	8680**
Breed	1	960	1	65	1	5370*	1	2850*	1	420
Night management	1	10480**	-	-	-	-	-	-	-	-
Season x Breed	1	1530*	1	840*	1	840	1	125	1	540
Breed x Night management	1	2950**	-	-	-	-	-	-	-	-
Season x Night management	1	340	-	-	-	-	-	-	-	-
Breed x Season x Night management	1	220	-	-	-	-	-	-	-	-
Error	24	345	12	157	12	660	12	530	12	660
Total	31		15		15		15		15	

* P< 0.05
** P< 0.01

Both breeds increased daily grazing time under free grazed management. However, under kraaled management the Hereford cows grazed longer, but under free grazed management, Boran cows grazed longer than the Herefords.

For ruminating time season and breed were significant effects but depended on each other. The times given in Table 8 show the Hereford cows ruminated longer in both the wet and the dry seasons, and rumination time was longer in the dry season than the wet season. The differences within breeds between season, and within season between breed were very marginal for an interaction.

4.4 The proportion of the various grazing activities relative to the total time on pasture

Proportionate times that respective breeds spent on various activities while on pasture are detailed in Tables 12 and 13. Kraaled cows spent, at least 55 percent of the total time on pasture, grazing and at least 9.6 percent ruminating. Free grazed cows spent over 35 percent of the total time on pasture, grazing and the proportionate values for various activities showing variations according to season and breeds can be compared in Table 12 and 13.

The proportionate times of activities as distributed between night and day are shown in Table 14. Cows mainly grazed during daytime. A range between 84.9 to 92.6 percent grazing was done during daytime depending upon breed and

Table 12: Proportion (%) of total time on pasture for various activities within each night management, season and breed.

Night management	Activity	Wet season		Dry season	
		Boran	Hereford	Boran	Hereford
Kraaled	Grazing	55.5	65.9	71.1	74.0
	Ruminating	14.2	12.3	9.6	9.5
	Standing [a]	13.9	14.4	17.2	22.8
	Lying [b]	26.2	16.6	12.9	9.2
	Resting [c]	25.7	19.1	14.0	12.2
	Total time per day (hours)	11.5		11.4	
Free grazed	Grazing	35.0	35.0	40.4	38.0
	Ruminating	30.1	32.1	32.9	34.8
	Standing [a]	22.5	26.7	16.2	24.0
	Lying [b]	32.6	35.7	39.7	36.9
	Resting [c]	32.0	30.3	23.9	26.1
	Total time per day (hours)	23.4		23.3	

[a] Standing time = Resting standing time plus ruminating standing time.

[b] Lying time = Resting lying time plus, ruminating lying time.

[c] Resting time = Standing resting time plus lying resting time.

Table 13: The ratio of grazing to ruminating time (GT/RT) and the proportion (%) of the components of idle time to total time on pasture.

Activity	Wet season				Dry season			
	Boran		Hereford		Boran		Hereford	
	Kraaled	Freed grazed	Kraaled	Free grazed	Kraaled	Free grazed	Kraaled	Free grazed
GT/RT	3.9	1.2	5.4	1.1	7.4	1.2	7.4	1.1
Idle time								
Resting standing	9.4	12.4	10.4	16.5	8.4	7.6	8.7	12.2
Resting lying	16.3	19.6	8.7	13.8	5.6	16.4	3.5	13.9
Walking	2.9	2.5	1.6	2.1	3.5	2.0	1.9	1.0
Drinking	1.0	0.4	1.1	0.5	1.8	0.8	1.9	0.8

Table 14: Proportion (%) between day and night periods for grazing, ruminating, and idle times of free grazed cows, within breeds and seasons.

Season	W e t				D r y			
Breed	Boran		Hereford		Boran		Hereford	
Period	Day	Night	Day	Night	Day	Night	Day	Night
Grazing time	90.1	9.9	84.9	15.1	92.4	7.6	92.6	7.4
Ruminating time	25.9	74.1	20.1	79.9	15.3	84.7	16.4	83.6
Idle time	37.4	62.6	41.6	58.4	35.6	64.4	36.7	63.3

Note: Idle time = Walking, drinking and resting.

season as shown in the table. A bigger proportion of ruminating and idling time was at night.

The ratio of grazing to ruminating time for the free grazed cows ranged between 1.1 to 1.2 as shown in Table 13. Boran cows showed a higher ratio than the Herefords. The ratio increased with declining pasture quality for all the cows in the dry season.

4.5 The pattern and the periodicity of the grazing behaviour

The pattern and periodicity of grazing time are clearly reflected in Figures 1 to 8. All cows, whether kraaled at night or free grazed, showed identical patterns of grazing periodicity during the time from 7.00 to 19.00 hours in both seasons. The free grazed cows also showed identical periodicity of night grazing irrespective of breed and season.

The night grazing intensity however, varied with breed and season. Normally, grazing by all cows started at 7.00 hours and reached a maximum at around 9.00 hours. Afternoon grazing started at around 12.00 or 13.00 hours. The kraaled cows grazed until penned at 19.00 hours. The free grazed cows normally stopped grazing at 20.00 hours and therafter grazing was irregular.

In general, night grazing (19.00 to 7.00 hours) was below 50 minutes per night by both breeds in both seasons, except Hereford cows which grazed 76 minutes in the wet season. Figures 7 and 8 show that night grazing was more in the wet season than in the dry season.

It was observed that all cows showed more intensive day time (7.00 to 19.00 hours) grazing in the dry season than the wet season, and also under kraaled management than free grazed night management.

Rumination formed a smaller peak as compared to the midnight peak, around midday. After midday, ruminating intensity would decrease gradually until 18.00 hours when the activity would start rising. Free grazed cows reached ruminating highest peak in the night at 22.00 hours and the ruminating intensity would subsequently decrease gradually until daybreak.

The Figures 1 to 8 do not show distinct ruminating intensity differences between the wet and the dry season.

Idle time, (time cows neither grazed nor ruminated) is reflected by blank space on the histograms shown on each of the figures. The larger proportion of idle time wasin the night when the cows reduced their grazing activity in both seasons and both breeds.

