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9. ABSTRACT
A PROJECT: To determine the essential mineral supplements for grazing animal diets to increase the efficiency of LDC meat and milk production systems. Conducted by the University of Florida in selected countries in Latin America, Africa and Southeast Asia.
DURATION: November 1, 1976 - November 1, 1980
DEVELOPMENTS: Literature related to mineral analyses of soils-plants-animals in Latin America has been extensively reviewed. Numerous mineral deficiencies, imbalances and toxicities are severely inhibiting the ruminant livestock industry in Latin American countries. In cattle, the most prevalent mineral element deficiency is lack of phosphorus. Next to phosphorus the most widely deficient minerals are cobalt and copper, with calcium deficiencies rare. Inadequacies of magnesium, sodium iodine, selenium and zinc and toxicities of molybdenum, selenium and flourine have been encountered in widely diverse areas. Experiments designed to pinpoint mineral deficiencies and toxicities for specific farms and regions are in progress in all participating countries. New research data are being generated through experiments designed to determine the mineral deficiencies and toxicities and the mineral relationships between levels in soils, plants and grazing ruminants. Phosphorus supplementation has been shown to dramatically improve the low reproductive performance. A study in Brazil resulted in a 77% calf crop when bonemeal was fed compared to 55% for the controls. Mineral supplementation trials are now underway in Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela. Country-by-country summaries are included.

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AID MINERAL RESEARCH PROJECT

Contract number AID/ta-c-1153

RESEARCH IN MINERAL DEFICIENCIES FOR GRAZING RUMINANTS

UNIVERSITY OF FLORIDA
Institute of Food and Agricultural Sciences
Center for Tropical Agriculture
Department of Animal Science

ANNUAL REPORT

November 1, 1976 through March 1, 1978

Prepared by: Joe H. Conrad and Lee R. McDowell

REPORT SUMMARY

A. Statistical Information

1. Project Title and Contract Number:

Research in Mineral Deficiencies for Grazing Ruminants

AID/ta-c-1153

2. Principal Investigator, Contractor and Mailing Address:

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H. D. Wallace, Chairman	J. F. Easley
C. B. Ammerman	J. K. Loosli
John Bell, Technician	J. E. Moore
H. L. Chapman	R. L. Shirley

Cooperating Graduate Students at University of Florida: Kiatoko Mangeye, Zaire; Soekanto Lebdosoekojo, Indonesia; Marcelo Mendes, and Julio Cesar de Sousa, Brazil and David Morillo, Venezuela.

Cooperating Animal Nutritionists from Latin American Countries: Listed in Appendix.

3. Contract Period (as amended): from November 1, 1977 to November 1, 1980.

4. Period covered by report: from November 1, 1976 to March 1, 1978.

5. Total AID funding of contract to date: $748,972.00

6. Total expenditures and obligations through previous contract years: 11/1/76 - 10/31/77 $113,214.65.

7. Total expenditures and obligations for current year: 2/28/78 $65,175.07.

8. Estimated expenditures for next contract year: $145,000.00.

B. Narrative Summary of Accomplishments and Utilization

1. Reconnaissance and Recruitment Phase

a. Literature related to mineral analyses of soils-plants-animals in Latin America has been extensively reviewed. A summary of this information is found in a number of published articles. Three major reviews have been published which summarize the incidence of mineral deficiencies and toxicities in tropical regions, emphasizing Latin America. The three reviews list 176, 269 and 451 references. The majority of the Latin American papers established sporadic mineral deficiencies or toxicities on the basis of mineral response, levels of minerals in animal tissues, or forage mineral concentration. A brief review is as follows: Numerous mineral deficiencies, imbalances and toxicities are severely inhibiting the ruminant livestock industry in Latin American countries. All minerals for grazing ruminants have been infrequently and sporadically studied. In cattle, the most prevalent mineral element deficiency throughout the world is lack of phosphorus. The most devastating economic result of phosphorus deficiency is reproductive failure, with phosphorus supplementation dramatically increasing fertility levels in grazing cattle from many parts of the world. Next to phosphorus the most widely deficient minerals are cobalt and copper, but the extent of these deficiencies has not been defined because of inadequate research. Calcium deficiencies, except during peak lactation periods, appear to be rare. Inadequacies of magnesium, sodium, iodine, selenium, and zinc and toxicities of molybdenum, selenium, and fluorine have been encountered in widely diverse areas of Latin

America, but all have been infrequently studied.

b. Personal contacts have been made through visits and correspondence with interested personnel in eleven Latin American countries. Active research is in progress in the Bahamas, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Peru, Uruguay and Venezuela. Visits to cooperating laboratories from 1 to 3 times annually are necessary for stimulating mineral research. In late 1977 visits were made to interested researchers in Indonesia, Malaysia and the Philippines. Research programs are now being considered in these countries. Future visits to several key African countries are currently being planned.

c. A list of research personnel, country by country contacts, and research institutions are presented in the appendix. Linkages and collaborations with other AID contacts, and national and international institutions include: in the Bahamas, BARTAD; in Bolivia, IBTA, CIAT-British Mission and Facultad Veterinaria y Zootecnia; in Brazil, EMBRAPA, EPAMIG, institutions in the states of Ceará, Minas Gerais, Mato Grosso, São Paulo, Rio Grande do Sul, and the Amazon Cattlemen's Association; in Colombia, ICA and Caja de Crédito Agrario; in Costa Rica, the University of Costa Rica and CONICIT; in Ecuador, INIAP; in El Salvador, Ministry of Agriculture (Ganadería) and the Universidad de El Salvador; in Guatemala, INCAP; in Indonesia, Gadjah Mada University, CSIRO and Bogor Agriculture University; Malaysia, Universiti Pertanian Malaysia and MARDI; in Peru, IVITA, Universidad Nacional Agraria and Universidad Nacional Pedro Ruíz Gallo; in the Philippines, University of the Philippines and PCARR; in Uruguay, National

Veterinary Research Center, Agronomy Faculty, University of the Republic; in Venezuela, Centro de Investigaciones Agronómicas, Universidad Central, Universidad de Oriente, and Universidad del Zulia.

d. Specific contributions of Latin American institutions compared to AID/Florida inputs are estimated to be 15-20:1. The project is conducting difficult analyses and is contributing professional expertise for design, implementation, and conduct of research, as well as interpretation of research data and also securing difficult to obtain chemicals, laboratory supplies, and expendable supplies for collection, preservation, and analysis of samples (details are given in the appendix).

2. Experimentation Phase

Experiments designed to pinpoint mineral deficiencies and toxicities for specific farms and regions are in progress in all participating countries. Research data from participating countries is further confirming the incidence of phosphorus deficiencies. As an example three recent theses have been completed in Costa Rica by the Department of Animal Science at the University of Costa Rica. In one thesis 100% of all farms had deficient forage phosphorus concentrations while 50% of the blood contained less than 4 mg% phosphorus. Similar conclusions were found in the other theses. During the past years mineral research data from Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras and Venezuela have indicated borderline to severe copper deficiencies in grazing cattle. Extensive analyses from vast areas of Colombia have indicated widespread copper deficiencies

in this country. Incidence of sodium, cobalt, zinc, manganese, magnesium and other mineral deficiencies are highly variable and are noted in individual country discussions. New research data are being generated through experiments in all cooperating countries which are designed to determine the mineral deficiencies and toxicities and the mineral relationships between levels in soils, plants and grazing ruminants.

In previous research, phosphorus supplementation has been shown to dramatically improve the low reproductive performance (i.e., Bolivia, Brazil, Colombia, Panamá, Perú and Uruguay). A study in Brazil resulted in a 77% calf crop when bonemeal was fed compared to 55% for the controls. Recent trials in the Colombian llanos demonstrated that the pregnancy rate was increased from 50% for the controls up to 84% when complete minerals were fed. Benefit to cost ratios have been at least 2:1 when phosphorus has been supplied to deficient cattle with low reproductive rates. During the past year attempts have been made to encourage mineral supplementation trials in Latin American countries to verify the effect of phosphorus on reproduction under conditions existing in other regions and countries. Mineral supplementation trials are now underway in Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela. The largest supplementation trial involves 1870 cattle in the Beni region of Bolivia.

3. Distribution and Application of Results Phase

The "Latin American Symposium on Mineral Research with Grazing Ruminants" was held in Belo Horizonte, Brazil, on March 22-26, 1976. This symposium was jointly sponsored by Brazilian universi-

ties, research organizations, and the Florida/AID project and each of the 250 participants from 10 countries received a copy of the proceedings in Portuguese at the beginning of the meeting. Brazilians presented 11 papers, University of Florida personnel 12 papers, and invited speakers 4 papers. This symposium was a major effort to stimulate research and update the available information on mineral deficiencies and toxicities in Latin America. The proceedings were published in Portuguese and in April or May, 1978 will soon be available and distributed in English and Spanish. Nearly 1500 copies of a manual on "Methods of Mineral Analysis for Plant and Animal Tissues" have been widely distributed in English, Spanish, and Portuguese.

Articles on mineral deficiencies and toxicities have been presented at national and international scientific meetings. Limited research results have been published, but the majority of research is in progress.

4. Extension Phase

Three years of mineral research were insufficient to scientifically establish the mineral status of the major ruminant livestock producing regions of Latin America. Below are some of the reasons why the mineral research project was extended for three more years:

a. Continue to determine the location of mineral deficiencies, adequacies and toxicities in selected areas of Latin America where grazing ruminants predominate.

b. Test the mineral research methodology by extending mineral research programs into several key countries of Africa (Mali and Kenya) and Southeast Asia (Indonesia, Malaysia and

the Philippines) using those principles which have proven to be best in Latin America.

c. Continue research on soil-plant-animal mineral relationships for diagnosis of mineral status of grazing ruminants.

d. Determine the cost/benefit ratio from the effect of supplemental phosphorus and other minerals on reproduction and gains.

e. Continue research to determine validity of different methodologies for establishing mineral status of grazing ruminant animals.

f. Continue to improve Latin American institutions' capacities to carry out mineral research.

g. Continue a few well controlled mineral supplementation studies at experiment stations.

h. Determine effect of phosphorus supplementation during the rainy season and the carryover effect from periodic mineral supplementation especially phosphorus.

i. Continue field trials to determine best methods to counteract molybdenum and selenium toxicity.

j. Continue to generate accurate data which can be used to design adequate mineral supplements for different regions where grazing ruminants are important.

k. Continue to improve a systematic approach for standardizing sample collections, analyses, and methods of reporting data.

l. Continue to publish and distribute research information in order to stimulate the widespread use of mineral supplements.

m. Continue to evaluate mineral supplements and to encourage mineral supplement companies, researchers, and ranchers to

formulate, produce, and use high quality and nutritionally adequate mineral supplements.

n. Publish producer oriented extension bulletins on mineral deficiencies and toxicities for grazing ruminants (in Spanish, Portuguese, and English).

5. Research Methodology

Research methodology is being studied which will permit rapid determination of the mineral status of ruminant livestock populations. An accurate review of the mineral status in a specific region will permit prescribing mineral supplements for correcting deficiencies and toxicities. Mineral status varies with soil type, forage species, age, and physiological function of animal. The following research techniques are being studied as integral parts of the research methodology.

a. Tissue collection and analyses.

Kinds of material: soil, plant, and animal tissues.

Physiological state of plants and animals.

Kinds of animal tissue: blood, liver, bone, milk, saliva, feces.

Sampling technique: liver biopsy of live animal or slaughter animal for liver sample.

Locations: farms and centralized commercial slaughterhouses.

Season of Year: wet, dry

b. Mineral supplementation.

The duration of the majority of mineral supplementation experiments is at least 2 years. Phosphorus supplementation to increase low reproductive rates is being emphasized.

Some isolated experiments have shown that a 50 to 55% calf crop can be increased to 75 to 80% by correcting the phosphorus deficiency. Supplementation studies are the most important for the livestock producer, but they are also the most difficult to control and conduct. A few well controlled experiments on experiment stations along with a number of trials on cooperating ranches are being conducted.

6. Contribution to Institution Building

This project has made and is continuing to make excellent progress toward increasing cooperating laboratories' capability to do mineral analyses. A manual on "Methods of Mineral Analysis for Plant and Animal Tissues" has been distributed to all cooperating laboratories in one of three languages - English, Spanish or Portuguese. This publication standardizes procedures for sample collection, identification and analysis. A total of 7 visiting scientists or laboratory technicians have spent anywhere from 2 weeks to 6 months at the University of Florida studying mineral laboratory techniques. Project personnel have visited all cooperating laboratories for periods of from one day to one week to discuss and demonstrate laboratory techniques. One or more laboratories in each country are currently conducting all mineral analyses, except cobalt, molybdenum and selenium, and these laboratories are serving as training centers for laboratory technicians throughout the country. Several different experimental designs have been prepared and discussed with cooperating country personnel.

From these, a satisfactory experimental design has been developed for each of their experimental situations. All phases of this project have been conducted in complete cooperation with indigenous and international research organizations. These organizations and cooperating personnel can be found in the appendix.

7. Utilization Plans

The ultimate objective is to have livestock producers use nutritionally formulated mineral supplements to correct mineral deficiencies. Results of the research to date have been presented at ALPA (Latin American Society of Animal Production), American Society of Animal Science, Latin American Livestock and Poultry Conference, Symposium on Mineral Research in Latin America, and at numerous national livestock meetings. Popular articles are being written regarding the value of using mineral supplements.

Mineral supplements are being evaluated and we are finding that few, if any, contain proper amounts of all of the required minerals. The 3 mineral elements most likely deficient for grazing livestock are phosphorus, cobalt and copper. Phosphorus is the most deficient and also the most expensive. Therefore, many mineral manufacturers formulate phosphorus deficient supplements. For many mineral supplements evaluated, cobalt, in the majority of cases is supplied in adequate concentrations. However, copper and usually zinc are generally provided in very suboptimal amounts. Livestock producers are being informed concerning nutritionally adequate mineral supplements and how they should be used.

ANNUAL RESEARCH REPORT

A. General Background

Mineral deficiencies have been identified as one of the major factors limiting ruminant livestock production throughout Latin America. Although Latin America has 21% of the world's cattle, tha annual slaughter rate is about 12% compared to 38% in the United States.

Many of the reasons for the low levels of cattle production are nutritionally related.

1. Reproductive performance of cattle is low and average calving rates are usually between 35 and 50% compared to 85% average in the U. S. Table 1 presents research data from 10 mineral supplementation trials carried out in 6 Latin American countries. In each instance mineral supplementation has dramatically increased average calf crop.
2. Most evidence indicates that the mortality rate for beef cattle in Latin America is at least 12 to 15% compared to 5 to 6% in the U. S.. These high mortality rates occur primarily during the first 3 months of life and during the first dry period post weaning. Mineral and other nutritional deficiencies are directly and indirectly a major cause of mortality.
3. Slow development of cattle to market weight is illustrated by the fact that they reach 400-450 kgs in approximately five years. Numerous studies have shown increased gains, from mineral supplementation in Latin America. A recent study in the high altitude grasslands of Ecuador showed daily gains of 80 g per day prior to mineral supplementation as compared to 212 g per day after.

Table 1. Latin American studies on effects of mineral supplementation on increased calving percentages.*

Country	Control	Control + mineral supplement	Reference
Bolivia	67.5	80.8[b]	Bauer (1976, unpublished data)
Brazil	55.0	77.0[b]	Conrad and Mendes (1965)
Brazil	49.0	72.0[b]	Guimarães and Nascimento (1971)
Brazil	25.6	47.3[b]	Grunert and Santiago (1969)
Colombia	50.0	84.0[c]	Stonaker (1975)
Panama	62.2	68.8[d]	Ríos Araúz (1972)
Panama	42.0	80.0[b]	Poultney (1972, personal communication)
Peru	25.0	75.0[e]	Echevarría *et al*. (1974)
Uruguay	48.0	64.0[b]	De León Lora (1963)
Uruguay	86.9	96.4[b]	Schiersmann (1965)

[a]Control animals received only common salt (NaCl).

[b]Bonemeal.

[c]Complete mineral mixture.

[d]Dicalcium phosphate + triple superphosphate.

[e]Dicalcium phosphate + copper sulfate.

*References noted in McDowell and Conrad (1978).

Often grazing livestock do not receive mineral supplementation and must depend largely upon forages to supply their requirements. Only rarely, however, can forages completely satisfy all of the mineral requirements. Borderline or deficient levels of certain elements were noted for many forages in the 1974 Latin American Tables of Feed Composition (AID-csd-2498): Co, 43%; Cu, 47%; Mg, 35%; P, 73%; Na, 60%; and Zn, 75%. Chemical analyses of feedstuffs gathered under the University of Florida Latin American Feed Composition Project (AID/csd-2498) have also revealed that an extremely small number of laboratories are actively engaged in performing trace mineral determinations.

B. Statement of Project Objectives as Stated in the Contract

The objective of this research contract is to determine the essential mineral supplements for grazing animal diets to increase the efficiency of Lesser Developed Countries' (LDC) meat and milk production systems with a resultant increase in quality and quantity of LDC diets and a subsequent increase in employment and income levels.

The Contractor shall establish collaborative research activities in Latin American countries that have institutional and scientific capability to carry out this research project. These countries shall include Brazil (Empresa Brasileira de Pesquisa Agropecuria, Brasília, and Belo Horizonte); Ecuador (Instituto Nacional de Investigaciones Agropecuarias, Santa Catalina); Colombia (Centro Internacional de Agricultura Tropical, Cali and Instituto Colombiano Agropecuario, Bogotá); and Costa Rica.

Selection of additional countries shall be made in consultation with the AID/W Project Officer and not limited to those countries specified in the foregoing.

This research will be carried out 1) to experimentally determine the

locations of mineral deficiencies, adequacies and toxicities in selected areas of Latin America where grazing livestock predominate; 2) to establish by experimentation the biological response and economic benefit of mineral supplementation to grazing animals; 3) to experimentally evaluat methods of mineral supplement administration for grazing cattle; and 4) to publish and distribute research information in order to stimulate the widespread use of mineral supplements. The work to be undertaken has been separated into the following phases: 1) Reconnaissance and Recruitment Phase, 2) Experimentation Phase and 3) Distribution and Application of Results Phase as follows:

1. Reconnaissance and Recruitment Phase

To carry out the Reconnaissance and Recruitment Phase, the litarature on grazing cattle must be evaluated and, also, contacts in participating countries must be established by both correspondence and personal visits. In each country under consideration, previous research on mineral concentrations of soils, forages and animal tissues, in addition to reports of clinical signs of plant and animal mineral deficiencies at specific locations, will be evaluated to determine the highest priority for cooperative mineral research project.

