OPTIMUM CRUDE PROTEIN REQUIREMENT OF GROWING ZEBU AND ZEBU CROSSBRED) CATTLE

BY

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THESIS
Submitted to
Ahmadu Bello University in
partial fulfilment for the
degree

MASTER OP SCIENCE IN AGRICULTURE
Department of Animal Science

JUNE

1977

THESIS APPROVAL

This thesis by Ali Dankintafo, meets the regulations governing the degree, Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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Acknowledgements

The author wishes to express his sincere gratitude to his academic adviser, Dr. N.N. Umunna, for his directives in the practical and written part of this work. He heartedly devoted his time to the success of this work. His advices, suggestions. criticism and reviews are fully appreciated.

He is grateful to the staff of the Faculty of Agriculture and the Institute of Agricultural Research for their co-operation. Much appreciation is expressed to Mrs. E. Oyegoke who bore the typing of this thesis and to Mr, S. Abel who directed the statistical analysis.

Thanks are due to the staff of NAPRI (National Animal Production Research Institute, Shika) for their cooperation and particularly to Mallam Haruna Adido who laboriously helped during the entire experimental period.

Much appreciation is expressed to Alhaji Amadu Dosso and his entire family for their hospitality during my stay in Zaria.

Special thanks are due to my wife Zalika and children Abdouramane, Laminou, Rahila, Aichatou and Gumarou for thier moral support during my study.

Finally, the author and his adviser, are grateful to the Ahmadu Bello University Board of Research for the financial support covering a great portion of this project.

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INTRODUCTION

The expansion of animal production is a goal in many countries especially in the subsahelian areas; but the problems associated with increasing livestock productivity in these areas are great, especially in the case of ruminants. Adequate nutrition is one of the major limitations. Herbage with a very low protein content forms the main diet of ruminants in many parts of Africa for several months of the year. This poor nutritional environment is the result of seasonal distribution of rainfall. Green grass is absent for five to eight months. The mature standing grass has a protein content of about 3%. Animals lose weight during this season unless supplemented with protein. With the advent of rainfall and the subsequent growth of grasses, they regain weight, but several months may elapse before the body losses, which occured during the dry season, are recovered and net gain of weight results. For this reason, it is the practical aim of many stockmen to maintain the weight of their stock in the dry season by giving a protein rich supplement, so that the potential of grazing in the rainy season for liveweight gain can be fully exploited. Because it is economically desirable to give the minimum of protein necessary to maintain weight or make a certain gain, the investigation of the animal protein requirements is of great significance.

Protein requirements are expressed on the basis of both total and digestible protein. They are specific quantities expressed wither as percentage of the ration or as an amount per animal per day. The protein requirement of an animal may be determined either from balance trial, in which the minimum protein intake required to keep an animal in nitrogen equilibrium is a good estimate of the requirement or from feeding trials which include slaughter data.

These requirements are thought to be a function of many variables such as: rate of gain, body weight, digestibility of the protein in the ration, amount of energy and protein-energy ratio.

For years stockmen and nutritionists working in developing nations have used figures determined for animals under temperate environment. There is no harm in using these levels but it does not mean that they automatically apply. These studies were therefore conducted to determine the optimum crude protein requirement for growing zebu and zebu crossbred cattle.

LITERATURE REVIEW

Nitrogen intake and utilization by the ruminant

In the digestion and absorption of food, the alimentary tract of the ruminant animal may be considered in at least four sections; first the pregastric fermentation and absorption from the rumen, reticulum and omasum; In the case of protein, the natural form consumed by the animal and taken into the rumen where it is attacked by the bacteria and protozoa, it is broken down to its respective peptides and amino acids. The later are partly absorbed by the microorganisms for their own protein synthesis. The rest of the amino acids are in turn deaminated to ammonia, carbon dioxide and short chain fatty acids (Leng, 1970). Secondly, the non degraded protein, the peptides, the amino acids and bacteria and protozoa pass from the rumen through the reticulum on past the omasum into the abomasum or the stomach. There, they are subjected to the hydrolytic action of the digestive juices and the resulting amino acids are absorbed; thirdly the abomasal content moves to the small intestine for further digestion and absorption; finally there is fermentation and absorption from the caecum (Hungate, 1966). As the digesta flows through these section of the digestive tract, their volumes and composition change considerably, not only as a result of the digestion and absorption of dietary nutrients, but also because of the secretion and absorption of water, minerals and organic substances by the digestive tract (Hungate, 1966).

