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This is to certify that the

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Growth and carcass characteristics of Senepol bulls on various energy levels over different time periods, under tropical conditions.

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GROWTH AND CARCASS CHARACTERISTICS OF SENEPOL BULLS ON VARIOUS ENERGY LEVELS OVER DIFFERENT TIME PERIODS, UNDER TROPICAL CONDITIONS

By

Douglas Wayne Wright

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ABSTRACT

GROWTH AND CARCASS CHARACTERISTICS OF SENEPOL BULLS ON VARIOUS ENERGY LEVELS OVER DIFFERENT TIME PERIODS, UNDER TROPICAL CONDITIONS

By

Douglas Wayne Wright

An experiment to test the effects of various energy levels and time periods on the growth and carcass characteristics of Senepol bulls on the island of St. Croix, U.S. Virgin Islands, was conducted for two different years.

A total of 200 bulls were tested for growth and 117 for carcass characteristics. A total of five feeding levels were used: unlimited native pasture, 1% body weight of corn and pasture, 1% body weight of a 14% protein feed and pasture, 1.5% body weight of a 14% protein feed and pasture, and 2% body weight of a 14% protein feed and forage in a feedlot situation. Three time periods were used: 112, 140 and 168 days.

Results indicate that an increase in energy increased average daily gain (ADG), final weight, dressing percentage, backfat, yield grade, kidney-pelvic fat, and marbling but has little effect on rib-eye area, Warner-Bratzler shear, or taste test scores. An increase in length of time on feed increased ADG, final weight, hot and cold carcass weight, and dressing percentage but had little or no effect on rib-eye area, backfat, Warner-Bratzler shear, yield grade, kidney-pelvic fat, marbling or taste panel scores.

Dedicated to my parents

Donald E. and Margaret I. Wright

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The author wishes to express his sincere appreciation to Dr. Robert J. Deans for his excellent guidance, counseling and assistance during the writing of this thesis.

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Appreciation is expressed to the Virgin Islands Senepol Association for their partial funding of the study; especially to Annaly Farms, Castle Nugent Farms and Granard Estates for the use of their animals and facilities in the two studies; and to all of the hired help at each location whose help was invaluable in the handling of the livestock.

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Last but not least, I owe a debt of gratitude, which I will never be able to repay, to my parents Donald and Margaret Wright who not only helped me financially, but through their strength and encouragement, helped me through some difficult times and taught me the real meaning of courage and life.

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I. INTRODUCTION

This study was designed to determine the effects of different feeding regimens and feeding periods on bull weight gain and carcass characteristics of Senepol cattle in the United States Virgin Islands (USVI). The traditional method of raising beef from weaning to slaughter on an extensive pasture system was to be used as a control.

The major breed of beef cattle on St. Croix is the Senepol, a locally developed breed. The Senepol is a cross of the N'Dama dams, which were imported from Senegal West Africa, and two Red Poll bulls, a British breed of cattle (Hupp, 1978). Starting in 1918 a Red Poll bull, from England via Trinidad, was mated to N'Dama dams and inter-se mated with the selected animals chosen on the basis of being red color, good conformation, early maturity, polled, meaty, definite heat tolerance and docile. In 1940 a second Red Poll bull was introduced into the herd and again inter-se mated (Hupp, 1978). The resultant animal has been called the "Cruzan breed", and St. Croix Senepol.

In 1954 the Senepol trademark was registered in Puerto Rico and the United States as "St. Croix Senepol". In 1976 a purebred registry was initiated and the Virgin Islands Senepol Association (V.I.S.A.) was founded to promote and register purebred animals.

In 1977 the Virgin Islands Agricultural Experiment Station (A.E.S.) initiated a research program to evaluate the Senepol under Virgin Islands conditions. Since the A.E.S. possessed neither animals nor land, a cooperative agreement was reached between VISA and its membership. This symbiotic relationship continues to the present. The following thesis is a result of one study conducted under this agreement.

The USVI imports a majority (83% of consumption) of its beef (Park et al., 1973). As a result AES and VISA started to evaluate more efficient methods of producing beef to lessen the dependence on imported beef products, and to increase the profitability of beef raising for the local producer.

At the time that this study was proposed, the common practice was to wean the calves at eight to ten months of age and put the calves on pasture until either slaughter or diversion into the breeding herd. All bull calves were left intact and run as a group separate from the heifer calves. The bulls that were not considered as sire prospects, were slaughtered at an age of 12-14 months weighing 365-410 kg. The heifers were generally not selected for possible replacement prospects until 18 months. The heifers not selected for replacements were slaughtered at older ages but at approximately the same weight as the bulls. There is no price differential at present for local beef carcasses marketed. Carcass price per pound does not fluctuate as in the continental U.S.

Since this management practice is very pasture extensive and dependant, it was determined that perhaps some sort of supplemental feeding or even a feedlot type arrangement might prove to be more effective use of resources. Due to the lack of a locally produced supplemental feed supply, (Park et al., 1973) all supplemental feed supplies had to be purchased from an off-island source.

Due to the ocean shipping involved and import handling costs, the supplemental feed becomes quite expensive compared to feed prices on the U.S. mainland. For example, in the 1980-81 feeding trial where corn was used as one of the supplements, the price for corn in the major U.S. grain markets was approximately $3.15/bu., while the price paid for the corn used in the feeding trial was $6.44/bu. Thus it was important to determine if the increases in production cost could offset the increased feed cost.

Objectives: The objectives of this study on Senepol bulls are:

1. Evaluate the effects of various feeding levels and time on growth of Senepol bulls.
2. Evaluate the corresponding carcass and taste panel trends.
3. Evaluate possible changes in production practices to increase beef production.
4. Evaluate economic analysis of the feeding experiments.
5. Determine nutritional levels for bull testing under tropical conditions with Senepol breed.

II. LITERATURE REVIEW

Prior to these feeding trials no other published research had been conducted on the Senepol breed, so one of the main thrusts of the investigation was to establish some base line data on this "new" breed pertaining to growth performance and carcass characteristics of young bulls, on varying diets for various lengths of time.

In recent years, much more research has been conducted on the Senepol and its crosses. Williams et al. (1986) studied the levels of inbreeding in the Senepol on St. Croix to see if inbreeding had increased due to the closed nature of the island. It was found that the actual inbreeding within the Senepol population on St. Croix averaged less than 1.00% over the years, mainly due to the exchange of animals between farms on the island.

Thrift et al. (1986) studied the preweaning traits of calves sired by Senepol bulls compared to other breeds. In Kentucky, Senepol sired calves were 1.3 kg. heavier at birth than were calves by Hereford sires, the weaning weights of both groups of calves were similar. In Louisiana Senepol calves were 1.2 kg. lighter than Red Poll calves at birth and 12 kg. lighter at weaning, but received higher condition scores than the Red Poll sired calves. However the Senepol sired calves were 4.7 kg. heavier at birth and 14 kg. heavier at weaning than Longhorn sired calves. Also heifers exposed to Red Poll bulls weaned 20 kg. more calf per heifer exposed than did heifers exposed to Senepol bulls. Heifers exposed to Senepol bulls weaned 13 kg. more calf per heifer than did heifers exposed to Longhorn bulls.

McGill et al. (1986) followed the same set of calves from the Louisiana study through slaughter and found that Red Poll sired calves produced heavier carcasses with higher quality grades, higher yield grades and more kg. of retail yield than the Longhorn and Senepol. The Longhorn calves had higher marbling scores ($P<.05$) than the Senepol calves but did not differ in quality grade ($P>.05$), carcass weight, retail yield, yield grade, fat thickness, rib-eye area and percent kidney-pelvic fat.

Binion et al. (1986) compared the growth and carcass characteristics of Angus and Senepol sired calves and found that Senepol sired calves were lighter at birth, four months of age, and weaning, but were heavier at ten months and a year. The Senepol calves had more kidney-pelvic fat, lower quality grade, less marbling and a less desireable yield grade than the Angus sired calves. They concluded that only small differences exist between Senepol and Angus sired calves for measures of growth and size, while slightly greater differences exist for carcass characteristics.

Tolleson et al. (1986) compared similar Senepol and Angus sired heifers from postweaning through 30 days post-partum and found that there were no differences between the two groups for total gain from weaning to eighteen months, yearling weights, or warm season gains. They did find that Angus sired heifers had greater eighteen month weights and cool season gains than did the Senepol sired a

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heifers. They also found that Angus sired heifers had less calving difficulty than the Senepol sired heifers, however there was a significant effect from sire of dam within a breed, indicating that calving difficulty probably varies more within a breed than between breeds.

Thallman et al. (1983) on the other hand found no significant difference in percent dystocia due to breed of sire, when they compared calves sired by Angus and Senepol bulls. They did find however that Senepol sired calves had a longer average gestation length and had longer average cannon bone measurements than Angus sired calves. Breed of sire also had no effect on birth weight or heart girth circumference at birth.

Eastridge et al. (1986) examined the effect of Senepol breeding and low voltage carcass stimulation on palatability. They studied four groups of Senepol, Senepol X Hereford, Senepol X Zebu and Hereford steers that were feedlot finished and found that the crossbreds had heavier carcasses and larger rib-eyes than the either the Senepol or Hereford groups. Yield grade was similar among all breeds as were the quality grades. Regardless of breed or carcass treatment, all the steaks were rated "very acceptable" by the sensory panel, although the panel was unable to detect the improved tenderness caused by the carcass stimulation as measured by Warner-Bratzler shear values.

Butts et al. (1984) followed the progeny of Senepol and Brahman sires mated to Angus females from birth to

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slaughter, and the reproductive performance of females from these crosses. They found that the Senepol sired calves had lighter birth weights, lighter weaning weights, less average daily gain, and lower frame and condition scores than did the Brahman sired calves. Postweaning performance and carcass characteristics were similar between the two groups with the quality grade and Warner-Bratzler shear favoring slightly the Senepol crosses. They also found that maternally, the Senepol crossbred cows were somewhat lighter in weight but equal in adaptation and maternal ability and had higher pregnancy rates than those from the Brahman sires.

Wildeus and Wright (1986) compared purebred Senepol with Senepol X Charolais crosses on St. Croix, and found that at weaning, backcross (3/4) Senepol calves were significantly heavier than F1 (1/2) and purebred Senepol calves respectively. For the yearling weights of bulls they found that F1 Senepol bulls were significantly heavier than either the backcross or purebred Senepol bulls, indicating that the backcross Senepol calves were heavier at weaning because of their F1 dams while the F1 Senepol bulls had heavier yearling weights because of greater hybrid vigor than the other two groups. F1 Senepol heifers also had a significantly lower age at first calving than either the backcross or purebred Senepol heifers.

A high protein supplement was selected for two of the feeding level treatments because of the belief that lack of protein in the pasture grasses may be one of the limiting factors to increased performance. Brenes et al. (1949) and Vincente-Chandler et al. (1958) found the crude protein level of unfertilized guinea grass (Panicum maximum) to range from 5.4 to 6.3%, while Vincente-Chandler et al. (1961) reported unfertilized pangola grass (Digitaria decumbrens) having a crude protein level of 5.5 to 6.3% depending on the cutting interval.

Shaake et al. (1986) examined the attributes of beef produced from forage diets versus high energy diets. They found that steers, on pasture only, had lighter slaughter weights than steers fed a corn, corn silage diet in drylot, as well as having a lower yield and quality grade. The pasture groups also had a higher percentage of lean when compared to the groups that had time in the drylot.

Anderson et al. (1986) compared the effect of dietary protein on growth and composition of gain on growing beef bulls. The low protein diet (10%) depressed average daily gains and resulted in poorer feed conversion. The low protein group had lower rates of protein accretion during the entire trial, despite compensatory protein gains during the last 60 days of the trial. The carcass fat gains were similar over the entire trial, although the high protein group (14%) gained more fat during the first half of the trial and less during the second half of the trial. Composition of gain between the 12% and 14% crude protein diets were similar.

