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211(d) ANNUAL REPORT

University of Florida

1 July 1974 to 30 June 1975

A Grant to Strengthen the Capabilities in
Ruminant Livestock Development Programs
for the Tropics: With Emphasis on
Nutrition and Forage Production and Use

Grantee:

Animal Science Department
Agronomy Department
Center for Tropical Agriculture
Institute of Food and Agricultural Sciences
University of Florida, Gainesville, FL 32611

211(d) Annual Report
AID csd 3684
July 1, 1974 to June 30, 1975

Title: "A Grant to Strengthen the Capabilities in Ruminant Livestock Development Programs for the Tropics: With Emphasis on Nutrition and Forage Production and Use."

Grantee: Animal Science Department
Agronomy Department
Center for Tropical Agriculture
Institute of Food and Agricultural Sciences
University of Florida, Gainesville, Florida 32611

Director: H. L. Popenoe, Director, Center for Tropical Agriculture
C. Y. Ward, Chairman, Department of Agronomy
Senior Scientist - Joe H. Conrad, Professor of Animal Nutrition and Coordinator of Tropical Animal Science Programs

Senior Scientist - G. O. Mott, Professor of Tropical Forage Crop Management and Coordinator of Tropical Forage Programs

A. Statistical Summary:

Period of Grant: 1 July 1972 to 30 June 1977
Amount of Grant: $500,000 of which $250,000 is to the Department of Animal Science and $250,000 is to the Department of Agronomy.
Expenditures: For current reporting period of 1974-1975, Animal Science and Agronomy (Pasture and Forage) accumulated expenditures were $145,513.93; those anticipated next year are $120,000.00.

B. Narrative Summary:

The 211d Tropical Livestock Consortium made good progress toward accomplishing its overall objectives during 1974-75. Both Agronomy and Animal Science Department representatives participated fully in the activities of the consortium composed of representatives from the University of Florida, Tuskegee Institute, Texas A and M University, and Purdue University.

During the year, University of Florida personnel met with other consortium members to assist in furthering the development of the "Ruminant Livestock Production Systems Model."

Drs. G. O. Mott, C. B. Ammerman, L. R. McDowell and Mr. Edward Golding met with consortium members at the University of Florida on August 22 and 23, 1974 during an animal nutrition and pasture and forage modeling seminar. This served to determine the type

of nutrition and forage inputs that could be included into the overall ruminant model in Guyana.

Drs. G. O. Mott and J. K. Loosli met with other consortium participants in Atlanta, Georgia on October 24, 1974. At this meeting, the following items were discussed: progress associated with the development of the Guyana model; evaluation of the need for additional information from Guyana; overall plans for the consortium and possible section of a second country for consortium involvement.

Another consortium meeting was held in Atlanta, April 14, 1975 to discuss progress on the Texas herd level model and the Purdue economic consortium model. Discussions also involved scheduling of model workshops in the U.S. and Guyana and possible second country involvement in Kenya.

Drs. G. O. Mott and W. R. Ocumpaugh attended the consortium meeting at Purdue University, June 30 to July 1, 1975. At this meeting, the Purdue model was discussed in detail and suggestions were made for additional inputs to modify and strengthen the overall model. It was decided that more time would be required in Guyana to complete the model before the consortium became involved in a second country.

Two new faculty members joined the University of Florida, one in the area of animal nutrition and another in tropical pastures and forages. Dr. J. K. Loosli joined the Department of Animal Science in September 1974 as Visiting Professor with major responsibilities in Tropical Animal Science Programs. Dr. William R. Ocumpaugh joined the Agronomy Department in May 1975 as an Assistant Research Scientist in the area of tropical forage production research and utilization.

The Carver Foundation of Tuskegee Institute conducted a survey of livestock producers in Guyana. From that survey, it was found that only 5 of 42 cattle producers in the Rupununi area fed salt and only 2 of 42 fed minerals. Only 15 percent of the cattle producers responding indicated they used any kind of feed supplements.

The University of Florida had an AID contract in Guyana from 1967 to 1973. During this time, a major effort was made to help develop the beef cattle and forage program at the Ebini Research Station in the Intermediate savannahs of Guyana. During this time, 51 trips were made to Guyana which involved 472 man days. This research provided excellent information for assessing the potential for beef production in Guyana. These data have been summarized in five Annual Reports, three scientific reports presented at the 4th meeting of the Latin American Association of Animal Production, and a report on "Estimated Resource Requirements, Costs and Returns for Five Beef Production Alternatives" based on experimental data from the trials. In addition, research information from the Ebini Research Station was used in a Master's thesis by Noel Holder, Livestock Officer and Director of the Ebini Research Station.

Research resulting in theses during the past year are listed under objective three, and the abstracts are presented in the Appendix. Some of these titles include response of a complex tropical pasture mixture to different grazing management systems; establishment techniques for perennial peanuts; micro-histological characteristics of three warmseason grasses in relation to forage quality and nutritional evaluation of Pensacola-Bahiagrass pasture by animal and laboratory techniques.

Therefore, the University of Florida has been generating and furnishing to the consortium nutritional, pasture and forage, as well as cattle production information. This information is based on research data which can be applied to developing micromodels suitable for evaluating production systems at the herd level and cattle development systems at the country level using micromodels.

The Departments of Animal Science and Agronomy have strong, tropically oriented teaching programs, in addition to the tropical research orientation. Courses for academic credit during the past year were taught in Animal Production in the Tropics, Tropical Pasture and Forage Science, and Tropical Soils. Moreover, many other courses have a strong tropical bias, such as Animal Nutrition, Forage and Pasture Science, Beef Cattle Science, Reproduction in Farm Animals, Dairy Cattle Nutrtion and Management, Physiology of Reproduction, Genetics of Animal Improvement, and Mineral Nutrition and Metabolism. The fact that the majority of Animal Science and Agronomy faculty have had tropical experience, the semi-tropical conditions of Florida and the large number of students from tropical areas outside the U.S. not only make this tropical bias relevant but also imperative.

Seminars and short courses, as a means of disseminating the latest information in animal science and tropical forages, continue to be among the most effective activities of tropical animal science programs at the University of Florida. The 24th Annual Beef Cattle Short Course held on May 1, 2 and 3, 1975 was attended by over 800 people. There were 40 people from 15 foreign countries and 50 people from 14 states other than Florida. This was followed by the 9th Annual Conference on Livestock and Poultry in Latin America on May 5-9, 1975. This conference was presented in Spanish and 215 attended from 17 foreign countries. Twenty-four University of Florida professors, four scientists from other countries, and twenty-five Spanish speaking students participated in the writing, translation and presentation of the latest information at this conference. Most of the information was concerned with recent developments in beef and dairy cattle production and tropical pastures and forages.

The second Annual Seminar and Laboratory on Meats for Latin America was presented in Spanish at the University of Florida from July 8-19, 1974 to twenty-three participants from seven countries. Seven professors from the University of Florida participated in the preparation and presentation of the material. This intensive course was presented in Spanish with the primary objective of helping Latin America improve its meat quality and sanitation programs.

The Central American Livestock Exposition Committee (EXPICA) requested that the Department of Animal Science at the University of Florida assist them in the organization and presentation of an intensive two-day Beef and Dairy Cattle Short Course. The fourth EXPICA Short Course was held March 10 and 11, 1975 in San Jose, Costa Rica, in which over 300 livestock producers participated. Four professors from the University of Florida presented papers.

The four above mentioned programs are all planned for 1975-76.

During the period of this report, four faculty members affiliated with Animal Science and three faculty members affiliated with pastures and forages spent 59-man months on over seas resident assignments in Brazil and Ecuador.

Partial or total travel expenses were paid from 211d funds to attend conferences and present papers.

Dr. J. H. Conrad represented the University of Florida at the FAO Expert Constultation on Animal Production and Health Research which was held August 12-15, 1974 in Copenhagen, Denmark. He also attended the European Association of Animal Production Meetings at Copenhagen August 18-24, 1974.

Drs. A. C. Warnick and L. R. McDowell presented papers at the Conference on Beef Cattle Production in Developing Countries at the University of Edinburgh which was held from September 1-6, 1974.

Drs. T. J. Cunha, J. K. Loosli, L. R. McDowell and J. H. Conrad attended and presented papers at the International Conference on Nutrition and Economic Development in the Tropics at INCAP, Guatemala City, December 2-7, 1974.

Drs. H. L. Chapman, J. H. Conrad and J. K. Loosli presented papers at the Seminar on Utilization of Local Feed Ingredients for Animal Feeding at Kingston, Jamaica, April 6-17, 1975.

Drs. G. O. Mott and John Brolman participated in the Australian Conference on Tropical Pastures at Townsville, Australia, May 3-19, 1975.

Dr. G. O. Mott presented a paper at the conference on Ecophysiology of Tropical and Sub-tropical crops sponsored by the Brazilian National Research Council at Manaus, Brazil, May 24-28, 1975.

The Department of Animal Science received funding of AID Contract TA-C-1153 for Research on Mineral Deficiencies for Grazing Ruminants in Latin America. The objective of this 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. Three animal science faculty are working full time on this project and five faculty are working part time. Research is in progress in Brazil, Colombia, Costa Rica, Ecuador and Guatemala.

The Agronomy, Microbiology and Soils Departments have an excellent research program in progress to study nitrogen fixation in tropical grasses. This is in cooperation with research scientists in other countries primarily Brazil.

Numerous scientists from Africa, Australia, Central and South America and Southeast Asia visited with the University of Florida faculty at Gainesville during the past year regarding ruminant nutrition and tropical pasture and forage programs. Over 325 visitors in 31 groups visited with faculty about international livestock and forage programs. Many of them also visited one or more of the six research centers in Florida where research programs are in progress with beef production systems and tropical pastures and forages.

C. Detailed Report

I. General Background and Purpose of the Grant

Ruminants include beef cattle, dairy cattle, sheep, goats and many game animals. They have a four compartment stomach and the ability to convert grass, forage, cereal crop residue and fibrous by-products into high quality protein foods for human diets. All of these animals and products are prevalent in the tropics. Most of these products are grown on land areas which are unsuitable for cereal grain production. Consequently, the best use of this land is to produce feed for ruminants. Ruminant livestock is both a source of protein food for the general population and a source of employment for large sub-sectors. In numerous situations, entire societies live directly from livestock.

Livestock plays important roles in economies which range from subsistence to highly developed. As economic development occurs, the demand for livestock products increases, in contrast to the demand for many crops which decrease as consumers can afford better diets. For this reason, in some LDCs, livestock could become a stable earner of foreign exchange.

This grant is one of four for activities which are exploring the livestock industry from a total systems viewpoint on the assumption that piecemeal attacks on a complex problem (nutrition, breeding, disease control or credit) have been inadequate.

Primary objective of this set of grants is to strengthen capabilities of four U.S. universities to identify opportunities for significant livestock development in LDCs, to analyze constraints to and resources for such development, and to design programs to overcome constraints through an integrated, multi-disciplinary team approach.

At the University of Florida, this grant is providing funds for cooperation with other consortium members in determining geographical foci for the problems, in identifying the bottlenecks to livestock development and, particularly, where these fall into the area of animal nutrition, the funds will be used to find ways to overcome these deficiencies. In this way, the University of Florida's competence will be enhanced in working across disciplines and with other universities generally and in working in the area of animal nutrition, with special emphasis on tropical feeds and forages. Current training within the Center for Tropical Agriculture at the University and abroad will be strengthened. An ongoing AID supported program to collect analytical feed and forage data from laboratories in Latin America has been strengthened.

II. Objectives of the Grant

1. Objective Restated

The four universities already have established institutional

commitments to agricultural programs in the developing nations. The universities have agreed that it is to their advantage, as well as to the benefit of the U.S. Foreign Assistance Program, to cooperate in the development of an approach to research and technical assistance focused on ruminant livestock systems for the wet/dry tropics. To achieve this objective within the limitations of available resources, they propose, during the five-year period of the grant, to engage in interdisciplinary and interinstitutional activities such as the following:

a. To develop a staff corps within each university structure which will:

   i) Identify viable projects aimed toward understanding management requirements and systems in tropical animal agriculture;

   ii) Provide for an interchange of staff among the cooperating universities to develop integrated, functional programs applicable to tropical animal agricultural development;

   iii) Utilize the expertise of visiting scientists from other universities for special requirements;

   iv) Develop collaborative workshop activities in specialized disciplines pertinent to tropical animal agricultural development.

b. To provide opportunities for education and training of the manpower required for development of the production potential of animals in wet/dry tropics, including:

   i) Orientation of resident instruction for in-depth training on the characteristics of animal agriculture and forage production in the tropics;

   ii) Establishment of student exchange mechanisms to permit sharing of the strengths of the various institutions and to provide practical experience in the wet/dry tropical environment;

   iii) Development of courses and research in tropical animal agriculture designed to hasten the training and maturity of U.S. and foreign scientists; and

   iv) Development of non-degree short courses and training seminars.

c. To develop and maintain active research on animal agriculture in the wet/dry tropics as a team effort.

   i) Provide staff experience and competence necessary for effective training; and

ii) Provide opportunity for student involvement in research as an essential part of training.

d. To accomodate requests for technical assistance and for consulting services relevant to animal agriculture in the wet/dry tropics:

i) Release of staff for assignments in specialized areas of animal agriculture; and

ii) Assignment of qualified students for activities which would contribute to their training.

e. To make available institutional physical resources, including office space, laboratories, equipment, and land for accomodation of activities of:

i) Resident staff and students;

ii) Exchange staff and students; and

iii) Visiting staff and scientists.

2. Review of Objectives

The objective of this grant approach is to improve the capacity of the University of Florida to assist the Agency for International Development, other developmental agencies and countries in ruminant nutrition and forage production as part of total livestock production and marketing systems. Such capacity will contribute to a systems approach in the design, organization, planning and implementation of research, training and teaching programs. This approach will improve the ability to adapt the system or "package" to tropical environments.

Scope of activities under this grant will include training for regular staff, increase in faculty, experience and research to develop a capability for a systems analysis approach to ruminant livestock development through effective linkages with members of the consortium, LDC institutions and other organizations.

Within this scope of activities, first attention will be given to faculty development, development of work plans with other members (grantees) and defining with more precision areas within the LDCs wherein grant activities will be concentrated.

Contribution of the University of Florida team to the objectives of the 211(d) consortium "Systems Approach to Ruminant Livestock Development."

The University of Florida has the responsibility of providing information in the area of animal nutrition with special emphasis on

tropical feeds and forages which is relevant for the model of ruminant livestock development in the tropics.

The scope of this grant is such that there will not be sufficient funds nor time to generate production parameters through field research. Therefore, results of research which has already been conducted or is being conducted will serve as the primary source of information. Production parameters from a number of published reports will also be generated. This includes, but is not restricted to:

a. Providing information concerning adapted species and varieties of legumes and grasses for various ecological zones of the tropics.

b. Making estimates from research information concerning the nutrient requirements of various feed (including forage) crops and their response to fertilizer nutrient inputs into the system.

c. Making recommendations on appropriate grazing management systems to maintain a balance of legumes and grasses in mixed swards.

d. Providing information on cropping systems (including fertilizer inputs and cultural practices) which will produce economical levels of production with a broad spectrum of potential supplemental feeds--corn, sorghum, soybean, peanuts, cassava, etc.

e. Making estimates of the quality of both native and introduced forages and their potential animal production.

f. Providing information concerning the response to mineral supplementation and to protein-energy feeds as supplements in feeding systems on native range and improved pastures.

g. Nutrients and nutritional level are known to affect fertility, calf survival, rate of gain, age at slaughter and economics of production. Making estimates of the direct effects (of various inputs into the system) upon these production parameters will be a part of the responsbility of the University of Florida team.

III. Accomplishments

Objective 1: "To develop a staff corps within each university structure which will...."

Dr. Joe H. Conrad, Professor of Animal Nutrition, and Dr. G. O. Mott, Professor of Tropical Forage Crop Management, have been designated as the two principal senior scientists at the University of Florida to participate in the activities of the consortium. These two men have participated fully in the activities of the consortium.

These men have assisted the consortium to:

1. Identify viable projects aimed toward understanding management requirements and systems in tropical animal agriculture;

2. Provide for an interchange of staff among the cooperating universities to develop integrated, functional programs applicable to tropical animal agricultural development;

3. Utilize the expertise of visiting scientists from other universities for special requirements;

4. Develop collaborative workshop activities in specialized disciplines pertinent to tropical animal agricultural development.

Dr. J. K. Loosli joined the Department of Animal Science in September, 1974 as Visiting Professor with major responsibilities in Tropical Animal Science Programs. His primary areas of interest are ruminant nutrition and tropical animal production which compliment the subject matter areas of our 211d grant. Dr. Loosli is co-author of the widely used college textbook "Animal Nutrition", has had resident assignments in the Phillipines and the University of Ibadan, Nigeria, was Professor of Animal Nutrition and Chairman of Animal Sciences until his recent retirement from Cornell University.

During his first year at the University of Florida, he gave numerous guest lectures in several courses and participated in many activities concerned with our tropical animal science programs. He gave lectures in AL 656 on Comparative Efficiency of Animals as Converters of Energy and Protein, Comparative Vitamin Requirements of Animals and Outlook for Increased Food Production from Animal Sources in the Tropics. He presented a discussion paper on "Role of Ruminants in Nutrution and Agricultural and Economic Development in the Tropics" at the International Conference on Nutrition and Agricultural Economic Development in the Tropics held at INCAP in Guatemala City, December 2-6, 1974. He also presented a paper on Use of Local Ingredients for Improved Dairy Cattle Nutrition at Kingston, Jamaica, April 14-18, 1975. He made two trips to Central America with Dr. L.R. McDowell to help initiate mineral research in anticipation of our mineral research grant and participated in a study in February, 1975 on "Potential for Development of Dairy Production in the Lower Gulf Coast of Mexico".

Dr. William R. Ocumpaugh joined the Agronomy Department in May 1975 as an Assistant Research Scientist in the area of tropical forage production research and utilization. Previous to this, he received the Doctor of Philosophy Degree from the University of Missouri. His dissertation was entitled "Sod Planted Soybeans for Hay, Grazing, and/or Grain." This research program gave him experience in forage production and forage utilization using ruminant livestock. Through these activities, he became knowledgeable concerning computor modeling and the use of computors. He has been able to make valuable contributions

toward developing forage production and utilization coefficients for the 21ld ruminant livestock consortium.

Mr. Heko Koster, research associate, has been working on mechanisms of regeneration of stoleniferous grasses. This graduate student has been supported for nine months with funds from this grant.

Objective 2: "To provide opportunities for education and training of the manpower required for development of the production potential of animals in wet/dry tropics, including...."

1. Resident instruction for in-depth training on characteristics of animal agriculture and forage production in the tropics. The following courses have direct application and were taught this past year by professors with extensive tropical experience:

Course No.	Name	No. Credits
ADP 322	Principles of Animal Breeding	5
AL 411	Beef Cattle Science	5
AL 527	Animal Nutrition	5
ADP 535	Animal Production in the Tropics	4
ADP 507	Reproduction in Farm Animals	4
AY 536	Tropical Pasture and Forage Science	3
AY 647	Crop Plants in Tropical Environments	12
FRE 411	Management of Farms in Tropical Areas	3
FRE 646	Agriculture's Role in the Growth of Latin American Nations	4
SLS 325	Tropical Soils and Their Environment	3
SLS 525	Tropical Soils	3
VY 663	Parasitic Diseases in the Tropics and Subtropics	5

2. Establishment of student exchange mechanisms. Approximately 35 percent of the graduate students in the Institute of Food and Agricultural Science are from other countries. Twenty-five Spanish speaking students from six different countries translated and presented papers at the 9th Annual Conference on Livestock and Poultry in Latin America May 5-9, 1975. Four scientists working in Latin American countries presented papers at this conference. Dr. Gustavo Cubillos, agrostologist from the Tropical Agricultural Research and Training Center (CATIE) Turrialba, Costa Rica presented a paper on Intensive Pasture Utilization for Milk Production in the Humid Tropics. Dr. Luis E. Tergas, visiting associate professor working with INIAP in Ecuador presented a paper on Factors Affecting Persistence of Legumes in Tropical Legume-Grass Associations. Dr. Ned S. Raun, Director of Animal Sciences at Centro Internationale de Agricultura Tropical (CIAT) Cali, Colombia presented a paper on

Legume and Legume-Grass Association in the American Tropics. Dr. David H. Timm, Instituto de Investigaciones Agronomicas Universidad del Zulia, Maracaibo, Venezuela presented a paper on Use of Nitrogen Fertilizer in Tropical Forage-Livestock Feeding Systems.

3. Development of courses and research in tropical animal agriculture. A Tropical Agriculture Committee, in their report to the Dean of Resident Instruction, suggested that new courses be developed in the following areas:

   a. Forage-Livestock Feeding Systems

   b. Cropping Systems in the Tropics

   c. Agriculture and Rural Development Administration

   In addition to the above suggested courses, it was recommended that "each department review its current course offerings and place more emphasis on application of the information to tropical environments." This committee also studied and suggested improvements in "Tropical Agriculture Specializations" for students to qualify for a "Certificate in Tropical Agriculture" or a "Certificate of Tropical Studies."

4. Development of non-degree short courses and training seminars. The 9th Annual Conference on Livestock and Poultry in Latin America was presented in Spanish at the University of Florida during May 5-9, 1975. Twenty-four University of Florida professors, four scientists from other countries, and twenty-five Spanish speaking students participated in the writing, translation and presentation of the latest information at this conference. This conference was attended by 215 people from 17 foreign countries. A nominal fee of $35 per participant was charged to cover costs of printing the materials and of transportation. A considerable amount of University of Florida IFAS faculty time went into the preparation of the Conference Proceedings and the conduct of the conference. However, no financial assistance was provided from 211(d) or University of Florida funds to participants of this conference.

   The Latin American Conference was preceded by the Beef Cattle Short Course on May 1, 2 and 3, 1975, in which over 800 people participated. Of this total, 40 people attended from 15 foreign countries and 50 people attended from 14 states other than Florida.

   Four years ago, the Central American Livestock Exposition Committee requested that the Department of Animal Science at the University of Florida assist them in the organization and presentation of an intensive two-day EXPICA Beef and Dairy Cattle Short Course. The first one was held in Guatemala City on March 13 and 14, 1972, at which over 500 livestock producers paid $25.00 each to attend. The second EXPICA Short Course was held March 19 and 20, 1973, at David, Panama, with an attendance of about 100. The change of meeting place during the week preceding the Short Course, the United

Nations Security Council meeting in Panama City at the same time, and other organizational factors contributed to the low attendance. However, five University of Florida professors and two members of the Florida Department of Agriculture presented papers and participated in this short course. The fourth EXPICA Beef and Dairy Cattle Short Course was held March 10 and 11, 1975 in San Jose, Costa Rica, in which over 300 livestock producers participated. Four professors from the University of Florida presented papers. All of these talks were reproduced in Spanish and presented to those attending the meetings. The next EXPICA Short Course is scheduled for May 3 and 4, 1976 in San Salvador, El Salvador.

In addition to the three short courses and conferences, another was began in 1973. The First Annual Seminar and Laboratory on Meat Classification, Sanitation, and Zoonosis Control in Latin America was presented in Spanish at the University of Florida from July 8-27, 1973 to thirty-five participants from 10 countries. Over five man months of faculty and graduate student time was required to develop and present this material. The Second Annual Seminar and Laboratory on Meats for Latin America was presented in Spanish at the University of Florida from July 8-19, 1974 to twenty-three participants from seven countries. Seven professors from the University of Florida participated in the preparation and presentation of the material. Planning and execution of the seminar was greatly facilitated by the addition of a Meat Scientist to the Animal Science faculty through 211(d) funding.

The Departments of Agronomy and Statistics sponsored a seminar by Dr. H. L. Lucas, Director of Biostatistics at North Carolina State University on December 16-20, 1974. Dr. Lucas, a leading authority in Biostatistics presented lectures on the following topics:

An overview of forage - livestock feeding systems.
Rational for mathematical models, quantification, theoretical and empirical models.
Chemical composition, digestibility and nutrient metabolism.
Factors associated with forage intake and appropriate models.
Components of grazing management: days rest, days grazing, grazing pressure.
Consultation with faculty of the Department of Statistics.
Designing experiments to study climate - soil - forage systems.
Designing experiments to study plant - animal relationships.
Problems associated with large animal experiments: Large error variances, small numbers, unequal numbers.

These lectures were well attended by faculty and graduate students from the departments of Agronomy, Animal Science, and Statistics. Several foreign visitors also attended.

Dr. W. Ross Cockrill, author of the book on "The Husbandry and Health of the Domestic Buffalo" presented a seminar on water buffalo on June 13, 1975.

Objective 3: "To develop and maintain active research on animal agriculture in the wet/dry tropics as a team effort."

The Departments of Animal Science and Agronomy have had, and currently do have, major research efforts in a number of countries in the areas of tropical livestock and tropical pasture and forage. During the period from July 1, 1974, to June 30, 1975, the contracts were in effect with the man months of scientific input on livestock and pasture and forage programs as follows:

Country	Contract	Funds	Dates	1974-75 Livestock Related in Man Months
Brazil	EMBRAPA Ministry of Agriculture	EMBRAPA Ministry of Agriculture	10/72-06/75	35
Ecuador	INIAP	IDB and GOE	01/71-12/75	24

In the Departments of Animal Science and Agronomy, a large proportion of the faculty have had overseas experience. During the period of this report, four faculty members affiliated with Animal Science and three faculty members affiliated with pastures and forages were on overseas resident assignments. These were as follows:

Brazil Contract: Dr. Don D. Hargrove
Dr. Richard Houser
Dr. A. F. Jilek
Dr. Stanley Schank

Ecuador: Dr. John P. Bishop
Dr. Roland G. Poultney
Dr. Luis Tergas

Six members of the Department of Animal Science at Gainesville were on one or more international short term consulting trips, a majority of which were backstopping activities affiliated with on going contracts. In addition, two of the Animal Science faculty at the Branch Stations were on short term assignments in the tropics. A number of faculty members of the Department of Agronomy made trips concerning tropical pasture forage production and utilization.

Dr. J. H. Conrad represented the University of Florida at the FAO Expert Consultation on Animal Production and Health Research (In Cooperation with the World Association for Animal Production, World Veterinary Association and European Association for Animal Production) which was held August 12-15, 1974 in Copenhagen, Denmark. He also attended the European Association of Animal Production meetings which were at Copenhagen August 18-24, 1974.

Dr. J. H. Conrad and Dr. L. R. McDowell attended the meetings of the American Society of Animal Science at the University of Maryland, July 29-31, 1974. They co-authored a paper on the Latin American Feed Composition Project and Dr. Conrad chaired a session on Beef Cattle Production in the Tropics as a member of the committee on International Animal Agriculture.

A conference on Beef Cattle Production in Developing Countries was held from the first to sixth of September, 1974 at the University of Edinburgh, Scotland. At this meeting, Dr. A. C. Warnick presented a paper on Management Factors Affecting Reproductive Efficiency of Beef Cattle in Developing Countries. Dr. L. R. McDowell, also from the University of Florida, presented a paper on Mineral Deficiencies and Toxicities and Their Effect on Beef Production in Developing Countries.

Dr. G. O. Mott consulted on tropical pasture and forage research with Dr. D. H. Timm at the University of Zulia, Maracaibo, Venezuela; with research workers at INIAP Ecuador and with research workers at CIAT, Cali, Colombia from September 9-20, 1974.

Dr. G. O. Mott consulted on tropical pasture and forage research programs with the staff at CATIE, Turrialba, Costa Rica as a member of the Board of Advisors, October 20-27, 1974.

Drs. T. J. Cunha, J. K. Loosli, L. R. McDowell and J. H. Conrad attended the International Conference on Nutrition and Agricultural Economic Development in the Tropics at INCAP, Guatemala City, December 2-7, 1974. Drs. Cunha and Loosli presented papers on Role of Ruminant Production in Increasing Animal Foods in Latin America. All four were helping to determine the possibilities of cooperative mineral research in Central America.

Drs. J. H. Conrad, B. H. Crawford, T. J. Cunha and Marvin Koger attended the fourth Central American Exposition on Beef and Dairy Cattle at San Jose, Costa Rica, March 10-14, 1975. This event was co-sponsored by the University of Florida and papers were presented on topics of interest to cattle producers in Central America.

A Seminar on Utilization of Local Ingredients in Animal Feeding was held in Kingston, Jamaica, April 6-17, 1975. Drs. J. K. Loosli, H. L. Chapman and J. H. Conrad presented papers on the utilization of tropical by-products for improving beef cattle, dairy cattle and swine production in the tropics. This was attended by livestock representatives from the Caribbean area.

Dr. G. O. Mott and Dr. John Brolmann, forage legume breeder at the University of Florida Agricultural Research Center at Fort Pierce, participated in the Australian Conference on Tropical Pastures at Townsville, Australia between May 3-19, 1975. This provided the opportunity to exchange ideas on tropical grass and legume research techniques and programs.

Between May 24-28, 1975, Dr. G. O. Mott attended a conference on "Ecophysiology of tropical and sub-tropical crops" sponsored by the Brazilian National Research Council at Manaus, Brazil. Drs. G. O. Mott and H. L. Popenoe co-authored a paper on Ecophysiology of Tropical Grasslands.

Dr. A. C. Warnick presented a paper on Livestock Development in Latin America - Present Status and Future needs at the tenth annual Conference of University Directors of International Programs, Cornell University.

Insufficient research on tropical pastures and forages has been conducted to determine the response of a complex pasture to different grazing management systems. A research project was initiated by Dr. G. O. Mott and associates at the Beef Cattle Research Unit in the summer of 1973, with the following objectives:

1. To determine the response of a complex pasture mixture to varying levels of the variables grazing days, resting periods and grazing pressure.

2. To express yields in terms of dry matter production, carrying capacity, as well as determine changes in botanical composition over time as influenced by treatment effects.

3. To estimate liveweight changes in the grazing animals and estimate the TDN consumption from the pasture.

4. To generate coefficients from the response surface design which will be useful in developing forage-livestock feeding systems and provide information for further research.

Details of the results of data collected during the 1974 growing season is presented in a thesis by Gerzy Ernesto Maraschin with the abstract in Appendix F.

A number of theses and publications based on research conducted at the University of Florida have been completed or published during the past year. These are directly applicable to the University of Florida's competence in tropical animal science and tropical pastures and forages. Author, title and major professor are listed below:

Adjei, Martin B. 1975. Establishment Techniques for Perennial Peanuts. M. S. Thesis. Major Professor G. M. Prine.

Brommelsiek, Wayne A. 1974. Effect of Methionine Hydroxy Analog or Choline Chloride on the Metabolizable Energy of Bird-Resistant Sorghum Grain When Fed to Steers. M. S. Thesis. Major Professor R. L. Shirley.

Bustillos, Abelardo C. 1975. Influence of Nitrogen and Energy Supplementation on the Utilization of Low-quality Bermuda and Pangola Hays by Ruminants. M.S. Thesis. Major Professor C. B. Ammerman.

De La Torre, Raul A. 1974. Micro-Histological Characteristics of Three Warm-Season Grasses in Relation to Forage Quality. Ph.D. Thesis. Major Professor J. E. Moore.

Fick, Karl R. 1974. Experimental Lead Toxicity in Sheep and Rats. Ph.D. Thesis. Major Professor C. B. Ammerman.

Maraschin, Gerzy E. 1975. Response of a Complex Tropical Pasture Mixture to Different Grazing Management Systems. Ph.D. Thesis. Major Professor G. O. Mott.

Martinez, Jose R. 1975. Formaldehyde Treated Soybean Meal as a Protein Supplement for Growing Lambs. M.S.A. Thesis. Major Professor C. B. Ammerman.

Neri-Flores, Oscar. 1975. Effect of Pelleting and of Forage Maturity on Quality of Paragrass and St. Augustine Grass. M.S.A. Thesis. Major Professors S. W. Coleman and J. E. Moore.

Prates, Enio Rosa. 1974. Nutritional Evaluation of Pensacola Bahiagrass Pasture by Animal and Laboratory Techniques. Ph.D. Thesis. Major Professor J. E. Moore.

Suber, Robert L. 1975. Blood and Rumen Fluid Profiles in Carbohydrate-Engorged Cattle. M.S.A. Thesis. Major Professor J. F. Hentges.

Abstracts of these theses are presented in Appendix F.