In ruminant nutrition, protein content is expressed on the basis of total nitrogen. The primary nitrogen input to the rumen is from the feed intake. The animal ingests a mixture of protein and non protein nitrogen. The second source of rumen nitrogen is saliva, (McDonald, 1948, Waldo, 1967) which had been known to contain nitrogen since 1921. The third source of rumen nitrogen is urea influx from the blood across the rumen wall (Simmonet et al, 1957). Both salivary and the blood urea influx into the rumen function primarily due to blood urea concentration. (Packett and Groves, 1965).

Forms of Nitrogen in rumen contents

After feeding, feed nitrogen decreases and microbial nitrogen increases. On feeding forage ration with higher N content, the N concentration increases but feed N and soluble N are of greater percentage of the total nitrogen. At lower N intake protozal N is a greater percentage of the microbial N. With a similar N intake, the total non feed N is considerably lower when casein is fed when forage protein is fed. Soluble protein is much more and microbial protein is much less when casein is fed than when forage protein is fed. Protozoal fractions are much greater than bacterial fractions when feeding casein, but the reverse is true when feeding forage protein. Amino acids fraction in the rumen are generally low (Lewis, 1955). They are rapidly degraded to ammonia by ruminal microbes.

The balance between the amounts and availability of N and energy to the rumen microorganisms has an important effect on the form of N in the rumen and the utilization of both nitrogen and energy. Inadequate N results in low utilization of N and energy. Continuously infusing 75g or 150g of urea solution daily to cows when fed oat straw with 0.46

to 0.53% N increased feed intake, rate and extent of fiber digestion and rate of sustained particles passage (Campling, 1962). However Olison Pigden (1961) did not obtain these improvement with continuous urea infusion when straw was fed. This might be due to an excess amount of urea infused.

Nitrogen utilization is reduced when the quantity of carbohydrate or energy is inadequate or too slowly available for rapid utilization of nitrogen. This sometimes occur when hay silage is fed (Fernando, 1966) or when NPN sources such as urea with slowly available carbohydrates are fed (Hemsley, 1964). Crampton (1965) proposed that nitrogen requirement be expressed relative to energy. In ruminants nitrogen metabolism cannot be considered separately from carbohydrate metabolism since balance of nitrogen and carbohydrate can influence nitrogen utilization, carbohydrate utilization and feed intake. Inadequate nitrogen supply slows fibre digestion which reduces feed intake (Waldo, 1967). Excess nitrogen relative to energy can produce high rumen ammonia, which reduces feed intake. Ammonia concentration in the rumen represents a balance between utilization by rumen bacteria, metabolism in the rumen wall, absoption into the portal vein and passage into the omasum. This ammonnia concentration is used as an index of usefulness of dietary protein to the animals (Chalmers et al, 1954). The higher the concentration of ammonia, the less usefull the protein.

Nitrogen disappears from the rumen by ammonia absorption through the rumen wall. This absorption was first demonstrated by McDonald (1948) who showed that it was by diffusion and increased with an increase in the rumen ammonia concentration. The permeability of rumen wall to ammonia is inversely proportional to the urine flow (Decker, 1961). Hogan (1961) showed ammonia absorption to be dependent on the concentration gradient at P^H 6.5 but absorption was nil at P^H 4.5. At the time of need for nitrogen, secretion of urea in saliva increases (Somers, 1961) and excretion of urea in urine decreases (Schmidt-Nielsen et al 1957). The absorbed ammonia is carried to the liver, where unless the concentration is unusually high, it is converted to urea. In general only a small quantity of ammonia are found in the peripheral blood. Lewis (1957) reported that the liver was able to convert all of the absorbed ammonia into urea until the level of ammonia in portal blood reached a level of 0.8mM. The urea so formed may either be excreted in the urine, or recycled into the rumen via the saliva and blood. Endogenous urea enters the rumen via saliva and by diffusion across the rumen wall (McDonal 1948, Houpt, 1959) and it is hydrolized by ruminal urease to ammonia, which may be used to maintain an active microbial population (Moir and Harris, 1962). Dietary carbohydrate improved the utilization of recycled urea (Houpt, 1959; Packet and Groves, 1965). The absorption of amino acids from the rumen is very small compared to ammonia. Blood amino nitrogen concentration range from 2-3 mg% versus 0.1 mg% in the rumen (Annison 1956). But the major pathway of nitrogen disappearance from the rumen is by the nitrogen washout down the G.I. tract and Yorlawa (1964) showed the nitrogen turn over time to be one day.

