Potential of Utilization of Feed Resources of Brazilian Cerrados for Grazing Livestock

Henrique Otavio da Silva Lopes* and Ilto José Nunes**

Abstract

Over 40% of the estimated 130×10^8 cattle population in Brazil is found in the "Cerrados" (savannas), a region which covers more than 200 million hectares. Livestock production levels per animal and per area are low and have remained stagnant for several decades. Forages are low in protein, digestible energy and minerals, particularly phosphorus, especially during the long dry season. It is estimated that by 1990 over 40 million hectares had been planted to pasture and over 12 million hectares had been planted to annual crops. More than 150 million tons of crop residues and by-products, mainly from corn, soybean and sugarcane are potentially available to help solve the dry season feed shortages in integrated crop-livestock production systems. Numerous forage grasses and legumes adapted to the cerrado ecosystem have been released. Recent research on legume-based pastures has demonstrated their large potential.

Effectiveness of cheaper alternative phosphorus sources has been demonstrated. The integration of livestock and annual crop production systems is new but shows promise of potential synergism with important advantages for both livestock and crops. One of the major goals in developing efficient and sustainable production systems for the cerrados to meet the growing demand for food is to reduce pressure on the rainforests of the Amazon basin.

Introduction

The potential of the Brazilian Cerrados which cover an area of more than 200 million ha and extend from latitudes 25°S to 6°N, (Fig. 1), is impressive. Low fertility levels and strongly acid soils combined with traditional burning management result in poor forage quality and production. Some climatic data representative of the cerrado area, are presented in Fig. 2. Livestock production in the Cerrados represents a significant and increasing proportion of the total Brazilian cattle industry with inventory growth rates well above the aggregate country wide figures (2.6% vs. 1.9% per year during the last two decades). On the other hand, livestock production per animal and per unit area is low and has remained almost stagnant at levels comparable to those recorded forty years ago, as shown in Fig. 3 (Sere, 1990).

Forages are, and will continue to be, the major, if not the only source of essential nutrients for grazing cattle. During the long dry season, forages, are almost always low in protein and digestible energy and high in fiber and lignin. Thus, animal performance is very poor. Forages are also very low in minerals, especially phosphorus, sodium and the trace elements zinc, copper, cobalt and iodine, year round (Lopes, 1985). It is important to note that

*EMBRAPA. Cerrados Agricultural Research Center. Caixa Postal 70.0023. 73.301, Planaltina, DF, Brazil.

**Veterinary School, Federal University of Minas Gerais. Caixa Postal 567.30.161, Belo Horizonte, MG, Brazil.

Fig. 1 Distribution of cerrado areas in Brazil.

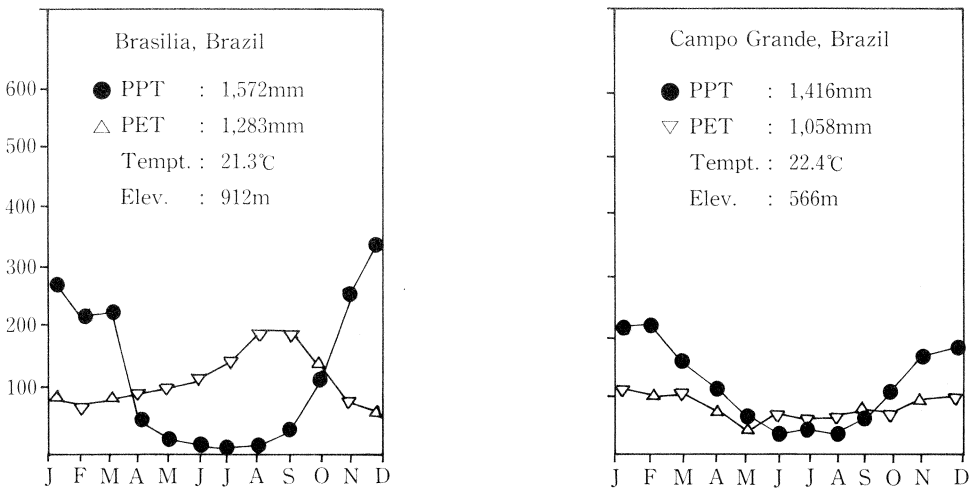

Fig. 2 Climate data on two locations of Brazilian savanna.