Andersen et al. (1975) found that at higher slaughter weights the fat percentage decreases rapidly with decreasing feeding level and the percentage bone and lean increases. They also found that average daily gain increased with increased energy.

Harpster et al. (1985) evaluated the effects of two protein sources and three protein levels on the performance and carcass traits of feedlot Charolais bulls and that growth performance was superior for bulls fed the high protein level, although previous work on smaller framed English breed bulls had indicated little benefit for elevating protein levels above the National Research Council (1976) recommendations. They also found no differences in yield grade, quality grade, lean color and rib-eye area due to either protein source or level.

Bidner et al. (1985) compared the performance and carcass characteristics of steers finished on forage or grain. The grain finished steers gained faster and had heavier final weight and carcass weights than the steers on forage. The steers on forage had less fat, smaller rib-eye area and a lower yield grade, while the grain fed steers had a higher degree of marbling and a higher quality grade. Diet had no effect however on Warner-Bratzler shear or sensory-panel traits.

The feeding trials were not only to evaluate supplemental feeds, but to also derive some basic data on performance on tropical pastures. Caro-Costas et al. (1961); Quinn et al. (1962) and Hodges et al. (1967) found that cattle grazing unfertilized pangola grass pastures gained .34 - .59 kg. per day. Caro-Costas et al. (1961) and Quinn et al. (1962) also reported that young cattle grazing unfertilized guinea grass pastures had average daily gains of .56 - .60 kg. per day.

Feeding period times were added to try and determine the optimum time and/or weight to slaughter the animals. Costas et al. (1965) had found that daily gains of bulls on pastures dropped off severely after the animals had reached approximately 400 kg. of liveweight, indicating that they should be sold to maximize efficiency.

McPeake and Buchanan (1986) compared the standard 140 day bull test period with shorter lengths of time for testing average daily gain. They obtained correlations for 84 day average daily gain or 112 day average daily gain with average daily gain for the entire test period of 140 days. The average correlation between 84 days and 140 days was 0.82, while the correlation between 112 days and 140 days was 0.91. They concluded that decreasing the length of the test period for centrally tested beef bulls from 140 to 112 days would still provide a satisfactory evaluation of growth rate.

Bailey et al. (1982) found that increasing the length of the feedlot period for bulls resulted in higher marbling scores, yield grade, and quality grade, however average daily gain, cutability and color of lean were affected negatively. They also found a reduction in rib-eye area as length of time on feed increased, but were unable to explain the cause.

Wilson et al. (1985) examined growth and carcass characteristics of steers fed for three different time lengths and two feeding levels. They found that dressing percentage, marbling score, kidney fat, and quality grade increased as length of time on feed increased. Although the shear values decreased as time on feed increased, there were no differences in taste panel tenderness, flavor and juiciness.

Winer et al. (1981) studied the palatability characteristics of young bulls from different beef breeds and their crosses. They found that overall breed type effects on color of lean, tenderness, desirability and Warner-Bratzler shear were not significant but that breed type did effect flavor and juiciness.

Toelle et al. (1986) also examined the lean and fat growth patterns of beef bulls from different breeds and found that composition of gain is fairly constant across slaughter weight and average daily gain within a breed. They also found that breed differences exist in composition of gain but were reduced at low average daily gain.

Van Ornum et al. (1986) fed bulls from various Bos taurus and Bos taurus X Bos indicus dams to find the feedlot and compositional characteristics. Using a low concentrate diet to feed the bulls to slaughter at twelve months of age, they found significant differences in dam breeds for weaning weight, final weight, average daily gain, hot carcass weight, backfat, percent kidney-pelvic fat, rib-eye area,

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cutability and marbling. However, dressing percentage, color of lean and shear force were similar for all dam breed groups. This would indicate that the former traits are determined more by genetic composition and the latter traits are more environment dependent.

Many studies have been done on comparing the performance of bulls versus steers, as a possible alternative to the current U.S. practice of using mainly steers and heifers in the feedlot. Bailey et al. (1966a) found that bulls grew more rapidly and had a higher feed efficiency than did steers during the feedlot period. The carcasses of bulls contained less fat, more muscle and more bone than steer carcasses. In a later test of carcass quality (Bailey et al., 1966b) they found that steers had lower shear values than bulls and a taste panel gave higher tenderness and flavor scores to steer carcasses, however the differences were not significant.

In a review on the effects of castration on meat quality and quantity, Field (1971) determined that the detrimental effects of castration with regard to growth rate and feed efficiency are more strongly expressed on a higher plane of nutrition than on a lower plane of nutrition. He found that percent fat in ribs from bulls fed high energy levels was only slightly higher than for bulls fed low levels of energy, while steers had a much larger difference. He also found that while shear values favored steers, taste panel differences for juiciness, tenderness, and flavor are small or nonexistent.

Seideman et al. (1982) came up with many of the same conclusions as Field, in that bulls grow faster and more efficiently than steers, produce leaner carcasses, and have higher shear values, but are still considered acceptable by taste panel tests.

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III. MATERIALS AND METHODS

Bulls were used in these trials, because of the common production practice of the VI beef producers not to castrate bulls.

1979-80 Feeding Trial

The 1979 feeding trial was a 3 X 3 factorial experiment comparing feeding levels versus length of time on feed and replicated at two farm locations on St. Croix. The three levels of feed were pasture, pasture plus 1% body weight of a 14% protein feed concentrate (Table 1) and feedlot with the same 14% protein feed concentrate, fed as 2% body weight plus hay (location 1) or greenchop (location 2). Feeding periods were 112, 140 and 168 days.

Five bulls were assigned to each feeding level by length subclass, for a total of 45 bulls at each of the two locations on the island. The bulls were blocked on sire and weight at each location because of the small number of sires represented and the wide difference in weight and age of the animals due to year round calving. A small number of the calves were the result of multi-sire breeding groups, making the determination of the actual sire impossible. Since these animals were all out of the same multi-sire breeding group, the group itself was listed as the sire for use in blocking the animals.

Because the feeding trial was in cooperation with local producers, the animals at each location were born on that farm. It was not possible, because of concern for disease

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Table 1.--Analysis of Feed Concentrate[a] Used in 1979-80 Feeding Trial.

Guaranteed Analysis (Dry matter basis)	
Crude Protein	14.0%
Crude Fat	3.0%
Crude Fiber	4.0%
Calcium	1.0%
Phosphorus	0.4%
Salt	0.5%

[a] 14%Beef Finisher (7388-R) manufactured by Central Soya, International Feed Division, Miami, Florida.

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transmission, to mix the two location groups, thus genetic composition, farm management, and location are confounded. A Memo of Understanding between the cooperating producers and AES placed all animals on experiment throughout the duration of the experiment.

After screening for leptospirosis and anaplasmosis, the bulls were wormed and given a two week adaptation period on the feeding level treatment in which they would be placed for the trial. At the start and end of the official test all bulls were weighed, graded, classified and measured. Measurements were taken of heart girth, length, hip height and length of hooks to pins. Classification scores were given for temper (relaxed, unsettled, nervous), color (dark, medium, light), head condition (polled, scurred, horned), headshape (flat to very pointed), presence of bumps (horns or scurs that had not broken the skin), scur size (length), sheath score (loose, medium, tight), body condition (3-17) and frame size (1-7).

Amounts of feed given were adjusted every 14 days based on the previous group weight plus group average daily gains of the previous period. The animals were group fed and individually weighed every 28 days with feed being withheld for twelve hours before each weighing.

A minimum of three bulls from each feeding level by length subclass at each location were selected to be slaughtered, based on pre-test selection by the owners. There were a total of 57 slaughter bulls. Once initially identified for slaughter, no animal was then allowed to have its status changed throughout the test.

The animals were slaughtered at the local federally inspected abattoir, within 24 hours after being weighed. Hot carcass weights were taken and the carcasses were cooled for 48 hours before the cold carcass weights and carcass data were taken.

Carcasses were split between the 12th and 13th ribs. A tracing of the ribeye was taken and ribeye area was determined using a compensating polar planimeter. Backfat thickness was measured at a point 3/4 of the lateral length of the ribeye muscle from the backbone. Other observations that were made by the animal scientist and his assistant, were marbling, conformation, color and texture, using accepted references (USDA, 1976). Kidney knob was estimated by visual appraisal after weighing a small number to determine accuracy. Yield grade and dressing percentage were determined using the U.S.D.A. regression equation[1] for yield grade, and cold carcass weight divided by live weight, respectively.

Meat samples for the Warner-Bratzler shear test and taste test panel were frozen, in three layers of freezer paper until all three groups had been slaughtered.

Warner-Bratzler shear tests were taken on 2.54 cm. loin steaks, at three different locations, central, medial and lateral, with 2-3 samples per location taken for the average

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[1] Yield grade = 2.5 + (2.5 X adjusted fat thickness, 12th rib) + (.0038 X hot carcass wt.) + (.2 X percentage kidney, pelvic and heart fat) - (.32 X ribeye area).

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of each location. The steaks were cooked to 70 ^{o}C internal temperature for the shear tests.

The taste panel loin steaks were cooked in an electric oven broiler to an internal temperature of 70^{o}C determined by the use of a meat thermometer. The taste samples were then cut from the center of each steak.

A maximum of ten samples were tasted at any one time with the ten panelists measuring initial and sustained juiciness, initial and sustained tenderness, and final intensity of flavor. A 3-5 minute break was given between each sample and the panelists were given their choice of an apple or apple juice between each taste test.

Prior to the taste test, panelists were given a triangulation test to determine taste sensitivity. Panelists passing that test were then given 5 weeks of twice weekly instruction in what was to be tested and actually tasted various grades of meat to orient themselves on the various classifications of juiciness, tenderness and flavor. All possible combinations of race (white, black) and sex were included in the final ten panelists selected.

1980-81 FEEDING TRIAL

The 1980 feeding trial was conducted in a similar manner, except that it was a 4 X 2 factorial experiment with four feeding levels and two lengths of time on feed, replicated at the same two locations as in the previous feeding trial. The four feeding levels were pasture, pasture plus 1% body weight of a similar 14% protein feed concentrate (Table 2) as used in the previous year, pasture and 1% of body weight of whole cracked corn (IFN 4-02-931), and pasture and a 1.5% of body weight of the 14% protein feed concentrate. The two lengths of time on feed were 140 and 168 days.

Six to eight bulls were selected for each feeding level by length subclass, blocking on sire and weight, at each of the same two locations as in the previous experiment, for a total of 111 bulls.

The rest of the 1980-81 feeding trial was conducted in the same manner as the 1979-80 trial except that 60 bulls were slaughtered for the carcass evaluation phase of the feeding trial. No taste panel test was done on the 1980-81 feeding trial due to time constraints and personnel changes.

Table 2.--Analysis of Feed Concentrate[a] Used in 1980-81 Feeding Trial.

Guaranteed analysis (Dry Matter Basis)	
Crude Protein, minimum........................	14.0%
Crude Fat, minimum...........................	2.0%
Crude Fiber, maximum.........................	7.0%

Ingredients

Plant Protein Products, Grain Products, Forage Products, Processed Grain-By-Products, Cane Molasses, Vitamin A Supplement (stability improved), D-Activated Animal Sterol, Vitamin E Supplement, Calcium Carbonate, Defluorinated Phosphate, Salt, Potassium Sulfate, Magnesium Sulfate, Ethylene Diamine Dihydriodide, Polysaccharide Complexes of: Zinc, Manganese, Iron, Copper, Cobalt.

[a] Trade name Red Hat Feeds manufactured by Molinos De Puerto Rico, Inc. San Juan, Puerto Rico.

