

THE GRAZING BEHAVIOUR OF PUREBRED ZEBU COWS
IN TRINIDAD, AND A COMPARISON WITH THE
GRAZING BEHAVIOUR OF CROSS-BRED ZEBU -
BOS TAURUS DAIRY COWS.

by

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INTRODUCTION

The complexity of the study of grazing behaviour, which is described by Hammond as "making a science of the stock man's art" was pointed out as long ago as 1926 by Stapledon and Jones (1927), who wrote: "So intimate is the grassland complex and all its relations, and the grazing animal and all its reactions, that it appears obvious that it is not possible to understand one complex without understanding the other".

In the Tropics, knowledge of the 'connection between the grassland complex and all its relations' is very far behind what it is in the Temperate regions. These studies of grazing behaviour in Trinidad therefore, have not taken into consideration the quality and quantity of grass as it might affect grazing behaviour, but until such time as more pasture grasses are found, and their capabilities determined, it is impossible for grazing behaviour studies to be on such a high plane as they are in Temperate regions.

This investigation is essentially a study of the grazing cycle of Zebu Cattle and how it is affected by seasonal and other factors. It is therefore, a study of the reaction of the animal to its environment, and to some extent of the factors influencing the environment.

The obvious practical application is that if as a result of behaviour studies, management practice can be altered in such a way as to reduce the amount of energy spent by cattle in obtaining their feed, than the time spent in studying time and motion in the physical activities of the stock will be worth while. Another aspect is that from such studies, the management might be altered so as to benefit the pastures better.

Tribe (1950) suggests that care must be taken in interpretation and application of results from animal behaviour studies, though Pearson-Hughes points out that various workers such as Doran (1943) Nicholls (1944), Seath and Millar (1947) and Taylor (1951) have successfully applied results from grazing habit studies in the solution of grass management problems. Taylor for instance has suggested that through the application of grazing habit studies the degree of helminth infestation in livestock can be reduced, as peculiarities of grazing behaviour might influence infestation by this parasite. Seath and Millar found that feeding supplementary hay on hot days when cows ceased to graze, did not increase the yield of milk.

As regards work in the tropics and sub-tropics, it has become increasingly evident that it is dangerous to apply techniques of grazing management of Temperate regions, to any breed of cattle in the Tropics: Payne et al. (1951) in Fiji have stressed this, and numerous other workers such as Bonsma et al. (1940), Rhoad (1938) and Seath and Millar (1946) have shown how hot climates strongly influence the grazing behaviour of Temperate breeds of animals with some Temperate blood in them. Furthermore the grazing behaviour of Zebu animals completely adapted to their environment is different to that of Temperate animals adapted to their respective environment.

With the increasing intensifying of animal management in the tropics as a result of increasing food requirements, it is becoming necessary to find out more about indigenous cattle as well as Temperate breeds and crosses. The grazing habits are a small part of the required knowledge, and it is known that Temperate breeds have different grazing habit in the Tropics. A small amount of work has been done studying these habits in the Tropics, but those of Zebus are not well known. It seems that it would be necessary to know something about their habits if they are to form a basis, and sometimes be the only suppliers of milk and meat of the steadily increasing populations in Tropical areas.

LITERATURE REVIEW.

Much work has been done on grazing behaviour in Temperate countries but not in the Tropics. In earlier years in England and the U.S.A. especially, random behaviour studies have been carried out with no clearly defined object in view, and such studies while they are of some aesthetic value in that they contribute to fundamental knowledge, have sometimes not shown much relationship to management practice. More recently however, investigations have been on a sounder basis, with increasing importance being attached to the obtaining of valid results through statistical analysis, the work of Hancock et al (1950) being outstanding in this respect. With regard to work in Temperate climates, Castle, Foot & Halley (1950) and Tribe (1950) have made reviews of work carried out prior to 1939. The work reviewed however was more in the nature of preliminary observations rather than critical work on a sound basis. Recently Hancock (1953) has published an excellent critical review of the work to date.

As regards the Tropics, scarcely any behaviour studies have been carried out, and none on a statistical basis. Like in the Temperate countries however, fundamental observations and studies have to a certain extent, and will no doubt in future, prove useful in supplementing other experimental data.

The first critical work was that carried out by Johnstone-Wallace (1944, 1948) and Johnstone-Wallace and Kennedy (1944). They made comprehensive studies of beef cows on pasture and recorded the hours spent in grazing, cudding, drinking, walking and resting, as well as data on defecation, micturition and suckling. The distances walked were recorded too. Four beef cows were observed over 24 hour periods over a period of 3 months on pastures of 3-7 acres. These workers came to the conclusion that an animal does not increase or decrease the number of hours of grazing according to the amount of grazing there is on the pasture and therefore an animal on sparse pasture would consume far less. Other workers have not been able to corroborate this however, and Atkeson, Shaw and Cave (1942) gave evidence as follows on the accommodation of grazing time according to the nature of the pasture :-

Good	-	5.6	hours	per	day
Fair	-	6.5	"	"	"
Poor	-	7.3	"	"	"

Hancock (1950) corroborated this evidence.

These workers used 56 cows and heifers and observed them over 24 hour periods on excellent Balbo rye pasture and the experiment took place in Kansas. They found that the average grazing time was seven hours, lying time thirteen hours, and standing time or walking time for four hours. 40% of the time was spent grazing in a 14 hour day and 16% in a 10 hour night. Of the lying time 30% was during the day and 80% at night.

A development in these workers' studies was that they recognized the importance of periodicity in grazing, and recorded the major grazing periods of which there were four during the day and two at night. Wardrop (1951) who was working with dairy cows in England, found only 5 grazing cycles per 24 hours. He transferred the cows to night paddocks however, and they did not remain on the same pasture throughout the 24 hour period. He also found that cows prefer to rest during hot periods and graze during cool spells and states further that grazing hours are longer when herbage is long and has a high fibre content, and when it is wet.

Taylor (1951) made some observations which are of general interest, in an experiment with a herd of bullocks. He found that the herd followed a repeated daily pattern closely related with environmental conditions. Varying hours of daylight produced gradual changes in basic pattern and weather and other disturbances had minor effects. He notes too, that disturbances caused by warble-fly on hot summer days exerted a major influence on grazing behaviour and on live weight gains. Next to seasonal effects he says, the system of management exerts the greatest influence on behaviour.