IV. Impact of Grant Supported Activities in Development Institutional Capabilities

The University of Florida had an ongoing program in Ruminant Livestock Development and Tropical Pastures and Forage prior to the awarding of the 211(d) grant to the Departments of Animal Science and Agronomy. Thus, the 211(d) grant has permitted flexibility in furthering the development of these two programs.

The Department of Animal Science has been able to use these funds for developing a stronger and broader Tropical Animal Science Program. It has been able to provide learning and research experiences for both professors and graduate research assistants which were previously not possible. In addition, they have been able to strengthen the meats teaching and research area which is highly essential for a ruminant livestock development program. Furthermore, they have been able to provide the scientific expertise required to contribute to nutritional inputs and parameters

necessary for a multi-disciplinary team approach to ruminant livestock development in wet/dry tropical environments.

The Department of Agronomy has been able to use these funds for the strengthening and expansion of tropical pasture and forage management teaching and research programs. It has been able to provide learning and research experience for both professors and graduate research assistants which were previously not possible. A full time assistant research scientist has been added in the area of tropical pasture and forage management. The awarding of the 211(d) funds has made it possible to backstop the program which was already underway and to expand the tropical pasture and forage program. With these funds, it has been possible to provide the scientific expertise required to contribute pasture and forage inputs and parameters necessary for a multi-disciplinary team approach to ruminant livestock development in wet/dry tropical environments.

V. Utilization of Institutional Resources in Development

Under Section III, Objective 3, two contracts were listed which were in effect during the current reporting period. These livestock development contracts are in Brazil and Ecuador. In addition, a Mineral Research Contract encompassing all of Latin America became effective in November, 1974. During the past year, 70 man months of faculty time have gone into these livestock, pasture and forage programs. In addition, a large number of man-days from the University of Florida faculty have been utilized in short term consulting which was not covered by formal contracts.

In September 1974, thirty-six of a total of seventy-four graduate students in the Department of Animal Science were international students from eighteen different countries. These students were from Australia, Brazil, Cameroon, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, Haiti, Ethiopia, Honduras, Jamaica, Mexico, Indonesia, Peru, Taiwan, Vietnam, Venezuela and Zaire. Twenty of these foreign students were working in the area of animal nutrition.

Foreign visitors and those interested in International Programs who have visited the Department of Animal Science and the Department of Agronomy (Pasture and Forages) between July 1, 1974, and June 30, 1975, were as follows:

Date	Names	Country and Organization	Sponsor
1/08	Mr. Edward J. Stone UNDP	Tanzania	UNDP
2/10-2/12	Dr. Moussa Coulibaly National Livestock Service Bamako, Mali	Mali	AAI State Dept.

Date	Names	Country and Organization	Sponsor
2/21	Sr. Humberto Culotta P. Sr. Fabio D. Salgado D. Sr. Miguel Angel Montoya D. Sr. Carlos Alberto Urrutia R. Instituto Nacional Agrario Tegucigalpa, Honduras	Honduras	State Dept.
2/21	Sr. Edwardo Maitret G., Rancher Ing. Noe Dennis Aragon, Banker Cattle development programs	Mexico	
4/02	Dr. D. A. Little CSIRO, Mineral and protein research	Australia	
4/14	Twenty cattle producers from Argentina	Argentina	Self
4/29	Sr. John Watmough, Director General Sr. Marco Drivio, Technical Director Concentrados Marinos	Peru Lima, Peru	Self
5/01-5/03	Beef Cattle Short Course was attended by 800 people. Fifteen foreign countries were represented by a total of 40 people.		
5/09	The Ninth Annual Conference on Livestock and Poultry in Latin America was attended by 215 people. Seventeen foreign countries were represented by a total of 185 people.		
6/12-6/13	Dr. W. Ross Cockrill Water Buffalo, FAO, Rome	Italy	F.A.O.
6/29-7/02	Dr. J. G. P. Dirven State Agricultural University Wageningen, The Netherlands	Netherlands	Self
7/08-7/19	Second Annual Seminar and Laboratory on Meats in Latin America. This was attended by 23 participants from seven foreign countries.		
7/10	Dr. Edward Carter, Adelaide	Australia	Self
7/11	Dr. Wood, CSIRO	Australia	Self
7/22-7/23	Dr. D. Halliday, Tropical Products Institute	Great Britain	T.P.I.

Date	Names	Country and Organization	Sponsor
7/26	Dr. Leon	Mexico	Self
8/07-8/08	Dr. Torres	Merida, Mexico	Self
8/08	Dr. Emmanuel D. Tebong Dept. of Agriculture	Cameroon	Training Grant
8/26	Dr. Nicolay Todorov Dept. of Animal Nutrition	Sofia, Bulgaria	A.S.A.S.
9/06-9/09	Dr. Martin Playne, C.S.I.R.O. Townsville	Queenland Australia	C.S.I.R.O.
9/11-9/12	Wendell Schronk Daniel Ellison	American Brahman Breeders Assn.	American Brahman Breeders Assn.
9/16	Dr. Slump, Central Institute of Nutrition	Netherlands	
9/25-9/27	Dr. Houndje Michel Director Livestock Services	Cotonou Dahomey	State Department
10/09-10/11	Dr. M. von La Chevallerie Beef Production at Agr. Res. Sta. Potchefstroon	South Africa	F.A.S.
11/11-11/13	Professor J. R. Gill, Head Dept. of Animal Production Welsh Agricultural College	Wales	Churchill Fellowship USDA
11/14-11/15	Dr. Joseph Awad Regional Ministry of Education	Juba, Sudan	AAI
11/27	B. V. Nimbkar, Agronomist	India	AID
12/2-12/3	Mr. Victor Clarke Ministry of Overseas Development	Great Britain	MOD
12/09-12/10	Six Graduate students and two Professors from Buenavista, Salillo, Mexico	Mexico	Self

Date	Names	Country and Organization	Sponsor
12/09-12/10	Dr. A. D. Tillman Rockefeller Foundation	Indonesia	Rockefeller Foundation
12/16-12/20	Dr. H. L. Lucas, Professor of Statistics, North Carolina State University		AID
12/16-12/20	Dr. Karel Vohmout, Tropical Pastures Dr. Manuel E. Ruiz, Ruminant Nutritionist CATIE, Turrialba	Costa Rica	

In summary, over 325 visitors in 31 groups came to the University of Florida to discuss tropical animal science and tropical pasture and forage programs.

VI. Other Resources for Grant-Related Activities

An extensive program in ruminant livestock development with emphasis on animal nutrition and forage production and use has been underway at the University of Florida for many years. Currently, there are eight ruminant nutritionists and four pasture and forage specialists who are devoting at least 20 percent or more of their time in this area. Two professors are devoting approximately full time to this program with only part of the salary being paid from 211(d) funds.

Out of state tuition is currently $1,400 per year. Approximately ten fee waivers between the two departments are used for graduate students whose research is related to the overall objectives of the program.

Only a fraction of the travel expenses are paid from 211(d) funds. None of these funds are used to pay travel to consult on contracts with Brazil and Ecuador or the Latin American Mineral Research Project AID/TA-C-1153.

Equipment, supplies, materials and publication costs are continually being incurred by the animal nutrition laboratory, the forage evaluation laboratory, AID Contract TA-C-1153, the Departments of Animal Science and Agronomy and the Center for Tropical Agriculture.

VII. Next Year's Plan of Work and Anticipated Expenditures

Anticipated expenditures for the fiscal year 1975-76 are listed in Tables 1 and 2.

University of Florida will continue to give full cooperation to the consortium by generating and supplying the necessary information based

on pasture, forage and nutritional research. These parameters will be supplied to Texas A&M University for their herd modeling and to Purdue University for their economic micromodeling. Parameters are being generated to apply to specific environmental and regional ruminant livestock situations, since each country will have substantial regional variation. The consortium will continue to use Guyana as a specific country from which to develop its models.

The consortium will sponsor a seminar workshop which will focus on the current status of its capabilities in designing and executing ruminant livestock development programs in the tropics. One should be held in the U.S. to test the model and then another should be held in Guyana to demonstrate to the Guyanese the applicability of these models to their conditions.

Mineral research will be continued by the Department of Animal Science through an Agency for International Development grant to determine essential mineral supplements for grazing livestock in Latin America. The objective is to increase the efficiency of meat and milk production systems by correcting the mineral deficiencies which exist in pastures and forages. Research will be conducted in cooperation with certain Latin American institutions in Brazil, Colombia, Costa Rica and Guatemala. Other countries will be included as interest, time and funds permit.

Seminar and short course activities are planned as follows:

July 7 to 18, 1975: Third Annual Seminar and Laboratory on Meats Classification, Sanitation and Zoonosis Control in Latin America at the University of Florida.

March 22 to 26, 1975: Latin American Symposium on Mineral Nutrition Research with Grazing Cattle. Belo Horizonte, Brazil co-sponsored by University of Florida.

May 3 to 4, 1976: Fifth Short Course on Beef and Dairy Cattle in Central America and Panama, San Salvador, El Salvador.

May 6 to 8, 1976: Twenty-fifth Annual Beef Cattle Short Course, University of Florida.

May 10 to 14, 1976: Tenth Annual Conference on Livestock and Poultry in Latin America, University of Florida.

In Tropical Pasture and Forages, funds will be used to support partial salary of a professor, full support for an assistant research scientist, a graduate research assistant and clerical support. Funds will also be used to support research activities designed to determine the response of complex pastures to different grazing and management systems.

In Ruminant Nutrition, funds will be used to support partial salaries of two professors, research activities and clerical support for tropical animal science programs. Funds for equipment, supplies and materials will be used to support and expand the ruminant nutrition and tropical pasture and forage programs in line with the consortium objectives to strengthen the capabilities in ruminant livestock development programs for the tropics.

TABLE I

Distribution of 211(d) Grant Funds and Contributions From Other Sources of Funding*

Review Period 1 July 1974 to 30 June 1975

Grant Related Activities	211(d) Expenditures				Non 211(d) Funding Amount
	Period Under Review	Cumulative Total	Projected Next Year	Projected to End of Grant	
Salaries for Research and Teaching	$ 99,537.51	$215,420.82	$ 94,500	$391,000	$ 68,000
Tuition and Fees	-	-	500	1,000	14,000
Travel	11,289.50	24,056.52	10,000	46,000	20,000
Equipment	-	600.00	1,000	3,000	10,000
Supplies and Materials	34,686.92	38,986.69	14,000	59,000	20,000
TOTAL	$145,513.93	$279,064.03	$120,000	$500,000	$132,000

*These figures are our best estimates.

TABLE II

Expenditure Report (Actual & Projected)

Under Institutional Grant #AID/csd-211(d) 3684

Review Period 1 July 1974 to 30 June 1975

Budget Items	Expenditures to Date		Projected Expenditures		Total Budget
	1974-1975 Period Under Review	Cumulative Total 'Same'	1975-1976 4	1976-1977 5	
Salaries	$99,537.51	$215,420.82	$ 94,500.00	$ 81,079.18	$391,000.00
Tuition & Fees	-	-	500.00	500.00	1,000.00
Travel	11,289.50	24,056.52	10,000.00	11,943.48	46,000.00
Equipment	-	600.00	1,000.00	1,400.00	3,000.00
Supplies & Material	34,686.92	38,986.69	14,000.00	6,013.31	59,000.00
TOTAL	$145,513.93	$279,064.03	$120,000.00	$100,935.97	$500,000.00

LIST OF APPENDICES

Appendix A	Specific activities and meetings directly related to the 211d Ruminant Livestock Consortium.
Appendix B	Information on conferences, short courses and seminars.
Appendix C	Conference papers and abstracts of journal articles directly related to pasture and forage production and utilization and animal nutrition.
Appendix D	Abstracts of theses completed during the past year which are directly applicable to the University of Florida's competence in tropical animal science and tropical forages.

APPENDIX A

Specific activities and meetings directly related to the 211d Ruminant Livestock Consortium.

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

GAINESVILLE, FLORIDA 32611

ANIMAL SCIENCE DEPARTMENT
2103 McCARTY HALL
TELEPHONE: 904-392-1911

June 27, 1974

Dr. H. A. Jasiorowski, Director
Animal Production and Health Division
Food and Agriculture Organization
of the United Nations
Via delle Terme di Caracalla
00100--Rome

Dear Dr. Jasiorowski:

This is in reply to your letter of June 18, 1974 concerning the Joint FAO, WAAP, EAAP, World Veterinary Association Seminar on the role of the advanced countries in animal production and health research for the developing countries. At this late date, I find I am not going to be able to attend your meeting on August 12-15, 1974. However, I would like to recommend that you allow Dr. Joe H. Conrad, who is Coordinator of Tropical Animal Science Programs in our department, to officially represent me at the Conference. This Conference is very important from the type of work we are doing here at the University of Florida in helping developing countries. Therefore, I hope you will accept his attending to officially represent me. I know that he can add to the Conference during the discussion periods after the various topics have been given. We have a very sizable program in Tropical Animal Science and in assisting the developing countries. We are especially heavy in our participation with almost all Latin American countries. In some cases, our participation is minor whereas in others it is heavy.

We also have a Latin American Livestock and Poultry Conference each year which is given in spanish and is attended by approximately 250 people from Latin America, each time. We also put on a Beef and Dairy Cattle Short Course in one of the Central American countries each year. Last year there were 500 cattlemen in attendance and it was held in Honduras. Next year it will be held in Costa Rica. We have also recently completed an extensive survey of feed composition data throughout Latin America and the results have been published in English, Spanish and Portuguese. These are just a few highlights of the Tropical Animal Science Program which Dr. Conrad is in charge of. With this background, I am sure he can make a good contribution to your Conference. Moreover, he can obtain information which

will be helpful in our future program.

Please let us know by return Airmail if it is agreeable with you for Dr. Joe Conrad to attend as an official representative in my place. If it is, we will go ahead and plan on his being there.

With best personal regards, I am

Sincerely,

T. J. Cunha, Distinguished
Service Professor & Chairman

TJC:wf
xc: Dr. Joe H. Conrad
Dr. Hugh L. Popenoe

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

COLLEGE OF AGRICULTURE AGRICULTURAL EXPERIMENT STATIONS AGRICULTURAL EXTENSION SERVICE SCHOOL OF FORESTRY

2001 McCARTY HALL
GAINESVILLE, FLORIDA 32611
TELEPHONE: (904) 392-1965
CABLE ADDRESS: CENTROP

INTERNATIONAL PROGRAMS
CENTER FOR TROPICAL AGRICULTURE

May 17, 1974

Miss Virginia C. Perelli
Contracting Officer
Contract Services Division
Office of Procurement
Department of State
Agency for International Development
Washington, D. C. 20523

Dear Miss Perelli:

Subject: Grant No. AID 211/csd 3684

Authority is requested for Dr. A. C. Warnick and Dr. Lee R. McDowell, faculty members of the Department of Animal Science, to use 211d funds for partial airfare, per diem and expenses to travel to Edinburgh, Scotland and present papers at the Conference on Beef Production in Developing Countries between September 2 and 6, 1974.

Dr. Warnick is presenting a paper entitled "Management Factors Affecting Reproductive Efficiency of Beef Cattle in Developing Countries" and Dr. McDowell's paper is "Mineral Deficiencies and Their Effect on Beef Production in Developing Countries". These activities are within the scope of our 211d objectives.

Requested expenses will be less than $400.00 each.

Thank you for your consideration.

Sincerely,

H. L. Popenoe, Director
Center for Tropical Agriculture

Approved by

M. J. Cunha, Distinguished Service Professor
and Chairman, Department of Animal Science

cc: Dr. Carl Sierk
Dr. A. C. Warnick
Dr. Lee R. McDowell
Dr. Joe H. Conrad

mf

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES
GAINESVILLE, FLORIDA 32611

AGRONOMY DEPARTMENT
2183 MCCARTY HALL

August 13, 1974

MEMORANDUM

TO: Dr. H.L. Popenoe
Dr. G. Killinger
Dr. W. Mendenhall III
Dr. R.C. Littell
Dr. M. Koger
Dr. Joe Conrad
Dr. John Moore

FROM: G. O. Mott

SUBJ: Modeling Forage-Livestock Feeding Systems

Dr. H. L. Lucas of the Department of Statistics, Biomathematics program of North Carolina State University has again been invited to the University of Florida for discussions on "Modeling Forage-Livestock Feeding Systems." His last visit occurred during a period when our graduate students were not able to benefit from his visit because of class schedules. Dr. Lucas has agreed to come during the week of December 16, the week after final examinations and before Christmas. If you know of any serious conflicts during this week, please advise.

GOM:amg

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

GAINESVILLE, FLORIDA 32601

ANIMAL SCIENCE DEPARTMENT
2103 McCARTY HALL
TELEPHONE: 904-392-1911

August 15, 1974

M E M O R A N D U M:

TO: Dr. C. B. Ammerman, Florida
Dr. T. C. Cartwright, Texas
Dr. George Cooper, Tuskeege
Mr. A. J. Dye, Texas
Mr. Edward J. Golding, Florida
Dr. Guillermo Joandet, Texas
Dr. Fred Maurer, Texas
Mr. Ralph May, Purdue
Dr. Lee R. McDowell, Florida
Dr. John Moore, Florida
Dr. G. O. Mott
Dr. Lee Schroder, Purdue
Dr. Carl F. Sierk, AID Washington
Dr. Kelly White, Purdue

FROM: Dr. Joe H. Conrad, Florida Joe H Conrad

RE: 211d Pasture and Forage programming and modeling meeting, August 22 and 23 at University of Florida.

Arrangements have been completed to have a 211d meeting at the University of Florida on Thursday and Friday August 22 and 23. The major activity of this meeting will be the programming of the pasture and forage model.

Emphasis will be concerned with the four regions of Guyana. Coefficients need to be generated to answer some of the following questions.

Given a certain type of land what is the quantity and quality of forage that can be produced?

What are the relative forage production patterns that can be expected?

What kind of forage should be produced?

Levels of fertilization and forage production curves.

What level of forage intake can be expected?

What level of animal response can be expected?

Meeting will begin in Room 1031A of McCarty Hall at 8:30 AM, Thursday August 22.

Reservations have been made for Dr. Guillermo Joandet, Mr. A. J. Dye, Dr. Lee Schroder and Mr. Ralph May at the Flagler Inn for arrival at 10:00 PM, August 21.

I received a telephone call from AID Washington that the West African Seminar has been postponed for one year. I have no further details on it at this time.

We look forward to your visit to the University of Florida.

cc: Dr. T. J. Cunha
Dr. H. L. Popenoe

bj

Report to 211(d) Consortium

Expanding Competence in the Design and Execution of Livestock Development Programs in the Tropics Emphasizing Ruminant Livestock Production Systems Through Improved Breeding and Disease Control.

August 26, 1974

The following representatives met in McCarty Hall at the University of Florida, Gainesville, on August 22 and 23:

Dr. G. O. Mott
Department of Agronomy
University of Florida

Dr. C. B. Ammerman
Department of Animal Science
University of Florida

Dr. Lee Schrader
Department of Agricultural Economics
Purdue University

Dr. G. E. Cooper
Department of Agricultural Sciences
Tuskegee Institute

Dr. A. J. Dye
Department of Range Science
Texas A&M University

Dr. L. R. McDowell
Department of Animal Science
University of Florida

Mr. Ed Golding
Department of Animal Science
University of Florida

Mr. Ralph May
Department of Agricultural Economics
Purdue University

Dr. G. E. Joandet
Department of Animal Science
Texas A&M University

Discussions centered around the development of a forage model which will simulate production patterns in Guyana. Details necessary for interfacing with and meeting the requirements for economic analysis were discussed, in addition to some of the parameters utilized in the animal production model constructed by Dr. Joandet.

Basic ideas underlying the forage model were presented and discussed. Dr. Mott presented data from earlier tropical research which will aid in forming a data base, and also provided some climatic and production data from Brazil which will be used in developing the forage model.

Submitted by A. J. Dye and G. E. Joandet

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CENTER FOR TROPICAL AGRICULTURE

2001 McCARTY HALL
GAINESVILLE, FLORIDA 32611
TELEPHONE: (904) 392-1965
CABLE ADDRESS: CENTROP

Miss Virginia C. Perelli
Contracting Officer
Contract Services Division
Office of Procurement
Department of State
Agency for International Development
Washington, D.C. 20523

September 18, 1974

Dear Miss Perelli:

Subject: Grant No. AID 211/csd 3684

Authority is requested for Dr. J.H. Conrad, Dr. T.J. Cunha, Dr. J.K. Loosli, and Dr. L.R. McDowell to attend the International Conference on Nutrition and Agricultural Economic Development in the Tropics to be held at INCAP in Guatemala from December 2-6, 1974. We are requesting authority to use 211d funds for airfare, per diem, and expenses to travel to and attend this conference. Since our grant in Animal Science is to strengthen the capabilities in ruminant livestock development programs for the tropics with emphasis on nutrition, we feel that this program would be of great importance to our group.

Dr. Cunha, who is Chairman of the Department of Animal Science, has been asked to present a paper on "The Role of Ruminant Production in Increasing Animal Food in Latin America." Dr. J.K. Loosli is a visiting professor here at the University of Florida, and all four of the men listed are actively engaged in tropical animal science programs. Therefore, we believe these activities are within the scope of our 211d objectives.

The requested expenses will be approximately $500 per participant. Thank you for your consideration.

Sincerely,

Hugh Popenoe

H.L. Popenoe, Director
Center for Tropical Agriculture

Approved by

T.J. Cunha, Distinguished Service Professor
and Chairman, Department of Animal Science

cc: Dr. Carl Sierk
Dr. J.H. Conrad
Dr. J.K. Loosli
Dr. L.R. McDowell

cms.

MEMORANDUM

TO: T. C. Cartwright
F. D. Maurer
G. E. Cooper
T. K. White
G. O. Mott

FROM: J. H. Conrad

DATE: November 6, 1974

RE: 211d Livestock Consortium Meeting and Progress Reports

This is to reconfirm our meeting at the Air Host Inn on Monday, November 18, 1974. I would like to start the meeting as soon after 9:00 AM as possible and finish by 3:00 PM so the Texas group can catch a plane shortly after 4:00 PM. Yesterday, I received a letter from Dr. Peter Fernandes, a copy of which is enclosed. In this letter, he reminds us that, in the minutes to which we agreed, there is a provision for supplying a 6-month progress report and, also, an annual report. I would like to request that each member of the Consortium send Dr. Fernandes two (2) copies of his annual report which was submitted to AID in Washington. In addition, I would like to request that one (1) copy each of these reports be sent to Dr. George Eason, the Food and Livestock Officer in Guyana. I hope this will be satisfactory with the committee, and we can discuss the matter further at our meeting.

JHC/cms.
cc: Dr. Carl Sierk
Encl.

February 12, 1975

Dr. Peter Fernandez
Chief Veterinary Officer
Ministry of Agriculture and Natural Resources
Georgetown, Guyana
SOUTHAMERICA

Dear Peter:

Last week we were priviledged to have a visitor from Guyana, via Tuskeegee Institute by the name of James Smith. I just wanted you to know how much we enjoyed his visit here at the University of Florida where he spent most of his time studying laboratory techniques, including three half days in our in vitro laboratory. James made a hit with everyone with whom he visited, and he seems to be motivated to continue his academic training as rapidly as possible. If he completes the bachelors degree at Tuskegee Institute, I am sure that we would try and find a place for him in our graduate program at the University of Florida.

He indicated that he thought he would be going to the Ebini Research Station as soon as he returns to Guyana. If this is where the ministry decides to send him, I am sure that he will be a tremendous asset to Noel Holder as a laboratory technician which will support the research program.

I just wanted you to know how much we appreciated his visit. With best personal regards; I am

Sincerely, yours,

G. O. Mott
Professor of Agronomy

GOM/vv

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

COLLEGE OF AGRICULTURE AGRICULTURAL EXPERIMENT STATIONS AGRICULTURAL EXTENSION SERVICE SCHOOL OF FORESTRY

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2001 McCARTY HALL
GAINESVILLE, FLORIDA 32611
TELEPHONE: (904) 392-1965
CABLE ADDRESS: CENTROP

March 4, 1975

Mr. Michael Galli, Acting Director
Technical Assistance Bureau/AGR
Room 2244
Department of State/AID
Washington, D.C. 20523

Subject: Grant No. AID 211/csd 3684

Dear Mr. Galli:

Authority is requested for Dr. J.K. Loosli, Dr. H.L. Chapman, and Dr. J.H. Conrad to present papers at the "Seminar on the Utilization of Local Ingredients in Animal Feedingstuffs" to be held in Jamaica April 6-18, 1975.

Mr. J.A. Richards, Director of Livestock Research, Ministry of Agriculture, Bodles, Old Harbour, Jamaica, requested assistance from the Animal Science Department to give plenary papers at this conference. He is expecting wide participation from the Caribbean area. Dr. Loosli is presenting a paper on the use of by-product feedstuffs for dairy cattle, Dr. Chapman on beef cattle, and Dr. Conrad on swine.

We are requesting authority to use 211d funds for airfare, per diem, and expenses to present papers at this conference. The Jamaican Ministry of Agriculture will defray some of the local hotel costs, but the exact amount is not known.

We believe this activity is within the scope of our 211d objectives with emphasis on animal nutrition.

The requested expenses will be approximately $400 per participant.

Thank you for your consideration.

Sincerely,

Hugh L. Popenoe

H.L. Popenoe, Director
Center for Tropical Agriculture

Approved by: _____
T.J. Cunha, Distinguished Service Professor
and Chairman, Department of Animal Science

HLP/cms.
cc: Dr. H.L. Chapman Dr. Nels Konnerup
Dr. J.H. Conrad Dr. J.K. Loosli

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

Call Leonard
904-392-1911

COLLEGE OF AGRICULTURE AGRICULTURAL EXPERIMENT STATIONS AGRICULTURAL EXTENSION SERVICE SCHOOL OF FORESTRY

NTERNATIONAL PROGRAMS
:ENTER FOR TROPICAL AGRICULTURE

2001 McCARTY HALL
GAINESVILLE, FLORIDA 32611
TELEPHONE: (904) 392-1965
CABLE ADDRESS: CENTROP

March 27, 1975

MAR 31 1975

Mr. Michael Galli, Acting Director
Technical Assistance Bureau/AGR
Room 2244
Department of State
Agency for International Development
Washington, D. C. 20523

Dear Mr. Galli:

Re: AID 211(d)/csd-3684

Authority is hereby requested for Drs. G. O. Mott and John B. Brolmann of the Agronomy Department of the University of Florida to attend and present papers at the Australian Conference on Tropical Pastures and to visit the Experiment Stations at the Fiji Islands on route.

The Australian Conference on Tropical Pastures is an internally planned workshop to evaluate the present knowledge of Tropical Pastures Science in Australia, plan future research and determine priorities. Since this workshop is usually entirely limited to research personnel in Australia, the University of Florida feels extremely fortunate that the Secretary of the organizing committee has extended an invitation to the University to be represented by two members of our faculty. Attendance at this conference will enable Drs. Mott and Brolmann to study the current research on the tropical legume Stylosanthes, which has become highly successful in the subtropics and tropical areas of Australia. Dr. Brolmann has been engaged for several years in a breeding program for the development of Stylosanthes for Florida conditions as well as tropical and subtropical America. This trip will give Dr. Brolmann an opportunity to observe first hand the breeding programs of the Australians on this very important legume and to obtain genetic stocks which will expedite his breeding program in Florida.

We are requesting authority to use 211(d) funds for airfare, per diem and expenses to present papers at this conference.

We believe that this activity is within the scope of our 211(d) objectives with emphasis on tropical pasture development.

The requested expenses will be approximately $3,000 per participant.

With best regards,

Hugh Popenoe

Hugh Popenoe
Director

HP/bc

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

GAINESVILLE, FLORIDA 32611

AGRONOMY DEPARTMENT
2183 MCCARTY HALL

April 16, 1975

MEMORANDUM

TO: H. Popenoe and J.H. Conrad

FROM: G.O. Mott

SUBJECT: 211-d meeting, April 14, 1975, Atlanta, Georgia
Air Host Inn

The meeting was called to order about 9:15 a.m. by chairman Kelley White from Purdue. Following is a list of those present:

Kelley White	-	Purdue University
Ralph May	-	" "
George Cooper	-	Tuskeegee
Ed Braye	-	"
Sociologist?	-	"
Tom Cartwright	-	Texas
Fred Mauer	-	"
Mike Galli	-	AID, Washington
Arlo Minden	-	"
G.O. Mott	-	Florida

The Texas Model

The first item for discussion was the Texas model by Tom Cartwright designed to simulate beef production under a wide spectrum of environments. The functions are biologically based and can be adjusted to apply to any breed for which basic data are available and for any set of circumstances. Within the general model they now have useable submodels in the area of:

1) Forage Production
2) Nutrition, and
3) Reproduction

More information is needed on the 1) way cattle react to forages and the 2) way forages react to cattle which influences the quantity and quality of feed on offer (Grazing pressure and it's long term effects upon production). The general mathematical model for expressing output of animal product as a function of grazing pressure is known, but simultaneous changes in quality are difficult to express in mathematical form since

both quality and quantity change with time. For the tropical environment very little information is available.

The nutrition model was discussed which includes computing the nutrient requirements of the animals in the herd and relating the requirements to the digestibility of forages. The relevant parameters are given in Ex.1. Some of the factors affecting the model are:

Cattle characteristics- size, milk yield, herd structure; some of these can be generated from cow wts, calf wts, reproduction and mortality data of cows and calves.

Nutrients- Quality and quantity of forage through time. Accessibility of feed and water and water quality.

Some outputs of the model are production and changes in herd composition.

Purdue Model

Kelley White and Ralph May.

For purposes of the Purdue model, four regions of the country have been considered as follows:

Rupununi
Matthews Ridge
Ebini
Coastal

For two of these regions we were given examples of how the model works to generate data for various parameters. An input form, country wide constraints and computer output for Rupununi and the Coastal region were given to those in attendance and the data generated was explained. (A copy of this information is in Mott's files).

Model Utilization Workshop

White suggests about a 2-day workshop of the consortium to discuss the models of both Texas and Purdue in the summer after each has had an opportunity to compute their data and examine various alternative solutions. This meeting would be in the U.S. and might require at least 2 nights so as to run several problems and obtain computer print outs the next morning.

A second workshop in Guyana is proposed to inform the Guyanese of the usefulness of the models and attempt to improve the coefficients through discussions with appropriate technicians. No date has been set for this meeting in Guyana but it would be after the workshop in the U.S.
NOTE: Kelley White wants schedules of Conrad and Mott through August.

Second Country Selection

In Kelley White's letter of March 13 to Dr. Bob Gray-Nairobi, Kenya, he explored the possibility of the consortium making Kenya the next country

Ex. 1. Nutrition model

$R = M + LR + PR + LGR + RLC$

When: $M>0$; $LR, PR, LGR, RLC>0$

R = Requirement
M = Maintenance requirement = $a_1 W^{0.75}$
LR = Lactational requirement = a_2 (amt. of milk)= $g(G,S_1)$
PR = Pregnancy requirement = $F(G,S_2)$
LGR = Lean growth requirement = $K(WMA-WM)$
RLC = Lack of condition requirement = $h(\frac{W}{WM})$ if $W<WM$
" " " = 0 if $W>WM$
WM = Condition constant weight
WMA = " " " at maturity
G = Genotype
S_1 = Stage of lactation S_2 = Stage of pregnancy
a_1, a_2, f, g, h, and k are constants.

I = intake $L = \min(PL, ML)$ $I \leq L$
D = digestibility
PL= physical limit of I; related to undigested intake portion.

$= \frac{.0107\ WM}{1-D}$ (.0107 from Rowetle work)

ML= physiological limit on I; related to digested nutrient intake

$= \frac{.025\ WM}{D}$ or $D(ML) = .025\ WM$

If $D \times L \leq R$ then $I = L$

If $D \times L > R$ then $R/D \leq I \leq L$ $I = \frac{L + R/D}{2}$

for building models of ruminant livestock production. Since no reply had been received up to April 7, Mike Galli sent a cable to Kenya asking for a response. A cable was received by Mike Galli on April 14 indicating some interest favorable towards the consortium but requesting further information. The cable also indicated a strong interest in sheep and goats. They want to know what resources will be needed for our program from the mission and from G.O.K.

White has asked for our suggestions as to what information and resources will be required by each member of the consortium and he will prepare a message to be sent by Galli to Kenya. The following items were mentioned by Kelley:

1) What kind of information is required
2) What in-country resources will be required
3) What can Kenya expect to get from the consortium

White plans to suggest that a team visit the country of Kenya composed of four (4 Universities) to seven (7 disciplines represented) people to explain the program and make some preliminary contacts. A week is proposed for this trip to be made as soon as acceptable to Kenya. White emphasized the necessity to proceed cautiously and carefully in our approach.