Pasture and Feed Evaluation

The pastures used in the experiment were in blocks of 15-25 acres. To eliminate pasture effects at each location, the feeding level groups were rotated at each intermediate weigh period. The flora species composition of the pastures was estimated visually by the animal scientist, his assistant, the Federal AES field biologist and the AES agronomist. The estimated sword percentages of each plant are listed in Table 3.

No attempts were made to determine the actual amount of forage harvested by the bulls, and the pastures were assumed to be non-selectively grazed. Therefore the ability to calculate feed consumption and feed efficiency is not possible. However a rough estimate by difference on the carrying capacity of various types of pasture can be roughly estimated, enabling the producers to put an estimated cost per unit on pasture for each animal (Park et al., 1973).

A problem develops however in that the rainfall pattern on St. Croix is variable year to year and especially season to season (Figure 1), making it extremely difficult to plan ahead. That point was well made in the 1979 trial in that two hurricanes (Frederic and David) came close to St. Croix, causing an unusual amount of rainfall over a very short period of time (Figure 2).

With 2.6-4 times the normal amount of rainfall in September 1979, pasture growth was accelerated compared to normal rates, but how much is difficult to determine without doing a feed consumption measurement. However in research done by Vincente-Chandler et al. (1958), they showed that a three time increase in rainfall caused the dry-matter yield of guinea grass to more than double in a six month period.

A representative sample of each pasture and the forage used in the feedlot treatment group, of 1979-80, was collected, oven dried and run through a Wiley mill and sent to the New York Dairy Herd Improvement Cooperative, Inc. Forage Testing Laboratory to be analyzed. The results are summarized in (Table 4).

Table 3.--Pasture Compositions.

West Location:

Pasture	Size	Composition		Description
A[a]	19 ac	Pangola grass[b]	30-40%	50-55% open
		Guinea grass[c]	55%	70% ground cover
		Palatable bush[d]	5%	10-15% rolling
		Legumes	2%	
B[a]	23 ac	Pangola grass	80-85%	95% open
		Guinea grass	12%	100% ground cover
		Legumes	2%	10-15% slope
C	15 ac	Pangola grass	60-70%	90% open
		Guinea grass	35%	5-10% rolling
		Legumes	1-2%	
D	20 ac	Pangola grass	93+%	90% open
		Guinea grass	6+%	5% slope
		Legumes	<.5%	

East Location:

Pasture	Size	Composition		Description
E	15 ac	Hurrican grass[e]	45%	70-80% open
		Bermuda sour grass	25%	85-90% cover
		Guinea grass	25%	level, gentle slope
		Casha brush[f]	5%	
F	25 ac	Hurricane grass	50%	90% open
		Bermuda sour grass	45%	85-90% cover
		Casha brush	5%	level, gentle slope
G[a]	20 ac	Guinea grass	80-90%	level, gently sloping
		Hurricane grass	5-10%	
		Brush	5%	
H[a]	20 ac	Pangola grass	80%	level, gently sloping
		Hurricane grass	15%	
		Brush	5%	

Table 3 (cont'd).

[a] Pastures used both years at each location

[b] Pangola grass (Digitaria decumbens)

[c] Guinea grass (Panicum maximum)

[d] Mainly tann-tann (Leucaena leucocephala)

[e] Hurricane grass (Bothriochloa pertusa)

[f] Casha (Acacia spp.).

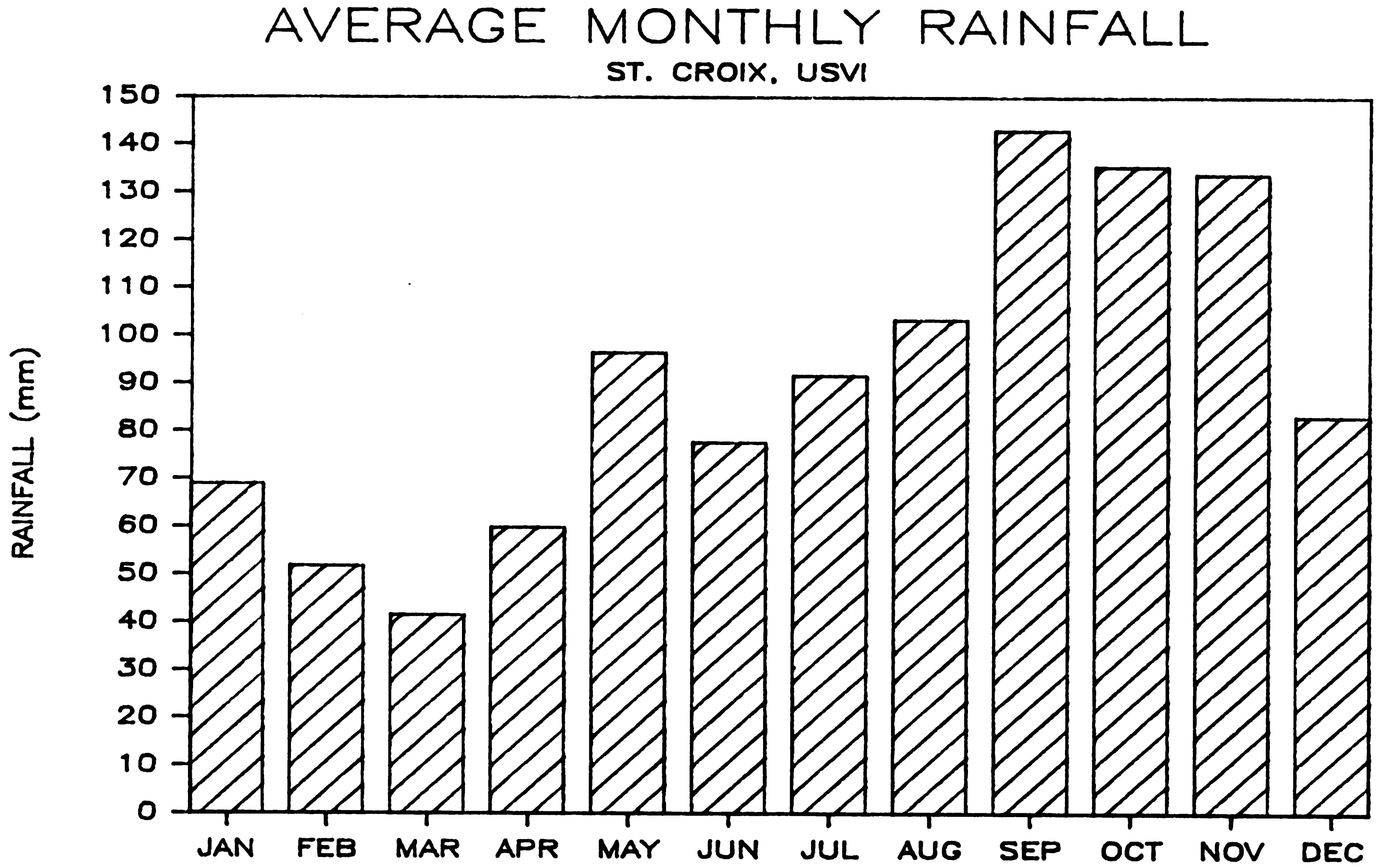

Figure 1.--Average Monthly Rainfall St. Croix USVI.

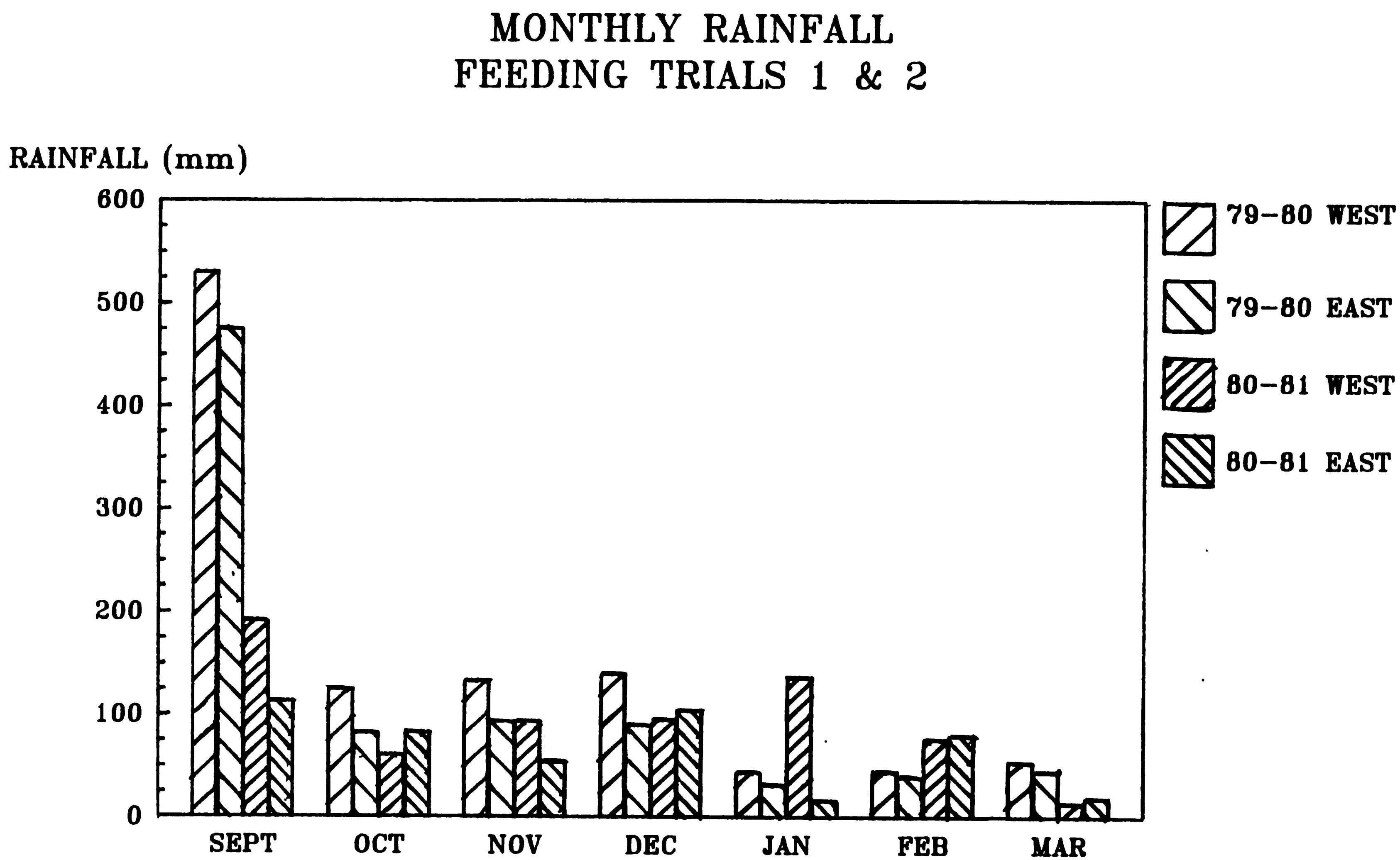

Figure 2.--Monthly Rainfall Feeding Trials 1 & 2.

Table 4.--Forage Analysis Reports for 1979-80 Feeding Trial.

Grass Hay Analysis Fed at East Location

% Dry Matter 97.3

	Dry Matter Basis
% Crude Protein	11.6
% Adjusted Crude Protein	11.6
% Acid Detergent Fiber	43.4
% TDN	58.0
Estimated Net Energy Mcal/Lb.	.36
% Calcium	.694
% Phosphorus	.25
% Magnesium	.21
% Potassium	1.35
% Sodium	.054
PPM Iron	480
PPM Zinc	26
PPM Copper	4
PPM Manganese	52
% Sulfur	.15

Green Chop Analysis Fed at West Location

% Dry Matter 97.7

	Dry Matter Basis
% Crude Protein	13.2
% Adjusted Crude Protein	13.2
% Acid Detergent Fiber	42.9
% TDN	58.0
Estimated Net Energy Mcal/Lb.	.36
% Calcium	.705
% Phosphorus	.26
% Magnesium	.31
% Potassium	1.44
% Sodium	.018
PPM Iron	314
PPM Zinc	29
PPM Copper	4
PPM Manganese	46
% Sulfur	.18

IV. DESCRIPTION OF STATISTICAL ANALYSIS

The data were analyzed by least squares methods for data with unequal subclass numbers (Mao, 1982). The results of the two feeding trials were analyzed in two stages. The first stage was to develop a model for the analysis of data on average daily gain (ADG) and final weight off test. Since there were different feeding levels and time periods between the two trials, each year's data was analyzed seperately. The second stage was to develop a model for the analysis of data on carcass and taste panel traits.