Research institutions and personnel shall be located that have the ability and desire to carry out the proposed mineral research. Laboratory equipment and the methods of analysis for each mineral shall be determined by the contractor. The specific contributions of both the Latin American institutions and the University of Florida to the mineral research program shall be clearly established. This phase shall be completed and AID advised within 4 months from initiation.

2. Experimentation Phase

The experimental field work shall be initiated and carried out during this phase. The experimentation phase shall consist of two separate phases; the Tissue Collection Phase and the Mineral Supplement Phase. During the Tissue Collection Phase, tissue samples (liver, blood and bone) shall be collected from cattle ranches and slaughterhouses. Analyses of these tissues shall pinpoint mineral deficiencies and toxicities for specific farms and regions within the participating countries. Soil and forage analyses on farms and ranches from which the animals originate shall permit development of soil-plant-animal relationships with respect to minerals and other nutrients as well as toxic elements. Following the Tissue Collection Phase, a Mineral Supplement Phase shall clearly demonstrate production and economic benefits from mineral supplementation. In addition to establishing appropriate mineral supplement mixtures, methods of mineral administration in specific cattle producing regions shall be investigated. Both the Tissue Collection Phase and the Mineral Supplement Phase shall be initiated in Brazil, followed by Ecuador and Colombia. The exact sites for experimentation within each country shall be decided in cooperation with the Ministry of Agriculture of Brazil, INIAP (Instituto Nacional de Investigaciones Agropecuarias) of Ecuador, and ICA (Instituto Colombiano Agropecuario), and CIAT (Centro Internacional de Agricultura Tropical) of Colombia, based on criteria established in the Reconnaissance and Recruitment Phase. It is anticipated that a large percentage of the analyses required herein will be carried out at the University of Florida.

3. Distribution and Application of Results Phase

Experimental results shall be distributed to farmers, government officials and scientists. Results shall be published in both scientific

journals and in one- to two-page summaries suitable for distribution to farmers through local livestock organizations where available in each country and through other means considered appropriate by the Contractor and/or the A.I.D. Research Specialist. Publications reporting this research shall be based on maps that establish mineral status of cattle producing regions within participating countries. In addition, publications shall recommend mineral mixtures suitable for specific areas.

Results of the experimental findings shall be presented at local Latin American short courses in conjunction with annual and semi-annual livestock meetings in each country in addition to national and international scientific meetings.

C. Continued Relevance of Objectives

The project objectives as stated in the contract are still relevant. Many individuals and institutions recognize the importance of mineral research. However, a large number of organizations lack equipment, methods, or techniques of analysis and technicians that can carry out mineral research programs. In order to improve the institution capacity to carry out mineral research, the AID-Florida contract is providing various types of assistance. Publication of the manual entitled "Methods of Mineral Analysis for Plant and Animal Tissues" has provided a systematic approach for standardizing sample collections, analyses and methods of reporting data.

An overall objective of the mineral research program is to encourage the use of mineral supplements. It is increasingly clear, however, that it is not enough to stimulate the widespread use of mineral supplements, but to insure that these supplements are adequate to meet the requirements of grazing animals. Often farmers believe that they are providing adequate

mineral supplements for their livestock, but in reality the mineral supplements used are extremely inadequate.

In addition to many inferior mineral supplements sold in the market place, many farmers have a poor understanding of animal requirements and methods of administration. For example, even though phosphorus supplements are administered to some cattle in Latin America frequently the quantities are insufficient, the incorrect class of animal is emphasized (animals growing or in maintenance versus breeding females) and minerals are supplied the wrong time of year (dry versus the wet season). Surveys from Colombia and Ecuador indicate that many farmers dilute mineral mixtures anywhere from 10:1 to 100:1 with additional salt.

More emphasis needs to be given to training people to do mineral research. People are frequently available who have nutritional and laboratory experience. However, these people often need short-term training in mineral research techniques. More of this kind of training is needed.

D. Accomplishments to Date

1. Findings: The activities under this research project were separated into three phases and the findings will be discussed as follows:

a. Reconnaissance and Recruitment Phase:

In the early phases of the program the project included 3 full-time animal nutritionists and 8 part-time animal nutritionists. The project has reduced the staff to 1 full-time animal nutritionist plus the 8 part-time animal nutritionists. A larger staff was needed during the beginning of the program to review literature, establish research procedures and initiate research programs in the respective countries.

1) A complete search of the literature on mineral research in Latin America

was conducted at the Hume Library, University of Florida, and Inter-American Center for Agricultural Documentation and Information (CIDIA) located at CATIE, Turrialba, Costa Rica. Visits were made to a number of research organizations throughout Latin America. A total of 269 articles from journals or other publications were reviewed.

Mineral research information has been summarized in three major publications. Mineral Deficiencies and Toxicities and their Effect on Beef Production in Developing Countries was presented at a conference in Edinburgh, Scotland, and published in the proceedings, Beef Cattle Production in Developing Countries, edited by A. J. Smith. This publication contained 176 references concerning the incidence of mineral deficiencies or toxicities in the tropical countries. A second publication "Current Status of Mineral Research in Latin America" was presented at the "Latin American Symposium on Nutrition Mineral Research with Grazing Ruminants". This paper contained 269 references and summarized all the published mineral research pertinent to grazing ruminants in Latin America. The proceedings were published in Portuguese in 1976. During the last half of 1976 and 1977 the Brazilian Proceedings were prepared for English and Spanish editions. This involved editing, translating, rewriting and adding a large photographic section of mineral deficiencies and toxicities.

In 1977 an extensive review which will appear as a chapter in the book entitled "CRC Handbook of Nutrition and Food" was written. The chapter is titled "Geographic Distribution of Nutritional Diseases in Animals" and contains 94 pages and 451 references. The majority of these references deal with the location of mineral deficiencies and toxicities in developing countries.

Brief summary of review of literature: Table 2 illustrates both

Table 2. Geographical locations of mineral deficiencies or toxicities of ruminants in Latin America[a]

Required elements	
Calcium	Argentina, Brazil, Colombia, Costa Rica, Guatemala, Guyana, Mexico Panama, Peru, Surinam, Venezuela.
Magnesium	Argentina, Brazil, Chile, Colombia, Costa Rica, Guatemala, Guyana, Haiti, Honduras, Jamaica, Peru, Surinam, Trinidad, Uruguay.
Phosphorus	Antigua, Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba Ecuador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Surinam, Uruguay, Venezuela.
Potassium	Brazil, Haiti, Panama, Venezuela.
Sodium	Brazil, Colombia, Guatemala, Panama, Surinam, Venezuela.
Sulfur	Brazil, Ecuador.
Cobalt	Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, Guyana, Haiti, Mexico, Nicaragua, Peru, Surinam, Uruguay.
Copper (or molybdenum toxicity)	Argentina, Brazil, Colombia, Costa Rica, Cuba, Guyana, Haiti, Mexico, Panama, Peru, Surinam, Uruguay.
Iodine	Antigua, Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Haiti, Nicaragua, Paraguay, Peru, Uruguay.
Iron	Brazil, Costa Rica, Panama.
Manganese	Argentina, Brazil, Costa Rica, Panama.
Selenium	Bahamas, Brazil, Costa Rica, Ecuador, Guyana, Honduras, Mexico, Paraguay, Peru, Uruguay.
Zinc	Argentina, Brazil, Costa Rica, Guyana, Panama, Peru, Puerto Rico.
Toxic elements	
Fluorine	Argentina, Guyana, Mexico.
Manganese	Brazil, Costa Rica, Peru, Surinam.
Selenium	Argentina, Brazil, Chile, Colombia, Ecuador, Honduras, Mexico, Peru, Puerto Rico, Venezuela.

[a]McDowell (1976); Fick *et al.* (1976).

confirmed as well as suspected Latin American locations of mineral deficiencies and toxicities in ruminants. The most widespread mineral deficiency for grazing livestock is that of phosphorus. Calcium deficiencies are rare under grazing conditions. This fact is especially important since many old texts used in Latin America have given greater importance to calcium than experimental evidence indicates.

Copper and cobalt deficient areas are likely to extend over wide areas of Latin America, but their limits are impossible to define because of inadequate research. During the past years' mineral research data from Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras and Venezuela have indicated borderline to severe copper deficiencies in grazing cattle. Extensive analyses from vast areas of Colombia have indicated widespread copper deficiencies in this country. Inadequacies of magnesium, sodium, iodine, selenium, and zinc and toxicities of molybdenum, selenium and fluorine have been encountered in widely diverse areas of Latin America but all have been infrequently studied.

Forages rarely provide all the mineral requirements of grazing cattle. Therefore, it is a highly recommended practice to provide adequate mineral mixtures to assure the necessary intake of the elements needed.

2) Project personnel made frequent trips to visit interested research people in several Latin American countries. Currently active research is in progress in Bahamas, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Peru, Uruguay and Venezuela.

Late in 1977, a visit was made to the Asian countries of Indonesia, Malaysia and the Philippines. Institutions in these countries have expressed a desire to establish mineral research programs. In 1978 the African countries of Kenya and Mali will be visited to determine the

possibilities of cooperative mineral research. Project personnel have been discouraged from stimulating mineral research in Paraguay because of AID project priorities.

During most of the time covered by this report, project personnel were as follows:

1 full-time Animal Nutritionist

8 part-time Animal Nutritionists

1 full-time laboratory technician

1.5 bilingual secretary equivalents

5 graduate students

b. Experimentation phase: a brief discussion of the research program in each country is as follows:

Bahamas

We have cooperated with the Bahamas Agricultural Research Training and Development Project (BARTAD), San Andros P. O., North Andros Island, Bahamas at the request of AID/TAB Washington. Liver samples where collected and sent to Florida in polyethylene bottles containing formaldehyde. Samples were analyzed for cobalt, copper and manganese but the results were inconclusive because the samples were badly decomposed on arrival. Attempts are being made to obtain other liver samples.

Bolivia

The mineral research program in Bolivia was only recently started in late 1976. There are two groups with potential to do mineral research: La Paz - Instituto Boliviano de Tecnología (IBTA), Santa Cruz - A cooperative program between Centro de Investigación Agrícola Tropical (CIAT) and the Facultad Veterinaria y Zootecnia.

A third potential organization for mineral research was the University of José Bollivian at Trinidad. Unfortunately the main contact to be involved in mineral research has resigned and therefore the possibilities of mineral research are very limited

La Paz Area Research

The main contacts at IBTA are Dr. Simón Riera G. and Ing. Querubín de la Zerda. On various occasions, mineral research has been discussed with members of IBTA. There has been agreement that this research was important and that it should be undertaken. However, to this date no research program has been written up and finalized for cattle.

During the last visit there was interest expressed in undertaking research with sheep and llamas in the Altiplano of Bolivia. A brief proposal was written up entitled "Evaluation of the Nutritional Status of Sheep and Llama, with Emphasis on Minerals in the Altiplano of Bolivia". This proposed research would be carried out at, or near the Altiplano experiment stations of Patacamaya and/or Belén. Animal tissues (blood and liver of sheep and llamas) along with forage samples will be collected to evaluate the status of the essential nutrients. This research will probably be part of a Master of Science degree program at the University of Florida. A prospective student will attend the University of Florida for course work. During an approximately two year program the student will return to the Altiplano of Bolivia 1-3 months for

sample collections. This research will therefore be in Bolivia and the candidate, on degree completion, will return to Bolivia trained in nutritional analysis and techniques needed for livestock improvement for the small farmer.

Santa Cruz Area Research

The main contacts in the Santa Cruz area are Dr. John Wilkins of the British Mission, Dr. Andrés Parra of the Facultad Veterinaria y Zootecnia and Egresado Hugo Pérez.

The Florida/AID contract is attempting to increase the laboratory capabilities of the CIAT laboratory. To do this, chemical supplies and materials have been provided to this laboratory. Also, Hugo Pérez spent 3 months in Florida learning laboratory mineral techniques.

Two mineral experiments have been planned for the Santa Cruz region. One of these involves collecting samples from cows, heifers and bulls obtained from slaughterhouses in this region. Another experiment would be a more complete study where 3 cattle producing zones would be evaluated. The eastern border of these regions is the Rio Grande. Region A (northernmost region) has the highest rainfall with 2,000 mm. Region B (including Santa Cruz and Montero) has a rainfall of 1,100 mm and region C (southernmost and driest region) has a rainfall of 700 mm. Soil, forage, blood and liver sample will be taken from representative farms in these regions. These samples will be taken twice during the year in March and September. March represents the end of the rainy season while September is toward the end of the dry season. Some of this research will be used for the thesis of Ing. Armando Peducasse for his Egresado Veterinario degree. Samples from these farms were taken by Egresado Pérez to Florida for analysis. There is a good possibility that after Ing. Peducasse receives his degree he will go on for his M. S. degree. If accepted by Florida, he will work in the mineral research area collecting

animal, soil and plant tissues for analysis.

Cooperative research is now being conducted with a private rancher in the Beni. The rancher, Mr. Bernardo Bauer, and his manager, Ing. Enrique Galdo, are overseeing a large mineral supplementation experiment. This experiment was assisted in being organized by personnel from the University of José Bollivian at Trinidad. In this experiment 936 females and 936 males (12 to 15 months of age) were blocked by age and sex and randomly allotted to the following treatments:

Treatment	No. of Animals	Female	Male
Control	288	144	144
NaCl only	544	272	272
Salt + dicalcium phosphate (3:2 ratio)	346	173	173
Salt + dicalcium phosphate (3:2 ratio)	694	347	347
Total	1872	936	936

Additional treatments consist of a factorial experiment utilizing 160 animals within each of the 3 larger treatment groups. The treatments will consist of control, selenium-vitamin E, copper, cobalt and iodine. Cobalt will be supplemented as bullets and selenium-vitamin E, copper and iodine as injections.

Since the experiment was initiated in June (1977) samples and injections have been administered or collected every 4 months. The duration of this experiment is 2 years with the possibility of a third year likely.

Since June, 1977, an additional supplementation experiment has been discussed with the organization Cooperación Técnica Suiza - CBF. This is a Ministry of Agriculture organization that is receiving assistance from the Swiss. This organization owns approximately 4,600 cattle, both Zebu and Criollo. Their handling facilities are very good and they have a small laboratory that could be used for sample preparation. There is both native

and improved pasture. There also is a large slaughterhouse where animals are killed three times per year. Cattle production in Reyes is very poor with 5-6 years required for animals to reach slaughter weight. The calving percentage for this area is between 40-50%. An official from this organization had expressed the desire that the Florida/AID mineral program initiate mineral supplementation experiments.

We discussed the possibility of mineral supplementation using bred heifers as follows: Treatment

1) Salt only
2) Salt + P and Ca supplementation (administered all year)
3) Salt + P and Ca supplementation (administered only during wet season)
4) Complete mineral supplement (administered all year)
5) Complete mineral supplement (administered only during wet season)
6) Complete mineral supplement (administered only during dry season).

A minimum of 100 bred heifers per treatment would be required with minerals administered free choice. Treatment 6 could be eliminated. The wet season is from November to March and the dryer season from April to October. It was noted that a person could be employed full time just for this experiment and/or it could be used as an egresado degree study. The duration of the experiment would be 2 years.

At this time we have had great difficulty in setting up this experiment. The logistics for travelling to Reyes are extremely difficult. One trip has already been cancelled due to plane schedule postponements. An attempt will be made to visit Reyes again in early 1978.

Brazil

The Latin American Symposium on Mineral Research with Grazing Ruminants held at Belo Horizonte on March 22-26, 1976, has had a far reaching and significant effect on ranchers and animal scientists throughout Brazil. Copies of the proceedings of this symposium in Portuguese have been widely distributed throughout Brazil and this has become the standard reference manual used by ranchers, teachers, researchers and students. This has stimulated a renewed awareness of mineral deficiencies and the importance of mineral supplementation throughout Brazil. Researchers use this as a standard reference for preparing research project outlines.

One trip by J. H. Conrad was made to Brazil between March 21 and April 18, 1977, four days of which 3/26 to 3/30 were spent in Montevideo, Uruguay. Another trip by J. H. Conrad was made between November 10 and December 15, 1977, six days of which 11/19 to 11/24 were spent in Uruguay. The itinerary for both trips was São Paulo, Porto Alegre, Santa Maria, Montevideo, São Paulo, Campo Grande, Rio de Janeiro, Belo Horizonte, Viçosa, Brasília, Fortaleza and Belém. Contact was made with those interested in mineral supplementation, those doing mineral research or interested in doing mineral research. During the first trip six seminars were given on "Phosphorus Supplementation for Increasing Reproduction in Cattle". During the second trip seven seminars were given on the material in Dr. Marcelo Mendes' thesis, "Mineral Status of Beef Cattle in the Northern Part of Mato Grosso, Brazil, as Indicated by Age, Season, and Sampling Technique". Both seminars were well received but great interest was shown in the latter which showed results of studies conducted in Brazil. An abstract of this Ph.D. dissertation can be found in the appendix.

The AID/Florida Mineral Research Project is cooperating with several

different research groups in Brazil and these will be briefly outlined below.

Dr. Waldemar Camargo and Dr. Nelson Fernandes of the Biological Institute of São Paulo have been cooperating with the Amazon Cattlemen's Association. They have been collecting samples, conducting research and analyzing plant and animal tissue samples from 35 ranches in the Amazon region. Phosphorus, copper, cobalt and zinc deficiencies appear to be widespread.

Dr. Enio Prates of the Federal University of Rio Grande do Sul collected samples of native grass pastures from four locations in Rio Grande do Sul, during the months of October, November and December over a period of two years. Twenty-three representative samples are being analyzed at the University of Florida. A cooperative mineral research project was being planned but changes in key personnel who worked for the Secretary of Agriculture have interrupted this project. Dra. Olga Gavillon who had conducted some excellent mineral research took early retirement and Dr. Jorge Lopes transferred under contract to the UFRGS (Federal University).

Dr. David Stiles replaced Dr. George Hall at the Federal University of Santa Maria. Dr. Lauro Muller and Dr. David Stiles are continuing the experiment to study the effects of selenium-vitamin E injections on sheep and cattle in the Levramento area of Rio Grande do Sul. They are writing a research project to tie together soil-plant-animals with a strong mineral component.

