FACTORS INFLUENCING INTAKE OF STEERS GRAZING ASIATIC BLUESTEM (BOTHRIOCHLOA) PASTURES

By

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CHAPTER I

INTRODUCTION

Forages form an integral part of the diet of ruminant livestock, and in many parts of the world are the only source of feed for production of meat, milk, and fiber. Production is keyed closely to the intake of nutrients, primarily energy, when forages are concerned. Several factors such as fragility, rate of passage of undigested residues, and rate of digestion influence intake of forages under pasture feeding conditions. Additional factors are important under grazing conditions, especially the manner (structure) in which the forage is presented to the animal. Some of the factors may be mitigated by behavioral changes.

The purposes of this study were: 1. to examine the effect of herbage mass on the intake, bite size, and behavior of steers, grazing on improved pasture, at two times during the year; and 2. to evaluate the effects of sward structure, to include the leaf to stem ratio of live and dead plant material, on these factors.

CHAPTER II

MATERIALS AND METHODS

Two intake and eating behavior trials with two forage varieties, four pastures per variety, and four animals per pasture were conducted. Each trial consisted of two collection periods of six days duration, one for each variety.

Pastures

Four pastures (approximately 0.8 ha each) were planted to Caucasian bluestem (*Bothriochloa caucasica*) in 1979 and four were planted to Plains bluestem (*Bothriochloa ischaemum*) in 1978. Four different grazing intensities were imposed on each variety to provide target levels of herbage mass ranging from scarce to abundant. Put and take animals were removed, or added, as necessary to maintain desired herbage levels. Herbage levels varied somewhat through the season in each pasture (Tables 1 and 2).

Pastures were situated on Dale silt loam. All received 84 kg N ha^{-1} in the spring prior to the start of forage growth.

Herbage mass and sward height were measured at frequent intervals throughout the growing season. Six 0.1 m^2

TABLE 1. HERBAGE MASS (KILOGRAMS PER HECTARE)

Date	Caucasian				Plains			
	Level 1	Level 2	Level 3	Level 4	Level 1	Level 2	Level 3	Level 4
June 28, 1982	4113	5448	3898	8378	2703	4753	3750	4475
July 15, 1982					2797	2707	2908	5698
July 20, 1982					1748	1713	2808	5605
July 22, 1982	2508	2852	2447	8230				
July 25, 1982					2430	2530	3060	4480
July 26, 1982	2260	2890	2960	7614				
July 28, 1982					2600	2700	2540	7800
August 2, 1982	2420	2090	1820	5470				
August 6, 1982	1038	1720	2058	3693	1707	2358	1817	4165
August 13, 1982	835	1835	1538	4127	1540	1783	1182	4225
August 20, 1982	1045	2098	1770	3015	1390	2147	1707	5575
August 28, 1982	1005	2327	1432	3168	1312	1282	1375	3145
September 3, 1982	1000	1848	1667	3852	1500	1755	1652	4430
September 10, 1982	1095	1615	1550	4750*	1330	1657	1768	4015
September 17, 1982	1510	2012	1362	10472	1142	2133	2165	4803
September 24, 1982	1042	1672	1222	5860	1230	2005	1768	4440
October 1, 1982					1975	3033	1738	3507

*Changed pasture to maintain appropriate levels of herbage mass.

TABLE 2. SWARD HEIGHT (CENTIMETERS)

Date	Caucasian Level 1	Caucasian Level 2	Caucasian Level 3	Caucasian Level 4	Plains Level 1	Plains Level 2	Plains Level 3	Plains Level 4
June 28, 1982	26.28	18.94	22.64	37.55	10.23	53.32	28.70	32.84
July 9, 1982					12.93	12.97	18.75	13.66
July 15, 1982					11.39	12.64	14.85	40.59
July 20, 1982					9.41	12.54	13.47	41.91
July 22, 1982	12.07	14.47	14.28	37.04				
July 25, 1982					9.52	11.09	11.11	51.66
July 26, 1982	10.4	13.28	9.82	44.06				
July 28, 1982					7.67	9.47	11.39	51.70
August 2, 1982	11.46	13.55	15.07	31.13				
August 6, 1982	7.20	12.07	10.34	27.56	13.08	9.47	9.63	50.76
August 13, 1982	8.78	12.88	15.53	21.91	10.98	10.68	11.55	39.26
August 20, 1982	8.93	10.05	11.98	18.27	8.78	9.48	8.40	27.68
August 28, 1982	9.20	11.18	11.98	19.02	7.03	9.72	8.63	26.77
September 3, 1982	7.83	9.72	9.08	19.14	6.39	9.92	9.82	30.83
September 10, 1982	6.50	8.70	9.77	34.80*	5.60	9.50	11.80	21.10
September 17, 1982	6.85	8.72	10.64	36.06	5.72	13.71	16.33	22.87
September 24, 1982	6.26	9.77	8.01	38.05	6.09	11.63	11.16	22.53
October 1, 1982					6.61	13.74	10.16	10.27

*Changed pasture to maintain appropriate levels of herbage mass.

quadrats were clipped to crown level and the collected herbage was oven dried at 65 C to obtain mass measurements. Herbage height measurements were made at 60 locations per pasture.

At the beginning of each collection period samples were clipped to crown level adjacent to the herbage mass quadrat in each pasture and the collected herbage separated into dead and live, leaf, stem, and flower.

Animals

Eighty-one steers, of mixed breeding, weighing 200 to 250 kg were used. Hereford and Hereford-Angus cross were the predominant types. Prior to the experiment, all steers were branded and inoculated against blackleg, hamophilous, and red nose.

Following initial processing four steers were randomly assigned to each pasture as tester, or experimental, animals. The remaining steers were assigned as grazers to maintain the desired level of herbage mass. During the peak forage production period (June), an additional 61 steers were used to reduce accumulated growth to desired levels.

All of the tester animals were shrunk 16 hours and weighed initially; and at intervals, without shrink, during the study. Two intake trials, consisting of six day collection periods were conducted. The two varieties were sampled in subsequent weeks during each trial. Prior to, and immediately following, each collection period the tester animals were weighed unshrunk.

In the first trial, $YbCl_3$ was dissolved in demineralized water and the resultant solution applied to forage collected from the pastures being used in the trial. To provide five to ten grams of Yb for the dose, 100 grams of forage was soaked in a solution containing 13 grams of $YbCl_3$ and 500 ml of distilled H_2O. After rinsing and air drying, 100 grams ($\pm$10 g) of the labeled forage was weighed out and placed in gelatin capsules. The remaining sample was ground to pass a 1.0 mm screen, bottled, and set aside for analysis.

Due to the excessive number of capsules (15 to 20) an alternate method of Yb administration was attempted in trial number two. Instead of coarsely chopped forage, the forage to be labeled was ground in a Wiley mill to pass through a 1 mm screen. Then one kg was saturated with a solution of 500 ml of distilled H_2O with 400 g of $YbCl_3$. After being allowed to equilibrate, the solution was poured off and the labeled forage air dried. Approximately 10 g was placed into each of sixty capsules with a Yb content of 1.5 to 2.5 g each. Each capsule was tared and weighed after filling to determine exact dose. These capsules were dosed at the rate of three (3) on the Caucasian pastures and two (2) on the Plains.

Observations and Collections

The following observations and collections were made during each trial. Fecal grab samples were taken at approximately 12, 18, 24, 36, 42, 48, 60, 72, 96, 120 and 144 hours post dose. In trial two the sample at 144 hours was deleted and an additional sample was taken to provide a sample interval of 12, 16, 20, and 24 hours on the first day. Elapsed grazing time was measured using an eight day Kienzle Vibracorder (Stobbs, 1970; Hodgson, 1982). The 20 bite method of Hodgson (1982) was used to determine rate of biting. Observations were made on four days, a.m. and p.m. each day.

Six steers were fitted with esophageal fistulas (Church, 1969; Stobbs, 1973a; and Hodgson, 1982) and used to obtain samples for diet quality estimates. Four samples were collected from each pasture during the intake trials. The methods utilized by Stobbs (1973a), Forbes (1981), and Hodgson (1982) formed the basis for collection procedures. The process was modified in that a sponge rubber plug in the lower esophogus was not utilized. This modification was made after problems were encountered in placing the plugs and in preventing regurgitation of the plug, along with rumen contents, during sample collection.

Sample Processing

Fecal Samples

Fecal samples were oven dried at 65 C, ground to pass through a 20 mesh screen and stored in plastic bags. Dry matter (DM) and organic matter (OM) were determined (AOAC, 1975). A 200 mg sample was weighed into a 50 ml centrifuge tube and 20 ml of ((Carboxymethyl)imino) bis-(ethyleneitrilo)) tetraacetic acid (DTPA) solution was added (Hart, 1981). The tubes were shaken for 30 minutes, supernatant collected under filtration and analyzed by atomic absorption spectrophotometry for Ytterbium (Yb) content. Standards were prepared from blank fecal samples and were used to establish a conversion scale from absorbance to concentration, in parts per million (ppm).

Fecal samples were then composited, within animal, and the composited sample was analyzed for dry matter (DM), organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF), and permanganate lignin (LIG). The analysis consisted of a modified Van Soest (1967) procedure in that an automatic reflux, filtering, and washing process was utilized.

Ytterbium concentration of the feces and labeled forage was determined by atomic absorption utilizing an NO_2 flame. The wavelength was set at 398.6 mm and the photomultiplier at 50. Flow rates of the gases were 42 for both NO_2 and acetylene. Standards were established by using feces in a

DTPA dilution mix adjusted to a desired concentration of Yb. The levels utilized were 0 ppm, 5 ppm, 10 ppm, 15 ppm, 20 ppm, and 40 ppm $YbCl_3$. The standards were read followed by 48 unknowns and a repeat of the standards. This procedure was repeated until the 176 unknowns of a given collection period were read. Ending standards were then read so that the absorption values associated with known concentrations could be used to determine the unknown concentration from the sample absorbtions.

Diet Samples

The four diet samples per pasture were collected via esophageal fistula during each trial. Each esophageal extrusa sample was freeze dried, ground to pass through a 1.0 mm screen and analyzed for DM, OM, NDF, ADF, LIG, and SIL. The same procedures as those used in the composite fecal analysis were used. In vitro organic matter disappearance was conducted using a modified Tilley and Terry (1963) procedure. Modifications were: the use of two animals to supply the rumen fluid after which equal parts were combined, samples were not dried prior to digestion, all samples were digested in duplicate.

Forage Samples

At the start of each collection period, six 0.1 m^2 quadrats were clipped to crown level and the collected forage frozen at -20 C. The frozen samples were later thawed and separated into live or dead; leaf, stem, and flower (Table 3). The fractions were dried and weighed.

The various fractions for a given pasture were composited within the groups noted above. These composite samples were then analyzed for DM, OM, ADF, NDF, and lignin (Goering and Van Soest, 1970).

The concentration of the marker in the feces over time, post dose, represented a classic fecal excretion curve, Figure 1, as described by Ellis et al. (1979) and Mader (1981). This curve is the result of a time dependent process.