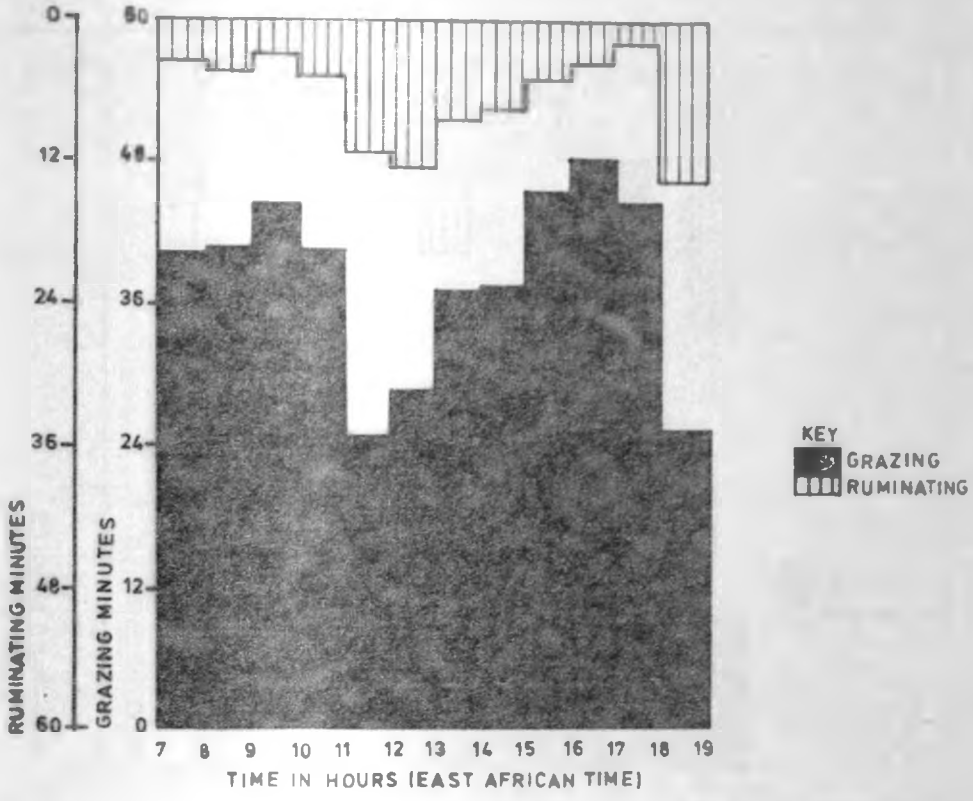

Fig. 1: Grazing and ruminating patterns of kraaled Hereford cows during wet season.

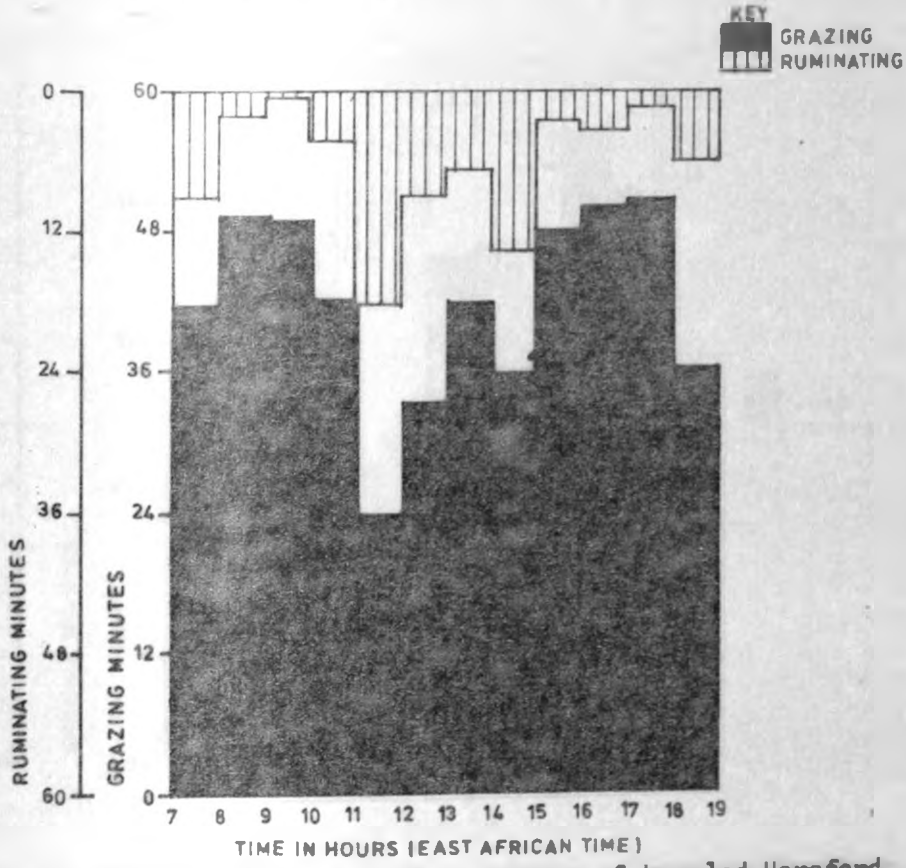

Fig. 2: Grazing and ruminating patterns of kraaled Hereford cows during dry season.