The EMBRAPA sponsored National Beef Cattle Project is located at Campo Grande, Mato Grosso. They are in the process of staffing, building and organizing. Armando Primo, technical director, returned to Florida in March to complete his research for the Ph.D. and he was replaced by Dr. Leonidas

Valle who has a Ph.D. in pasture and forages from Florida. Dr. Júlio César de Sousa just completed his Ph.D. in mineral research at Florida and went to Campo Grande to head the analytical laboratory. This laboratory is equipped with an Atomic Absorption Spectrophotometer (Perkin-Elmer 306) which was purchased in 1976 and a smaller Perkin-Elmer 103. It is apparent that this laboratory will be well equipped and have capable personnel to do excellent mineral research.

Dr. Jürgen Döbereiner and Dr. Carlos Tokarnia at EMBRAPA/RJ, Km 47 and Universidade Federal Fluminense have been doing mineral research along with the study of toxic plants for many years. Samples of jaw bones in formaldehyde were brought to Dr. Hines and Dr. Stanley at the Dental Faculty, University of Florida. Histological examinations will be made to attempt to identify causative factors associated with a periodontal condition in cattle.

Professor Roberto da Silva is in charge of the analytical laboratory at the Veterinary School, Belo Horizonte. He has a Perkin-Elmer 403 and the laboratory has the capacity for 100 samples daily in which 6 minerals are determined. Their effort is on identification of mineral deficiencies in Central Brazil primarily the large cattle producing areas of Minas Gerais and assistance with analyses related to Master of Science theses.

The Zootecnia Department, Federal University of Viçosa, Viçosa, Minas Gerais has 75 graduate students in Animal Science. Several of these are working on minerals and their availability in various plants.

Henrique Otávio S. Lopes at the EMBRAPA Cerrado Research Center has been working on mineral research in Goiás. He obtained the following results

Mean liveweight gains (grams/animal/day) during a wet and dry season from April 11, 1976 to June 10, 1977.

Treatment	Mean liveweight gain (gram/animal/day) Wet season	Dry season	Wet + dry season
A. Salt	236	-130	53
B. Salt + P	267	- 86	90
C. Salt + P + Co + Cu + I	280	- 5	137
D. Salt + P + Co + Cu + I + Zn + Fe + Mn	274	- 49	112

Forage analyses indicate that about 50% of the forage samples have less than 0.18% phosphorus, 5 ppm copper and 20 ppm zinc. Forage and liver samples are being analyzed for cobalt and molybdenum at the University of Florida.

Dr. José Adalberto Gadêlha at the Federal University of Ceará, Fortaleza, and his group plan to collect and analyze forage and animal tissue samples from five different areas of the state of Ceará in northeast Brazil. Cobalt, copper and phosphorus deficiency are thought to be widespread, but no supplemental trials have been conducted.

Dr. Adilson Serrão and Cristo Nazaré are working primarily with forages and they plan to determine the mineral content of some of the forages common to the Amazon region.

Costa Rica

The mineral research program at Costa Rica has been highly active and productive. The leaders of the program are Prof. Hernán Fonseca and Ing. Emilio Vargas of the Animal Science Department, University of Costa Rica. For the mineral research program, the Animal Science Department is receiving funds from CONICET, an organization which supports research. In addition, eleven Peace Corps volunteers have devoted a great deal of time to collecting liver, blood, and forage samples from selected regions of Costa Rica. As of the middle of 1977, 1700 blood, 1700 forage and 600 liver samples have been collected. A high percentage of these have been analyzed. The plans of the program are to conduct mineral research studies in all of the major dairy and beef cattle regions of Costa Rica.

The University of Florida/AID program has contributed $7,000.00 per year for two years to assist with the mineral analyses.

This support was only needed for 2 years for the salary of Ing. Emilio Vargas. Since October, 1977, the University took over the salary support as Ing. Emilio Vargas is now a permanent member of the department. The Costa Rica mineral project will therefore no longer require any direct financial support from the Florida project.

The earliest stages of the mineral research program involved two University of Florida graduate students who did their M.S. research in Costa Rica. The titles of these theses are "Phosphorus and Trace Mineral Status of Beef Cattle in the Guanacaste Region of Costa Rica" and "Mineral Status of Cattle in the San Carlos Region of Costa Rica". The results of this data were discussed in a previous annual report. Data from these theses have been submitted to the "Journal of Dairy Science" and "Tropical Agriculture". Also this data will be presented at the 1978 World Animal Production Meetings in

Argentina. This data is likewise being written up as part of an extension bulletin.

Dr. Nestor Marciles of Argentina is temporarily working with the University with a grant from the Atomic Energy Commission. He will be working with the University until November, 1978. Dr. Marciles will be working on nuclear research techniques in the mineral area, particularly where there are suspected problems. From the mineral research program, they have found low blood calcium and forage levels from dairy cattle in Coronado (just north of San José). The phosphorus levels are high to normal with a large percentage of the cows anemic as shown by low hematocrits (i.e., 24-25%). Dr. Marciles will work with radioisotopes (i.e., P^{32} and Fe^{59}) to evaluate the status of cattle in this area.

Samples collected by the Peace Corps volunteers are used for "Egresado" (B.S.) degree theses. Eight "Egresado" theses have now been completed and at this date we have received 3 of these. The quality of these theses is excellent.

Conclusions from 3 theses are as follows:

Olger Murillo Bravo Thesis

The title of this thesis is "An Evaluation of Mineral Nutrition Status of Grazing Cattle in Cañas County, Guanacaste. In this experiment, 19 beef cattle farms were utilized from Cañas county with samples taken during the dry season. There were a total of 90 forage, 106 blood and 8 liver samples analyzed.

Conclusions:

a) Crude protein: 80% of the forages contained less than 7% protein with the average being 2.86%.

b) Calcium: The majority of the blood calcium values were normal being over 9 mg%. However, 68.9% of the forages contained less than 0.18% calcium.

c) Phosphorus: The average phosphorus concentrations were 4.27 mg%. 50% of blood phosphorus values were less than 4 mg%. Only 6 of 19 farms had normal average blood phosphorus levels. Approximately 89% of the forage samples contained less than .18% phosphorus. The average phosphorus was 0.09%. 100% of the farms had deficient average forage phosphorus levels.

d) Magnesium: Only 1.89% of the blood magnesium was less than 1.8 mg% and only 5.6% of the forage samples contained less than 0.05% magnesium. It could be concluded that magnesium status of these animals was adequate.

e) Potassium: Approximately one-third of the forage potassium samples were less than 0.6% with the average potassium forage concentrations of 1.15%. Four of these farms had average values of less than 0.60%.

f) Iron: The average forage iron for all farms was 148 ppm with all farms being adequate in forage iron. Liver samples were also adequate in iron concentration.

g) Copper: Approximately 81% of the forage samples contained less than 4 ppm copper. Over 99% of the samples contained less than 10 ppm. The overall copper forage mean was 2.81 ppm. Only 4 of the 19 farms had average copper forage values of 4 ppm or more. Six liver samples varied from 78 to 250 ppm with the average being 157.8 ppm.

h) Manganese: Forty percent of the forage samples contained less than 20 ppm with the overall average being 27 ppm. Eight of 19 farms had averages of less than 20 ppm. Eight liver samples ranged from 2-7 ppm averaging 4.75.

i) Zinc: Sixty percent of the forage samples contained less than 20 ppm with an overall average of 20.05 ppm. Twelve of 19 farms had averages less than 20 ppm. Six liver samples ranged from 99 to 150 ppm.

In this thesis forage species differences were noted for both protein and minerals. The overall conclusions would be that phosphorus and crude protein are severely deficient, copper is deficient with borderline to deficient concentrations of manganese and zinc noted in forages and livers.

Manrique Alonso Guzman

The title of this thesis is "Evaluation of Mineral Status of Beef Cattle in Pastures in the Districts of La Cruz, Cañas Dulces and Filadelfia in the Province of Guanacaste During the Dry Season". In this study three districts

are involved. There are 5 farms from La Cruz, 1 from Filadelfia and 6 from Cañas Dulces. In general, there were 5 samples of blood, liver and forage collected and analyzed per farm.

a) Protein: 95% of the forages contained less than 8% protein.

b) Calcium: Approximately 27% of the blood values were low containing less than 8 mg/100 ml. Forage calcium levels were also quite low with 40% containing less than .18%.

c) Phosphorus: 27% of the phosphorus concentrations were less than 4 mg/100 ml. Forages were also low in phosphorus containing less than 0.18%.

d) Magnesium: A large proportion of the animals (43%) contained low levels of blood magnesium (less than 2 mg/100 ml). Forage magnesium levels were also low with 43% containing less than .04%.

e) Potassium: 42% of the forage values contained less than .6% potassium.

f) Iron: 13% of the forages contained less than 10 ppm of iron.

g) Copper: Copper forage concentrations were low with 13% containing even less than 3 ppm. 4 of 9 liver samples contained less than 75 ppm of copper.

h) Manganese: 3% of forage manganese values were less than 6 ppm and 8 of 9 liver samples were also less than 6 ppm.

i) Zinc: 8% of the forage values contained less than 10 ppm while 2 of 9 liver samples contained less than 84 ppm.

The data from this thesis also contains correlation coefficients and shows differences among farms and forage species. The general conclusions would be that protein and phosphorus would be at insufficient concentrations. Magnesium levels suggest problems in this area, calcium levels were low for a relatively large percentage of blood calcium analyses and manganese and zinc were relatively low in forages.

Luis Fdo. Palmer Francis

The title of this thesis is "Evaluation of the Mineral Nutrition Status of Cattle in the Province of Cartago". In this study 34 farms (mostly dairy)

from the Province of Cartago were studied during the dry season. There were 2-6 farms utilized per county. Of the samples analyzed, there were 64 forage, 68 blood and 10 liver samples.

a) Crude protein: Approximately 94% of the forage samples contained more than 7% protein averaging 13.76%. This would be quite contrary to the areas where data was taken for the other two theses.

b) Calcium: 65% of the blood calcium values were less than 9 mg% and 98.4% of the forage samples were less than .44% calcium. For instance, 43.8% contained less than .16% calcium.

d) Phosphorus: 51.5% of the blood phosphorus levels were less than 4 mg% with the average being 4.17 mg%. 65.6% of forage samples contained less than.16% phosphorus (92.2% contained less than .30% phosphorus, averaging 0.15%).

e) Magnesium: 94.1% of blood magnesium was normal with forage magnesium levels averaging 0.22%.

f) Potassium: Forage potassium levels were normal ranging between 0.83 and 8% with an average of 3.44%.

g) Iron: 12.5% of the forage contained less than 100 ppm of iron averaging 297 ppm. Ten liver samples ranged from 58 to 196 ppm.

h) Copper: 75% of the forage samples contained less than 10 ppm averaging 8 ppm. Eight of 10 liver samples were below 75 ppm averaging 44 ppm. Copper liver ranged from 15 to 144 ppm.

i) Manganese: 78.1% of the manganese forage values ranged between 25 and 100 ppm averaging 111 ppm. However, the liver manganese values (10 samples) were low averaging 4 ppm.

j) Zinc: 82.8% of the forage contained less than 40 ppm averaging 33 ppm. Ten liver samples averaged 54 ppm ranging from 30 to 103 ppm.

This data also contains correlation coefficients and it shows differences among farms, forage species and animal classes. Phosphorus appeared to be the most severe mineral deficiency with low levels of forage and blood calcium noted. The analyses would indicate that copper, manganese and zinc are all borderline to deficient in these samples.

Colombia

A research program between CIAT and the University of Florida has been in progress since March, 1975. Mr. Soekanto Lebdosoekojo had been working on a Ph.D. research program at the Caramagua experiment station entitled "Mineral Supplementation of Breeding Cattle in the Colombian Llanos". Soil, animal tissue and forage samples were collected in herd system programs and were analyzed and written up into a thesis. In 1977 the thesis was completed and an abstract of data from the thesis was presented at the 1977 ALPA meetings in Cuba. There is now no longer a cooperative program between the Florida-AID program and CIAT.

A cooperative mineral research program between ICA and the Florida-AID contract has been in effect since July, 1975. The leader of this program is Dr. Arturo Gil. Some of the early research in this program involved pilot projects in 8 ICA experiment stations. Two treatment groups were used with the treatments being with and without mineral supplementation. Every three months liver biopsy, blood and forage samples were collected. Only a small number of animals were used per treatment and therefore statistical evaluation was difficult. However, conclusions were made as to future studies that needed to be undertaken.

The mineral research to date has had both problems and successes. The biggest disappointment was the termination of 4 mineral supplementation experiments that were in progress in the Medellín and Montería (Caucasia) regions of Colombia. These experiments were in progress for 6 months but were abruptly terminated when the animals were sold. Also there have been failures with supplementation trials with ranches which were part of the Fondo de Ganadería de Meta, Tolima and Antioquia.

Some of the best experimental results have come from the Puerto Boyaca

region. In a previous experiment, animals receiving a supplement containing arsenic, sulfate and additional copper had double the weight gains as animals receiving a standard mineral mixture. Further analysis indicated that not only was this area high in selenium but it was also high in molybdenum, thus complicating the copper deficiency. There is currently a big push to determine molybdenum concentration of forages from different parts of Colombia. Ing. José Daniel Gómez who is one of Dr. Gil's associates spent one month in various regions of Colombia collecting forage samples. His primary emphasis was north of Bogotá and along the Atlantic coast area. Forages that are collected will be analyzed for both copper and molybdenum content.

A new supplementation experiment was initiated late in the year at Caramagua. The title of this experiment is "The Effect of Supplementation with Urea and Phosphorus on Utilization of Forage and the Effect on Reproduction". There are 30 animals for each of the following eight treatments: 1) complete mineral supplement fed all year long, 2) salt only fed all year long, 3) phosphorus fed all year long, 4) phosphorus and nitrogen fed all year long, 5) complete mineral supplement fed during the wet season, 6) salt fed during the wet season, 7) phosphorus fed during the wet season and 8) phosphorus and nitrogen fed during the wet season. This experiment will be very good to determine the economics of the mineral supplementation. The 240 head are breeding animals.

Analyses from the area called Nariño have indicated that copper and zinc concentrations of liver and forages are low. Most of the information was from liver biopsies carried out on a small pilot study. An experiment is now underway with two treatments containing 25 animals each. One treatment would contain a complete mineral supplement and the other treatment would contain only salt + copper + zinc. In this particular region the phosphorus con-

centrations were adequate.

In the Bogotá area, research has noted that phosphorus deficiencies are prevalent and that urea + phosphoric acid increased milk production. There is now an experiment underway comparing three phosphorus sources. There are 50 animals per treatment. Unfortunately these treatments are from three different farms that are located close to one another.

Another experiment is underway in El Nus for a duration of two years. There are 20 animals per treatment. The first treatment is a complete mineral supplement comparing it to a mineral supplement containing only salt, copper, zinc and phosphorus. The latter mineral supplement would be much more economical than the complete mineral mixture.

At this time the researchers at ICA have collected a tremendous amount of samples and have completed numerous mineral analyses. This large quantity of data needs to be summarized. There is currently a rough summarization of the mineral status for 33 distinct regions of Colombia. Based on forage, liver and blood analyses, various areas have been noted to fall in the following category for the specific minerals: toxic, high, normal, low, deficient and severely deficient. With this information a better idea is now becoming apparent as to which minerals are problems in specific regions.

An interesting study in the Puerto Boyaca region was undertaken by a botanist who was working with Dr. Gil. The purpose of this study was to identify the various plants in this selenium toxic region and to determine the selenium concentration. In this way they could determine if there were selenium indicator plants. This data has been written up as a thesis and there are definitely selenium indicator plants.

An additional interesting study has been undertaken in the Puerto Boyaca region studying the effects of the high molybdenum on copper metabolism.

Animals were given radioactive copper (copper-64) and the rate of elimination and retention was studied. After 7 to 8 hours only 10% of the copper-64 was retained for controls while those animals which had been in a molybdenum toxic area retained 60% at this time. The molybdenum content in many forages in the Puerto Boyaca region is approximately 20 ppm. Also studies have been made using ceruloplasmin. This copper-containing enzyme was lower in animals with copper deficiencies and positively correlated with low hematocrits. This work wa included in a thesis by Patricia Jímenez and Lucía Pabón and was published this year. Data in this particular thesis also published summarized data of copper in relation to samples taken from slaughterhouses and also from liver biopsy. It is apparent that copper deficiency is a severe problem in many regions of Colombia. The translated title of this thesis is "The Possible Deficiency of Copper in Beef Cattle".

A large amount of mineral analyses have been completed and it is possible at this time to make some general summarizations. A large percentage of all forages are low in sodium and phosphorus. A high percentage of the forages contain less than .2% magnesium. The majority of the forages contain less than 30 ppm of zinc. The general statements for specific regions are as follows: los llanos - the most severe deficiencies are phosphorus and protein; Caqueta - there appears to be a calcium deficiency here; Puerto Boyaca region - there are deficiencies of copper, phosphorus, calcium and toxicities of molybdenum and selenium; La Sabana region near Bogotá, Tolima and Huila - these areas are deficient in copper, zinc, perhaps cobalt, and have toxic concentrations of molybdenum; Turipana, Caribia and Montilonia - in this region the most severe deficiency is copper. Caribia appears to be all right in phosphorus and calcium but Turipana and Montilonia are deficient. El Nus, Palmira and Obonuco - these three areas have similar problems with

severe copper deficiencies and marginal zinc deficiencies. Antioquia - phosphorus deficiency is the most noticeable problem. Valle and Nariño the mineral status in regards to phosphorus seems adequate but copper is deficient.

Dr. Ed Stone and Mr. Wayne Miles of FAO are also interested in mineral research. They are currently making plans to collaborate with Dr. Gil in some joint projects. Dr. Stone is the head of the program while Mr. Miles is a retired forage expert and is doing consulting work for FAO. Mr. Miles has been very interested in the possibilities of alternate sources of phosphorus. He is concerned with the very high cost of mineral supplements. As a result, he is trying to gather information on the possibilities of feeding triple super phosphate and also basic slag. We will make some basic analyses of these products at Florida to assist him in deciding the use for these products.

Dr. Stone has started a livestock program in the state of Antioquia. There will be 33 farms selected in each of the north, central and south regions of this state. These programs will include rotational grazing, introducing new forage species. It is on these farms that Dr. Stone and Mr. Miles are interested in getting mineral supplementation programs established. After research at Antioquia is finished they will continue working, expanding to the llanos area.