A two compartment model has been constructed, based on this mechanism, utilizing a nonlinear mathematical analysis. This model, known as the Ellis Gamma time dependent model, Ellis et al. (1977), utilize the time dependent function between the first and second compartments (G_1). A time independent fraction, Mader (1981), for exiting the compartment (G_2) and lag (L) factor representing the time it takes to clear the rest of the tract. An estimate is made of the rumen concentration of the marker at time zero (C) and assigned a 0.95 asymtotic confidence interval. Figure 2, from Ellis et al. (1979) and Mader (1981), graphically illustrates the model. The equation, from Ellis et al. (1979), is as follows:

TABLE 3. SWARD CHARACTERISTICS (PERCENT)

Plant Part	Level 1	Level 2	Level 3	Level 4
	Trial 1 - Caucasian			
Green Leaf	19.41± 7.31	29.64± 5.22	22.85± 6.01	25.99±12.88
Dead Leaf	20.37± 5.62	17.62± 8.01	23.66± 8.23	10.38± 2.14
Green Stem	14.41± 6.23	25.34± 4.92	20.33± 9.22	43.60±16.24
Dead Stem	45.81±11.02	27.40± 4.34	33.16± 6.52	19.69± 6.38
Green Flower				0.27± 0.27
Dead Flower				0.07± 0.32
	Trial 1 - Plains			
Green Leaf	25.34± 5.44	15.43± 3.20	18.60± 6.92	34.92± 6.09
Dead Leaf	16.39± 8.13	23.85± 4.63	21.89± 5.91	14.84± 2.79
Green Stem	22.89± 2.75	20.43± 8.34	19.19± 8.09	40.39± 5.52
Dead Stem	35.38±10.87	40.29±11.61	39.25±17.17	8.45± 5.62
Green Flower			1.07	1.17± 1.96
Dead Flower				0.23

TABLE 3. (Continued)

Plant Part	Trial 2 - Caucasian Level 1	Level 2	Level 3	Level 4
Green Leaf	24.08± 8.74	16.73± 7.96	15.97± 6.40	17.87± 5.24
Dead Leaf	14.87± 5.13	20.38± 4.95	19.90± 4.29	18.73± 6.01
Green Stem	18.43±10.04	20.19± 7.92	16.86± 4.86	22.41± 7.41
Dead Stem	42.42±14.35	41.69±15.73	46.76±12.97	40.53±11.97
Green Flower	0.10	0.20	0.29± 0.53	0.37± 0.61
Dead Flower	0.10		0.22	0.09
	Trial 2 - Plains			
Green Leaf	17.57± 5.02	19.73± 3.87	19.26± 7.35	6.32± 2.81
Dead Leaf	25.87± 6.86	18.75± 5.74	16.60± 9.45	20.20± 1.73
Green Stem	21.05± 6.18	22.28± 5.30	25.44±10.73	17.85±11.86
Dead Stem	35.51± 9.47	38.49± 6.87	35.84±12.94	54.98±12.12
Green Flower		0.75± 0.56	2.86± 3.80	0.36± 0.19
Dead Flower				0.29± 0.08

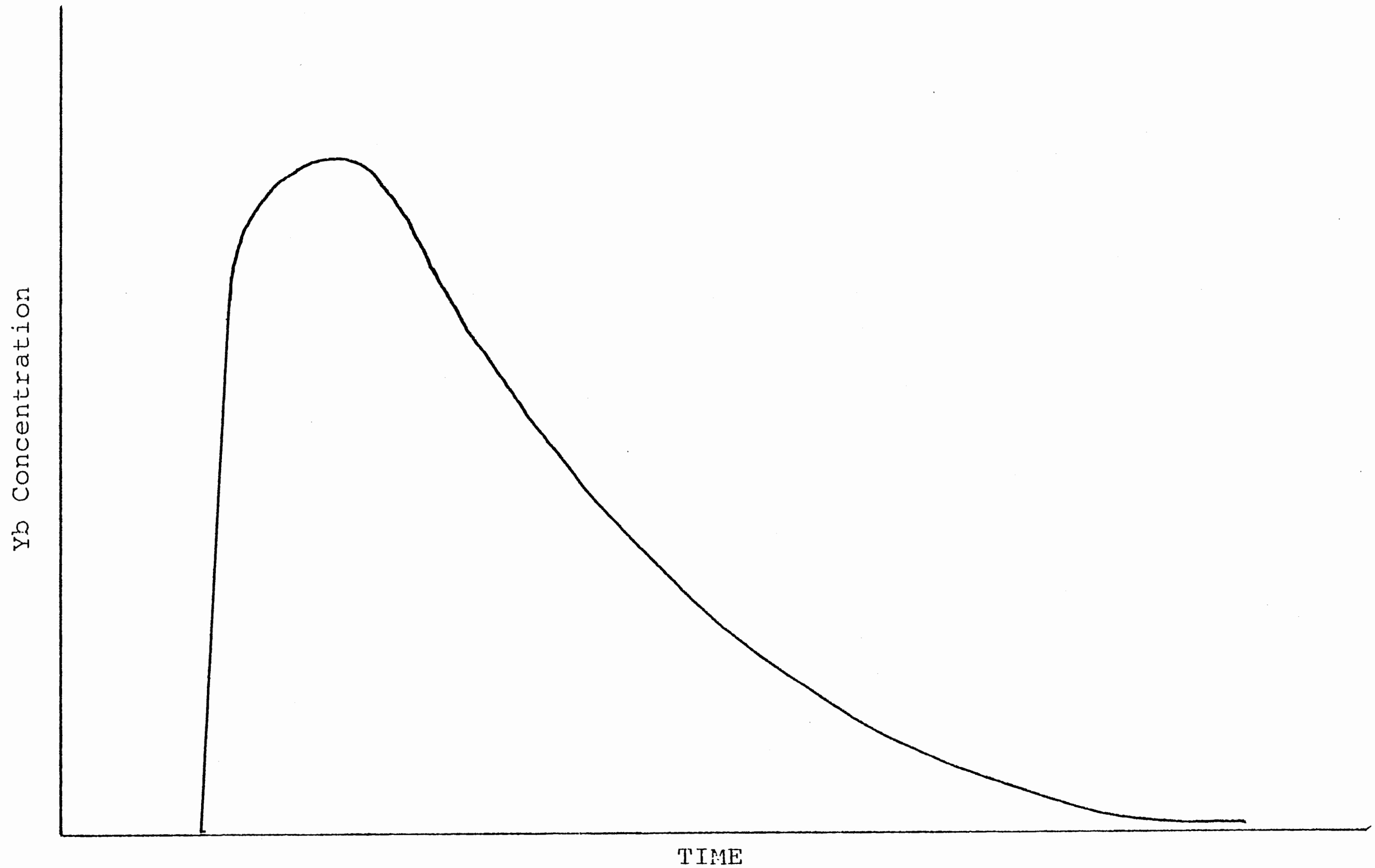

Figure 1. Fecal Concentration Curve (from Mader, 1981)