The most comprehensive grazing behaviour work yet carried out, was that of Hancock (1950) in New Zealand. He worked with dairy cows and in four years of work he recorded nearly 2,000 cow days thereby eliminating his own criticisms of other behaviour work, that is that too few animals had been watched, that repeated trials on the same animals had not been carried out, and that in some cases days of unsuitable weather had been avoided for the convenience of the workers. The following comprehensive trials were carried out :

1. Uniformity trials on monozygotic twins and the collection of base line data.
2. Influence of quantity and quality of grass and of the feeding of concentrates on grazing behaviour.
3. Inter-relationship between the dry matter intake, grazing behaviour

and the production of individual cows within a herd.

4. Influence of the quantity of grass offered on the inter-relationship of grazing behaviour, dry matter intake and production of individual cows.

5. Influence of rotational grazing and set-stopping managements on grazing behaviour.

Hancock then discusses variations in grazing behaviour under the following headings and suggests that such a method or pattern for the analysis of results might well be followed by other workers. The modifying factors are :

- (1) Metabolic diurnal and seasonal rhythms.
- (2) Weather.
- (3) Quantity and quality of pasture.
- (4) Individual idiosyncrasies.
- (5) Environment - inheritance interactions.
- (6) Herd laws.

A considerable amount of other work has been done in the United Kingdom especially, mainly with varying and confusing results, and Hancock (1953) has attempted to sort out the work done in the last decade. He starts by defining the terms which he uses for the physical activities and which in the past have been rather confused. The activities are grazing, rumination, loafing, idling, resting and lying, and he then sets forth to discuss influences of :

- (a) Weather.
- (b) Effect of day and night.
- (c) Influence of quality and quantity of pasture.
- (d) Feed intake.
- (e) Pasture and animal management.
- (f) Individuality.

on the six physical activities.

With regard to weather, he finds that temperature has little overall effect on grazing performance, and it is only minor temporary extremes which radically alter their behaviour. In the tropics however, temperature plays a more important role in that it causes temperate breeds of cattle to graze a good deal more during the night. The effect of day and night has been fairly well established in that cattle only graze at night when day temperatures are too high for comfort, or the length of day is very short as occurs in Temperate climates. One worker (Stein 1935) found that cattle only grazed at night during twilight or moonlight. Hancock also points out that the division between a.m. and p.m. milkings is of more

importance than division between day and night, as it is generally between the milkings that the cows are put on different pastures.

With regard to quantity and quality of pasture, it appears to be fairly well established that if the quantity of pasture is sufficient for the cattle, the grazing times are long. If the quality is mixed, intermediate if the quality is good, and long if the quality is poor. One of Hancock's newest and most interesting findings is that concerned with amount of rumination as determined by the quality and quantity of pasture. It can best be put forward by this diagram which is as follows :-

Quantity.	Quality.	G. Time.	R. Time.
High	{ Good	Intermediate	Short.
	{ Mixed	Long	Long
	{ Poor	Short	Long.
Low	{ Good	Long	Short
	{ Mixed	Long	Intermediate
	{ Poor	Long	Intermediate.

The rumination time seems to depend on the quantity and quality of the grass which the cows eat but rumination time would be a poor indication of the amount of feed intake because of differences in selectivity between cows as well as inherent differences in amount of rumination. For grazing it might be said that there is a relationship between grazing time and theoretical feed requirements within a herd but which is obscured by individual differences and diurnal variations unless a large number of cattle are observed a number of times at close intervals.

Hancocks (1950) uniformity trials with monozygotic twins showed conclusively that inherent individuality was a most important factor in determining grazing behaviour. This applies to amount of cudging also distances walked per day. As regards walking distances, recordings made by various observers are variable and Hancock finds that the main factors which influence the distances walked are: warm weather, wet and windy conditions and gadflies.

Castle (1951) found that cows walked 4,000 yds. in a day on old hay and half as much on fresh good hay. Waite et al (1951) found no differences in average distance covered by rationally grazed and close folded dairy cows.

Little work has been done in the Tropics with regard to grazing behaviour and virtually none with cattle indigenous to the Tropics. Rhoad (1938) and Bonsma et al (1940) made observations of a selection of cattle ranging from

pure-bred *Bos Taurus* to pure-bred *Bos Indicus*. Their work was mainly directed to assessing the heat tolerance of various breeds as reflected in their grazing behaviour, and some interesting facts emerged from their investigations.

It was found that under sunny, windy conditions, the grazing time varied according to the amount of tropical blood present and very striking differences between the behaviour of pure-bred Tropical breeds and pure-bred Temperate breeds was shown. Bonsina in South Africa found that under temperatures varying between 76°F and 103°F under dry sub-tropical conditions, Afrikanders (*B. Indicus*) spent 89% of the day grazing and ^{Aberdeen angus, Shorthorn and} Herefords spent 75, 78 and 79% respectively of the day in grazing. Rhoad in the U.S.A. under similar climatic conditions in Louisiana, though probably more humid, had arrived at exactly the same figure for grazing for the pure-bred Aberdeen Angus, but somewhat lower (81%) for pure-bred Brahman.

Furthermore Rhoad found that cattle spent some 19% of their time resting in the sun and never sought the shade, while temperate breeds always did. On hot, sunny days without wind, resulting in trying conditions for cattle, Aberdeen Angus spent only 54% of the time grazing and the rest of the time in the shade. Pure-bred Brahman grazed 71% of the time, and when it rested it did so only in the sun. Bradbury (1949) in Trinidad noticed that pure-bred Nellore Zebus continued to graze contentedly in the heat of the sun, while pure-bred and cross-bred temperate breeds had all found the shade.