The AID-University of Florida program has been providing $7,000.00 a year to assist the ICA mineral research program. This amount has now been reduced to $4,000.00. These funds have been used for travel and the purchase of laboratory supplies. In addition, the Florida-AID program has provided additional consumable supplies and has completed analyses of some of the more difficult minerals (for example, cobalt and molybdenum). The mineral research

program is being assisted by Dr. Juan Salazar who is the Director of the Programa Ganadero, Caja Crédito Agrario. In the early part of the program the Bayer Company provided some mineral supplements. The Pfizer Company is now providing mineral supplements made to the researchers' specifications.

Ecuador

Florida personnel are working directly with researchers of the Instituto Nacional de Investigaciones Agropecuarias (INIAP). The two main contacts are Ing. O. Molina in the highlands region of Quito and Dr. Raúl de la Torre in the tropical region headquartered at Pichilingue.

Research in the Pichilingue Area

Four beef cattle ranches in the Santo Domingo region and 5 in the Quevedo area were selected to determine the mineral status of cattle in these regions. Blood samples have been taken during 3 different periods of the year. In addition, 1/2 of the cattle on ranches in the Santo Domingo region received injections of selenium-vitamin E due to reports of white muscle disease in this area. During the year the selenium-vitamin E injected animals did not gain better and calf deaths and abortions were still in evidence.

Muscle and liver tissues sent to Florida for necropsy work did not reveal white muscle disease. One of the necropsy reports indicated hepatic lesions that probably are caused by a toxic substance. The selenium status of these cattle cannot be confirmed until blood and forage selenium analyses are completed at Florida. There was a report concerning cattle at the ranch Santa Marianita in the Santo Domingo region. Apparently some of the cattle have misshapen feed and missing tails which suggest a possible selenium toxicity.

Much of the mineral and statistical analyses have now been completed. With the exception of phosphorus there were significant seasonal differences among minerals. Both the Quevedo and the Santo Domingo regions are somewhat low in phosphorus status. This was particularly noted where mineral supplements were not fed or were available on an irregular basis. In one of these

ranches phosphorus was fed but diluted heavily with salt. It appears that the Santo Domingo area has more of a phosphorus deficiency problem than the Quevedo region. In both regions copper was borderline to deficient and zinc was borderline. The levels for both copper and zinc were lowest at the end of the rainy season and extended into the dry season.

Mineral consumption data from Pichilingue revealed 59.2 and 31.0 g per day for the rainy and dry season, respectively.

Plans are being made for expanding mineral research into other areas of tropical Ecuador. El Puyo which is in the Oriental near Limoneocha will be a location for mineral research. It has been noted that the calving percentage is less than 50% in this area. When minerals were fed to one group of cows the calving percentage was increased to 90% the first year and 84% the second year. From El Puyo blood and liver samples will be collected twice a year from slaughterhouses. The collection periods will be August and March The total rainfall in this region is very high at 5,000 mm annually. August will represent the dryest and March the wettest times of the year. Samples from steers will be collected from 4 farms from each of 4 zones. Ten animals will be collected per farm. At the slaughterhouse farms will be identified and visited where questionnaires will be filled out and forage samples taken. It is unclear as to when the research in El Puyo will be initiated due to the accidental death of Dr. Wilson Olmedo. Dr. Olmedo was to be in charge of this particular program.

Later this year or next year mineral research will be in the Manabí state (north coast of Ecuador). This is the largest area of beef cattle numbers in Ecuador. Twenty percent of all cattle and 40% of cattle from the coast are in this state. Research will be carried out in the Chone region of Manabí where the greatest concentration of cattle are located. Research will

be conducted by Ing. Carlos Forfon from the Portorrejo experiment station in Chone. He will be working with veterinarians collecting samples from slaughterhouses and farms. Cattle production from the area is very poor with calving percentages estimated at 40% and heifers not bred for the first time until 4 years of age.

In March, 1978, a mineral supplementation trial was initiated at Pichilingue. This experiment would have been initiated 9 months earlier except for the problem of locating a high quality phosphorus supplement. The translated title of the program is "Benefits of Mineral Supplementation to Beef Cattle at Pichilingus". Approximately 120 criolle, 3 1/2 years of age will be allotted to 3 treatments as follows: 1) common salt only, 2) salt + a phosphorus source, and 3) a complete mineral supplement.

The cattle are now pregnant with their second calf and each group will be allotted to 32 Ha. Each pasture will be divided into 4 sections for rotational purposes. The duration of the experiment is 2 years and 3 times each year blood, liver biopsy and forage samples will be taken for mineral analysis.

Research in the Quito Region

Recent research has attempted to relate mineral status to reproduction in dairy cattle in the Machachi Valley and the Santa Catalina experiment station. The data compared the mineral status between cows with reproductive problems and normal animals (thesis of Ing. Hervas). Some of the animals in both groups were low in blood phosphorus. Limited data indicated that manganese blood levels were significantly lower for cattle with reproductive problems. Serum iron, copper and zinc appeared to be quite high for both groups. Forage levels of copper were highly variable with some being quite low. It was suggested that liver biopsy be employed for some of their future

studies.

Future mineral supplementation experiments are being considered. With the type of dairy farms involved phosphorus supplementation trials are very difficult. Although not an experiment in the true sense, observations could be made between years on various farms. The records could be compared between years of with and without mineral supplementation for a particular farm.

A completed experiment at Santa Catalina involved 37 heifers divided into 2 groups receiving 1) pasture + 1/2 kg of molasses + 100 g of minerals and 2) pasture + minerals. The group which also received molasses had a calving percentage of 83.3 versus 42.9 for the minerals alone. In this experiment diammonium phosphate (18-46-0) and super triple phosphate (0-46-0) as the phosphorus source was used. Diammonium phosphate was later substituted for super triple phosphate due to its lower fluorine content. Aluminum sulfate was added to the mineral mixture to counteract a fluorine toxicity.

Some of the work using triple super phosphate at Santa Catalina has indicated that fluorosis would develop but a long time (4 years) was required before clinical signs were in evidence. With this in view, experiments are now being planned to evaluate triple super phosphate as an alternative phosphorus source. Experiments will involve various levels of triple super phosphate and aluminum sulfate. Performance will be evaluated along with bone fluorine concentrations.

El Salvador

The mineral research program in El Salvador was slow in getting started but at this time considerable progress has been made. Dr. Ferdinando Perla, the Ministry of Agriculture (Ganadería), is chairman of the mineral research program. The mineral research is a cooperative endeavor between Ganadería and the University of El Salvador. The Florida-AID program is providing $4,000.00 per year for the purchase of laboratory supplies. Ganadería has the responsibility of collecting the samples from various farms throughout Central America. Analyses are completed by personnel at the University of El Salvador. Some of the more difficult analyses such as cobalt and molybdenum have been completed at Florida. There have been two laboratory technicians who have come to the University of Florida for training in mineral research techniques. In 1977 one technician spent three months at Florida analyzing samples that originated in El Salvador.

For the past year the research organizations of Ganadería and the University of El Salvador have dedicated a considerable portion of their resources to mineral research. As many as 10-12 man years may be put into this program in the calendar years of 1977 and 1978.

During the past year forage, blood and liver samples have been taken from 12 ranches during both the wet and dry seasons. During each of these times 120 liver biopsy samples were collected without any difficulties. The general design of the experiment was to collect samples from 10 farms which had traditional management, where no mineral supplementation existed and 2 ranches which had good management including the use of mineral supplements. Samples were collected both during the wet and dry seasons and from 2 classes of animals. The 2 classes of animals represented young animals aged 1-2 years and cows, 1-5 months in lactation.

In another experiment liver and blood samples were collected from 8 slaughterhouses located throughout the country. These samples were analyzed for the typical minerals and represented different classes of animals.

Some of the research data was written up in an abstract and submitted for presentation at the 1977 ALPA meetings. The translated title of the abstract was "Mineral Status of Cattle from Slaughterhouses Located Throughout El Salvador".

Some of the data was statistically analyzed in El Salvador and the remainder was sent to Florida and is now being statistically evaluated.

After evaluation of the data is completed, additional mineral studies will begin. Some mineral supplementation trials will be carried out in several parts of El Salvador.

Guatemala

The mineral research program in Guatemala started in January, 1975. The organization doing mineral research is INCAP. Their laboratory has a Perkin-Elmer 305 Atomic Absorption Spectrophotomer with a graphite furnace and a fluorometer for conducting selenium analyses. The Florida-AID program is providing $6,000.00 per year for 3 years. Dr. Marco Tulio Cabezas is in charge of the mineral research program and Ing. J. Antonio Flores, an M.S. graduate from INCAP, is working full time on the program. The $6,000.00 is used to pay the salary of Ing. Flores.

The research has involved collecting animal tissues and forage samples from a large ranch in Sonsonate, El Salvador. This particular ranch has some reproductive problems. Both dairy and beef cattle are found on this ranch. To date a large number of samples have been collected. In this experiment blood and forage collections are being made 5 times with the first collection being April, 1976. From the dairy samples that were collected, cows representing three levels of production were evaluated.

The results indicated borderline levels of hemoglobin. The beef cattle had higher hemoglobin levels than dairy animals. The average phosphorus status of the cattle was good averaging about 5.5 mg%. However, some individual animals were very low. At one collection 21% of the animals had levels less than 4.5 mg%. The main incidence of the lower levels was during the dry season. The magnesium and calcium status of all animals was good.

Of the minerals studied copper blood levels seemed to be the most deficient. Younger animals had the lowest levels and this was the most severe during the dry season. This was true for beef and dairy animals. Approximately 65% of the dairy animals had low blood copper during the dry season. The surprising fact was that forage copper levels were quite adequate and molybdenum

levels were low. However, molybdenum levels in soils were quite high (12-13 ppm). It is possible that soil consumption (i.e., molybdenum) could be affecting the copper status.

Zinc forage levels were very low while blood levels were very high. They suspect possible contamination.

Last July (1977) a new experiment was initiated with Ing. Flores working with 3 veterinary students. They are collecting blood, liver and forage samples twice a year in Guatemala as follows:

Location of Farms	No. of Farms
Pacific Coast	3
Highlands (Central Guatemala)	2
Atlantic Coast	3

Indonesia

Contacts were not made until last November, 1977. There are two research groups that have potential to undertake mineral research with grazing ruminants. These would be Gadjah Mada University at Yogyakarta and Bogor Agriculture University located near Jakarta.

Gadjah Mada University

The main contact at Gadjah Mada University is Dr. Soekanto Lebdosoekojo. Dr. Lebdosoekojo recently received his Ph.D. degree from the University of Florida in ruminant nutrition. During the November meeting discussions were held on the need for mineral research.

Mineral nutrition with ruminants has not become a major endeavor in Indonesia. However, there are indications that there are mineral deficiencies in Sulawesi and Sumatera and possibly other places. There are reports of "unthrifty" cattle on a ranch near Palembang on the island of Sumatera. The quality of feed appeared to be sufficient but the animals were in poor condition. Also, there are incidents of broken bones on fattened cattle in the eastern islands, especially in Timor and goiter is an endemic disease among the people of Java. However, cases of iodine deficiency have never been found in animals.

In Sulawesi, both at the Bila River Ranch and at Maiwah, exotic legumes do not grow well unless phosphorus, sulfur and molybdenum are added. They also reported that Pennisetum purpureum at Maiwah failed to grow until the sulfur and molybdenum were added; phosphorus addition alone was not effective. With the addition of all three minerals, the yields of the legumes were increased approximately two and one-half times.

It has been observed that Bali cattle on the Bila River Ranch, which were grazing a native grass, were in very poor condition. The annual calving

percentage was less than 50%. The annual calving percentage for all cattle in Indonesia is suspected to be less than 50%. In this particular instance, it was suspected that phosphorus was the first limiting mineral for these Bali cattle.

The possibilities for a comprehensive mineral research program were discussed with the following conclusions: a) Sulawesi - 1) the Bila River could conduct mineral supplementation trials using cows on pasture. 2) their feedlot could conduct mineral supplementation trials. 3) P. T. United Livestock (BULOG) will build a slaughterhouse in Para-Pare. Bones, tissues and blood samples could be obtained from the control and mineral fed cattle. 4) UNHAS could cooperate by supplying animals. b) Sumatera - There are several universities which could cooperate here. Also the P4 research center and the University in Bogor have an interest. c) Java - the Kampung cattle trail would offer possibilities for collecting samples. Cattle in this area go to slaughterhouses in various cities. Tissue samples could be collected at these sites.

It is fairly certain that the Gadjah Mada University will have a superior laboratory with good equipment by early 1979. This laboratory will contain equipment for making mineral analysis including an atomic absorption spectrophotometer. This is an Australian atomic absorption unit and will arrive in approximately one year. However, at the present time, there are facilities to do phosphorus analysis and several other minerals. Since a large number of mineral analyses could not be accomplished immediately, emphasis will start with supplementation trials. Dr. Soekanto has submitted a program for mineral research. Acceptance of this program will not be known until late March.

Bogor Agriculture University

The main contact here is Dr. Toha. It was suggested that Dr. Toha might work in cooperation with Dr. Soekanto in initiating a comprehensive mineral research program. There appeared to be great interest in the overall mineral research program. The faculty will have a meeting concerning mineral research and will inform Dr. Soekanto and us in relation to a comprehensive mineral research program.

From this region, some of the mineral related problems appeared to be related to the fact that soils were extremely low in calcium, phosphorus and copper. Several minor trials had been done and one of these indicated good response to iodine supplementation for growing bulls and heifers. It was noted that the chief human nutrition problems were deficiencies of vitamin A, protein-calories, iodine and the occurrence of anemia.

Malaysia

The first visit to determine the possibilities of cooperative mineral research was not until December, 1977. There are two research groups that have the potential to undertake mineral research with grazing livestock. These are the University Pertanian Malaysia and the Malaysian Agriculture Research and Development Institute (MARDI) both of which are located at Serdang, Selangor (near Kuala Lumpur). The chief contacts would be Dr. Rudy I. Hutagalung of the University and Dr. C. Devendra and Mr. Thomas Lee Kok Cho of MARDI.

Very little mineral research has been done with the ruminant livestock. In the 1950s some preliminary work showed a phosphorus deficiency based on low serum phosphorus levels. Also, later work has shown low blood copper concentrations. However, these low levels do not correlate with low levels in hepatic tissues. Low molybdenum concentrations are also reported in soils for forages. Some of the best research has shown that there is a cobalt deficiency in one region of Malaysia. This research was carried out by MARDI on its research station near Kluang, Johore. Friesian crossbred and Kedah-Kelantan cattle failed to thrive in this region. The animals were listless, had rough coats and lost weight leading to emaciation, often resulting in death. In the experiment there was a dramatic increase in live weight gain as a result of vitamin B_{12} and cobalt administration. However, there were no effects from copper or terramycin administration.

In evaluating our meetings with both the University and the research experiment station, we concluded that in relation to the University, someone would be coming to the University of Florida for laboratory training. Most likely this individual would bring selected animal and forage tissues for analysis. With the research institution, there is a possibility of a

student coming for an advanced degree. One possibility is for a student to collect forage and animal tissues for ruminant livestock areas of Malaysia and bring these samples to Florida for analysis. Samples from three distinct regions of Malaysia could include the central, western, northeastern and southern regions. Many of the animals in these areas are imported breeds, however, they have been in these areas for more than one year. One suggested possibility was to collect samples from water buffaloes and cattle grazing on the same pastures.

Peru

The mineral research program in Peru did not start until February, 197 However, a Peruvian student, Dr. Ricardo Valdivia, has been working toward his Ph.D. for the last 3 years. Dr. Valdivia's thesis is entitled "Effect of Dietary Aluminum on Phosphorus Utilization by Ruminants". Dr. Valdivia has now returned to Peru.

hree research groups are now investigating the mineral status of ruminants in Peru. The main contacts of these institutions are as follows:

a) Universidad Nacional Mayor de San Marcos (IVITA) - Dr. Oswaldo del Valle and Dr. Ricardo Valdivia.

b) Universidad Nacional Agraria (La Molina) - Dr. Juan Kalinowski.

c) Universidad Nacional Pedro Ruíz Gallo (Lambayeque) - Ing. Hélido Vidal.

Universidad Nacional Mayor de San Marcos Research

This institution has a great interest in mineral research and has had experience with analyses. The atomic absorption equipment is available and technicians are well trained.

A mineral research project has been written up with a translated title of "Mineral Deficiencies - Evaluation of Effects of Mineral Deficiencies on Cattle Production". There would be 3 subprojects under this:

I - Determination of mineral content of soil, forage and animal tissues obtained from the tropical zone at Pucallpa. In this experiment samples will be taken from 5 farms during both the wet and dry seasons. The samples will be collected from animals that are taken to slaughterhouses. A complete history of these animals will be known. The 5 farms will include the IVITA farm at Pucallpa, San Jorge, Tournavista, Bella and Tupac Amaru. Samples will be taken from both growing animals versus those in pregnancy and/or lactation.

II - Evaluation of the Effect of Mineral Supplementation on the Growth of Beef Cattle (Nelore). The duration of this experiment is 15 months and it will commence in August of 1978. In this experiment steers 8 months of age will be given the following treatments: a) control pasture without mineral supplementation, b) pastures with salt only, c) pasture with salt + a calcium phosphorus source and d) pastures + salt + calcium and phosphorus + copper + cobalt + zinc. Approximately 200 animals will be used in this experiment. Samples of blood, liver, forages and soils will be collected every 4 months for analysis

III - The Effect of Mineral Supplementation on Live Weight Gains and Reproduction in Nelore Heifers. The duration of this experiment is 24 months and will be initiated in August of 1978. This experiment is approximatel the same as experiment II except in this case heifers will be used and effect of mineral supplementation on reproduction will be evaluated. The treatments are the same as those of experiment II.

The majority of the mineral analyses for these experiments will be completed in Lima at the San Marcos University. Analysis of cobalt, selenium and molybdenum, however, will be made at the University of Florida. The University of Florida-AID program has assisted the University of San Marcos by providing laboratory consumable supplies and by purchasing some needed parts for their atomic absorption unit.

Much of the mineral research involved with cattle will be carried out at the Pucallpa experiment station. At this experiment station there are 1500 cattle. Soils on this experiment station are very acid and average a pH of 4. The soils are low in organic matter, magnesium, calcium and potassium. They are moderately low in phosphorus and available nitrogen as expected. Since the soils are acid they contain considerable quantities of iron and aluminum. The

research at the experiment station already completed notes that forages are low in phosphorus as well as copper. Cobalt, however, appears to be in adequate concentrations. An interesting observation was made in relation to zinc deficiency lesions. A small percentage of the cattle had these lesions which were cured and prevented by additions of zinc salts.