Growth Performance Analysis

Model With Interaction of Feeding Levels by Time Periods

To determine if a feeding level by feeding time interaction existed, the following model with the interaction was developed:

$$Y_{ijk} = \mu + F_i + T_j + L_k + (FT)_{ij} + b_1(SW)_{ijk} + b_2(SA)_{ijk} + b_3(SHG)_{ijk} + b_4(HH)_{ijk} + e_{ijk} \quad (1)$$

where

Y_{ijk} is the resulting observation on either ADG or final weight in 1979 or 1981 of a bull assigned to feeding level i, in time period j and at location k;

μ is the overall mean common to all observations;

F_i is the effect of the ith feeding level, with i = 1,2,3 for 1979 data and i = 1,2,3,4 for 1980 data;

T_j is the effect of the jth time period, with

$j = 1,2,3$ for 1979 data and $j = 1,2$ for 1980 data;

L_k is the effect of the kth location, $k = 1,2$;

$(FT)_{ij}$ is the effect peculiar to the ith feeding level and the jth time period;

$(SW)_{ijk}$ is the starting weight corresponding to y_{ijk};

b_1 is the partial regression coefficient corresponding to $(SW)_{ijk}$;

$(SA)_{ijk}$ is the starting age corresponding to y_{ijk};

b_2 is the partial regression coefficient corresponding to $(SA)_{ijk}$;

$(SHG)_{ijk}$ is the starting heart girth corresponding to y_{ijk};

b_3 is the partial regression coefficient corresponding to $(SHG)_{ijk}$;

$(HH)_{ijk}$ is the starting hip height corresponding to y_{ijk};

b_4 is the partial regression coefficient corresponding to $(HH)_{ijk}$; and

e_{ijk} is the random error corresponding to y_{ijk}.

If the interaction effect was present, it would be impossible to draw inferences regarding only main factors. Therefore it served no purpose to have main factors as seperate entries in the model. Instead a subclass factor was used to include both main factors and their interactions. The resulting model, equivalent to model 1, is then:

$$Y_{ijk} = \mu + L_k + FT_{ij} + b_1(SW)_{ijk} + b_2(SA)_{ijk} + b_3(SHG)_{ijk} + b_4(HH)_{ijk} + e_{ijk} \qquad (2)$$

where $FT_{ij} = F_i + T_j + (FT)_{ij}$

From (2), the normal equations, $\underset{\sim}{X}'\underset{\sim}{X}\underset{\sim}{b} = \underset{\sim}{X}'\underset{\sim}{y}$, will be developed. Since the $\underset{\sim}{X}'\underset{\sim}{X}$ matrix from any model containing fixed factors is non-full rank, an unique inverse $(\underset{\sim}{X}'\underset{\sim}{X})^{-1}$ does not exist. Therefore a generalized inverse $(\underset{\sim}{X}'\underset{\sim}{X})^{-}$ will be used to solve the normal equations: $\tilde{\underset{\sim}{b}} = (\underset{\sim}{X}'\underset{\sim}{X})^{-}\underset{\sim}{X}'\underset{\sim}{y}$.

The sum of squares due to fitting the model, SS_R, can be determined by $SS_R = \tilde{\underset{\sim}{b}}'\underset{\sim}{X}'\underset{\sim}{y}$, where $\tilde{\underset{\sim}{b}}$ is a set of solutions. The total sum of squares SS_T is $\underset{\sim}{y}'\underset{\sim}{y}$. To determine the usefulness of a model, and R^2 value which is called coefficient of multiple determination will be computed as:

$$R^2 = (\tilde{\underset{\sim}{b}}'\underset{\sim}{X}'\underset{\sim}{y} - n\bar{y}^2)/(\underset{\sim}{y}'\underset{\sim}{y} - n\bar{y}^2),$$

where $\bar{y}$ is the sum of y divided by n, the total number of observations. The variance (σ^2) of the model will then be determined by:

$$\hat{\sigma}^2 = (\underset{\sim}{y}'\underset{\sim}{y} - SS_R) / (n - r)$$

where r is the degrees of freedom for fitting the model.

Model Without Interaction

A model (model 3) without the feeding level by feeding time interaction was:

$$Y_{ijk} = \mu + F_i + T_j + L_k + b_1(SW)_{ijk} + b_2(SA)_{ijk} + b_3(SHG)_{ijk} + b_4(HH)_{ijk} + e_{ijk} \qquad (3)$$

Using the same techniques as in the previous analysis, a solution set, the sum of squares due to fitting the model, the total sum of squares, coefficient of multiple determination, R^2, and the variance were determined for this model.

Significance of Interactions

A Fisher's variance-ratio (F-test) (Gill, 1978) was used to determine the significance level of the interactions using the following equation:

$$F = (SS_{R1} - SS_{R2}) / (r_1 - r_2) \times \hat{\sigma}^2$$

where SS_{R1} is the sum of squares due to fitting model 2, SS_{R2} is the sum of squares due to fitting model 3, r_1 is the rank of model 2, r_2 is the rank of model 3 and σ^2 is

$$(\underset{\sim}{y}'\underset{\sim}{y} - SS_{R1}) / (n - r_1).$$

If F is not greater than the $F_{r,n-r}$ value at the $P<.50$ significance level, then it will be determined that the interaction of feeding level and feeding time is not significant.

If interaction is not significant, model 3 will be used to conduct analyses outlined in the following sections.

Significance of Model

The proportion of the total variation that could be attributed to the factors and variables in the model, over and beyond the constant (μ), is then determined. To do this a F value was used to determine the significance of the SS_R:

$$F = (SS_R - n\bar{y}^2) / ((r-1) \times \hat{\sigma}^2).$$

The resulting F value was then compared to $F_{r-1,n-r}$ to determine the level of significance of the model. A R^2 value was also calculated using the formula previously stated.

Significance of Treatments

Again a F value was determined for treatment effect using the formula:

$F = (SS_R - SS_{Rt}) / (r - r_t) \times \hat{\sigma}^2$, where SS_{Rt} is from the sum of squares due to fitting the model without the treatment included and r_t is the corresponding degrees of freedom. This value was then compared to $F_{r-k,n-r}$ to determine the signficance level of treatment effects. Any treatment effect with a significance level less than P<.10 was considered to be not significant.

Significance of Subclasses Within Treatments

Each subclass within a treatment was compared to all the other subclasses within that treatment to determine if they were any significant differences. As before, a F value was used to determine if there were any significant differences between the subclasses. The F value formula used was:

$$F(h_0) = (\tilde{\underset{\sim}{b}}'K[K'(\underset{\sim}{X}'\underset{\sim}{X})^{-}K]^{-1}K'\tilde{\underset{\sim}{b}}) \;/\; s\sigma^2$$

where K' is a matrix of chosen constants for contrasting a pair of treatment classes of s rows and p (number of elements in $\tilde{\underset{\sim}{b}}$) columns. The F value was compared to $F_{s,n-r}$ where s is the number of simultaneous hypotheses that are being tested, to determine the significance level. Any subclass differences with a significance level less than P<.05 was considered to be not significant.

Significance of the Covariates

The significance of each covariate was determined by testing the hypothesis: Is the regression coefficient significantly different from zero? The F value to determine this hypothesis was determined by the same formula in the previous section with s = 1. The resulting F value was then compared to $F_{1,n-r}$ to determine the level of significance. Any covariate with a significance level less than P<.10 was considered to be not significant and equal to zero.

Determination of Least Square Means

The determination of the least square means for each treatment class was accomplished by first of all finding the treatment class with the largest number of observations or the class that was crossed out in the $\underset{\sim}{X}'\underset{\sim}{X}$ matrix to rid of dependencies. The sum of observations for that class is then divided by the number in that class to give the "base", which is also the least square mean for that treatment. The least square means for the other classes, are then obtained by adding the solution for each class, to the "base" least square mean.

Carcass Traits and Taste Panel Analysis

Model With Interaction of Feeding Levels by Time Periods

As with the growth performance analysis, a determination of whether or not there was a feeding level by feeding time interaction was tested. The following model with the interaction was developed:

$$Y_{ijk} = \mu + F_i + T_j + L_k + (FT)_{ij} + b_1(ADG)_{ijk} + b_2(FHG)_{ijk} + b_3(SLA)_{ijk} + e_{ijk} \qquad (4)$$

where

Y_{ijk} is the resulting observation of the carcass traits and taste panel scores in 1979 or 1980 of a bull assigned to feeding level i, in time period j and at location k;

μ is the overall mean common to all observations;

F_i is the effect of the ith feeding level, with $i = 1,2,3$ for 1979 data and $i = 1,2,3,4$ for 1980 data;

T_j is the effect of the jth time period, with $j = 1,2,3$ for 1979 data and $j = 1,2$ for 1980 data;

L_k is the effect of the kth location, with $k = 1,2$;

$(FT)_{ij}$ is the effect peculiar to the ith feeding level and the jth time period;

$(ADG)_{ijk}$ is the average daily gain corresponding to y_{ijk};

b_1 is the partial regression coefficient corresponding to $(ADG)_{ijk}$;

$(FHG)_{ijk}$ is the final heart girth corresponding to y_{ijk};

b_2 is the partial regression coefficient corresponding to $(FHG)_{ijk}$;

$(SLA)_{ijk}$ is the slaughter age corresponding to y_{ijk};

b_3 is the partial regression coefficient corresponding to $(SLA)_{ijk}$; and

e_{ijk} is the random error corresponding to y_{ijk}.

If the interaction effect was present, it would be impossible to draw inferences regarding main factors exclusively. The resulting model, equivalent to model 4, is then:

$$Y_{ijk} = \mu + L_k + FT_{ij} + b_1(ADG)_{ijk} + b_2(FHG)_{ijk} + b_3(SLA)_{ijk} + e_{ijk} \qquad (5)$$

Using the techniques previously stated, a solution set, the sum of squares due to fitting the model, and the coefficient of multiple determination, R^2, and the variance were determined for this model.

Model Without Interactions

After the above values were determined, a model (model 6) without the feeding level, feeding time interaction was:

$$Y_{ijk} = \mu + F_i + T_j + L_k + b_1(ADG)_{ijk} + b_2(FHG)_{ijk} + b_3(SLA)_{ijk} + e_{ijk} \qquad (6)$$

Using the same techniques as in the previous analysis, the solution set, the sum of squares due to fitting the model, the total sum of squares, and the coefficient of multiple determination, R^2, were determined for this model.

Significance of Interactions

A Fisher's variance-ratio (F-test) was used to determine the significance level of the interactions using the same equation as was used to determine the interaction significance in the growth performance model. If the resulting F value is not greater than the $F_{r,n-r}$ value at the $P<.50$ significance level, it is determined that the interaction of feeding level by time period is not significant.

If the interaction of feeding level and feeding time is not significant, model 6 will be used to conduct analyses outlined in the following sections.

Analysis of Carcass and Taste Panel Traits

The testing of the significance of treatments, classes within treatments, and of the covariates was done using the same methods used in the analysis of the growth performance traits model.

Least squares means were determined for each class within a treatment, using the same technique as described earlier.