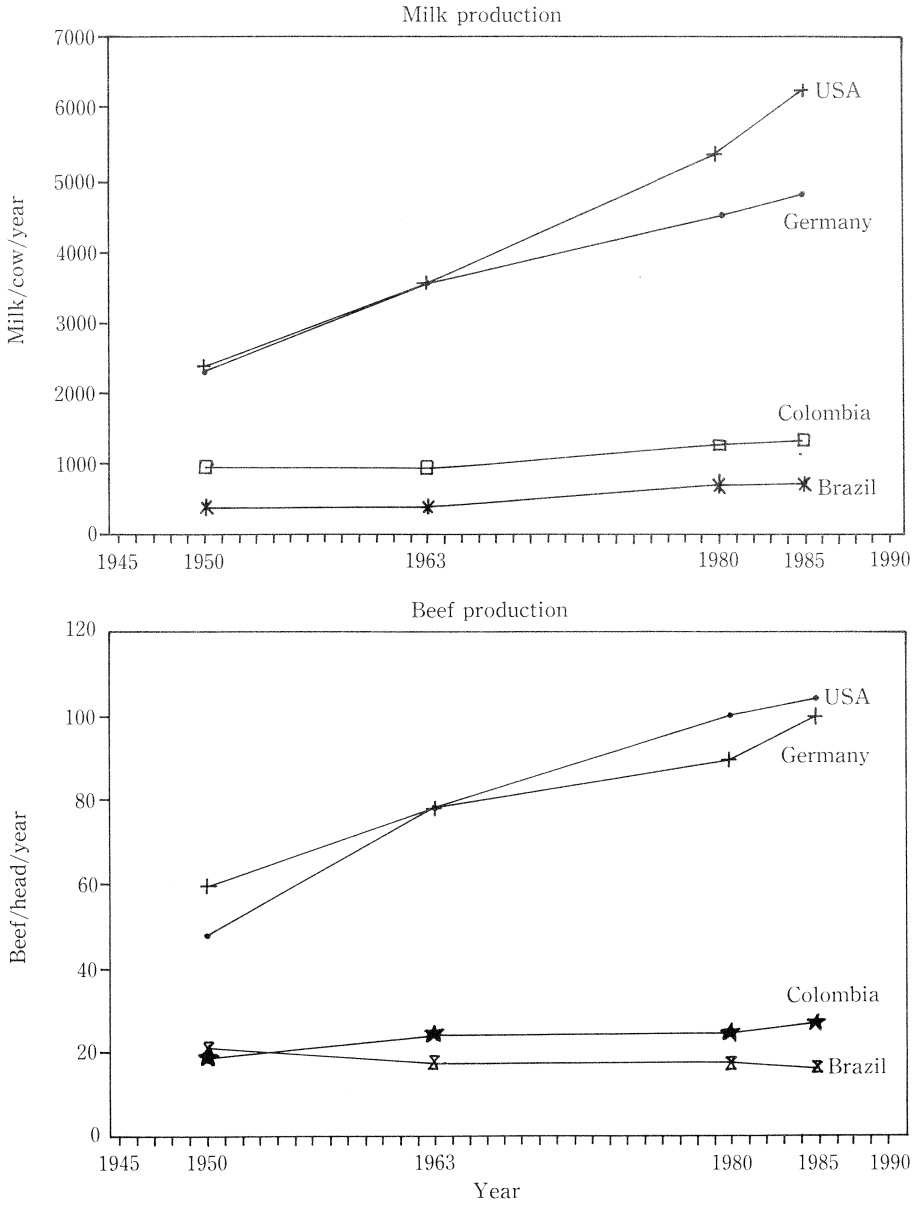

Fig. 3 The productivity of dairy and beef cows in selected countries, 1945–1987.
Source : after Sere (1990).

livestock production in the Cerrados is moving to marginal lands, characterized by poor soils, releasing better and more expensive lands near population centers for crop production. In spite of using land resources of lower fertility, livestock productivity has been sustained.

The potential for livestock production from crop residues and by-products, particularly in the Cerrados, is tremendous. From 1950 to 1990, the arable crop area planted in the region increased from 4 million hectares to 12 million hectares and grain production increased to 19

million metric tons by 1990, as shown in Fig. 3 (Spain, 1990).

Some successful research efforts which have been developed in the last decade to increase the productivity of ruminant livestock systems will be discussed in this paper. Examples of recent research advances on pastures, supplementary feeding of grazing animals, mineral supplementation, crop residues and by-product utilization will be given.

Future prospects for ruminant livestock production in the 1990's especially focused on the cerrado ecosystem will also be explored.