Payne et al (1951) in Fiji did grazing behaviour observations with six selected grade Friesians with the same productivity, and made five minute interval observations for twelve 24 hour periods. They made these observations at approximately one month intervals, and found that the grazing behaviour did not vary widely from cow to cow or from month to month. They found that 67% of the total grazing time was at night, and that the total grazing time fell during the hot months, and suggest that it might be due to the diminution of length of day grazing. This seems doubtful though as it is more likely to be a physiological effect of the high temperature on the metabolism of the cows. They do however conclude that it is dangerous to apply techniques of management of temperate zones to tropical areas. They also said that dairy cattle should be placed in the best pastures at night and early morning, and that they require shady paddocks for daytime grazing. This however does not seem to follow from the findings which are that the highest grazing peak is just after afternoon

milking which ends at 4.30 p.m. and that practically no grazing takes place after 3 a.m. till after morning milking, after which they graze intermittently till 1 p.m.

Seath and Millar (1951) recommend that cows should be on the very best pasture during the forenoon if they are to become filled before the heat of the day forces them to seek shade. If there is a choice of fair and excellent pasture, he states that they should have the fair pasture at night when they can spend more time grazing their fill. Castle et al (1950) and Hancock (1950) found that the longest grazing periods occur immediately after morning and evening milkings, and this does appear to be a general rule.

Both Payne et al (1951) and Seath and Millar (1946) conclude that the main effect of high maximum temperature is to cause cows to spend approximately 30% less of their total grazing time between milking in the daytime than they do in temperate climates. This applies to temperate or grade animals in the Tropics, and unfortunately no work has been done with cows of tropical or mainly tropical blood.

IV. OBJECTS.

1. To study the grazing habits of a herd of 14 Nellore Zebu cows on Savannah grass pasture (*axonopus compressers*) under the conditions prevailing at the Government Stock Farm in Trinidad.
2. To determine whether there is a difference in grazing habits during wet and dry seasons.
3. To determine whether there is a difference in grazing habits on days of full moon, and on days of new moon.
4. To determine the patterns of grazing behaviour of Zebu cows under different treatments (Season, intensity of moonlight) and to compare them with those of a herd of eight cross-bred Holstein Zebu cows watched on elephant grass pastures (*Pennisetum Purpureum*) at the New Farm, I.C.T.A.
5. To find as far as possible, what effect climate has on the grazing behaviour of Zebu cows as compared with the effect on cross- bred cows.

IV. DESIGN.

A herd of fourteen Nellare Zebu cows were observed on the Government Stock Farm, St. Joseph, though in the original design only eight cows were to be watched. Alterations in the design had to be made because of being unable to differentiate the animals at night without undue disturbance. As a result of this it was impossible to record individual behaviour at night, and the difference in behaviour between animals was not taken into account in the analysis, though differences during the day were recorded.

These cows were watched over eight 24 hour periods between November, 1952 and March, 1953. Four of the periods were in the dry season and four in the wet season, four took place during full moon and four during new moon. The treatments were therefore as follows:-

- (1) Wet season, moonlight nights
- (2) Wet season, dark nights
- (3) Dry season, moonlight nights
- (4) Dry season, dark nights

Each treatment was replicated once.

A split plot design was used with four main plots, eight sub-plots and eighty-eight sub-sub plots, diagrammatically as follows:-

		Wet		Dry	
		Full Moon	New Moon	Full Moon	New Moon
Replication (1)					
Replication (2)					

Eleven 2 hour periods for each treatment.

ditto

The cattle were fed concentrates (about half a pound per head) from 7.30 to 9.30 each morning, so there was one sub-sub plot less during the day, making it five periods during the day, six during the night, and eleven in all. Observations commenced at 9.30 a.m. each day and continued till 7.30 a.m. the next morning.

As regards direct treatment effects, comparison could therefore be made between seasons, between night light intensities, and the interaction between the two. Further, comparisons could be made between 2 hour periods,, two hours having been chosen as it is a convenient minimum period of time for cows to be moved onto or off a pasture. If for instance half hour periods had been used, more accurate results might have been obtained in that they graze significantly more in one half hour than the next, but it would not have been of much practical significance. Interactions between periods and the two treatments, and the second order interaction of periods and the treatments would be analysed.

Originally it was intended to determine the effect of different pastures on the grazing habits e.g. fresh and used pasture, but unfortunately it was not possible to alter the pastures and consequently all the observations were made using permanent savannah grass (*axonopus compressus*) pastures. This grass has a very low feeding value and the amount of time spent grazing would probably have been somewhat less had the experiment taken place on good pastures. These animals did no work however, and produced nothing, so they could probably get their maintenance requirements from the pasture in the wet season without having to spend much more time grazing than they would have on good pastures.

Only one pasture on the Government Stock Farm was used, and this constituted about twelve acres of Savannah grass which was fairly heavily infested with *Mimosa Pudica* in parts. A number of Samaan trees provided adequate shade, and on the whole the pasture was well sheltered from winds, and therefore was inclined to become relatively hot during days of intense sunshine. Adequate water was available in the form of a trough of water in the middle of the field.

During the dry season, the pasture showed signs of overgrazing much more than in the wet season, which was reflected in the way the cows grazed, if not in the length of time they spent grazing. It appeared that they spent a good deal of time obtaining very little food, and they spent a lot of time grazing in lower more damp portions of the field and on the sides and bottoms of drains where there was slightly more grass. Even this ran short when it was very dry, and cows were even seen to chew at sensitive plants (*Mimosa Pudica*).

The cows used were a fairly homogeneous herd of white-haired Zebus consisting mainly of Mysore, Nellore and Guzerat Zebu purebreds and Zebu foundation ($3\frac{1}{2}$ Bostaurus and less.) The Zebus which were introduced twenty-five and more years ago as draft animals from India, have since been superceded by Water Buffalo and up to now only been used to cross with European breeds to obtain better adaptability in half-breds and grades. In the near future these animals will probably be replaced by wild breeds from India and it was rather unfortunate that in this experiment no indication of the effect of the pasture on the animals in the form of liveweight gains, or milk production could be obtained. "The out put of animal production proves the best yardstick of grazing performance, and feed intake data is very desirable". Hancock (1953). However, animals would first have to be watched individually over a 24-hour period for production records to be of value, and the work involved in obtaining feed intake data would not be justified with present state of animal and pasture management in the Tropics.