Nitrogen Requirement for Maintenance

A daily supply of protein is needed by the animal to replace the daily breakdown or wear and tear of the protein tissues of the body. Likewise there must be protein for growth of hair and wool and the skin and hoofs, which are all composed of protein (Morrison, 1959). These needs for the endogenous losses and the mere production are the protein requirements for maintenance. Cutherbertson (1969) estimated these needs as :

- Endogenous nitrogen excretion: 0.12g/day/kg $W^{0.73}$
- Loss of nitrogen in hair and scurf from the skin 0.02gN/day W $Kg^{0.73}$
- Retention of nitroge[illegible] for fleece growth of adult sheep, from 0.6gN/day to 1.09[illegible]/day
- Metabolic fecal excretion of N: 5gN/kg dry matter intake of cattle and sheep.

These needs should be met before growth or production could be achieved. Fortunately the daily need for protein for mere body maintenance is relatively small (Morrison, 1950)

The protein requirements which are used in most of the feeding trials, represent intake, in ration considered otherwise satisfactory, which are found adequate for keeping the animal in good condition without a loss of weight. The maintenance of weight and condition is no certain measure of the intergrity of the nitrogenous tissue or of the minimum requirement for this purpose, but the ration which proves satisfactory for such maintenance over extended period are considered to supply an amount of protein which is at least adequate (Morrison, 1961). In practice, ruminants are not fed at the absolute minimum level of protein needed for maintenance since the animals are usually producing some products although the level of production and requirement may be quite low.

The maintenance requirement for a 500 kg cow is 0.3 kg of digestible protein (NRC, 1966). The values of other live-weight could be calculated at the same rate per unit of metabolic weight. Morrison (1959) stated that when ample amount of carbohydrate have been provided, a 1000 Ib. animal required 0.5 to 0.6 lb. of protein or less. Brody (1964) in his feeding standard suggested 0.699 lb. of digestible crude protein to be adequate for the maintenance of a 1000 lb. animal. These values are examplified by nitrogen balance studies and are equivalent to four times the endogenous nitrogenous losses. Maynard and Loosli (1962) concluded that 0.6 lb. of protein per 1000 lb. body weight would have general application for cattle and sheep. The Agricultural Research Council (1965) recommended 110g/day for a 450 kg liveweight animal. Preston (1966) expressed the maintenance protein requirement as 2.78 and 2.19 g/W $kg^{0.73}$ for cattle and sheep respectively.

Protein Requirement for Growth

Growth consists largely of an increase in the size of the muscles and other protein tissues. It is then obvious that far more protein is required for growth than for maintenance or fattening. Younger animals require the larger portion in their ration, because of the extremely rapid growth of protein tissues in their bodies. The proportion of protein gradually decreases as the animal becomes older and stores less protein and more fat (Morrison, 1959).

The protein requirement for growth includes the requirement for maintenance in addition to that needed for growth. Generally the daily requirement increases with age and size of the animal up to maturity, but the requirement expressed as percent of the ration decreases with age, since the need to replace the endogenous losses forms a greater portion of the total as age increases and the requirement for growth decreases. Theoretically, the protein level which will give maximum nitrogen retention in a growing animal would be the requirement for growth of that animal (Church, 1971). Standard requirements for growing animals are given by the National Research Council (NRC) and the Agricultural Research Council (ARC). The Factorial estimates of protein requirement reported by the ARC appear to be largely different from most of the experimental results particularly for heavier cattle gaining rapidly in live-weight (Kay, Bowers and McKiddie, 1968). And the protein requirements recommended by NRC are given without reference to the energy content of the diet although Preston (1966) suggested that a digestible protein - digestible energy ratio would be appropriate. Preston et al (1973) using 11, 13 and 15% dietary protein levels observed no significant ($P \leq .10$) increase in average daily gain. With high concentrate rations significant ($P < .01$) linear response in daily gain was observed by increasing the energy level. However, Bowers (1965) suggested that at least 16% crude protein (or approximately 12% digestible protein) in dry matter was necessary to produce maximum gain for cattle given diets containing **barley** whereas the value given by the ARC was approximately 6.6% digestible crude protein. Kay, Bowers and McKiddie (1968) concluded that diets containing approximately 2.9 Mcal metabolizable energy should contain more than 11% crude protein in the dry matter if maximum gains are to be achieved whereas for animals weighing more than 250 kg liveweight 11% crude protein was adequate. This apply to rapidly growing animals. For young calves (Whitelaw, 1961) 19.4% crude protein in dry matter (16.3% in air dry feeds) is about the optimum level for a 52 kg animal. Below this level, nitrogen retention was limited by nitrogen intake whereas at levels above 19.4% nitrogen retention was adequate, but rate of growth and nitrogen retention may be limited by energy intake. Brown et al (1958) gave a contradictory result in not finding significant difference in growth or nitrogen retention between calves given concentrate mixture varying in crude protein content from 12% to 24%. Bailey and Broster (1957) indicated that 0.8 to 0.84 lb. crude protein, equivalent to 0.59-0.64 lb. digestible crude protein was adequate for near maximum rate of liveweight gain in animals of 310-320 lb. liveweight. Reduction in protein intake caused a decline, whilst a greater protein intake did not cause an increase in rate of liveweight gain. Steensberg (1947) and Lofgreen (1951) found 1.073 to 1.10 lb. crude protein corresponding respectively to 0.72 to 0.80 lb. digestible crude protein to be optimum for 300 to 400 lbs. animal.