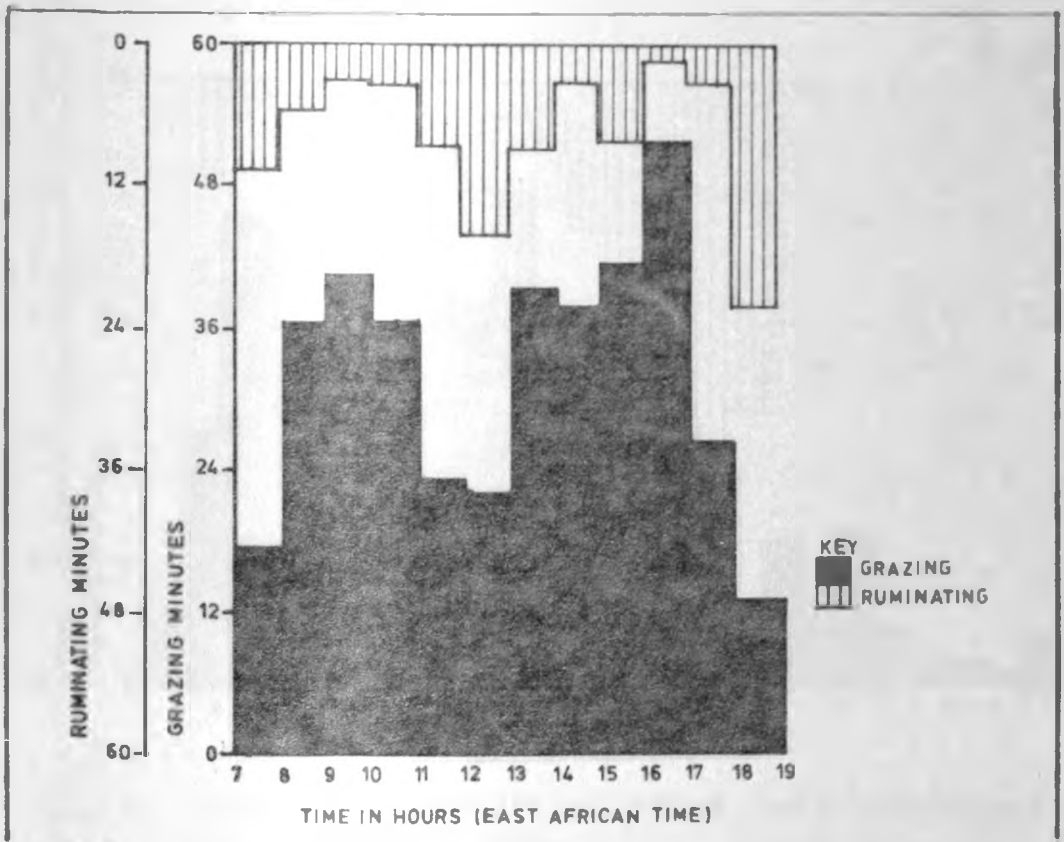

Fig. 3: Grazing and ruminating patterns of kraaled Boran cows during wet season.

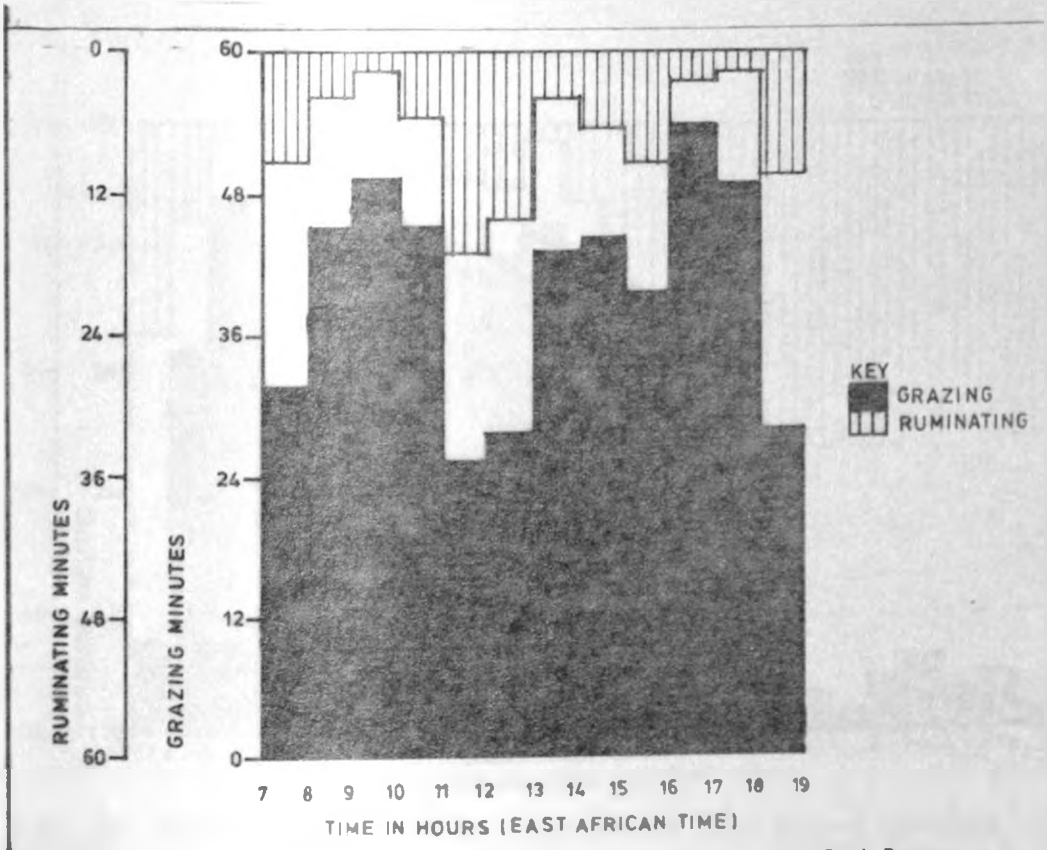

Fig. 4: Grazing and ruminating patterns of kraaled Boran cows during dry season.