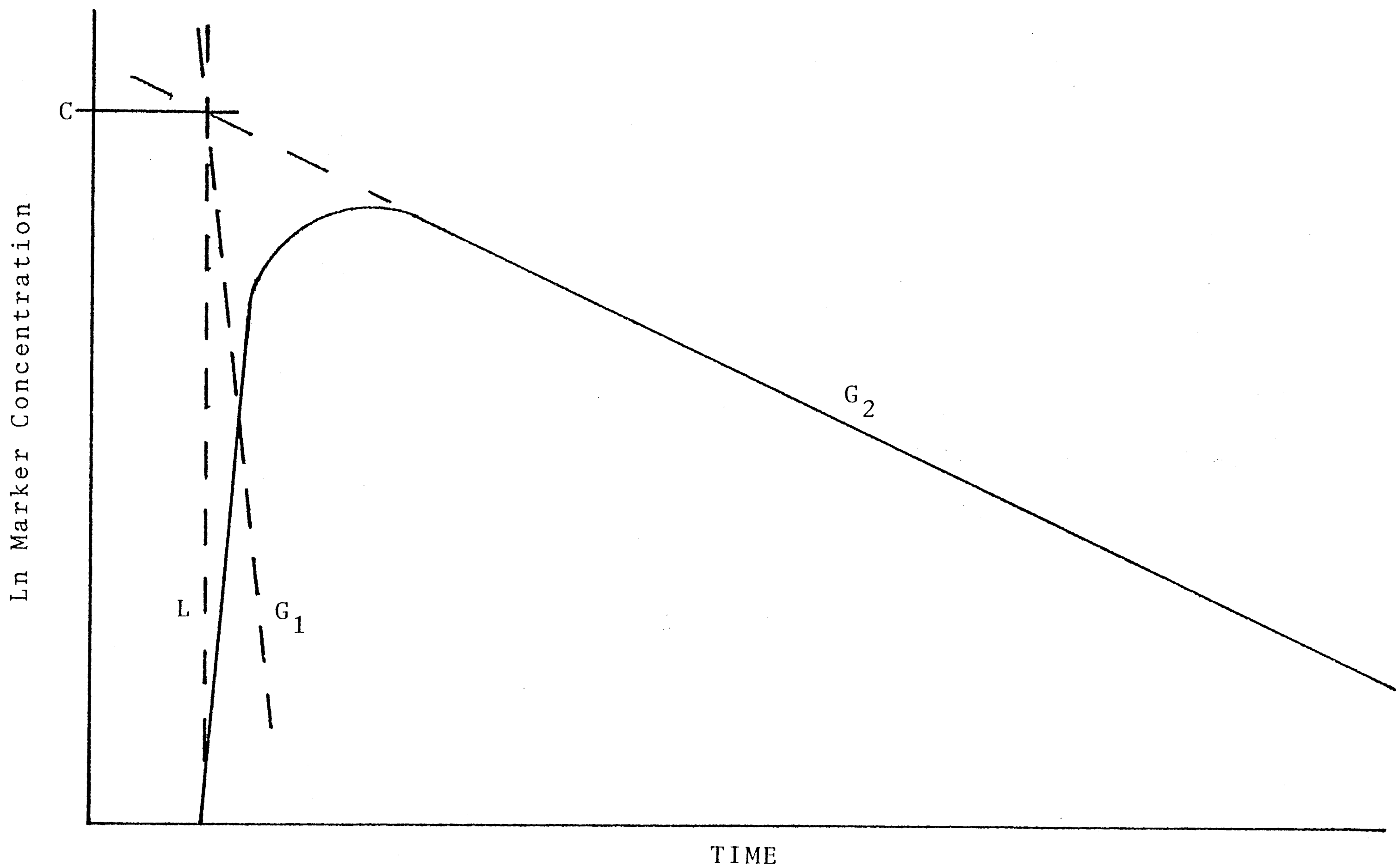

Figure 2. Natural Logarithm (Ln) of Marker Concentration of the Fecal Excretion Curve

```
      P = EXP (-G1*(T-L))

      Q = EXP (-G2*(T-L))

      K = G1/(G2 - G1)

Model Y = C*(P*(G1*K*(T-L) - K*K) + Q *K*K)
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CHAPTER III

REVIEW OF LITERATURE

Introduction

The intake and grazing behavior of grazing animals is dictated by the amount, height, and composition of the sward being grazed. Grazing behavior can have considerable impact on productivity as it can have a marked impact on intake. This review will look at sward composition and mass, rate of intake, grazing behavior, and a model used to describe the relationship between the animal and the sward being grazed.

Sward Composition and Mass

Woodward (1936) conducted one of the first studies directed toward sward composition and its effect on an animal's intake. He found that producing dairy animals, grazing improved rye grass pastures, required a minimum of 560 kg of forage dry matter per hectare to maintain adequate intake. This was observed on lush forage with a dry matter content of 20% clipped to one inch above ground level. It was also observed that, in one day, the animal would graze 2.43% of the grass on one hectare of land.

Herbage mass is the dry matter, or organic matter weight, of herbage per unit area (Hodgson, 1977; Gibb and Treacher, 1978; Hodgson and Jamieson, 1981; Forbes, 1982). Gibb and Treacher (1978) also used herbage allowance which is the amount of herbage per kilogram of animal live weight per day. Both of these measurements have their application and will be discussed further.

The effects of herbage mass on intake are well documented (Langlands and Bennett, 1973; Hodgson, 1976; Hodgson, 1977; Hodgson, 1981; Hodgson, 1982; Reardon, 1977; Combellas and Hodgson, 1979; Hodgson and Jamieson, 1981; Forbes, 1982). These are different studies which are in general agreement as to the restrictive effects low herbage mass has on intake. It was also noted by Combellas and Hodgson (1979) that very heavy swards may restrict intake when compared to somewhat lighter, though clearly adequate, swards. At lower sward levels (below 3000 kg ha^{-1}) Langlands and Bennet (1973) found that as the total herbage available decreased, organic matter intake also declined. Depending on the sward, and the time of the year, Hodgson (1977) noted that there is no clear cut level at which intakes decline. Rather, a broad range of herbage mass delineates the level below which intake declines at an increasing rate. This range, on temperate swards, is 1100 to 2800 kg DM ha^{-1}. Higher levels were observed on subtropical swards but no general limits were established. On high quality temperate swards grazed by sheep, 1200 kg ha^{-1} was the absolute lower limit, below which intake begins its asymptotic decline. These conclusions are at variance with Woodward (1936) and Johnstone-Wallace and Kennedy (1944) who reported this limit to be as low as 560 kg ha^{-1}. This is best explained by the increased sophistication of measurement techniques and analytical procedures plus differences in herbage collection in that Woodward did not clip to ground level.

Combellas and Hodgson (1979) noted that as herbage mass became greater, with weights above 4000 kg ha^{-1}, intake was lower than on swards with less herbage mass. This agrees in principle with the work on Van Der Klay (1956), Arnold (1964), Hodgson and Wilkenson (1967a), and Hodgson et al. (1977). Reardan (1977) suggests that the presence of more mature forage and the consequent increase in the ratio of stems to leaves (Stobbs, 1973a) in the sward is responsible for this decrease. It appears that the optimum level of herbage mass, to maximize intake, is in the range of 1100 to 2800 kg ha^{-1}.

Sward Structure

Surface characteristics, or average sward height, affect the grazing behavior and intake of livestock grazing temperate swards (Hodgson et al., 1977; Jamieson and Hodgson, 1979a,b; Hodgson, 1981; Hodgson, 1982; Forbes, 1982). Digestibility of a sward decreases vertically as height increases (Stobbs, 1973a). Also, density of plant material decreases with height (Hodgson and Wilkenson, 1968). Reduction in the grazing animal's intake has been observed and attributed to these factors.