Finally, some smaller drawbacks in the design of this experiment were:

- (a) That the periods from 17.30 to 19.30 and from 5.30 to 7.30 were always partly day and partly night. The greatest difference in length of day between December and March is 48 minutes or 24 minutes in each of these periods. On the average however, of the 17.30 - 19.30 period, 30 minutes were light and in the 5.30 - 7.30 period, 90 minutes were light, so the former period was treated as a dark period, and the latter as a light period.
- (b) Unfortunately the times of the seasons in which the observations were made were not typically representative. The end of the wet season was not particularly wet, and furthermore was somewhat prolonged so that observations in the earlier part of the dry season were still in the wet season so to speak. This drawback was not foreseeable though if time had allowed the observations might have been made in the middle of each respective season. The observations not having been in clear cut seasons, might account partly for the differences in length of grazing in different seasons being so insignificant. The main reason for the insignificance is insufficient replications, and will be referred to in the statistical analysis.

V. METHOD.

The method used in doing observations in this experiment were as far as possible the methods found most sound by workers in other countries. The method of recording used was that of discontinuous observation, on recording the particular activity of the animal at definite time intervals, in this case five minute intervals. As cattle do not change their activities very frequently, not much error is likely to occur as in a one hour period of grazing the maximum error could be ten minutes, five minutes or just under, at the beginning and at the end, and over a large number of observations this error should cancel itself out.

It therefore, boils down to continuous observation, which in itself can be tedious to the observer if he has to observe the exact duration of each activity of a number of cows at the same time. Furthermore Hancock in New Zealand has found statistically that observations at five minute intervals is very satisfactory. From anyone's point of view it does not cause undue fatigue, does not allow sufficient time to lapse for the observer to become bored or sleepy and yet give an accurate picture of the behaviour without losing undue activity. This method of observation has been used by Hancock (1950) in New Zealand and by Payne et al. in Fiji.

As it was impossible originally intended to observe the Zebu animals on different pastures, the number of days of observation to include all treatment combinations were reduced from eight to four. It was therefore, decided to replicate observations on each treatment once, so there were eight days of observation in all.

Observation of individual cows could not be done at night due to the nervous temperament of these animals, and it was also impossible to see whether they were cudding or idling. The activities of the whole herd were therefore recorded at night, that is each five minutes the number of cows grazing, lying or standing were recorded. Only eight cows activities were observed during the day, and the five activities, grazing, lying cudding, lying idling, standing cudding and standing idling were recorded. In grazing time was included short walks between bites, and in cudding time was included short rests between swallowing and regurgitation. The number of times of defecation and micturition were recorded as far as possible, though during the night it became impossible. The number of drinks were recorded too.

The five former activities, which for purposes of statistical analysis have been reduced to the three activities, grazing, standing and lying, are the most important for a preliminary experiment over a short period of time such as this one. It would certainly give future workers on animal behaviour under wet tropical conditions a definite picture of the cycle of grazing under these conditions. Somewhat more comprehensive observations, the most important of which being the distances walked would have been desirable however, and some method of identifying Zebus at night should be evolved.

In detailed experiments such as Hancock's observations on the distances walked, number of bites of grass, number of bolusses and number of bites per bolus were all recorded. In this experiment however, lack of materials and facilities did away with any possibility of detailed studies of grazing behaviour ^{the} in relation to/pasture, but at least it was possible here to use pasture which remained in approximately the same condition during any one season and varied with the season in a typical manner so although less detail was obtained, a possible variable factor was removed which simplified interpretation of other findings.

In the course of this experiment the animals were disturbed as little as possible and all disturbances were noted. During the day animals became used to the observers' presence and were not easily disturbed, but during the night a torch had to be used. On dark nights especially it had to be used merely to see whether animals were lying or standing and this always caused some disturbance as some cows would always look up and turn their heads if the torch was switched on for any length of time. Cows did however, become used to the light to some extent and would take less notice of it at the end of a period of watching. It furthermore seems evident that the change over periods at night - that is when the animals were for instance settling down to rest after a period of grazing, were sometimes considerably prolonged by the switching on and off of the torch each five minutes. It also quite frequently occurred that cows which were lying down and had got up due to some disturbance would start grazing, whereas they might have continued to lie down had they not been disturbed. Probably these effects did not have much effect on the overall grazing time, though possibly on the periodicity to slight extent.

VI. RESULTS.

(A) Statistical.

From the statistical analysis it is evident that there is no significant difference between the grazing behaviour of Zebu cattle during different seasons or during different phases of the moon, nor does the interaction of different phases of the moon on different seasons alter the grazing behaviour significantly. This applies to the three activities, grazing, standing and lying. The only vestige of significance is in the analysis of variance for lying, where there is considerably more lying in the wet season. This is probably because more time was spent wandering about looking for a bite of grass in the dry season.

There is however, in all three activities, a highly significant difference between 2-hour periods in the F-test, and in the case of grazing and lying, significance is evident in the interaction of periods and seasons that is the intensity of grazing and lying during certain periods, is altered with the change of season.

The "between periods" variant has been split up further into day periods, night periods, and day versus night so as to ascertain whether the proportion of variance between periods is evenly distributed or not. Furthermore the fact that the variance between periods is split up, will facilitate the interpretation of results.

When periods are split up in the case of grazing, by far the largest variance is between day and night, as F for day versus night is nearly 20 times as great as F for night, and nearly 7 times as great as F for day. The variance in all three terms is still highly significant however. As regards lying, the proportion of variance is distributed in approximately the same proportion, though the variance between day and night is not nearly so great. In the analysis of standing, there is no significant variance in the day, significant at 1% in the night, and again highly significant between day and night.

With regard to analysing period differences, the periods are set out as follows:-

TABLE I.

Period	Day				Night				Day		Day
	1	2	3	4	5	6	7	8	9	10	
Time	9.30- 11.30	11.30- 13.30	13.30- 15.30	15.30- 17.30	17.30- 19.30	19.30- 21.30	21.30- 23.30	23.30- 01.30	01.30- 03.30	03.30- 05.30	05.30- 07.30

"t-test".

In grazing during the day, periods 1, 3 and 4 are significantly greater than period 11 at .1% significance level. Period 4 is greater than 1 at 1%. In night grazing periods 5, 7 and 8 are greater than 6, 9 and 10 at .1%.