V. RESULTS

1979-80 FEEDING TRIAL

Main Effects

The results of the 1979-80 feeding trial are shown in Table 5 for the on feed summaries. Location 1 (East) bulls had a significantly lower starting weight (P<.01) but had a higher A.D.G. (P<.05) and final weight (P<.01), than location 2 (West) bulls. Since there were approximately the same number of bulls at each location and the same supplemental feed was used at each location, one can conclude that this difference was attributable, to the quality and/or quantity of the pasture, any significant genetic differences that may exist between the two herds or the possibility of an interaction between those two factors. With the confounding of genetic composition and location, the actual differences cannot be partitioned out.

The effects of feeding level were highly significant (P<.001) for A.D.G. and final weight. There was a positive increase in A.D.G. and final weight as feeding level increased. These results are to be expected since at each level more protein and energy would be available for the animal to consume (Andersen et al., 1975; Harpster et al., 1985; Anderson et al., 1986; Bidner et al., 1986; Shaake et al., 1986). The bulls receiving supplement expended less energy foraging for feed. This is especially true, in the confinement feedlot situation.

The effects of feeding length were significant for

Table 5.--1979-80 Least Squares Means[a] for Growth Performance.

Effect	On feed weight, kg.	A.D.G. kg./day	Final weight, kg.
Location (L)	**	*	**
East (L1)	276.7[c]	0.93[c]	410.4[c]
West (L2)	290.4[d]	0.83[d]	394.3[d]
Feed Level (F)	NS[b]	***	***
Pasture (F1)	293.8[c]	0.58[c]	377.4[c]
1% Suppl. (F2)	290.7[c]	1.00[d]	435.9[d]
2% Suppl. (F3)	290.0[c]	1.11[e]	453.6[e]
Feeding Time (T)	NS	*	***
112 Days (T1)	288.6[c]	0.79[c]	376.8[c]
140 Days (T2)	292.5[c]	0.91[d]	415.5[d]
168 Days (T3)	288.2[c]	0.95[d]	449.3[e]
Covariates:			
b1 (ONWT)	----	-.001 NS	.836 ***
b2 (AGE)	.036 NS	.002 *	.334 *
b3 (H.G.)	11.431 ***	.019 NS	1.890 NS
b4 (H.H.)	16.394 ***	.083 *	11.860 *

* P<.05
** P<.01
*** P<.001

[a] Significance of the F-test for each fixed effect is presented

[b] NS = not significant

[c,d,e] Means, in the same column within an effect, that do not have a common superscript letter are different (P<.05).

A.D.G. (P<.05) and final weight (P<.001). The bulls in the 168 day feeding period group had a significantly higher A.D.G. than the 112 day group bulls, but was not significantly higher than the 140 day group. This is in contrast to the findings of Bailey et al. (1982), where averrage daily gain was affected negatively as length of time on feed increased. There was a positive increase in final weight as length of time on feed increased. These results would be expected since the bulls that are on feed longer, would simply have a longer period in which to gain weight.

Covariates

On feed weight was not significant for A.D.G. but was highly positively significant (P<.001) for final weight. Since it has no effect on A.D.G., it would be expected that, everything else being equal, the heavier the initial weight is to begin with, the heavier will be the final weight.

On feed age was not significantly associated with on feed weight, but was positively significant (P<.05) for both A.D.G. and final weight.

On feed heart girth measurement was highly positively significantly correlated (P<.001) with on feed weight but was not correlated with A.D.G. and final weight.

On feed hip height was highly positively significant (P<.001) for on feed weight and significant (P<.05) for A.D.G. and final weight. This would indicate that both heart girth and hip height are excellent indicators of the weight of a bull of this breed, however for predicting how an animal will perform, hip height is a much better indicator than heart girth. Similar results, on the effects of hip height on future growth performance, have been found by others (Brown et al., 1973; Johnson et al., 1980; Zerbino et al., 1982; Baker et al., 1982).

1980-81 FEEDING TRIAL

Main Effects

The results of the 1980-81 feeding trial are in Table 6, for the on feed summaries. As in the 1979-80 trial, the East site bulls had a significantly (P<.05) higher A.D.G. and final weight than the West site bulls. The effect of location was highly significant (P<.001) for A.D.G. and final weight. Since there was a different set of feeding regimens in 1980-81 than in 1979-80, it appears more likely that this growth performance can be attributed to location, management and genetic composition being confounded between the two herds rather than the nutrient intake.

The effects of feeding level are highly significant (P<.001) for A.D.G. and final weight. The animals in the 1.5% supplement group and the 1% supplement group had a significantly higher A.D.G. and a heavier final weight than the 1% corn and the pasture group. The animals in the 1% corn group also had a significantly higher A.D.G. and a heavier final weight than the pasture group animals. However there were no significant differences in A.D.G. and final weights between the 1% and 1.5% supplement groups, indicating, along with information from the 1979-80 trial,

Table 6.--1980-81 Least Square Means[a] for Growth Performance.

Effect	On feed weight, kg.	A.D.G. kg./day	Final weight, kg.
Location (L)	NS[b]	***	***
East (L1)	290.5[c]	0.93[c]	434.1[c]
West (L2)	286.8[c]	0.72[d]	402.3[d]
Feed Level (F)	NS	***	***
Pasture (F1)	276.8[c]	0.45[c]	345.9[c]
1% Corn (F2)	276.2[c]	0.82[d]	403.2[d]
1% Suppl. (F3)	270.2[c]	0.94[e]	422.1[e]
1.5% Suppl. (F4)	276.7[c]	1.03[e]	436.8[e]
Feeding Time (T)	NS	NS	***
140 Days (T2)	278.6[c]	0.81[c]	391.1[c]
168 Days (T3)	276.8[c]	0.80[c]	411.8[d]
Covariates:			
b1 (ONWT)	----	.027 NS	.959 ***
b2 (AGE)	-.054 NS	.001 NS	.166 NS
b3 (H.G.)	17.919 ***	.000 NS	.082 NS
b4 (H.H.)	15.176 ***	-.007 NS	.013 NS

*   P<.05
** P<.01
*** P<.001

[a] Significance of the F-test for each fixed effect is presented

[b] NS = not significant

[c,d,e] Means, in the same column within an effect, that do not have a common superscript letter are different (P<.05).

that the supplement must be doubled, from the 1% to 2% supplement level before any additional significant effect can be seen.

The results from the effects of feeding level are quite similar to the previous Senepol feeding trial and the work of others (Andersen et al., 1975; Harpster et al., 1985; Anderson et al., 1986; Bidner et al., 1986; Shaake et al., 1986), in that the more energy and protein available to the animal the better it is likely to perform. The difference between the supplement diets and the corn diet would be expected due to the lower percent protein of the corn (10%) versus the supplement (14%) and the lower Mcal/kg. in the corn.

The 168 day bulls had a significantly heavier final weight (P<.001) than the 140 day bulls. There were no significant feeding time effects for A.D.G., even though Bailey et al. (1982) found A.D.G. to be negatively affected by length of time on feed. As in the 1979-80 trial the final weights differ because the bulls are kept on feed for a longer period of time and since their A.D.G. is the same, they weigh more at the end of the trial.

COVARIATES

On feed weight was not significant for A.D.G. but was highly positively significant (P<.001) for final weight. Since on feed weight had no effect on A.D.G., as in 1979-80, the same principle holds that the bulls of higher initial weights will have heavier final weights.

Unlike the 1979-80 feeding trial, on feed age was not significant for on feed weight, A.D.G., or final weight. This would indicate that for young bulls, the on feed age would not affect gain performance unless the feeding period length takes the bulls past the peak in their growth curve.

As in the 1979-80 feeding trial, on feed heart girth was highly positively significant ($P<.001$) for on feed weight but was not significant for either A.D.G. or final weight.

On feed hip height was highly positively significant ($P<.001$) for on feed weight, as it was in the 1979-80 trial, however it was not significant for either A.D.G. or final weights. In 1979-80 it was significant ($P<.05$) for both A.D.G. and final weight. This further indicates that both on feed heart girth and hip height are very good indicators of present weight, in these types of animals. With the results from 1980-81 though, it is not clear whether either one is indicative of future growth, since in the 1979-80 trial it was evident that hip height was the only measurement of the two that showed an effect on future performance. From other studies (Brown et al., 1973; Johnson et al., 1980; Zerbino et al., 1982; Baker et al., 1982), though it still appears that hip height is the most highly correlated predictor of future growth in young cattle.

1979-80 CARCASS EVALUATION

Main Effects

The live and carcass weights are shown in Table 7. The live weights of the slaughter bulls were significantly heavier ($P<.001$) at the West site as were both the hot carcass ($P<.01$) and cold carcass ($P<.01$) weights. Dressing percentage was not significantly different.

Even though the carcass weights were different for the two locations, it is interesting to note that the dressing percentages remained constant between the two locations.

The effects of feeding level were significantly related ($P<.01$) to dressing percentage, but were not significantly different for live weight, hot carcass weight, and cold carcass weight. This is in contrast to the findings of (Bidner et al., 1985; Harpster et al., 1985; Shaake et al., 1986) where steers on low energy diets had lighter slaughter weights than steers on high energy diets. The 1% and 2% supplement group had a significantly higher dressing percentage than the pasture group, but were not significantly different from each other.

Even though the live weights are not significantly different, the trend is for the pasture group to be heavier than the 1% supplement group and for the 1% supplement group to be heavier than the 2% supplement group. If all the bulls used in the feeding trial are included, the order is just the reverse, as indicated by final weights in Table 5. This suggests that by allowing the owners to pre-select the bulls that would be slaughtered, a possible bias is built

Table 7.--1979-80 Least Squares Means[a] for Carcass Weights.

Effect	Live weight, kg.	Hot carcass weight, kg.	Cold carcass weight, kg.	Dressing %
Location (L)	***	**	**	NS[b]
East (L1)	396.4[c]	223.4[c]	218.2[c]	54.7[c]
West (L2)	419.1[d]	234.2[d]	228.5[d]	54.3[c]
Feed Level (F)	NS	NS	NS	**
Pasture (F1)	371.4[c]	198.7[c]	193.9[c]	52.1[c]
1% Suppl. (F2)	362.0[c]	202.4[c]	197.6[c]	54.7[d]
2% Suppl. (F3)	355.9[c]	202.0[c]	197.0[c]	55.2[d]
Feeding Time (T)	***	**	**	+
112 Days (T1)	398.7[c]	225.9[c]	220.5[c]	55.1[c]
140 Days (T2)	408.5[c]	226.5[c]	221.3[c]	53.9[d]
168 Days (T3)	434.2[d]	247.5[d]	241.4[d]	55.3[c]
Covariates:				
b1 (A.D.G.)	96.969***	67.221***	65.732***	1.115+
b2 (F.H.G.)	17.122***	9.725***	9.536***	.024 NS
b3 (S.L.A.)	.082 NS	.063 NS	.062 NS	.002 NS

+ P<.10
* P<.05
** P<.01
*** P<.001

[a] Significance of the F-test for each fixed effect is presented

[b] NS = not significant

[c,d] Means, in the same column within an effect, that do not have a common superscript letter are different (P<.05).

into the carcass data. Even with the possibility of a weight bias it can still be seen that the bulls on the higher energy diets have an increased dressing percentage compared to the bulls on pasture, probably due to increased fat deposition (Andersen et al., 1975; Bidner et al., 1985; Bidner et al., 1986).

The effects of feeding period were significant for live weight ($P<.001$), hot carcass weight ($P<.01$), cold carcass weight ($P<.01$), and dressing percentage ($P<.10$). The 168 day bulls had a significantly heavier ($P<.05$) live weight, hot carcass weight and cold carcass weight than the 140 day and 112 day groups. The live weight, hot carcass weight and cold carcass weight were not significantly different between the 112 day and 140 day bulls. The 140 day bulls had a significantly ($P<.05$) lower dressing percentage than either the 112 or 168 day bulls.