Universidad Nacional Agraria Research

The National Agrarian University at La Molina has been responsible for a great deal of agriculture research in the past years. Part of this research included some studies with mineral deficiencies.

There is now a sheep experiment underway with 1200 animals in the Central Highlands. The treatments are as follows: 1) salt + iodine + copper + cobalt, 2) salt + iodine + copper + cobalt + zinc, 3) salt + iodine + copper + cobalt + zinc + phosphorus. Another experiment is involved with growing lambs and will last 6 months. The treatments are the same as the first experiment. A third experiment is at Pucallpa on a large ranch. Here Nellore cattle, 6 years of age, are being used. The treatments for this experiment include: 1) sodium + iodine, 2) sodium + iodine + copper + cobalt, 3) sodium + iodine + zinc, 4) sodium + iodine + zinc + copper + cobalt + phosphorus.

In the area of Ju....., neonatal ataxia in sheep has been observed. It was felt that this was not caused by a simple copper deficiency or a molybdenum induced copper deficiency. Some thought is that possibly high zinc levels may cause a copper deficiency. Additional research has noted low cobalt and zinc areas in the Cusco region.

The staff at La Molina would like to be more involved in a mapping type of mineral research using liver, blood and forage samples, and also more mineral supplementation experiments. It is hoped that the staff of La Molina

will cooperate with IVITA in carrying out mineral experiments.

The University of Florida-AID contract has provided cobalt bullets and other consumable supplies to La Molina.

Universidad Nacional Pedro Ruíz Gallo Research

Mineral research is now underway in the Lambayeque region. The German government has recently donated laboratory equipment to the Universidad Nacional Pedro Ruíz Gallo which included an atomic absorption spectrophotometer. The laboratory facilities and equipment are now adequate to undertake mineral research.

Mineral research is being carried out on dairy cattle farms in a cooperative program between the University Nacional Pedro Ruíz Gallo, Centro Regional de Investigaciones Agropecuarias CRIA-II and the Mission from the German government. The first stage of research is to collect liver, blood and forages from 5 to 10 farms where cattle graze and also those on a zero pasture system. The collection system will be employed in both the wet and dry seasons for Chacupe and Sasape regions of the Lambayeque state. The University will be responsible for sample collection and analyses. Personnel of Centro Regional de Investigaciones Agropecuarias CRIA-II will assist in locating farms and taking sample collections while the German mission will provide equipment and some chemical supplies. Florida will assist with coordination when needed and supply expendable supplies, mostly for collecting samples.

The mineral research program to date is going along very well. There were some early problems with equipment but now the analyses are proceeding well. Liver, blood and forage samples have been taken from the regions of Lambayeque, Chiclaye and Ferreñafe. From 142 total samples, blood phosphorus levels were deficient in 18.8, 39.0 and 28.6 (av. 25.4) of the regions, respectively. It is hoped to have some of the trace element analyses soon.

The institution is planning to look into the possibilities of mineral research in the region of the Amazon. It is felt that there is great potential for cattle in this area.

The Philippines

In December, 1977, a visit was made to the Philippines. The organizations responsible for research are the University of the Philippines and the Philippines Council for Agriculture and Resources Research (PCARR), both located at Los Baños. The main contacts from the Department of Animal Science are Dr. Vicente Momoñgon (Head), Dr. Arsenio D. Calub and Dr. Perla L. Lopez. Contacts at PCARR are Dr. Joseph C. Madamba and Dr. Alfonso N. Eusebio.

There has not been a lot of mineral research done in the Philippines. There is currently a three-year trace element research program but this is for soils only and it is supported by the Atomic Energy Commission. There is no atomic absorption unit at the nutrition laboratory. Soils are prepared in the nutrition lab and then sent to the Soils Department. In the future equipment requirements for mineral research should not be a problem since equipment has been ordered under the World Bank loan program which would be available next year.

It was noted that apparently mineral nutrition was important for the local forages. Based on lack of response, apparent sulfur and trace element deficiencies were suspected. Some soil mapping has been done throughout the Philippines but many of the results are inconclusive. It is apparent, however, that phosphorus levels are quite low.

It was noted that in order to carry out mineral research, funds would need to be secured from somewhere for a laboratory technician. Also funds were needed for visiting farms for collection of samples. We were asked if the AID-Florida program could provide $5,000.00 for this undertaking. Upon returning to Florida request was made to AID-Washington and was granted for $5,000.00 to be used in the Philippines program.

There is a possibility that a laboratory technician will be sent to

Florida for training for 3-6 months. There was interest expressed in the liver biopsy technique and, as a result, the cattle here and at three other experiment stations will be used for collecting samples. Over the next six months forage, blood and liver samples will be collected from herds of cattle in three to four regions of the Philippines. After this more definite plans will be made for experiments which might include supplementation trials.

Uruguay

Two short trips have been made to Uruguay after we found they were interested in mineral research. Three working days March 28, 29 and 30, 1977 and four working days November 22-24, 1977 were spent there.

Dr. Ian Newsam who is project manager of the United Nations Special Fund Project with the Rubino Veterinary Research Centre has been very interested and helpful. Personnel changes have prevented their Varian Techtron Model AA-6 from becoming operational. However, Dr. Fernando Riet has blood serum phosphorus levels from several ranches in Uruguay indicating osteomalacia is a serious problem.

Eight forage samples were analyzed at the University of Florida Nutrition Laboratory. All samples were deficient in calcium and phosphorus with the phosphorus values being extremely low. Only two magnesium levels were below the requirements but 5 of 8 sodium values were below the requirement. Four of the 8 zinc levels were low but information on the other trace elements are inconclusive due to possible contamination during grinding.

Supplemental trials are in progress comparing treatments of (1) salt, (2) salt + dicalcium phosphate and (3) salt + mineral-protein block.

The University of Florida is analyzing 40 forage samples and plan to analyze about 250 more forage samples. There is much interest in mineral research and mineral supplemental trials in the cattle and sheep raising areas of the northwest part of the country.

Venezuela

Contacts were first made in December,

mineral research. Three research groups are interested in investigating the mineral status of cattle in Venezuela.

Maracaibo - The Veterinary and Agronomy faculty at the University of Zulia are interested in studying the mineral status of cattle in the Lake Maracaibo region. They plan to collect soil, forage and animal tissue samples from ranches in each of the 4 different regions.

One mineral supplementation program has now been completed. This experiment involved 196 animals (both steers and bulls). These animals were divided into combinations of treatments to include steers vs. bulls, Ral-Grow, selenium-vitamin E, and copper. The results of this experiment have not yet been statistically analyzed. However, apparently there was no effect with the copper supplementation. Administration of selenium-vitamin E did however improve the growth response.

During this mineral supplementation program an interesting development occurred with 6 of the animals. At one time, these animals were down with what appeared to be grass tetany. Magnesium sulfate was administered and 5 of these animals responded quickly with the sixth animal responding more slowly.

Later in 1977 Dr. Capote initiated an experiment south of Maracaibo. This experiment had the same design as the previous one with the exception of cobalt bullets also being administered.

The veterinary section at the University of Zulia has recently received new laboratory facilities and equipment. In 1978 these facilities will be operational and mineral analyses will be undertaken.

The group at Maracaibo is also interested in studying the factors

responsible for the low calving interval in cattle, particularly between the first and second calves. They are considering undertaking studies on this problem.

An additional experiment has been set up to study the effect of additions of 1, 2 and 3% proprionic acid on the mineral status of sheep. The duration of this study will be 56 days with animals in metabolism cages. Feces, blood and urine samples will be collected and analyzed in addition to feed. The mineral analysis will include calcium, phosphorus, potassium, magnesium, copper and manganese.

Maracay - The main contacts in Maracay are Dr. C. J. Perdomo of the Universidad Central de Venezuela and Dr. Claudio Chicco of the Sección de Zootecnia, Centro de Investigaciones Agronómicas. Unfortunately at this time, there appears to be no mineral research taking place in Maracay. It is unfortunate that there have been no follow-up on the mineral research in the Apure state related to "falling disease". There are symptoms of a long-hair syndrome from some cattle in the llanos. A mineral analysis has been done but no differences between normal and abnormal animals could be found. Dr. Perdomo is considering a supplementation trial using copper, selenium-vitamin E and iodine.

The main mineral research which will be coming out of the Maracay region is the thesis results of Ing. David Morillo. While in Maracay David Morillo spent one year collecting samples from distinct areas in the llanos in which efficiency of production is low. One of these ranches has a severe problem of "falling disease".

Ing. Morillo has collected forage, blood, liver, feces and soil samples from 11 farms in the llanos. These collections have been made for 2 classes of animals: pregnant-lactating animals and growing animals, twice a year (wet and dry seasons). Ing. Morillo is now at the University of Florida

taking course work and doing the analysis towards his M. S. degree.

Jusepin - In Jusepin Ing. José Velasquez of the Universidad de Oriente has undertaken a very active mineral research program. Ing. Velasquez received funds from CONICIT to carry out this mineral research program. To date, Ing. Velasquez has taken soil, forage and blood samples from eleven ranches in Monagas state. All of the analyses have been completed for the dry season. In September, 1977, he finished taking all of the samples for the wet season and these are now being analyzed.

From the 11 ranches ten samples of forage were taken per pasture and in some cases there were as high as 100 total samples (10 samples X 10 per pasture). The following is a summary of the results of the pasture analyses:

Potassium - many of the samples were all right in potassium with most samples being in the range of 1-2%. However, some farms had concentrations less than .4%.

Magnesium - these values were quite low, generally ranging from .03-.05%.

Calcium - these samples were also low. Most of the samples were .10% calcium or less. On farms with pangola grass this level was approximately doubled.

Phosphorus - more than 90% of the samples were 0.06% phosphorus or less. Only 24 of 299 total samples had .1% phosphorus or more.

Iron - these concentrations were fairly good with 70% containing 40-60 ppm.

Manganese - manganese was also relatively adequate with the majority being 20-30 ppm or more.

Sodium - 9 farms were adequate in sodium having a range of between .1 and .2%. Two farms, however, were low, containing .03 and .06%.

Zinc - zinc forage levels were very low with many less than 20 ppm.

Copper - copper likewise was very deficient with the majority between 1-4 ppm.

Molybdenum - molybdenum values were highly variable ranging from non-detectable to 30 ppm.

In general, the mineral status based only on the forage analyses would appear to be very poor. It is interesting that one farm which had quite high levels of forage copper apparently was using a herbicide which contained this element.

The following summarizes the information concerning the blood serum levels.

Calcium - for the dry season analyses, the blood calcium was extremely high. Some values were 20-40 mg%. We would expect errors when such high values are recorded.

Potassium - there are some reports that note below 52 mg% as a critical level for this element. The majority of the potassium serum levels were low, avaraging between 35 and 45%.

Magnesium - magnesium status appeared to be adequate with little variation between animals and farms.

Phosphorus - most of the blood phosphorus levels were high, ranging between 9 and 12 mg%.

Sodium - there was little variation in the sodium concentrations with most values approximately .68 mg%.

Copper - most of the farms appeared to be adequate in copper, however, four or five farms were quite low in this element. From these farms, levels of copper ranged from what would be considered to be adequate to severely deficient.

From the soil data it was noted that the soils ranged between 4.5-5.0 in pH. The majority of samples are 4.5 or less. Organic matter in the soils is considered low. Phosphorus levels ranged from 1-7 ppm.

Ing. Velasquez outlined supplementation programs that will be undertaken in two ranches in Monagas state. In one experiment, the effect of calcium, phosphorus and salt on cattle reproduction will be studied. There will be 28 animals for each of the following four treatments: 1) calcium only, 2) phosphorus only, 3) salt only and 4) calcium + phosphorus salt. In a second experiment, the effect of calcium, phosphorus, copper, cobalt and selenium-vitamin E on the growth rate of calves will be studied. Animals will and will not be receiving calcium and phosphorus. In addition, eight subtreatments will be used with injections of selenium-vitamin E, copper and cobalt bullets. The various combinations of these trace minerals will be administered. This experiment will be for one year starting with 6-month-old calves.

The University of Florida-AID program is only providing consumable supplies, mostly used for sample collections and injections of various minerals.

2. Interpretation of Data and Supporting Evidence: Available research data indicates that phosphorus is the most widespread mineral deficiency for grazing livestock. Calcium deficiencies are rare under grazing conditions and this is an important fact because many older textbooks in Latin America emphasize calcium deficiencies rather than phosphorus.

Copper and cobalt deficient regions extend over wide areas of Latin America, but these areas are poorly defined. Inadequacies of magnesium, sodium, iodine, selenium, and zinc and toxicities of molybdenum, selenium and fluorine are encountered in diverse areas of Latin America.

The soil-plant-animal relationship h s to make the interpretation of mineral research data complex. In addition, the many soil types and forage species necessitate an intensive mineral research effort. The mineral research abstracts in the Appendix emphasize some of the data which is available and the need for more specific data.

3. Research Design: Currently we are cooperating with mineral research programs in fourteen countries and each country has a number of different regions. Research people in these countries have certain problems and priorities. We are making a major effort to assist each country in developing and applying acceptable mineral research design and scientifically based research techniques.

Research emphasis is being placed on regions where reported "problem" areas exist which suggest mineral deficiencies or toxicities. This approach is more feasible than attempting to map large areas where deficiencies or toxicities are not apparent. As a result, emphasis has been placed on the following "problem" areas:

a. Bolivia - Beni region low production and phosphorus deficiency.

b. Brazil - Mato Grosso apparent mineral deficiency or toxicity, Ceará cobalt deficiency and Rio Grande do Sul selenium deficiency.

c. Colombia - central selenium toxic, llanos (low production) and in large areas copper deficiency alone or molybdenum induced copper deficiencies.

d. Costa Rica - Guanacaste (low production), San Carlos high forage oxalates and throughout country severe phosphorus deficiencies.

e. Ecuador - highlands, reproductive problems and western, selenium inadequacies or toxicities.

f. Indonesia, Malaysia and the Philippines - Cobalt deficiency in Malaysia and clinical signs resembling mineral deficiencies in each country.

g. Venezuela - Llanos low production and clinical signs resembling copper deficiency.

Sample collection and preservation under field conditions are problems. Separation of the serum or plasma from whole blood rapidly and without hemolysis under field conditions is difficult. Undertaking mineral supplementation studies on private farms are often necessary but can be unproductive. Experiments on private farms in some instances have been initiated and several months later the animals were sold prior to obtaining useful data. Collecting forage samples which represent what the animals consume is nearly impossible. Logistics of carrying on field research at locations distant from research institutions is complicated. However, we were aware of these at the beginning and better methods of improving sample collection, storage, and analysis are constantly being evaluated. Many worthwhile research publications in Latin America such as theses and symposia proceedings are not readily available to libraries

and abstracting journals.

E. Dissemination and Utilization of Research Results

More than 1,000 copies of the manual entitled "Methods of Mineral Analysis for Plant and Animal Tissues" are being distributed in English, Spanish and Portuguese throughout Latin America and other regions of the world.

Nearly 500 copies of the proceedings entitled "Latin American Symposium on Mineral Nutrition Research with Grazing Ruminants" have been distributed in Portuguese throughout Brazil. In April or May, 1978, translations to English and Spanish will be complete. Approximately 2,000 English and 1,500-[illegible],000 Spanish copies will be available for distribution. Other articles that have been presented at symposia and acientific meetings have been widely distributed.

A review article entitled "Trace Mineral Nutrition in Latin America" is being published in the "World Animal Review", which has a large circulation in developing countries. An additional 500 copies have been ordered and will be distributed to interested researchers.

Large quantities of theses and other reports are also sent to collaborators and other interested persons. For example, 200 copies of the thesis entitled "Mineral supplementation of grazing beef cattle in the Eastern Plains of Colombia" were distributed to interested persons. This particular thesis illustrated mineral research procedures very well.

1. This project has stimulated tremendous interest in the mineral problems of grazing ruminants in the Latin American countries in which we have cooperated. Research, extension, producers and commercial personnel have known they had problems; now they see the possibility of finding the correct solution to these problems.

All personnel directly associated with the mineral project are constantly answering questions concerning formulation of mineral mixtures and the correct use of mineral mixtures. During country visits most meetings with researchers are in small groups. However, seminars on mineral research are often requested and given to larger audiences.

It is significant and noteworthy that organizations not directly involved with the AID/Florida contract requested information on methods and procedures for mineral research.

Most of the information which is being distributed has direct application and we see evidence that this information is being applied as we travel within the cooperating countries.

2. A cooperative mineral research symposium attended by 250 people was our most effective way to expand the use of research results. For five days these participants heard and discussed mineral research results and mineral problems. Many people are interested in finding the solution to mineral problems. This project has encouraged them, provided standard techniques and provided some materials for them to get started. We frequently find the following situation: They have the interest and many of the materials for doing mineral research. Governmental personnel recognize that minerals are limiting, but this is not a top priority. Research reviews and sample research designs, often written in Spanish or Portuguese, are provided by the University of Florida. This information along with personal visits is often sufficient to stimulate an in-country mineral research program. By starting with the areas where mineral problems are clearly evident, there is a good possibility that the solution can be found and that it will be applied by the livestock producers in the area.

Mineral research in Latin America is an extremely ambitious program. We are currently working in fourteen countries and some of these programs are just beginning to gather momentum. We would like to expand this program into other countries as time, personnel and funds permit. It requires several years of concentrated effort to identify and correct these mineral problems.

3. All research in progress is in full cooperation with LDC personnel and institutions within the respective countries. During the reconnaissance and recruitment phase of this contract only interested personnel at institutions capable of supporting mineral research were selected. The majority of both human and physical resources for mineral research are provided by the cooperating countries.

a. Planning the project. This mineral research program does not have a standard research plan that can be used in every country. However, we do have models which personnel can modify to best coincide with their specific conditions in their own country.

b. The execution of the field work. Limited human and financial resources are available within the framework of this project. What is available is used primarily to supply technical information and ideas, expendable materials which are difficult to obtain within the cooperating country and in some cases seed money with which to initiate mineral programs.

c. The analysis and reporting of results. Data generated within each country is the property of this country. The University of Florida assists with some of the more difficult analyses, interpretation, and summary of data as requested. Permission must be obtained in writing and credit given as co-author and cooperating agency when

applicable.