Cuthbertson (1966) recommended 13% crude protein in all concentrate diets for cattle from 200 kg. to slaughter (400 kg).

It could be seen from the literature reviewed that all the work on protein requirements were for animals in the the temperate environment. Nutritionists and stockmen working in the tropics have for years been forced to use these levels established for temperate animals. As was previously stated (Babatunde et al.1972) there was no harm in using these figures but it does not automatically imply that such figures are adequate for tropical livestock. For one, tropical animals are exposed to low quality feed and may therefore require more of such feed to meet their needs. Two, the environmental stress conditions may impose additional requirement on the nutrient needs. The studies reported herein were therefore undertaken to determine the optimum crude protein requirement of growing zebu and zebu crossbreds fed a typical growing ration.

EXPERIMENTAL PROCEDURE

The project was conducted at the Animal Science Research Station at Shika, located at about twenty kilometers North-West of Zaria town, on latitude 11° 12' North and longitude 7° 34' East at an altitude of about 2350 feet above sea level. The relevant climatic data during the periods of study are given in Table I.

Growth Study 1

Eighteen Bunaji (White Fulani, Zebu) and Friesian X Bunaji crossbred (F_1) bull calves of average initial weight 111.8 kg were used in this study which lasted for 274 days. On the basis of initial weight and breed, the calves were randomly assigned to the three treatments such that each treatment had three animals of each breed. Treatments corresponded to dietary crude protein levels and were 12.1, 16.6 and 20.9% (dry basis) for treatments 1, 2 and 3 respectively. See table 2.

A week prior to the start of the experiment, the animals were drenched for worms with Thibenzole (Thibendazole/MDS by Merck Sharp and Dohme Ltd.) after which

Table I Representative Meteorological Observations of the Samaru - Shika area

		Rain-fall	Air Temperature		Relative Humidity	
			Min	Max	AM	PM
June	1975	135.5	20.4	30.9	68.4	34.4
July	"	303.1	19.6	27.5	80.9	70.3
August	"	113.4	19.5	23.7	82.4	69.5
September	"	212.2	19.2	28.8	76.9	68.7
October	"	8.3	17.1	31.1	57.0	38.3
November	"	0.0	14.5	32.2	26.6	19.5
December	"	0.0	12.9	29.0	[illegible]	13.2
January	1976	0.0	13.0	29.3	16.6	13.5
Febuary	"	0.0	17.5	34.0	24.6	14.6
March	"	0.0	18.8	34.8	17.[illegible]	12.0
April	"	82.2	21.2	35.1	42.5	33.7
May	"	135.5	21.0	32.1	68.0	50.6
January	1977	0.0	12.7	29.4	20.0	20.0
Febuary	"	0.0	14.0	30.6	13.5	10.0
March	"	0.0	18.9	32.3	15.8	11.7
April	"	0.0	20.8	36.8	26.6	13.9

they were housed and fed Elephant grass silage (Pennisetum purpureum) until the start of the study. All animals were individually penned and fed on laterite floored and roofed barn, the experimental ration comprising 40% Elephant grass silage and 60% supplement (on dry basis) once in the morning to appetite.

Growth Study 2

In this study lasting 147 days, thirty zebu bull calves (24 Bunaji and 6 Sokoto Gudali) of average initial weight 174.2 kg were used. They were assigned at random to the three treatments (as experiment I) based on initial weight and breed. They were individually housed and fed ad lib on concrete floored shaded-barn throughout the period of the study.