For lying, period 11 is greater than period 2 and both are greater than 1, 3 and 4 at .1% during the day. At night, periods 9 and 10 are greater than periods 5, 6, 7 and 8 at .1%. 7 is greater than 6 at 1% and 9 greater than 10 at 5%.

For standing there is no significance during the day, but at night period 6 is greater than 10 at .1%, greater than 9 at 1% and greater than 8 at 5%. In all three activities, differences between day and night are highly significant that is more grazing during the day, and more standing and lying during the night.

From the statistical analysis it is obvious that there are various clearly cut peaks of the various activities during a 24-hour period. The degree of difference between periods, or how far peak periods might overlap periods which have a much lower mean, can only be assessed from diagrams however.

When the t-test is applied to interactions which have shown significance in the F-test, it appears that the grazing in periods 5 and 8 has increased significantly at a 1% level with the onset of the dry season. In period 7 it has decreased at a 1% level. From Table No. II it is evident that more night grazing takes place during the dry season than during the wet season. The explanation of the above changes is that instead of one grazing peak during the night between 9.30 p.m. and 11.30 p.m., there are two peaks of night grazing in the dry season namely between 5.30 p.m. and again between 11.30 p.m. and 1.30 a.m. The former period is the tail end of the afternoon grazing, and sufficient to cause the midnight grazing period to be pushed on to the next period. This phenomenon is also shown on the graphs of daily grazing.

(5) OBSERVATIONAL

From Table 11 which are percentages computed from average grazing times, it is evident that there are slight differences in the activities of animals during different seasons, and during different phases of the moon.

TABLE 11

Activities expressed as percentage of average 24 hour day

	Percentage	Season		Interv. of Moonlight.		Whole Experiment.
		Wet	Dry	Moon	No Moon.	
Grazing.	of day	68.51	61.58	65.56	66.53	65.04
	of night	18.80	23.96	21.32	21.63	20.6
	of 24 hr. period.	40.54	41.06	40.69	40.90	40.8
Lying.	of day	20.60	26.14	22.82	23.93	22.8
	of night	51.85	37.42	44.69	44.57	44.6
	of 24 hr. period.	37.65	32.29	34.75	35.19	34.97
Standing.	of day	12.60	7.67	9.77	10.48	10.13
	of night	29.83	32.76	28.07	34.91	31.49
	of 24 hr. period.	22.0	21.56	19.75	23.81	21.78

7% more time is spent grazing during the day in the wet season and 5% more during the night in the dry season. This is no doubt due to the meteorological factors, and lower humidity at night during the dry season is probably the main reason. The meteorological data for the four treatments is set out in the table below:

TABLE 111

	Rain.		Hours of Sunshine.	Temp.		Humidity.	
	Total	Duration		Max.	Min.	8 a.m.	4 p.m.
Wet light	.5	.2	8.7	88	68	96	79
Wet dark	.16	.4	6.95	85.5	68.5	91.5	71
Dry light	.01	.3	7.5	84.5	68	86	68
Dry dark	.22	3.3	6.75	84	71	74	69

Over the 24 hour period however, there is virtually no difference between grazing time in different seasons. Reasons for this might be:

- (a) The wet season at the end of 1952 and the beginning of 1953, and the early part of the dry season in 1953 were not sharply divided.
- (b) That Zebu cattle do not increase their grazing time on pastures which have deteriorated due to seasonal effects.
- (c) That the pasture was so poor in the first instance, that during both the wet and the dry season they were grazing to their maximum physical capabilities.
- (d) That there were not sufficient replications of the treatments to bring out the differences.

The first and last possibilities seem to be the most feasible, as it did happen that the seasons were not clear cut at the time that the experiment took place, and if more replications had been made a more representative picture might have been obtained of the grazing times.

The second and third possibilities are merely vague possibilities, and it seems that it is fairly well established that cattle do graze more on pastures which are poorer in quantity and quality (Hancock(1953)). It is not very likely either that they were grazing to their maximum physical capabilities as their condition would have shown it had it been the case.

With regard to standing (cudding) and idling) there is 5% more during the wet season in the day, and 3% more during the dry season at night. Over the 24 hour period it was again much the same. The decreased amount of time spent standing during the day in the dry season is probably because there is considerably less grazing, which in turn is due climatic effects.

As regards lying, they spent more time lying in the day during the dry season, and at night during the wet season. Altogether, twice as much time was spent lying at night, and more during the wet than the dry season.

VII. DISCUSSION

It is obvious that there is a definite grazing cycle for Zebu cattle in Trinidad which did not vary greatly with the conditions under which this experiment took place. The conditions did not vary a great deal over the whole period however, and due to a low number of replications of the treatments, the seasonal effects were not borne out clearly. As for the effect of moonlight nights on grazing time, there seems to be none at all.

Most of the grazing takes place during the day, in contrast with findings of workers with cross-bred cattle under Tropical and sub-tropical conditions (Payne et al., 1952, Seath and Millar 1946). The first grazing peak during the day is immediately after coming into the pasture from the feeding stalls. This is^a fairly intensive grazing period but not as intensive as the afternoon period, which extends from about 1 p.m. till 6 p.m. There was always a period of rest at or soon after mid-day. This rest period was of varying length but all 14 cows were never all resting at the same time for longer than 30 minutes, and usually there was some grazing all the time.

During the night there was always some grazing, the first period being virtually an extension of the afternoon grazing period, and a period of grazing around midnight. The length of this period varied from 2 to 6 hours and the intensity of grazing was about half that of the afternoon grazing period. There was usually a short grazing period just after dawn.

The difference in the cycle of grazing of cross-bred cattle at the New Farm as compared with the Zebu cycle was quite marked and due mainly to temperature effect. In the grazing of the cross-breds, there was an average of half an hour per day less grazing per cow over the whole period. There was less grazing during the day, and more during the night than the Zebus and there were 4 grazing peaks, which were at different times to the Zebu's peaks except the midnight one.