4. Recent abstracts related to mineral research can be found in the appendix.

F. Work Plan and Budget Forecast for Coming Year.

1. Each of the fourteen cooperating countries are in a different stage of their mineral research programs. Comparatively speaking the most effort is in Brazil, Costa Rica and Colombia. The greatest effort for a mineral supplementation program is in Bolivia. Mineral research programs are all going well in Ecuador, El Salvador, Guatemala and Venezuela. Cooperating with two countries (Peru and Uruguay) is at a modest beginning, while programs in the Asian countries of Indonesia, Malaysia and the Philippines are still in the discussion phase. Mineral research in the Bahamas is of a very limited nature.

Anticipated accomplishments for the coming year include initiating research programs in other countries (i.e., Kenya and Mali), establishing comprehensive research programs in Indonesia, Malaysia and the Philippines and for all countries assistance with analyzing samples for mineral concentrations, analyzing and interpreting data, and publishing results. Anywhere from 1 to 3 trips are needed for each country annually in order to adequately supervise and encourage the mineral research programs.

2. Procedures to be used and activities to be carried out include following: Finish publishing and then distributing the symposium proceedings "Latin American Symposium on Mineral Nutrition Research with Grazing Ruminants" in English and Spanish.

Continue distribution of the manual "Methods of Mineral Analysis for Plant and Animal Tissues" in Spanish, English and Portuguese to appropriate persons and institutions.

Provide personnel and facilities at the University of Florida to help train 2 to 3 technicians during 3 months or more in analytical procedures for mineral analyses.

Continue to improve analytical methods for analysis of selenium, cobalt, molybdenum and sulfur and update laboratory manual.

Encourage and assist cooperating country personnel to present results at conferences and to publish results and write extension type publications for the producers.

Work with producers and companies in the formulation and feeding of mineral supplements.

Continue to stimulate mineral research through correspondence, publication of popular articles and the attendance at conferences, seminars and workshops.

Make personal visits to cooperating countries from one to three times annually and provide limited financial resources and difficult to obtain expendable materials.

3. Cooperating country personnel and the degree of commitment by their governments are the principle factors which will promote or impede accomplishments. Mineral programs in the cooperating countries will progress in relationship to the number of dedicated scientists working in the mineral program and the support which they obtain from their host governments and industry.

4. Dissemination and utilization of expected research results will continue to be emphasized through publications, field days, conferences, seminars and workshops. Approximately 3,500-4,000 copies of the "Latin American Symposium on Mineral Research with Grazing Ruminants" will be distributed in Spanish and English. The manual "Methods of Mineral

Analysis for Plant and Animal Tissue" will continue to be distributed in Latin America and other parts of the world in English, Spanish and Portuguese.

The majority of the individual country research information will be written in Spanish and Portuguese which will be published locally and regionally. It is anticipated that this information will be presented at meetings of ranchers and producers whenever appropriate.

Producers are seeking economical ways of increasing the level of production and correcting mineral deficiencies has been shown to return at least $2.00 for every dollar invested in many studies.

5. Budget Statement:

BUDGET STATEMENT (Fiscal Report)

Contract No. AID/ta-c-1153
Between the United States of America
and the University of Florida

Category	Funds Available 11/1/74-10/31/79	To Date 12/31/77
Salaries	$247,983.00	$133,473.72
Fringe Benefits	30,899.00	15,302.05
Overhead	125,102.00	66,771.70
Cooperating Country and/ or 3rd Country Nationals	57,250.00	20,079.27
Travel and Transportation	124,106.00	74,344.98
Equipment, Materials and Supplies	133,273.00	107,460.18
Other Direct Costs	30,359.00	17,874.88
Totals	$748,972.00	$442,246.78

Overhead:
On Campus (45% X 13,205.55) = $5,942.50.

G. Appendix

1. Contacts visited in Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Indonesia, Malaysia, Peru the Philippines, Uruguay and Venezuela.

2. Titles and authors of papers presented at the 1976 Latin American Symposium on Mineral Research with Grazing Ruminants, Belo Horizonte, Brazil. Publication of Symposium Proceedings, available in both English and Spanish, will be published and distributed in 1978.

3. Bibliographic list of publications from November 1, 1976 to March 1, 1978.

4. Abstracts (or summaries) of selected papers submitted for publication or published between November 1, 1977 and March 1, 1978.

a) Alonso Guzman, Manrique. 1977. Evaluación del estado mineral del ganado y los pastos en los distritos de La Cruz, Cañas Dulces y Filadelfia de la provincia de Guanacaste durante la época seca. Tesis. Facultad de Agronomía, Universidad de Costa Rica, San José.

b) Döbreiner, Jürgen, Jerônimo Alves Chaves, Ivan Valadão Rosa and Richard H. Houser. 1975. Efeito da transferência de bovinos com "cara inchada" (doença peridentária) para pastos de região indene. Pesq. Agropec. Bras., Sér. Vet., 10: 99-103.

c) Kiatoko, M., L. R. McDowell, K. R. Fick, H. Fonseca, J. Camacho, J. K. Loosli and J. H. Conrad. 1978. Mineral status of cattle in the San Carlos region of Costa Rica. J. Dairy Sci. (accepted for publication).

d) Lebdosoekojo, Soekanto. 1977. Mineral supplementation of grazing beef cattle in the Eastern Plains of Colombia. Ph.D. thesis. Gainesville, Florida.

e) Lebdosoekojo, S., C. Ammerman, N. Raun, J. Gómez and R. Litell. 1977. Suplementación mineral del ganado en pastoreo en los llanos orientales de Colombia. ALPA R-52.

f) McDowell, L. R. 1977. Current mineral research in Latin America. Eleventh Annual Conference on Livestock and Poultry in Latin America. p. B10-25, University of Florida, Gainesville (in English and Spanish).

g) McDowell, Lee R. 1977. Investigaciones minerales en ganado en Latinoamerica. Segundo Curso en Nutrición y Alimentación. p. 1-24, Lima, Perú.

h) McDowell, Lee R. 1978. Geographical distribution of nutritional diseases in animals. Chapter in "CRC 1978 Handbook of Nutrition and Food". 94 pp. CRC Press, Inc. Cleveland, Ohio.

i) McDowell, Lee R. and Joe H. Conrad. 1978. Trace mineral nutrition in Latin America. World Animal Review, No. 24, 24-33.

j) McDowell, Lee R., Joe H. Conrad, Jenny E. Thomas, Lorin E. Harris and Karl R. Fick. 1977. Nutritional composition of Latin American forages. Tropical Animal Production (in press).

k) McDowell, L. R., Carlos E. Lang, J. H. Conrad, Frank S. Martin and Hernán Fonseca. 1977. Mineral status of beef cattle in Guanacaste, Costa Rica. Tropical Agriculture (submitted).

l) Mendes, M. O. 1977. Mineral status of beef cattle in northern part of Mato Grosso, Brazil, as indicated by age, season and sampling technique. Ph.D. dissertation, University of Florida, Gainesville.

m) Murillo Bravo, Olger. 1977. Evaluación del estado de nutrición mineral del ganado bovino en pastoreo en el canton de Cañas, Guanacaste. Tesis, Facultad de Agronomía, Universidad de Costa Rica, San José.

n) Palmer, Francis, Luis Fdo. 1977. Evaluación del estado de nutrición mineral del ganado bovino de la Provincia de Cartago. Tesis, Facultad de Agronomía, Universidad de Costa Rica, San José.

o) Perdomo, J. T., R. L. Shirley and C. F. Chicco. 1977. Availability of nutrient minerals in the form of tropical forages fed freshly chopped to sheep. J. Anim. Sci. 45: 114-119.

p) Perla, Ferdinando, Luis A. Silva, Guillermo Acosta M. and Francisco de Moreno. 1977. Estado de minerales en ganado de abasto de El Salvador. Submitted abstract for 1977 ALPA meetings, Havana, Cuba.

q) Valdivia, Ricardo. 1977. Effect of dietary aluminum on phosphorus utilization by ruminants. Ph.D. Thesis, Gainesville, Florida.

r) Valdivia, R., C. B. Ammerman, J. P. Feaster, P. E. Loggin and P. R. Henry. 1977. Effect of aluminum on phosphorus utilization by lambs. 1977 American Society of Animal Science abstracts p. 265.

5. Annual estimated cost of mineral research in Latin American countries.

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Latin American Symposium on Mineral Research with Grazing Ruminants

Belo Horizonte, Brazil
March 22-26, 1976
(Listed in Order of Presentation)

1. Mineral Problems as Related to Tropical Climates, J. K. Loosli (Florida) and Antonio Carlos Guedes (UF Santa Maria).

2. Classification and Distribution of Tropical Soils, Raimundo Costa de Lemos (OESA and SEEBIA - Rio de Janeiro).

3. Methods of Analyzing Soil Fertility, José Mario Braga (UF Viçosa).

4. Properties of Soil which Affect the Availability of Minerals for Plants and Animals, S. J. Volkweiss (UFRGS - Porto Alegre).

5. Mineral Composition of Tropical Grasses and Forage Legumes, José Alberto Gomide (UF Viçosa).

6. Water as a Source of Minerals, R. L. Shirley (Florida) and Jose Herculano de Carvalho (MA, Teresina, PI).

7. Magnesium in Ruminant Nutrition, J. A. Carneiro Viana, (UF Minas Gerais).

8. Copper and Molybdenum in Ruminant Nutrition, José Fernando Coelho da Silva, (UF Viçosa).

9. Sample Preparation and the Analysis of Animal Tissues, R. M. Silva (UF Minas Gerais).

10. Calcium, Phosphorus, and Fluorine in Ruminant Nutrition, D. J. Thompson (International Minerals and Chemical Corp. Joaquim C. Werner (Nova Odessa, S.P.).

11. Sodium and Chlorine in Ruminant Nutrition, J. K. Loosli (Florida) and José Ribeiro (UFRGS - Porto Alegre).

12. Sample Preparation and Soil Analyses. Victor Goncalves Bahia, (USP - Piracicaba).

13. Potassium and Iodine in Ruminant Nutrition, D. J. Thompson (International Minerals and Chemical Corporation) and João M.S. Andrade (EPAMIG - Belo Horizonte).

14. Sulfur in Ruminant Nutrition, R. L. Shirley (Florida) and Artur Mariante (EMBRAPA-Brasília).

15. Selenium in Ruminant Nutrition, C. B. Ammerman (Florida), S. M. Miller (Florida), L. R. McDowell (Florida) and Edvaldo Correca de Araujo (EMBRAPA-Recibe).

16. Iron, Manganese and Zinc in Ruminant Nutrition, L. R. McDowell (Florida), R. H. Houser (Florida), K. R. Fick (Florida) and Marcelo O. Mendes (EMBRAPA - Rio de Janeiro).

Cobalt in Ruminant Nutrition, R. H. Houser (Florida), K. R. Fick (Florida), L. R. McDowell (Florida) and José Herculano de Carvalho (MA - Teresina - PI).

18. Newer Elements, Essential and Toxic, in Mineral Nutrition, L. R. McDowell, K. R. Fick, C. B. Ammerman, S. M. Miller, R. H. Houser (Florida) and Júlio Cesar de Sousa (EMBRAPA - Sete Lagoos).

19. Biological Availability of Macro Elements, D. J. Thompson (International Minerals and Chemical Corporation) and Marcelo O. Mendes (EMBRAPA - Rio de Janeiro).

20 Biological Availability of Micro Elements - A review, C. B. Ammerman, S. M. Miller (Florida) and José Herculano de Carvalho (MA - Teresina - PI).

21 Soil, Plant, and Animal Tissue as Predictors of the Mineral Status of Ruminants, J. H. Conrad (Florida) and Júlio Cesar de Sousa (EMBRAPA - Sete Lagoos).

22 Evaluation of Mineral Supplements for Ruminants, R. H. Houser (Florida) and Leonidas Valle (EMBRAPA - Brasília).

23 Current Status of Mineral Research in Latin America, K. R. Fick, L. R. McDowell, R. H. Houser (Florida), and Hamilton da Silva (UFMG - Belo Horizonte).

24. Mineral Deficiencies of Cattle under Range Conditions in Brazil, Carlos Hubinger Tokarnia (UFF - Niteroi) and Jürgen Dobereiner (EMBRAPA - Rio de Janeiro).

25. Mineral Research Studies of Ruminants in the Amazon Region, Nelson S. Fernandes and Waldemar V. Camargo (Biological Institute, São Paulo).

26. What Type of Information Do the Mineral Companies Need from the Researchers. João Soares Veiga (TORTUGA - São Paulo).

27. Identification and Supplementation of Limiting Nutrients for Grazing Ruminants B. D. H. Van Niekerk (Voermol Products - South Africa) and E. Adilson S. Serrão (EMBRAPA, Belém).

List of Publications from Nov. 1, 1976 to March 1, 1978
(Not Including Individual Papers in 1978 Brazil Conference
Proceedings, English and Spanish).

Alonso Guzmán, Manrique. 1977. Evaluación del estado mineral del ganado y los pastos en los distritos de La Cruz, Cañas Dulces y Filadelfia de la provincia de Guanacaste durante la época seca. Tesis. Facultad de Agronomía, Universidad de Costa Rica, San Jose.

Ammerman, C. B. and Ricardo Valdivia. 1977. Mineral supplementation for beef cattle in Latin America. Eleventh Annual Conference on Livestock and Poultry in Latin America. p. B1-9, University of Florida, Gainesville (in English and Spanish).

Conrad, Joe H. and Lee R. McDowell. 1977. Research in mineral deficiencies for grazing ruminants. Annual report for AID mineral research project contract number AID/ta-c-1153. Gainesville, Florida.

Conrad, Joe H. and Lee R. McDowell. 1978. Latin [illegible] Symposium on Mineral Research with Grazing Ruminants Proceedings. University of Florida, Gainesville, Florida. (in press).

Döbereiner, Jürgen, Jerônimo Alves Chaves, Ivan Valadão Rosa and Richard H. Houser. 1975. Efeito da transferência de bovinos com "cara inchada" (doença peridentária) para pastos de região indene. Pesq. Agropec. Bras. Sér Vet., 10:99-103.

Gil, Arturo, Lee McDowell and Joseph Tritschler. 1977. Deficiencias y toxicidades de minerales para bovinos y ovinos en la principales áreas ganadera del país. Programa Nacional de Nutrición Animal. Informe Anual de 1976. Bogotá, Colombia.

Kiatoko, M., L. R. McDowell, K. R. Fick, H. Fonseca, J. Camacho, J. K. Loosli and J. H. Conrad. 1978. Mineral status of cattle in the San Carlos region of Costa Rica. J. Dairy Sci. (accepted for publication).

Lebdosoekojo, Soekanto. 1977. Mineral supplementation of grazing beef cattle in the Eastern Plains of Colombia. Ph.D. thesis. Gainesville, Florida.

Lebdosoekojo, S., C. Ammerman, N. Raun, J. Gómez and R. Litell. 1977. Suplementación mineral del ganado en pastoreo en los llanos orientales de Colombia. ALPA R-52.

Loosli, John K. 1977. Utilización de suplementos de nitrogen no protegico para rumiantes. Segundo Curso en Nutrición y Alimentación. p. 1-19, Lima, Perú.

McDowell, L. R. 1977. Current mineral research in Latin America. Eleventh Annual Conference on Livestock and Poultry in Latin America. p. B10-25, University of Florida, Gainesville (in English and Spanish).

McDowell, Lee R. 1977. Investigaciones minerales en ganado en Latinoamerica. Segundo Curso en Nutrición y Alimentación. p. 1-24, Lima, Perú.

McDowell, Lee R. 1978. Geographical distribution of nutritional diseases in animals. Chapter in "CRC 1978 Handbook of Nutrition and Food". 94 pp. CRC Press, Inc., Cleveland, Ohio.

McDowell, Lee R. and Joe H. Conrad. 1978. Simposio Latinoamericano sobre investigaciones en nutrición mineral de los rumiantes en pastoreo, Proceedings. University of Florida, Gainesville, Florida (in press).

McDowell, Lee R. and Joe H. Conrad. 1978. Trace mineral nutrition in Latin America. World Animal Review, No. 24, 24-33.

McDowell, Lee R., Joe H. Conrad, Jenny E. Thomas, Lorin E. Harris and Karl R. Fick. 1977. Nutritional composition of Latin American forages. Tropical Animal Production (in press).

McDowell, L. R., K. R. Fick, R. H. Houser, J. H. Conrad and J. K. Loosli. 1978. Meeting mineral requirements for grazing livestock in the tropics. Symposium on Feed Composition, Animal Nutrient Requirements and Computarization of Diets. Utah State University, Logan (in press).

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Molina, E., Orlando and Vicente León V. 1977. Melaza y minerales en la suplementación alimentacia de vaconas. Boletín Técnico No. 19, Santa Catalina, Ecuador.

Murillo Bravo, Olger. 1977. Evaluación del estado de nutrición mineral del ganado bovino en pastoreo en el canton de Cañas, Guanacaste. Tesis. Facultad de Agronomía, Universidad de Costa Rica, San José.

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Pate, F. M. and J. R. Crockett. 1977. Honduras beef cattle project nutritional evaluation studies summary report-1977, Belle Glade, Florida.

Perdomo, J. T., R. L. Shirley and C. F. Chicco. 1977. Availability of nutrient minerals in the form of tropical forages fed freshly chopped to sheep. J Anim. Sci. 45:1114-1119.

Perla, Ferdinando, Luis A. Silva, Guillermo Acosta M. and Francisco de Moreno. 1977. Estado de minerales en ganado de abasto de El Salvador. Submitted abstract for 1977 ALPA meetings, Havana, Cuba.

Valdivia, Ricardo. 1977. Effect of dietary aluminum on phosphorus utilization by ruminants. Ph.D. Thesis, Gainesville, Florida.

Valdivia, R., C. B. Ammerman, J. P. Feaster, P. E. Loggins and P. R. Henry. 1977. Effect of aluminum on phosphorus utilization by lambs. 1977 American Society of Animal Science abstracts p. 265.

Alonso Guzmán, Manrique. 1977. Evaluación del estado mineral del ganado y los pastos en los distritos de La Cruz, Cañas Dulces y Filadelfia de la Provincia de Guanacaste durante la época seca. Tesis. Universidad de Costa Rica, Facultad de Agronomía, Escuela de Zootecnia, San José, Costa Rica.

Sumario

El presente trabajo de investigación evaluó el estado mineral de los distritos de La Cruz, Cañas Dulces, y Filadelfia de la provincia de Guanacaste.