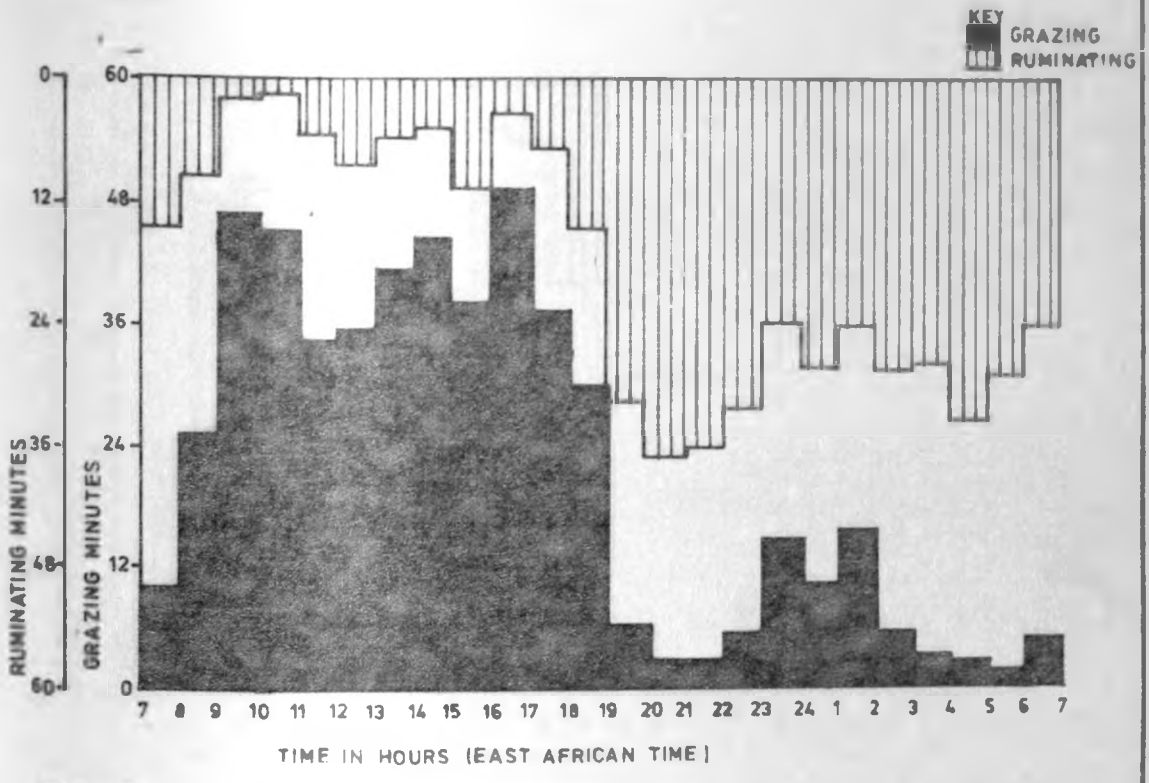

Fig. 5: Grazing and ruminating patterns of free grazed Hereford cows during wet season.

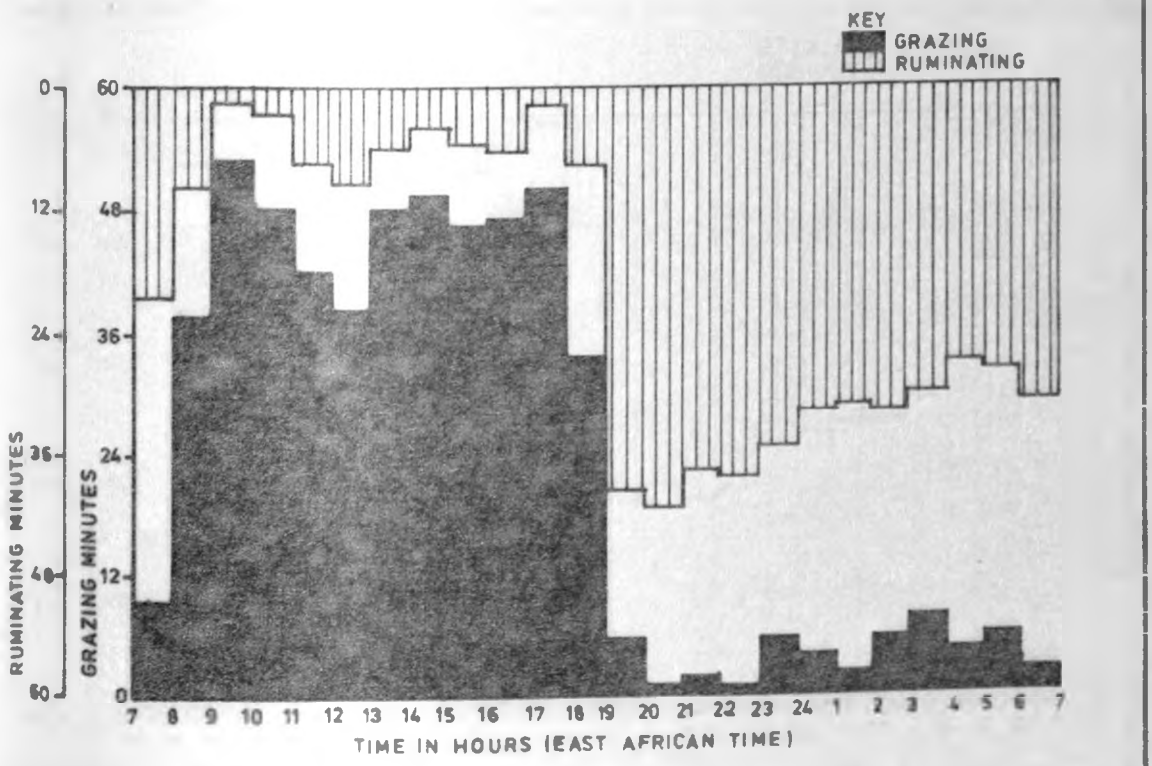

Fig. 6: Grazing and ruminating patterns of free grazed Hereford cows during dry season.

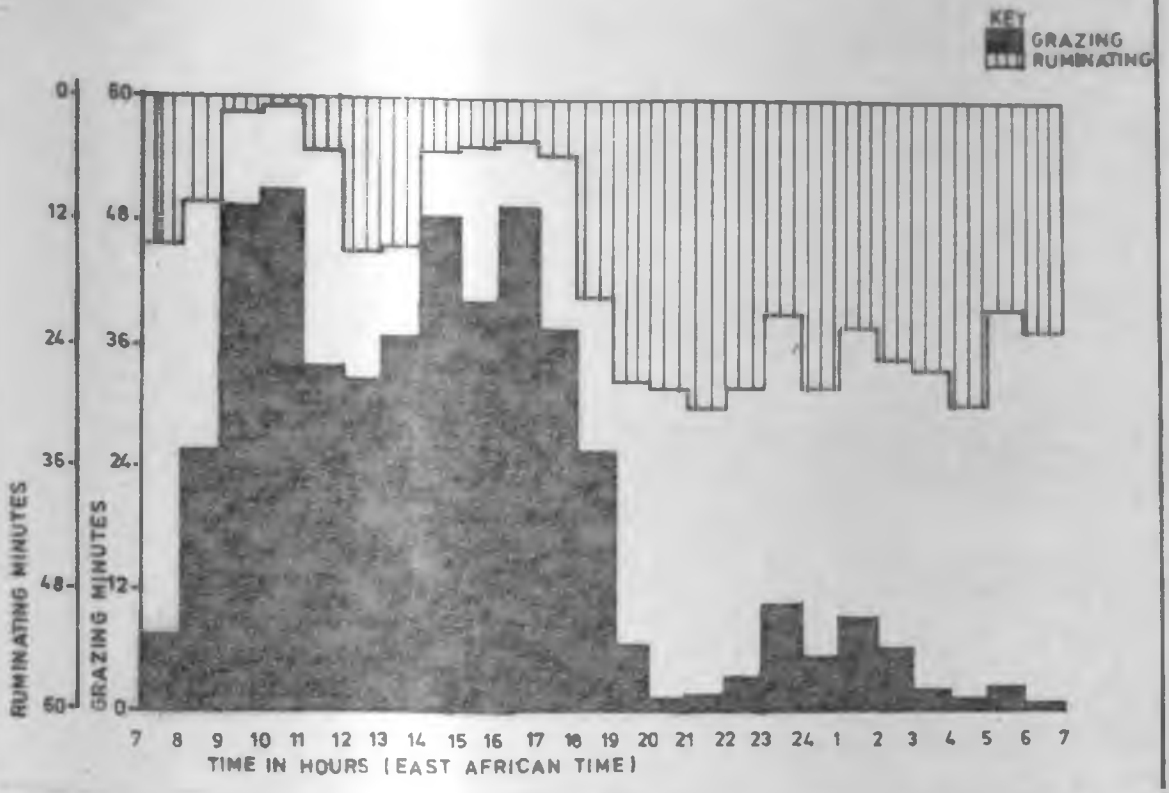

Fig. 7: Grazing and ruminating patterns of free grazed Boran cows during wet season.