Canopy composition, generally considered to be analogous to structure (Stobbs, 1973a,b) is possibly as important to intake and grazing behavior as herbage mass or height. Stobbs (1973b), Chacon and Stobbs (1976), Chacon et al. (1977), Hodgson (1977) and Hodgson (1982) all note that the amount of vegetative material (leaf) relative to stem greatly influences the intake of the grazing animal. Higher levels of stem in a pasture, or high levels of dead leaf and stem (Chacon et al., 1978) have a depressing effect on the intake of the grazing animal. This was also noted by Chacon and Stobbs (1976) and bulk fill was suggested as one of the factors limiting intake. Another factor in reduced intake may be the density of forage at the grazing level (Chacon and Stobbs, 1976). The higher you go vertically, the lower this density in kg ha^{-1} cm^{-1}. This causes the animal to cover a larger area in its procurement of feed and eventually intake declines (Johnstone-Wallace and Kennedy, 1944; and Woodward, 1936).

Grazing Behavior

Grazing behavior is associated with location, procurement, and ingestion of forage by the grazing animal (Tayler, 1953; Gary et al., 1970; Chacon and Stobbs, 1976a,b; Chacon et al., 1976). Grazing time (Allden, 1962;

Allden and Whittaker, 1970; Stobbs, 1970; Hodgson, 1982; Forbes, 1982), bite size, and biting rate (Allden and Whittaker, 1970; Stobbs, 1970; Stobbs, 1973b, Stobbs 1974; Chacon et al., 1976; Chacon et al., 1978; Hodgson, 1982; Forbes, 1982) were studied and related to sward characteristics. These components interrelate with the sward factors and each other to determine the intake of the animal.

Grazing Time

Grazing time can be an important delimiter dictating the leve of intake (Stobbs, 1970; Stobbs, 1973b; and Chacon and Stobbs, 1976). Hodgson (1977) noted that grazing time will increase up to 15% in response to declining herbage mass. At this point further declines in herbage mass result in lower intake. At very low tiller heights, five cm or less, corresponding to 700 kg DM ha^{-1} herbage mass the animal's grazing time decreases dramatically (Allden and Whittaker, 1970). An explanation for this decrease (Chacon and Stobbs, 1976) suggests that short tiller swards are low in percentage of leaf, and the slow rate of passage associated with stem and dead plant material results in high bulk fill, reduced intake, and a consequent reduction in grazing time. That nutrient quality is a factor as well is suggested by the animal's reaction when the rumen was partially emptied (Chacon and Stobbs, 1976). On a pasture which was high in stem content, but nutritionally adequate, the animal responded with increased grazing time. However, on short, low quality pastures, no subsequent increase in grazing occurred. Hodgson and Milne (1978) suggested that an increase in grazing time is a response to lowered organic matter intake (OMI), but that this increase is generally ineffective in maintaining a desired intake.

Bite Size

As herbage mass declines, Chacon and Stobbs (1976) and Hodgson (1982) noted a corresponding decrease in bite size. Stobbs (1973a,b) observed that changes in plant structure, leaf to stem ratio, and grazing horizon affect bite size. In the case of grazing horizon a low density of forage at the level where the animal is grazing will result in longer selection times, reduced bite size and an increase in grazing time. Another factor of importance is the amount of forage per unit area rather than per animal unit. Hodgson and Milne (1978) noted that as herbage mass per unit area decreased the animal must, of necessity, take smaller bites over a larger grazing area. However, a decrease in herbage mass per animal unit did not necessarily affect bite size. This observation agrees with those of Johnstone-Wallace and Kennedy (1944), Stobbs (1970), Whittaker (1970), Chacon and Stobbs (1976), Hodgson (1977), and Chacon et al. (1978).

Other factors which may affect bite size are sward structure (Hodgson, 1977), leaf to stem ratios (Chacon and

Stobbs, 1976) and horizon densities (Stobbs, 1973b; Stobbs, 1975). In the latter case it was noted that herbage density at the grazing level of less than 25 kg DM ha^{-1} cm^{-1} precipitated a decrease in bite size. This decrease in bite size was accompanied by a reduction in intake and a leveling off of the, to this point, increase in grazing time. Thus, it appears that 25 kg DM ha^{-1} cm^{-1} is that level where increased grazing time can no longer compensate for a reduction in bite size.

In an earlier study, devoted to measurement of grazing time, Stobbs (1970) observed that selectivity by the grazing animal also affected grazing time without modifying intake. On the other hand, increased intake was obtained at the expense of increased grazing time. Chacon and Stobbs (1976) further noted that the grazing animal selected approximately 80% vegetative matter (green leafy material) as it grazed pastures with greater than 3000 kg DM ha^{-1}. As the ratio of green leafy material decreased relative to stems and dead material, bite size decreased (Stobbs, 1974) due to selection. This is similar to the combination of two forage types in a pasture where one is highly preferred by the grazing animal. In a combined rye grass and red clover pasture Hodgson (1975) noted that as the ratio of clover to rye grass decreased, bite size also decreased and the animal spent more time selecting the more palatable species. A commensurate increase in grazing time was also noted.