El material de trabajo de este estudio consistió en muestras de suero sanguíneo, hígado y pasto. Se analizaron en el suero, los minerales calcio, fósforo y magnesio; en el hígado, hierro, cobre, manganeso y zinc; en los pastos, calcio, fósforo, magnesio, potasio, hierro, cobre, manganeso y zinc.

El nivel promedio del calcio en el suero sanguíneo en los animales de la zona estudiada fue de 11.52, no presentándose variación ($P < .05$) entre los diferentes distritos. Tampoco se encontraron variaciones estadísticas en el nivel de fósforo en el suero, cuyo promedio fue de 5.88 mg/100 ml de suero. El nivel de magnesio en el suero fue de 2.92 mg/100 ml de suero.

En relación a los minerales encontrados en el tejido hepático se obtuvo un promedio para el hierro de 313 ppm, para el cobre de 114 ppm, para el manganeso de 6 ppm y para el zinc un promedio de 93 ppm.

En los pastos se obtuvieron promedios de 0.241% para el calcio y de 0.097% para el fósforo, no mostrándose diferencia significativa alguna para los diferentes distritos. El promedio para el magnesio fue de 0.182%, encontrándose diferencias significativas entre las fincas, pero no entre los distritos. Lo mismo se encontró para el potasio con un promedio de 1.89%. El promedio para hierro fue de 194 ppm, para el cobre de 5 ppm, para el manganeso de 39 ppm y para el zinc de 31 ppm. No se obtuvo ninguna variación ($P < .05$) para ninguno de los casos anteriores. El promedio para proteína fue de 3.76%, presentándose diferencias significativas para cantón, distrito, finca, especie y edad de pasto.

Döbereiner, Jürgen, Jerônimo Alves Chaves, Ivan Valadão Rosa and Richard H. Houser. 1975. Efeito da transferência de bovinos com "cara inchada" (doença peridentária) para pastos de região indene. Pesq. Agropec. Bras., Sér Vet., 10:99-103.

Abstract

A group of 34 mostly young cattle, affected by the periodontal disease called "cara inchada" (Swollen face) and in bad condition, was transferred from a region where the disease occurs to a farm situated in a healthy region. Half of the cattle survived in spite of their ill health and the adverse conditions of a prolonged draught. Clinical examinations of the buccal cavity of these animals revealed a regression of the periodontal lesions after only 2 months and, in a certain way, a cure of the lesions after 4 to 6 months. Most of the animals improved their condition considerably and their haircoat became less rough. At the beginning and the end of the experiment, four animals were sacrificed for close macroscopic examination and comparison of the periodontal changes and to collect liver samples for future chemical analyses.

The clinical and anatomo-pathological findings in this experiment strengthen the hypothesis that the etiology of "cara inchada" is related to one or more alimentary factors present in the regions where the disease occurs.

Kiatoko, M., L. R. McDowell, K. R. Fick, H. Fonseca, J. Camacho, J. K. Loosli and J. H. Conrad. 1978. Mineral status of cattle in the San Carlos region of Costa Rica. J. Dairy Sci. (accepted for publication).

Abstract

Two experiments were conducted on 12 beef and 9 dairy cattle farms to determine the mineral status of grazing cattle in the San Carlos region of Costa Rica by evaluating liver, plasma and forage mineral concentrations; bone ash and forage oxalate contents.

In the beef cattle experiment, mean liver copper (< 75 ppm) and cobalt (< 0.07 ppm), and mean plasma phosphorus (< 4.5 mg/100 ml) and magnesium (< 1.8 mg/100 ml) were borderline to deficient on 1, 3, 12 and 5 farms, respectively. Of the total livers analyzed, 23% and 27% were borderline to deficient in copper and cobalt, respectively. Liver iron (< 180 ppm), zinc (< 84 ppm) and manganese (< 6 ppm) were lower than the reported normal levels for 63, 16 and 44% respectively, of the total animals studied.

In the dairy cattle experiment, 10 blood and 1 to 2 forage samples were collected on 5 farms with 4 farms without the forage, Setaria sphacelata. Forage calcium (< 0.43%) and phosphorus (< 0.33%) as well as plasma phosphorus levels were low on all farms. Oxalate levels were higher in Setaria pastures (2.30%) than in non Setaria pastures (1.24%). Low forage calcium and phosphorus and high oxalate levels in Setaria pastures may be responsible for the high incidence of a milk fever-like condition in dairy cattle.

Lebdosoekojo, Soekanto. 1977. Mineral supplementation of grazing beef cattle in the Eastern Plains of Colombia. Ph.D. thesis. Gainesville, Florida

Abstract

Investigations were conducted in the Eastern Plains of Colombia to study the effects of mineral supplementation and pasture type on grazing beef cattle. Eight herds of zebu cows of 30-35 cows per herd were used. Two herds grazing native pasture were supplemented with salt only; two herds grazing native pasture received a complete mineral supplement consisting of salt, dicalcium phosphate and trace minerals (copper, iron, zinc, manganese iodine and cobalt); two herds grazed native pasture during the dry season and molasses grass (Melinis minutiflora) during the rainy season and received complete mineral supplementation; and the two other herds grazed molasses grass the entire year and received complete mineral supplementation. One herd of each treatment group received a urea-molasses-sulfur supplement during the dry season.

Analyses of native and molasses grass hand plucked pasture samples were: in vitro organic matter digestibility, 44.61 and 48.64 percent; nitrogen, 1.42 and 1.41 percent; phosphorus, .12 and .21 percent; calcium, .13 and .21 percent; magnesium, .16 and .18 percent; potassium, .90 and 1.15 percent; sodium, .012 and .008 percent; iron, 566 and 389 ppm; manganese, 186 and 95 ppm; zinc, 13.4 and 18.4 ppm; copper, 1.7 and 2.6 ppm; cobalt, .1 and .08 ppm and molybdenum .55 and .49 ppm, respectively. The values were influenced by season and by burning the native pastures. In the dry season nitrogen and phosphorus increased in native grass but decreased in molasses grass. In both grasses calcium and magnesium decreased while potassium, sodium, and copper increased during the dry season.

Comparisons between cows receiving salt and complete mineral supplementation

while grazing native pasture showed that cows receiving the complete mineral mixture had higher ($P < .01$) liveweight (302 vs 330 kg) and calf weaning weight (132 vs 172 kg) and tended to increase calf weaning percentage (36.5 vs 57.8 percent). The complete mineral supplementation increased serum inorganic phosphorus, but the increase depended on season. In the rainy season, cows receiving salt exhibited low serum inorganic phosphorus levels (less than 4.5 mg per 100 ml) and had lower ($P < .05$) serum copper (82.4 μg per 100 ml) than those receiving the mixture (97.8 μg per 100 ml).

Comparisons between young bulls grazing native pasture and receiving either salt or complete mineral supplementation indicated that in the rainy season the bulls receiving salt had lower ($P < .05$) density of fat-free metacarpal bone (1.49 vs 1.61), metacarpal bone ash (62.23 vs 64.46 percent), phosphorus concentration of metacarpal bone ash (17.06 vs 17.77 percent). The complete mineral supplementation increased ($P < .05$) liver cobalt (.17 vs .34 ppm), but decreased ($P < .05$) liver molybdenum (4.45 vs 3.89 ppm).

Comparisons between cows grazing different pasture types and receiving complete mineral supplementation indicated that cows receiving urea-molasses-sulfur supplement during the dry season had higher ($P < .01$) liveweight (325.6 kg) than unsupplemented cows (305.6 kg). The urea-molasses-sulfur supplementation tended to increase calf weaning percentage (55.7 vs 60.3 percent). Cows grazing molasses grass maintained normal serum inorganic phosphorus levels (5.9 mg per 100 ml) during early rainy season while those grazing native grass had low serum phosphorus levels (4.5 mg per 100 ml). Serum calcium of cows grazing native grass was lower ($P < .05$) than that of cows grazing molasses grass (9.57 vs 9.89 mg per 100 ml).

Lebdosoekojo, S., C. Ammerman, N. Raun, J. Gómez and R. Litell. 1977. Suplementación mineral del ganado en pastoreo en los llanos orientales de Colombia. ALPA R-52.

Sumario

Se llevaron a cabo investigaciones en 1975 y 1976 en los Llanos Orientales de Colombia para determinar el efecto de la suplementación mineral en ganado pastoreando praderas naturales. Se estudiaron cuatro hatos de vacas Cebú con 30-35 vacas en cada hato. Dos hatos fueron suplementados con sal únicamente, y dos hatos con sal, fosfato bicálcico y minerales trazas (cobre, zinc, cobalto, yodo, hierro y manganeso). Un hato de cada grupo recibió una suplementación de urea-melaza-azufre durante la estación seca. La suplementación mineral incrementó ($P < .01$) el peso de las vacas (302 vs 330 kg), el peso al destete (132 vs 172 kg), la natalidad (36.5 vs 57.8%), el fósforo inorgánico en el suero (3.27-5.63 vs 4.44-6.14 mg por 100 ml) con mayor incremento en la estación lluviosa cuando se observaron niveles más bajos en todos los hatos en comparación con la estación seca, incrementó ($P < .05$) el cobre en el suero (82.4 vs 97.8 mg por 100 ml) en la estación lluviosa. En toretes la suplementación mineral incrementó ($P < .05$) el cobalto en el hígado (.17 vs .34 ppm), tendió a incrementar el cobre (231 vs 342 ppm), pero bajó ($P < .05$) el molibdeno en el hígado (4.45 vs 3.89 ppm); incrementó ($P < .05$) la densidad osea libre-de-grasa del metacarpo (1.49 vs 1.61), las cenizas del hueso metacarpal (62.2 vs 64.5%), y la concentración de fósforo en las cenizas del mismo hueso (17.1 vs 17.8%).

McDowell, L. R. 1977. Current mineral research in Latin America. Eleventh Annual Conference on Livestock and Poultry in Latin America. p. B10-25, University of Florida, Gainesville (in English and Spanish).

Abstract

Nutritional disorders including numerous mineral deficiencies, imbalances and toxicities are a major limitation to ruminant livestock production in tropical countries. Often grazing livestock do not receive mineral supplementation and must depend largely upon forages to supply their requirements Only rarely, however, can forages completely satisfy all of the mineral requirements. Borderline or deficient levels of certain elements were noted for many forages in the 1974 Latin American Tables of Feed Composition: Co, 43%; Cu, 47%; Mg, 35%; P, 73%; Na, 60% and Zn, 75%. Calcium deficiency is suspected or confirmed in 11 Latin American countries, Mg in 14, P in 23, Na in 7, Co in 13 and Cu in 13 countries. The most widespread mineral deficiency for livestock is that of phosphorus. Copper and cobalt deficient areas are likely to extend over wide areas of Latin America, but their limits are hard to define at present. The University of Florida, with assistance of a grant from the United States Agency for International Development, is cooperating with Latin American institutions to initiate and establish mineral research. At the present time cooperative research is underway in Bolivia, Brazil, Colombia, Costa Rica, Guatemala, Ecuador, El Salvador, Peru and Venezuela. A systematic mapping technique, based on animal tissues and forage concentrations can be employed to predict where mineral deficiencies or toxicities will occur. Attempts to raise livestock productivity in tropical countries will be unsucessful unless the nutritional environment, including adequate mineral nutrition, is likewise elevated. Mineral supplementation is a least cost input to improvement of livestock production.

McDowell, Lee R. 1977. Investigaciones minerales en ganado en Latinoamérica. Segundo Curso en Nutrición y Alimentación. p. 1-24, Lima, Perú.

Sumario

Disturbios nutricionales incluyendo numerosas deficiencias minerales, inbalances y toxicidades son la mayor limitación para la producción de los rumiantes en los países tropicales. Muchas veces el ganado en pastoreo recibe suplementación mineral y solo depende de forrajes para suplir sus requerimientos. Solo en raras ocasiones, sin embargo, los forrajes reúnen los requerimientos minerales.

Los niveles marginales o deficientes en ciertos elementos fueron notados en muchos forrajes en las Tablas de Composición de Alimentos para América Latina, 1974; así: Co, 43%; Cu, 47%; Mg, 35%; P, 73%; Na, 60% y Zn, 75%. La deficiencia de Ca es sospechada o confirmada en 11 países de América Latina, Mg en 14, P en 23, Na en 7, Co en 13 y Cu en 13. La deficiencia mineral más ampliamente distribuida en el ganado en pastoreo es la del P. Las deficiencias de Ca son muy raras bajo condiciones de pastoreo. Las áreas deficientes en cobre y cobalto son más probables que se extiendan sobre grandes áreas en América Latina, pero sus límites son desconocidos hasta el presente. La Universidad de Florida, con la asistencia de un fondo de la Agencia para el Desarrollo Internacional, está cooperando con instituciones latinoamericanas para iniciar y establecer la investigación de minerales. Hasta ahora, una investigación muy cooperativa está llevándose a cabo en Bolivia, Brazil, Colombia, Costa Rica, Guatemala, Ecuador, El Salvador, Perú y Venezuela. Una técnica sistemática de mapeo, basada en tejido animal y concentraciones de forraje puede ser empleada para predecir donde pueden ocurrir deficiencias o toxicidades minerales. Los esfuerzos por incrementar la producción ganadera en los países tropicales será en vano a menos que el medio ambiente nutricional, incluyendo una nutrición mineral adecuada, sea

igualmente elevada. La suplementación mineral es una inversión a bajo costo para el majoramiento de la producción ganadera.

McDowell, Lee R. 1978. Geographical distribution of nutritional diseases in animals. Chapter in "CRC 1978 Handbook of Nutrition and Food". 94 pp. CRC Press, Inc. Cleveland, Ohio.

Abstract

Numerous nutrient deficiencies, imbalances and toxicities severely inhibit animal production in many countries of the world. Nutrient deficiencies or toxicities can be region specific or can in no way be related to geographical locations. For all nutrients, the determining factor as to the incidence of a deficiency or toxicity is often influenced by management capabilities or cultural and religious practices of a particular region. Profound differences in nutrient requirements exist between species, between breeds or types, within a species and individual animals and thus their adaptability to extreme geographical climatic conditions. In general protein, energy and vitamin deficiencies are less accurately ascribed to geographical locations and can be deficient in all world regions and under all climatic and environmental conditions. Mineral and water deficiencies, unlike other classes of nutrients are often dependent and influenced to a large extent on world geographical locations.

Inadequate supplies of energy and/or protein are usually the major nutritional limitations to livestock production in many countries of the world. Specific soils of the world are deficient or in toxic concentrations for certain minerals. Livestock receiving all of their feed from a small defined area have an increased likelihood of developing mineral deficiencies or toxicities.

Often grazing livestock do not receive mineral supplementation and must depend largely upon forages to supply their requirements. Only rarely, however, can forages completely satisfy all of the mineral requirements. Borderline or deficient levels of certain elements were noted for many forages in the 1974 Latin American Tables of Feed Composition: cobalt, 43%; copper,

47%; magnesium, 35%; phosphorus, 73%; sodium, 60% and zinc, 75%. Calcium deficiency has been reported in 15 developing tropical countries, magnesium in 16, phosphorus in 38, sodium in 14, cobalt in 21 and copper in 20 countries. A systematic mapping technique, based on animal tissues and forage concentrations can be employed to predict where mineral deficiencies or toxicities will occur. Attempts to raise livestock productivity in the diverse geographical locations of the world will be unseccessful unless the nutritional environment is likewise elevated.

McDowell, Lee R. and Joe H. Conrad. 1978. Trace mineral nutrition in Latin America. World Animal Review, No. 24, 24-33.

Abstract

Inadequate trace mineral nutrition is limiting livestock production in Latin America. The incidence, significance, detection techniques and preventive methods for livestock trace mineral deficiencies and toxicities in Latin America is described briefly. Provision of mineral supplements to grazing ruminants is more complicated than for monogastric livestock. Mineral supplementation represents low input/high output nutrients for greatly increasing livestock production.

McDowell, Lee R., Joe H. Conrad, Jenny E. Thomas, Lorin E. Harris and Karl R. Fick. 1977. Nutritional composition of Latin American forages. Tropical Animal Production (in press).

Abstract

The Latin American Tables of Feed Composition published in 1974 contained data on 3,390 feeds. Of this total, 85% were different from those of the U. S. and Canada. Approximately 77% (2615) of the entries were forages. Of the forage entries, 74% included values for the complete proximate analysis and approximately 43% included both calcium and phosphorus values. Data on only a small percentage of the forage entries included mineral concentrations and forage evaluation methods. Approximately 25% of both the Latin American and U.S.-Canadian forages contained 7% crude protein or less. Latin American forages tended to have higher ash and crude fiber but lower nitrogen-free extract than U. S.-Canadian forages. Of the forages, almost 75% of the phosphorus and 31% of the calcium entries were 0.3% or less, which may be borderline to deficient in these elements. Borderline or deficient levels of certain elements were reported for many entries: Co, 43%; Cu, 47%; Mg, 35%; Na, 60% and Zn, 75%. Widescale deficiencies of iron, manganese, and potassium or toxicities of molybdenum are not to be expected.

McDowell, L. R., Carlos E. Lang, J. H. Conrad, Frank S. Martin and Hernán Fonseca. 1977. Mineral status of beef cattle in Guanacaste, Costa Rica. Tropical Agriculture (submitted).

Abstract

An experiment was conducted to obtain information on the mineral status of grazing cattle in the Guanacaste region of Costa Rica. Liver and blood samples of 3- to 4-year-old steers were obtained from 15 farms located in five counties.

Of the total cattle livers analyzed, approximately 36.0, 30.7, 37.3, 33.3 and 34.7 percent were borderline to deficient in copper, iron, manganese, selenium and zinc, respectively. Forty-nine percent of the total samples were considered borderline to deficient in phosphorus. There was no significant difference ($P > .05$) in tissue mineral concentration due to county location, with the exception of selenium. Differences ($P < .01$) in tissue concentrations among farms were found for all six tissue minerals. In general, tissue minerals could be directly related to use or absence of mineral supplements.

Abstract of Dissertation Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

MINERAL STATUS OF BEEF CATTLE IN THE NORTHERN PART
OF MATO GROSSO, BRAZIL, AS INDICATED BY AGE,
SEASON, AND SAMPLING TECHNIQUE

By

Marcelo de Oliveira Mendes

December 1977

Chairman: Dr. J.H. Conrad
Major Department: Animal Science

Two experiments were conducted in the northern part of Mato Grosso, Brazil, to investigate the mineral status of cattle, to determine the classes of cattle which are most susceptible to specific mineral deficiencies or toxicities, as reflected by low tissue mineral concentrations, to study the effect of season of the year on mineral deficiencies in cattle as evidenced by low tissue mineral concentrations, and to evaluate the suitability of the liver biopsy technique to investigate the status of selected minerals in cattle.