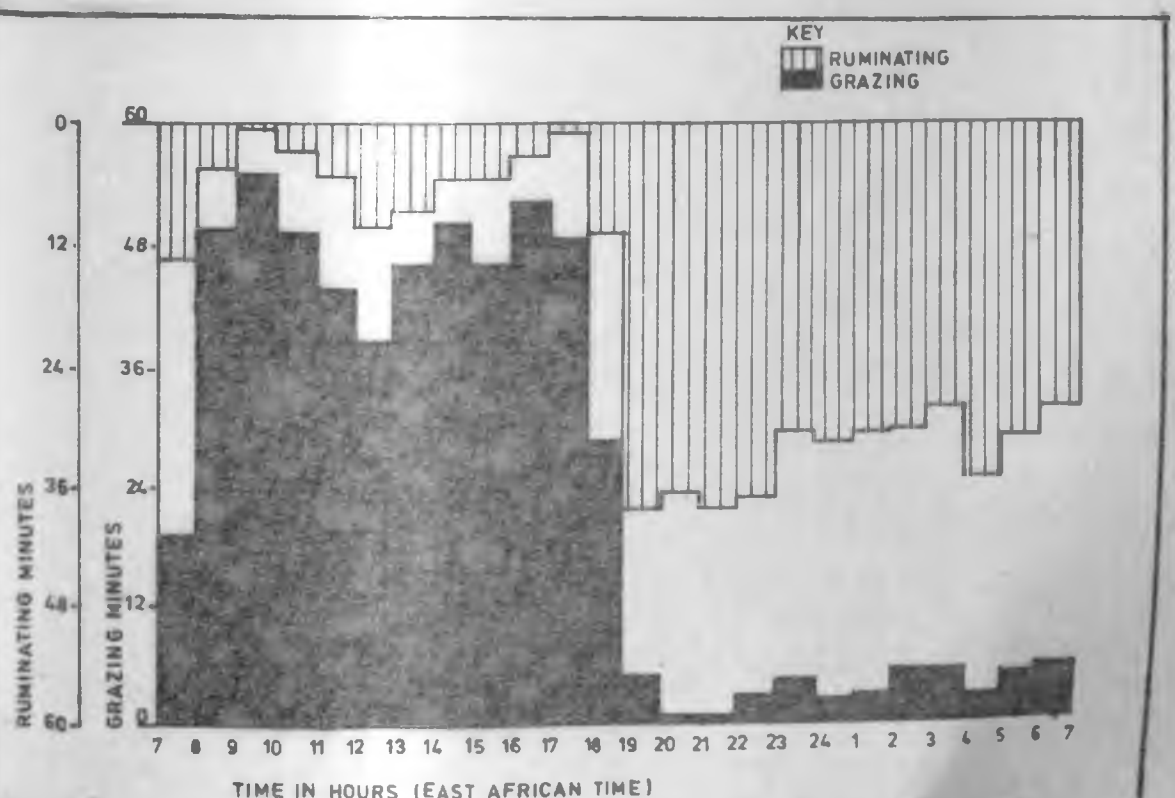

Fig. 8: Grazing and ruminating patterns of free grazed Boran Cows during dry season.

CHAPTER 5

5. D I S C U S S I O N

5.1 Interaction effects on the grazing behaviour

5.1.1 Grazing time

The interaction of season and breed for grazing time was highly significant ($P< 0.01$). When comparing grazing time means (Table 8) between breeds in the wet season, the Hereford cows took longer time grazing than the Boran cows. The Hereford cows average liveweight was 503.0 kg and were heavier than Boran cows by 206.8 kg. It is possible that the Hereford cows in this study took a longer time grazing inorder to reach a level of intake that will meet their body sizes and nutritional requirements given that both the Herefords and the Borans were grazing on same quality and quantity pastures. In the dry season, both breeds increased grazing time relative to their respective grazing times taken in the wet season. The Hereford cows increased grazing time by an average of 0.71 hours per day and Boran cows increased grazing time by 1.58 hours daily. In the dry season, when pasture was of poorer quality, it is likely that there was a lot of selective grazing for more palatable softer leaf portion. In wet season, the abundance of succulent herbage as a result of rain, induced little selective grazing and cows' appetite and gut fill were satisfied in a shorter time. Similar observations were reported by Hughes *et al.* (1951); Lofgreen *et al.* (1957); Hutchison *et al.* (1962).

There was a slight tendency for the reverse observation that Boran cows graze longer time than the Hereford cows in the dry season. The calculated difference of 0.03 hours per day is most unlikely to be of any significance. However, it could be explained that Boran cows might have been engaged in grazing for the most palatable herbage (Bertha, 1975). Consequently, selective grazing was more intensive by the Boran cows than by the Hereford cows. Herefords, on the other hand, might have been affected by dry season higher temperatures causing grazing activity declining (Bonsma, 1949).

The interaction of grazing time between breeds and night management reflected differences between breeds for the two night managements. Free grazed cows spent longer time grazing because they were able to graze during night time whilst their counterparts, kraaled cows, were in the kraals. (Harker, et al., 1956; Joblin, 1961; Kyomo et al. 1972). Under kraaled management, the Hereford cows grazed longer time than the Boran cows, possibly because of the bodily nutritional requirements as already hypothesized.

Both breeds showed longer grazing time under free grazed management than under kraaled management. It was also observed that the grazing time per day for free grazed Boran cows was higher than that of the free grazed Hereford cows. This observation that Zebu cows were more affected by kraaling than the Bos taurus is contrary

to the observations by Joblin (1961). There might have been individualist behavioural characteristics amongst the Hereford cows that influenced shorter time under free grazing management in the dry season.