Growth Study 3

Twenty-four bull calves (12 Bunaji and 12 Friesian X Bunaji crossbred, F_1) weighing an average of 113.9 kg were used in this study which lasted 84 days. They were on the basis of initial weight and breed randomly assigned to three treatments such that each treatment had four of each breed. Treatments corresponded to dietary crude protein

Table 2

Percent Composition of Supplements fed in growth studies 1 and 2

	Treatments		
	1	2	3
Sorghum	80.78	60.24	36.69
Groundnut cake	16.20	37.24	61.69
Bone meal	2.50	2.00	1.50
Salt	0.50	0.50	0.50
Minerals (premix[1])	+	+	+
Vitamin A[2]	+	+	+
Analyzed Chemical Composition (%) on Dry matter basis			
Dry matter	92.8	93.8	94.3
Crude protein	16.8	24.3	30.8
Calcium	0.64	0.56	0.48
Phosphorus	0.51	0.51	0.60
Silage (Elephant grass)			
Dry matter 27.03			
Crude protein 5.03			

[1]Premix contained salt 48.75%, calcium 15%, Phosphorus 7.5%, Magnesium 0.24%, Cobalt 200mg/kg, copper 150mg/kg, manganese 340 mg/kg, zinc 28mg/kg, iron 700 mg/kg, iodine 32 mg/kg and vitamin A 29.00 IU/kg.

[2]Vit. A added to provide 20,000 IU/hd/day

Table 3

Percent composition of supplements fed in growth study 3 and digestion trial

	Treatment		
	1	2	3
Sorghum	88.5	72.1	55.4
Groundnut cake	9.4	26.1	42.05
Bone meal	1.5	1.25	1.0
Salt	0.5	0.5	0.05
Trace minerals[1]	+	+	+
Vitamin A[2]	+	+	+
Analyzed Chemical composition (%) on Dry matter basis			
Dry matter	94.20	94.6	55.3
Crude protein	14.1	19.07	26.3
Calcium	0.57	0.51	0.46
Phosphorus	0.52	0.56	0.60
Silage (Elephant grass)			
Dry matter	30.0		
Crude protein	6.05		

[1]Premix contained (see table 2)

[2]Vitamin A added to provide 20,000 IU/head/day

levels and were 10.1, 12.9 and 16.2% on dry matter basis for treatments 1, 2 and 3 respectively. The experimental ration comprised 50% Elephant grass silage and 50% supplement on dry basis (Table 3).

In all the three studies, the initial, interim and final weights were shrunk weights (without feed and water for about 16 hr.). The calves also had free access to water and mineral blocks. The procedural method of feeding and worm treatment for experiments 2 and 3 were as described for experiment 1.

Digestion Study

Twelve Bunaji and Friesian X Bunaji cross-bred calves of average initial weight 132 kg were used in this study which involved two collection periods for a total of eight observations per treatment. The calves were randomly assigned to the treatments (same as in experiment 3 - See Table 3) for a 15-day preliminary period which was immediately followed by a 13-day collection period.

All dry matter and nitrogen determinations were according to A.O.A.C. (1970). The data were subjected to the analysis of variance and treatment comparison by Duncans' Multiple Range test (Steel and Torrie, 1960).

RESULTS

Growth study 1. The results are given in Tables , and 5. There were no significant ($P<.05$) differences in ADG and feed efficiency attributable to treatments. However, feed intake was significantly ($P<.05$) different among treatments. Calves fed the medium protein diet ate significantly ($P<.05$) more feed than those on the low and high protein diets. No significant ($P<.05$) differences were detected for any of the parameters measured between breeds; and the interaction of treatment X breed was also not significant. ($P<.05$).

Growth study 2 The results of this study are presented in Table 6. Feed intake among the treatments was significantly ($P<.05$) different. Calves on the low and medium protein diets ate more ($P<.05$) feed than those on the high protein diet. ADG and feed efficiency were not significantly ($P<.05$) affected by treatments.