Trends in pasture production

Until the sixties, cerrado farming consisted of subsistence agriculture and extensive beef cattle production on native savannas with minimal animal management (Vilachica *et al.*, 1990). Native pastures are deficient during the dry season in quantity or quality and often in both. There is considerable research indicating that dry season shortage is mainly associated with protein deficiency and unless this primary deficiency is corrected little can be expected from energy and/or phosphorus supplementation.

To a large extent, more successful livestock production for the last two decades in the Cerrados was made possible by the introduction of adapted pasture grasses, particularly *Brachiaria decumbens* cv. Basilisk.

The replacement of native pasture species with this grass started in the early seventies with the utilization of the traditional rice-pasture system. After clearing of the original vegetation, upland rice is grown for two or three years, usually with little or no limestone and with only maintenance row application of fertilizers. As the fertility declines, and weed problems increase, *Brachiaria* is introduced. *Brachiaria decumbens* capable of consistently higher productivity levels than native pastures, covered large areas in the Cerrados. However, the dry season problem still remained and after some time, *Brachiaria decumbens* pastures 'ran down', decreasing drastically the carrying capacity and animal performance, especially during the dry season. This degradation was aggravated by severe spittle bug attacks (*Deois flavopicta*). Beginining in the late 1970s other species, *Brachiaria humidicola* and *Brachiaria ruziziensis*, were also introduced to the region, on a smaller scale.

During the eighties, two improved grasses, *Andropogon gayanus* cv. Planaltina and *Brachiaria brizantha* cv. Marandu were released. Both are resistant to the spittle bug and have already achieved a positive and continuous growth, replacing areas of degraded *Decumbens* and native pasture. The accumulated area under *Andropogon* established by 1988/89 was estimated at 640,000 ha with good chances that the next four years could see that figure doubled (Saez and Andrade, 1990).

It has long been known that the addition of legumes to grass pastures results in significant improvement in the quality of pastures. Research data summarized by Spain (1990) showed that, even on poor savanna soils, legume-based pastures are capable of doubling yields per animal and increasing yields per hectare by ten to fifteen fold, when compared to production from traditionally managed native savannas.

Many promising legumes, including species of the genera *Arachis, Stylosanthes, Centrosema, Pueraria* and *Desmodium* are in the early phases of testing at CPAC. Three species of *Stylosanthes* are in advanced stages of evaluation in large grazing trials, with excellent performance and good grass legume balance and persistence nearly four years after planting. Important research progress has been achieved in studying the factors responsible for productivity, stability and persistence of legumes in associations with grasses.

Agricultural by-products for livestock

There are a large number and variety of crop residues and agro-industrial by-products

Table 1 Characteristics of selected fibrous agricultural by-products in Brazil

	DM %	Yield t DM/ha	CP %	Cell Wall %	DE MJ/kgDM	Density kg/m³
Crop residues						
Bean, straw	30-40	1.0	4 - 6	65-70	7.4- 9.2	50-100
Cassava, aerial portions	25[Z]	3.6	16[Z]	35-40	12.9-13.8	100-200
Corn, straw	55-80	4.0	5 - 7	70-80	7.0- 8.3	50-100
Peanut, straw	70-85	1.3	10 -15	40-50	8.3-10.1	50-100
Rice, straw	40-70	4.0	3 - 4	65-70	6.8- 7.9	50-100
Soybean, straw	30-40	-	4 - 6	65-70	7.4- 9.2	50-100
Sugarcane, tops	20-50	6.0	6 - 8	65-75	8.9-10.1	100-150
Industrial by-products						
Citrus, bagasse, dry[Y]	90	-	6.4	23.8	-	-
Coffee, pulp	80-90	0.015	9 -13	35-40	9.6-11.1	200-250
Corn, cobs[X]	90	0.22	2.8	70-80	-	-
hulls[X]	60-70	0.4	3.7	65-83	-	-
Cottonseed, hulls	75-85	0.3	4 - 5	85-90	5.5- 7.4	150-200
Rice, hulls[X]	92	-	3.3	65	-	-
Sugarcane, bagasse	48-54	9.8	0.5- 2.4	85-90	4.6- 5.5	120-170

Source : Adaptated from Escobar and Parra, 1984 ; [Z] Carvalho, 1984 ; [Y] Burgi, 1986 : [X] Bose and Martins Filho, 1984.