5.1.2 Ruminating time.

The interaction of ruminating time between the breed and the season suggests that there are differences in ruminating within the breed between the wet and the dry season and within the season between the Hereford and the Boran. It is shown by ruminating time (Table 8) that both breeds increased ruminating in the dry season.

Cows took a longer time ruminating per day in the dry season than during the wet season; possibly because of pasture quality. Pasture quality as shown in Table 6 was more fibrous and contained higher levels of dry matter and lignin during the dry season than that of the wet season. The cows took longer time remasticating grass ingested in the dry season, possibly, to reinsalivate the feed further to enhance its fermentation rate. This suggestion agrees with some views that greater saliva production promotes fermentation and digestibility rates.(Phillips, 1961). It was also reported by Hancock (1954) that the longer ruminating time by dairy cows (Bos taurus) was associated with the intake of more fibrous feed per unit dry matter ingested. Lofgreen et al. (1957) also reported a relationship of digestibility to ruminating time. In this study

it is shown in Table 7 that pasture in the wet season was more digestible than that in the dry season.

Hereford cows, consistently ruminated longer than the Boran cows in both the dry and the wet season. It has been reported that the Hereford cows digest the organic matter of low quality roughages less efficiently than Borans (Phillips, 1961). So, protracted rumination by the Hereford cows was, perhaps, an effort to improve efficiency of digesting the pasture by prolonged remastication and reinsalivation of the ingesta.

5.2 The effect of season on the grazing behaviour

5.2.1 Ruminating time

Ruminating was observed to be the second "time taking" activity, after grazing, for cows that were free grazed in both the wet and the dry season. The ruminating time ranged between 30.1 to 32.1 percent of the total time on pasture in the wet season and 32.9 to 34.8 percent in the dry season. Similar values have been reported in East Africa and elsewhere (Johnstone-Wallace et al., 1944; Harker et al. 1954; Wilson, 1961).

Season also affected ruminating time of kraaled cows. Kraaled cows proportionate ruminating time when on pasture ranged between 12.3 to 14.2 percent in the wet season and 9.6 to 9.7 in the dry season. The decrease

in ruminating time in the dry season reflects the vigour of grazing activity when cows are out of kraals in a dry season; at a time when pastures are very stemmy.

5.2.2 Idling time

The time cows neither grazed nor ruminated was less in dry season than wet season. The reduction of idle time in the dry season was consistent with the observations in the same season that cows grazed and ruminated longer. Increased idle time for cattle is closely associated with higher embient temperatures (Lampkin et al., 1962). However, in the present study, inspite of comparable higher ambient temperatures in the dry season than the wet season, cows did not take longer time idling. It is likely that cows' appetite for better herbage overrode temperature levels that would have depressed grazing. Nevertheless, it is important to mention that Kabete location and the year 1979 did not typify a tropical hot dry season. Maximum temperatures ranged between 23°C to 26°C (Appendix II) and those were probably not high enough to cause apparent stress in the grazing cows that would have been reflected by longer idling time.

5.2.3 Resting time

The time cows spent resting was significantly different between dry and wet season. In the wet season, cows spent comparatively shorter time either ruminating or grazing for reason pertaining to pasture quality as explained elsewhere

in the text. Cows might have taken advantage to rest longer in the wet season after saitsfying their gut fill and appetite from the soft and abundant pasture. Another reason that could probably have caused longer resting time in the wet season is the incidence of rains. Lampkin et al. (1958) observed that steers under sub-tropical climate at Muguga neither grazed nor ruminated in times of drizzles and suggested that probably this was because the steers felt uncomfortable. It was similarly observed in the present study that in times of prolonged rains cows would only stand and rest up to the time the rains were over and then would start their normal activities.

5.2.4 Drinking time

Cows spent more proportionate time on watering during the dry than the wet season. In comparatively higher air temperatures and drier environments prevalent in the dry season, cows possibly lost comparatively more bodily water through sweating and evaporation. Therefore, cows would need to balance their body water requirement by increased water intake (Lampkin et al., 1958, 1961; Wilson, 1961; Wigg, 1973). On the other hand, animals lost relatively less body water in the wet season due to lower ambient temperatures. Furthermore apart from drinking water, cows' body water requirement was partly met from the wet, juicy herbage particularly when it rained. Consequently, watering activity was reduced in the wet season thereby showing shorter time spent on drinking water. It could be inferred, therefore,

that the longer time spent drinking water in the dry season than in the wet season meant comparatively larger quantity of water intake. This is implied as water intake levels were not studied.

5.2.5 Walking time

Hutchison et al. (1962) found that free walking relates closely to pasture quality. Season, would therefore be associated with animal walking, under tropical conditions, because quality of grass changes with season.

The results of the present study do not associated walking time to dry or wet seasons. In the dry season when pasture was scanty, more fibrous and of lower protein values, cows should have taken longer time in walking activity, but in this study, free grazed cows took longer time walking during the wet season than during the dry season. However, kraaled cows walked longer time when out of kraal in the dry season. It is possible that this rather out of the ordinary observations could be explained by the fact that the free grazed cows had limited grazing area and there was, therefore, no incentive for wider walking.

5.3 The effect of breed on the grazing behaviour

5.3.1 Total standing time

Total standing time, time cows spent standing either ruminating or resting was significantly different between breeds ($P < 0.01$). The Hereford cows stood longer time, a

mean of 5.94 hours per day than the Boran cows which spent a mean of 4.78 hours. The observation is contrary to the studies of Grade and Zebu steers reported by Lampkin et al. (1958) but in agreement to that reported by Musangi (1965). The Hereford, having inefficient bodily thermoregulatory systems to dissipate excessive heat, might have been trying to expose greater parts of their bodies to the atmosphere by standing especially during day time when temperature reached their maximum levels. Animals in standing positions are cooled better by convection and conduction of the surrounding air than when in a lying position (Steinhauf, 1977, Personal communication).

5.3.2 Total lying time

The time cows were either ruminating or resting while lying was significantly different between the breeds. The longer time of lying by Borans compared to Herefords might have been induced by the total time Boran cows spent walking. Boran cows spent longer time walking than the Hereford cows, suggesting that Boran cows, having superior walking ability (Meyn, 1970) and less body weights, were able to walk longer distances in search of more tasty herbage to eat (Bertha, 1975). Consequently, while Herefords stood ruminating or resting, Boran cows, probably walked in search of softer and tasty herbage so much so that after frequent movements, they felt tired and subsequent resting or ruminating was mainly by lying other than standing.