The main peaks in cross-bred grazing were after the milking periods, but in the day there was about half as much grazing as the Zebus (from 10 a.m. to 4 p.m.). At night the Zebus grazed far less, though the midnight peak was of slightly higher intensity. The fourth grazing peak occurred just before milking but was of much lower intensity than the Zebus over the same period.

During the heat of the day, when the Zebus rested, they usually did it in the sun and would lie down to rest. The cross-breds on the other hand, would seek shade and if they were in a paddock without shade, would sooner

sooner/ stand and rest, presumable because it was easier for them to breathe when standing in the heat with an increased respiration rate.

Another feature of the Zebus grazing was that they kept together as a herd far more than the cross-breds and unless the grazing was very scarce, they always grazed together, especially at night. This applies to lying down to rest too. On the whole the temperament of the Zebus was different, and they were always on the alert and easily disturbed. The cross-breds on the other hand, were not easily disturbed, due probably to having had more handling.

A final small point of difference which was marked, was that the Zebus would scatter and look for shelter whenever it started to rain, while the cross-breds did not mind the rain and would go on grazing contentedly.

RECOMMENDATIONS:

It is highly possible that in grazing as in other aspects of animal behaviour, there is a series of gradations correlated with the climate or microclimate of the regions concerned. When studies of behaviour are undertaken therefore, more attention should be paid to these factors, and notes made thereof as the observations made will then be of more value to both workers in the same field in other countries, and to people who would like to apply recommendations made elsewhere.

As much importance should be attached to other environmental conditions under which the experiment took place, such as the type and size of pastures and the conditions during various stages of the experiment. The breed of cattle is also important as there are definitely differences in the grazing behaviour of different breeds, and intermediate type of behaviour in crosses. These differences, however, are mainly due to differences in heat tolerance, which further emphasizes the importance of noting the meteorological conditions. This applies mainly to work in tropical and sub-tropical regions, as temperatures of the range encountered in the temperate zones had little effect on the time or distribution of grazing time. (Hancock 1953).

With the increasing need of mixed farming practices in both the wet and dry tropics, and the increasing realization that the use of Zebu cattle for crossing or otherwise is essential, it is evident that more work will have to be done on grazing behaviour in the tropics. If comprehensive behaviour studies were done with a range of animals ranging from pure Zebu to 50% Zebu, under different tropical environments, it might be possible to be able to predict the extent to which animals will be able to alter their grazing habits to meet the requirements of a change to what might be an adverse tropical environment. This should assist people trying to breed animals better adapted to their environment, and also people who wish to introduce cattle from different environments.

SUMMARY.

- (1) There are three main peaks of grazing in the 24-hour grazing cycle of Zebu cattle. One in the morning, one in the afternoon and evening, and one at around midnight. The afternoon and evening period is the longest and most intensive.
- (2) There is no significant difference in the length of time spent grazing in different seasons. The afternoon grazing period is extended after dark in the dry season however, and the night grazing period is later, that is it is after midnight.
- (3) There is no statistically significant evidence that the length of grazing time or the periodicity is effected by moonlight nights in contrast with dark nights.
- (4) There is a difference in the periodicity and length of grazing time of Zebus and cross-breds under similar climatic conditions, but on different pastures. There are also differences in the general grazing behaviour of these two breeds, due to :
 - (a) Differences in temperament.
 - (b) Different effects of the climate.
 - (c) Different management.

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ANALYSIS OF VARIANCE

Variant	D.F.	Sums of Squares.			Mean Squared			F.		
		Grazing	Standing	Lying	Grazing	Standing	Lying.	Grazing	Standing	Lying.
Replications	1	2567.1	3335.0	13.6	2567.1	3335.0	13.6	4.55		
Seasons	1	22.3	15.2	2235.7	22.3	15.2	2235.7			8.9
Error (a)	1	1036.5	19738.6	286.3	1036.5	19738.6	286.3			
Total (main plots)	3	3625.9	5310.4	2535.6						
Light	1	3.6	1337.7	15.7	3.6	1337.7	15.7			
Light & Season	1	247.3	1447.5	117.4	247.3	1447.5	117.4			
Error (b)	2	645.6	4132.1	9656.0	322.7	2066.0	4328.0			
Total (sub-plots)	7	4532.4	12227.7	12324.4						
Periods	10	311990.5	54342.7	219755.5	31199.0	5434.3	21975.5	*** 41.379	*** 7.72	*** 31.98
Periods	(Seasons)	10	22535.7	5940.1	2253.5	594.0	673.3	** 2.988	2.08	2.34 *
	(Light)	10	4618.8	14673.8	461.8	1467.4	1607.8			
	(Season & Light.)	10	6980.1	11538.7	698.0	1153.9	1122.2		1.64	1.63
Error (c)	40	30159.2	28145.7	27481.4	753.98	703.6	687.0			
Total	87	380816.7	126868.7	293594.6						

ANALYSIS OF PERIOD VARIANTS

(a) GRAZING.

Variant	D.F.	S.S.	M.S.	F
Between Periods.	10	311,920.5	31,199.05	
Day	4	109,568.5	27,392.1	36.3
Night	5	43,452.3	8,665.4	11.5
Day vs Night	1	158,969.8	158,969.7	210.8
Error (b)	40	30,159.24	753.98	

(b) LYING.

Between Periods.	10	219,755.5	21,975.5	
Day	4	86,363.75	21,590.9	31.4
Night	5	97,034.18	19,406.8	28.2
Day vs Night	1	36,357.51	36,357.6	52.9
Error (b)	40	27,481.4	687.04	

(c) STANDING

Between Periods	10	54,342.7	5,434.3	
Day	4	871.06	217.76	
Night	5	16,789.78	3,357.95	4.7
Day vs Night	1	36,681.36	36,681.86	52.1
Error (b)	40	28,145.7	703.64	

ANALYSIS

F-Test: Where $n_1 = 1$ and $n_2 = 1$ $F @ 5\% =$

Where $n_1 = 1$ and $n_2 = 2$ $F @ 5\% =$

No significance.

Where $n_1 = 10$ and $n_2 = 40$ $F @$

{ $5\% = 2.09$
 $1\% = 2.82$
 $1\% = 3.93$

Significance in Periods for the three activities.