Fourth year grant reviw

There will be a comprehensive review of the acitivities and accomplishments of the 211-d consortium at which time the review team will probably make recommendations for extension of the funding, extension without or changed level of funding, or termination. The review will probably be of all four Universities at one location rather than each University separately. The timing of the review will be from Jan to June of 1976. Galli has suggested a warm-up review among ourselves sometime in the fall of 1975. The review will be primarily a technical one and will include fulfilling all aspects of the contract. What has happened at the University during the term of the consortium? - no of faculty involved in international programs, throught patterns of the administrators, changes in domestic programs and thinking of the faculty, improvements in subject matter areas, training of graduate students - foreign and domestic, and relevance of institutions contribution to the consortium. Arlo Minden emphasized that moneys not actually spent on June 30, 1977 could no longer be used without special authorization. All salaries, faculty, staff and graduate students would terminate on June 30 whether they had completed their work or not.

Extension of Grants

The consortium idea has had several failures during the past few years and 211-d has a bad image in USAID Washington. Extensions are going to be extremely difficult to justify.

PURDUE UNIVERSITY inter office memorandum

To T.C. Cartwright, F.D. Maurer, G.E. Cooper, G.O. Mott, and J.H. Conrad

From Kelley White KW

Date May 22, 1975

Subject 211(d) Modeling Workshop June 30-July 1

The proposed agenda for the modeling workshops to be held at Purdue on June 30 and July 1 is as follows:

Monday, June 30

A.M.

1. Overview of Consortium, and purpose and organization of the workshops
2. Description of the Purdue model and presentation of base run output
3. Participant modification of Purdue model input

P.M. (afternoon and evening session)

1. Description of the Texas model and presentation of base run output
2. Participant modification of Texas model input
3. Discussion and evaluation of output from participant modification of Purdue model
4. Second participant modification of Purdue model input
5. Discussion and evaluation of output from participant modification of Texas model
6. Second participant modification of Texas model input

Tuesday, July 1
A.M.

1. Discussion and evaluation of output from second participant modification of Purdue model
2. Discussion and evaluation of output from second participant modification of Texas model
3. Summary comments on workshop
4. Comments by Will Candler (we have asked Will to comment on organization of a modeling workshop in Guyana, where the Consortium's future emphasis should be, and the role of system modeling in livestock development)

P.M.

Consortium business meeting

1. Planning for Guyana workshop
2. Second country involvement – [illegible]
3. 211(d) Grant review
4. Election of chairman

We anticipate that this program will require two full days. Therefore, I encourage you to arrive on Sunday so that we can get started early on Monday. We would also like to provide an opportunity for the group to do a little socializing on Tuesday night if you can arrange your return travel for Wednesday morning.

If each of you will provide the names of those attending we will make room reservations at the Union. Also, if you are going to need transportation from Indianapolis, give me your flight and arrival time, and we can provide transportation.

It is extremely important that all disciplines be represented since this is our first opportunity to try using the models in a truly multidisciplinary fashion. We will provide you with some advance materials on the Purdue model so that you can be better prepared to use it.

We look forward to seeing all of you at Purdue.

KW:me

cc: Mike Galli
Will Candler
Lee Fletcher

APPENDIX B

Information on conferences, short courses and seminars.

Twenty-Fourth Annual

BEEF CATTLE SHORT COURSE

May 1, 2, 3, 1975

Held at

CECIL M. WEBB
LIVESTOCK PAVILION
UNIVERSITY OF FLORIDA
GAINESVILLE, FLORIDA

Sponsored by
Institute of Food and Agricultural Sciences
Agricultural Extension Service
and
Center for Tropical Agriculture
University of Florida

Quarto Cursillo del Istmo Centroamericano Sobre Ganado de Carne y de Leche

10 Y 11 DE MARZO DE 1975
El Cariari Country Club

Patrocinado por el
Comité Permanente de Exposiciones
Pecuarias del
Istmo Centroamericano

el

Ministerio de Agricultura y Ganadería

el
Centro Agronómico Tropical
de Investigación y Enseñanza (CATIE)
la
Universidad de Costa Rica
y el
Centro de Agricultura Tropical
Instituto de Ciencias
Alimenticias y Agropecuarias
Universidad de Florida, Gainesville

HORARIO DEL IV CURSILLO CENTROAMERICANO SOBRE GANADO DE CARNE Y DE LECHE

Lunes, 10 de Marzo de 1975

Preside—Sr. Tomás Batalla Esquivel

A.M.

7:30 Inscripción

8:30 Bienvenida ..... Hernán Garrón Salazar
Ministro de Agricultura y Ganadería

9:00 Importancia de la genética en la cría actual de animales y la forma en que el ganadero debe aprovecharla ..... Dr. Marvin Koger
Florida

10:00 Receso

10:15 El papel de los cruzamientos en la productividad del ganado de carne ..... Dr. J. W. Turner
Mississippi

Almuerzo

P.M.

2:00 Uso de las pruebas de comportamiento en el mejoramiento del ganado de carne ..... Dr. Dieter Plasse
Venezuela

3:00 Crianza y alimentación de la hembra de reemplazo ..... Dr. Marco T. Cabezas
Guatemala

4:00 Receso

4:15 Manejo y administración de la empresa ganadera ..... Ing. H. Murcia
Costa Rica

5:45 Discusión de los temas tratados
Coordinador: ..... Dr. Héctor Muñoz
Presidentes de mesa: ..... Sr. Tomás Batalla
Ing. Oscar Echandi

6:45 Conclusión

Martes, 11 de Marzo de 1975

Preside—Sr. Oscar Pacheco

A.M.

8:00 Las deficiencias minerales y su relación con el crecimiento y la reproducción del ganado de carne ..... Dr. T. J. Cunha
Florida

9:00 La explotación de una finca lechera en Costa Rica ..... Sr. Jorge González
Costa Rica

10:00 Receso

10:15 El manejo y utilización de los pastos para la producción de carne ..... Dr. Gustavo Cubillos
Costa Rica

Almuerzo

P.M.

2:00 El uso de los subproductos agroindustriales en la producción del ganado de carne ..... Dr. Manuel Ruiz
Ing. Minor Leiva
Costa Rica

3:00 Relación entre forma y función del caballo ..... Dr. Ben. H. Crawford
Florida

4:00 Receso

4:15 El manejo y la alimentación como medios de aumentar la eficiencia de la reproducción animal ..... Dr. Randall Grooms
Texas

5:15 Discusión de los temas tratados
Coordinador: ..... Dr. Hernán Fonseca
Presidentes de mesa: ..... Sr. Oscar Pacheco
Ing. Alvaro Muñoz

6:15 Conclusión

NINTH ANNUAL CONFERENCE ON LIVESTOCK AND POULTRY IN LATIN AMERICA

May 5, 6, 7, 8 and 9, 1975

FLAGLER INN
Gainesville, Florida

Sponsored by

Center for Tropical Agriculture

and the

Cooperative Extension Service
Institute of Food and Agricultural Sciences
University of Florida

NOVENA CONFERENCIA ANUAL SOBRE GANADERIA Y AVICULTURA EN AMERICA LATINA

5, 6, 7, 8 y 9 de Mayo de 1975

FLAGLER INN
Gainesville, Florida

Patrocinada por el
Centro de Agricultura Tropical
y el
Servicio Cooperativo de Extensión
Instituto de Ciencias Alimenticias y Agropecuarias
Universidad de Florida

UNIVERSITY OF FLORIDA
Gainesville, Florida

Ninth Annual Conference
on
Livestock and Poultry
in Latin America

May 5-9, 1975

Official List of Student Translators

Name	Country	Department	Title to be obtained
Jorge Beltran	Venezuela	Animal Science	M.S.
Carlos Campabadal	Costa Rica	Animal Science	Ph.D.
Fausto Capote	Venezuela	Animal Science	Ph.D.
Héctor Castillo-Rojas	Mexico	Animal Science	M.S.
Alvaro Castro H.	Colombia	Animal Science	Ph.D.
María I. Chavez	Venezuela	Animal Science	M.S.
Róger López	Costa Rica	Entomology	M.S.
Sergio López-Barbella	Venezuela	Animal Science	M.S.
Ursulino Manrique	Venezuela	Dairy Science	M.S.
José Rafael Martínez	Venezuela	Animal Science	M.S.
José Luis Montesinos	Venezuela	Animal Science	M.S.
Oscar Neri-Flores	Mexico	Animal Science	M.S.
Orlando Osuna	Colombia	Veterinary Science	M.S.
Lis M. Rodríguez	Venezuela	Dairy Science	M.S.
Heriberto Román-Ponce	Mexico	Dairy Science	Ph.D.
Jaime Mauricio Salazar	El Salvador	Animal Science	Ph.D.
Luis Alonso Silva	El Salvador	Dairy Science	M.S.
Ricardo Valdivia	Peru	Animal Science	Ph.D.
Carlos Alfredo Zometa	El Salvador	Dairy Science	M.S.

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ANNOUNCEMENT OF LECTURE SERIES

MATHEMATICAL MODELING OF FORAGE - LIVESTOCK FEEDING SYSTEMS

BY

H. L. LUCAS

PROFESSOR AND DIRECTOR, BIOMATHEMATICS PROGRAM
DEPARTMENT OF STATISTICS, NORTH CAROLINA STATE UNIVERSITY

DECEMBER 16-20, 1974

THE FIRST LECTURE WILL BE AT 9:00 AM., DECEMBER 16, 1974 IN ROOM 6086 MCCARTY. LECTURES WILL BE SCHEDULED DURING EACH HALF DAY THE REMAINDER OF THE WEEK. THE TOPICS TO BE DISCUSSED, TIMES AND PLACES WILL BE ANNOUNCED LATER.

PLEASE CALL PROFESSOR G.O. MOTT, 392-1823 IF YOU HAVE ANY QUESTIONS.

DR. J. K. LOOSLI

VISITING PROFESSOR OF ANIMAL SCIENCE

FORMER CHAIRMAN, ANIMAL SCIENCE DEPARTMENT,
CORNELL UNIVERSITY

AUTHOR OF BOOK ENTITLED "ANIMAL NUTRITION"

WILL PRESENT THREE LECTURES
ROOM 2102 MCCARTY HALL

MON. JAN. 27 - COMPARATIVE EFFICIENCY OF ANIMALS AS CONVERTERS OF ENERGY AND PROTEIN

WED. JAN. 29 - COMPARATIVE VITAMIN REQUIREMENTS OF ANIMALS

FRI. MAR. 14 - OUTLOOK FOR INCREASED FOOD PRODUCTION FROM ANIMAL SOURCES IN THE TROPICS

YOU ARE INVITED TO JOIN THE
AL 656 CLASS FOR THESE LECTURES

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

GAINESVILLE, FLORIDA 32611

ANIMAL SCIENCE DEPARTMENT
2103 McCARTY HALL
TELEPHONE: 904-392-1911

SEMINAR

by

Dr. W. Ross Cockrill
FAO, Rome

on

WATER BUFFALO

Today, Friday, June 13

at

11:00 A.M.
2108 McCarty Hall

Dr. Cockrill edited the recent book

The Husbandry and Health of the Domestic Buffalo

Reprinted from "Forage Fertilization." Mays, D. (Ed.). Copyright © 1974, American Society of Agronomy, 677 S. Segoe Rd., Madison, WI 53711.

15 Nutrient Recycling in Pastures

G. O. MOTT
University of Florida
Gainesville, Florida

I. INTRODUCTION

Nutrients essential for plant production in a grazed pasture pass through a cycle from soil to plant and either directly or through the grazing animal back to the soil. The availability of the nutrients in the cycle determines to a great extent productivity of the pasture and yield of animal product. When additional nutrients are introduced into the nutrient pool, the fate of these nutrients in soil-plant-animal systems determines the efficiency of their conversion to plant and animal production. The size of the nutrient pools in each of the three principal compartments determines nutrient accessibility, but of much greater importance is the rate of transport between the pool and consequently the rate of recycling of the essential nutrients. However, the output of the system is the quantity of animal product generated by the grazed pasture.

The purposes of this paper are: (1) to review some of the current concepts of nutrient recycling; (2) to examine some of the factors which may contribute to greater retention in nutrient pools and accelerate their rate of transport between compartments; and (3) to assess the consequences of these mechanisms upon agronomic practices and livestock management.

II. THE SOIL-PLANT-ANIMAL SYSTEM

A. Definitions of Compartment Pools

A simplified concept of the recycling mechanism is illustrated in Fig. 1. There are three main compartments, the soil, plant, and animal, which represent pools of nutrients identified in recycling. The nutrient pool of the soil is in an equilibrium state with the residues pool, which has been defined by Till, May, and McDonald (1970) as the organic fraction in soil, dead plant ma-

Reprinted from *Journal of Dairy Science*, Vol. 57, Oct. 1974, pages 1258-1259.

Recovery of Residual Organic Matter from In Vitro Digestion of Forages[1]

J. E. MOORE and G. O. MOTT
Departments of Animal Science and Agronomy
University of Florida, Gainesville 32611

Abstract

After two-stage in vitro digestion of about .44 g of initial forage organic matter, residues in fermentation tubes were filtered sequentially through glass wool mats, sintered glass crucibles, and glass fiber discs. Only .002 g of residual organic matter which passed glass wool was retained by sintered glass. The residue on sintered glass did not include recognizable forage particles. Glass fiber retained .029 g of residual organic matter which had passed both glass wool and sintered glass. Calculations of in vitro organic matter digestion were not affected by including the residue retained by sintered glass in addition to that retained by glass wool. Inclusion of the residue retained by glass fiber reduced digestion percentages by 1.9 units. Glass wool mats are easily prepared in 25-ml porcelain Gooch crucibles, and filtration through them is rapid.

Introduction

The two-stage in vitro digestion procedure (5) generally has been adopted, with certain modifications, for routine quality screening of forages. In this procedure, fermentation with rumen microorganisms is followed by digestion with acid-pepsin, and the undigested residue is recovered and weighed. Recovery of undigested residues by filtration has been accomplished with sintered glass crucibles (2), glass fiber filters (1), filter papers (4, 5), or filter sticks (3). Slow filtration may occur with sintered glass and glass fiber. Paper may result in lower apparent digestion (4) perhaps because of retention of microbial matter synthesized during fermentation. Van Soest et al. (6) filtered rumen fluid through glass wool prior to inoculation, and this suggested that glass wool might retain undigested forage particles.

Our study evaluated the use of glass wool mats in porcelain Gooch crucibles in contrast to the use of sintered glass or glass fiber for recovery of in vitro residual organic matter.

Procedure

In vitro organic matter digestion (IVOMD) was determined on 12 forage samples, in duplicate in each of two replications. Four blanks (no sample) were included in each replication. Initial organic matter (OM) was about .44 g. Rumen fluid was strained through glass wool and mixed with CO_2-saturated McDougall's saliva (2), and 50 ml were used per fermentation tube (100 ml polyethylene) including blanks. After 48 h anaerobic incubation at 39 C, 6 ml 20% (vol/vol) HCl and 2 ml 5% (wt/vol) aqueous pepsin were added, and incubation was continued for 46 h. After pepsin digestion, residues were filtered through mats of Pyrex glass wool (Corning 3950) in 25-ml porcelain Gooch crucibles (Coors 270, size 3). Glass wool was cut into squares of approximately 20 mm by paper cutter. Only one layer of glass wool was cut at a time. It was essential that the glass wool be cut cleanly. Otherwise, tearing the pieces apart created small glass particles which irritated skin and throat. About six squares were placed in each crucible. Each glass wool mat was used only once.

In Experiment 1, the filtrates passing glass wool were filtered immediately through Pyrex sintered glass crucibles (Corning 32940-50C) to determine the amount of residue passing glass wool which was retained by sintered glass. In Experiment 2, the filtrates from eight sample and four blank tubes which had passed both glass wool and sintered glass were filtered through glass fiber discs (Reeves Angel 934 AH) in 25-ml porcelain Gooch crucibles. All crucibles, filters, and residues were dried at 110 C, and residual OM was determined as the loss in weight after ashing at 500 C for 4 h. The IVOMD was calculated with glass wool residues only, and glass wool residues plus the additional residues retained on either sintered glass (Exp. 1 and 2) or glass fiber (Exp. 2).

Results and Discussion

The residual OM passing glass wool but re-

Received April 11, 1974.

[1] Florida Agricultural Experiment Stations Journal Series No. 5376.

Reprinted from CROP SCIENCE
Vol. 14, May-June 1974, p. 468-471

Seed Production of *Stylosanthes humilis* as Influenced by Origin and Temperature During Flowering[1]

H. C. Schoonover and L. R. Humphreys[2]

ABSTRACT

Ten selections of the tropical annual pasture legume *Stylosanthes humilis*, grown in controlled-environment cabinets, were induced to flower at a common time and then subjected for 60 days to 31/24, 24/17, or 17/10C, day/night temperatures. Mature seed were not formed on inflorescences differentiated at 17/10C. This regime also decreased inflorescence number and floret number. Seed production at 31/24 and 24/17C was similar, but selections differed in their response to temperature and in the pathways through which response was reflected. The cultivar 'Lawson' and a selection from Dayboro, Queensland, were superior. Ecological implications are considered.

Additional index words: **Tropical, Annual, Pasture legume.**

STYLOSANTHES humilis H.B.K. is a pasture legume widely naturalized and sown in northern Australia (3). It is used by some ranchers in southern Florida (5) and shows promise in many tropical regions with a defined wet-dry climate. Seed production has particular ecological significance for natural regeneration of this annual and for stock diet.

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[2] Research Associate and Visiting Professor (present address: Department of Agriculture, University of Queensland, St. Lucia, Q 4067, Australia).

LA COMPATIBILIDAD, PERSISTENCIA Y VALOR NUTRITIVO DE ASOCIACIONES DE GRAMINEAS Y LEGUMINOSAS EN EL TROPICO ECUATORIANO *

Robert E.Hudgens, Luis E. Tergas y Gerald O. Mott **

INTRODUCCION

La demanda interna de carne y leche, así como el potencial de exportación de estos productos hacia otros países del área, ha estimulado el interés en aumentar la producción ganadera en el Litoral ecuatoriano.

Las extremas variaciones ecológicas que se observan en esta región han determinado la necesidad de desarrollar prácticas de manejo de pastos específicos para cada zona. En general, se ha observado que el principal factor que afecta la producción y calidad del forraje es la desuniforme distribución anual de las lluvias con los consecuentes efectos sobre la producción y reproducción animal. Por lo tanto, es necesario obtener información acerca de los efectos de sistemas de pastoreo, fertilización a base de nitrógeno, incorporación de una leguminosa en asociación con las gramíneas etc, sobre la distribución de la producción de forraje durante todo el año y el mantenimiento del valor nutritivo durante la estación seca, en una forma que resulte económica para el productor.

Una gran mayoría de las leguminosas tropicales tienen su orígen en América Latina, sin embargo, todavía no se ha aprovechado su potencial como especies forrajeras, principalmente por el desconocimiento de la contribución general de estas especies a la producción de forraje de buena calidad, sobre todo durante la estación seca, y la falta de prácticas de manejo de pastizales necesarias para un buen establecimiento y persistencia de las asociaciones.

Este trabajo se diseñó con el objeto de: estudiar la compatibilidad de 18 asociaciones de gramíneas y leguminosas forrajeras tropicales; determinar su persistencia bajo dos frecuencias de corte; y medir la contribución de la leguminosa a la producción y calidad del forraje durante las dos estaciones del año.

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** Estudiante Graduado Asistente, Profesor Asociado Visitante y Profesor, Departamento de Agronomía, Universidad de Florida, Gainesville, Fla. 32611

LIVESTOCK DEVELOPMENT IN LATIN AMERICA - PRESENT STATUS AND FUTURE NEEDS[1/]

A. C. Warnick, University of Florida[2/]

It would be best to enumerate some of the major problem areas before giving details of development. This presentation will be concerned primarily with livestock development with emphasis on beef cattle. In most countries cattle are much more important economically than swine, sheep, goats or horses.

The FAO (1972) indicated that 42% of the economically active population in Latin America are in Agriculture but they generate only 17% of the Gross Domestic Product. Thus output per person in Agriculture is below the nonagriculture sector.

There were some general trends in Agriculture noted in this FAO report. Fertilizer application increased in Latin America but two countries (Brazil and Mexico) use more than half of the fertilizer for the region. Most of the fertilizer is used on export crops such as sugar cane, bananas, cotton and coffee. Irrigation is used mainly for export crops. Of the total crop land in Latin America 11.5 million hectares or 8% is irrigated. Mexico accounts for 45% of total area irrigated and Brazil is putting greater emphasis on irrigation. There was a 5% increase in tractors in 1970 but 2/3 of the number occurs in Argentina, Brazil and Mexico.

Some of the basic problem areas involved in beef cattle breeding

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2/ Professor, Department of Animal Science.

in Latin America have been listed by Plasse (1973) as: (1). Socio-economic factors may be more important than the biological factors. He indicates that one type of ownership is the large extensive holdings where the person has another primary profession in the city and the ranch is not the main economic concern. In some cases the ranch is used for social status rather than maximum cattle production. The other group is the very small land holding which is not an economic unit and there is a lack of finances and technical information. Also, the lack of adequate roads and transportation to markets is a handicap. (2). Climatic factors in which there is a traditional wet and dry season means special management is required. High temperature and humidity complicate adaptability of imported cattle. Of course, the lack of frost and moderate temperatures offer possibilities for year-around forage production if moisture is available. (3). Nutritional factors such as energy, protein and mineral deficiencies are common especially during the dry season. Thus, a program of feed supplementation is necessary. (4). Disease factors are estimated to cause losses of 1/3 of the total livestock production in Colombia. Some of the diseases encountered are anaplasmosis, piroplasmosis, foot and mouth disease, ectoparasites, endoparasites and reproductive diseases. (5). Management factors exist where cattle run on unfenced native lands, without castration, identification or control of the breeding season. Thus, a program to design fencing, working pens, watering facilities and control of the breeding season needs to be installed.

The low level of beef cattle production in the Latin American tropics has been indicated by Plasse (1973) in table 1.

Table 1. Estimated Beef Cattle Production In Latin American Tropics

Trait	Present Production Level
Birth rate	35-60%
Death loss to breeding age	10-25%
Weaning weight at 7 months	120-150 kg
Age at first calf	3-4 years
Slaughter age	3.5-5 years
Slaughter weight	350-450 kg
Extraction (slaughter beef)	8-15%

Some of the experiments that have been conducted in Latin America which indicate that cattle production can be improved are shown in the following examples. In the Northern area of Argentina (Corrientes province) an experiment was conducted using cottonseed meal to supplement weanling heifer calves and breeding cows during the winter or dry season by Warnick et al. (1963). This is an area where beef cattle are raised on native pasture and cottonseed meal is available as a by-product of cotton production. The weanling heifers and breeding cows were divided at random into groups in which one received the cottonseed meal (cows/ 1 kg daily, heifers 200 gms daily) for 100 days while one group received no cottonseed meal. All cattle received a mixture of bone meal and salt free choice. The weights and gains are indicated in table 2.

Table 2. Comparison of Weights in Heifers and Cows Fed Cottonseed Meal for 100 Days During Winter

Group	No. ♀	Wt. end of supplementation (Sept.) kg	Wt. end of spring (Dec.) kg
Heifers with protein	50	163	194
Heifers without protein	50	143	175
Difference		20	19
Cows with protein	41	316	338
Cows without protein	46	301	330
Difference		15	8

The heifers getting cottonseed meal were 20 kg heavier at the end of the feeding period and this weight advantage was maintained at the end of the spring grazing period on good grass. Also, the value of this increased weight gain was valued at twice the cost of the supplement indicating an economic advantage. The other advantage would be that heifers would make enough weight gain so they were developed sexually so breeding could occur at 2 years of age vs. present practice of not breeding until 3 years of age.

Work by Chicco (1972) in Venezuela has shown a satisfactory system for growing steers during the dry season with poor quality pastures. A comparison was made of feeding molasses, molasses plus urea and hay alone to three groups of steers for 100 days. All three groups were fed the low quality Pangola hay (4.3% protein). The weights and gains are shown in table 3.

Table 3. Weights and Gains of Steers Fed Low Quality Pangola Hay Plus Supplement

Item	Control (Hay)	Molasses	Molasses + Urea
Initial weight, kg.	283	283	282
Final weight, kg.	281	284	295
Daily gain, gm.	-18	9	132

You will notice that the control nonsupplemented steers lost a little weight, those on molasses maintained their weight while those getting urea plus molasses gained nearly 1/3 lb. per day. This shows the need for supplemental protein during the dry period when growing cattle are on low quality pastures.

Another program that has been used to increase beef production in Latin America as well as other parts of the world is that of cross-breeding. The increased production is based upon the principle of

heterosis or hybrid vigor. This has been demonstrated in comparisons both in Bolivia by Bauer (1973) and in Venezuela by Plasse (1973).

The work in Bolivia by Bauer was in a herd of Criollo beef cattle (Natives) run on the low savanna area where flooding occurs and there is a dry season. Beginning in 1962, Zebu bulls from Brazil were introduced to cross on the Criollo type cows. Also, a select herd of 500 Criollo cows was established for raising Criollo bulls. A select herd of 500 head of Zebu females was established by purchase and saving replacement females to produce bulls for the crossing program. A systematic program of crisscrossing was begun in which daughters of the Criollo bulls are mated to Zebu bulls and the daughters of the Zebu bulls are mated to Criollo bulls. The increased weights at weaning for the crossbred and Zebu calves are shown in table 4.

Table 4. Average Weaning Weights and Daily Gain of Calves in Bolivia

Breed	No. Calves	Wean. Wt. (kg)	Avg. daily gain, kg.	Index
Criollo	436	123	.479	100
Zebu	392	152	.604	125
Crossbred	3,024	138	.540	112

We notice that the crossbreds are 12% heavier at weaning than Criollo while Zebu were the heaviest. The overall increased beef production can be seen in table 5 where calving rate, mortality, growth rate and slaughter weight are considered.

Table 5. Estimated Production of Criollo, Zebu and Crossbred Cattle Per 1000 Cow Herd

Item	Criollo	Zebu	Crossbred
Calves born, No.	828	810	817
Calf loss - preweaning - %	3.0	5.0	3.0
Calves weaned - No.	803	770	793
Calf wean. wt., kg.	123	152	138
Postweaning loss - %	1.7	3.8	1.7
Calves at 16 months, No.	789	741	780
Avg. Slaughter wt., kg.			
Bulls	285	345	316
Cows	177	202	198
Total Slaughter wt., kg.	179,205	202,592	200,460

The overall production of slaughtered beef in the Zebu and Crossbred is 12 to 13% above the Criollo cattle. This author further states that a significant increase in the reproduction rate was made over the years by controlling the breeding season length and time so calves were born ahead of the flooding period. Also, a culling program of nonpregnant cows and a strict sanitation and vaccination program helped to reduce calf losses and increase the weaning percentage.

In Venezuela, Plasse (1973) has shown an average heterosis of 10% in weaning weights of the crossbred compared to the two straightbred groups of Criollo and Brahman breeds. Also, weights at 18 months of age showed 18% heterosis for the crossbred cattle vs. the two parent breeds of Criollo and Brahman. The pregnancy percentage in 2 year old crossbred heifers was 91.6% compared to 83.6% for the Criollo and Brahman heifers giving a heterosis value of 10%.

An example of the progress that can be made when improved management, selection, better nutrition and a good sanitation program is used has been shown in a purebred Brahman herd in Venezuela by Plasse (1973), table 6.

Table 6. Progress in Production in Brahman Herd at the La Cumaca Experiment Station, Venezuela Between 1964 and 1970

Trait	No. Cattle	No. Years	Average 1st Year	Average Last Year	Progress %
Weight, kg.					
Cows			404	431	+ 7
Heifers			328	348	+ 6
Total or Avg.	1,073	6	389	417	+ 7
Pregnancy, %	1,251	7	56.5	85.1	+51
Birth weight, kg.	525	5	25.2	27.5	+ 9
Weaning, %	-	6	41.0	66.5	+62
Weaning weight (205 days), kg.	406	5	142	164	+15
18 Month wt., kg.	273	4	255	311	+22

The greatest percentage increase occurred in the reproduction rate along with a substantial increase in growth rate. Plasse indicated that a controlled breeding season of 3 months for heifers and 4 months for cows with the beginning date for heifers being 15 days ahead of the cows was practiced. A culling program of nonpregnant heifers and cows was practiced. The nutritional level was increased by providing supplemental feed for heifers after weaning during their first winter. Mineral supplement was provided on a continuous basis. An adequate number of fertile bulls were rotated during the breeding season. Also, a herd health program was followed which included vaccinations. Thus there are specific research projects being carried out in various countries which show increases can be made in cattle production.

Several organizations are working to enhance livestock development in the various countries. The Latin American Free Trade Area (LAFTA) is an organization of all South American countries to sponsor economic integration for mutual benefit of the countries. The Central American

Common Market (CACM) was organized to improve market information and help finance agriculture exports. Also, most countries have 5 to 10 year programs which includes public investment programs to increase their annual gross domestic product 5 to 7%. As an example in Mexico the National Maiz program in the State of Mexico has produced sufficient corn so a pork production program was established. By September 1971, the state had financed without interest 226 new swine enterprises for hog houses, pigs and protein supplement. Animal Husbandmen and Veterinarians were provided by the state to give technical help to inexperienced farmers.

The Centro International Tropical Agriculture (CIAT) group at Cali, Colombia was organized by the Rockefeller, Ford and other foundations to support research and development in livestock and forage production under tropical conditions. A recent conference was held there on February 18-21, 1974 to discuss potentials to increase beef production. Authorities were present from various countries to discuss the following areas:

(1) Range management and establishment of improved pastures;

(2) Management, nutrition and animal breeding;

(3) Animal health;

(4) Intensive fattening systems;

(5) Socio/economic considerations;

(6) Development projects.

You will note that these are similar to the basic problems outlined earlier by Plasse (1973).

The World Bank is sponsoring a large credit program to Venezuela which is concerned with livestock production. This program stipulates that the producer must have supervision of the credit by a technically

trained livestock person to initiate improved practices. This system should assure the adaption of improved practices to increase livestock production. Previously, credit has been extended without technical assistance so approved practices were not assured.

There are several US AID sponsored programs between specific countries and various U.S. Land Grant Universities in Agricultural development. One example is the University of Florida and Brazilian National Beef Cattle Project. The University of Florida has provided 4 people working in the areas of forage production, beef breeding and nutrition and reproductive physiology. Research is being conducted by these people working together with Brazilian counterparts. Also, a grant from the U.S.A.I.D. to departments at Texas A&M University, University of Florida, Purdue University and Tuskegee Institute to strengthen capabilities in ruminant livestock development programs for the tropics has been funded for a five year period - July 1972 to July 1977. The grant to the University of Florida amounts to $500,000 for the 5 year period to be used in the Animal Science and Agronomy departments.

The UNFAO has funded special projects in various countries for agriculture and livestock development. These are projects designed for specific questions usually for a 5 year period in which FAO and local country counterparts work together.

The educational needs of technically trained people are being supported by the various countries, the Rockefeller, Ford and Kellogg Foundations as well as the FAO. Students from the various countries are sent to study and work toward M.S. and Ph.D. degrees to strengthen their Universities as well as provide people for research and Extension work with the Ministry of Agriculture. The University of Florida,

Department of Animal Science, has 21 graduate students from Latin America of a total graduate student population of 57 or 37%. These 21 students represent 8 Central and South American countries.

Also, an annual Latin American Short Course on livestock production is given at the University of Florida, Gainesville, in Spanish for technical workers and producers from Latin America. This is a 5 day program sponsored by the Center for Tropical Agriculture and the respective departments. Current and new information is given aimed at Latin American conditions. This year approximately 275 people attended. Also, a 3 week Meat Short Course and Seminar on meat classifications, sanitation and zoonosis control in Latin America was held at the University of Florida Meats Laboratory in 1973. There were 35 participants from 10 Latin Countries and this will be repeated this year.

A cooperative 2-day seminar on livestock and forage production has been held in conjunction with the annual Central American Livestock Exposition and the University of Florida. It has now been held in Guatemala, Panama and Honduras. Approximately 500 producers have registered at the seminars. There have been five or more people participate from the University of Florida each year plus the local technicians and producers.