Growth study 3 The results are presented in Table 7 and do show that ADG and feed efficiency were significantly ($P<.05$) affected by treatments. Each increment in the level of

Table 4 Animal performance data from growth study 1

	Ration Number and Treatment			
	1	2	3	
Protein content of diet (%)	12.1	16.6	20.5	SE[1]
No. of calves	6	6	6	
Av. initial wt, kg.	105.2	114.3	116.0	
Av. final wt, kg	234.0	281.0	252.2	
Av. daily gain, kg	0.47	0.57	0.46	0.06
Av. daily feed intake, kg[a]	4.76	5.34	4.41	0.24
Feed conversion	10.26	9.85	9.61	1.15

[1]Standard Error

[a]Significant at ($P < .05$); Treatments 1 and 3 are significantly ($P < .05$) different from treatment 2

Table 6 Animal Performance data from Growth Study II

	Ration number and Treatment			
	1	2	3	
Protein content of diet (%)	12.1	16.6	20.5.	SE[1]
Number of calves	10	10	10	
Av. initial wt, kg.	172.8	170.1	179.7	
Av. final wt, kg.	251.0	251.7	240.6	
Av. daily gain, kg.	0.51	0.56	0.41	0.06
Av. daily feed intake, kg[a]	5.20	5.12	4.29	0.27
Feed conversion	10.14	9.23	10.36	1.56

[1]Standard Error

[a]Significant at ($P < .05$); Treatments 1 and 2 are significantly ($P < .05$) different from treatment 3

dietary protein significantly ($P < .01$) improved feed efficiency. Also ADG of calves fed the high protein diet was significantly ($P < .05$) higher than for calves fed the low protein diet. There were however, no significant ($P < .05$) differences in ADG between calves on the low and medium nor the medium and high levels of dietary protein. No significant breed differences were detected for all the parameters measured; and the treatment X breed interaction in all the parameters were also not significantly affected.

Digestion study: Mean values of the digestibility figures are shown in Table 7. There was no detectible significant difference in dry matter digestibility but protein digestibility was increased significantly ($P < .01$) with each increase in the ration protein level.

Table 7 Animal Performance data from Growth Study III

	Ration Number and treatment			
	1	2	3	SE[1]
Protein content of diet %	10.1	12.9	16.2	
Number of calves	8	8	8	
Av. initial wt, kg.	118.3	113.3	110.0	
Av. final wt., kg	147.5	152.0	156.6	
Av. daily gain, kg[a]	0.35	0.48	0.560	0.06
Av. daily feed intake, kg	3.98	4.17	3.88	0.26
Feed conversion (F/G)[b]	11.6	9.4	7.0	0.60
D.M. digest (%)	68.5	70.9	68.2	0.63
Protein digest (%)[b]	59.4	72.7	75.9	0.26

[1] Standard Error

[a] Significant at ($P < .05$); treatment 3 was significantly ($P < .05$) different from treatment 1.

[b] Significant at ($P < .01$); all the treatments were significantly ($P < .01$) different from each other.

Table 8 Animal Performance data from Growth Study III: Breed Comparison

	Ration number and Treatment						
	1		2		3		
Protein content of diet (%)	10.1		12.9		16.2		
Breeds[1]	Z	ZX	Z	ZX	Z	ZX	SE[2]
Number of calves	4	4	4	4	4	4	
Av. daily gain, kg.	0.420	0.276	0.54	0.42	0.50	0.61	0.08
Av. daily feed intake, kg.	4.60	3.35	4.38	3.95	3.67	4.08	0.370
Feed conversion	11.06	12.23	9.93	9.76	7.33	6.74	0.90

[1] Z, Zebu; ZX, Friesian X Zebu cross

[2] Standard Error.

Table 9 Animal Performance data from Growth Studies I & III : Breed Comparison

Protein content of diet (%)	10.1		12.9		16.2		20.5		
Breeds	Z	ZX	Z	ZX	Z	ZX	Z	ZX	SE
Number of calves	4	4	7	7	7	7	3	3	
Av. daily gain kg.	0.420	0.276	0.525	0.43	0.53	0.63	0.47	0.47	0.07
Av. daily feed intake kg.	4.60	3.35	4.49	4.49	4.38	[illegible]	4.24	4.70	0.007
Feed conversion	11.06	12.23	9.08	10.53	8.35	7.79	9.29	10.20	0.55

1 Z, Zebu; Zx, Friesian x Zebu cross

DISCUSSION

These results suggest that for growing cattle that 12-16% crude protein on dry basis is adequate for optimum growth of animals up to 250 kg. liveweight and that increasing the protein level would be of no advantage. This observation is in agreement with the previous report of Peterson et al (1970) who showed that average daily gain of growing steers increased with increasing level of protein up to 15% crude protein then decreased with further increases in level of dietary protein. Our data also agreed with that reported by Bowers (1965) who stated that 16% crude protein in dry matter is required for maximum growth. Bailey (1957) and Cuthbertson (1966) reported similar results but recommended an adequate supply of energy. However, Brown, (1958) reported different results when he observed no growth differences from calves given diets varying from 12 to 24% dietary crude protein.