Biting Rate

Biting rate is described by Forbes (1982) as the number of bites associated with a specified length of time (i.e., bites per minute). The bite, as described by Johnston-Wallace and Kennedy (1944) and Stobbs (1973a), includes various manipulative movements of the jaw and tongue in procuring the forage prior to harvesting it with the tearing action of the head movement. Biting rate varies considerably from sward to sward (Stobbs, 1973a,b; Jamieson and Hodgson, 1979). Thus, reliable estimates of the effect of a sward on biting rate cannot be based on observations of a sward composed of different species.

A confounding factor observed by Chacon et al. (1976) was the presence of observers in the plot. When observations are being made care must be taken not to interfere with the orderly grazing process. It was also noted that the time of day was a factor, as biting rates were significantly higher in the morning hours and day time rates were higher than night time rates. This is in general agreement with the findings of Stobbs (1974) and led him to conclude that grazing time measurements are less precise and of less value than biting rate.

One of the limiting factors in intake is the number of bites an animal can be reasonably expected to take in a day. It was observed by Jamieson and Hodgson (1979) that calves are limited to a maximum of 65 eating bites per minute and

36,700 eating bites per day. This is a little higher, but in general agreement with the findings of Stobbs (1973b). Some of the reasons suggested for the lower numbers reported by Stobbs were the older age of his animals and the tropical nature of the sward being studied.

If the number of bites necessary to maintain required intake levels is projected to higher levels, intake declines. It is thus apparent that bite rate is as much a factor in intake determination as are grazing time and bite size. A combination of all these factors, considered with the type of sward being grazed (Stobbs, 1973a) should make it possible to delineate those sward characteristics which control intake.

Estimating Intake of the Grazing Animal - Use of Markers

To establish the fecal concentration curve, forage, of the type being grazed, was labeled with the lanthanide rare earth, Ytterbium (Yb). Several factors must be considered when choosing a marker, all of which are adequately filled by Yb. Of primary importance is the ability of the marker to mimic the flow of ingested particulate matter (Ellis et al., 1979; Hart, 1981). Of equal importance is the binding affinity of the marker to the labeled particulate matter and the rate of expected migration to other, nonlabeled, particles in the rumenal environment. Other factors to be considered are the marker effects on carrier degradation and the management associated with administering the marker to the animal.

In studies conducted by Teeter (1981) it was observed that Yb mimics the flow of particulate digesta accurately. This was in agreement with Ellis et al. (1979), Mader (1981), and Hart (1981), particularly with forage studies. When feedstuffs with higher carbohydrate values were used, the accuracy of Yb as a marker declined. Teeter and Owens (1981) and Ellis et al. (1982) ascribed this to the lower binding affinity Yb has for carbohydrates as compared to high lignin and protein feeds. This lower affinity resulted in increased migration of the marker to rumenal fluids and unlabeled particulate digesta. Teeter (1981) suggests that some of this displaced Yb will bind to volatile fatty acids, or remain in the fluid medium, removed from the normal particulate flow. Additionally, migration and attachment to other particles may expidite or hinder passage from the reticulate rumen depending on the size of the particle. Once the marker has exited the rumen migration between particles will have little effect on the final results (Teeter, 1981).