Table 2 Comparative confinement feeding trial with straws and corn-grass silage

	T1	T2	T3	T4
Weight gain/day-tg	1.04	0.74	0.75	0.97
Total weight gain-tg	98.42	70.77	70.87	92.43
Feed conversion	8.78	9.85	8.94	7.45

Note : Basal diet : Urea 1%, Sugarcane molasses (1%), and soybean meal and corn grits to reach 12% crude protein.
T1=corn and elephant-grass silage 70%DM (1:1)
T2=rice straw 70%DM
T3=soybean straw 70%DM
T4=bean straw 70%DM
Source : Queiroz, 1989.

available for developing viable sustainable crop-livestock systems in Brazil. Successful utilization of these by-products requires a thorough understanding of their nutritional limitations (Table 1), processing, economic aspects and opportunity costs.

Utilization of oil seed meals from crops, eg. soybean and cotton and rice and wheat brans in livestock diets, is well established and hence will not be discussed here. It is important to note that the gross energy content of many crop residues is quite close to that of grain and root crops. However, animals do not use this energy as efficiently because the cellulose structure is highly ordered and often associated with indigestible lignin (National Research Council, 1989).

Successful methods for improving the feeding value of lignocellulose materials such as crop by-products and straws are described in the literature. Generally these methods use treatment with chemicals such as alkalis, ammonia, urea, hydrogen peroxide and others. The high cost and the potential detrimental effects on the environment of these chemicals have

limited their large scale use, especially for smallholders. Frequently, crop residues such as corn stalks and cobs and rice straw are left standing in the field and used almost entirely for livestock feeding untreated or they are ploughed back in the soil. In Brazil, successful utilization of rice, soybean and bean straws for fattening steers was reported by Queiroz (1989), as shown in Table 2.

Cassava and its by-products are among the most efficient energy and protein producers in tropical countries. While cassava roots have a high energy content, the aerial portions (stem, petioles and leaves) are high in protein. The wide spectrum of cassava and by-products and their use in feeding systems were described by Carvalho (1984). The full potential of cassava utilization especially for smallholders, is far from being fully realized.

The citrus crop is of great economic importance to Brazil. Orange juice is one of the most important sources of foreign exchange credits. Citrus bagasse has a reasonable nutritive value for ruminants but processing costs, such as drying and pelleting are quite high.

Perennial crops such as sugarcane have a tremendous potential for integrated alternative fuel energy and livestock feeding systems. The plant's C4 pathway for photosynthesis confers both high yield potential and energetic efficiency (Preston, 1984). Currently, Brazil's estimated production is about 12 billion liter of alcohol used primarily as fuel for motor vehicles. Sugarcane is cultivated in almost all the farms in Brazil, regardless of their size and kind of exploitation. In addition, sugarcane has a quite flexible harvest time and its nutritive value remains almost the same all the year round, even in the dry season.

Conventional production of sugar produces, either readily biodegradable by-products such as molasses, and fibrous residues such as bagasse. Molasses have been largely used for increasing palatability, pelleting and reducing dustiness in livestock rations, as well as in beef cattle fattening and supplementary systems combined with urea and/or natural protein

Table 3 Chemical composition of *'In natura'* (BIN) and hydrolyzed sugarcane bagasse at 17 kgf/cm² for 5 minutes (BAH 17/5)

Determination	BIN	BAH 17/5
Dry matter, %	48.31	40.32
pH	5.5	3.0
Density, kg/m³	100-150	300-400
Friability	yes	no
Composition, g/100g DM		
Crude protein	1.86	1.67
Crude fiber	45.09	34.45
Ether extract	2.26	4.86
Mineral matter (ash)	2.73	4.77
Nitrogen-free extract	48.06	54.25
Neutral detergent fiber	85.24	58.16
Acid detergent fiber	62.33	62.65
Cellulose	44.69	43.99
Hemicellulose	22.91	-
Acid detergent lignin	14.89	15.06
Calcium	n.a.	0.12
Phosphorus	n.a.	0.02
Potassium	n.a.	0.16
IVDDM[z]	33.31	64.82

[z] *In vitro* digestibility of dry matter.
n.a. not available
Source : Burgi, 1985 ; apud Santos, 1990.

sources. Furthermore, especially for small-scale farms, chopping of the whole plant has proved to be an economical solution for dry season cattle feeding.

1 Steam-pressure treatment of sugarcane bagasse has been shown to improve the nutritive value significantly as shown in Table 3.

2 Processed bagasse, properly supplemented with protein and minerals, has been efficiently utilized in large scale commercial feedlots, located near sugar factories. Sugarcane tops have also been utilized for fattening steers with good results.