Both breeds took a higher proportionate time lying than they took in standing position. Cows ruminated or rested a longer time lying than standing as a means of conserving energy. It has been shown by Ritzman and Benedict (1938) cited by Lampkin et al. (1958) that cattle spend 9 percent more energy while standing than while lying. Therefore it could be postulated that cows spent more idle time lying in a bid to conserve energy.

5.3.3 Watering time

The results of proportionate time indicated that Herefords took a longer time on drinking than the Boran cows. Harrocks and Phillips (1961) have shown that water requirements of Bos taurus cattle is more than that of Bos indicus. The results in this study agree with the above report. Hereford cows apparently drank more water than Boran cows; in terms of longer time taken on watering activity. Hereford cows whose average weight was 503.0 kg were heavier than Boran cows weighing an average of 396.2 kg thus water requirement was correspondingly higher (Wigg et al., 1973). It should be noted that recording minor habits of cattle every fourth minute is associated with much variation, and it was reported by Harker et al. (1954) that the error for drinking water was found to be ± 62 percent. Therefore only obvious conclusions were drawn from the results of watering in the present study.

5.4 Effect of kraaling on the grazing behaviour

5.4.1 Grazing time

Kraaling cows from 19.00 to 7.00 hours next morning reduced time of grazing for both breeds and both seasons as shown in chapter 5 of this text; under interaction effects on grazing behaviour (5.1.1). Although feed intake estimations were not made in the present study, Castle et al. (1950), MacDonald and Holmes (1951) cited by Musangi (1965) showed positive correlation between the time spent grazing and the amount of forage consumed on dry and wet matter basis respectively. So it can be inferred, therefore, that kraaling reduced feed intake.

Kropp, et al. (1973) found that grazing time, apparently was not related to forage intake. Nevertheless, Hancock (1953) explained that within a herd, a relationship between grazing time and feed requirement exists but individual differences, in feed intake per unit time, are of sufficient importance to obsecure such relationship.

5.4.2 Ruminating time

Kraaled cows took a comparatively smaller proportionate time ruminating and idling while on pasture between 7.00 hours to 19.00 hours in both seasons than free grazed during the same times and seasons. The shorter time of ruminating and idling shows how kraaled cows were inclined to grazing activity during the time they were out of kraals.

5.5 General pattern and distribution of grazing behaviour

5.5.1 Grazing time distribution

Cows showed intensive grazing habit in the dry season and also under kraaled management. Pasture in the dry season was stemmier than wet season so that cows exhibited intensive grazing activity in an effort of selecting palatable herbage. Night kraaled cows intensive grazing was probably an attempt to overcome the disadvantage of the limited available pasturing time and likely postponed ruminating and idling until in the night when kraaled (Smith, 1961).

Morning grazing peaks and afternoon grazing peaks were the same intensity. Although free grazed cows exhibited a depression in grazing intensity between the two peaks, yet it was not as low as a corresponding depression shown by night kraaled cows. It would be inferred that grazing was more continuous in free grazed cows than kraaled cows contrary to report by Smith,(1961). Probably free grazed cows were grazing continuously during daytime because it was not worth postponing grazing into the night in a limited grazing area.

In the present study, the grazing time in the night during the wet season was shown to be longer than that in the dry season. Probably, dry season daytime maximum temperatures averaging $24^{o}C$ were not sufficiently high to influence cows to postpone their grazing time into cooler hours of the nights.

5.5.2 Grazing time/ruminating time (GT/RT)

Boran cows, showed slightly higher ratio values than the Hereford cows in both seasons. Herefords ruminated comparatively longer time than Borans. It has already been shown (Phillips, 1961) that Borans are more efficient in fermenting and digesting low quality roughage than Herefords. To this effect, Herefords were ruminating for a longer time than Borans, probably to remasticate and reinsalivate the ingesta longer to render it more fermentable and digestible, thus making the ratio of a comparable lower value especially in dry season when pasture was more fibrous.

In wet season, the time when pasture was leafy and not coarse, Borans and Herefords grazed for almost the same length of time. However, ruminating time by the Herefords was a little longer as explained above.

The ratio increased with deterioration of pasture quality for kraaled cows in dry season. It is likely that as most of pasture became coarse, scanty and unpalatable cattle tended to spend longer time grazing on selecting for softer and palatable grass leaf portions.

CHAPTER 6

6. SCOPE FOR FURTHER STUDY

During present study, weather conditions between wet and dry seasons were not very distinct. Average of maximum daily temperatures, daily relative humidities and sunshire hours per day in the two seasons were very close as shown in the Appendix I. The unusual showers in the dry season did not typify the season in affecting the pasture quality and the behaviour of the cows. Weather factors coupled with short period of study could have influenced the responses of the breeds to the seasonal changes especially at Kabete. Therefore, it would be appropriate if the trials are conducted throughout the year, and several times, using cattle of uniform age to eliminate seasonal variations that occur from one year to the other.

Another factor that might have affected the experiment is age variation between the breeds. Boran average age was 3 years whilst Hereford average age was 5 years consequently weight variation was enormous. It could be proper if average between the breed could be uniform and thereby eliminate undue weight variation.

The other aspect to investigate fully is the dry matter intake by the foraging cattle in relation to their activities and type of management. It would be interesting to compare food intake of kraaled and free grazed cattle so as to establish the loss, in terms of feed intake, by the animals denied of night grazing in either wet season or dry season.

This would, further, clarify fully the relationship of feed intake to either ruminating or grazing time.