What does the future hold for agriculture development in Latin America? The increased number of technically trained agriculture workers which are returning to their respective countries should provide for the adoption of improved methods to increase agricultural production. Some of these people are being appointed to positions in the Ministry of Agriculture so they have some political as well as technical influence. Many of these trained people are conducting research and teaching in their various countries to solve problems of

national interest.

The research that has been done in these countries shows that production can be increased with livestock by planned breeding programs, supplemental feeding and systematic crossbreeding plans. There is a need for a strong Extension program to get available information out to the producers so a wide scale improvement may occur.

The use of National financing programs coupled with technical assistance should implement improved development programs. Also, some of the local private Agricultural companies such as Protinal in Venezuela are providing credit, technical assistance and social programs to improve production of livestock and crops as well as improve the living conditions of the people.

There are many resources such as land, temperature, rainfall and labor which are available for increased Agricultural development. It is up to the people in the various countries to make use of these resources along with help from outside agencies for financial help and technical assistance.

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POTENTIAL FOR DEVELOPMENT OF DAIRY PRODUCTION IN THE LOWER GULF COAST OF MEXICO

J. K. Loosli
Dairy Consultant

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Introduction

The writer visited the three River Basin Commissions, Panuco, Papaloapan, and Grijalva-Usumacinta, along with C. Sierk on February 13-27, 1975. Information on livestock production based on a survey completed in November, 1974, in the Bajo Papaloapan region and data from a few farm surveys were provided with reference to the areas under consideration. Because of the very limited factual data available, the time was devoted to interviews with 1) the Commission Director in the regions, 2) Fondo personnel, 3) Nestle staff, and 4) to making visits to governmental research stations, educational and training institutions, milk processing and distributing plants and dairy farms. It was possible to over-fly the Papaloapan basin for a wider view and to drive by highway from Vera Cruz via Ciudad Alemán to Villahermosa as well as considerable distances within each basin.

This brief survey emphasized the great importance of livestock in these Gulf Coast regions, but also the fact that there is much land either under-utilized or entirely undeveloped. The importance of drainage and water control is very evident in many areas.

Objectives

Objectives (reference terms) were to study the possibilities of development of dairy production in the three basins of the lower Gulf Coast.

General Conclusions

1. There is great potential for expansion of dairy farming and milk production in all three basins of the Gulf Coast. There are currently many apparently successful dairy farms in these regions, some at low altitudes. The farms vary greatly in size, type of operation, and level of productivity. Unfortunately, very little reliable data are available from these farms or any other source to determine which system is most profitable.

2. Any land areas in the region that are properly drained and will produce pasture or forage crops can be utilized for establishing dairy farms.

3. Milk production could be increased by two or more times on many of the present dairy farms by improving the pastures by planting better varieties of grasses, applying fertilizers, practicing rotational grazing, and preventing weed competition.

4. Increasing milk yields will also depend on introducing record keeping on individual cows to allow selection of better producers and providing supplementary feeding in line with milk yields. Many of the Zebu X dairy cross cows lack genetic ability to produce much milk. There is also considerable variation among Holstein and Brown Swiss cows, and they should be selected for productivity.

5. Efficient milk production depends on providing adequate forage during the dry season which varies from 2 to 5 or 6 months in the Gulf Coast regions. Storing surplus forage as silage or growing special forage for dry season is critical.

6. Increased availability of high-protein and energy-rich concentrate feeds is the only way to supplement grass when needed to meet the requirements of higher producing cows at peak yields.

7. Although it is technically feasible to develop dairy farms in the low-land areas under study, there is a question about the desirability of this when considerable land higher in elevation which offers fewer constraints is also available for development or improvement in the Gulf Coast Region.

8. For the production of high quality milk, there are advantages to developing large enough farms to justify the installation of milk cooling and holding equipment at each milking center. Larger herds of cattle also justify more adequate disease control and health care measures, more effective A.I. service, and more efficient advisory services for operations and management.

9. A critical limitation to rapid expansion of additional modern dairy farms or increasing productivity of existing farms is the scarcity of agricultural advisors having the training and experience to teach the farmers proper management systems. There are also questions for which there are not suitable answers, and which require research before the most economical systems can be defined.

Observations and Background Information

Present status of dairy production

A preliminary survey of climatic and topographic conditions makes it clear that, while there are many regions with more favorable climates for Holstein, Jersey, Brown Swiss cattle or other pure dairy breeds than the low-land tropical Gulf Coast, there are large areas in this region where livestock, including dairy cattle, is produced at present. Considerable milk is now being produced in this region, and it is obvious that the amount could be markedly increased by improving the dairy merit of the cattle and the general feeding and management of the milking cows.

Different systems are in use with crossbred and pure dairy cattle. Many cows of Zebu or Criollo X Holstein or Brown Swiss are milked once a day while suckling their own calves. They depend on pasture almost entirely and milk production is low. Several herds of pure Holstein and Brown Swiss cattle have been established in the Gulf Coast. A limited number of these were visited. They are briefly summarized and some advantages and limitations of the different systems of dairy farming are offered in a later paragraph.

Estimates of the number of cattle in Mexico vary from 27.5 to 29.1 million. About 10 million are classified as dairy cattle with some 4.5 actually producing milk. In 1970-71, the Ministry of Agriculture and Livestock listed 3.9 million cattle in the States of Veracruz and Tobasco, 15% of the national herd, but there were no data available on the number used for dairy purposes.

A 1974 survey of livestock in Bajo Papaloapan region showed 1,384,158 cattle. Some 3,772 properties had 5 to 50 head of cattle; 1,685 had 51 to 150; and 646, more than 150 head. About 37% of the cattle were kept primarily

for milk, 20% dual purpose, 18% for beef only. The breeds of cattle included 44% Brown Swiss, 15% Gir, 15% Brahman, 11% Charolais, and 11% Indubrasil. Some 90% of the cattle had some Brown Swiss blood. It was reported that 42% of the cattle which were milked produced more than 3 liters of milk per day, 55% produced 2 to 3 liters, and the rest less than 2 liters. About 85% of the cattle are fed only pasture, 75% fed common salt, 4% iodized salt, and 3.6% salt with other minerals.

In the absence of accurate milk production data in the low-land tropical Gulf Coast, a tabulation of reported milk yields on several farms and research stations visited by the team are shown in Table 1. Data are also shown of publised research in Fiji to illustrate the effect of feeding supplements to pasture and of a breeding experiment in Venezuela where feeding and management was at a reasonably high level. The other data are estimates based on oral reports from personnel at the dairy farms or research stations visited. In most cases, milk was being weighed or measured, but actual yearly production was not available.

Table 1. Estimated Milk Production

Type of cows	Milk produced (liters) Days	Year	Per Day	Source of data
Holstein		4737		Cabello et al. (1971)
Brown Swiss		2677		"
Jersey		2930		"
Holstein	310	3720	12.0	Paso del Toro
Brown Swiss	296	2660	9.0	"
Holstein	300	3000	10.0	Tampico
Zebu X Brown Swiss	250	875	4.3	"
Crossbred average	200	600	3.0	"
Holstein	300	4500	15.0	Tobasco
"	300	2850	9.5	"
"	300	2100	7.0	"
Holstein, pasture only	250	1870	7.5	Fiji (McIntyre, 1973)
" , pasture + coconut	280	3365	12.0	"
" , pasture + molasses	270	2807	10.4	"
Brown Swiss	300	3630	12.1	Venezuela (McDowell, 1972)
Criollo	250	1775	7.1	"
Holstein	287	4018	14.0	"
7/8 Holstein X 1/8 Criollo	290	3643	12.6	"
3/4 Holstein X 1/4 Criollo	285	3560	12.5	"
1/2 Holstein X 1/2 Criollo	278	3087	11.3	"

References: Cabello et al., Tecnia Pecuaria en México, Nums. 15, 16: 5-8, 1971; McDowell, R.E. Improvement of livestock in warm climates. W.H. Freeman and Co., San Francisco; McIntyre, K.H. Tropical Agric. (Trin.) 50:17-24, 1973.

Present milk production systems

Extensive systems with crossbred cows. At higher elevations north and west of Tampico, there are many cows of Holstein breeding, but, in the lower areas of the three Gulf Coast regions under study, most cattle appear to be pure Zebu or Zebu crossbred with Brown Swiss or Holstein. Many of the crossbred cows are milked once a day. The system used is to graze the cows and their calves on pasture during the day from 8 or 9 in the morning after milking until about 4 or 5 in the evening, and then separate the calves from the cows during the night. In the morning, the calf is allowed to start sucking its mother to stimulate milk letdown. It is then tied up near the cow's head while the cow is milked and the calf and cow are turned to pasture for the day. Pasture is generally the only feed available and many of the pastures viewed from the highway and the air early in the dry season appeared to be overgrazed and depleted of forage. To store surplus forage as silage for dry season storage is considered too expensive. One farmer said he grew a few hectares of sugar cane to feed along with molasses and urea when the pastures dried up. This farmer said he made more money from selling the surplus cattle for beef than from milk sales, but he wanted the daily income from the average of 3 liters of milk obtained from the 75 cows he was milking.

Intensive systems with Holstein cows. Three dairy farms were visted in Plan Chontalpa. Some data about the farms are shown below:

	C-9	C-10	C-15
No. of cows	163	270	256
Avg. milk production, l/d	7.0	10.0	9.5
Supplemental feed, kg/cow/d	4.0	5.0	15 1 - 8.0 kg 10 1 - 6.0 kg 6 1 - 4.0 kg
Molasses	?	ad lib	ad lib
Stored feed	?	5,000 tons silage	grass silage
Silos, bunker type	1 covered	7 open	5 open
Manager training	?	Veterinary	Agr. & Tech. Sch.
General management	poor	good	good
Years since established	4	3	2

All three farms had pure Holsteins imported from Canada. Some cows were too thin, especially on C-9, and the calves and young stock did not appear as clean and well fed as on the other two farms. The buildings on all three farms were of pole construction with thatch roofs and were well designed. Free stalls bedded with sand and feeding manger were well sheltered from sun and rain. The entire area was concreted. The milking parlors had alfa-Laval or Babson milking machines and milk cooling tanks. They were using milk replacers to rear all bull and heifer calves. Breeding was by A.I. and no breeding bulls were maintained with the exception of farm C-9 which had one mature bull. Milk production records were being kept, but we could not communicate well enough to learn whether lactation yields were available, nor to determine calving intervals, conception rates, calf losses, and other important information. Performance data on these farms should be studied.

We were told that seven of these pilot farms had been established. The three visited had been constructed with the concrete level of the pens only a few inches above the level of the flat surrounding pastures. In one case, a lagoon was only slightly below the floor level of the calf rearing pen at this stage of the dry season. The milking parlor pit was a meter below the surrounding level. Clearly, the entire unit complex should have been elevated about a meter above the general ground level to allow reasonable drainage of liquid wastes and maintain dry conditions for the cattle. The pole construction with thatch roofs of the open shelters seemed of good design to take advantage of wind movement and should prove satisfactory for the warm climate. These units could serve as models for other units.

There are several aspects of the management of these dairy farms that should be improved. All units were raising all of the heifer and bull calves on the place and some were past yearlings. Since milk replacers were being fed instead of whole milk, it would be desirable to rear the young stock in a separate unit as an aid in limiting spread of diseases and permitting employees to specialize on calf rearing or entirely on milk production.

Milk Marketing and Processing

The price paid for milk varies from $2.55 to $2.90 per liter, depending on the area and whether it is delivered to the collecting plant or picked up at the farm. If a cow producing even as little as 2,000 liters of milk per year can be maintained on one hectare of pasture, the return would appear to be about the same as the return from pineapples or bananas, for example.

We were told by the milk collecting and processing plants visited that they had capacity to handle up to four times more milk than was presently available and that the demand for milk and other dairy products far exceeds the present supply. Considering the 60,000 tons of dried skim milk imported into Mexico in 1974 and the availability of large areas of undeveloped and under used land, it appears that increased milk production has excellent prospects along with increased beef cattle production.

An important problem of milk processers is the wide variation in milk production between the wet and dry seasons. A more uniform supply would lower processing costs and could help stimulate local milk consumption. It seems clear that problems concerned with processing and marketing of extra milk can be more easily resolved than those concerned with increasing the amounts produced. Consideration should be given to establishing farmer-owned cooperative milk processing and distribution plants as more capacity is required.

Effects of Climatic Stress on Milk Production

Climatic chamber studies with controlled temperature and humidity have shown the comfort zone of temperate type cattle to be -1° to 16°C, compared to 10° to 27°C for tropical type cattle (Zebu). The critical temperatures at which milk yield was depressed were reported to be about 27°C for Holsteins and Jerseys, 30°C for Brown Swiss, and above 32°C for Zebu. There was considerable variation among animals of any breed in tolerance to heat stress, sug-

gesting that adaptation and selection could have great importance in developing dairy cattle for tropical climates. More recent studies have shown that temperate types of cattle do not suffer important declines in milk production unless temperatures above 30° to 35°C persist for 2 to 3 days without night time falls below the critical temperature. These results suggest that climatic chamber studies are less important in measuring the adaptability of cattle to warm climates than growth rates, milk yields, reproductive performance, and general thriftiness of animals and that there will be considerable variation among individual animals of the temperate breeds of cattle especially. It is important to note that improved breeds of dairy cattle (Holstein-Friesian, Jersey, Brown Swiss) produce more milk than Zebus or native heat-tolerant cows, even in very hot areas, and they should be used either as purebreds or in crossbreeding for milk production.

Climatic chamber studies at the University of Missouri showed that decreased feed intake is the most important factor causing declined milk yields at high temperatures and that the depression can be partially overcome by feeding higher concentrate and lower roughage rations. Holstein cows producing 30 kg or more milk per day exhibit some depression in appetite at 25°C, a marked decline at 30°C, and practically stop eating at 40°C. Forage intake declines first, but full intake of concentrates continues until temperatures exceed 35°C. Decreasing roughage and increasing concentrate allowances reduce heat production and help to maintain higher intakes and milk yields. The activity of walking and grazing also increases heat production. Thus, providing feed to cows in shaded pens increases milk yields even without increasing the quality of the ration. Restricting grazing to late afternoons, night time, and early mornings has also improved production. When high humidity is not an added handicap, high temperature can be largely overcome by proper feeding and management. In Israel, for example, some large herds of Holstein-Friesian cows produce an average of more than 10,000 kg of milk in a 10-month lactation, and the national average of all cows on which records are available is between 7,000 and 8,000 kg of milk. Calving rates and longevity are equal to those found in Europe and temperate America. Climatic stress is a small and manageable problem compared to those of disease prevention and developing the managerial skill needed to adequately care for high producing dairy cows in the Gulf Coast. From a practical point of view, since there is no important heat stress problem at elevations above 700 to 800 meters, there are reasons to stress intensive dairy production at higher elevations.

A System for the Production of Milk-Fed Veal Calves

The milk-fed veal calf should be well fattened, weigh 125 to 135 kg live weight, and be anemic in order to yield white meat. This requires feeding only milk or milk replacers without supplementation with usual concentrates or forages which contain iron; otherwise, the meat will be too dark in color to demand the top price in the European market. There is a question whether it would be economical to produce veal calves rather than selling the milk. The sale price of fat veal calves varies and the fixed milk price may be more profitable in Mexico at present than veal production.

In view of the ban on import of all meat and meat animals into the European Community in 1974, one might look with skepticism on any development to meet a small and very specialized European market unless it also has some potential market in Mexico. Such a local market is not unreasonable since American tourists in Europe often find veal steak the most satisfactory meat in hotels and restaurants.

Any cow that will produce 6 to 8 kg of milk daily should be able to produce a fat veal calf in 100 to 135 days. If the cow is a persistent milker, she should produce two fat calves in a lactation. A selected crossbred Zebu X Brown Swiss or Holstein capable of producing 10 to 12 kg of milk daily should be able to fatten two calves nursing together in early lactation and a third calf or even a fourth calf in later lactation if good quality pasture and concentrates are fed.

Crossbred or pure Holstein or Brown Swiss calves are larger at birth (35 to 40 kg) and they gain weight appreciably faster than Zebu or Criollo cattle and, thus, they are more satisfactory for veal calf production. Veal calves should be penned or tied in the shade with access to fresh water, but not forage or other feed. The calves should be allowed to suckle the cow twice a day, morning and evening. They will gain 0.7 to 1.0 kg per day, and be ready for market in 3 to 4 months. Most cows can be trained to accept a second calf if it is introduced along with her own calf soon after calving. Once she is trained, she will accept other calves in later lactation, especially if she is tied up or in a small pen. In New Zealand, Friesian cows were trained to adopt and suckle 4 calves at a time, even on pasture.

The production of veal calves may be a good way to market surplus milk in isolated areas where there is no collecting system for fresh milk. It eliminates the problem of milking and caring for the milk which is always difficult in a hot region. Commercial dairies usually will sell surplus bull calves because it is more profitable to sell milk than feed it to calves.

Presumably, veal calves would be slaughtered in Mexico and the dressed carcasses or perhaps the packaged wholesale or retail cuts exported to Europe.

The most commonly used system of producing veal calves in the U.S. and Europe is to feed milk replacers to surplus bull calves from dairy herds. Holstein and Brown Swiss calves grow rapidly and make good quality veal on commercially available milk replacers at lower costs than on whole milk.

Applied Research for Development of Dairy Production in the Low-Land Gulf Coast

There is critical need for greatly expanded applied research and demonstrations to solve problems which limit the productivity of dairy cows in the Gulf Coast regions. Although results from other countries may be transferable to Mexico, many situations exist in which the effective application of livestock production techniques will depend upon adaptive research in different situations. Among the many questions which need answering are the following:

1. Which crops will produce the most milk per hectare at lowest cost, improved grasses, sugar cane, corn for silage, other?

2. Compare the performance and economy of pure dairy cattle with different grazing-management systems vs confined feeding with adequate supplements.

3. What are the most profitable types of dairy cows for the lowland, tropical Gulf Coast region? Compare pure Holstein, Brown Swiss, and selected Zebu with crossbred Zebu X Holstein and Zebu X Brown Swiss.

4. Will parasites and diseases increase with time on a humid, lowland, dairy farm in the tropical Gulf Coast or can this be prevented?

Proposed Management Systems for Milk Production for Elevations of 100 Meters and Less

1. Extensive, low production.

   Cows: Zebu X Brown Swiss or Holstein.

   Milk yield: 600 kg in 200 days plus rear a calf once daily milking.

   Management: pasture only, native or little improvement, no supplemental feeding except salt and minerals.

   50% calf crop each, year, 1 cow and calf on 2 hectares.

2. Intermediate system and production level.

   Cows: selected Zebu X Brown Swiss or Holstein (up to 3/4 dairy).

   Milk yield: 1,500 kg in 250 days, twice daily milking.

   Management: separate calves and feed limited milk or replacer for 30 to 45 days. Improved pasture 1-1/2 to 2 cows per hectare. Feed concentrate 1.0 kg per 4 kg milk above 5.0 kg per day. Feed cut forage or extra concentrate when pasture is short.

   75% calf crop.

3. Semi-intensive system.

   Cows: pure or high-grade Holsteins or Brown Swiss.

   Milk yield: 3,000 kg in 300 days, twice daily milking.

   Management: separate calves and rear separately. Pasture, improved, high quality, rotational grazing, 2 to 3 cows per hectare to avoid heat of day time, silage or cut forage when pasture is limited, feed concentrates - 1.0 kg per 3.0 kg milk. If needed, allow concentrates one month before calving to improve condition of the cow.

85% calf crop per year, keep heifers from best cows for herd replacement.

4. Intensive dairy production (most adaptable to Panuco basin).

Cows: selected Holstein or Brown Swiss.

Milk yield: 4,000 kg or more in 300 days, twice daily milking.

Management: separate calves for rearing; limit pasture grazing to nights, early morning, and late evening; best quality grasses to feed 4 to 5 cows per hectare; feed silage or cut grass in shaded pens each day between morning and evening milkings; feed molasses free choice; liberal concentrate feeding; 1.0 kg to 2.5 kg milk; condition cows for calving by feeding concentrates; cull and sell low producing cows or those that will not calve within 15 to 16 months.

90% calf crop, keep heifers from best cows for herd replacement, calving interval - 390 days.

APPENDIX C

Conference papers and abstracts of journal articles directly related to pasture and forage production and utilization and animal nutrition.

ECOPHYSIOLOGY OF TROPICAL GRASSLANDS

G.O. Mott, Professor of Agronomy
H.L. Popenoe, Director of Center for Tropical Agriculture

Institute of Food and Agricultural Sciences
University of Florida
Gainesville, Florida
May, 1975

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INTRODUCTION

Tropical and subtropical grasslands encompass a large floristic diversity, a wide spectrum of environmental circumstances, and include, for the purposes of this discussion, man's domestic livestock. Most other papers being presented at this symposium include only one species, some of which occupy a very limited niche in the environment. The authors of this paper must take into account the heterogeneity of plant species, principally those in the grass and legume families and the wide range of environments in which they grow between 30 N and S latitude. A brief summary of the natural grassland ecosystems of the tropical zone is given to acquaint the reader with their floristic composition, their similarities and differences, and some factors which have influenced the development and production of certain ecosystems.

Any particular natural tropical grassland is composed of a multitude of species, and any change in a single component of the environment may bring about drastic changes in the ecosystem. Components of the environment such as light, temperature and water are dealt with only in a general way, since quantitative data for natural grasslands are non-existent and only recently has data become available on a few cultivated forage species. The main emphasis is upon the soil factors which limit production of the primary producers in soil - plant-animal systems. The interface between the soil and plant is of primary concern, although the authors are well aware of the effect of grazing pressure upon the ecophysiology of tropical grasslands. The subject of forage utilization by grazing animals, the effects of quantity and quality of forage on offer and grazing and animal management are omitted from this discussion.

FLORA OF NATURAL GRASSLANDS

DISTRIBUTION OF THE GRASS FAMILY

There is a phylogenetic similarity among the grasses associated with natural grasslands throughout the tropical regions of the World. If the classification of Stebbins and Crampton (1959) is accepted most grasses occur in the subfamilies of Panicoideae and Eragrostoideae. We must be aware, however, that a wide spectrum of environments occurring in tropics suggests that a variety of genera and species have evolved, some of which fit into very narrow niches of ecosystems. If we define the tropical and subtropical region to include in many parts of the world up to 30 N and S latitudes we greatly expand the environments to which tropical grasses have become adapted. Within this zone there are large variations in light intensity and duration, oscillations in temperature, large differences in altitude, amount and distribution of rainfall and tremendous variations in all aspects of soil environment.

The sensitivity of certain genera and species of grasses to specific components of the environment is becoming better understood. Kikuyugrass, (Pennisetum clandestinum) grows well at an altitude of 2500 to 3000 m near the Equator but descends to near sea level at 30 N and S latitude. Certain grasses are adapted to aquatic conditions and a complete spectrum of moisture conditions are to be found in the Amazon basin from almost continuous flooding to very dry desert conditions. It is of interest to note that even with this very broad spectrum of conditions, the primary subfamily of grasses represented is Panicoideae. It is in this subfamily that most of the grasses of the tropics occur, with a few grasses from Eragrostoideae. On the other hand, as we move out of tropical regions

of the world, Festucoideae become the dominant subfamily.

Speciation in the grass family is extremely difficult because changes in environmental circumstances result in morphologically distinguishable differences within species. We are also dealing in many cases with extreme difference in chromosome numbers without any morphological manifestations. To add to the difficulty, apomictic swarms occur in many genera of the Panicoideae subfamily which are difficult to classify. In recent years, the plant geneticist has discovered sexual types in Cenchrus ciliaris and Panicum maximum and this has provided a means of releasing the gene pool. Many new types of grasses are being developed which differ greatly from parent plants both morphologically and agronomically. This promises to be one of the most important developments for production of new cultivars which, no doubt, will increase the range of adaptation of many tropical grasses. Many other species of tropical grasses also have an apomictic behavior and the development of new cultivars awaits discovery of sexual plants within these species.

A classical example of improvement which can be realized by development of new cultivars is that of the selection of a hybrid made by Dr. Glenn Burton at Tifton, Georgia. This is a hybrid between a South African introduction and a naturalized Cynodon dactylon growing in Georgia. This hybrid is almost completely sterile, so it is dependent upon vegetative methods for propagation. It is much more productive than naturalized forms of Cynodon introduced in Southeastern United States and at least five million hectares of 'Coastal' bermudagrass are now being grown in Southern United States. Another cultivar, 'Midland' bermudagrass, has extended the range of the genus Cynodon several degrees further north in the temperate region of

United States. This grass provides a very important source of feed during periods of the year when temperate species are of low production or low quality. Coastcross-1 is another hybrid Cynodon which was selected specifically for its higher rate of digestibility. These examples serve to illustrate some potential improvements which may be made by genetic manipulation of grasses available in the tropics.

THE AFRICAN GRASSLANDS

African grasslands have been the source of most tropical grasses used in improved pastures throughout the world. A description of these grasslands is too complex to include in this paper, but they are well described by Rattray. (1968). African grasslands cover a wide spectrum of environments from dry deserts of the Sahara to the tropical rain forest of Zaire. Ecologically, most grasslands of this continent must be considered disturbed grasslands because of the long influence of man. Another unique feature of African grasslands has been the presence of ungulate animals which have been an important factor in development of grasslands of high productivity in terms of animal products.

Our interest in African grasses relates to the migration of these grasses to other tropical regions of the world and the superiority of many of these grasses to indigenous species of the grasslands of South America, Australia, and Asia. In Central and South America, as well as Australia, most artificial pastures are being planted to grasses which have their origin on the African continent. Forested areas in the Amazon basin are being cleared and planted to perennial African grasses. Similar procedures are being practiced in Central America, in Australia, the cerrados of Brazil, the sabanas of Venezuela and the llanos of Colombia. The superiority of African species is well

recognized, and research is now progressing at a rapid pace to explore the gene pools of a large number of African genera and species for purposes of developing superior grasses for animal production which fit a particular niche in the environment. The migration of African grasses has recently been discussed by Parsons (1972). Some of the most important migrants have been species of Panicum, Pennisetum, Melinis, Hyparrhenia, Cynodon, Brachiaria, Cenchrus and Chloris.

SOUTH AND CENTRAL AMERICAN TROPICAL GRASSLANDS

For purposes of this discussion, major areas of tropical natural grasslands as represented by the cerrados and caatingas of Brazil, savannas of Amapa and Roraima in Brazil, as well as savannas of Venezuela, Guyana, Surinam, and llanos of Colombia will be considered. The cerrados of Central Brazil are mixed formations of trees, shrubs, and an understory of grasses. They occupy extensive areas in the central plateau region of Brazil, primarily in the States of São Paulo, Minas Gerais, Goiás and Mato Grosso. Most natural grasses are very low in quality and belong to the genera Panicum, Paspalum, Andropogon, and some less important genera. Ecologists do not entirely agree as to the reasons for this vast area of grasslands in the central plateau. Three primary factors have been associated with the existance of this grassland region. It has been suggested that cerrados represent a disclimax because of the occurence of annual burning. It has also been suggested that the forest has been prevented from developing because of moisture deficiency due to the relatively long dry season, while others accept the theory that edaphic factors associated with extremely low level of nutrients in the soil are responsible for the grassland type of vegetation. A most important feature of the flora of the cerrados is the number of species and

diversity of the legumes which occur in this region of extremely low soil fertility. This region is a very important source of the genera Stylosanthes, Arachis, Desmodium, Galactia and many other tropical legumes peculiarly adapted to this particular climatic and soil environment. Since there are regions of the world which have similar environmental circumstances, this area may serve as a source of genes for plant breeding programs around the world. Without doubt, one of the most important research efforts which should be undertaken by Brazilian institutions of investigations is to make extensive collections of this treasure of legume germplasm and to make provisions for its preservation for future generations of plant scientists. Most legumes indigenous to this region are very tolerant of acid soils, extremely low fertility, high aluminum and manganese levels, and to moisture stress.

The savannas of Northern Brazil are dominated by the grass genera Trachypogon, Andropogon, Paspalum, Panicum and Axonopus.

Since the soils of the Guyanas, Venezuela and Colombia are heavily leached and the region is characterized by a wet-dry season pattern of rainfall, a thread of similarity exists among the genera of grasses represented throughout this region. There are local differences which are easily recognized by the taxonomists and ecologist, but the procedures for development and improvement of these grasslands for animal production are very similar. Many genera of legumes also occur in the savannas and representatives of the genera Stylosanthes, Desmodium, Aeschynomene, Calopogonium, Centrosema, Clitoria, Galactia, Indigofera, Phaseolus, Teramnus, Vigna, and Zornia are to be found. Very little if any exploitation of these herbaceous legumes has been made and researchers need to avail themselves of the opportunity of

developing these legumes for livestock production.

THE TROPICAL AUSTRALIAN GRASSLANDS

The characteristic species of humid and subhumid tropical grasslands of Australia are *Heteropogon contortus* and *Themeda australis*. There are many other species in the genera *Sorghum*, *Dichanthium* and *Bothriochloa*, but the first two genera are the ones that dominate the vegetation. As rainfall diminishes towards the interior of the continent and conditions become more arid, species of *Aristida*, *Triodia*, and *Astrebla* dominate the vegetation. As in the American tropics there has been a migration of African species into Australia including *Panicum maximum*, *Digitaria decumbens*, *Melinis minutiflora*, *Setaria anceps*, *Cenchrus ciliaris*, *Pennisetum purpureum*, and *Cloris gayana* for improved pasture. The Australian scientists have made great strides in developing tropical legumes which are adapted to a wide range of conditions in the Australian grassland environment. For the humid and subhumid tropical region, *Centrosema pubescens*, *Desmodium intortum*, *Glycine wightii*, *Pueraria phaseoloides* and *Macroptilium atropurpureum* are being planted as rapidly as seed stocks become available. In dryer regions, three different species of *Stylosanthes* are finding a place in their pasture programs. Most of these legumes have been imported from tropical America, although some have been introduced from other tropical regions of the world.

Only a very small area of tropical Australia exceeds 1600 mm of annual rainfall. The relatively low summer rainfall characteristic of tropical Australia has provided an incentive to seek tropical grasses and legumes which will tolerate a long dry season. Many of the same problems associated with low fertility levels, high acidity and moisture stress found in the savannas of tropical America also occur in Australia.

TABLE 1 Physiological features of temperate (C_3) and tropical (C_4) grasses

Characteristics	Temperate	Tropical
Photosynthetic Capacity	20-30 MG $CO_2DM^{-2}H^{-1}$	40-60 MG $CO_2DM^{-2}H^{-1}$
Growth Rate at Optimum	X	2-3X
Photorespiration	Present	Absent
Efficiency of Water use	X	2-3X
Optimum Growth Temperature	15-22°C	25-35°C
Low Temperature Limit	5°C	10°C
High Temperature Limit	30°C	45°C
Light Saturation	20-30 Klux	60 Klux or more

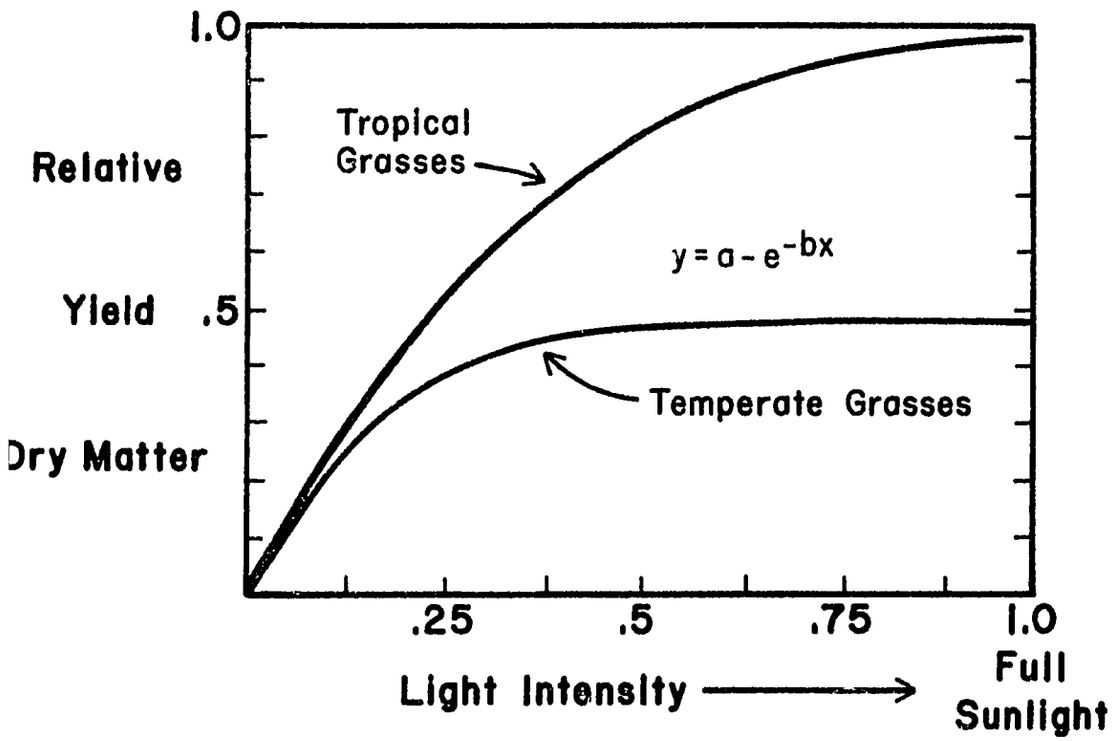

Fig. 1 Relationship of light intensity and yield in tropical C_4 and temperate C_3 grasses.