Significance in Periods & Seasons for grazing and lying.

T-test:

Standard Error of difference of 2 means of 4 plots.

$$\text{For Grazing} = \sqrt{\frac{753.98 \times 2}{4}} = 19.416$$

$$\text{For Standing} = \sqrt{\frac{703.64 \times 2}{4}} = 18.8$$

$$\text{For Lying} = \sqrt{\frac{687.04 \times 2}{4}} = 18.5$$

Standard Error of difference between 2 means of 8 plots:

$$\text{For Grazing} = \sqrt{\frac{753.98 \times 2}{8}} = 13.7$$

$$\text{For Standing} = \sqrt{\frac{703.64 \times 2}{8}} = 13.3$$

$$\text{For Lying} = \sqrt{\frac{687.04 \times 2}{8}} = 13.1$$

Where $n = 40$, $t @$ { $5\% = 2.021$
 $1\% = 2.704$
 $1\% = 3.552$

Therefore for significant differences between two means for the different items is as follows :-

For Periods.			For Interaction	
Grazing	@	{ $5\% = 26.5$	=	37.4
		{ $1\% = 35.4$	=	50.0
		{ $1\% = 46.5$	=	65.7
Standing.	@	{ $5\% = 26.88$	=	37.99
		{ $1\% = 35.96$	=	50.83
		{ $1\% = 47.24$	=	66.78
Lying	@	{ $5\% = 26.5$	=	37.4
		{ $1\% = 35.4$	=	50.0
		{ $1\% = 46.5$	=	65.7

Analysis of Period variances:

For $n = 40$ $t @ .1\% = 3.552$

Day vs Night

S.E. of difference of 1 mean of 40 plots and 1 mean of 48 plots.

$$(a) \quad \text{Grazing:} \quad = \quad \frac{753.98}{40} + \frac{753.98}{48}$$

$$= 5.88$$

$$\text{Sig. diff. @ } 1\% \quad = 20.89$$

$$(b) \quad \text{Standing} \quad = \quad \frac{703.64}{40} + \frac{703.64}{48}$$

$$= 5.679$$

$$\text{Sig.diff. @ } 1\% \quad = 20.172$$

$$(c) \quad \text{Lying} \quad = \quad \frac{687.04}{40} + \frac{687.04}{48}$$

$$= 5.611$$

$$\text{Sig.diff @ } 1\% \quad = 19.930$$

Totals.

	Day	Night.	Difference.
Grazing.	4995.6	1897.5	3098.1
Lying	1795.0	4113.4	2318.4
Standing	778.1	2902.0	2123.9

M E A N S

Periods

GRAZING:

	1	2	3	4	5	6	7	8	9	10	11
Periods.	147.1	95.0	161.3	183.3	57.7	15.1	77.9	71.1	10.9	4.6	37.8
Periods x Seasons.											
Wet	144.2	107.7	174.5	186.5	34.6	4.8	109.2	43.7	6.1	0	44.75
Dry	150.0	82.3	143.0	180.0	80.8	25.25	46.5	98.4	15.7	9.2	30.90
Diff's					-46.2		+62.7	-54.7			

LYING:

Period.	8.7	73.6	18.1	1.25	36.3	76.7	48.1	62.6	128.4	162.1	122.6
Period x Season											
Wet	9.8	63.2	5.3	1.5	48.5	90.8	37.6	87.7	149.0	183.9	118.0
Dry	7.8	84.0	3.1	1.0	24.2	62.6	58.7	37.5	107.8	140.4	127.2
Diff's								+50.2	+41.2	+43.5	

STANDING:

Periods.	17.6	20.1	11.6	17.6	76.6	87.6	65.5	57.2	42.8	33.0	25.2
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Note: All figures are in 5 minute units.

Results from t-tests applied to period differences

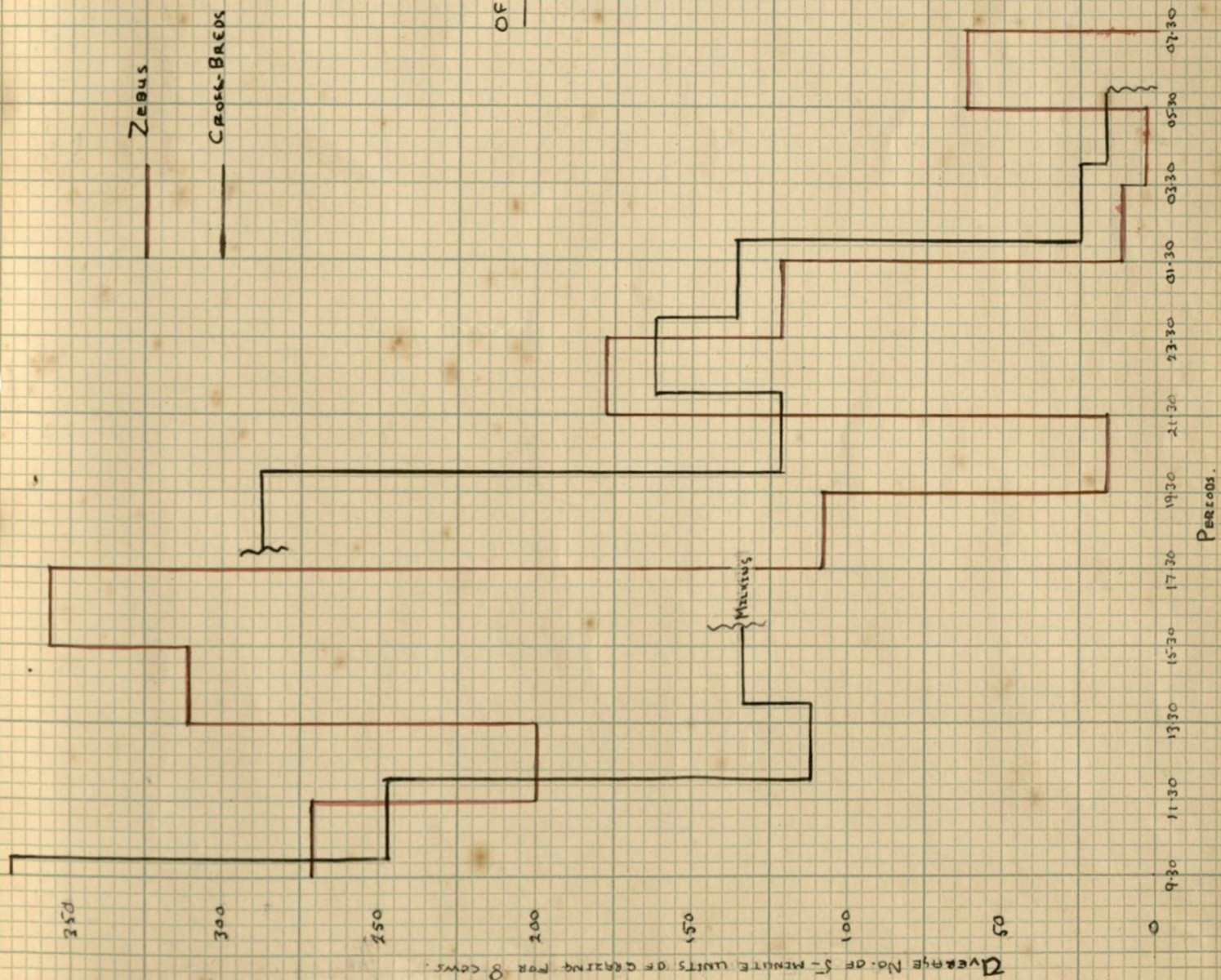
	Day	Night.
Grazing.	1,3,4 > 2 > 11 4 > 1	5,7,8 > 6,9,10
Lying	11 > 2 > 1,3,4	9,10 > 5,6,7,8 7 > 6 9 > 10
Standing.	No significant difference in day.	6 > 10 6 > 9 6 > 8