Slaughter weight and hot carcass weight increased as length of time on feed increased as was reported in previous studies, (Stringer et al., 1968; Bailey et al., 1982). Stringer (1968) also found that dressing percentage did not consistently increase as length of time on feed increased, although in his study there was a slight overall tendency for dressing percentage to increase as time on feed increased. Wilson et al. (1985) also found that dressing percentage increased as length of time on feed increased. Andersen et al., (1977) also found that dressing percentage increased with increasing age per weight. In this study bulls from the shortest and longest times on feed groups had the highest dressing percentage and the middle time group was significantly lower.

Covariates

Feed test A.D.G. was highly positively significant ($P<.001$) for live weight, hot carcass weight, cold carcass weight and positively significant ($P<.10$) for dressing percentage. As in other studies, the effect on dressing percentage is not as great because the fast gaining animal is leaner and the lean/fat ratio has an effect on dressing percentage.

Final heart girth was highly positively significant ($P<.001$) for live weight, hot carcass weight, and cold carcass weight, but was not significant for dressing percentage. As in the feeding phase of the trial, heart girth is a very good indicator of predicting the weight of an animal, since an animal with a larger volume would be expected to weigh more than a smaller volume animal, assuming that the condition of the animals was similar.

The age at slaughter was not significantly related to live weight, hot carcass weight, cold carcass weight or dressing percentage.

1979-80 CARCASS QUALITY TRAITS

Main Effects

The results of the 1979-80 feeding trial are shown in Tables 8 and 9 for the carcass quality traits. The East side location bulls had a significantly lower rib-eye area (REA) but a significantly greater backfat thickness (FOE),

Table 8.--1979-80 Least Squares Means[a] for Rib-eye Area, Fat Over Eye and Warner-Bratzler Shear.

Effect	REA cm	FOE mm	WBS kg.
Location (L)	**	+	NS[b]
East (L1)	65.01[c]	2.73[c]	9.16[c]
West (L2)	71.18[d]	2.20[c]	9.54[c]
Feed Level (F)	NS	***	NS
Pasture (F1)	63.25[c]	0.98[c]	8.82[c]
1% Suppl. (F2)	56.62[d]	2.51[d]	9.75[c]
2% Suppl. (F3)	59.24[cd]	3.49[e]	8.64[c]
Feeding Time (T)	NS	NS	NS
112 Days (T1)	69.31[c]	2.92[c]	9.94[c]
140 Days (T2)	67.15[c]	2.94[c]	10.00[c]
168 Days (T3)	71.90[c]	2.57[c]	9.11[c]
Covariates:			
b1 (A.D.G.)	1.197[*]	.546[NS]	-1.460[NS]
b2 (F.H.G.)	.243[**]	.020[NS]	.658[*]
b3 (S.L.A.)	.002[NS]	.004[NS]	.022[NS]

+ $P<.10$
* $P<.05$
** $P<.01$
*** $P<.001$

[a] Significance of the F-test for each fixed effect is presented

[b] NS = not significant

[c,d,e] Means, in the same column within an effect, that do not have a common superscript letter are different ($P<.05$).

Table 9.--1979-80 Least Squares Means[a] for Yield Grade, Kidney-pelvic Fat and Marbling.

Effect	Yield grade	KP, %	Marbling[b]
Location (L)	**	**	NS[c]
East (L1)	1.8[d]	2.2[d]	3.5[d]
West (L2)	1.5[e]	1.9[e]	3.3[d]
Feed Level (F)	*	NS	**
Pasture (F1)	1.5[d]	1.7[d]	2.3[d]
1% Suppl. (F2)	2.0[e]	1.9[d]	3.3[e]
2% Suppl. (F3)	2.0[e]	2.0[d]	4.0[f]
Feeding Time (T)	NS	NS	NS
112 Days (T1)	1.7[d]	2.2[d]	3.6[d]
140 Days (T2)	1.8[d]	2.2[d]	3.6[d]
168 Days (T3)	1.6[d]	2.0[d]	3.8[d]
Covariates:			
b1 (A.D.G.)	-.002[NS]	.362[*]	.367[NS]
b2 (F.H.G.)	-.037[NS]	.007[NS]	.076[NS]
b3 (S.L.A.)	.000[NS]	.000[NS]	.002[NS]

* P<.05

** P<.01

[a] Significance of the F-test for each fixed effect is presented

[b] (1 = Devoid, 5 = Traces +)

[c] NS = not significant

[d,e,f] Means, in the same column within an effect, that do not have a common superscript letter are different (P<.05).

yield grade and kidney pelvic fat percentage (KP) than the West side location bulls. There were no significant differences in Warner Bratzler shear (WBS) and marbling. As would be expected since the East site bulls have a smaller REA, greater FOE and a higher KP percentage the yield grade is naturally higher, although it should be noted that with our current grading standards, both groups would still be classified as yield grade 1's even though they are significantly different.

The feeding level significantly increased FOE (P<.001), yield grade (P<.05) and marbling (P<.01), but was not significant for REA, WBS, and KP. The same results were found by others (Bidner et al., 1981; Bidner et al., 1985; Bidner et al., 1986; Shaake et al., 1986). However, Harpster et al. (1985) found no difference in yield grade for Charolais bulls fed different levels of protein. The lack of a significant difference in WBS due to diet was also supported by previous research (Bowling et al., 1978; Smith et al., 1979; Bidner et al., 1985). The pasture group REA was significantly (P<.05) larger than the 1% supplement group, and the pasture group had a greater REA than either the 1% or the 2% supplement group.

The 2% supplement group had a significantly (P<.05) greater FOE than the 1% supplement and the pasture group, with the pasture group having the least FOE of the three treatments. This would indicate that the extra energy is going into the production of fat instead of lean muscle (Andersen et al., 1975; Bidner et al., 1985; Shaake et al., 1986).

The pasture group had a significantly (P<.05) lower yield grade than the 1% and 2% supplement groups, while there was no significant difference between the 1% and 2% supplement groups. The animals on pasture had the lowest yield grade because of the larger REA and less FOE while having the same KP as the other two diets. The yield grade of the pasture group was consistent numerically with other studies of cattle on pasture (Barksdale et al., 1980; Wyatt et al., 1980).

The 2% supplement group had a significantly (P<.05) higher marbling score than either the 1% supplement or the pasture group and the 1% supplement group had a significantly higher marbling score than the pasture group. As with the FOE, the increased energy intake is resulting in the laying down of intra muscular fat in the bulls.

The effects of feeding length were not significant for REA, FOE, WBS, yield grade, KP or marbling. This contradicts the findings of Stringer et al. (1968) where the REA increased as length of time on feed increased, Bailey et al. (1982), where the length of time on feed resulted in a higher marbling score, Barksdale et al. (1980), where yield grade and FOE increased as length of time on feed increased, and Wilson et al. (1985) where marbling score and kidney fat increased as length of time on feed increased.

Covariates

Feed test A.D.G. was positively significant (P<.05) for REA and KP percentage, but was not significant for FOE, WBS, yield grade and marbling. This agrees with the findings of Stringer et al. (1968) in that REA increased as mean live weight or carcass weight increased, and since A.D.G. was highly significant for live weight and carcass weight one would expect A.D.G. to be significant for REA.

Final heart girth was positively significant for REA (P<.01) and WBS (P<.05), but was not significant for FOE, yield grade, KP or marbling. Orme et al. (1959) found that the correlation coefficient obtained between REA and circumference of body at the fore flank was highly significant. Therefore animals with a larger body circumference tend to have larger ribeyes.

As with all the prior carcass traits, slaughter age was not significant for REA, FOE, WBS, yield grade, KP or marbling, although from the work of others (Binion et al., 1986) it might be expected that slaughter age would be significantly related to yield grade or kidney-pelvic fat.

1979-80 CARCASS TASTE PANEL TEST

Main Effects

The results of the 1979-80 feeding trial are shown in Table 10 for the carcass taste panel test. The East side location group had a significantly (P<.10) higher initial tenderness than the West side group, but there were no significant differences in initial juiciness, sustained

Table 10.--1979-80 Least Squares Means[a] for Taste Panel Scores.

Effect	Intial juiciness[b]	Sustained juiciness[b]	Int. tender.[c]	Sustained tender.[c]	Flavor int.[d]
Location (L)	NS[e]	NS	+	NS	NS
East (L1)	5.29[f]	4.77[f]	5.52[f]	5.33[f]	4.56[f]
West (L2)	5.09[f]	4.57[f]	4.96[f]	4.85[f]	4.70[f]
Feed Level (F)	NS	NS	NS	NS	NS
Pasture (F1)	5.31[f]	4.82[f]	5.64[f]	5.56[f]	4.85[f]
1% Suppl. (F2)	5.70[f]	5.42[f]	5.83[f]	5.44[f]	4.79[f]
2% Suppl. (F3)	5.73[f]	5.22[f]	5.94[f]	5.61[f]	4.53[f]
Feeding Time (T)	NS	NS	NS	NS	NS
112 Days (T1)	5.12[f]	4.66[f]	5.02[f]	5.03[f]	4.40[f]
140 Days (T2)	5.25[f]	4.60[f]	4.92[f]	4.78[f]	4.66[f]
168 Days (T3)	5.08[f]	4.52[f]	5.16[f]	4.98[f]	4.71[f]
Covariates:					
b1 (A.D.G.)	-.359 NS	-.525 NS	-.365 NS	-.259 NS	-.109 NS
b2 (F.H.G.)	-.064 NS	-.059 NS	-.129 +	-.121 +	-.057 NS
b3 (S.L.A.)	.000 NS	.000 NS	-.005 NS	-.003 NS	.002 NS

\+ P<.10
* P<.05
** P<.01
*** P<.001

[a] Significance of the F-test for each fixed effect is presented

[b] (1 = extremely dry, 8 = extremely juicy)

[c] (1 = extremely tough, 8 = extremely tender)

[d] (1 = extremely bland, 8 = extremely intense flavor)

Table 10 (cont'd.).

[e] NS = not significant

[f] Means, in the same column within an effect, that do not have a common superscript letter are different ($P<.05$).

juiciness, sustained tenderness and flavor intensity. The slight significant difference in increased initial tenderness of the East site group might be partially explained by the lower Warner-Bratzler shear value from the East site bulls although that lower value was not significantly different.

The effects of feeding level were not significant for initial juiciness, sustained juiciness, initial tenderness, sustained tenderness and flavor intensity. Although not significant, initial juiciness seemed to increase slightly with increased energy level in the diet. It would seem, that there would have been a much bigger difference in juiciness considering the significant differences in marbling scores between the three diets, and the findings of others (Dinius and Cross, 1978; Aberle et al., 1980; Bidner et al., 1986), although Bidner et al. (1985) found no difference in sensory panel traits from steers fed different levels of energy.

However, other studies have found that while trained sensory panels were able to detect differences in tenderness, juiciness, and flavor, consumer taste panels were not able to detect differences due to diet of the animals tested (Malphrus et al., 1962; Marchello et al., 1979; Bidner et al., 1981; Bidner et al., 1986). This would indicate that perhaps the sensory panel needed more training or were not sensitive enough.

Length of time on feed was not significantly associated with initial juiciness, sustained juiciness, initial tenderness, sustained tenderness, and flavor intensity. This contradicts the findings of Winer et al. (1981) where there were significant positive linear regression effects of length of time on feed for taste panel juiciness scores, but is supported by Wilson et al. (1985), where length of time on feed had no effect on taste panel scores. Although not significantly different, the pattern of initial tenderness for the three diets, i.e. 168 days the highest, 140 days the lowest, fits the pattern of Warner-Bratzler shear values, 168 days the lowest, 140 days the highest. Although from the work of Liboriussen, et al. 1977, it would be expected that the older the animal is at slaughter, the more the collagen solubility decreases, making the meat tougher.