Trends in mineral supplementation

In Brazil, the mineral most deficient for grazing cattle is phosphorus, followed by sodium, zinc, copper, cobalt and iodine. A large body of research data has shown that providing mineral supplementation to grazing cattle significantly increases both growth and reproductive performance. McDowell (1985) reviewed sixteen experiments from tropical countries in which the average calving percentage was increased from 52 to 74% by mineral supplementation. Phosphorus deficiency is by far the most widespread and economically important mineral deficiency affecting grazing livestock in the Cerrados.

The cost of mineral supplementation in Brazil is extremely high. The cost of phosphorus, usually from dicalcium phosphate, may represent as much as 70% of the total cost of a good mineral mixture. In addition, there is currently a serious shortage of phosphorus supplements in Brazil. It is estimated that there is a potential annual need for 800,000 tons of phosphorus (dicalcium phosphate equivalent) only for cattle. Since the available supply is about 300,000 tons there is a shortage of about 500,000 tons. In order to overcome this dramatic shortage, research on effectiveness of cheaper alternative phosphorus sources has been conducted by CPAC scientists since 1985.

A number of long-term on-farm mineral supplementation experiments and radio-isotope metabolism trials have been conducted and are still under way, with very positive results. An economic analysis of these experiments is also being carried out. A brief summary of the still largely unpublished research results will be given.

Alternative phosphorus sources, such as rock phosphate and selected fertilizer-grade phosphates, contain adequate levels of phosphorus and are cheaper but contain high fluorine levels and their biological phosphorus availability is not as high as that of dicalcium phosphate. Biological availability, as determined by radio-isotope techniques, reflects the

Table 4 Chemical composition, biological availability, of phosphorus and relative cost of various phosphates in Brazil

Description	Chemical composition			Biological availability of phosphorus[z]	Relative cost[z]
	P (%)	Ca (%)	F (%)		
Dicalcium phosphate	18.0	24.0	0.15	100	100
Triple superphosphate	21.5	16.0	0.60	95	45
Monoammonium phosphate	23.9	0.89	0.21	85	75
Rock phosphates:					
- from Patos	11.0	26.0	1.5-1.8	72	6
- from Tapira	15.0	28.4	1.0-1.2	70	NA
- from Catalão	15.5	28.2	2.5-3.0	70	5

[z] Dicalcium phosphate is used as standard reference (100%).
NA, not available for sale.
Source : Lopes *et al.*, 1989b, 1990b ; Silva Filho, 1990.

true absorption of P from the mineral source studied, in comparison to a reference standard.

Fluorine toxicity and recommended fluorine tolerance levels for livestock are well established (National Research Council, 1979, 1984). Brazilian rock phosphates generally contain lower fluorine levels than the majority of foreign rock phosphates. Furthermore, various fertilizers made from these parent rocks also contain relatively low fluorine levels.

The research conducted takes into account the phosphorus and fluorine levels of alternative supplements, as well as, the fluorine tolerance levels of different classes of livestock. It is well known that younger cattle are much more susceptible to high fluorine levels than older cattle. Data on chemical composition, true phosphorus absorption (phosphorus availability) and the relative costs of various phosphates are shown in Table 4.

As a general rule, animals received adequate levels of salt plus trace minerals in all the trials. The use of Catalão rock phosphate as the sole P source, for finishing feedlot steers during an 84-day period, was very successful compared with dicalcium phosphate. No fluorosis problems were detected and there was an estimated profit of US$ 5 per head as cost advantage for animals receiving rock phosphate (Lopes, 1989, unpublished data). The use of Patos rock phosphate to supplement 24 month-old growing steers on pastures in a 658-day on-farm trial was shown to be economical (Lopes *et al.*, 1989a). At the end of trial, the levels of fluorine accumulation in the rib bone of the animals which received rock phosphate were within the normal range (National Research Council, 1989).

In another long-term (818-day) on-farm feeding trial, animals started receiving Patos and Tapira rock phosphate as early as at the time of weaning (8 month-old),which resulted in a very poor animal performance and severe fluorine toxicity. At the end of the trial, fluorine levels above 7000 ppm for the rib bone were recorded in the animals receiving rock phosphate as compared with 500 ppm in the animals which received dicalcium phosphate. A number of research results indicate that triple superphosphate fertilizer-grade (TSP) may be almost as good as dicalcium phosphate for providing phosphorus to grazing beef cattle (Lopes, 1991, unpublished data). In addition, there is a potentially significant economic advantage over dicalcium phosphate. This can be better illustrated with the results of an on-farm feeding trial in which one group of growing steers on pasture received TSP as phosphorus source and an other similar group received dicalcium phosphate. After a 170-day period there was no significant difference in weight-gain between the two treatment groups and a US$ 7 advantage per head for the TSP group (Lopes *et al.*, 1990a). As one could expect, based on the age of the animals and the fluorine levels (0.2%) of the mineral TSP mix, no fluorosis problems were observed.