Interactions

Grazing : In periods 5 & 8 the grazing has increased significantly at a 1% level with the onset of the dry season. In period 7 it has decreased at a 1% level.

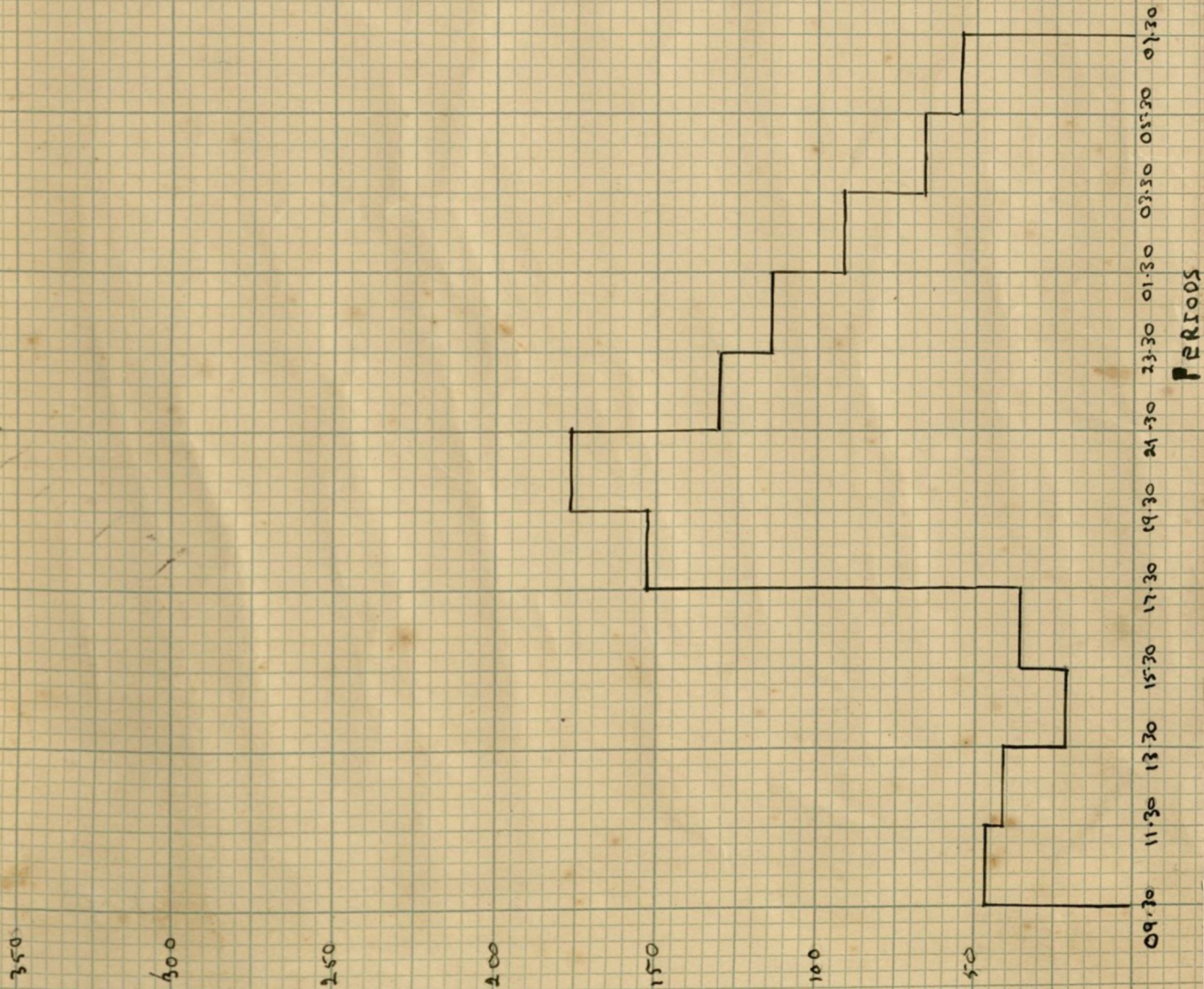
Lying: In periods 8, 9 & 10, the amount of lying has decreased significantly at a 5% level with the onset of the dry season.

APPENDIX (b)
A COMPARISON OF THE GRAZING CYCLES
OF ZEBU AND CROSS-BRED COWS.



APPENDIX (C)

CYCLE OF STANDING



Appendix (d)

Cycle of Lying