The digestible crude protein intake for the different treatments are presented in Table 7. The general trend observed was of an increasing level of intake with each increase in the dietary crude protein level. These figures are higher than those of the National Research Council (1970) and the Agricultural Research Council (1965) and generally are little closer to the figures determined by Kay, Bowers and Mckiddie (1968). See Table 10

Average daily dry matter intake for growth studies 1 and 2 were also affected by treatment. In both studies calves fed the medium (16.6%) protein ration significantly (P .05) ate more feed than those fed the high (20.5%) dietary crude protein. In both studies feed intake was depressed at high (20.5%) dietary crude protein level as compared to the low and medium dietary protein levels. Also in one of the studies, feed intake of the low protein (12.1%) group was significantly ($P < .05$) less than for the medium protein fed-group. It is possible that the reduced intake of cattle on the low level of protein might have been mediated through decreased palatability of the ration, a point also made by Kay _et al_ (1968). However, the reasons for reduced feed intake of the high protein group is unknown especially since it has been shown that dry matter intake is positively correlated to dietary protein

Table 10 A comparison of the intakes of digestible crude protein (g/day) with the requirements suggested by NRC (1970), ARC (1965) and by Kay, Bowers and Mckiddie (1968)

Live wt. kg.	Protein content of diet			NRC		Kay et al Protein content of diet		
	Low	Medium	High	-	ARC	Low	Medium	High
100	-	-	-	-	180	-	-	-
122	171	271	379	-	-	-	-	-
136	227	416	483	-	-	205	315	445
150	250	452	573	260	-	223	352	488
200	-	-	-		280	270	450	578

1

N.R.C., U.S. National Research Council

A.R.C., Agricultural Research Council, London

Some of the figures given for Kay et al are by interpolation

These figures were based on growth study 3 level irrespective of the other dietary constituents (Elliot et al. 1963). However, it should be remembered on the other hand that it has been observed that lipids in ruminant rations not only depress ration digestibility but also acceptability (Erwin, 1956; Brethour, 1958) and earlier on Brooks et al (1954) had suggested that oil and fat in ruminant feeds among other things detrimentally affected the utilization of other nutrients. Because of the high level of groundnut cake and its high lipid content, the ether extract content of the high protein supplement was higher than for the other two (3.5, 3.7 and 4.2% for the low, medium and high protein supplements respectively.

Feed conversion in all the three studies was definitely superior for cattle fed the 16% protein ration. In growth studies 1 and 2, these differences were not significant but were significant ($P<.05$) for the third growth study.

In growth studies 1 and 3, where breed comparisons were made, no significant ($P<.05$) differences existed for breed in all the parameters measured. One would have expected the crosses to have performed better than the purebred zebu (Ledger et al, 1970) but this was not the case.

Since the standard errors for the various parameters between growth studies 1 and 3 did not differ significantly, the data were pooled and these are presented in Table 9. It suffices to say that no significant ($P < .05$) differences were detected for any of the parameters measured; however, cattle fed the 16.% protein ration performed superior to others.

The results of these studies would suggest that for growing zebu and Freisian x zebu crossbred cattle, that between 12-16% dietary crude protein level or about 10-12% digestible protein was adequate for optimum growth and that increasing the protein level would be of no particular advantage.

SUMMARY

Three growth studies and a digestibility study were carried out with 72 calves (Zebu and Friesian X Zebu crossbred, F_1) given diets containing either 12.1%, 16.6% or 20.5% crude protein in the dry matter in trials 1 and 2 and either 10.1%, 12.9% or 16.2% crude protein in dry matter in trial 3.

There were no significant (P<.05) differences in ADG and feed efficiency between breeds and among treatments in trials 1 and 2. There was a significant (P<.05) difference in feed intake among treatments in trials 1 and 2. Dry matter intake of the calves fed the 20.5% protein level was lowest.

In trial 3, calves fed 16.2% protein diet gained faster and more efficiently (P<.05) than those fed the 10.1% protein diet. No significant breed differences were detected for any of the parameters measured in both trial 3 and the pooled data of trials 1 and 3.

The results of these studies suggest identical protein requirement for growing zebu or zebu crossbred calves; it further indicates that about 12-16% dietary crude protein or about 10-12% digestible protein in the dry matter to be adequate for optimum growth.