THE TROPICAL ENVIRONMENT AND GRASSLANDS

LIGHT

Radiant energy is one of the great assets of tropical environments since the variation in the amount of solar radiation received at the top of the atmosphere during the year is quite small. Many tropical species of grasses have a unique CO_2 fixation pathway which, at higher light intensities results in a much higher rate of photosynthesis when compared with temperate species. Currently, two major pathways of photosynthesis are recognized and plants are classified as either C_3 or C_4 plants. A comparison of some physiological features of C_3 and C_4 grasses is summarized in Table 1.

Rates of photosynthesis in tropical grasses (C_4) is in the order of two to three times that of temperate grasses (C_3) and tropical legumes (C_3). This high rate of CO_2 fixation is partially accounted for by a more complicated biochemical photosynthetic pathway and is also partially due to lack of photorespiration. These differences in rate of CO_2 fixation between the C_3 and C_4 plants become much more apparent at higher light intensities. Our present knowledge suggests that C_4 plants may not reach light saturation even at highest levels of solar radiation (Fig. 1), whereas assuming that temperature, CO_2 levels and other factors of the environment are not limiting, light saturation is achieved for C_3 plants at solar radiation levels of less than one-fourth of maximum. C_4 grasses have the facility to convert up to 5 to 6% of incoming solar radiation at the earth's surface at relatively high temperatures giving them a comparative advantage over C_3 tropical legume species. Since variation in solar energy is much

smaller during the year under tropical than temperate climates, if other environmental conditions are near optimum for forage growth, high rates of production can be realized. Yields of over 50,000 kg dry matter per hectare per year have been reported from such grasses as Pennisetum purpureum and Panicum maximum. On the other hand, a high yield of pure tropical legume swards would be in the order of 12,000 to 16,000 kg/ha.

Light Response and Legume-Grass Association

Establishment and maintenance of legume-grass swards in tropical environments have been difficult to achieve. There are many factors which affect the balance between these two plant families, and it is apparent that the difference in their photosynthetic mechanism is one of these factors. Since C_4 grasses have a growth rate of at least twice that of C_3 tropical legumes, optimum nutrient levels for legumes must be provided, and defoliation systems devised to utilize the faster growth of tropical grasses, if the association is to be maintained. Research is being concentrated on this subject to develop production and management systems which will maintain both components in the sward at levels satisfactory for high production and forage quality. Legume-grass associations are very complicated ecosystems in which the environmental factors, light, temperature, nutrient supply and moisture, play important roles. Growth habits of species, their geometry and their recovery mechanisms may also be critical factors in their persistance.

Many tropical legumes are viney plants which maintain a high level of exposure to solar energy by climbing on tall tropical grasses. These are Pueraria phaseoloides, Centrosema pubescens, Macroptilium purpureum and many others. If environmental conditions are optimum for the growth of legumes, it is not uncommon for legumes to become dominant

and to eliminate associated grasses, even though grasses have a comparative advantage of a faster growth rate.

Plant Geometry and Light Interception

Species of tropical grasses differ greatly with respect to their ability to trap solar radiation and thus their net assimilation rate. The optimum leaf area index (LAI) varies from an LAI of 2-3 up to over 15 among species, and there are also extreme differences among strains within species. Some strains of Pennisetum purpureum and Panicum maximum have nearly vertical leaves during much of their growth period, which permits the development of large leaf areas and greater efficiency of intercepted light. Other species of Cynodon, Digitaria, and Brachiaria have their leaves oriented more nearly horizontal and develop much lower leaf areas. Most species of viney legumes have mostly horizontal leaves and relatively low LAI's when compared with grasses. This marked difference between leaf structure of tropical legumes and some tropical grasses adds another complicating factor to management of tropical legume-grass associations. The foliage area required to intercept most incoming radiation is a very important concept in maximizing production of pasture swards. Canopies which display a more horizontal leaf surface will probably have an advantage under more frequent defoliations by grazing animals than those which are more nearly vertical. The latter will reach their maximum production level with less frequent defoliation so that the canopy can better attain it's optimum LAI. Herein lies one of the difficulties of maintaining legume-grass associations with C_3 legumes having a high extinction coefficient, which attain their maximum growth rates at an LAI of about 4, and associated C_4 grasses having low extinction coefficients which attain their maximum growth rate at an LAI of about 12. The concept is illustrated in the

generalized curves in Figure 2. Although the curves do not indicate any specific legume-grass combination, the relationship is obvious. Grasses have a comparative advantage, assuming that other conditions of the environment are optimum for each component of the mixture. However, legumes may occupy about the same competitive position as grasses under low light intensities - rates of CO_2 fixation are about the same for C_3 legumes and C_4 grasses at light intensities of about one-fourth full sunlight - if they have a viney type of growth and are able to maintain a high level of leaf exposure to solar energy. The fact that mixtures of Macroptilium, Centrosema, and Pueraria in combination with Panicum maximum, Pennisetum purpureum and Brachiarias spp. are found under high rainfall conditions, where a heavy cloud cover is common, suggests that grasses and legumes under this light environment are about equally competitive and form compatible mixtures. Areas where such combinations seem to thrive are the wet coastal areas of Queensland, the high rainfall areas of western Ecuador and Columbia, the piedmont region on the eastern slopes of the Andes, and the Southeastern littoral areas of the Brazilian coast. No doubt, many areas of the Amazon basin will also support such legume-grass associations.

PHOTOPERIODIC RESPONSE

Since relatively short day lengths prevail in the tropics, it would be expected that most tropical grasses and legumes would be short day plants. It is well known that some species and cultivars of tropical forages are indeterminate over a wide range of day lengths and show very little photoperiodic response while others are very sensitive to length of day. Some cultivars of Paspalum notatum

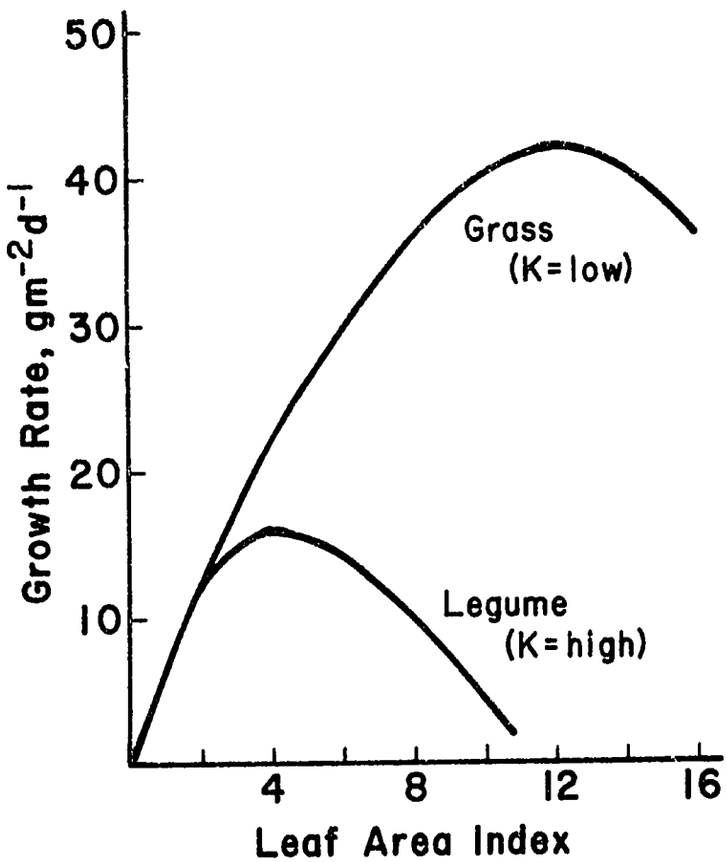

Fig. 2 Leaf area index and growth rates in grasses and legumes as related to leaf architecture. K = extinction coefficient

produce abundant seed at higher latitudes, but never flower at low latitudes. A collection of ecotypes of Panicum maximum in Florida (ca 30 N) exhibits a wide spectrum of photoperiodic responses ranging from types which do not flower during the growing season to those that flower profusely even during the longest days of the year. A similar collection of Pennisetum purpureum in Venezuela (ca 10 N) has both abundant-flowering and non-flowering types. As a pasture grass, Melinis minutiflora performs quite differently at about 20 S latitude in Brazil than it does at low latitudes in Colombia. Initiation of reproductive tillers in many tropical grasses results in the interruption of growth which is frequently followed by a period of dormancy or relatively slow growth. Maintaining grasses in a vegetative state is usually favorable to sustaining a high nutritive value for grazing animals, as well as preserving high growth rates over a longer period of time. The above statements are from observations made by the authors; there is very little critical data available on flowering responses in tropical grasses. The conflict of interest between plant breeders, who strive for high yielding types which produce an abundance of seed, and pastoral agronomists, who prefer non-flowering types with high nutritive value suggests, that new cultivars should include the combined efforts of the two disciplines. Future development of new cultivars for the tropics may require close interregional cooperation with seed being produced of a superior strain in a seed producing environment, which then can be grown for pasture and forage in an environment where no flowering occurs, so that a high nutritive value may be attained. If the development of new cultivars of tropical species is to progress at a rapid pace, then there must be simultaneous screening and selection of superior types under a broad spectrum of

environments. This will provide exposure to all kinds of environmental stresses, including differences in solar radiation, temperature, water and nutrient supply, as well as biological factors such as diseases, insects, weeds and the stress imposed by the grazing animal. Today, the grassland husbandman in the tropical and subtropical regions of the world is dependent upon his seed supply from an entirely different set of environmental circumstances from that in which he operates. Many failures have occurred and will continue until the breeder tests his material under a much broader environment. The photoperiodic response is only one aspect of the total development problem, but a very important one when considering seed propagated cultivars.

Most of the principles with respect to photoperiodic response suggested for grasses also apply to tropical legumes. Photoperiodic response in the genus Stylosanthes (Table 2) was studied by t'Mannetje (1965). The strain of S. guyanensis which he studied, flowered only at the 8 and 10 hr photoperiod while S. mucronata flowered at all photoperiods observed including 14 hrs. Yield of dry matter continued to increase in both species as length of day increased. Since natural distribution of S. guyanensis extends beyond 25 N and S latitude, a broad spectrum of photoperiod responses would be expected within the species. Much more research is needed to determine the strains best adapted to a particular environment.

TEMPERATURE

Temperature is an important factor in determining the general distribution of both grasses and legumes in the tropics and, no doubt, had a major role in the evolutionary development of both families. The two aspects of temperature are seasonal changes, which occur

Table 2 Photoperiodic response of *Stylosanthes guyanensis* and *S. mucronata*. (t'Mannetje. 1975)

	Photoperiod - hrs.			
	8	10	12	14
	No. of days to flowering			
S. guyanensis	52	52	-	
S. mucronata	51	53	54	62
	Yield of Dry Matter - g			
S. guyanensis	9.60	8.77	12.30	12.08
S. mucronata	2.78	2.69	2.18	4.10

during the year and are usually expressed as average daily means, and diurnal variations which are indicated by the oscillation of day and night temperatures. The amplitude of these variations increases with increase in latitude and altitude. Low temperatures restrict the growth of both tropical legumes and grasses and, when temperature during any period of the day drops to 10 C, growth rates approach zero. General relationships between temperature and growth rates of temperate grasses and legumes, tropical legumes and tropical grasses are shown in Figure 3. Optimum temperatures for maximum production of temperate species are in the range of 20 C, for tropical legumes 30C, and for tropical grasses may be as high as 40 C. From physiological studies on other crop plants, increases in temperatures are known to increase rates of respiration, and this general relationship probably also applies to tropical forages. With legume-grass associations, high temperatures above the optimum for tropical legumes would seem to favor the tropical grasses, since tropical legumes reach their maximum growth rate at lower temperatures.

MOISTURE REGIMES

Moisture relationships and their effect upon distribution of tropical forage species and their seasonal production are too complex to deal with in this paper. However, it is well known that water balance in a particular environment may be the dominant factor for pasture production. The water available to forages takes into account the rainfall, the rate of evaporation and the amount of water which the soil is capable of storing within the root zone. Since the root zone differs for different plants, this means that, in addition to physical factors associated with water balance, utilization

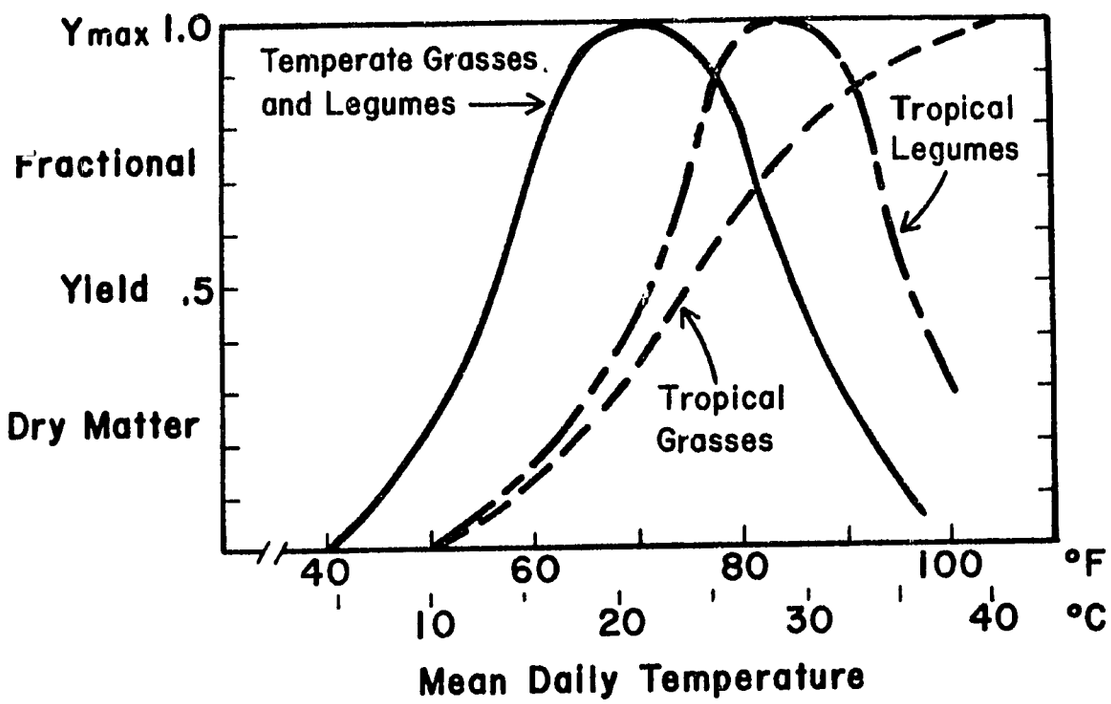

Fig. 3 Temperature and fractional dry matter yield in tropical and temperate grasses and legumes.

of water is also species dependent. Australian investigators (Fitzpatrick and Nix 1970) have developed a model for expressing a moisture index which takes into account long term weekly rainfall and observed or estimated evaporation. The decline of the ratio of actual to potential evapotranspiration as the available water in the root zone is reduced was estimated by a continuous function. A moisture index was derived from the ratio of actual evapotranspiration to potential evapotranspiration. The model has given satisfactory relationships with the production of forages under Australian conditions.

The pattern of rainfall, especially the length of the dry season, is an overriding factor in production of forages in the tropics. The ability of many species to withstand moisture stress determines to a large extent their adaptation to a particular region. Areas in which moisture supply is adequate throughout the year are limited, but length and severity of dry periods are extremely variable. Wide spectrums of moisture regimes in the regions of natural distribution of many species have resulted in development of large numbers of ecotypes of both grasses and legumes.

It has already been mentioned that C_4 grasses use water much more efficiently than C_3 plants (See Table 1). Different cultivars and species of grasses give different responses to the amount of water available and nitrogen levels as indicated by the work of Burton *et al* (1957). Three cultivars of *Cynodon dactylon* and one each of *Paspalum notatum* and *Digitaria decumbens* were studied at three nitrogen levels under field conditions. In the first year, the rainfall during the growing season was 1007 mm and during the second year 347 mm. Results are given in Table 3. All three factors had large effects upon water efficiency. 'Suwannee' had the greatest efficiency and 'Common' the

Table 3 Effect of different grasses, rainfall and nitrogen levels upon water use efficiency (Burton et al. 1957)

	1953 (1007 mm rain)			1954 (347 mm rain)		
N levels (Kg/ha)	56	112N	224N	56N	112N	224N
	Kg water/Kg dry matter					
Cynodon dactylon, Common	6812	2896	1546	9738	5028	4336
Cynodon dactylon, Coastal	2478	1431	803	1547	982	641
Cynodon dactylon, Suwannee	1923	1105	692	1107	725	452
Paspalum notatum, Pensacola	2200	1321	870	3103	1945	1239
Digitaria decumbens, Pangola	2249	1585	2240	2843	2513	3016

lowest efficiency of the grasses. With the exception of 'Pangola', increased nitrogen levels improved water use efficiency. 'Coastal' and 'Suwannee' showed greater efficiency during the dry year than during the wet year, while the reverse was true for the other three grasses.

THE SOIL ENVIRONMENT

Classification of Soils

This discussion of the soil environment will be focused upon soils as a medium for production of forage plants and how it can be modified to provide for more efficient food production for man. Based upon most recent taxonomic nomenclature the following orders of world soils account for the major land surface dedicated to forage and pasture production in the tropics: Oxisols, Ultisols, Alfisols, Inceptisols and Entisols. These are arranged in the descending order of age or degree of weathering. Inceptisols, being of more recent origin, are extremely variable, depending upon the origin of the parent materials, and may or may not be useful for crop production. Oxisols represent the most extreme weathering of parent materials and Ultisols are for the most part highly weathered. McLean (1971) suggests that there is no clear line of demarcation with respect to chemical and physical properties of soil orders, but that they represent a continuum from most recent deposits with little or no weathering to extreme weathering of the Oxisols (Table 4). Since soil acidity and the nutrient supplying power of soils is of primary concern in forage production, the characteristics discussed by McLean are pertinent to this review. As degree of weathering increases, the predominant source of soil acidity shifts from the H-ion concentration to

Table 4 Acid soil continuum: Soil attributes pertinent to liming effects (McLean. 1971)

	Attribute	Mollisols	Alfisols	Ultisols	Oxisols
1.	Permanent charge acidity	H+(some OH-Si^{2+})	OH-Al^{2+}	Al^{3+}	Al^{3+}(Fe^{3+})
2.	Type of clays	Illite, Mont.	Chloritized Mont. and Illite	Kaolinite, Hydrous Oxides	Hydrous Oxides. Kaolinite
3.	Crystallinity of clays	Crystalline	Crystalline	Crystalline & Amorphous	Amorphous & Crystalline
4.	Ionic exchange cap.	High Cation	High Cation (OH-Al Blocked)	Low Cation, Low Anion,	High Anion, Low Cation
5.	Base (Ca & Mg) sat.	Relatively High	Medium to Low	Low	Very Low
6.	Phosphate fixing tendency	Low	Medium	High	Very High
7.	Potassium release tendancy	High	Medium	Low	Low
8.	Structure	Excellent (Ca Aggregates)	Good to Fair (Ca & Al Aggreg.)	Fair to Poor (Fe & Al Aggreg)	Good to Excellent (Fe & Al Aggreg

Al^3. Cation exchange capacity shifts from a high level in a temperate zone Mollisol to a very low cation exchange capacity with a high anion exchange capacity in an Oxisol. Base saturation (Ca and Mg) shifts from high to very low, K release from high to low and P fixation from low to high, as degree of weathering increases.

Water Relationships

Physical relationships of interest are structural stability of soil aggregates (Table 4), rainfall acceptance of the soil as measured by infiltration rate, permeability and rate of percolation and the soil's retention of moisture. Mollisols and Oxisols would seem to have an advantage because of their more stable aggregates, formed as a result of binding by organic matter and hydrous oxids, respectively, although there is considerable variation within the orders. Most heavily weathered Oxisols from both the savannas and forested areas have high infiltration and percolation rates. A grass cover has a modifying effect upon these physical characteristics by intercepting raindrops, formation of a mulch on the soil surface and increasing organic matter content of the soil.

Response to Plant Nutrients

The adaptation and production of tropical forages in many cases will be dependent upon nutrient supplying power of the soil and input of artificial fertilizers into soil-plant-animal systems. If a mixture of tropical legumes and grasses is the objective for a pasture ecosystem, nutrient requirements of legumes must first be met for them to survive. It does not necessarily follow that all tropical legumes have a higher nutrient requirement than grasses growing in the same environment. Some species of Desmodium, Stylosanthes and Arachis are unusually effective

in extracting nutrients which are at very low levels of availability in the soil. Oxisols and Ultisols are the natural habitats of many species of these genera. Neither should one conclude that these legumes will not respond to applications of nutrients which are very deficient. Levels of critical nutrients may be the key to the persistance of legumes in an association. A useful mathematical function for expressing the response to a nutrient or combination of nutrients is the following:

$$Y = A - Be^{-CX}$$

where Y = yield
A = yield when nutrient is adequate
B = sensitivity of the plant to a nutrient or level in nutrient pool
C = curvature of the response
X = nutrient added

Appropriate coefficients are species dependent which is probably also true for strains within species, so that the values of A, B and C will have to be determined experimentally for each species and combination of species.

Recycling of Nutrients

Efficiency with which nutrients are utilized in any agricultural system is dependent upon amounts and frequency of recycling of those nutrients. Mott (1974) has discussed some key ideas in recycling of nutrients in soil-plant-animal systems. A simplified concept of the recycling in such a system is illustrated in Fig 4. The three main compartments are the soil, plant, and animal. The soil is in an equilibrium state with residues which are mainly organic in nature and serve as the principal reservoir of nutrients for plant growth The sizes of unavailable nutrient pools vary considerably for different nutrients and soils with different chemical and physical

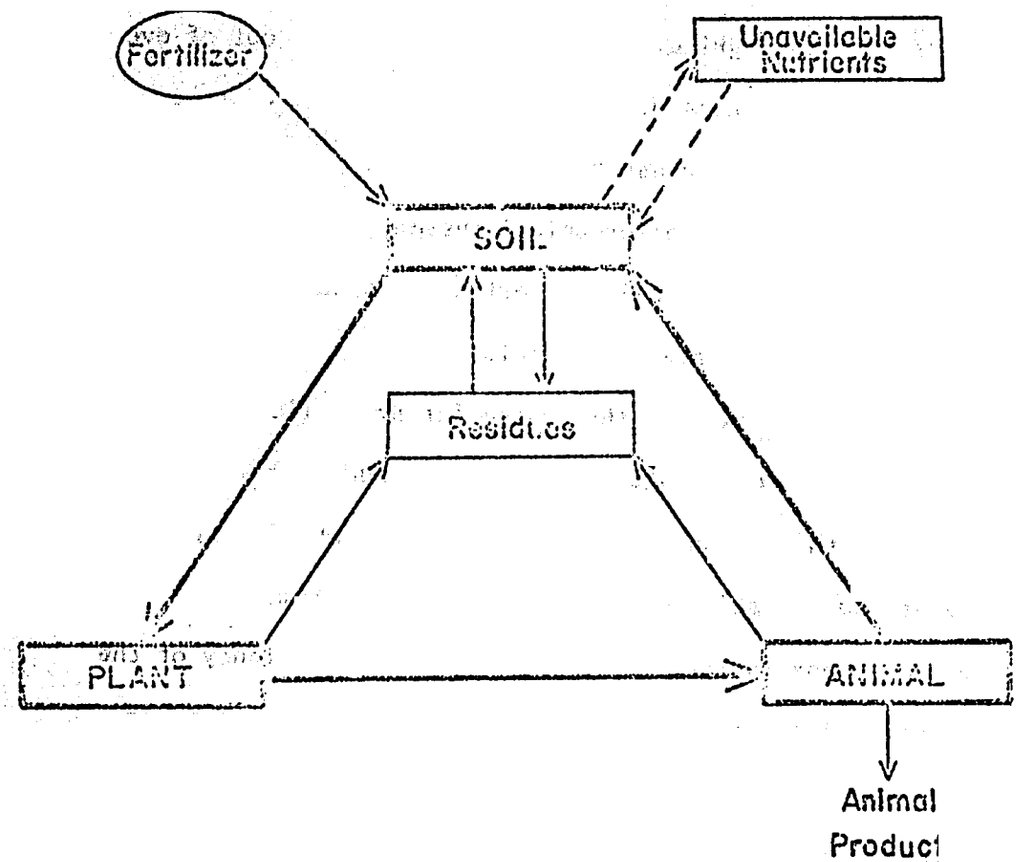

Fig. 4 Nutrient recycling in grazed grasslands.

properties. In Oxisols and Ultisols, with their low contents of total cations - Ca, Mg, and K, - and their extremely low levels of P, only very small amounts of these elements enter the recycling stream and become available for plant growth. These are nutrients which are harvested in shifting agriculture in one or two crops out of every 15 to 25 years. Many years of solar energy are required to generate these nutrients during a forest fallow, which is quickly destroyed by a good burn. In a soil-plant-animal system, the animal is a very important component, continually converting solar energy captured by photosynthesis in forage plants to useful products and recycling inorganic nutrients back into the system for production of more forage. Up to 90% of mineral nutrients and N are returned in excreta of grazing animals, making the grazing animal an effective vehicle for retention and frequent reutilization of nutrients in the system.

There are many factors which influence the efficiency of the recycling mechanism but only a few will be considered. The more intensively the system is managed, the more rapid will be the turnover of nutrients. As yield of biomass is increased there will also be an increase in amount of organic matter in the soil which will increase amounts of nutrients in the residue pool and in the recycling stream. Since levels of nutrients in many tropical soils is inherently very low, some input of aritificial fertilizers may be needed to set the mechanism in motion and maintain a high level of nutrient flow. If a suitable environment for biological N fixation can be created, then this can become the source of N in the system. Intensive systems with high stocking rates, now common on the humid grasslands of Africa can be achieved in other areas with the technology now available.

Little attention has been given to the role of insect fauna in accelerating rates of transport or retention of nutrients in the recycling stream. Lindquist (1933) studied the activity of several different species of coprophagous beetles in native and cultivated pastures of Kansas (Table 5). He found that beetles were not only effective in disposing of cow dung at a very rapid rate, but they also excavated large amounts of soil. Recently, Australian scientists have observed that dung tends to accumulate in their pastures where beetles associated with cattle do not occur. This is in contrast to South African pastures where dung beetles are abundant in excreta of domesticated cattle. Several thousand species of dung beetles are known, and steps are being taken to introduce species into Australia which are adapted to that environment Where dung beetles are present, it has been observed that dung dropped in the pasture by grazing animals may disappear within 24 hours, thus accelerating rates of recycling and retaining most of the nutrients in the nutrient pool.

Nitrogen Relationships

For grasses in a pasture sward, N is frequently the most important nutrient limiting factor. Only rarely does a lack of response occur to an application of N fertilizer in a cultivated pasture. A recent review by Vicente-Chandler (1974) indicates some of the potential production of humid tropical grasslands. Studies have been made upon *Panicum maximum*, *Digitaria decumbens*, *Brachiaria mutica*, *Cynodon nlemfuensis*, *Pennisetum purpureum* and many others in Puerto Rico, Brazil, Venezuela, Colombia and Nigeria. Responses to N fertilizer have been almost linear up to 400 to 600 kg of N/ha/year. At higher levels, the rate of response diminishes until no further increase occurs.

Table 5 Quantities of dung buried and soil excavated by coprophagous beetles. (Lindquist, 1933)

Species	Quantity/burrow, g	
	Dung buried	Soil excavated
Pinotus carolinus	48.5	287.1
Copris tulius	7.3	37.8
Phanaeus spp.	9.6	93.4

Within this range of application, increases in dry matter production are from 30 to 50 kg for each kilogram of N applied. Under grazing conditions, an increase of 1.2 to 2.0 kg of liveweight of beef was obtained for each kilogram of N applied. Gross annual yields of dry matter have exceeded 50,000 kg/ha under favorable humid tropic conditions at high levels of fertilizer inputs. These responses occurred under conditions of minimum moisture stress and where other nutrients in the system were near optimum. These rates of increase were obtained on an Ultisol with from 30 to 50% slopes, with an initial pH of 4.8 to 5.2 and 4 to 8 meq of exchangeable bases/100g of soil. Annual rainfall ranged from 1500-2000 mm, and mean monthly temperatures from 21 to 27C. These data are cited here to indicate levels of production which are possible on highly weathered soils. It is not suggested that these ecosystems are economically feasible or desirable, but the results under experimental conditions reveal some of the biological potentials and limitations associated with the soil.

Possible sources of N to the soils-plant system include biological N fixation by both legumes and grasses. Fixation of atmospheric N by legume-Rhizobium symbiosis is well known and does not need elaboration. Reports of annual N fixation rates in excess of 200 kg of elemental N/ha have been recorded for tropical legumes. This is in the same order of magnitude as for temperate legumes and should be an incentive to exploit tropical legumes for forage, for cover crops and as green manure crops in rotational and multiple cropping systems. In intensive grazing management systems, at least a portion of the N generated by the legumes is recycled, and the

general level of N in the nutrient pool is raised.

It has been known for sometime that certain organisms associated with members of the grass family fix N. Dobereiner in Brazil has described such associations in Paspalum notatum, Pennisetum purpureum, maize and sugarcane.

Since 1972, new evidence has been discovered that N fixation in a much broader spectrum of grasses may be occurring in the tropics, and this discovery could have far reaching implications in the future development of forage-livestock feeding systems (Dobereiner and Day, 1974). Nitrogenase activity has been demonstrated in a number of grasses including Digitaria decumbens. The organism has been identified as Spirillum lipoferum and is concentrated in cortex cells. There is a suggestion that it is associated with C_4 grasses which have malate as one of its primary products of photosynthesis. S. lipoferum is known to utilize malate as an energy source, and it seems reasonable to assume that malate may be available as a substrate. In any symbiotic relationship, there is a partnership between the host plant and the microorganism. In this case, the Spirillum appears to be genotype specific, and the matching of the proper strain of Spirillum with the grass genotype is of utmost importance.

Phosphorus

In highly weathered soils of the tropics, total and available P levels are very low. Fixation of P is extremely high due to formation of Fe and Al phosphates. Small amounts of P released in ash from burning the forest in shifting cultivation or in the savanna are either quickly utilized by crops planted by farmers or by regrowth of savanna vegetation. Very little P in available form is in the soil for an

extended period of time. The adaptation of savanna grasses to these very low levels of P is related to their ability to extract P and their physiological tolerance. Many African introductions will not tolerate these low levels of P and require phosphate fertilizers to be productive.

Applications of lime to raise pH to a level of between 5 and 6 may neutralize exchangeable Al sufficiently to reduce fixation of P and increase rates of decomposition of organic matter, but great care must be taken to avoid overliming which may have an adverse effect upon availability of other nutrients. The possibility also exists that, as more P is released, the decrease in P levels will be more rapid. In this respect, liming highly weathered soils may have a long term deleterious effect upon the savanna and upon shifting agriculture. Application of 100-250 kg/ha of molybdenized superphosphate in seedings of several tropical legumes in Australia is standard practice followed by a maintenance application every one to three years. This amount is not sufficient to attain maximum yields initially, but, as production increases and with constant recycling of an increment of the P previously applied in a grazed pasture, levels of P can be increased over a period of time. Similar phenomena also occur with other nutrients which are not easily leached.