Covariates

Feed test A.D.G. was not significantly related to any of the taste panel test scores, nor was slaughter age significant for any of the test scores.

Final heart girth was slightly associated ($P<.10$) with initial and sustained tenderness, but it was a negative correlation.

1980-81 CARCASS EVALUATION

Main Effects

The results of the 1980-81 feeding trial are shown in Table 11 for the carcass weights. Hot carcass weights, cold carcass weights and dressing percentage were significantly heavier for the East Location group than for the West

Table 11.--1980-81 Least Squares Means[a] for Carcass weights.

Effect	Live weight, kg.	Hot carcass weight, kg.	Cold carcass weight, kg.	Dressing %
Location (L)	NS[b]	*	**	***
East (L1)	425.5[c]	247.8[c]	237.4[c]	55.6[c]
West (L2)	418.0[c]	233.9[d]	222.5[d]	53.0[d]
Feed Level (F)	NS	NS	NS	+
Pasture (F1)	384.2[c]	212.7[c]	200.9[c]	52.2[c]
1% Corn (F2)	385.5[c]	222.2[c]	214.3[c]	55.4[d]
1% Suppl. (F3)	398.5[c]	227.0[c]	217.3[c]	54.3[cd]
1.5% Suppl. (F4)	390.9[c]	225.8[c]	218.1[c]	55.5[d]
Feeding Time (T)	**	**	NS	NS
140 Days (T2)	404.1[c]	229.5[c]	222.6[c]	54.9[c]
168 Days (T3)	424.5[d]	244.4[d]	230.2[c]	54.0[c]
Covariates:				
b1 (A.D.G.)	34.790 +	26.470 +	23.703 +	.601 NS
b2 (F.H.G.)	23.601 ***	16.000 ***	15.069 ***	.218 NS
b3 (S.L.A.)	-.075 NS	-.101 NS	-.059 NS	-.003 NS

\+ P<.10
* P<.05
** P<.01
*** P<.001

[a] Significance of the F-test for each fixed effect is presented.

[b] NS = not significant

[c,d] Means, in the same column within an effect, that do not have a common superscript letter are different (P<.05).

location group, but live weights were not significantly different.

The live weights of the bulls selected for slaughter were heavier at the East site as were the hot carcass and cold carcass weights, whereas in the 1979-80 trial the results were just the opposite. It would still appear that the initial selection process of determining which bulls would be slaughtered is still imposing a bias on the results, since in both feeding trials the final weight of all the bulls was greatest at the East site. The weights of the bulls selected for slaughter were greater at the West site in 1979-80 and at the East site in 1980-81, even though in 1980-81 the difference was not significant.

As in 1979-80, the feeding level did not significantly increase live weight, hot carcass weight, and cold carcass weight but was slightly significant ($P<.10$) for dressing percentage, although it would be expected that the animals on the higher energy diets would have heavier carcass weights (Bidner et al., 1985; Harpster et al., 1985; Shaake et al., 1986). The bulls on pasture had a significantly ($P<.05$) lower dressing percentage than the 1% corn and the 1.5% supplement group. As in the previous trial dressing percentage is higher for the bulls on the higher energy diets.

Feeding length was significantly related to live weight ($P<.01$) and hot carcass weight ($P<.01$), but not to cold carcass weight or dressing percentage. The bulls fed for 168 days were heavier at slaughter time and had heavier hot

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carcass weights than the bulls fed 140 days. As in the 1979-80 trial and other studies (Stringer et al., 1968; Bailey et al., 1982) the longer the animal is on feed the heavier the slaughter weight and hot carcass weight will be.

Covariates

In the 1980-81 trial, A.D.G. was only slightly positively significant (P<.10) and not significant for dressing percentage, while in the 1979-80 feeding trial, feed test A.D.G. was highly positively associated (P<.001) with live weight, hot carcass weight, and cold carcass weight. Even though A.D.G. is not as positively significant as it was in the first trial, it still indicates that a fast growing animal will generally produce a leaner, heavier carcass than a slow gaining animal tested for the same period of time.

The results for final heart girth were the same as in the 1979-80 trial, in that it had a highly significant positive correlation (P<.001) for live weight, hot carcass weight, and cold carcass weight, but was not significant for dressing percentage.

As in the previous trial, age at slaughter was not significantly related to live weight, hot carcass weight, cold carcass weight or dressing percentage, indicating that it could be left out of the model for predicting the four previously mentioned traits.

1980-81 CARCASS QUALITY TRAITS

Main Effects

The results of the 1980-81 feeding trial are shown in Tables 12 and 13 for the carcass quality traits. The East side location group had a significantly higher (P<.05) marbling score than the West side location group, but there were no significant differences in REA, FOE, WBS, yield grade or KP percentage. This contradicts the findings of the 1979-80 feeding trial where all the quality traits except WBS and marbling were significant. In both trials however, the East site bulls did have the higher marbling score, as well as the higher FOE, KP percentage and yield grade.

Feeding level did not have a significant effect on REA, WBS, yield grade, and KP percentage. This corresponds with the 1979-80 feeding trial, except that in 1979-80, yield grade was also correlated for feeding level (P<.05). The 1.5% supplement group had a significantly greater FOE and marbling score than the other groups. This is the same result that was obtained in the 1979-80 feeding trial, where the extra energy is going into the production of fat instead of muscle.

As in the previous trial, the effects of feeding length were not significant for REA, FOE, WBS, yield grade, KP or marbling, even though from the prior literature, (Stringer et al., 1968; Liboriussen et al., 1977; Barksdale et al., 1980; Bailey et al., 1982; Wison et al., 1985), one would expect that the REA, FOE, yield grade and marbling scores

Table 12.--1980-81 Least Squares Means[a] for Rib-eye Area, Fat Over Eye and Warner-Bratzler Shear.

Effect	REA cm	FOE mm	WBS kg./2.54 cm
Location (L)	NS[b]	NS	NS
East (L1)	69.22[c]	3.08[c]	9.52[c]
West (L2)	68.24[c]	2.67[c]	9.31[c]
Feed Level (F)	NS	+	NS
Pasture (F1)	63.51[c]	1.73[c]	10.66[c]
1% Corn (F2)	65.69[c]	2.16[c]	9.29[c]
1% Suppl. (F3)	64.41[c]	1.93[c]	10.19[c]
1.5% Suppl. (F4)	67.34[c]	3.03[d]	8.80[c]
Feeding Time (T)	NS	NS	NS
140 Days (T2)	66.93[c]	2.34[c]	9.20[c]
168 Days (T3)	66.55[c]	2.87[c]	9.72[c]
Covariates:			
b1 (A.D.G.)	-.154 NS	.863 +	-.946 NS
b2 (F.H.G.)	.298 ***	.174 *	.064 NS
b3 (S.L.A.)	.004 NS	.002 NS	-.008 NS

+ P<.10
* P<.05
** P<.01
*** P<.001

[a] Significance of the F-test for each fixed effect is presented.

[b] NS = not significant

[c,d] Means, in the same column within an effect, that do not have a common superscript letter are different (P<.05).

Table 13.--1980-81 Least Squares Means[a] for Yield Grade, Kidney-pelvic Fat and Marbling.

Effect	Yield grade	KP, %	Marbling[b]
Location (L)	NS[c]	NS	*
East (L1)	2.0[d]	2.7[d]	3.5[d]
West (L2)	1.8[d]	2.4[e]	2.9[e]
Feed Level (F)	NS	NS	+
Pasture (F1)	1.8[d]	2.5[d]	2.3[d]
1% Corn (F2)	1.8[d]	2.6[d]	2.6[d]
1% Suppl. (F3)	1.9[d]	2.6[d]	3.1[d]
1.5% Suppl. (F4)	1.8[d]	2.5[d]	3.6[e]
Feeding Time (T)	NS	NS	NS
140 Days (T2)	1.8[d]	2.4[d]	3.3[d]
168 Days (T3)	2.0[d]	2.5[d]	3.6[d]
Covariates:			
b1 (A.D.G.)	.247[NS]	.057[NS]	.644[+]
b2 (F.H.G.)	-.009[NS]	.041[NS]	.059[NS]
b3 (S.L.A.)	-.001[NS]	.002[NS]	-.006[NS]

\+ P<.10
* P<.05

[a] Significance of the F-test for each fixed effect is presented

[b] (1 = Devoid, 5 = Trace +)

[c] NS = not significant

[d,e] Means, in the same column within an effect, that do not have a common superscript letter are different (P<.05).

would increase as length of time on feed increased.

Covariates

Feed test A.D.G. was positively associated ($P<.10$) with FOE and marbling, but there was no significant relationship wtih REA, WBS, yield grade or KP percentage. This contradicts the 1979-80 feeding trial and the work of Stringer et al. (1968), where A.D.G. was positively significant for REA. One would not expect A.D.G. to be positively correlated with FOE or marbling, since a faster growing animal is leaner than a slower growing animal (Andersen et al., 1977).

Final heart girth was significantly related to REA ($P<.001$) and FOE ($P<.05$), but not for WBS, yield grade, KP percentage and marbling. As in the 1979-80 feeding trial and Orme et al. (1959), the correlation between heart girth and REA was highly significant.

As with all the prior 1980-81 carcass traits, and like the 1979-80 carcass traits, slaughter age was not significant for REA, FOE, WBS, yield grade, KP percentage or marbling, even though Binion et al. (1986) found that slaughter age was significant for yield grade and kidney-pelvic fat.

Economics of the Trial

Although a detailed financial analysis of the feeding trials was not part of the experiment, it is meaningful to determine costs and resources for each one of the feeding regimes. The only available published data on costs of a beef operation on St. Croix, is that of Park et al. (1973). In 1973, total expenses per acre, including land taxes, wages and salaries, buildings and facilities, production inputs, machinery and equipment, and interest on operating capital, per year were $41.22. In 1979 and 1980, the estimated costs per acre were $43.69 and $42.46 respectively, based on index statistics for the Southeast region (USDA, 1984).

It is difficult to get an actual price to put on the forage that was used for the feedlot phase of the 1979-80 trial, because the yield or cost of green chop has not been calculated for the Virgin Islands. It is just as difficult to put an accurate price on the hay that was used at the East location in place of the green chop, because hay was almost never used for beef production there at that time. A present day realistic cost though would be about $80/ton, not including storage or transportation, based on the fact that small farmers and horse raisers pay about $2.00 per bale, (50 pound bales), in Puerto Rico, for hay of the same approximate composition. St. Croix is similar enough to Puerto Rico that production costs would probably be about the same, if people were to raise hay on St. Croix on a commercial basis. For calculations, it is assumed that green chop would be the same cost on a dry matter basis, although another study (Wilson, 1982) showed that harvesting (chopping and hauling) of hay crop silage requires almost four times more energy per dry ton than any hay system.

Certain assumptions had to be made for the cost calculations. Based on prior data (Park et al., 1973) and personal observation, it is assumed that it typically requires 4.0 acres to support an animal unit (AU), with a cow and calf equaling 1.0 AU and a yearling 0.6 AU, if no supplemental feed is provided.

Since actual amounts of forage or pasture consumed were not measured, it was necessary to use NRC (1976) requirements to estimate the amount of dry matter expected to be consumed daily by bulls of that weight. Then by subtracting the amount of dry matter consumed in the form of supplement, the amount of forage or pasture consumed was then estimated.

Because the bulls on each feeding regime ended the trial at a different weight, it is necessary for the economic analysis to establish equal starting and finishing weights, to accurately compare each feeding level. The average starting weight was set to 280 kg. and the expected finished weight was set to 400 kg. Assuming that the bulls would gain at the same rate as in the feeding trial, although the time required to gain 120 kg. may be more or less than the actual length of the trial, the number of days to gain the required weight is then calculated.