In order to control the factors discussed above, Yb as a marker should be equilibrated with the labeled forage in a Yb saturated solution. Following equilibration the labeled forage should be thoroughly washed (Mader, 1981) to remove all surface and loosely attached Yb. This will result in a labeled marker which will dissociate at a rate of approximately 0.27% hr^{-1}, or 12% over 48 hours (Teeter, 1981). These rates were established through the use of in situ nylon bag studies and in vitro digestions, and are considered to be fairly constant for native grasses. This rate may vary slightly for other forages but not to any significant degree. Teeter (1981) suggest that more study is needed to pinpoint both the degree of migration and the effect this migration might have on the estimates of fecal output and intake derived from the use of Yb as a marker. However Ellis et al. (1979) feel that Yb, properly fixed as described above, accurately mimicked digestion throughout the tract.

CHAPTER IV

RESULTS AND DISCUSSION

Summary

Intake, grazing time, bite rate, and bite size were compared over a range of herbage masses of Asiatic bluestem pastures (Table 4). Thirty-two crossbred steers were allocated to eight pastures seeded to *Bothriochloa caucasica* or *B. ischaemum*. Four pastures of each variety were used with four animals allotted per pasture. Herbage mass and herbage height were controlled by varying grazing pressure to provide different levels of grazable material. Intake trials, consisting of one six-day collection period per variety, were conducted in July and September. Ytterbium (Yb) was used as a single dose pulse marker. Four esophogeal cannulated animals grazed each pasture and extrusa samples were collected to determine organic matter (OM) digestibility of the herbage being grazed. Grazing time was recorded using Kienzle vibracorders and bite rate was estimated visually. Bite size was calculated from intake, bite rate, and grazing time. Herbage mass, height, leaf to stem ratio, green to dead ratio, and sward density were measured. Daily OM intake, grazing time, bite rate,

TABLE 4. PASTURE AND ANIMAL RESPONSE VARIABLES

Herbage Mass (kg DM/ha)	Herbage Height (cm)	Intake (kg DM/ha)	Grazing Time (min/day)	Bite Rate (bites/min)	Bite Size (mg)	Leaf: Stem	Green: Dead	Green Density (kg DM/cm/ha)	Digest-ibility (IVOMD)
Trial 1 - Caucasian									
2396± 308	11.31±0.80	4.93±1.16	622± 43	43.8±2.6	181±40	0.66	0.51	73.5± 8.8	0.68±0.05
2475± 353	13.77±0.51	5.27±1.24	591±102	46.8±5.4	191±35	0.90	1.22	119.7±17.2	0.64±0.02
2544± 350	13.06±0.58	4.69±1.13	633± 48	44.6±1.7	166±43	0.87	0.76	130.1±17.9	0.59±0.02
7113± 742	37.41±2.21	4.98±1.57	528± 19	36.2±2.8	260±86	0.57	1.19	93.8± 9.8	0.66±0.01
Trial 1 - Plains									
2325± 304	10.10±0.58	5.03±1.19	584± 52	49.2±1.37	191±45	0.54	0.59	50.9± 6.7	0.68±0.02
2346± 327	12.10±1.08	3.20±1.75	624± 17	35.7±5.09	143±81	0.77	0.98	92.0±12.8	0.56±0.03
2925± 265	13.14±0.80	6.24±0.94	650± 25	42.5±5.57	226±57	0.73	0.54	73.6± 6.7	0.63±0.03
5261±1103	44.72±2.17	4.65±0.51	526± 42	42.2±4.87	209±30	1.05	3.60	104.7±21.9	0.66±0.03

TABLE 4 (Continued)

Herbage Mass (kg DM/ha)	Herbage Height (cm)	Intake (kg DM/ha)	Grazing Time (min/day)	Bite Rate (bites/min)	Bite Size (mg)	Leaf: Stem	Green: Dead	Green Density (kg DM/cm/ha)	Digest-ibility (IVOMD)
Trial 2 - Caucasian									
1302± 147	6.67±0.38	5.35±0.45	624±26	46.2±2.5	186±21	0.39	0.36	44.2± 5.0	0.61±0.03
1456± 346	10.21±0.40	4.37±0.74	556±17	44.3±2.4	177±33	0.47	0.43	47.7±11.3	0.60±0.05
1813± 165	8.71±0.67	4.63±0.88	599±58	46.7±3.1	166±23	0.62	0.56	66.9± 6.1	0.62±0.03
7613±1839	35.43±1.82	5.95±0.93	578±12	42.9±1.1	240±32	0.56	0.49	45.1±10.9	0.61±0.03
Trial 2 - Plains									
1186± 208	5.90±0.55	4.08±0.44	642±31	47.1±2.3	134±18	0.75	0.63	78.4±13.8	0.64±0.02
1966± 301	13.74±1.25	5.17±0.79	598±77	49.6±3.1	174±17	0.74	0.60	59.6± 9.1	0.66±0.02
2069± 221	12.67±1.48	4.94±0.82	592±35	50.9±2.5	164±30	0.64	0.75	74.3± 7.9	0.64±0.02
4622± 778	22.70±2.23	3.32±1.08	447±48	41.6±2.6	178±48	0.45	0.86	90.9±15.3	0.57±0.03

Mean of 18 samples taken during the collection period.

OM intake, grazing time, bite rate, and bite size were regressed on herbage mass, height, density, leaf to stem ratio, and green to dead ratio. Pastures were the experimental unit. Intake was not affected by the five pasture and herbage characteristics. However, NDF and IVOMD of the grazed forage were related to intake ($P<0.05$ and $P<0.10$, respectively), with intake decreasing as digestibility decreased. Grazing time and biting rate decreased as mass ($P<0.025$) or height ($P<0.05$) increased, whereas bite size increased as mass ($P<0.001$) and height increased ($P<0.001$). As the green to dead ratio increased, grazing time decreased ($P<0.15$). As digestibility (IVOMD) increased, bite rate decreased ($P<0.15$).

Pasture Characteristics

An examination of herbage mass, height, leaf to stem ratio, green to dead ratio, density, green density, and digestibility (Table 4) revealed two highly significant relationships and two pronounced trends. Herbage mass and height were closely related ($P<0.005$) (Figure 3), and as height increased percent green herbage (Figure 4) increased ($P<0.01$). Green material was similarly related to herbage mass, though not significantly ($P<0.15$).