Sulphur

Sulphur deficiency is of very frequent occurrence in highly weathered soils of the humid tropics. This deficiency is frequently not evident since other nutrients, especially N and P, are at such a low level that symptoms of S deficiency do not appear. Raising N levels in cultivated pastures by N fertilizer application may result

in an increase in organic matter sufficient to create an imbalance in the N:S ratio so that S becomes unavailable and symptoms become strikingly evident. With the disappearance of fertilizers containing sulphur, such as ammonium sulphate and simple superphosphate, the S problem with both tropical crops and cultivated pastures promises to become more acute. Sulphur is a critical element for both tropical grasses and legumes.

Potassium

There are at least five different forms of K in the soil-plant system: K in the organic residues, exchangeable K, fixed K, K in the crystalline matrix and K in the soil solution. In soil-plant-animal systems, the major pool of K available to plants and in the recycling stream may be found in the organic residues. Residue K is in equilibrium with exchangeable and soil solution K, and the key to a sufficiency of K in the system is dependent upon applying K if it is not already present in the soil. Potassium responses on well established productive pastures is seldom observed because of effective recycling of K in the system.

Critical Plant Percentages of Phosphorus, Potassium and Sulfur

Andrew and his coworkers (1969a, 1969b, 1974) in Australia have established critical percentages of P, K, and S for several of the more common tropical legumes. The critical percentage is defined as the "percentage of the element in the plant tissue corresponding with optimum growth, above which no further yield response may be expected and below which additional growth could be expected if the element concerned was supplied." The critical percentages were obtained under standardized growth conditions, sampling procedures, and with

all other nutrients except the one being tested supplied at adequate levels. The results are presented in Table 6. Stylosanthes humilis and Centrosema pubescens reached optimum levels of production at lower levels of P, K and S than most other legumes. The requirements of alfalfa (Medicago sativa) are obviously higher than for most tropical legumes except for P. Five of the seven legumes appear to have as high a requirement for P as Medicago sativa. This seems to indicate that P may be a key element in the satisfactory production of tropical legumes especially on highly weathered soils which are very low in available P. Levels as high as those provided for Medicago sativa may be needed for some tropical legumes.

Calcium

In temperate zones of the world, lime is applied as a soil amendment to adjust pH to 6.5 or above for crop production. Research during the past 25 years by soil chemists suggests that lime should, on some soils, be considered as a source of nutrient Ca rather than as a soil amendment. In Table 4, it is indicated that the source of soil acidity in a Mollisol is the H^+ ion concentration while in the Ultisols and Oxisols, Al^{3+} is the primary source. It is now known that poor growth of many crop plants on the highly weathered soils of the humid tropics is due to toxic levels of exchangeable Al and in some cases Mn. A comparison of tropical and temperate legumes and their response to increasing ratios of Al to Ca + Mg is given in Fig 5. Very little quantitative data is available for forage legumes and grasses as to their tolerance to Al and it is very difficult to separate the effects of pH, nutrient Ca, toxic levels of Mn and availability of micronutrients from Al toxicity in a soil-plant system.

Table 6 Critical percentage levels of phosphorus, potassium and sulphur in the tops of eight legume species. Preflowering stage. (Andrew and Robins. 1969a, 1969b; Andrew. 1973-1974)

	Critical Percentage		
	P*	K+	S‡
		% of Dry Matter	
Macroptilium lathyroides	0.20	0.75	0.15
Macroptilium atropurpureum	0.24	0.75	0.17
Desmodium intortum	0.22	0.72	0.17
Desmodium uncinatum	0.23	0.80	0.17
Stylosanthes humilis	0.17	0.60	0.13
Glycine wightii	0.23	0.80	0.18
Centrosema pubescens	0.16	0.75	0.15
Medicago sativa	0.24	1.20	0.21

*Andrew and Robins, 1969. +Andrew and Robins, 1969. ‡Andrew, 1974.

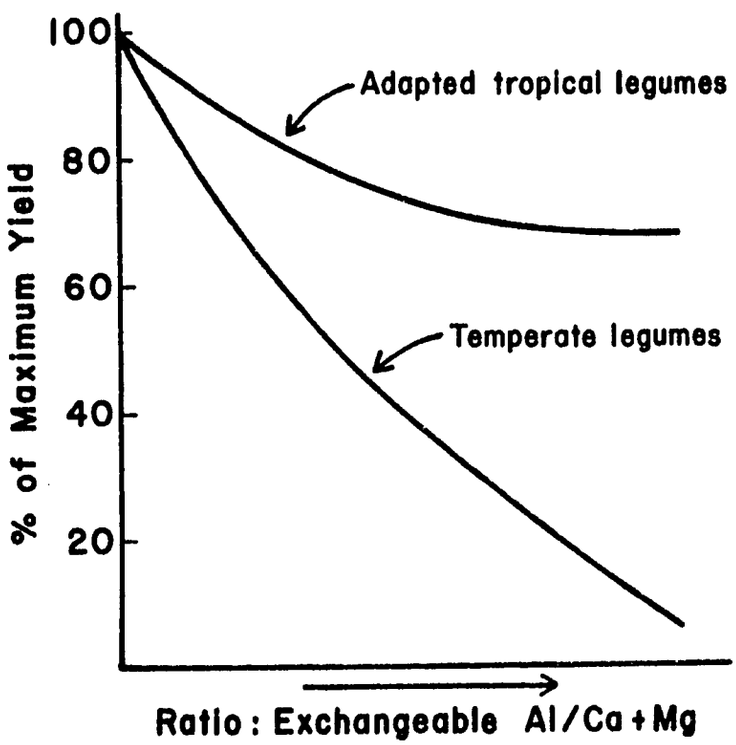

Fig. 5 Exchangeable Al/Ca + Mg ratios and fractional yield of tropical and temperate legumes.

There are some indications that the yield of some tropical legumes is reduced in yield to about 70% of maximum at high levels of exchangeable Al, whereas temperate legumes may not survive under similar conditions. It is not clear, however, whether the effect is solely toxic Al or whether a combination of factors are operating. Some examples of cation - Al relationships in Brazilian soils are given in Table 7. The pH of all soils is low and Al saturation of the exchange capacity ranges from 2 to 90%. Ratios of Al/Ca + Mg found in some of these soils will depress the yield of some of the most Al tolerant legumes. Under these conditions, a small amount of calcium carbonate applied to the soil may have a marked effect upon yields.

Spain (1975) studied the effect of lime application rates upon yield and composition of tropical legumes on an Oxisol in the llanos of Colombia. The soil had a pH of 4.5, 3.5 meq./100 gm of Al^{+++}, 0.5 of Ca^{++} and 0.3 of Mg^{++}. His results indicate that only 150 kg/ha of lime was required to give nearly maximum yields and that up to four metric tons gave no further increase. Percent Ca in plant tops increased markedly for the first 150 kg/ha and continued with a small incremental increase up to four tons of added lime. Percent Mn decreased drastically for the first 150 kg/ha and continued to decrease as the rate of lime increased up to four tons. The results for Stylosanthes guyanensis are presented in Fig 6. These results suggest that tropical legumes respond to nutrient Ca but are probably quite tolerant of Al and Mn. Further research is needed to more clearly define the effect of Ca upon the other nutrients in the system and their interaction with various tropical legume and grass species.

In solution culture, Andrew and Hegarty (1969) studied the

Table 7 pH, exchangeable cations, percent aluminum saturation and exchangeable Al/exchangeable cation ratios of some highly weathered tropical soils.

Soil	pH	Exchangeable Ca & Mg (meq/100g)	Exchangeable Al (meq/100g)	Aluminum saturation %	Al/Ca + Mg ratios	Source
Red yellow latasol (1)	4.3	0.3	1.7	83	5.7	Pratt & Alvahydo 1966
Red yellow latasol (1)	5.5	4.2	0.1	2	02	idem
Red yellow latasol (1)	4.5	1.3	0.8	36	.6	idem
Red yellow podzolic(1)	3.7	.3	3.8	90	13	idem
Hydromorphic laterite (2)	4.2	.1	2.24	49	22	OEA-1974
Hydromorphic laterite (2)	5.0	.14	4.14	77	30	idem
Yellow latosol (2)	4.7	.24	1.83	24	8	idem

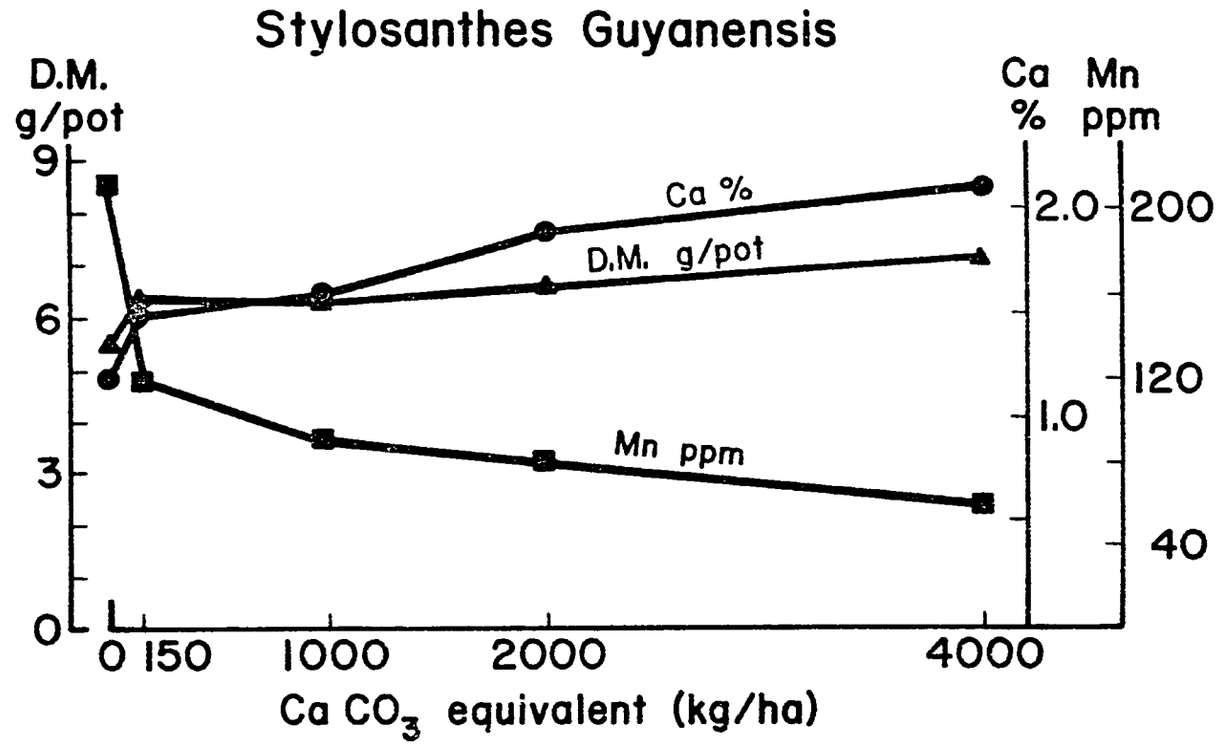

Fig. 6 Effect of lime upon dry matter production and Ca and Mn concentration of Stylosanthes guyanensis.

effect of Mn concentration upon the yield of several legumes and established their tolerance levels to this potentially toxic element. Their results are presented in Table 8. The seven legumes are listed in order of their tolerance of Mn in the solution. At the highest concentration of Mn studied - 40 ppm - the percent of maximum yield ranged from 70% for C. pubescens to 9% for M. atropurpureum indicating a far greater tolerance of C. pubescens than M. atropurpureum. Toxicity threshold was defined as the concentration of Mn in plant tops which corresponded to a 5% reduction in yield. C. pubescens had the highest concentration, followed by S. humilis, D. uncinatum and M. sativa with the lowest concentration at the toxicity threshold.

Micronutrients

With the low level of macronutrients in highly weathered soils of the tropics, micronutrient deficiencies have been obscured or do not exist. As the fertilizer input has been increased for more intensive crop production, deficiencies of one or more of the micronutrients have appeared. Another factor which has increased the likelihood of micronutrient deficiencies is the use of higher analysis fertilizers with less micronutrient impurity. Under natural savanna conditions, micronutrient deficiencies are seldom observed, but, as more legumes and grasses which have a higher nutrient requirement are introduced, micronutrient deficiencies begin to appear.

There are many difficulties in assessing the micronutrient situation in tropical pastures because of extreme variations in local soil situations and the variation among species and cultivars in their ability to extract nutrients from the soil. The situation becomes clear in the case of Mn (Table 8), where the concentration of

Table 8. Manganese toxicity associated with yield of legumes (Adapted from Andrew and Hegarty. 1969)

Species	Rank	Yield b* grams	% yield at 40ppm+ .5ppm=100	Toxicity threshold‡ p.p.m.
Centrosema pubescens	1	-.0023	70	1600
Stylosanthes humilis	2	-.0038	50	1140
Macroptiluim lathyroides	3	-.0066	29	840
Desmodium uncinatum	4	-.0080	24	1160
Medicago sativa	5	-.0102	18	380
Glycine wightii	6	-.0128	11	560
Macroptilium atropurpureum	7	-.0159	9	810

* Unit decrease in yield (log) per unit increase of Mn in solution culture

\+ Percentage yield when 40 ppm Mn supplied in solution culture

‡ Toxicity threshold level = concentration of Mn in dry matter of the tops, which corresponds to a 5% reduction in yield.

Mn in the dry matter of seven legumes, which results in a 5% reduction in yield, varies from 380 to 1600 pm (Andrew and Hegarty, 1969). Documentation of micronutrient deficiencies in tropical forages is rare, but deficiencies of zinc, cooper, boron, molybdenium, iron and manganese are certain to receive greater attention as pasture-livestock feeding systems become more intensive. It is also well known that legumes have greater sensitivity to micronutrient deficiencies than grasses. As scientists and farmers attempt to include legumes in pastoral systems, micronutrients seem certain to enter as limiting factors for production.

FIRE AS AN ENVIRONMENTAL FACTOR

Burning of grasslands and use of fire as a management tool have both been the subject of much discussion for many years. Differences of opinion stem from personal experiences of scientists working with various grassland types in different parts of the world under a wide variety of circumstances. There seems to be little justification for burning a grassland which remains acceptable to the grazing animal during most of the year, as is the case of many improved pastures in the humid tropics. Solar energy stored in the pasture sward, which can be utilized to produce a useful animal product, justifies the utilization of that forage if productivity of the grassland is maintained. Some ecologists have difficulty in accepting man and his domesticated animals as components of grassland ecosystems, and any change which occurs as a result of man's intrusion is considered to be a degradation of the ecosystem. Fire is also one of those components of the environment which is considered in a negative sense, since many ecologists regard a natural grassland savanna as a disclimax. It does

not matter that all evidence points to the existance of fire as an environmental factor without the presence of man. These authors prefer to include fire as a component of grasslands ecosystems over which man may or may not exercise a degree of control.

Fire in wet-dry tropics has resulted in the evolution of grasses and other plants which have a high degree of resistance to burning. Very little if any burning occurs in the wet-humid tropical environment subjected to a dry season of less than two months. In areas where a longer dry season is characteristic of the environment burning the natural grassland savannas every one to three years is a common practice. The necessity and advantages of burning have been reviewed by Tothill (1971). He quotes from West (1965) who gave six main reasons for using fire regularly as a management practice in a pastoral system.

1. To remove top hamper in order to increase the availability of new season's growth and to remove patchiness in unevenly grazed pastures.

2. To stimulate growth at a time when it might otherwise not occur.

3. To control regrowth of trees and shrubs and to clean up fallen timber.

4. To attract animals to areas that might otherwise be left ungrazed.

5. To remove the hazard of wild fires and to establish fire breaks.

6. To control diseases, and pests such as ticks.

If the objective is to maintain the species already present in the native grassland, then burning near the end of the dry season will probably accomplish this objective. The indigenous plants have evolved over the ages from a similar burning regime. Burning at periods other than at the end of the dry season may adversely effect

some of the native grasses. Considerable shifts in botanical composition have been reported in Africa and Australia from off season burning. Since less than 50 percent of the biomass is utilized on most native tropical grasslands, there is usually plenty of fuel for fire.

Burning removes unpalatable accumulation from the previous wet season's growth and contributes to more uniform utilization of forages by grazing animals. It also keeps in check invasion of trees and shrubs which frequently reduce production of desirable forage species. There are numerous examples of the invasion of trees and shrubs into grasslands which were originally grasslands. Much of western Texas was covered with short grasses prior to settlement by European immigrants. When the incidence of fire was reduced from that set by the American Indians, Prosopis juliflora moved in from stream banks and completely invaded the grasslands. Similar invasions have been observed on the margins of the gallery forests and tall grass prairies of the Central United States and the forest-savanna margins in Africa.

Burning of the savanna is charged with reducing the organic matter content of the soil but this has been extremely difficult to document. However, two very deficient nutrient elements are almost completely volatilized in the burning process - nitrogen and sulphur. Since sulphur is present at such extremely low levels in the atmosphere over the tropics, loss of this element in the burning process may be a serious loss. A large proportion of mineral nutrients are in plant tops and litter; non-volatile ones are released in the ash and become more readily available to growing plants early in the next rainy season. It is evident that fire provides a means of accelerating

the recycling of nutrients in soil-plant-animal systems. Extreme care must be exercised, however, to prevent burning of the savanna after new growth has started in order to prevent injury to the desirable species. A period of rest during the previous wet season to allow for an accumulation of fuel and build-up of food reserves, and another period of rest after the burn to prevent the depletion of reserves by overgrazing, are sound pre and post-fire management practices.

CONCLUSIONS

Grasses and legumes occupying the highly weathered Oxisols and Ultisols of the South American grasslands are adapted to very low fertility levels, high levels of exchangeable aluminum and, in some cases, manganese, periods of moisture stress and frequently to abuse from overgrazing. Not enough attention has been given to these indigenous plants to determine the potential of selected species as feed for domestic animals. Scarcity and high cost of fertilizers and other physical inputs used in pasture-livestock systems dictate that improvement in production must come from systems which make maximum use of the natural grasslands and the species which are best adapted to the environment . A better understanding of the physiology of these forage species, their responses to various components of the environment and to changes which can be imposed by man will provide a basis for the development of production systems which are economical and which will preserve the ecosystem. However, they have been almost completely neglected. Most of the exotic tropical forages introduced from other parts of the world require high levels of inputs for their maintenence. Under certain circumstances, their strategic use in forage livestock systems may be justified to provide higher quality feed than that provided by the natural grasslands, but benefits obtained must be balanced with the additional costs. A combination of a relatively large area of natural pastures for the breeding herds and a small area of high producing, high quality pasture for the young stock and for flushing the females during the breeding season appears to be a viable system of management.

The shift from forest to grassland, as is occurring at a very rapid pace in the Amazon region, presents another problem. Native forages are almost entirely absent, and the only species available for planting are the exotics. Since almost the entire nutrient supply of the tropical forest ecosystem is retained in the above-ground biomass, the relatively small quantity of nutrients released by burning is quickly leached and may be lost beyond the root zone of the forage species. This is especially true if a few years of intertilled crops are grown before pasture establishment. Unless legumes which are adapted to the climatic environment and particularly to the soil environment are included in pasture mixtures, the chances of a productive pasture for any long period is remote. Even the indigenous legumes, which are well adapted to the highly weathered soils, will require additional nutrients to persist in association with the exotic grasses.

The nutrient demand varies greatly between species, between strains, and between cultivars of tropical grasses and legumes. Research efforts should be focused upon the development of forages which are highly efficient in their extraction of soil nutrients and accelerate their turn-over rate in the system. Most evaluation of forages by the introduction specialist and plant breeder is conducted under higher fertility levels than those to which the released cultivar will be exposed. Under such a testing regime, superior germplasm may be discarded because it fails to respond to high levels of fertilizer.

Central and South America provide the natural habitat of almost all the known genera and species of promising tropical forage legumes. The conservation of this treasure of germplasm is urgent, since large areas of natural grassland and forest fringe areas, where these legumes

occur, are being destroyed by settlement schemes. If an extensive program of plant collection is not initiated soon, a large proportion of the gene pool will be lost. This will narrow the genetic base available in the future for improvement and development of cultivars adapted to a wide spectrum of environments. Before it is too late, germplasm banks for these promising species should be established in several countries of Latin America.

Additional research is needed to determine the net primary production of tropical grasslands and their effectiviness in controlling erosion. The role of the grazing animal as a component in the system for recycling nutrients needs further investigation. It is of interest in this connection that the most productive natural grasslands of the world occur in regions where there is a long history of large populations of ungulate animals, which suggests that the animal may have been an important agent in reducing the losses of nutrients and may have contributed to the retention of small increments of N added to the system by biological and non-biological N fixation. The possibility of accelerating this rate of soil improvement through the use of legumes and selected grasses, biological N fixation, and fertilizer N deserves intensive study.

The use of animal products to alleviate the food deficiency situation in certain countries has been criticized on the basis of the inefficiency of the grazing animal in converting above-ground plant biomass to an acceptable food product. The critics do not seem to understand that the biomass which is converted to animal product has no alternative use for food except through fermentation by the ruminant animal. Meat is often considered to be a food product for only the affluent, developed countries, but it is well known that millions of

people subsist from foods generated by their herds and flocks. Perhaps the grassland scientist can make a contribution to mankind by developing techniques for increasing the productivity of grasslands and their conversion to animal based foods.

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PRESENTATION PAPER

Conference on Beef Cattle Production in Developing Countries.
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Lee R. McDowell
Assistant Professor
Department of Animal Science

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Center for Tropical Agriculture
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MINERAL DEFICIENCIES AND TOXICITIES AND THEIR EFFECT ON BEEF PRODUCTION IN DEVELOPING COUNTRIES (Abstract)

L. R. McDowell
University of Florida, Gainesville, Florida, U.S.A.

Beef cattle productivity in the developing countries is extremely low. To illustrate with double the cattle numbers Latin America produces half as much beef as the United States. Nutritional disorders, including numerous mineral deficiencies, imbalances and toxicities contribute heavily to the low level of productivity. Factors affecting mineral requirements include nature and level of production, age, chemical form of elements, interrelationship with other nutrients, mineral intake, breed and cattle adaptation. Often grazing cattle do not have access to mineral supplementation with total dependence on forages to meet these needs. It is uncommon when forages can completely provide all the mineral requirements of grazing cattle particularly when many forages are grown on highly weathered, leached soils of the tropics. Mineral concentration in forages is dependent upon the interaction of a number of factors including soil, plant species, stage of maturity, yield, pasture management and climate. On the basis of clinical signs, forage and tissue analyses, and response due to mineral supplementation, deficiencies of thirteen different minerals have been demonstrated to inhibit cattle production in the developing countries. Phosphorus deficiency is the most frequently encountered mineral deficiency for grazing cattle while inadequacies of Co, Cu, Na and I and toxicities of Se and F are also widespread throughout the developing countries of the world. Over 30 developing countries have reported P deficiencies. Many investigators have noted a 20 to 50% increase in calf crops due to P supplementation. Although mineral concentrations of tropical forages are lowest during the dry season, numerous reports including those from Kenya, Brazil and the Union of South Africa note that specific mineral deficiencies are more prevalent during the wet season. During the wet season mineral requirements are

greatly elevated since cattle are making rapid gains due to sufficient energy and protein supplies. On the contrary, mineral requirements are lower during the extensive dry season since cattle often are losing weight or in maintenance. Liver tissue concentrations are good indicators of Co, Cu, Mn and Se mineral status while blood levels provide useful aids in diagnosing Ca, Mg, P and Zn deficiencies. Additional animal tissues employed to assess mineral status include saliva (Na), milk (I), hemoglobin (Fe), bone (F toxicity) and hair (Mn toxicity). A systematic mapping technique, based on tissue and forage mineral analyses can be employed to predict where mineral deficiencies or toxicities will occur for grazing animals. Borderline mineral deficiencies with no obvious clinical signs are far more common than acute deficiencies. Attempts to raise cattle productivity in developing countries will be unsuccessful unless the nutritional environment, including adequate mineral nutrition, is likewise elevated. In order to ensure adequate mineral nutrition sufficient mineral supplements should be available "free choice" to cattle. Mineral supplementation is a least cost input to improvement of beef cattle production. Molybdenosis can be controlled by Cu supplementation, fluorosis by periodic or complete removal of cattle from fluoridated waters and selenosis by rotational grazing to avoid continuous access to high Se forages or by diluting the ration with feeds low in Se.

MINERAL DEFICIENCIES AND TOXICITIES AND THEIR EFFECT ON BEEF PRODUCTION IN DEVELOPING COUNTRIES

L. R. McDowell

University of Florida, Gainesville, Florida. U.S.A.

Introduction

Numerous mineral deficiencies, imbalances and toxicities are severely inhibiting the cattle industry in most developing countries. At least fifteen mineral elements, including calcium (Ca), chlorine (Cl), Magnesium (Mg), phosphorus (P), potassium (K), sodium (Na), sulfur (S), cobalt (Co), copper (Cu), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se) and zinc (Zn) are nutritionally essential for cattle. In specific areas, toxic concentrations of Cu, fluorine (F), Mn, Mo or Se limit cattle production.

My remarks concerning mineral deficiencies and toxicities will be directed to countries in Latin America, Africa and parts of Asia. Geographically the discussion is applicable to all of the developing countries located 35° North and South (N-S 35°) of the equator (near tropics, subtropics and tropics). It is beyond the scope of this report to elaborate on the many diverse functions of mineral elements. The discussion will emphasize the probable incidence, significance, detection techniques and preventive methods for cattle mineral deficiencies and toxicities.

Low reproductive rate, characterized by first calvings at 4 to 5 years of age with a calf in alternate years only, is the most important single factor limiting cattle production in developing countries. As an example, Latin America with double the cattle numbers produces one half as much beef as the United States.

Nutritional disorders account for a major segment of the factors limiting productivity of cattle. Wasting diseases, loss of hair, depigmented hair, non-infectious abortion, diarrhea, anemia, loss of appetite, tetany, low fertility and pica are clinical signs often suggestive of nutrient or more specifically mineral deficiencies throughout

the world. Energy and protein are frequently in short supply but the extent to which a deficiency is responsible for certain clinical signs is still largely unanswered. Numerous investigators, however, have observed that cattle sometimes deteriorate in spite of an apparent adequate feed supply (Davis, 1951; Russell and Duncan, 1956; Sutmöller, Vahia de Abreu, Van der Grift and Sombroek, 1966). Cattle grazing forages in a severe Co or Cu deficient area are even more limited by lack of these elements than either that of energy or protein. Many investigators in developing countries have indicated that the addition of only a P supplement to grazing cattle would increase calving percentage from 20 to 50% above the previous rate (Bisschop and Groenewald, 1963; Ward, 1968; Poultney, R. E., Personal Communication, 1972; Brumby, 1974). Frequently, beef cattle in the developing countries depend almost entirely upon forages to supply their mineral requirements. Only rarely can forages completely provide all the mineral requirements of grazing cattle.

Factors affecting the mineral content of plants

Concentrations of mineral elements in forages are dependent upon the interaction of a number of factors including soil, plant species, stage of maturity, yield, pasture management and climate. Most naturally occurring mineral deficiencies in cattle are associated with specific regions and are directly related to soil characteristics. Young and alkaline geological formulations are more abundant in most trace elements than the older, more acid, coarse, sandy formations (Hartmans, 1970) Poor drainage conditions increase extractable trace elements, thereby resulting in a corresponding increase in plant uptake (Mitchell, Reith and Johnston, 1957). As the soil pH increases the availability and uptake of Fe, Mn, Zn, Cu and Co decreases, whereas Mo and Se concentrations increase (Latteur, 1962; Pfander, 1971; Miller, Lassiter and Jones, 1972).

Large variations in mineral content of different plant species growing on the same soil have been reported by a number of researchers (Thompson, 1957; Underwood, 1966;

Gomide, Noller, Mott, Conrad and Hill, 1969). As an example in certain regions, accumulator species containing over 1,000 p.p.m. Se are found growing alongside grasses containing less than 10 p.p.m. (Beeson, 1961).

As forages mature a corresponding decrease in minerals occurs thereby decreasing forage quality for grazing cattle in the tropics. Underwood (1966) noted that in most circumstances P, K, Mg, Na, Cl, Cu, Co, Zn and Mo decline as the plant matures. Data on six Brazilian forages revealed significant decreases ($P < .01$) in K, P, Mg, Cu and Fe as plant age increases from 4 to 36 weeks (Gomide et al., 1969). Losses of nutrients from forages as plants mature are probably due to translocation to the root system (Tergas and Blue, 1971).

Pasture management and forage yield influence plant mineral composition. Cattle grazing pressures will influence the species of forage predominating in pastures, thereby affecting mineral composition. From India, Whyte (1962) observed that good perennial grasses are "grazed into the ground" late in the dry season, resulting in disastrous effect on their powers of regeneration and replacement with tougher species of inferior quality.

Pasture management involving liming and fertilization can be extremely beneficial to increasing forage mineral concentrations. Overliming, however, can accentuate a Se or Mo toxicity in livestock by increasing plant concentrations of these elements and at the same time favor Co and Mn deficiencies due to lowered plant uptakes. Overuse of Nitrogen (N) and K fertilizers increases the incidence of grass tetany (Kemp, Deijs, Hemkes and Van Es, 1961) and K fertilization also dramatically reduces forage Na content in plants (Underwood 1966). Increased crop yields remove trace elements from the soil at a fast rate with the result that deficiencies are frequently found on the most progressive farms (Schütte, 1964).

Factors Influencing Mineral Requirements

Approximate mineral requirements and toxicities for beef cattle are presented

in Table 1. Many factors affect mineral requirements including nature and level of production, age, level and chemical form of elements, interrelationship with other nutrients, mineral intake, breed and cattle adaptation. Mineral requirements are highly dependent on the level of productivity (Agriculture Research Council, ARC, 1965; National Research Council, NRC, 1970). Improved management practices that lead to improved milk production and growth rates for cattle will necessitate more attention to mineral nutrition. Mineral deficiencies, perhaps only marginal until this time, are likely to become important, and previously unsuspected nutritional deficiency signs may occur as production level increases (Long, Ndyanabo, Marshall and Thornton, 1969; Thornton, Long and Marshall, 1969).

Specific mineral requirements are difficult to pinpoint since exact needs depend on chemical form and numerous mineral interrelationships. The chemical form of mineral elements vary greatly in amount of dietary mineral supplied and in biological availability (Ammerman and Miller, 1972; Peeler, 1972). Examples of the numerous mineral interrelationships which affect requirements include Ca-P, Ca-Zn, Cu-Mo, Cu-Fe, Se-As, Se-S, Fe-P, Na-K, Al-P and Mg-K. In addition, vitamins D, E, and B_{12}, goitrogenic substances, oxalic acid and phytic acid each influence specific mineral requirements.

Adequate intake of forages by cattle is essential in meeting mineral requirements. Factors which greatly reduce forage intake, such as low protein content and increased degree of lignification, likewise reduce the total minerals consumed.

Since tropical forages contain less minerals during the dry season, it is logical to assume that cattle would most likely suffer mineral inadequacies during this time. On the contrary, numerous reports including those of Kenya (Hudson, 1944), Brazil (Corrêa, 1957) and Union of South Africa (Van Niekerk, 1974) noted specific mineral deficiencies more prevalent during the wet season. Grazing cattle were more prone to develop Co or P deficiencies, and the clinical signs were severest,

TABLE 1. SUGGESTED MINERAL REQUIREMENTS AND TOXICITIES FOR BEEF CATTLE
(In percentage or amount per kilogram of dry ration)[a]

MINERALS	REQUIREMENT OR TOXICITY
	Requirement
Calcium, %	0.18 - 0.60
Magnesium, %	0.04 - 0.18
Phosphorus, %	0.18 - 0.43
Potassium, %	0.60 - 0.80
Sodium, %	0.1
Sulfur, %	0.1
Cobalt, mg	0.05 - 0.1
Copper, mg	4 - 10
Iodine, mg	0.05 - 0.80[b]
Iron, mg	10 - 30
Manganese, mg	20 - 40
Molybdenum, mg	0.01 or less
Selenium, mg	0.05 - 0.10[c]
Zinc, mg	10 - 50
	Toxic Level
Fluorine, mg	40 - 60[d]
Manganese, mg	1000 - 2000[e]
Molybdenum, mg	6 - 20[f]
Selenium, mg	5[c]

[a]National Research Council (1970, 1971) and Agricultural Research Council (1965) recommendations.