Recently, the field phase of another long-term on-farm feeding trial has been completed. The response to various alternative phosphorus sources in growing animals was compared with dicalcium phosphate. The experiment lasted more than 700 days and the average initial age was seven months. Liveweight gains of the animals receiving TSP and monoammonium phosphate (MAP) were not significantly different from those of the animals receiving DICAL However, preliminary economic analysis of the trial showed significant advantages for the TSP treatment group over MAP and DICAL groups. Rib bone fluorine levels are still being analysed but no clinical signs of fluorosis were observed.

The results of these trials also give support to another conclusion, related to interactions between protein and phosphorus supplementation, particularly in the dry season. Phosphorus supplements showed no advantage in preventing weight loss during the dry season. On the other hand, urea, even in the absence of phosphorus, resulted in reduced animal weight losses in the dry season. With time protein deficiency was undoubtedly the primary limiting factor.

However, in the rainy season, phosphorus appears to be the major limiting factor. The results of these trials confirm the basic concepts formulated by Niekerk and Jacobs (1985) regarding the interactions among protein, energy and phosphorus of animals consuming low-quality, protein-deficient forages. Furthermore, preliminary research is showing that a

low-cost mixture of salt, phosphorus sources, trace elements, urea, true protein and energy may be an excellent alternative to economically supplement grazing animals during the dry season (Lopes *et al.*, 1991, unpublished data). Great savings can be obtained by reducing the phosphorus levels and/or using cheaper alternative P sources for finishing animals either in feedlot or on pasture and mature animals not directly involved in reproduction or lactation. Equally important is the fact that the phosphorus levels may be appreciably reduced in the dry season for grazing cattle.

Future research prospects on feed resources for beef cattle

Sustainable economic and ecological feeding systems for the grazing livestock will certainly be closely linked to crop and pasture integration. Continuous arable cropping systems utilized in the Cerrados, are not as profitable as they were in the last decade. Furthermore, they are degrading the soil and its long-term productivity is expected to decline, even with high levels of chemical inputs. Research already has shown that associations of arable crops and pasture crops, planted in sequence, can be both ecologically and economically complementary. Intensification of agriculture can not continue any more based on frontier expansion. Research on new technologies will be required to increase yields per unit area on currently cultivated lands.

Impressive advances have been made in the selection of grasses and legumes adapted to cerrado ecosystems and this search needs to be continued. Additional research on pasture and grazing management is urgently needed to develop sustainable legume-based pastures. A great deal of research is required to improve the lignocellulose contained in the agricultural by-products. Economical viability of crop-livestock systems cannot be achieved without the utilization of all potential of the agricultural by-products.

Research is needed to develop microbiological, chemical, and physical methods to improve the bioavailability of lignocellulose (National Research Council, 1989). The potential of sugarcane for integrated energy and animal food production has not been fully investigated and needs to be thoroughly explored. The alcohol production program must be continued to allow Brazil to reach higher levels of energy self-sufficiency.

Despite the large volume of research that has been conducted, the interactions between protein, energy and phosphorus in preventing dry season weight losses are not still fully understood. Research to elucidate these interactions is needed as a basis for economically supplementary feeding of grazing cattle. Much more is needed to be done in developing cost-reducing technologies of mineral supplementation, to grazing cattle, based on alternative phosphorus sources.

Hopefully, development and intensification of ecologically and economically sustainable integrated agropastoral systems in the cerrado region will help to preserve the tropical Amazon forest.

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Discussion

Pradhan, K. (India) : Since rock phosphate contains a large amount of fluorine, can it be used for cattle at a young age or is it restricted to older animals on feedlot?

Answer : Our research data have shown that rock phosphate should be used only for animals which are at least 2 years old. The utilization of rock phosphate for older feedlot animals has been very successful. Based on trials, we observed that the accumulation of fluorine after 68 days did not exceed 3000ppm.

Tsuda, T. (Japan) : Do you think that the trend in the increase of the cattle population recorded in the last few decades is likely to continue in future?

Answer : I believe that the rate of growth of the cattle population in Brazil will not be as rapid as we observed especially in the last two decades. Moreover the quality is improving.