Digestibility increased ($P<0.06$) as the percent leaf, expressed by leaf to stem ratio, increased. It also tended to increase as green density and total green material increased.

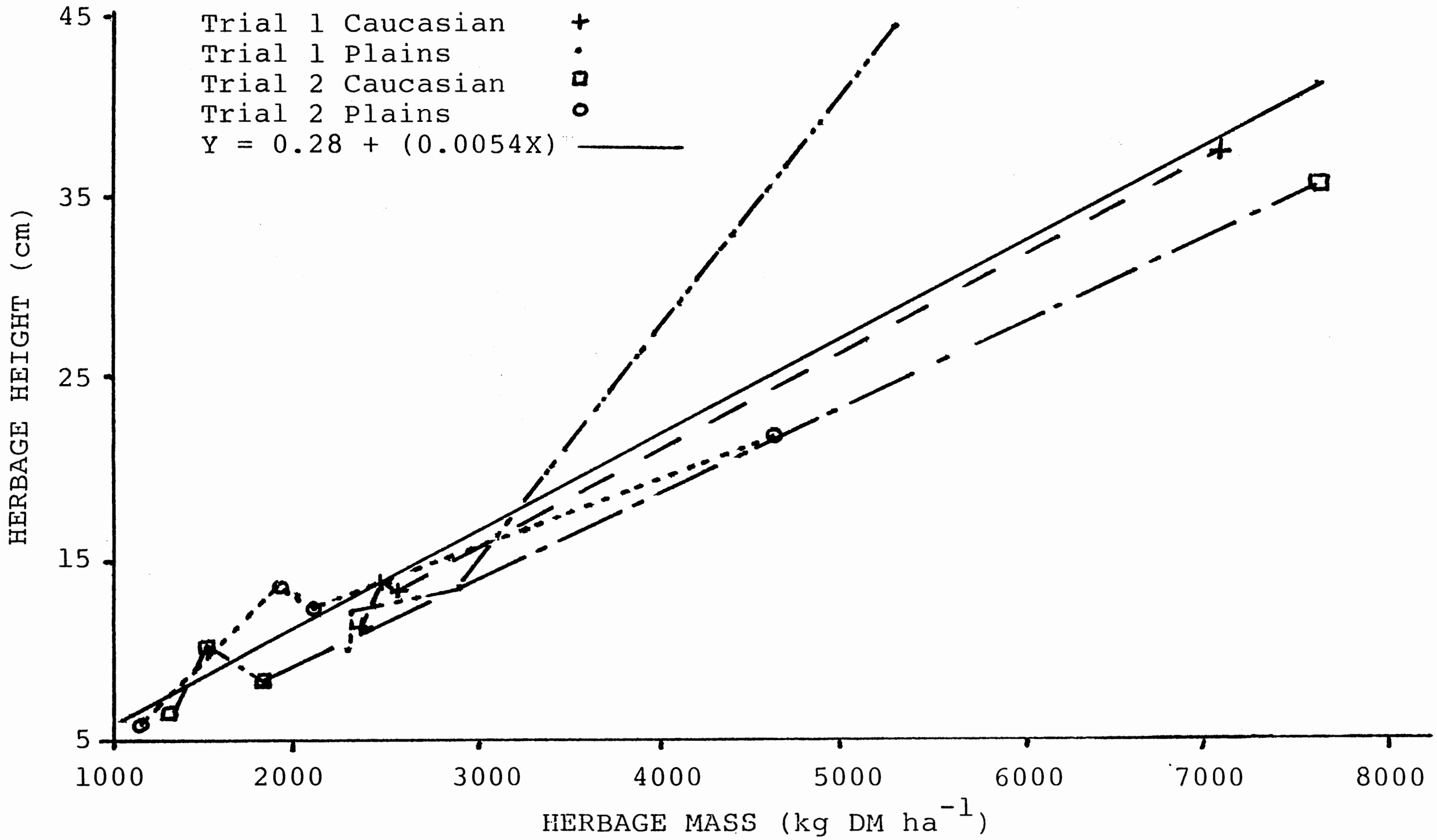

Figure 3. Mass of Herbage Height Relative to Mean of Herbage Mass (P 0.001)

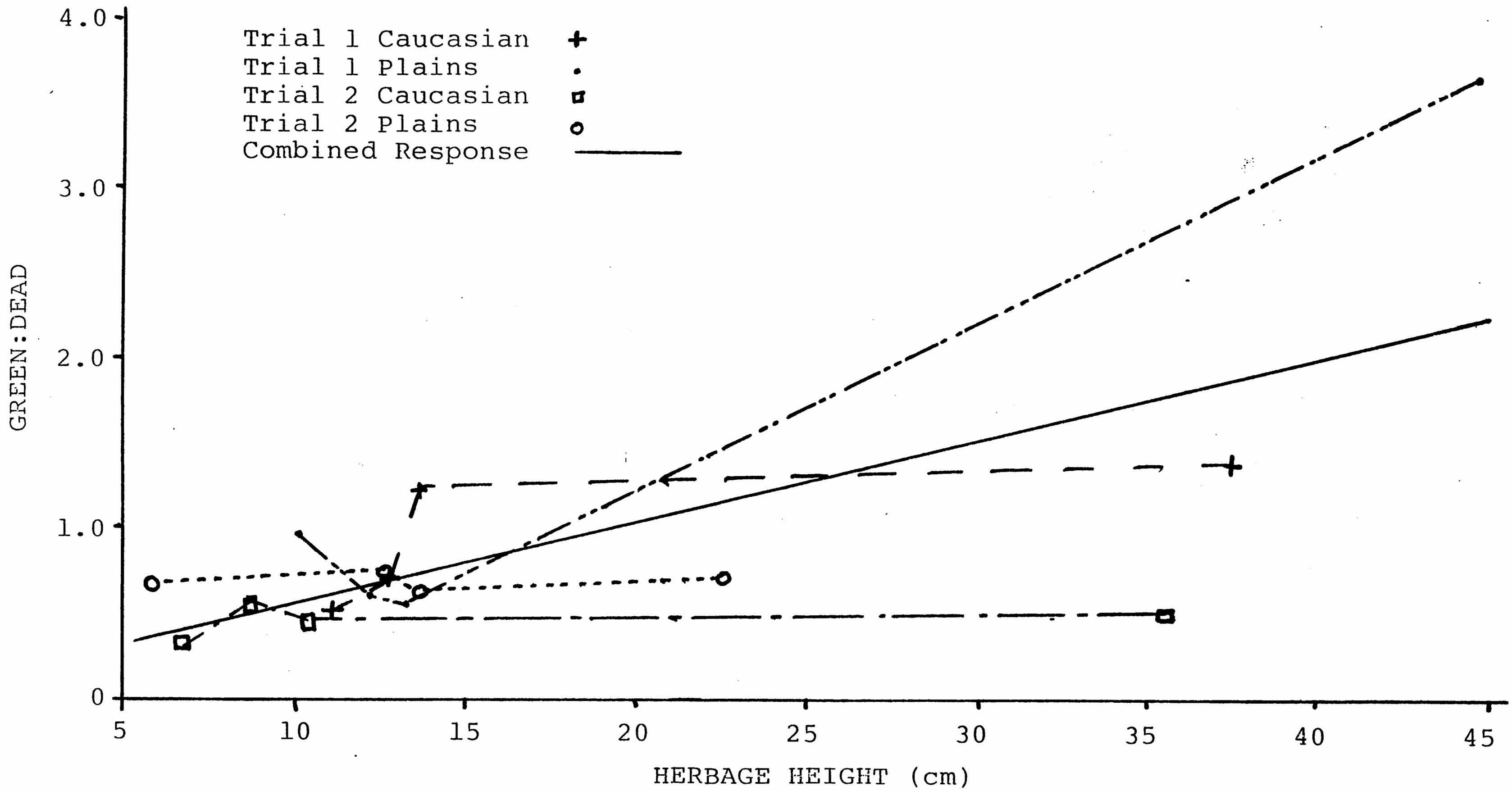

Figure 4. Relationship of Green:Dead Ratio to Mean Herbage Height

The close relationship of mass to height is useful in planning future trials as height can be used as the controlling parameter. The increase in green material as height incrased is consistent with work done by Chacon and Stobbs (1976). They noted that short swards are low in leaf content and low in digestibility. This is due to grazing selectivity, the tendency of the animal to graze leaf parts to the exclusion of the less digestible stem material.

Animal Measurement

Intake Responses

An interaction between varieties and herbage mass (Figure 5) was observed for daily intake. In Caucasian pastures, intake was linearly ($P<0.20$) related to herbage mass, while in Plains pastures a quadratic relationship was observed ($P<0.07$). Intake was similarly related to herbage height.

Digestibility of the diet was significantly related to intake ($P<0.075$) but was a component in the intake equation so a relationship was expected. A quadratic equation best described the relationship between NDF and intake (Figure 6) and is consistent with the model derived by Montgomery and Baumgardt (1965) for gut fill based on fiberosity and intake.

Hodgson (1977) also observed that intake was essentially unchanged when the mass of rye grass pastures

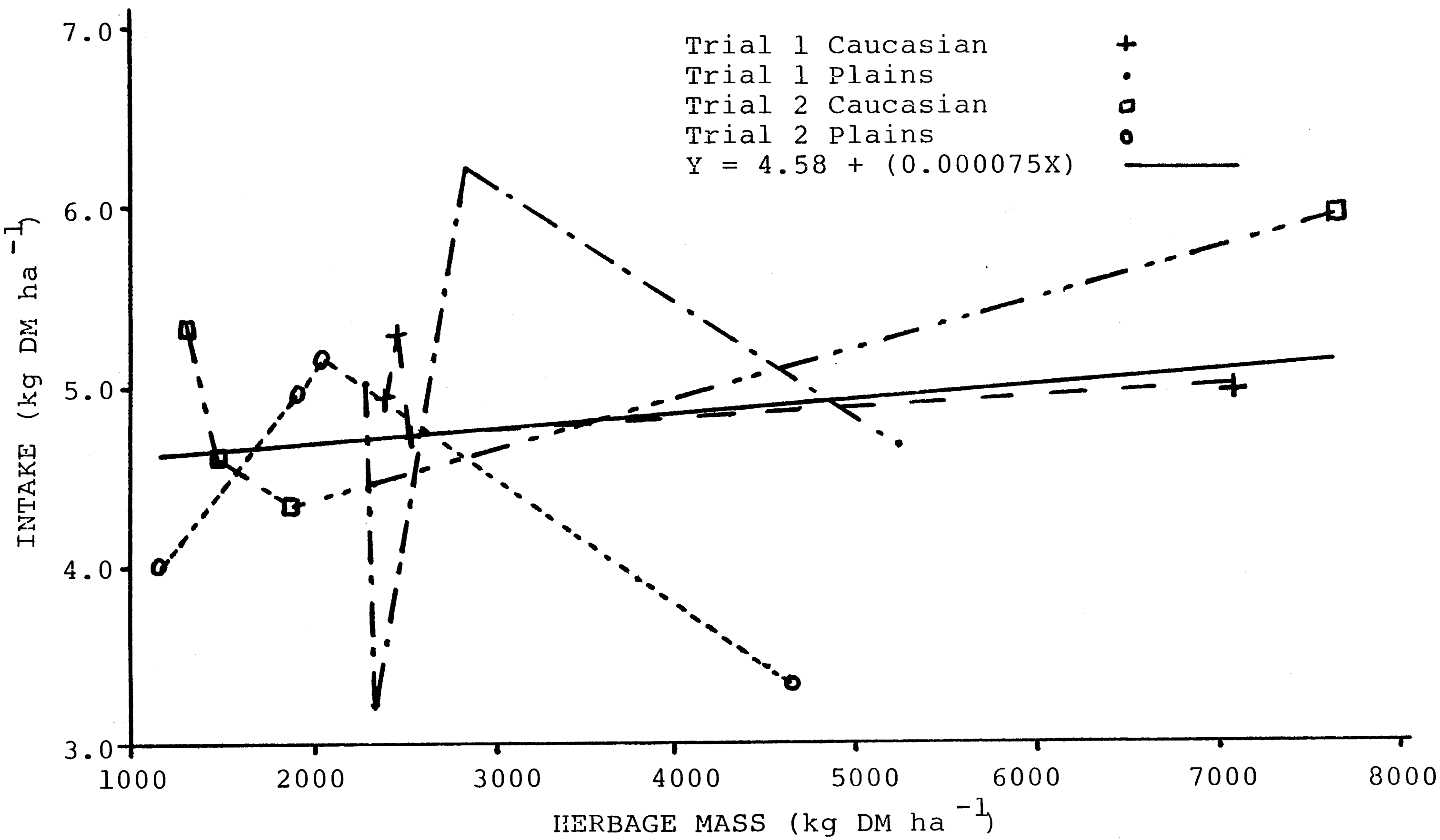

Figure 5. Pasture Means of Organic Matter Intake Relative to Herbage Mass

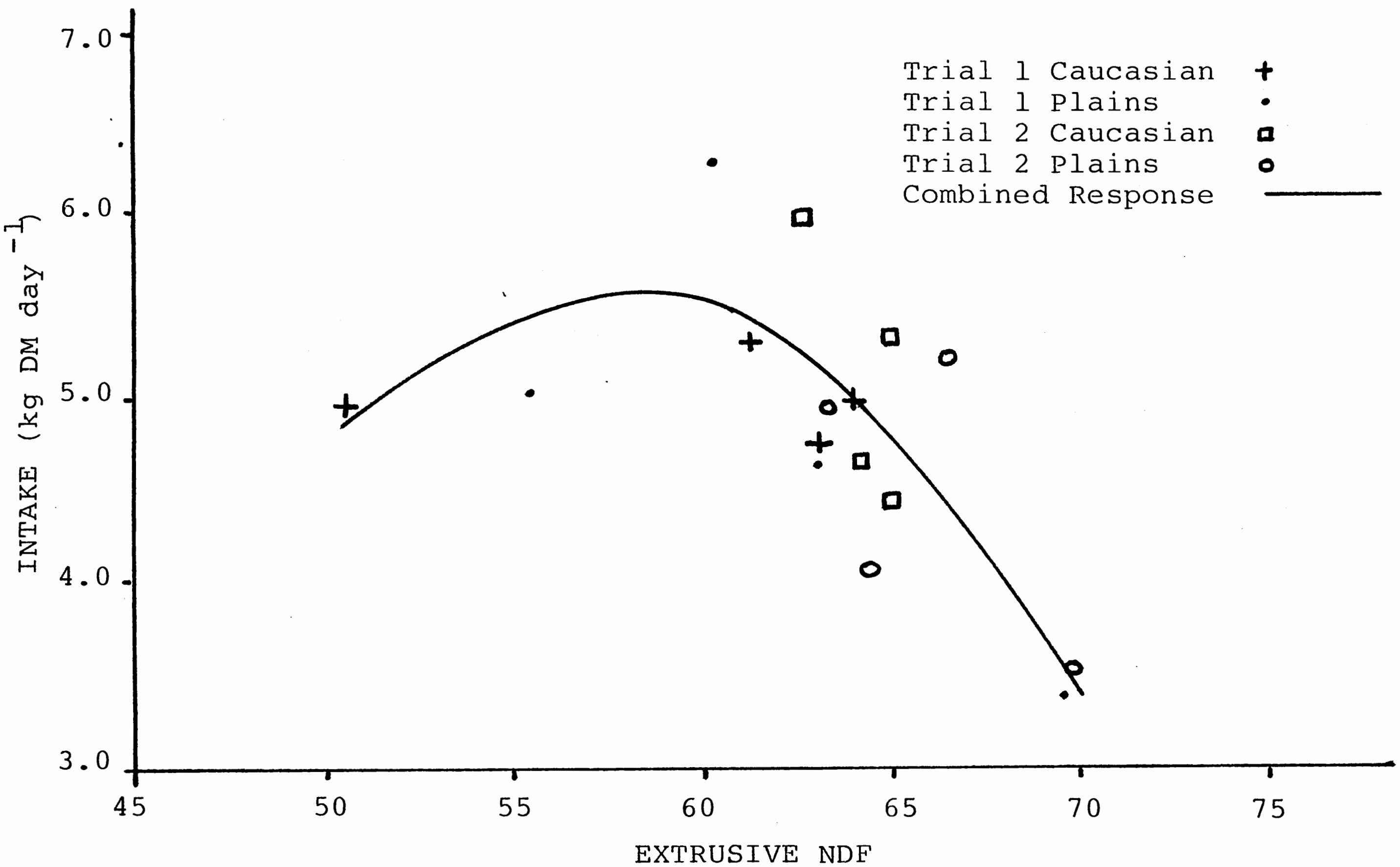

Figure 6. Pasture Means of Intake Relative to Extrusive NDF Means (P 0.005)

changed from 1100 to 2800 kg DM ha^{-1}. In addition, Allden and Whittaker (1970) noted that very short tillers, five cm or less, were necessary to have a marked adverse affect on intake. None of the herbage masses in this study were below 1100 kg DM ha^{-1} or less than five cm average tiller height. Future studies should be approached with the intention of establishing a sward with mass and heights well below the values discussed above.

Grazing Times

Grazing time decreased as herbage mass ($P<0.025$) increased (Figure 7). A similar response ($P<0.05$) was effected by herbage height (Figure 8). As the green to dead ratio increased, grazing time was reduced ($P<0.11$) (Figure 9). Other pasture characteristics failed to significantly influence grazing time. However, trends were consistent with the other variables.

The decreased grazing time with increased herbage mass and height is consistent with Chacon and Stobbs (1976) and Chacon et al. (1978). The lack of relationship with density or leaf to stem ratio in this study is inconsistent with their findings. However, they obtained densities at different horizons and the data cannot be compared directly to overall sward density, as determined in this study. The lack of relationship between leaf:stem and grazing time is a result of large variation in leaf to stem ratio.

Grazing time differed 15.2% percent from abundant and

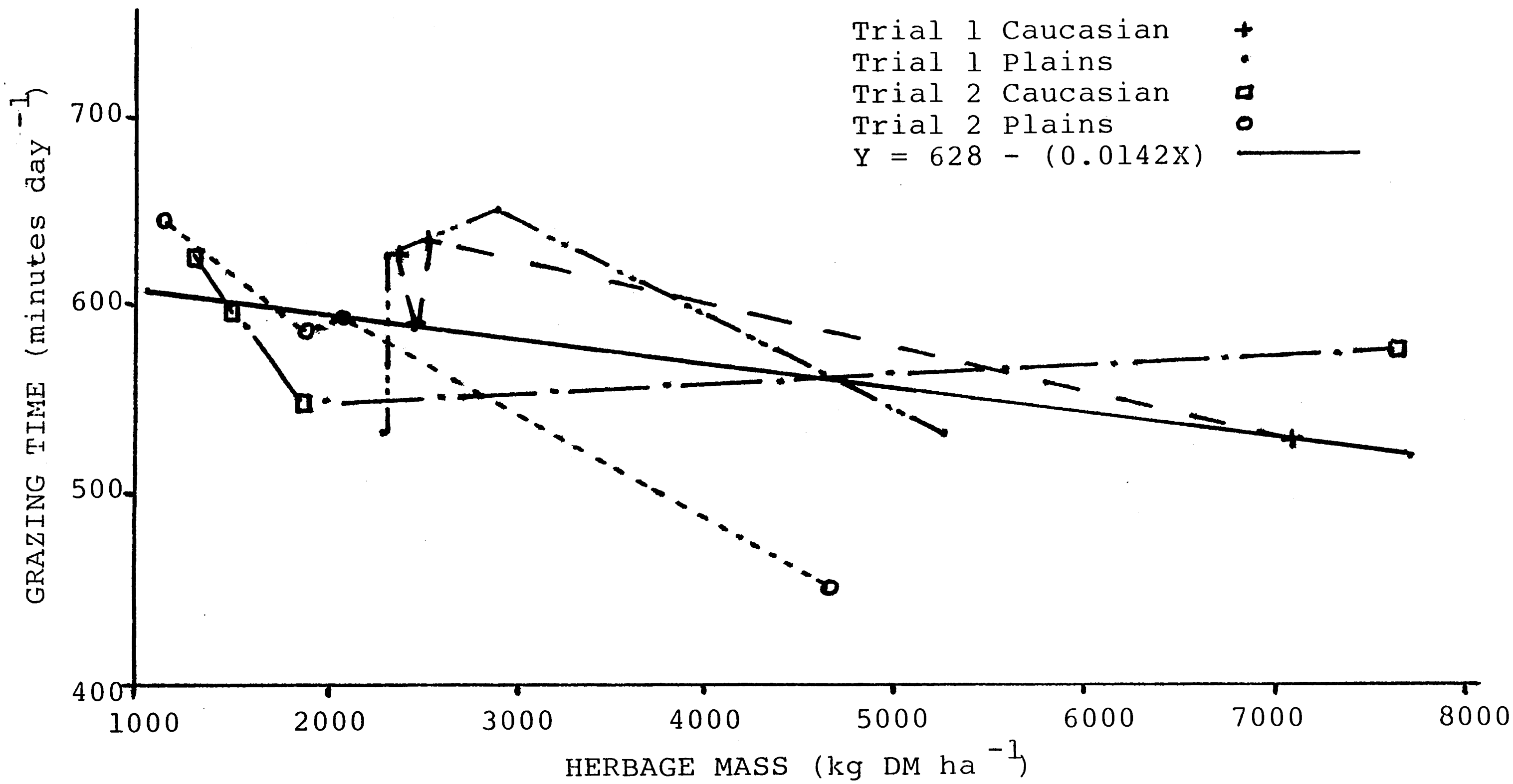

Figure 7. Pasture Means of Grazing Time Relative to Mean Herbage Mass (P 0.05)

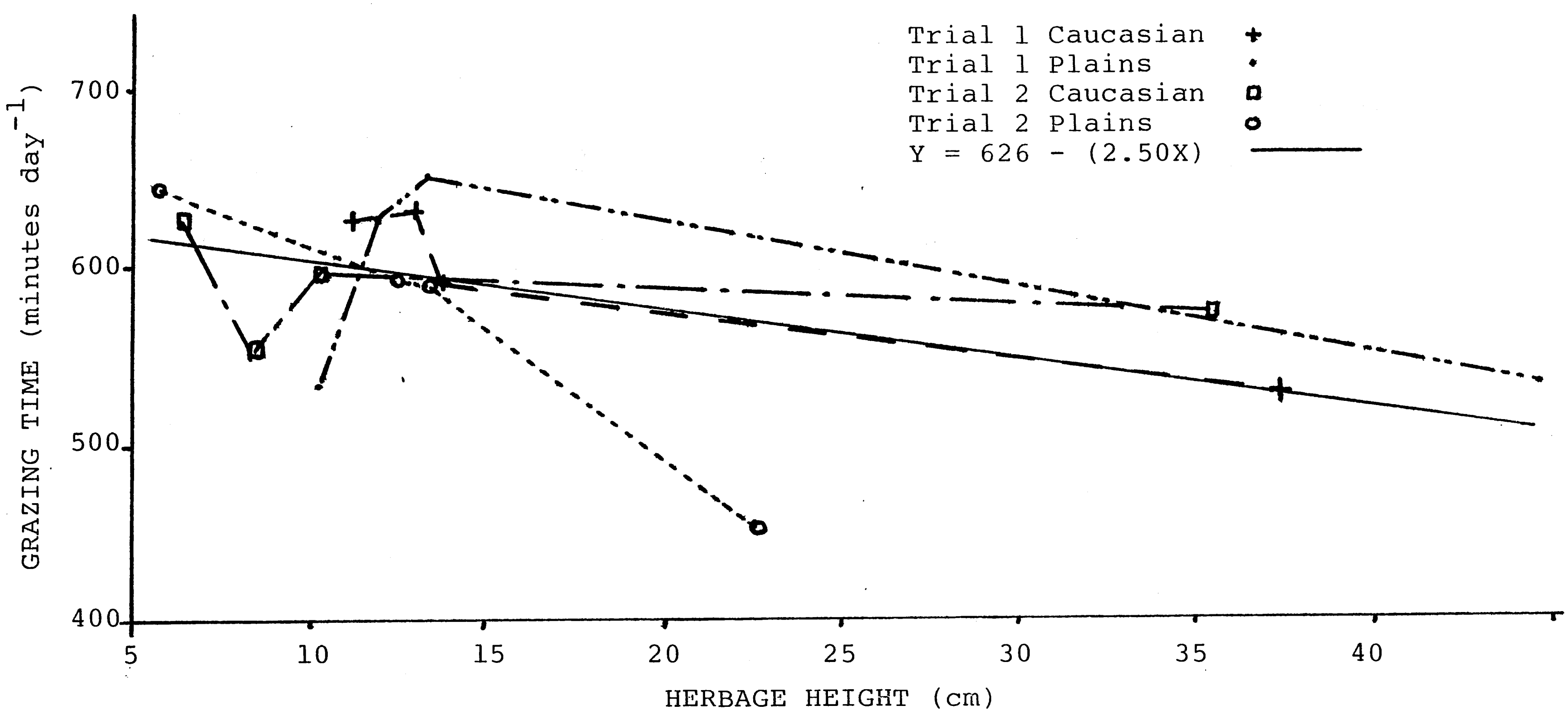

Figure 8. Pasture Means of Grazing Time Relative to Mean Herbage Height (P 0.05)

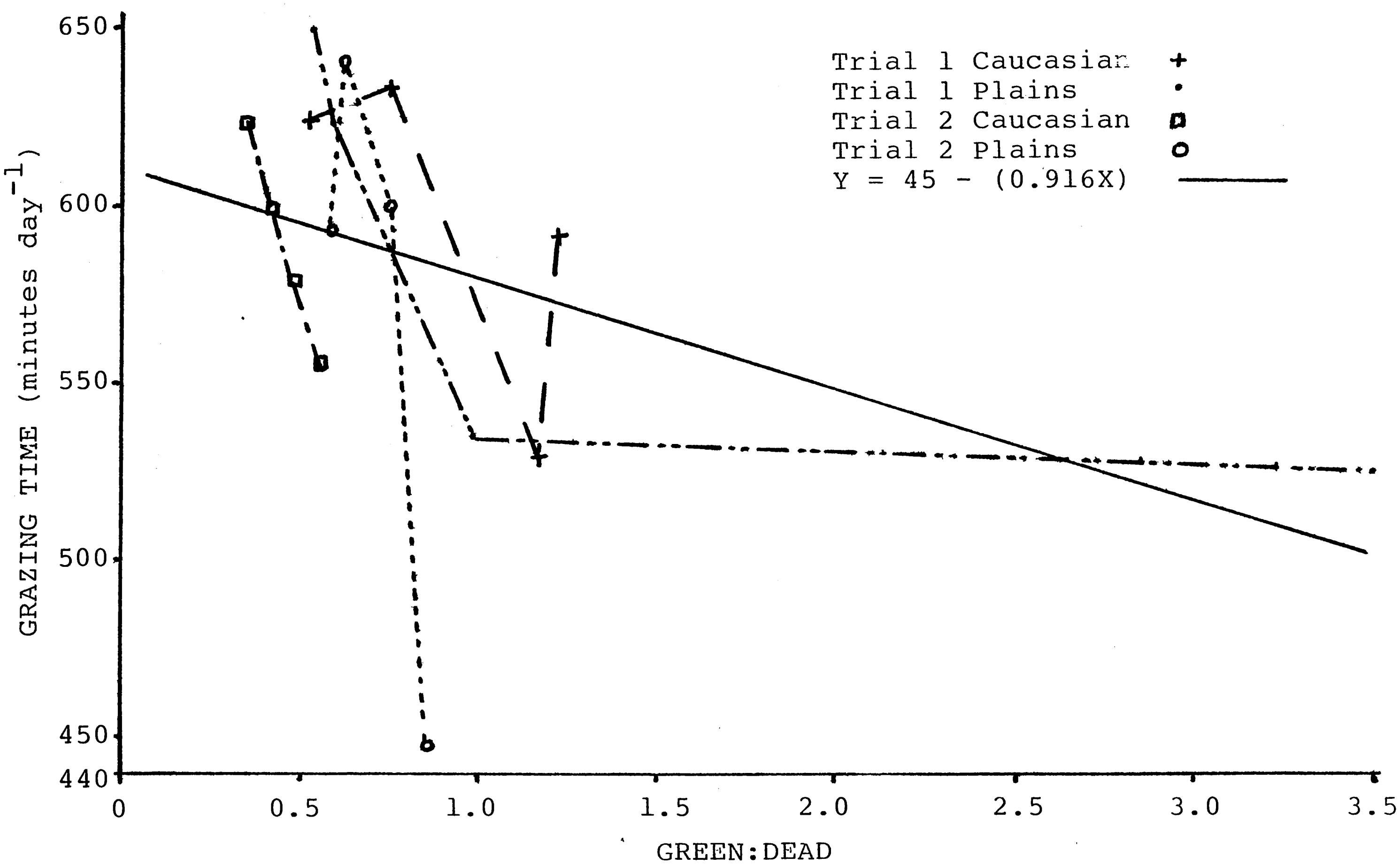

Figure 9. Effect of Green to Dead Ratio on Grazing Time (P 0.11)

scarce pastures. Hodgson (1977) stated that an animal, attempting to maintain a fixed level of intake, could compensate as much as 15% as sward mass decreased. Since there was no difference in intake due to different mass, while the difference in grazing time was 15.2%, it appears that herbage mass ranged from the limit of the animals' ability to compensate.

Bite Rate

Bite rate decreased as herbage mass and height increased ($P<0.025$ and $P0<.05$, respectively) (Figures 10 and 11). IVOMD was directly related ($P<0.15$) to bite rate, suggesting less grazing time as the digestibility increased.

Bite rate was similar to grazing time in the magnitude of response to different treatments. The predicted low to high values differed by 17% and represent a behavioral adjustment by the grazing animal to maintain intake. As digestibility improved, bite rate also increased.