[b]If feed contains goitrogens these levels should probably be increased by 1.2 mg/kg dry matter.

[c]National Academy of Sciences (1971) recommendations.

[d]National Academy of Sciences (1974) recommendations.

[e]Cunningham, Wise and Barrick (1966).

[f]Molybdenum toxicity in beef cattle can usually be overcome by 1 g per head daily of copper.

after the rains when pastures were green and plentiful. The explanation for an increased incidence of mineral deficiencies during the wet season is less related to the concentration of minerals in the forage than to the greatly increased requirements for these elements by the grazing animal. During the wet season cattle gain weight rapidly since energy and protein supplies are adequate. Associated with rapid growth during the wet season, mineral requirements are high while during the dry season inadequate protein and energy result in animals losing weight, thereby greatly limiting mineral requirements.

Important differences in mineral metabolism can be attributed to breed and adaptation. The effect of breed differences on mineral requirements has often been observed in ruminants (Phillips, 1956; Corrêa, 1957; Wiener and Field, 1969; Sutmöller, P., Personal Communication, 1973). It is not unusual for cattle introduced into an area to show deficiency signs while the indigenous breeds that are slow-growing and late-maturing do not exhibit the deficiencies to the same degree (Allman and Hamilton, 1949). Payne (1966) suggests the possibility that unacclimatized cattle of temperature type which sweat profusely and lose saliva and mucus from the mouth may lose significant quantities of minerals, particularly in the arid tropics.

Nutritional Deficiencies and Toxicities in Cattle

Allman and Hamilton (1949) gathered information from various parts of the world on locations of livestock nutritional deficiencies. Information on mineral deficiencies and excesses for livestock in Latin America has been updated by Phillips (1956) and De Alba (1971). An attempt has been made in the compilation of Table 2 to list the occurrence of cattle mineral deficiencies and toxicities prevalent in the developing countries of the world. Table 2 includes both confirmed as well as highly suspected geographical locations of mineral deficiencies and toxicities in cattle. Obviously, this constitutes a very generalized approach with important geographical omissions inevitable but it does indicate the scope of the

Table 2. Geographical Locations of Mineral Deficiencies or Toxicities in Cattle of Developing Countries

Required elements

Calcium	-Brazil (84); Colombia (27); Guyana (92); India (74, 92); Panama (96); Peru (32); Philippines (96); Senegal (17) Uganda (13, 65, 68); Venezuela (21).
Magnesium	-Argentina (23); Brazil (86); Chile (72); Costa Rica (27); Haiti (72); Honduras (72); Jamaica (72); Kenya (47); Peru (4); Surinam (86); Uganda (13); Uruguay (76).
Phosphorus	-Antigua (72); Argentina (24, 72, 96); Botswana (75); Brazil (84, 91, 94); Ceylon (3); Chile (27); Colombia (72) Costa Rica (60); Ecuador (72); Egypt (2, 26); Ghana (61); Guyana (72); Haiti (72); Honduras (72); India (74); Jamaica (72, 96); Kenya (47); Malagasy Republic (3); Malaysia (28, 44); Mexico (98); Nicaragua (72); Nigeria (61) Panama (73); Paraguay (72); Peru (27); Senegal (18); Somalia (3); Southern Rhodesia (51); Surinam (27); Tanzania (3); Uganda (78); Union of South Africa (87, 88, 93); Uruguay (27); Venezuela (21); Zaire (3)
Potassium	-Brazil (86, 41); Haiti (72); Panama (20); Uganda (13, 65).
Sodium	-Brazil (8, 86); Chad (43); Kenya (19, 47, 49); New Guinea (43); Nigeria (7); Northern Rhodesia (55, 95); Panama (20); Senegal (17); Surinam (29); Uganda (13, 65); Union of S. Africa (30); Venezuela (37).
Sulfur	-Ecuador (72); Uganda (36).
Cobalt	-Argentina (72); Brazil (22, 25, 52, 89); Colombia (33); Costa Rica (72); Egypt (1); El Salvador (72); Guyana (72 Haiti (58, 72); India (31); Katanga (85); Kenya (48, 50); Mexico (72); Nicaragua (72); N. Africa (17); Peru (40) Surinam (29); Uganda (66); Union of S. Africa (11); Zaire (85).
Copper (or Mo toxicity)	-Argentina (10); Brazil (72, 90); Colombia (77); Costa Rica (60); Haiti (58); India (74); Kenya (49); Malaysia (45); Mexico (39); Panama (5); Peru (40, 72); Rhodesia (12); Senegal (38); Surinam (72); Tanzania (70); Union of S. Africa (81); Uruguay (71).
Iodine	-Worldwide (34, 57).
Iron	-India (83); Panama (20).
Manganese	-Argentina (72); Brazil (86); Costa Rica (60); Panama (20); Uganda (13); Union of S. Africa (11); Burma (14).
Selenium	-Mexico (42); Peru (9); Uganda (63); Union of S. Africa (97).
Zinc	-Brazil (41); Guyana (62); India (80); Panama (20); Puerto Rico (56); Uganda (64).

Toxic elements

Fluorine	-Algeria (3); Argentina (3, 72, 24); Guyana (72); India (3, 82); Mexico (72); Morocco (79); Saudi Arabia (82); Tanzania (82); Tunesia (3); Union of S. Africa (3, 82).
Manganese	-Costa Rica (35, 59); Surinam (72).
Selenium	-Central African Republic (54); Chad (54); Chile (72); Colombia (6); Ecuador (72); India (54, 67); Iran (46); Kenya (54); Madagascar (54); Mexico (54); Nigeria (54); N. Africa (67); Peru (72); Puerto Rico (54); Sudan (54); Union of S. Africa (16, 15); Venezuela (53, 54, 69); Upper Volta (54).

Table 2 (continued) -

References: (1) Abou-Hussein, Raafat, Abou-Raya and Shalaby (1970); (2) Abou-Raya, Raafat, Abou-Hussein and Abd-El Motagalli (1971); (3) Allman and Hamilton (1949); (4) Alvarado, González, Meini and Clavo (1970); (5) Ammerman, Loaiza, Blue, Gamble and Martin (1974); (6) Ancizar-Sordo (1947); (7) Anderson, 1933, cited by Rhodes (1956); (8) Andreasi, Veiga, Mendonca, Prada and Masotti (1967); (9) Beeson, K. C., personal communication (1974); (10) Bingley and Carrillo (1966); (11) Bisschop and Groenewald (1963); (12) Boyazoglu, Barrett, Young and Ebedes (1972); (13) Bredon (1964); (14) Brooks, H. K., (1974) personal communication to G. K. Davis; (15) Brown and De Wet (1962); (16) Brown and De Wet (1967); (17) Calvet (1971); (18) Calvet, Picart, Doutre and Chambron (1965); (19) Chamberlain (1955); (20) Chicco (1972); (21) Chicco and French (1959); (22) Corrêa (1957); (23) Culot and Tunón (1967); (24) Culot, Tunón, Fernández Bolaño, Petroni and Garcés (1967); (25) Dâmaso and Tokarnia (1961); (26) Danasoury, El Noubi and Makky (1971); (27) De Alba (1971); (28) Devendra, C., personal communication, (1973); (29) Dirven (1963); (30) du Toit, Louw and Malan (1940); (31) Dube (1964); (32) Echevarria (1973); (33) Estevez Cancino (1960); (34) Follis (1956); (35) Fonseca and Davis (1968); (36) French, (1955); (37) French and Chaparro (1960); (38) Friot and Calvet (1971); (39) Gomez (1962); (40) Gomez, Merrera and Beeson (1967); (41) Gomide, Noller, Mott, Conrad and Hill (1969); (42) Gutierrez, Smith, Wallace and Nelson (1974); (43) Hartmans, J., personal communication (1973); (44) Hill and Rajagopal (1962); (45) Hill, Thambyah, Wan, Shanta (1962); (46) Hosseinion, Bazargani, Nahani, Mohammadiha and Owlia (1972); (47) Howard (1963); (48) Howard (1970); (49) Howard, Burdin and Lampkin (1962); (50) Hudson (1944); (51) Hurrell and Dugdale (1958); (52) IRI (1966); (53) Jaffé, Chávez and Mondrágon (1967); (54) Jaffé, Chávez and Mondrágon (1969); (55) Jones (1963); (56) Kayongo-Male, Thomas and Ullrey (1973); (57) Kelly and Snedden (1960); (58) King and Price (1966); (59) Lang (1971); (60) Lang (1974); (61) Lansbury (1962); (62) Legg and Sears (1960); (63) Long and Marshall (1973); (64) Long, Marshall, Ndyanabo and Thornton (1972); (65) Long, Ndyanabo, Marshall and Thornton (1969); (66) Long, Thornton, Ndyanabo, Marshall and Ssekaalo (1970); (67) Mahadevan (1954-55); (68) Marshall, Ndyanabo, Long and Thornton (1973); (69) Mondrágon and Jaffé (1971); (70) Naik (1965); (71) Nores (1944); (72) Phillips (1956); (73) Poultney, C., personal communication (1972); (74) Ray (1963); (75) Reed, Smith, Doxey, Forbes, Finlay, Geering and Wright (1974); (76) Riet, Riet and Paladino (1944); (77) Robinson and Edgington (1948); (78) Rollinson and Bredon (1960); (79) Russell and Duncan (1956); (80) Saraswat and Arora (1972); (81) Schultz, Vander Merwe, Van Rensburg and Swart (1951); (82) Schütte (1964); (83) Sen and Ray (1964); (84) Sobrinho (1943); (85) Suter (1962); (86) Sutmöller, Vahia de Abreu, Van der Grift and Sombroek (1966); (87) Theiler, Green and du Toit (1924); (88) Theiler, Green and du Toit (1928); (89) Tokarnia, Canella, Guimarães and Döbereiner (1968); (90) Tokarnia, Guimarães, Canella and Döbereiner (1971); (91) Tokarnia, Langenegger, Langenegger and de Carvalho (1970); (92) Underwood (1966); (93) Van Schalkwyk and Lombard (1969); (94) Villares and Teixeira Silva (1956); (95) Walker (1957); (96) Williamson and Payne (1965); (97) Wolf, Kollonitsch and Kline (1963); (98) Zavala and Galván (1973).

problem.

As noted in Table 2 the mineral most likely deficient for grazing cattle is P followed by Co and Cu. Deficiencies of Na and I are also widespread as are lack of Co and Cu. Under most circumstances,however, deficiencies of Co and Cu generally are more detrimental to cattle production than either Na or I. Toxicity of both Se and F are common thoughout the developing countries of the world.

Calcium and Phosphorus

Calcium and P are considered together because they are closely interrelated along with vitamin D in bone metabolism and the requirements of these nutrients are dependent on the concentrations of each other. A Ca/P ratio of 1:1 to 2:1 is usually recommended with a close ratio most critical if P intake is marginal or inadequate. With wide Ca/P ratios the balance of these nutrients is unfavorable, thereby increasing requirements for both P and vitamin D. Incidence of milk fever (parturient paresis), a disturbance of Ca metabolism, can be reduced by maintaining a narrow Ca/P ratio (Stott, 1965). The balance of the minerals is often upset when legumes with a Ca/P ratio of 6 to 10:1 are fed or likewise a wide ratio exists when only overly mature tropical forages, particularly low in P, are available to grazing cattle during extended dry seasons.

In addition to the balance between Ca/P and vitamin D, requirements for these minerals are influenced by availability of different sources of these minerals (Peeler, 1972) and interrelationships with additional elements. Phytin P is believed to be 50 to 70% as valuable as well utilized inorganic sources. In India, Ca deficiency is reported for cattle fed rice straw due to the large amounts of oxalates in this feed (Ray, 1963).

In the 1974 edition of Latin American Tables of Feed Composition (McDowell, Conrad, Thomas and Harris, 1974) average Ca values are shown for 1128 forage entries and average P values for 1106 forage entries. For these forages 72.8% of the P values are 0.3% or

less and 31.1% of the Ca values are 0.3% or less which may be borderline to deficient in these elements for most classes of beef cattle. Phosphorus deficiency is reported in parts of 35 developing countries (Table 2). In addition to low forage P levels, 13 of these countries (Argentina, Botswana, Brazil, Costa Rica, Kenya, Malaysia, Mexico, Panama, Senegal, Southern Rhodesia, Uganda, Union of S. Africa and Venezuela) also note reduced plasma P concentrations. Compared to P inadequacies, Ca deficiency is rare in grazing cattle with the exception of cows lactating large quantities of milk or those on acid, sandy or organic soils in humid areas where the herbage consists mainly of quick growing grasses and is devoid of legume species (Underwood, 1966). However, on the basis of decreased Ca levels in blood and forages, areas of Brazil, Colombia, Guyana, India, Panama, Peru, the Philippines, Senegal, Uganda and Venezuela are considered deficient in this mineral (Table 2).

Phosphorus deficiency indirectly results in death as illustrated in Senegal (Calvet, Picart, Doutre, Chambron, 1965) and Brazil (Tokarnia, Langenegger, Langenegger and de Carvalho, 1970) where P deficient cattle developed Botulism due to pica. In areas of Piauí (Brazil) an estimated 2 to 3% of approximately 100,000 cattle die annually of Botulism (Tokarnia _et al_. 1970).

In cattle, the most prevalent mineral element deficiency throughout the world is lack of P. In most cattle grazing areas of developing countries, soils and plants have low P contents. Many grass species containing over 0.3% P during early stages of growth are available to grazing cattle for short periods. For the greater part of the year, however, only mature forage containing less than 0.15% P is available. A P deficiency commonly occurs when cattle must subsist for long periods on mature, nonleguminous, dried grass and herbage.

In many countries high amounts of soil Fe, Ca and Al accentuate a P deficiency by forming insoluble phosphate complexes. Soils in the humid tropics are characteristically acid with high percentages of exchangeable Al which complexes with P making it unavailable to plants (Woodruff and Kamprath, 1965).

The most devasting economic result of P deficiency throughout the world is an increase in reproductive failures that annually cause large losses to the cattle industry. Marked inhibition of the estrus cycle associated with P deficient pastures has been reported from many developing countries. Hignett and Hignett (1952) reported that P deficiencies produced various types of ovary disfunction resulting in inhibition, depression or irregularity of estrus.

Phosphorus supplementation has dramatically increased fertility levels in grazing cattle from many partsof the world. In two year observations of 200 South African cattle, calf crops increased from 51% in control cattle to approximately 80% for cattle supplemented with bone meal or other P sources (Theiler, Green and du Toit, 1924 and 1928). Administration of a P supplement to grazing cattle in Mato Grosso, Brazil (Conrad, J. H.,Personal Communication, 1966) and Panama (Poultney, R. G., Personal Communication, 1972) increased calving percentage from a range of 42-45% to 80%.

Under conditions of extreme P shortage, cattle may go for two or three years without producing a calf or even coming into estrus (Phillips, 1956). In P deficient areas, if a calf is produced cows may not come into a regular estrus again until body P levels are restored, either by feeding supplementary P or by cessation of lacation. Anestrus has been considered to be a combination of a P and protein deficiency since both nutrients are generally in short supply in the more mature tropical forages. However, O'Moore (1952) reported that administering a protein supplement low in P (blood meal) to anestrus cattle was without effect while disodium phosphate returned cattle to estrus after 10-35 days of supplementation.

Cobalt

The need for Co for beef cattle is related to its being an essential element for vitamin B_{12} synthesis by rumen microorganisms. Cobalt deficiency occurs in large areas of many countries and is largely, but not exclusively, restricted to grazing ruminants which have little or no access to concentrates. With the exception of P

and possibly Cu, Co is the mineral most severely deficient for grazing cattle in developing countries. Nineteen developing countries or regions have noted Co deficiencies or low forage concentrations of this element (Table 2).

Severity of Co deficiency may vary from a mild deficiency to an acute stage. In the acute form cattle appear starved and are characterized by listlessness, emaciation, dull appearance, anemia and weak calves. Loss of appetite is one of the earliest signs of a Co deficiency. In Colombia, Co supplementation for seven days significantly increased forage consumption and milk production in cattle (Estevez Cancino, 1960). Forage consumption, however, declined sharply 3 weeks after discontinuation of the Co supplement. Cobalt deficiency signs are not specific and it is often difficult to distinguish between a deficiency of Co and malnutrition due to low intake of calories and protein. However, Co-deficient cattle respond quickly to Co treatment recovering appetite, vigor and weight.

Cobalt sub-deficiencies or border-line conditions are extremely common and are characterized by low production rates unaccompanied by clinical manifestations or visible signs. Sub-deficiencies of Co often go unnoticed thereby resulting in great economic losses to the cattle industry (Latteur, 1962).

Prior to the recognition of Co deficiency, in many parts of the world cattle could be maintained on deficient pastures only if they periodically moved to "healthy" ground. Cobalt deficiency was prevented by taking animals every year for a few months to a "healthy" region preferably during the rainy season (Tokarnia, Döbereiner, Canella and Damaso, 1961).

A deficiency of Co may be suspected from low soil and herbage Co concentrations, while being positively diagnosed by low liver Co (or vitamin B_{12}) values or by feeding Co to cattle and comparing their progress to untreated animals. An example where soil, plant and animal tissue each clearly indicated a Co deficiency is illustrated in the state of São Paulo, Brazil (Corrêa, 1957). Average Co concen-

trations in soil, forage and liver samples were 0.797, 0.046 and 0.058 p.p.m. for Co deficient areas versus 20.37, 0.334 and 0.201, respectively, for Co adequate regions.

Cobalt deficiency in ruminants can be corrected or prevented by administration of Co in salt mixtures or as a drench, treatment of soils with Co-containing fertilizers, injections of vitamin B_{12} and use of cobalt oxide pellets, which yield a relatively steady supply of Co to the rumen fluid.

Copper and Molybdenum

Throughout extensive regions of the world, lack of Cu is the most severe mineral limitation to grazing cattle with the exception of P and possibly Co. Copper deficiencies in cattle, as with Co, occur mainly under grazing conditions with gross symptoms of the deficiency rare when concentrates are fed (Ammerman, 1970).

Of the numerous world reports of Cu deficiency only a few are concerned with a deficiency induced by the presence of unusually low concentrations of Cu (< 3 p.p.m.) in the feed. The majority of reports refer to a "conditioned" Cu deficiency where normal amounts of Cu (6-16 p.p.m.) are inadequate due to other forage constituents such as Mo and sulfate which block utilization of Cu (Russell and Duncan, 1956).

The amounts of Cu needed to counteract excess Mo are variable due to the interrelationships between Cu, Mo, sulfate and other factors. Copper deficiencies usually occur when forage Mo exceeds 3 p.p.m. and the Cu level is below 5 p.p.m. (Cunha, 1973). The level of sulfate (or S-amino acids) in the forages will result in differences in the level of Mo which is toxic and the level of Cu needed to counteract it.

Many disorders in cattle are associated in a simple or induced (high Mo and sulfate) Cu deficiency including anemia, severe diarrhea, depressed growth, change of hair color, neonatal ataxia, temporary infertility, heart failure and weak, fragile long bones which break easily (Cunha, Shirley, Chapman, Ammerman, Davis,

Kirk and Hentges, 1964; Underwood, 1971).

Subclinical Cu deficiencies are thought to be very widespread and are likely to be of more economic significance than easily recognized cases. Thornton, Kershaw and Davies (1972) reported Cu supplementation during a 6 month period increased live-weight gains in cattle by 10-70% over controls, even though, with few exceptions, control stock showed no clinical signs of hypocuprosis.

Copper deficiencies reported in developing countries are presented in Table 2. Hill, Thambyah, Wan and Shanta (1962) reported the extent of Cu inadequacy in Malaysia by noting that 80% of the surveyed cattle and buffalo were Cu deficient. Due to the extremely high Mo content of feeds in certain regions of Colombia (Robinson and Edgington, 1948), it is expected that Colombia cattle are affected with an induced Cu deficiency.

Chronic Cu toxicity occurs under grazing conditions as a result of high Cu intake or very low Mo and SO_4 intakes. A Cu content in feed over 20 p.p.m. can cause chronic poisoning in sheep (Netherlands Committee on Mineral Nutrition, 1973). Todd (1969) in reviewing Cu toxicity concluded that chronic Cu toxicity in ruminants is almost entirely confined to sheep.

Clinical signs of Mo toxicity are similar to Cu deficiency. An excessive intake of Mo will seriously deplete Cu reserves in cattle quickly leading to scouring, loss of condition and other signs associated with Cu deficiency. Molybdenum toxic areas characteristically occur on poorly drained neutral or alkaline soils which favor Mo uptake by plants and reduce the availability of Cu. Both Mo toxicity and Cu deficiency are corrected by providing additional Cu to the animals' diet.

Sodium and Chlorine

The craving of livestock for common salt is well established. Sodium is the essential nutrient in salt and evidence of a naturally occurring dietary deficiency of chlorine, as distinct from sodium has not been established (French, 1957; Underwood, 1966; McDonald, 1968).

Common forages normally do not contain sufficient quantities of Na to meet cattle requirements throughout the year. This inadequacy is easily overcome by the practice of providing common salt ad libitum. Nevertheless, most grazing cattle in developing countriesreceive insufficient salt or have only very limited access to salt during certain times of the year. According to Sutmöller et al. (1966) the lack of Na is the most widespread mineral deficiency in the Amazon Valley of Brazil (~3.5 million square km).

The NRC recommends 0.1% Na for beef cattle. Fifty-nine percent of 144 forage averages in the 1974 Latin American Tables of Feed Composition contained mean Na values of 0.1% or less (McDowell et al., 1974). Natural forages low in Na have been reported in numerous countries throughout the world. Various researchers including Dirven (1963) and Underwood (1966) suggest that under tropical or hot semi-arid conditions where large losses of water and Na occur in sweat, the Na requirement may be higher. Deficient cattle exhibit a depraved appetite, unthrifty condition, lusterless eyes and a loss in weight and milk production. Cattle deprived of salt may be so voracious that they often injure each other in attempting to reach salt.

Several experiments with grazing animals in tropical areas have demonstrated no benefits from salt supplementation. The Na conserving mechanisms of the body are so effective that as a Na deficiency develops, the Na content of urine, plasma, saliva and other fluids is decreased. However, for cattle that are growing, lactating or working, Na conserving mechanisms will eventually be inadequate, particularly in hot environments where low Na forages are consumed.

In Northern Rhodesia, Walker (1957) reported that the daily feeding of 1 oz. of NaCl per animal resulted in a marked increase in weight gains for grazing steers while protein supplementation without NaCl produced no significant effect upon growth. Australian workers (Murphy and Plasto, 1973; Gartner and Murphy, 1974) noted dramatic responses in beef cattle supplemented with salt.

According to Underwood (1966) a dietary deficiency of Na is most likely to occur

(1) during lactation, due to considerable secretion of Na in the milk; (2) in rapidly growing animals; (3) under tropical or hot semi-arid conditions where large losses of water and Na occur in the sweat and where pastures are low in this element; (4) in animals grazing pastures heavily fertilized with K, which depresses herbage Na levels.

Iodine

Iodine deficiency in man and farm animals as endemic goiter is one of the most prevalent deficiency diseases and has been shown to occur in almost every country in the world. Follis (1966) reports that endemic goiter exists in all of the continental Latin American countries. The number of goitrous people in the world is estimated to be approximately 200 million (Kelly and Snedden, 1960).

Incidence of deficiency has declined in many countries as a result of the widespread use of iodized salt. However, in the developing countries of the world endemic goiter remains an exceedingly serious human and livestock problem. Iodine deficiency has been stated to be the most widespread of all mineral deficiencies in grazing stock (Allman and Hamilton, 1949; Underwood, 1966). Goiter or other I deficiency signs are reported in animals in most areas where human goiter is endemic. Since animals usually receive feeds produced locally they are often more susceptible to goiter than human beings.

Iodine functions as an essential component of the thyroid hormones. Deficiency of I results in a lack of these hormones as manifested by calves showing general weakness and stunted growth or born dead with goiter. Clinical signs of I deficiency are seldom apparent in adult cattle (Megale, 1949; NRC, 1970). Nevertheless, I deficiency in breeding animals results in suppression of estrus periods in the female and lack of libido in the male (Church, 1971).

Although I deficiency results primarily from low dietary intake of I, its incidence is greatly enhanced by intake of goitrogens that interfere with I utilization (Underwood, 1962). The net effect of goitrogens in most instances is to increase the

I requirement. Goitrogenic activity has been observed in many plants including most cruciferous plants, soybeans, flaxseed, peas and peanuts.

Factors contributing to an I deficiency include low I soils, distance of regions from the sea with the influence of rains high in I, effect of light soils which facilitate leaching, variation in ability of plant species to absorb I, interrelationships with other nutrients and goitrogens.

The most effective method of goiter prevention is to provide I in the mineral mixture. Unstabilized potassium iodide is less effective under wet tropical conditions since I in this form is readily volatilized or leached. Calcium or potassium iodate, stabilized potassium iodide, or pentacalcium orthoperiodate are much more stable forms of I.

Magnesium

Hypomagnesemia tetany, encountered in both grazing cattle and calves can be readily relieved by Mg therapy. The tetanous symptoms and low blood Mg values develop in calves reared too long on milk, without access to other feeds. Susceptibility to grass tetany is increased in older cattle because of the decreased ability to mobilize skeletal Mg with increasing age (Blaxter and Sharman, 1955). Developing countries where Mg tetany is encountered include Argentina, Chile, Haiti, Honduras, Jamaica, Peru, Surinam and Uruguay (Table 2). Suspected but unconfirmed cases of Mg tetany have been noted for Kenya, Uganda and Costa Rica.

Grass tetany generally occurs during early spring, or a particularly wet autumn, among older cattle grazing grass or small grain forages in cool weather. T'Hart (1960) concluded that hypomagnesemia occurred mainly when the temperature was rather cool (5-15° C) and the incidence was higher in years with a sudden growth of grass. Kemp et al. (1961) reported that Mg availability improves with increasing maturity of grasses and that the low availability of Mg in young grass may be accentuated by heavy K and N fertilization.

Tetany occurs in all ranges of severity with different combinations of clinical signs. These include unusual alertness, nervousness, incoordination, muscle twitching, labored breathing, convulsions and finally death. Clinical tetany is endemic in some countries affecting only a small proportion of cattle (1 to 2%). However, individual herds may report tetany as high as 20% (Underwood, 1966). Dutch workers (Netherlands Committee on Mineral Nutrition, 1973) note that the incidence of non-clinical hypomagnesemia is far greater than clinical tetany. Although non-clinical hypomagnesemia is not characterized by death, the economic consequences of lowered milk and production rates are substantial.

Grass tetany is most likely to occur when pastures contain less than 0.2% Mg (Underwood, 1966). Slightly over one-third of 288 forages included in the 1974 Latin American Tables of Feed Composition contained 0.2% Mg or less (McDowell *et al.*, 1974). Confirmation of grass tetany, however, is only justified when blood or urine samples are low in Mg (Netherlands Committee on Mineral Nutrition, 1973).

Prevention of grass tetany may include Mg fertilization, adding Mg to feed or salt blocks, and avoiding high K fertilizers. In southeastern United States a complete mineral mixture with 25% MgO (14% Mg) has been effective in preventing grass tetany in beef cattle (Cunha, 1973).

Selenium

For over 100 years, Se was known only as a toxic element. In 1957 an essential role for this element began to emerge (Schwarz and Foltz, 1957). Beef cattle producers in developing countries need to carefully evaluate nutritional disorders involving both Se deficiencies and toxicities.

Selenium as a toxic element

Allaway (1969) has suggested that Se may be the most toxic element in the environment on a molar basis. Consumption of feedstuffs containing high levels of Se presents a world-wide problem to grazing cattle. Chronic Se poisoning results from continuous

ingestion of feeds that provide .3-20 p.p.m. of Se in the diet (National Academy of Science, 1971). Acute Se poisoning is most often associated with consumption of Se accumulator plants (i.e. Astragalus racemous) which may contain from 100 to over 9,000 p.p.m. Se. Accumulator plants rarely occur outside seleniferous areas and may therefore be used as indicators of Se toxic regions (Underwood, 1966).

Clinical signs of selenosis in cattle include atrophy and cirrhosis of the liver, chronic nephritis, myocardium necrosis, loss of vitality, loss of hair, lameness, elongated hooves and in prolonged toxicity the hooves may be sloughed off (Moxon, 1937). In acute Se poisoning cattle exhibit blindness, abdominal pain, excessive salivation, teeth grating, paralysis and respiratory failure.

Developing countries where selenosis is encountered include three Latin American countries (Mexico, Colombia and Venezuela) in addition to Iran and the Union of South Africa (Table 2). Possible, but unconfirmed, occurrences of selenosis include Chile, Ecuador and Peru (Phillips, 1956) and India and North Africa (Mahadevan, 1954-55; Jaffé, Chávez and Mondragón, 1969). Jaffé et al. (1969) also suggested the likely existence of seleniferous zones in the following countries: Central African Republic, India, Kenya, Madagascar, Mexico, Nigeria, Puerto Rico, Upper Volta, Sudan and Chad. At present, practical measures for controlling Se poisoning for grazing cattle rely on pasture rotation and the use of supplemental feeds from nonseleniferous areas.

Selenium as an essential element

The Se requirement for beef cattle is between 0.05 and 0.10 p.p.m. (NRC, 1970). Since 1957 an interrelationship between Se and vitamin E has been established. Both nutrients are essential and in some instances vitamin E will substitute for Se and vice versa.

In grazing animals, three distinct Se-responsive syndromes have been described: "white muscle disease" (WMD) in newborn or young lambs and calves; unthriftiness, with poor growth rates, which may occur in the absence of any other recognizable

disease; and infertility.

In calves and lambs, the most widely recognized and clearly defined Se-deficient disease is WMD. This is a degenerative disease of the skeletal and cardiac muscles and is reported by most of the major ruminant-producing countries of the world; (Wolf, Kollonitsch and Kline, 1963). During some years incidence of WMD in certain regions is sporadic with less than 1% of the herds affected. In other areas such as Turkey and New Zealand a 20 to 30% incidence of WMD may occur (Wolf et al., 1963).

According to Underwood (1971) the total areas of the world affected by Se deficiency are far greater than those afflicted with Se excess. It seems inconceivable to suppose that the huge land masses included in the category of developing countries would not have extensive Se deficient areas in addition to Se toxic areas. However, the only African country reporting WMD is the Union of South Africa (Wolf et al., 1963) while Se deficiency is only suggested in Uganda (Long and Marshall, 1973), Mexico (Gutierrez, Smith, Wallace and Nelson, 1974) and Peru (Beeson, K. C. Personal Communication, 1974).

The principle methods of increasing Se intake by livestock include providing (1) a free choice Se mineral supplement, (2) Se fertilization, (3) injections of Se and (4) Se-ruminal pellets.

Fluorine

Fluorine is a structural component of bone and teeth, nevertheless the essentiality of F remains incompletely resolved and only the harmful effects of F are likely of present importance in livestock feeding.

Fluorine is a very toxic element with fluorosis found in certain regions of the world. Reported incidences of fluorosis in developing countries include Algeria, Morocco, Tunisia, Saudi Arabia, India, Tanzania, South Africa, Argentina, Guyana, and Mexico (Table 2).

Chronic fluorosis in livestock is generally observed under three conditions: (1) drinking water high in F, (2) continuous consumption of high F mineral supplements,

and (3) grazing F contaminated forages adjacent to industrial plants which emit F fumes or dust (Underwood, 1966). The F content is seldom more than 1 to 2 p.p.m. since most plants have a limited capacity to absorb this element.

Water high in F (3 to 15 p.p.m. or more) is usually from deep wells originating from deep rock formations rather than surface water supplies. Allowing water to stand in troughs will result in a higher concentration due to evaporation. The more common incidence of fluorosis results when grazing cattle consume contaminated forages near industrial plants which have emitted F compounds into the environment, or have consumed mineral supplements high in this mineral.

Livestock are protected temporarily against fluorosis by increased urinary excretion and by deposition of the element in the skeletal tissue. Nevertheless, F is a cumulative poison and once bone tissue is saturated continued intakes result is metabolic disturbances and eventual death. Clinical signs of fluorosis include teeth modified in shape and color, becoming mottled and pitted often with the pulp cavities being exposed, development of exostoses of the jaw and long bones with thickening of joints causing the animal to become lame, and enlarged and chalky-white appearance of affected bones.