In Experiment I, liver samples were obtained by biopsy from 420 cattle on six ranches during two seasons, grouped in five classes, according to age and physiological state, with seven animals per class.

Blood samples were collected from 5 animals in each of the five classes in two seasons.

In Experiment II, blood samples and liver biopsy were collected from 72 animals from the above six ranches in two seasons. A second liver sample and rib bone sample [illegible] the same animals.

Liver samples were analyzed for iron, copper, zinc, manganese, cobalt, and molybdenum, while phosphorus, calcium, and magnesium were determined in blood serum and bone. Bone ash percentage was also determined. Mineral mixtures being used at the six ranches were analyzed for the appropriate minerals.

The levels of all minerals in the liver were lower ($P < .01$) in the rainy reason than in the dry season, while those in blood serum were lower ($P < .01$) in the dry season.

Differences ($P < .01$) in liver and blood serum mineral levels among ranches were detected. Except for liver copper ($P < .02$) and cobalt ($P < .08$), the differences among ranches due to season of the year for all liver and blood serum mineral concentrations were significant at t .% level.

In both seasons the average levels of iron (> 180 ppm), copper (> 50 ppm), cobalt (> .08 ppm), calcium (> 9 mg %), and magnesium (> 2 mg %) in the six ranches were satisfactory. Zinc levels in the rainy season were borderline for ranch 3 and deficient (< 84 ppm) for the other ranches. Manganese values in the rainy season were deficient (< 8 ppm) for all ranches, and in the dry season were deficient for ranches 2, 3, and 4. Molybdenum levels were low (< 2 ppm) only for ranch 5 in both seasons. Phosphorus adequacy in the six ranches was based on the levels found in bone ash from slaughtered animals in Experiment II. Although phosphor appeared to be borderline for the non-productive slaughter animals, growing animals and lactating cows were borderline or deficient because their requirements are higher especially during the rainy season.

Mineral mixtures in the six ranches supplied the most critical minerals at much lower levels than the animals' requirement, except cobalt, which was supplied at 100 to 740% of the requirement.

The effect of cattle class on liver mineral concentration was most notable in classes 1 (growing animals) and 3 (lactating cows), which tended to have a lower copper, zinc, manganese, cobalt, and molybdenum level during the rainy season. It was concluded that for the determination of mineral status of a specific mineral in a cattle herd, liver samples should be obtained from the above classes toward the end of the rainy season.

Correlations were found among liver and serum minerals.

In the rainy season, the values were lower for bone ash ($P < .06$) phosphorus, and magnesium ($P < .02$) than in the dry season. No difference ($P > .06$) was detected in bone ash calcium levels between seasons.

The effect of liver sampling techniques and seasons was detected only on concentration of iron in the dry season ($P < .02$), zinc ($P < .01$) in both seasons, manganese ($P < .01$), and cobalt ($P < .02$) in the rainy season. It was concluded that the mineral status of specific minerals in cattle can be determined satisfactorily in the liver samples obtained either by biopsy or by slaughter, in late rainy season, since this is the time of the year in which the animals are most productive and their requirements are highest.

Murillo Bravo, Olger. 1977. Evaluación del estado de nutrición mineral del ganado bovino en pastoreo en el cantón de Cañas, Guanacaste. Tesis. Universidad de Costa Rica, Facultad de Agronomía. Escuela de Zootecnia. San José, Costa Rica.

Sumario

La presente investigación se realizó en el Cantón de Cañas, Provincia de Guanacaste, para llevar a cabo una evaluación del estado de nutrición mineral de bovinos en pastoreo en dicha zona; se incluyeron 19 fincas con diferentes tipos de manejo, distribuidas en el cantón, a las cuales se les tomaron muestras de sangre, forrajes e hígado entre los meses de diciembre de 1976 a marzo de 1977. En la sangre se analizaron los elementos calcio, fósforo y magnesio, en forrajes calcio, fósforo, magnesio, potasio, hierro, cobre, manganeso y zinc; también se analizó la proteína cruda. Por último en el hígado se hicieron análisis para el hierro, cobre, manganeso y zinc.

Los datos obtenidos se analizaron estadísticamente mediante Andeva, Stepwise, $MAXR^2$, así como correlaciones entre los elementos estudiados.

Se encontraron concentraciones promedios en la sangre de bovinos de 10.84, 4.27 y 2.67 mg/100 ml de suero para los elementos calcio, fósforo y magnesio respectivamente; además se encontró una marcada deficiencia de fósforo en la sangre de bovinos en pastoreo.

En los forrajes estudiados se obtuvieron concentraciones promedios de 3.86, 0.25, 0.09, 0.12 y 1.15 por ciento en base seca para la proteína cruda, calcio, fósforo, magnesio y potasio respectivamente; para los elementos hierro, cobre, manganeso y zinc las concentraciones promedios encontradas fueron de 148, 2.81, 27 y 20.05 ppm en base seca respectivamente. En todas las fincas estudiadas los forrajes no mostraron concentraciones que suplieran los requerimentos mínimos de fósforo para ganado bovino.

Además un alto porcentaje de las muestras de forrajes estudiadas en las fincas no dieron concentraciones satisfactorias para llenar los requerimentos

de cobre, el cual parece ser un grave problema en la zona de estudio. También en algunas fincas estudiadas se encontraron concentraciones inferiores a los requerimentos para el manganeso y zinc.

De las muestras de hígado analizadas, solamente el manganeso mostró concentraciones por debajo de lo normal en el tejido hepático, encontrándose un promedio de 208.5, 157.8, 4.75 y 117 ppm en base seca para los elementos hierro, cobre, manganeso y zinc respectivamente.

En base a los resultados obtenidos se recomienda suplementar en la zona con fuentes altas en fósforo, cobre y posiblemente manganeso y zinc para llenar los requerimentos que no llegan a suplir los forrajes.

Palmer, Francis, Luis Fdo. 1977. Evaluación del estado de nutrición mineral del ganado bovino de la provincia de Cartago. Tesis, Universidad de Costa Rica, Facultad de Agronomía, Escuela de Zootecnia, San José, Costa Rica.

Sumario

El presente estudio se llevó a cabo con el fin de evaluar el estado de nutrición mineral en el ganado bovino de la provincia de Cartago, involucrando 34 fincas de manejo diferente situadas en los cantones Central, Paraíso, Turrialba, Alvarado y Oreamuno.

Se recolectaron muestras de hígado, sangre y forrajes entre los meses de diciembre de 1976 y abril de 1977. Analizándose en sangre calcio, fósforo y magnesio; en hígado, hierro, cobre, manganeso y zinc finalmente en forrajes proteína, calcio, fósforo, magnesio, potasio, hierro, cobre, manganesc y zinc.

Con los resultados obtenidos se hicieron analisis estadísticos de Andeva, Stepwise, MaxR^2 e interrelaciones entre los elementos estudiados. Encontrándose que en la zona de estudio en general se presentan problemas de calcio, fósforo, cobre, además niveles elevados de manganeso en los distritos Orosi de Paraíso, Central y Santa Cruz de Turrialba y San Rafael de Oreomuno.

Los demás elementos en suero sanguíneo y forrajes obtenidos fueron normales según la literatura. Para el hígado de animales se encontró que todos los minerales evaluados mostraron niveles inferiores a lo normal en dicho tejido.

Se recomienda, basado en lo anterior, suplementar con fuentes altas en calcio y fósforo como harina de hueso, fosfato dicálcico, además óxido de cobre, sulfato de cobre o carbonato de cobre para aumentar los bajos niveles de esos minerales encontrados.

Perdomo, J. T., R. L. Shirley and C. F. Chicco. 1977. Availability of nutrient minerals in the form of tropical forages fed freshly chopped to sheep. J. Anim. Sci. 45:1114-1119.

Abstract

Digitaria decumbes Stent (Pangola digitgrass), *Panicum maximum* Jaq. (guineagrass), *Cynodon plectostachyum* Pilger (stargrass), and *Brachiaria decumbens* Staph (Sheepgrass) were harvested at 28, 42 and 56 days of regrowth and fed fresh to wethers. Mineral levels in the fresh forage and digestibilities and retention by wethers were determined. With maturity K, Na, Cu and Zn decreased in concentration. Pangola had notably low K and high Fe and Na content. Digestibility and retention of Ca, P, Na and Cu by sheep tended to decline with maturity while availability of Mg and Fe tended to increase.

Perla, Ferdinando, Luis A. Silva, Guillermo Acosta M. and Francisco de Moreno. 1977. Estado de minerales en ganado de abasto de El Salvador. Submitted abstract for 1977 ALPA meetings, Havana, Cuba

Sumario

A mediados de la época lluviosa, de 70 muestras de sangre e hígado, colectadas de novillos y vacas de varias edades ($\bar{x}$ = 4.9 ± 2.2 años) proveniente de siete mataderos del país, se analizaron por métodos colorimétricos y especto fotometría de absorción atómica. El 18% de las muestras presentaron niveles deficientes de P sanguíneo ($\bar{x}$ = 67.0 ± 23.9 ppm) encontrándose mayores concentraciones de este elemento en novillos ** y entre mataderos *. En Mg sanguíneo ($\bar{x}$ = 20.1 ± 5.1 ppm) se encontró el 51.4% de deficiencia; no hubo diferencias entre novillos y vacas, solo entre mataderos *. La concentración mineral en muestras de hígado, indicó que el 4% fueron deficientes en P ($\bar{x}$ = 122265 ± 2294 ppm); el 51.4% deficientes en Mg ($\bar{x}$ = 594 ± 60 ppm); el 64.3%, deficientes en Ca ($\bar{x}$ = 194 ± 35.2 ppm); el 38.6%, deficientes en Fe ($\bar{x}$ = 217 ± 91 ppm); el 40.0%, deficientes en Cu ($\bar{x}$ = 108.6 ± 71.6 ppm); el 12.8%, deficientes en Zn ($\bar{x}$ = 122.0 ± 53.6 ppm) y el 64.2%, deficientes en Mn ($\bar{x}$ = 8.6 ± 2.4 ppm) en vacas **, los demás elementos no presentaron diferencias por sexo. Solamente Mg, Zn y Mn, presentaron diferencias significativas * entre mataderos. Los resultados obtenidos confirman lo ya observado por otros autores, que animales, en esta época con mayor tasa de crecimiento y producción, sin suplementación mineral presentan deficiencias acentuadas.

Valdivia, Ricardo. 1977. Effect of dietary aluminum on phosphorus utilization by ruminants. Ph.D. thesis, Gainesville, Florida.

Abstract

Experiments were conducted to study the effects of dietary aluminium upon phosphorus utilization by ruminants. In an 84-day feeding trial, 24 steers (226 kg body weight) were allotted to four treatments: basal diet, and basal diet plus 300, 600, and 1,200 ppm added aluminum (aluminum chloride). After the feeding trial, steers were slaughtered and tissues removed for analysis. Feed intake (kg/day) and weight gain (kg/day) were 5.92, 5.81, 5.36, 6.33 and .94, .92, .74, .89, respectively, and were not affected by treatments. Phosphorus, calcium, magnesium, aluminum levels in plasma and hemoglobin and hematocrit values were not affected. Zinc concentrations in liver and kidney ($P < .01$) and copper level in kidney ($P < .05$) increased with dietary aluminum.

Another experiment involving 20 lambs (36.7 kg body weight) was conducted to study the effects of dietary aluminum and phosphorus on animal performance, phosphorus absorption and retention and tissue mineral composition. A 2 x 2 factorial design with two levels of added aluminum to a basal diet (0 and 2,000 ppm) and two levels of phosphorus in the diet (.15 and .29%) was used. For a 56-day feeding trial, feed intake (kg/day) and weight gain (g/day) for treatments (low P/low Al, high P/low Al, low P/high Al, and high P/high Al) were: 1.28, 1.32, .78, 1.08 and 109, 117, -39, 15, respectively. Dietary aluminum and phosphorus affected these responses ($P < .05$). Plasma phosphorus values were 6.90, 7.82, 3.62, and 7.73 mg/100 ml. Dietary aluminum depressed ($P < .05$) and phosphorus increased ($P < .01$) plasma phosphorus. Plasma calcium changed in the opposite direction to phosphorus levels and magnesium was depressed ($P < .01$) by dietary aluminum. Three animals per group were injected intravenously with ^{32}P to measure

metabolic fecal phosphorus excretion. True phosphorus absorption (%) and retention (mg/animal/day) were: 28.7, 32.8, -9.2, 8.5 and -48, -4, -404, -325. Dietary aluminum depressed ($P < .05$) both parameters. Dry matter and organic matter digestibility and apparent magnesium absorption were not affected by treatments. Aluminum in liver increased ($P < .05$) with the high aluminum diet. Iron in liver and kidney and copper in kidney increased ($P < .05$), and magnesium decreased ($P < .01$) with high dietary aluminum. Zinc in kidney ($P < .01$) and manganese in muscle ($P < .05$) decreased with high phosphorus diets.

A phosphorus balance was conducted to study the effects of soils included in the diet of sheep on phosphorus utilization. Eighteen wethers (46.8 kg body weight) were fed a basal diet containing either 10% sand (control), Colombian, or Costa Rican soils. The contents of aluminum, iron, and manganese in the sand, Colombian, and Costa Rican soils were (%): .064, 1.620, traces; 6.150, 3.050, .005 and 14.400, 9.230, .139. Radioactive phosphorus was injected intravenously to determine metabolic fecal phosphorus. No effects on weight gain and organic matter intake were observed. Serum inorganic phosphorus (mg/100 ml) with Colombian soil (9.08) was higher ($P < .05$) than with the Costa Rican soil (7.22) and sand diet (7.33). True phosphorus absorption (71.5%) and phosphorus retention (206 mg/animal/day) were higher ($P < .01$) with Colombian soil, compared to Costa Rican soil (59.8% and -11 mg/day) and sand (54.7% and 75 mg/day). The apparent digestibility of organic matter or absorption of ash, calcium, magnesium, copper, zinc and manganese were not affected by soils or sand in the die Apparent absorption of iron for Costa Rican (23.8%) and Colombian (9.9%) soil was higher ($P < .05$) than that for the sand diet (-18.9%). Depression of phosphorus absorption seemed to be related mostly to the levels of iron and aluminum in the soils.

Valdivia, R., C. B. Ammerman, J. P. Feaster, P. E. Loggins and P. E. Henry. 1977. Effect of aluminum on phosphorus utilization by lambs. 1977 American Society of Animal Science abstracts p. 265

Abstract

Twenty wether lambs (36.7 kg) were randomly assigned to 4 treatment groups in a 2 x 2 factorial arrangement with 2 levels of dietary Al (28 and 2200 ppm) and 2 levels of P (.15 and .29%) for a feeding trial followed by a P-balance study. The basal diet contained 10.4% protein and, expressed in %, corn meal 44.0, cottonseed hulls 26.0, corn starch 20.2, molasses 3.0, soybean meal 2.0, alfalfa meal 2.0, urea 1.5 and 1.3, vitamins and minerals. The Ca:P ratio was between 1.4 to 1.5 for all diets. In treatments designated as low P, low Al; high P, low Al; low P, high Al and high P, high Al; the average daily gains (ADG) were 109, 116, -39 and 15 g; average daily intakes (ADI) were 647, 668, 394 and 545 g; average feed conversions (AFC) were 5.37, 5.39, -- and 18.86. At the end of the feeding trial, serum levels of inorganic P were 6.90, 7.83, 3.62 and 7.73 mg/100 ml, respectively. Differences ($P < .05$) among treatments for ADG, ADI, AFC and serum P were found. In the P balance study, ^{32}P was injected daily for 10 days to measure endogenous fecal P which averaged 77, 131, 41 and 86 mg/kg live weight, respectively. True absorption of P was 28.7, 32.8, -9.2 and 8.5% ($P < .05$). Concentrations of Al in fresh liver were 2.6, 2.9, 6.7 and 6.3 ppm ($P < .01$). Similar values for muscle were 2.3, 2.8, 4.1 and 3.9 ($P > .05$).

Annual Estimated Cost of Mineral Research in Latin American Countries

Country	Country Cost*	Direct Florida-AID Contract Cost**
Brazil	$224,000	-------
Colombia	62,000	$8,000
Costa Rica	68,773	7,000
Ecuador	36,000	-------
El Salvador	57,611	4,000
Guatemala	31,000	6,000
Venezuela	103,500	-------
Total	$582,884	$25,000

*Figures do not include previously purchased equipment or overhead.

**Each country receives in addition $200-900 in consumable supplies.

COSTA RICA

a.	Estimated total cost per year (CONICET)	$ 20,773
b.	Eight equivalent Peace Corps Volunteers (for Costa Rica Agriculturist to carry out these duties, the estimated cost would be at $6,000 each)	48,000
c.	Fulltime M. S. degree staff member	8,000
	Total	$ 76,773

ECUADOR

a.	Two equivalent laboratory and/or field technicians at $6,000	$ 12,000
b.	One equivalent supervisory staff at $15,000	15,000
c.	Chemical analyses	4,000
d.	Logistical support for travel and supervising experiments	3,000
e.	Supplies other than chemicals	2,000
	Total	$ 36,000

EL SALVADOR

a.	Estimated budget for 1 year	$ 17,611
b.	Five equivalent Veterinary, Field and Laboratory technicians at $8,000	40,000
	Total	$ 57,611

GUATEMALA

a.	Estimated budget for 1 year	$ 18,500
b.	Half Laboratory technician at $7,000	3,500
c.	Half Supervisory Staff at $18,000	9,000
		$ 31,000

VENEZUELA

1. Maracaibo

a.	Equivalent of 3/4 full time supervisory staff at $18,000	$ 13,500
b.	One equivalent laboratory technician at $9,000	9,000
c.	Chemical analyses	4,000
d.	Logistical support for travel and supervising experiments	3,000
e.	Supplies other than chemicals	2,000
	Total	1,500

2. Maracay

a. Support of research assistants, M. S. program	$ 10,000
b. One-fourth equivalent supervisory staff at $20,000	4,000
c. One laboratory and/or field technician	8,000
d. Chemicals, supplies, and logistical support	6,000
Total	$ 28,000

3. Jusepin

a. Research support from CONICET	$ 40,000
b. One-fourth equivalent supervisory staff at $16,000	4,000
Total	$ 44,000
Total Venezuela	$103,500