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A P P E N D I X

Table 11 Analysis of variance of data from growth study I

		mean squares		
Source	DF	ADG	Feed intake	Feed conversion
Total	16	-	-	-
Treatment	2	0.018	1.553[1,2]	1.266
Error	14	0.017	0.350	7.909

[1] Significant at ($P < .05$)

[2] Duncan's Multiple Range test
At the 0.050 level, L.S. R[a] = 3.03, 3.12
calves on treatment 2 significantly ($P < .05$) ate more feed than those treatments 1 and 3.

[a] L.S.R. = Least significant ranges.

Table 12 Analysis of variance for Growth
Study I: Breed Comparison

Source of variation	DF	SS	MS	F	Sign. of F
Main effects	3	0.039	0.013	0.789	0.525
Treat	2	0.035	0.017	1.047	0.384
Breed	1	0.004	0.004	0.214	0.652
2 way interactions	2	0.045	0.023	1.363	0.296
Treat x Breed	2	0.045	0.023	1.363	0.296
Explained	5	0.085	0.017	1.019	0.452
Residual	11	0.182	0.017		
Total	16	0.267	0.017		

Table 13 Analysis of variance for the effect of treatment and breed on feed intake: Growth study 1

Source of variation	DF	SS	MS	F	Sign of F
Main effects	3	3.513	1.171	3.338	0.060
Treatment	2	2.988	1.494	4.259	0.043
Breed	1	0.408	0.408	1.163	0.304
2 way interactions	2	0.636	0.318	0.907	0.432
Treat-Breed	2	0.636	0.318	0.907	0.432
Explained	5	4.150	0.830	2.366	0.109
Residual	11	3.859	0.351		
Total	16	8.008	0.501		

Table 14 Analysis of variance for the effect of treatment and breed on feed efficiency: Growth Study I

Source of variation	DF	SS	MS	F	Sign. of F
Main effects	3	3.620	1.207	0.144	0.931
Treatment	2	2.334	1.167	0.139	0.872
Breed	1	1.088	1.088	0.130	0.725
2 way interaction	2	18.224	9.112	1.086	0.371
Treat x Breed	2	18.224	9.112	1.086	0.371
Explained	5	21.844	4.369	0.521	0.756
Residual	11	92.258	8.387		
Total	16	114.102	7.131		

Table 15 Analysis of variance of data from growth study II

		Mean squares		
Source	DF	ADG	Feed intake	Feed Conv.
Total	29	-	-	-
Treatment	2	0.0522	2.8892[1]	21.8481
Errors	27	0.0300	0.7440	24.6493

1. Significant at $(P < .05)$

Table 16 Analysis of variance of data from growth study III

Source	DF	ADG	Feed intake	Feed conv.
Total	23	-	-	-
Treatment	2	0.0879[1]	0.1798	42.8054[2]
Error	21	0.0217	0.5549	2.8542

1. Significant at $(P < .05)$
2. Significant at $(P < .01)$

Table 17 Analysis of variance for the effect of treatment and breed on average daily gain - Growth Study III

Source of variation	D.F.	SS	MS	F	Sign. of F
Main effects	3	0.179	0.060	2.686	0.077
Treat.	2	0.176	0.088	3.964	0.037
Breed	1	0.003	0.003	0.130	0.723
2 way interaction	2	0.053	0.027	1.197	0.325
Treat - Breed	2	0.053	0.027	1.197	0.325
Explained	5	0.232	0.046	2.090	0.114
Residual	2	0.399	0.022		
Total	23	0.631	0.027		

Table 18. Analysis of variance for the effect of treat & breed on feed efficiency;Growth Study III

Source of variation	DF	SS	MS	F	Sign. of F
Main effects	3	85.662	28.554	8.871	0.001
Treat.	2	85.611	42.805	13.298	0.001
Breed	1	0.051	0.051	0.016	0.901
2 - way interaction	2	1.949	0.974	0.303	0.743
Treat - Breed	2	1.949	0.974	0.303	0.743
Explained	5	87.611	17.522	5.444	0.003
Residual	18	57.939	3.219		
Total	23	145.549	6.328		

Table 19 Analysis of variance for the effect of Treat-Breed on feed intake - Growth Study III

Source of variations	DF	SS	MS	F	Sign. of F
Main effects	3	0.666	0.222	0.396	0.751
Treat.	2	0.360	0.180	0.321	0.729
Breed	1	0.306	0.306	0.547	0.469
2-way interactions	2	1.269	0.635	1.134	0.344
Treat. Breed	2	1.269	0.635	1.134	0.344
Explained	5	1.935	0.387	0.691	0.637
Residual	18	10.078	0.560		
Total	23	12.012	0.522		