CHAPTER 7

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APPENDIX I: WEATHER CONDITIONS DURING EXPERIMENTAL PERIOD

(a) WET SEASON - DECEMBER 1978

Date	Temperature (centigrades)		Percentage relative humidity		Rainfall (cm)	Radiation (Langleys)	Sunshine hours per day	Windrun (Kms.)
	Max.	Min.	Max.	Min.				
5.12.78	17.5	12.6	100	84	2.0	246.4	3.0	96.86
6.12.78	20.5	13.4	99	60	11.1	462.2	8.4	144.00
7.12.78	22.0	14.8	98	52	0.0	655.9	8.4	154.3
8.12.78	21.0	14.1	99	63	0.0	504.9	8.0	153.18
9.12.78	21.5	13.6	99	63	0.6	471.4	5.3	138.3
10.12.78	22.0	14.0	98	63	0.0	392.3	8.3	168.95
11.12.78	21.5	14.5	99	69	4.4	462.2	5.3	161.06
12.12.78	23.9	14.8	99	61	0.0	462.2	4.2	142.88
13.12.78	22.4	14.1	98	64	5.8	456.2	5.6	80.77
14.12.78	22.5	13.5	99	61	5.8	477.8	4.0	54.55
15.12.78	22.9	12.7	100	60	23.7	626.5	8.0	32.34
16.12.78	23.9	14.6	98	37	4.4	538.7	7.4	49.56
Daily average	21.80	13.89	99.8	61.4	4.82	440.47	6.33	114.7

Langley = gm $Cal/cm^2/day$

APPENDIX I: (b) DRY SEASON - MARCH 1979

Date	Temperature (centigrades)		Percentage relative humidity		Rainfall (cm)	Radiation (Langleys)	Sunshine hours per day	Windrun (Kms.)
	Max.	Min.	Max.	Min.				
10.3.79	24.9	12.9	98	43	0.0	574.7	8.5	82.86
11.3.79	25.9	15.5	99	44	0.0	583.8	8.6	61.79
12.3.79	26.0	14.6	98	40	0.4	580.8	6.3	79.16
13.3.79	25.0	15.5	99	47	0.0	538.2	8.9	94.61
14. 3.79	23.0	14.0	99	52	5.5	498.7	5.6	82.38
15.3.79	24.3	13.5	98	41	7.3	556.5	9.0	78.68
16.3.79	25.4	15.5	98	45	0.3	550.4	7.3	78.19
17.3.79	23.5	13.8	98	53	0.0	462.2	4.1	50.78
18.3.79	24.0	13.7	98	54	12.6	501.8	6.1	56.48
24.3.79	24.6	15.5	99	47	0.0	626.4	8.7	119.71
25.3.79	24.0	13.0	100	48	2.7	480.5	7.5	80.13
26.3.79	24.1	15.4	97	49	12.6	529.1	7.3	110.06
Daily Average	24.55	14.4	98.4	46.9	3.45	540.26	7.33	81.24

Langley = gm Cal/cm^2/day.

APPENDIX II: THE CHEMICAL COMPOSITION PERCENTAGE OF THE HERBAGE GRAZED DURING DRY AND WET SEASONS (ON DM BASIS)

	Wet season		Dry season	
	First week	Second week	First	Second week
Moisture	9.37	8.67	7.15	6.16
Ether extract	4.96	4.18	4.02	2.76
Crude protein	15.43	15.09	9.49	11.29
Nitrogen free extracts	32.77	35.27	40.16	36.83
Crude fibre	28.34	26.27	29.63	32.53
Ash	9.13	10.26	9.55	10.43
Lignin %	4.85	5.13	7.37	7.94

APPENDIX IIIa: TIME (MINUTES) COWS SPENT ON RESPECTIVE ACTIVITY DURING WET SEASON OBSERVATION

A. COWS OBSERVED AND RECORDED 12 HOURS PER DAY (7.00-19.00 hours)

Breed	Borans				Herefords			
Cow expt. No.	B1	B2	B3	B4	H1	H2	H3	H4
Total time cows observed	8285	8285	8285	8285	8285	8285	8285	8285
Grazing	4355	4145	5215	4690	4810	5015	6190	5840
Rum. St.	290	440	385	510	505	275	275	405
Rum. Ly.	860	1025	640	760	705	1075	345	505
Total Rum.	1150	1465	825	1270	1210	1350	620	910
Walking	180	190	190	220	130	205	125	85
Rest Std.	790	770	540	910	1200	665	680	905
Rest Ly.	1750	1665	860	1120	840	945	595	485
Drinking	60	50	40	75	95	105	75	60

B. COWS OBSERVED AND RECORDED 24 HOURS PER DAY

Breed	Borans				Herefords			
Cow expt. No.	B5	B6	B7	B8	H5	H6	H7	H8
Total time observed	16865	16865	16865	16865	16865	16865	16865	16865
Grazing	5380	5955	6145	6100	5360	6240	6420	5560
Rum. Std.	1680	1400	1800	1960	14555	1360	1690	2415
Rum. Ly.	3445	3810	3305	2930	4240	3945	3855	2695
Total Ly.	5125	5210	5105	4890	5695	5305	5545	5110
Walking	385	535	400	395	265	345	420	391
Rest Std.	2285	2355	1565	2135	3100	2415	2195	3420
Rest Ly.	3625	2750	3595	3275	2385	2515	2200	2215
Drinking	65	60	55	70	60	45	65	90

Note: Rum. = Ruminating
Ly. = Lying
Std. = Standing

APPENDIX III(b): TIME (MINUTES) COWS SPENT ON RESPECTIVE ACTIVITY DURING DRY SEASON OBSERVATIONS

A. COWS OBSERVED AND RECORDED IN 12 HOURS (7.00-19.00 hours)

Breed	Borans				Herefords			
Cow Exp. No.	B1	B2	B3	B4	H1	H2	H3	H4
Total time cows observed	8180	8180	8180	8180	8180	8180	8180	8180
Grazing	6040	5790	5705	5515	5685	6030	6375	6020
Rum. Std.	500	220	480	380	605	365	405	690
Rum. Ly.	355	800	460	815	340	750	465	455
Total Rum.	855	1020	940	1195	945	1115	870	1145
Walking	245	185	170	220	195	175	65	85
Rest Std.	690	460	805	800	965	580	500	645
Rest Ly.	275	655	520	365	290	210	295	200
Drinking	75	70	40	85	100	70	75	85

B. COWS OBSERVED AND RECORDED 24 HOURS PER DAY

Breed	Borans				Herefords			
Cow exp. No.	B5	B6	B7	B8	H5	H6	H7	H8
Total time cow observed	16805	16805	16805	16805	16805	16805	16805	16805
Grazing	6395	6780	6795	7065	6400	6285	6420	6330
Rum. Std.	1545	1255	1640	1695	1770	1830	2305	2050
Rum. Ly.	1325	4295	4120	3830	3870	4530	3750	3285
Total Rum.	5270	5550	5760	5525	5640	6360	6055	5335
Walking	65	245	130	235	195	200	135	135
Rest Std.	1875	1500	1400	1400	2030	1615	1875	2690
Rest Ly.	3180	2690	2520	2350	2495	2310	2285	2280
Drinking	20	40	40	30	55	35	35	35

Note: Rum. = Ruminating
Ly. = Lying
Std. = Standing