Bite Size Relationship

As mass and height decreased bite size decreased ($P<0.001$). None of the other variables had significant relationships. Bite size was also affected by characteristics of the sward (Figures 12 and 13) (Arnold, 1964; Stobbs, 1973a,b; Hodgson, 1977, 1982).

Bite size tended to decrease with increased sward density. The relationship of density to mass is such that

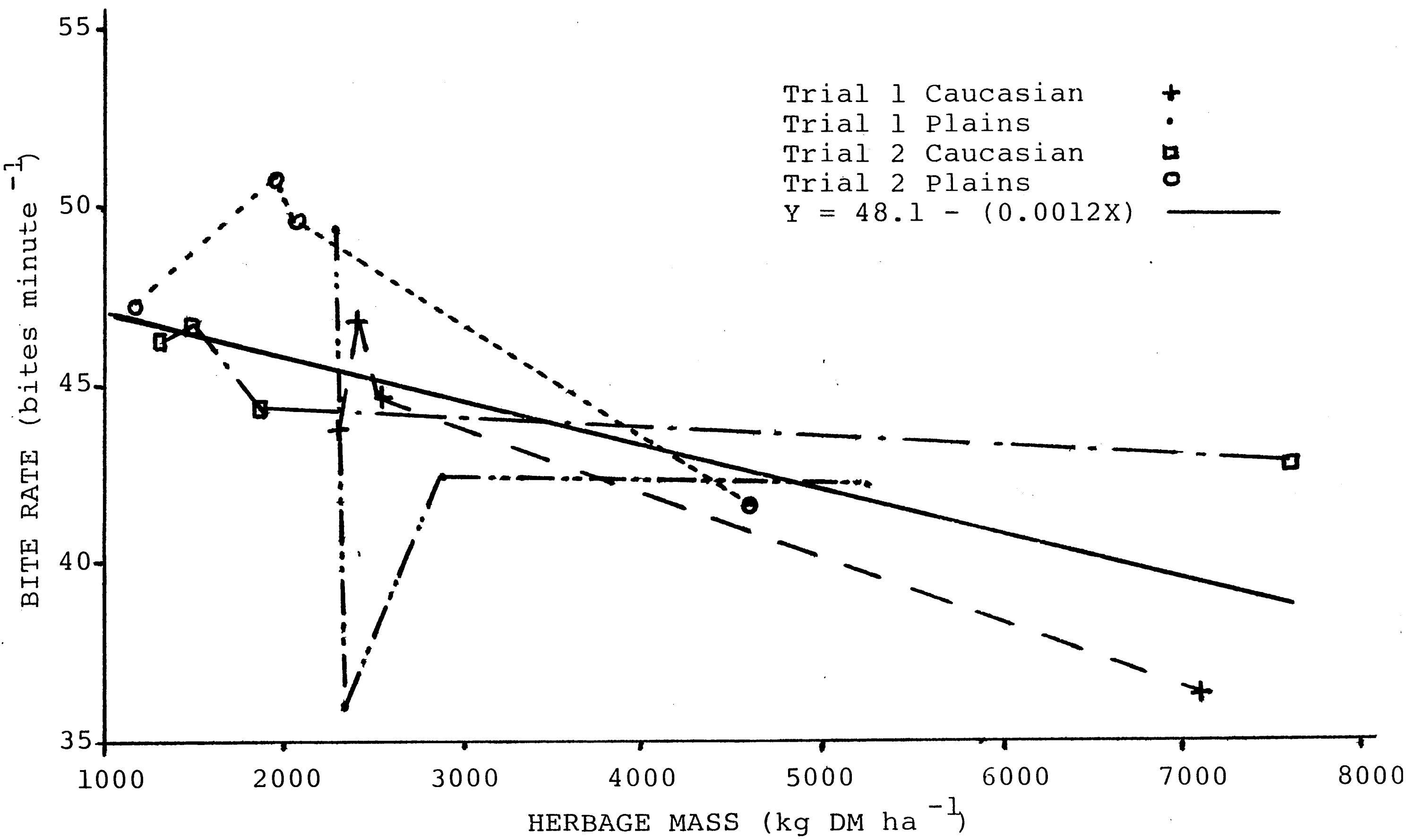

Figure 10. Pasture Means of Bite Rate Relative to Mean Herbage Mass (P 0.025)

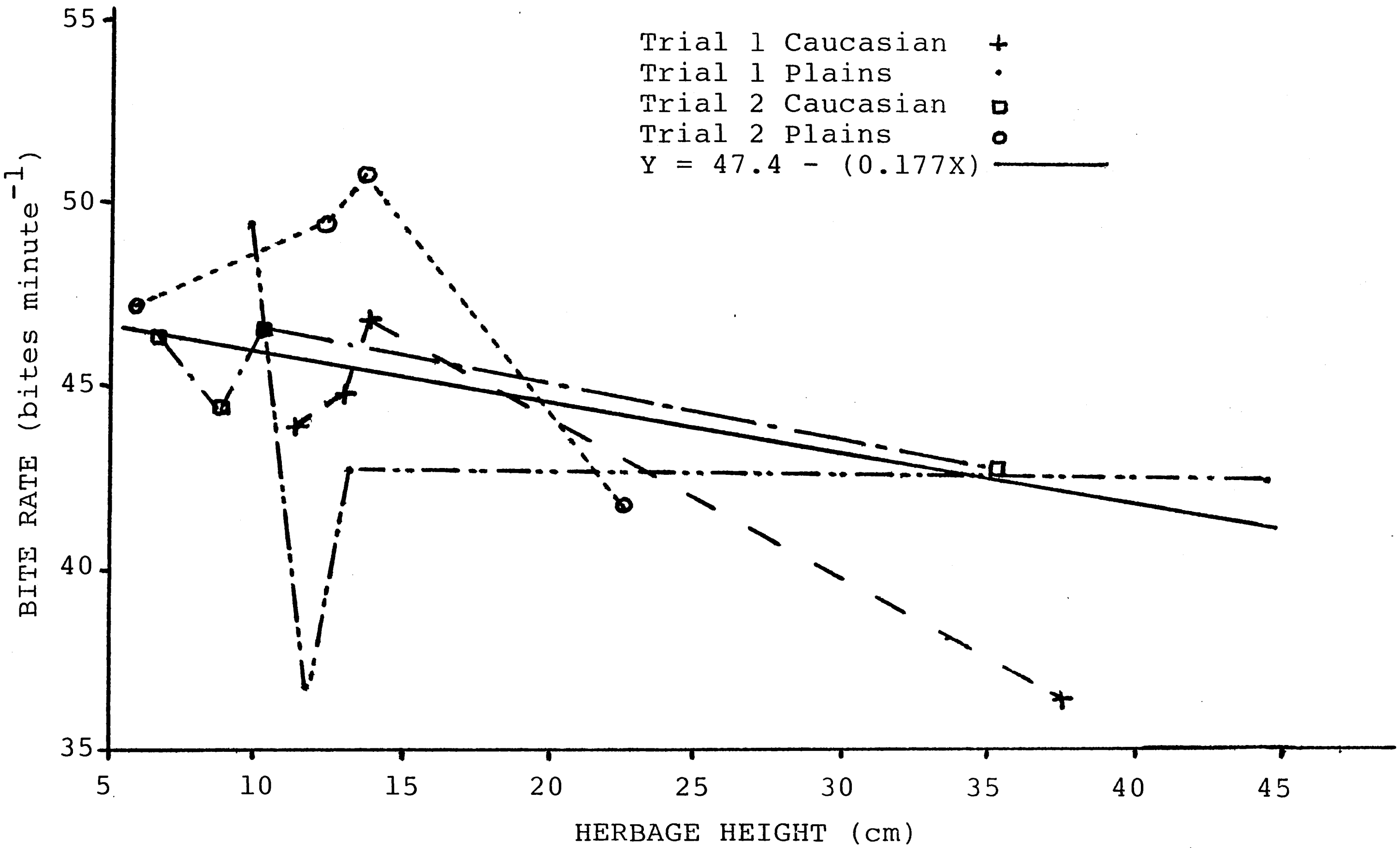

Figure 11. Pasture Means of Bite Rate Relative to Herbage Height (P 0.05)

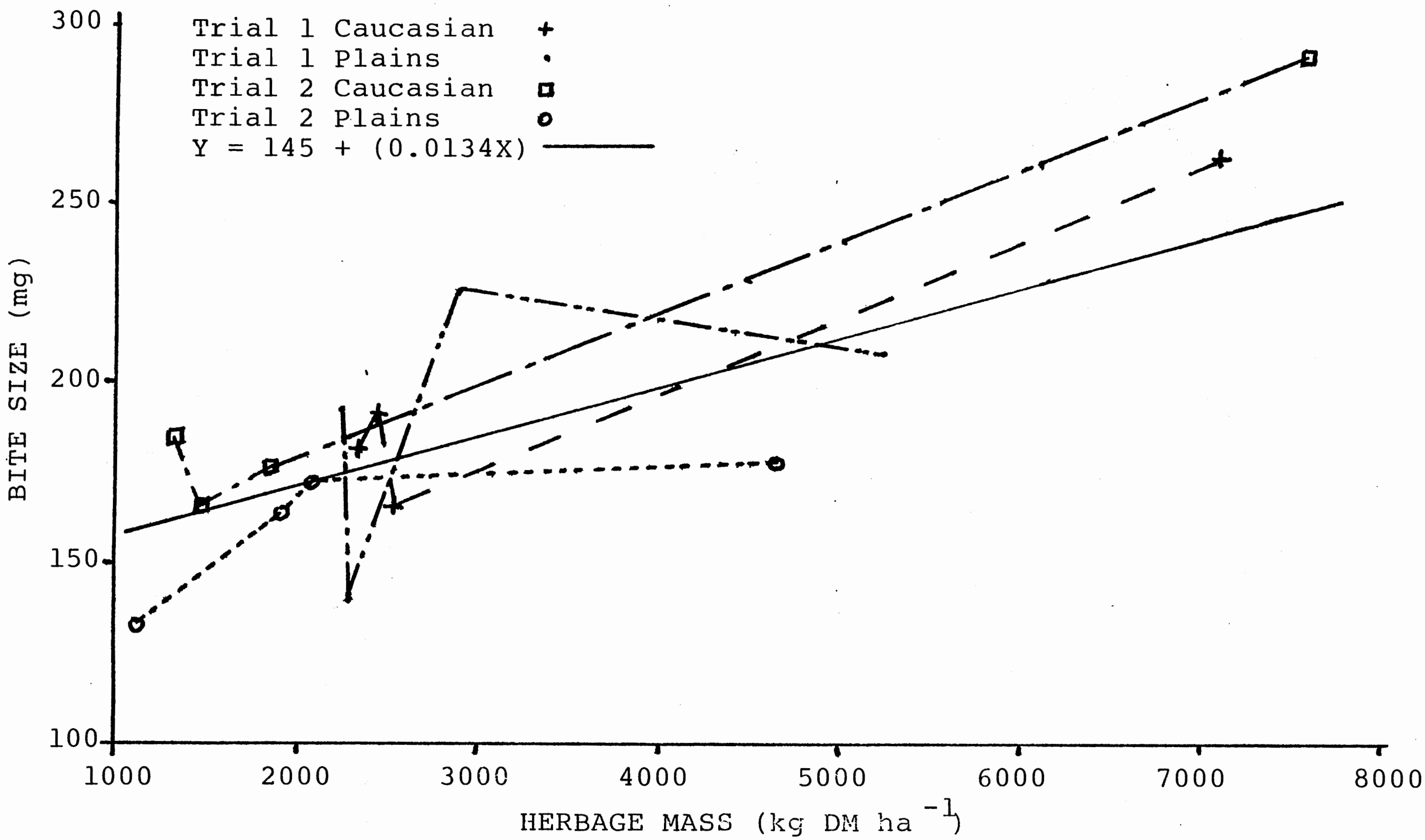

Figure 12. Pasture Means of Bite Size Relative to Herbage Mass (P 0.0005)

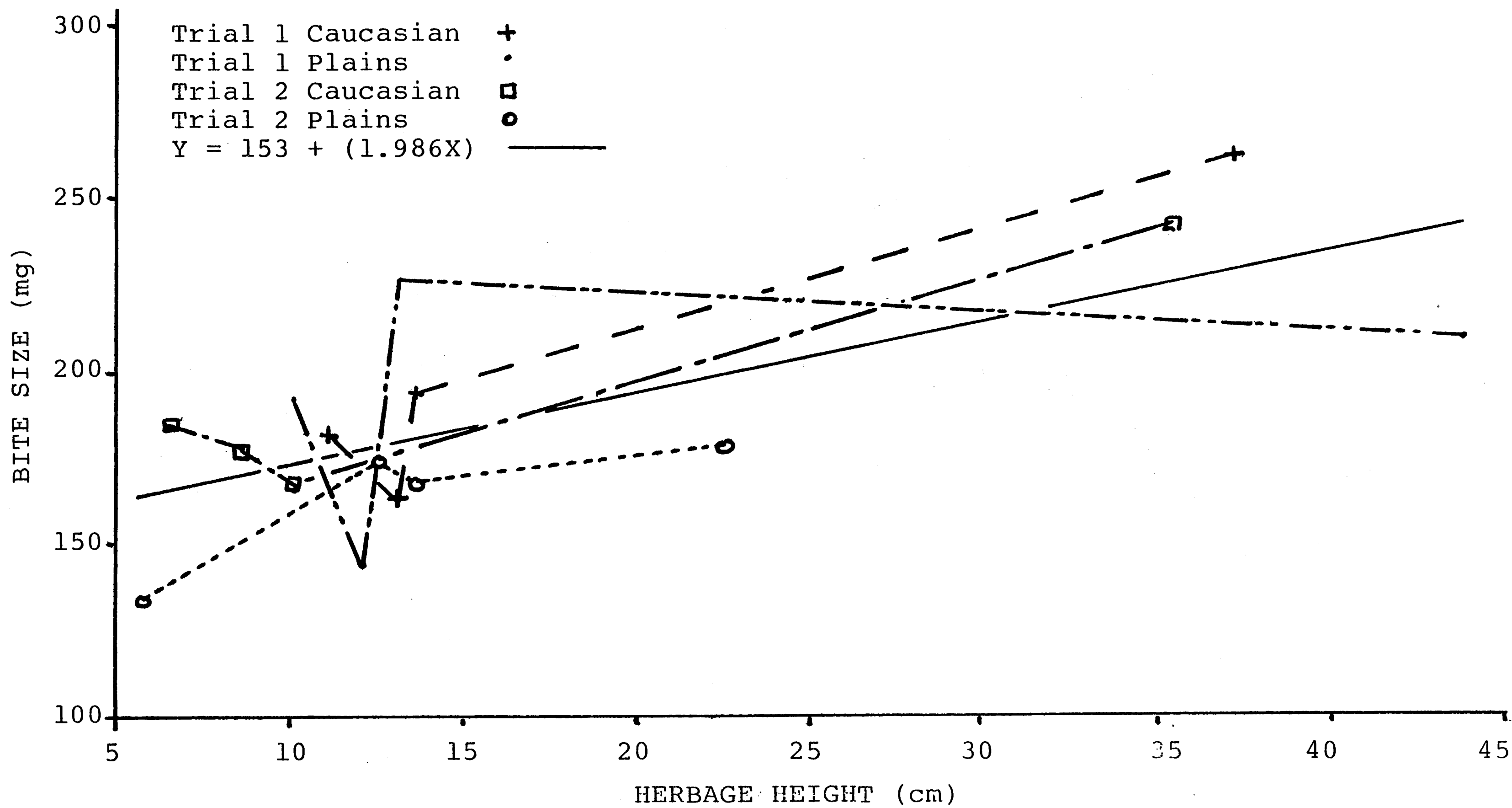

Figure 13. Pasture Means of Bite Size Relative to Herbage Height (P 0.005)

the short swards have a greater overall density than the tall swards because of the higher proportion of stem in short swards. Therefore the high density swards are associated with low mass pastures which support low bite size.

Bite size tended to increase as green herbage mass increased. One factor which negated the effects of more mature pastures was the high ratio (approaching 3:1) of green to dead material on these pastures. For this reason a reduction in intake was not noted on the more mature pastures.

Conclusions

It appears that reduced bite size is the parameter most closely related to decreased herbage mass and height. The animals compensated for the reduced bite size with increased bite rate and grazing time to maintain intake. Bite rate increased by 17% and grazing time by 15.2% when measured on the fitted line. Bite size decreased nearly 100% over the range of herbage mass and 15.5% over the fitted line from regression. This adjustment in grazing behavior is at the limit possible for the animals while maintaining constant intake. Due to the very close relationship between herbage mass and height, height could be used to regulate pastures rather than mass, which is much more difficult to estimate. More frequent and more accurate observations can be made of height in less time. Consequently, better control of sward treatment levels is possible. Mass data could then be collected during the trial for analysis purposes only.

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APPENDIX

Calculations for Intake Determination

In order to set the scale of the marker concentration plot, and to provide a generated value which can be used without further modification, the following equations were applied to the data.

T = ET - where ET is the elapsed time generated by SAS 82 and T is the time, in hours, post dose.

YBOM = (YBHAT * 20)/(PCTOM * 0.200) - where YBOM is the concentration of Yb in Mgrams per gram of fecal organic matter. YBHAT is the concentration of Yb in the DTPA dilution mix and 20 represents the volume in milliliters (ml). PCTOM is the percent organic matter in the fecal material and .200 is the dry matter weight of the analyzed fecal sample in grams.

To complete the analysis the amount, in grams, of Ytterbium (Yb) dosed to each animal had to be determined. With minor modifications due to differences in trials the determination follows.

[WTOMLFS = WTLFS * PCTDMLFS * PCTOMLFS] - where WTOMLFS is the organic matter weight of the Yb labeled forage sample analyzed by atomic absorption spectrostophy. WTLFS is the weight of the labeled forage sample analyzed. PCTDMLFS is labeled forage sample dry matter percent. PCTOMLFS is labeled forage sample organic matter percent.

[YBDOSED = ((((CONC * 20)/WTOMLFS) * 20)/1 x 10^6) * OMWTLF] - where YBDOSED is weight of Ytterbium dosed. CONC is the concentration of Yb in the labeled forage sample diluted in 20 ml of DTPA. 20 is the dilution factor applied to bring the DTPA diluted samples within the range of the atomic absorption spectrostophy. In trial two this factor was 0.50. 1 x 10^6 converts micrograms to grams. WTLF is the weight, in grams, of labeled forage dosed to the animal.

These procedures provide the necessary information for determination of rumen fill and fecal output (Ellis et al., 1979; Mader, 1981; and Teeter, 1981) and intake (Ellis, 197 ; Ellis 1979; and Hart, 1981). The process involved is as follows:

Rumen Fill (RF) = YBDOSED/C

Fecal Output (FO) = RF * G2 * 24 hr

Intake (I) = FO/1 - IVOMD

IVOMD is the in vitro organic matter disappearance and is the estimate of digestibility of the forage. Extrusive samples were used to establish this value, and while they are not a precise sample of what was being grazed they are the most representative measure available.

VITA

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