Since some of the feeding levels were repeated both years, an average was taken for the rate of gain for the pasture and 1% supplement bulls. Pasture costs and supplement costs were also averaged for the two years, giving an average pasture cost of $43.18 per acre, average 14% protein supplement price of $239.20 per ton ($230.40 per ton in 1979 and $248.00 per ton in 1980) and a corn cost of $230.00 per ton.

The last assumption was that if the cattle had been sold, they would have brought $0.55/lb. or $1.21/kg. on a liveweight basis.

The estimated costs and returns are summarized in Table 14. The greatest net income per head came from the bulls on pasture only, followed by 1% supplement, 1% corn, 1.5% supplement and 2% supplement. However, on a net income per day calculation, the greatest income comes from the bulls on 1% supplement followed by 1.5% supplement, 2% supplement, 1% corn and pasture only. This would indicate that if the ranchers only have a set number of calves per year that they can feed, it is more economical to feed them out on pasture, but if they have the animals to constantly replace the ones slaughtered, as in a mainland feedlot, they would realize a greater profit per head per day by feeding the 1% supplement.

Because they are limited in the amount of land available, it would appear that pasture feeding is the best option at this time, unless the additional land that would be available from feeding a supplement would be enough to

Table 14.--Economic Analysis of Senepol Bulls on Various Feeding Regimes on a per Head Basis.

	Pasture	1% Corn
A.D.G., kg.	0.52	0.82
Days on feed	231	146
Acres pasture needed	1.519	0.660
Total pasture cost	$ 65.59	$ 24.50
Forage needed, kg.	----	----
Forage cost	----	----
Purchased feed, kg.	----	496.4
Purchased feed cost	----	$125.85
Total feed cost	$ 65.59	$150.35
Gross income	$485.00	$485.00
Net income	$419.41	$334.65
Net income/kg. gain	$ 3.50	$ 2.79
Total feed cost/kg. gain	$ 0.54	$ 1.25
Net income / day	$ 1.82	$ 2.29
Supplement breakeven price to equal pasture per ton	----	$ 75.00

Table 14 (cont'd.).

	1% Suppl.	1.5% Suppl.	2% Suppl.
A.D.G., kg.	0.97	1.03	1.11
Days on feed	124	117	108
Acres pasture needed	0.558	0.405	----
Total pasture cost	$ 24.09	$ 17.49	----
Forage needed, kg.	----	----	427.2
Forage cost	----	----	$ 37.59
Purchased feed, kg.	421.6	596.7	734.4
Purchased feed cost	$111.16	$157.33	$193.64
Total feed cost	$135.25	$174.82	$231.23
Gross income	$485.00	$485.00	$485.00
Net income	$349.75	$310.18	$253.77
Net income/kg. gain	$ 2.91	$ 2.58	$ 2.11
Total feed cost/kg. gain	$ 1.13	$ 1.46	$ 1.93
Net income / day	$ 2.82	$ 2.65	$ 2.35
Supplement breakeven price to equal pasture per ton	$ 89.30	$ 73.13	$ 34.59

support the cows necessary to provide the additional calves needed to make supplementation a profitable alternative.

If the prices of the supplements were to decrease, supplemental feeding, on a per head net income basis could become equal to pasture-only feeding. But as can be seen from Table 14, those prices would have to fall so low, as to be unprecedented.

VI. DISCUSSION AND CONCLUSIONS

These findings indicate that an increase in energy will increase A.D.G., final weights, dressing percentages, backfat, yield grade, kidney and pelvic fat, and marbling but has little effect on rib-eye area, Warner-Bratzler shear, or taste test scores. The increases in A.D.G. and final weights have been documented in other studies and would be expected (Andersen et al., 1975; Harpster et al., 1985; Anderson et al., 1986; Shaake et al., 1986). The carcass traits and taste panel test score trends appear to agree with numerous other studies (Bowling et al., 1978; Smith et al., 1979; Bidner et al., 1981; Bidner et al., 1985; Bidner et al., 1986), although one would have expected significant differences in carcass weights, since the final weights of all animals on test were significant, which again leads to the conclusion that the selection procedure for slaughter bulls was biased.

An increase in length of time on test causes an increase in A.D.G., final weight, hot carcass weight, cold carcass weight, and dressing percentage but has little or no effect on rib-eye area, backfat, Warner-Bratzler shear force, yield grade, kidney-pelvic fat, marbling or taste panel test scores. Correlation between final weight and length of feeding period was expected although the increase in A.D.G. was not, based on the results of Bailey et al. (1982), where A.D.G. decreased as length of time increased. The results of the carcass quality traits were unexpected since in other studies (Stringer et al., 1968; Barksdale et al., 1980; Bailey et al., 1982; Wilson et al., 1985), increases in yield grade, marbling score, FOE, REA and KP have been observed as length of time on feed increases.

In both trials however, there was no significant difference between 140 and 168 days for A.D.G., indicating that the animals may be reaching the peak of their growth curve somewhere between these two times. The final weights of these two groups of animals would agree with the findings of Costas et al. (1965) where the A.D.G. of young bulls dropped off after reaching a weight of approximately 400 kg.

It would appear from this experiment and others (Thallman et al., 1983; Butts et al., 1984; Binion et al., 1986; Eastridge et al., 1986; McGill et al., 1986; Thrift et al., 1986; Tolleson et al., 1986; Wildeus and Wright, 1986) that Senepol cattle can compete fairly equally with British breeds for growth performance and carcass characteristics, provide the tropical adaptability sought after in the Brahman, and can be successfully crossed with other breeds.

If in the future a similar type experiment is performed with Senepol bulls, it would appear from this experiment and from the work of others (Harpster et al., 1985; Anderson et al., 1986) that it is not necessary to feed bulls as high a level of protein as was used in this experiment and the maximum protein need not be any higher than the NRC recommended amount, especially since Senepol are not a large framed breed that may require higher amounts of protein (Harpster et al., 1985).

It would also appear that Senepol bulls do not need to be fed any longer than 140 days to express their full genetic potential since their A.D.G. after 168 days is not significantly greater than for 140 days. This conclusion would be in some agreement with the work of McPeake and Buchanan (1986) where they found that 112 days was still as satisfactory as 140 days for testing the growth rate of bulls. Of course that conclusion was based on using a high energy diet in a feedlot situation. In a pasture feeding situation, like on St. Croix, maximum performance does not always coincide with maximum monetary return.

This experiment indicates that given the input conditions and costs at the time of this study, it would not be economically beneficial for the beef producers on St. Croix to use a supplemental feed diet to reach the desired endpoint for cattle there with the present marketing system and no price differential for different grades of beef. A change in the market price of cattle of different grades or of feed supplements could change this, making supplemental feeding a competitive alternative to current practices.

VII. RECOMMENDATIONS AND COMMENTS

While the study failed to prove any benefits for using supplemental feeding, on a per head basis, it should definitely be used to make a case for the investigation of using locally available feed supplements. Other areas of the Caribbean have proved that locally available feedstuffs could be successfully integrated into the diet and produce lower costs of gain (Costa, 1981). With coconuts, bananas, various fruits, indigenous legumes, and a fishing industry, it would appear that a multitude of choices are available for experimentation, although at this time none of the fruit byproducts are `commercially available in large quantities and the main fishing industry is in Puerto Rico. It has also been proven that sorghum and alfalfa can be grown on St. Croix, which would open up the option of making some sort of a commercial feed that could combine the two traditional crops with the locally available feedstuffs.

Since St. Croix has a large distillery industry the use of molasses as a substitute for energy supplementation should also be investigated. Brenes et al. (1947) found molasses to be a good substitute for corn and could be used in a one to one exchange with it. All molasses however is imported into the islands, so the increased cost due to shipping would have to be accounted for before using it as a supplement.

Kirk et al. (1963) replaced part of a cottonseed meal supplement with urea to be fed along with either pangola hay or silage and found that there was no significant difference in gain, dressing percentage or carcass grade between either the cottonseed meal and cottonseed meal urea mixture, or between pangola hay or silage. This would indicate that the use of urea or of a different method of making forage could be a possible alternative, although there are certain dangers associated with the use of urea, indicating that careful management would be needed if it were to be used successfully. McCaleb et al. (1965) found that by ensiling pangola grass the loss of crude protein was only 1.52 to 2.11% from freshly cut forage to the time of feeding.

Although this experiment does not indicate it, the most obvious answer to the question of how to produce more feed, would be either the use of fertilizer or the combining of a legume into existing pastures. Numerous studies (Brenes et al., 1949; Rodriguez et al., 1949; Vincente-Chandler et al., 1958; Caro-Costas et al., 1960; Vincente-Chandler et al., 1961; and Quinn et al., 1962) have shown that crude protein, and dry-matter yields can be doubled with as little as 90 kg. of nitrogen per acre per year. The addition of fertilizer also showed a significant increase in the A.D.G. of cattle put on these pastures.

Since the beef ranchers do not feel it economically beneficial to buy fertilizer (Gasperi, 1985; Lawaetz, 1985; and Nelthropp, 1985) because of the preceived small returns to cost, the next logical step would be the introduction of a legume. Brenes et al. (1950) showed that the use of tropical kudzu with guinea grass doubled the weight gain of cattle compared to guinea grass only. Establishment of legumes in grass pastures has been difficult thus far though. Because of the higher quality, cattle selectively graze the legumes and if the pastures are not carefully managed, the legumes can quickly die out. A possible alternative to this problem would be to grow pure stands of the legume selected and bring the resulting forage in the form of hay, greenchop or silage to the cattle.

It would appear from the feed analysis of the hay and green chop (Table 4) that native legumes, primarily tann-tann (Leucaena leucocephala) already influence the nitrogen available to the grasses, since the crude protein levels of the samples are consistent with an application of 180-360 kg. of nitrogen (Vincente-Chandler et al., 1958; and Vincente-Chandler et al., 1961).

The use of locally available feedstuffs could also allow the ranchers to afford to import feed supplements because they would not have the need to use as much to feed out an animal.

A factor that should be pointed out is that a majority of the pasture land on St. Croix is rented from others for short periods of time (1-5 year leases common). Agricultural land can cost anywhere from $2000-8000 per acre, or up to $50,000 per acre if the land is suitable for residential or tourist development.

Park and Park (1973) showed that land used for grazing declined from 19,611 acres to 7,583 acres in a period of six years while the population almost doubled from 22,000 to 41,000 in the same amount of time. At the present the land used for grazing has remained relatively stable from the 1973 figures, but the population has continued to increase to a level of approximately 52,000.

With the rapidly encroaching commercial developments on the island, the available pasture land is either going to be soon priced out of reach for rental purposes, or will not be available at all (Lawaetz, 1985; Gasperi, 1985). When that happens, the ranchers may have no choice but to either get out of the business or to go to an alternative method of management such as the use of supplemental feeding. Although the profit may not be as high, on a per head basis, from the two feeding trials it is self evident that a profit could still be realized from any of the feeding levels, based on the conditions at those two times.

It must be remembered that the live cattle price used is the price paid for local native consumption. If the ranchers were able to feed their cattle to a grade needed for tourist consumption, they may be able to realize a better profit because of the higher price paid for choice beef by the local restaurants for the tourist trade, although it would appear from these two experiments, that the amount of feed necessary to reach a choice grade would be cost prohibitive and choice beef can usually be imported from the mainland cheaper than what ranchers on the island can produce grass fed beef.

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APPENDIX

APPENDIX

Table 15.--Feeding Trial Locations.

Study Site 1 (East Location)

Geographic location: 17° N lat. / 64° W long.

Elevation: 35 m

Temperature range (annual): 20° C min., 33° C max.

Annual rainfall: 1040.4 mm

Study Site 2 (West Location)

Geographic location: 17° N lat. / 64° W long.

Elevation: 53 m

Temperature range (annual): 20° C min., 33° C max.

Annual rainfall: 1474.5 mm