Toxicity of F is a reflection of amount and duration of ingestion, solubility of fluorides ingested, age of animal, nutrition, stress factors, and individual animal differences (Shupe, 1970, cited by Swenson, 1970). Suttie, Miller and Phillips (1957) observed that lactating cows could tolerate 30 p.p.m. with no apparent difficulty, that 40 p.p.m. was a marginal tolerance and that 50 p.p.m. would result in fluorosis within 3 to 5 years.

Cattle are less tolerant to F toxicity than other grazing livestock (Phillips, Greenwood, Hobbs, Huffman and Spencer, 1960). Cattle in tropical countries that are provided with inadequate supplies of energy and protein during extended dry seasons are particularly susceptible to F toxicity. Crampton (1968) and Suttie and Faltin

(1973) have indicated that general undernutrition enhances the deleterious effects of F toxicosis.

For the prevention of fluorosis, F content of water and supplemental phosphates should be determined. Only defluorinated phosphates (< 0.01% F) should be supplemented to cattle with avoidance of feeding fertilizer rock phosphate.

Manganese, Zinc, Iron, Potassium and Sulfur

Manganese deficiency in beef cattle results in delayed estrus and conception, and calves born with neonatal skeletal abnormalities (Bentley and Phillips, 1951; Rojas, Dyer and Cassatt, 1965). Conception rates in British cattle were increased from 48 to 72% following Mn supplementation (Munro, 1957). Forages containing low levels of Mn have been reported in Argentina, Burma, Brazil, Costa Rica, Panama, Uganda and Union of South Africa. Low liver Mn levels suggestive of a Mn deficiency were noted in 63% of the cattle examined in western Costa Rica (Lang, 1974). In a different region of Costa Rica, characterized by volcanic soils, Mn toxicity was observed which resulted in low reproductive rates of cattle (Fonseca and Davis, 1968; Lang, 1971).

A Zn deficiency in cattle was once thought unlikely under practical conditions. However, a severe Zn deficiency in grazing cattle has been reported in Guyana (Legg and Sears, 1960) and also in Norway and Finland, as reviewed by Miller (1970). Legg and Sears (1960) found a parakeratosis skin disorder in cattle of Guyana which were consuming forage containing 18 to 42 p.p.m. Zn. Developing countries where potential Zn deficiencies may occur due to low reported forage concentrations include Brazil, Guyana, India, Panama, Puerto Rico, and Uganda.

Except in animals with severe parasitism or hemorrhaging, Fe deficiency is considered rare for grazing cattle due to generally adequate pasture concentrations together with contamination of plants by soil. Nevertheless, Fe deficiency has been reported in Florida when cattle grazed forages grown on white and gray, sandy loam and fine, sand soils (Becker, Henderson and Leighty, 1965). Also, newborn calves receiving milk have increased hemoglobin formation as a result of supplemental Fe (Thomas, Okamoto,

Jacobson and Moore, 1954). Data from Panama (Chicco, 1972) suggest that certain forages are marginal in Fe in relation to cattle requirements. Iron deficiency may be a problem in India, where cattle are fed on straw for extended periods (Sen and Ray, 1964).

There are unlikely to be K deficiencies in most conventional ruminant diets (ARC, 1965) Nevertheless, livestock suffering from a K deficiency have been reported in Haiti (Phillips, 1956). In K deficient areas, soils were high in Ca and deficient in K as well as P. Low K values have been reported for forages in Brazil, Panama and Uganda. In Brazil the average content of six grasses at 4 weeks was 1.42% versus 0.30% at 36 weeks of age (Gomide et al., 1969). In tropical regions it is possible that K deficiencies may arise in view of the large decrease in content of this mineral with increasing maturity during the extended dry season.

Sulfur supplementation will most likely be needed to meet the requirements of cattle when poor quality roughages grown on S-deficient soils or roughages combined with non-protein nitrogen (NPN) are fed (Whanger, 1972). Indications of S deficiency have been reported from Ecuador (Phillips, 1956) and Uganda (French, 1955) as evidenced by improved animal response following S supplementation.

Detection of Mineral Deficiencies or Toxicities

Clinical signs of mineral deficiencies along with soil, water, plant and animal tissue analyses have all been used to establish mineral deficiencies and toxicities. The most reliable method of confirming mineral deficiencies is response derived from specific mineral supplementation. Severe deficiencies of I, Mg and Cu and toxicities of Se and F are often characterized by specific clinical signs. However, the majority of mineral deficiencies or toxicities, particularly borderline conditions, do not result in clinical signs specific only to a given mineral. Therefore, in order to determine mineral insufficiencies chemical analyses are often required.

A soil survey can provide clues to potential livestock deficiencies. However,

numerous factors affect forage mineral uptake from soils. Disadvantages of relying on forage element analyses to assess mineral adequacy for cattle include (1) uncertainty of collecting samples comparable to what cattle consume, (2) difficulty of estimating forage intake and (3) possibility of forage samples containing soil contamination. Mitchell (1963) indicated that soil contains 20 to 1000 times the Co and Fe content found in pastures grown on a particular soil.

Without question forage analysis is a much better indicator of mineral availability than is soil analysis. Likewise, animal tissue mineral concentrations are better indicators of the availability of minerals than are forage analyses. Grazing livestock obtain part of their mineral supply from the consumption of water, soil, leaves, tree bark, etc. versus entirely from forages. Cattle mineral tissue concentrations, therefore, more accurately portray the contribution of the total environment in meeting the mineral requirements of grazing animals. As an illustration, neither the Cu content of soils or herbage show any positive relationship with the Cu status of the animal (Sutmöller et al., 1966; Hartmans, 1970). However, Cu liver concentrations of less than 25 p.p.m. coincide with Cu deficiency signs in cattle (Sutmöller et al., 1966; Tokarnia et al., 1961).

Recently, excellent reviews (Netherlands Committee on Mineral Nutrition, 1973; Miller and Stake, 1974) have discussed methods of chemically diagnosing mineral deficiencies. Table 3 illustrates the analyses of greatest value in assessing specific mineral deficiencies and toxicities.

A Mapping Technique for Determination of Potential Area Mineral Deficiencies or Toxicities

Mineral deficiencies or toxicities in grazing livestock can be predicted by use of a systematic mapping technique or mineral survey. Kubota, Allaway, Carter, Cary and Lazar (1967) and Kubota (1968) analyzed Se and Co levels of United States forages for the purpose of relating concentrations of these elements to Se and Co responsive

TABLE 3. DETECTION OF SPECIFIC MINERAL DEFICIENCIES OR TOXICITIES IN CATTLE.

Element	Analyses for assessment of mineral status	Critical level
		Deficiency
Calcium		0.18 - 0.60%[a]
		8 mg/100 ml[b]
Magnesium		1 - 2 mg/100 ml[c]
		2 - 10 mg 100 ml[c]
Phosphorus		4.5 mg/100 ml[d]
		0.18 - 0.43%[a]
Potassium		0.60 - 0.80%[a]
Sodium		100 - 200 mg/100 ml[c]
		0.1%
Sulfur		0.1%[a]
Cobalt		0.05 mg/kg[a]
		0.05 - 0.1 mg/kg[a]
Copper		25 mg/kg[e]
Iodine		300 µg/day[c]
Iron		10 g/100 ml[f]
		13 - 15% saturation[g]
Manganese		10 mg/kg[h]
		20 - 40 mg/kg[a]
Selenium		0.25 - 0.5 mg/kg[i]
		0.05 - 0.10[j]
Zinc		0.04 mg/100 ml[c]
		10 - 50 mg/kg[a]
		Toxicity
Copper		700 mg/kg[c]
Fluorine		4,500 - 5,500 mg/kg[k]
Manganese		70 mg/kg[l]
		1000 - 2000 mg/kg[m]
Molybdenum		6 - 20 mg/kg[c]
Selenium		5 - 15 mg/kg[n]
		5 mg/kg[a]

References: (a) National Research Council, 1970, 1971 and Agricultural Research Council, 1965; (b) Cunha et al., 1964; (c) Netherlands Committee on Mineral Nutrition, 1973; (d) Underwood, 1966; (e) Sutmöller et al., 1966 and Tokarnia et al., 1961; (f) Swenson, 1970; (g) Miller and Stake, 1974; (h) Van Koetsveld, 1958; cited by Sutmöller et al., 1966 and Rojas et al., 1965; (i) Hartley, 1967; (j) National Academy of Sciences, 1971; (k) Suttie et al., 1958; (l) Lang, 1971; (m) Cunningham et al., 1966; (n) Dudley, 1936; Miller and Williams, 1940; Moxon and Rhian, 1943 and Maag, Orsborn and Clopton, 1960.

diseases. Similar mapping techniques based on forage analysis have been undertaken for Ca and P in Brazil (Gavillon and Quadros 1970) and Se in Venezuela (Jaffé et al., 1967, Mondragón and Jaffé, 1971).

Cobalt and/or Cu deficiencies of grazing ruminants have been established in specific Brazilian regions as a result of low liver concentrations of these elements (Dâmaso and Tokarnia, 1961; Tokarnia, Mitidieri and Affonso, 1959; Tokarnia, Canella and Döbereiner, 1960; Tokarnia et al., 1961; Tokarnia, Guimarães, Canella and Döbereiner, 1971). Phosphorus deficiencies, likewise, were established in Venezuela by Chicco and French (1959) and in Panama by Chicco (1972) as a result of low serum P levels.

Correction of Mineral Deficiencies and Excesses

Indirect methods of providing minerals to grazing cattle include use of mineral containing fertilizers, altering soil pH, and encouraging growth of specific pasture species. Direct administration of minerals to cattle through water, mineral licks, mixtures and drenches, heavy pellets and injections are generally the most economical methods of supplementation. Benefits and disadvantages of mineral supplementation methods are discussed by Underwood (1966). Cunha (1971) noted that self feeding trace mineralized salt is low cost insurance against deficiencies. In the United States beef cattle can be supplied with I, Cu, Fe, Co, Zn and Mn for less than 25 cents per year per animal.

As a result of limited information on the mineral content of soils, forages and water in many developing countries, it is difficult to determine which minerals are required and in what quantities (McDowell, 1972). In order to insure adequate mineral nutrition, "complete" mineral supplements should be available "free choice" to cattle. Suitable "complete" mineral mixtures for cattle have been described by Cunha et al. (1964) and Smith and Loosli (1970)

A "complete" mineral mixture should include salt, a low fluoride P source, Ca, Co, Cu, I, Mn and Zn. Selenium, Mg, K, S, Fe or additional elements can be incorporated

into a mineral supplement as new information suggests a need. In the case of Mg an oral supplement would only be of value during the seasonal occurrences of grass tetany (Allcroft, 1961). Calcium, Cu, or Se when in excess can be more detrimental to cattle production than any benefit derived by providing a mineral supplement. In regions where high forage Mo predominates, 3-5 times the Cu content in mineral mixtures is needed to counteract Mo toxicity (Cunha et al., 1964). Thus, the exact level of Cu to use in counteracting Mo toxicity is a complex problem and should be worked out for each area. Salt content of water supplies is important in formulating mineral supplements since cattle consume less minerals when water is high in salt. In Florida, mineral mixtures can be based on a 86.1% salt content for sandy soils and 43.0% in brackish areas (Becker et al., 1965).

Mineral toxicities are more difficult to control than deficiencies, especially under grazing conditions. Molybdenosis is controlled by additional doses of Cu, fluorosis by periodic removal of cattle from fluoridated waters and selenosis by rotational grazing to avoid continuous access to high Se forages or by diluting the ration with feeds low in Se (Underwood, 1971).

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ROLE OF RUMINANT PRODUCTION IN INCREASING ANIMAL FOODS IN LATIN AMERICA

by
T. J. Cunha, Chairman
Department of Animal Science
University of Florida
Gainesville, Florida

There is a tremendous undeveloped potential for increasing ruminant production in Latin America. This is especially true for beef cattle and to a considerable extent for dairy cattle. The least potential would be for sheep and goats. The abundance of forage, and the availability of large land areas throughout Latin America which can be developed for forage production gives Latin America a great potential for increasing ruminant production.

Ruminants can be helpful

The need of ruminants in Latin America is apparent since most of the land area in the South American countries and much of the land area in Central American countries is still not being well utilized by ruminant production enterprises which make good use of improved pastures and new animal production technology currently available. These land areas have the potential for producing tremendous amounts of forage for ruminants. Most of this land area has little use other than for grazing ruminants for many years to come. Much of it is not suitable for intense tillage and some of it will not be needed for this purpose for decades. Therefore, increasing ruminant production is one means of making this land more productive and helpful to the total economy of Latin America. The animals on these areas would not be competing with humans for the forage grown therein. Humans would not consume the forages produced since they would be inedible for them. So ruminant production is the best method for converting forages into animal products for human food and other uses. These animal products would add quality and palatability to the diet and give more pleasure to eating.

Economics will determine expansion

There is no doubt that ruminant production can be greatly increased in Latin America. But, before this can be done, there needs to be a market for the animals and the people must be able to purchase the animal products produced. So equally important to solving animal production problems are economic and social programs designed to make it possible for the people to have a better life and to be able to purchase the meat, milk and other foods they need. So increased ruminant production needs to be kept in line with market demand for it in each country or for export purposes. A limiting factor in the expansion of ruminant production in Latin America is that the price paid for live animals is low. Consequently, the returns to cattle producers make it uneconomical to buy much, if any, fertilizer; buy better quality breeding stock; buy all the supplemental feeds needed for the forage program; plus purchase many other items associated with high level productivity. Thus, the demand for beef and milk, and their price level at the farm, will be very important in determining how much expansion will occur and the quality or productivity of the farms involved.

The human population in Latin America is growing at a faster rate than in any other area of the world. Food production is not keeping pace with population growth. Therefore, more meat products and other foods need to be produced in order to more adequately feed the human population in this area of the world.

Ruminant productivity is low

Most of the areas in Latin America are still not using much of the new technology which is now used routinely in the more developed countries. There are exceptions to this statement in most countries where, in certain areas, there are some very good ruminant enterprises. But, these enterprises are, for the most part, located in the more developed areas of each country. In the undeveloped areas, the use of new technology is very low.

As a consequence, in Latin America, it takes 4 to 5 years or more for beef cattle to reach market weight. Animal slaughter is less than 12% of the cattle population as opposed to 38% in the U.S. In most cases, selection is mostly for survival and not top productivity. The calving rate is estimated to be between 40 to 50% as compared to 86% in the United States. Most evidence indicates that the mortality rate is at least 12 to 15% versus 5 to 6% in the U.S. (1).

Latin America and the remainder of the 80 developing countries have about 60 percent of the world's livestock and poultry but produce only 22 percent of the world's supply of meat, milk and eggs (2,3). This is shown in Table 1. This indicates the low level of animal productivity in Latin America. It also indicates the tremendous potential for increasing productivity of ruminant animals in this area (4). Latin America has twice as much land area and twice as many cattle as the United States. Yet, they produce only one-half as much beef. Therefore, the ratio of productivity is 1 to 4 which means Latin America is feeding 4 times as many cattle as the United States to produce a ton of beef (5,6). Moreover, their beef would not all meet U.S. quality standards. This indicates that increasing the quality of cattle and improving production and management programs can expand beef and milk production a great deal in Latin America.

Table 2 shows that the developing countries lag considerably behind the developed countries in animal production per animal. This is especially the case in ruminant production of beef, veal and milk (2).

Table 3 shows that the developed countries produce the major part of the world's supply of meat, milk and eggs even though they have a smaller percentage of animals than the developing countries. This indicates that the developing countries are still in the beginning stages of intensifying their animal enterprises and making use of new technology.

Research needs to be increased

Some ruminant research programs are underway in Latin America but they are on a small scale compared to the need. Very little research is being conducted in the interior in the hot, humid areas where the largest land areas are located. Some of these areas need to be developed in the near future. Others will need to be developed later on as population pressure and economic conditions warrant it. Research results from the U.S. and other countries of the world are of some value in Latin America. But, such research is limited in its application and will not substitute for adaptive research needed "on the spot" where results are to be applied. Therefore, much research work is needed in each country in order to meet the local conditions encountered, the breed of animal used, the forage and other feed supply available, the level of management used, the level of productivity desired, the disease and parasite problems encountered, the market price and demand and many other factors associated with a total ruminant production and marketing program. Therefore, in order for real progress to occur in Latin America, considerably more emphasis is needed on research and education programs designed to improve production rate, efficiency and marketing of ruminant animals.

Forage production

Ruminant animals depend to a large extent on forage production in Latin America. In the U.S., it was reported in 1971 (8) that 72 percent of the feed consumed by beef cattle, 66 percent by dairy cattle and 90 percent by sheep and goats came from forages, both pasture and harvested forage. In Latin America, even a higher percentage of the total ration for these animals comes from forage. Forages, therefore, serve as the main feed source for beef, sheep and goats and to a lesser extent for dairy dattle.

Latin America has the advantage of plenty of sunlight, a long growing season and a warm climate. These are all important in forage production if they can be controlled and made to work as plus factors. However, in many areas there is a lack of soil fertility plus long seasonal dry periods which greatly restrict the continuous year around production of quality forage. But, these are things man can do something about if research information is available on how to correct mineral deficiencies, extend the grazing season, preserve forage and supply other needed nutrients if the economics will justify doing so. Proper fertilization can do wonders toward increasing forage production in Latin America. But, economical conditions will greatly limit the level of fertilization. This means that to begin with, the more fertile soils need to be used. In addition, crop rotations need to be developed which minimize the need for fertilizer when the pasture phase is put into use. The development of legumes to use in combination with grasses would also lessen the need for fertilization. In addition to fertilization, we should not forget the problems of adapted forage varieties, disease control and other problems of forage production.

Beef Cattle

Beef cattle have the greatest potential for expansion in Latin America. This is due to the very large land areas available for which the most logical use for many years to come is beef cattle. Much of this area is in sparsely populated and underdeveloped locations where beef cattle grazing is the preferred method of utilizing the land and the resources available.

There are many problems to be solved in order to develop the full potential for beef production in Latin America. Better quality cattle, improved breeding programs, proper feeding and nutrition, better disease and parasite control, improved management and many other production problems need to be solved or improved upon. Development of an improved marketing program is of prime importance.

This includes a simplified beef grading system which would reward the rancher producing the better quality beef. Until he can obtain more money for his cattle, he does not have much incentive to improve the quality of animal produced.

Exports of beef provide some incentive for increasing beef production in Latin America. But, expansion for this purpose should be kept in line with the amount of future demand as well as the continuity of this demand. Problems associated with a fluctuating demand for beef exportation should be carefully considered.

Dairy Cattle

It is difficult to predict how much expansion will occur with dairy cattle in Latin America. There are some who feel that it is more economical to import dried milk powder and reconstitute it into fluid milk. They also feel that butter, cheese and other milk products can be imported cheaper than they can be produced in Latin America. A lack of proper transportation, pasteurization, processing and marketing facilities for milk in many areas adds credence to those who do not think the dairy industry will expand very much. Others, however, feel that there will be considerable expansion in the Latin American dairy industry. Something between these two viewpoints will probably prevail as better transportation, processing and marketing facilities are developed. Some very good dairy operations already exist near the larger cities of Latin America. As better quality cattle and as better feeding, production, management, marketing and other factors improve, there will result an increasing level of milk production per cow. This is important since Latin America produces less than 30% as much milk as North America (9). There will, of course, be more demand for milk as the human population continues to increase in the future. To begin with, more emphasis should be placed on improving the productivity of present dairy herds since this in itself could result in a 50 to 100 percent increase in milk production.

Sheep and goats

Some expansion of sheep and goats will occur in Latin America but it will be small. In tropical areas, severe parasite problems exist and especially with improved breeds brought in from other areas. In Florida, the native sheep in the state are relatively resistant to parasites but high death losses due to parasites occur when improved sheep breeds from other states are brought to Florida (10, 11, 12). Therefore, it is logical to assume that any move to increase sheep production in Latin America should make use of the native sheep in each area as the base for commercial flocks. Interest in sheep in tropical Latin America is small. Sheep would do best in the cooler and higher altitude areas of Latin America. They will perform better than cattle in the mountainous country and in areas where the amount and quality of forage is lowest.

Goats could be used more than they are in Latin America. They can serve as a source of milk as well as meat for the small farmer or the poor people who otherwise would have little or no milk or meat for their family. Goats can be staked out to consume forage along roadsides, ditches and other areas where the forage might otherwise go to waste. This forage plus some mineral (and possibly other supplementation) would result in fairly good milk and meat production. This would be an important supplement for the poor farmer whose income may average $100 to $200 per year. It would also supply much needed protein as well as minerals (especially calcium) and vitamins (especially vitamin A) to their diet.

SUMMARY

There is a tremendous undeveloped potential for increasing ruminant production in Latin America. This is especially true for beef cattle and to a considerable extent for dairy cattle. A small increase should occur with goats and sheep. The availability of large land areas with considerable potential for forage production

makes ruminant enterprises the preferred method of utilizing the land and other resources available. In these areas, the ruminants would not be competing with humans for the forage grown since it would be inedible for them. Increased ruminant production should be kept in line with domestic demand and, to some extent, the export market which might vary periodically. Economic and social programs are needed which will increase the purchasing power of people for animal products and other foods. This will determine how much animal product consumption will occur in each country. Presently, productivity levels of ruminants are low. Research and education programs are needed to raise the production rate and efficiency of beef, dairy, sheep and goats, the quality of the product produced and its marketing and distribution system. Latin America has the advantage of plenty of sunlight, a long grazing season and a warm climate. However, in many areas there is a lack of soil fertility and long dry periods which greatly restrict the continuous year around production of quality forage. But, these can be corrected when the economics justify doing it. Therefore, Latin America has many favorable factors indicating the potential for a considerable increase in ruminant production. This can be done by increasing the total land area utilized for ruminants, by intensification on existing ranches and by innovation and the application of new technology. The increased use of animal products would add quality and palatability to the diet and would give more pleasure and satisfaction to eating.

TABLE 1. World's livestock and poultry production in 1962 in 1,000 metric tons (2)

Country or area	Meats							Total animal products	Percent of world production
	Pork	Poultry	Bovine	Other	Total	Milk	Eggs		
United States	5,430	3,265	7,747	1,483	17,925	56,828	3,806	96,484	19
Developed Countries	12,356	5,404	15,840	5,795	39,395	187,464	8,682	274,936	54
Less-Developed Countries	3,021	1,241	10,420	3,816	18,489	74,275	2,496	113,758	22
Total World Production	23,045	8,155	31,840	12,010	75,050	346,880	13,929	510,909	--

TABLE 2. Pounds of production per animal yearly (7)

	Production in developed countries	Production in developing countries
Beef and veal	156	35
Milk	1784	213
Mutton, lamb and goat meat	14	8
Pork	184	88
Eggs	12	6

TABLE 3. Animal distribution and production in developed countries (7).

	Percent of world's animals	Percent of world's animal production
Cattle and water buffalo	30.1	78.3 (milk) 66 (beef, veal)
Sheep and goats	36.5	49.7 (meat)
Pigs	40.3	58.8 (pork)
Chickens	43.7	61.2 (eggs)

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Discussion of the Paper by T.J. Cunha on

ROLE OF RUMINANTS IN NUTRITION AND AGRICULTURAL AND ECONOMIC DEVELOPMENT IN THE TROPICS

J.K. Loosli
University of Florida
Gainesville, Florida

Dr. Cunha has effectively summarized the main problems and potentials for increasing protein production by ruminants in Latin America. Since the other discussants will give further details with reference to Latin America, I plan to cite some problems and successes in other countries.

There are tremendous potentials for increasing animal protein production in many tropical areas, but whether or not these potentials will be achieved in any country depends on whether a) diseases and parasites can be controlled, b) the genetic merit of the animals will be upgraded, and c) nutrition and management can be improved to make economic production a reality. Past attempts to modernize cattle production in tropical countries have often failed because of the lack of adequate inputs, especially nutrition and management, but there have been some recent successes.

Traditional livestock owners in West Africa and areas of East Africa are nomadic. They do not own land and have permanent homes, but move their families with their cattle as they search for feed. They range across national boundries into the Sahel during the rainy season, then south again in the long dry season. The cattle are milked and the milk used by the family or exchanged for cereals, clothing and other necessities. Surplus males are sold after they reach maturity and these provide the beef for the villages and cities. The females are needed to maintain the breeding herd. Productivity is very low. The calf crop is only 30 to 50% compared to 85% in the U.S.A., and death losses are high. Carcass weights of the animals are about one third of those in Europe and the U.S.A.

Some dwarf and semi-dwarf cattle are found in the southern rain forest and intermediate savanna areas of West Africa. These are owned by the local village rulers and used largely for celebrations and, thus, they contribute little protein on a regular basis.

Formerly, the tropical climate and disease problems were blamed for the low productivity of the cattle. Much progress has been made in reducing losses from diseases and parasites, but there are still some unresolved problems. Very little progress has been seen in improved management except in isolated instances. Recent experience has demonstrated that European breeds of dairy and dual purpose cattle are able to grow rapidly and produce 2 to 5 times more milk than native tropical cattle if they are protected from diseases and fed and managed to minimize stress. At elevations above 1,000 meters, there is no important heat stress problem.

In the rain forests of Africa, the slash and burn, bush fallow system of farming is the only method that has maintained a reasonable level of soil fertility over centuries. Domestic animals play no part in this system, except for a few native goats, pigs, and chickens as scavengers. It would seem that a grass rotation using ruminants would be more productive.

There are more difficulties in producing and processing milk than meat in the humid tropics. Striking success has been achieved, however, in Kenya in stimulating milk and beef production on small farms using grass-crop rotations. Governmental aid in providing credit, land, and cattle ownership, training in production methods, and price stabilization to give needed incentives have made this possible. This could serve as a model for other tropical countries.

In Batangas, Philippines, the small farmers keep 1 to 3 cows to graze coconut groves and consume rice straw, weeds, corn stalks, and vegetable and fruit residues. They supply some milk and significant cash income when sold for beef. In Nigeria, government-owned cattle ranches have met with only limited success. Some private ranches now being started should become more productive, but financial returns on these enterprises is lower than for industrial development or housing units. There is much unused or poorly used land in Africa that could be used for livestock if people were trained in husbandry and assisted in starting the operations.

Ruminants have the advantage that they can be fed grass, weeds, and food crop wastes. They can add to the total food supply without competing with the land used to produce food. They can effectively use waste products from the breweries, sugar refineries, and fruit and vegetable pro-

cessing plants. They can be integrated into small farms and add income, and improve human nutrition. Large beef cattle and dairy farms could be developed if incentives were available.

A few sheep and goats are seen in Africa with the migratory herds of cattle to supply meat for the family. Dwarf goats are widely distributed in the villages throughout tropical Africa and Southeast Asia where they survive as scavengers, consuming the grass, weeds, and brush on the roadsides and garbage in the streets and markets. Most of the sheep occur in the drier regions and higher altitudes of the tropics, but some dwarf types are found in lowland humid areas of Africa, along with the goats. Sheep and goat meat is well accepted. The smaller size of these animals is an advantage in rural villages without refrigeration, where distribution and use of the meat is easy on the day of slaughter. Unfortunately, they are butchered primarily for festivals and celebrations, and little of the protein is given to the young children who have critical need.

No mention was made of the water buffalo, a most important ruminant in southern Asia and India and, to some extent, in the Middle East as a source of power for farming and transport, as well as meat and milk. Domesticated buffaloes are not found in tropical Africa and only a few in the Amazon basin in Brazil in Latin America. There are vast areas of swamps and wet lands largely unused along coast lines, rivers, and lakes where water buffaloes could thrive with limited care and without competing with other animal production or crop farming. They could greatly increase the efficiency of the labor intensive food crop production in tropical Africa. The meat is comparable to beef and the milk is higher in protein and fat than milk from cattle or goats.

USE OF FORAGE AND BY-PRODUCT FEEDS IN TROPICAL BEEF PRODUCTION[1/]

H. L. Chapman, Jr.[2/]

The land between latitudes 30° N and 30° S will be a major beef cattle producing area of the world in the future. There is much environmental variation in this area, ranging from the arid to humid tropics and from low to high altitudes. These variations make it impossible to categorize the whole area as one. In Latin America conditions vary from the dry Pacific areas to the rainfall forests and from the tropical conditions at low altitudes to the more temperate conditions of the higher altitudes. However, most areas in Latin America have warm temperatures, good rainfall at least part of the year, and fertile soils conducive to growing large quantities of pasture forage. Many of these areas are still relatively lightly populated and there are vast acreages available for beef cattle production. These advantages are accompanied by some problems. Many of the areas are in the development stages. Grains and protein meals are scarce and must be used for human consumption and/or monogastric animals. In high rainfall areas the practice of preserving surplus roughage for deficient periods is limited. Some of the more fertile lands are used for sugarcane, bananas, cotton, vegetable and fruit production. Fertilizers are often scarce. These and other problems dictate that beef cattle in the tropics have and will continue to obtain the bulk of their nutrition from forage and that supplemental feeds will be limited principally to materials that cannot be efficiently used by humans and/or monogastric animals such as swine and poultry. Not long ago it was

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1/ Paper presented at seminar on utilization of local ingredients in animal feeding stuffs, held in Jamaica, April 1-18, 1975.

2/ Center Director and Animal Nutritionist, University of Florida Agricultural Research Center, Ona, Florida, 33865.

reported that 60% of beef exports from Australia and 90% from New Zealand were produced on pasture. The vast majority of the beef produced in the low and wet tropics of Latin American countries are produced primarily on forage. As more is learned about tropical forage, how to supplement them and as production practices become more intensive we will see an increase in supplemental feeding in the tropics, but it will continue to be a forage-oriented beef cattle industry for many years.

Nutritional Requirements of Beef Cattle

There are many excellent references on beef cattle nutrition (20, 23, 33, 36, 38)[3/] and these will not be discussed in detail. The nutritional requirements of beef cattle have been summarized by the National Research Council (42) and show nutritional requirements to be affected by sex, level of production, size of animal and the stage of the animal's life.

For example, as shown in Table 1 the net energy need is affected by body weight, rate of gain and sex. The net energy requirement to maintain a growing beef animal increases as body weight increases. The net energy required for gain increases as the daily gain increases and more net energy is required for heifers to gain at the same rate as steers.

Similar factors affect the daily requirement for dry matter, protein, total digestible nutrients (TDN) and other nutrients (Table 2). The requirement for these nutrients are affected by body weight and rate of gain. Also the stage of the reproductive cycle has an important bearing on nutritional requirement. During the first 3 to 4 months after calving, the protein and phosphorus requirements of beef cows more than double, the TDN requirement increases 75% and the

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3/ Numbers in parenthesis refer to literature cited.

Table 1. Net energy requirements of growing and finishing beef cattle (Megacalories per animal per day).1/

Body weight (kg):	100	200	300	400	500
NE_m required:	2.42	4.10	5.55	6.89	8.14
Daily gain (kg)	NE_{gain} required				
Steers					
0.1	0.17	0.28	0.39	0.48	0.56
0.3	0.52	0.87	1.18	1.47	1.74
0.5	0.89	1.49	2.02	2.51	2.97
0.7	1.27	2.14	2.90	3.60	4.25
0.9	1.67	2.81	3.82	4.74	5.60
1.1	2.09	3.52	4.78	5.93	7.00
1.3	2.53	4.26	5.77	7.17	8.46
1.5	2.99	5.02	6.81	8.46	9.98
Heifers					
0.1	0.18	0.30	0.41	0.51	0.61
0.3	0.57	0.95	1.29	1.60	1.90
0.5	0.99	1.66	2.25	2.79	3.30
0.7	1.44	2.42	3.27	4.06	4.80
0.9	1.92	3.23	4.37	5.42	6.41
1.1	2.43	4.09	5.55	6.88	8.13
1.3	2.98	5.01	6.79	8.42	9.96
1.5	3.56	5.98	8.11	10.06	11.90

1/ Nutrient requirements of beef cattle (3).

Table 2. Nutrient requirements of beef cattle (daily nutrients per animal)1/

Body weight (kg)	Average daily gain (kg)	Daily dry matter per animal (kg)	Total protein (kg)	TDN (kg)	Ca (g)	P (g)
Growing steers						
150	0.00	2.7	0.21	1.5	5	5
	0.25	3.1	0.34	2.0	8	7
	0.50	3.2	0.39	2.3	12	10
	0.75	3.2	0.43	2.5	17	13
200	0.00	3.3	0.26	1.9	6	6
	0.25	4.5	0.45	2.6	8	8
	0.50	4.9	0.54	3.1	13	10
	0.75	5.0	0.56	3.5	18	14
Dry pregnant mature cows						
350	--	5.8	0.34	2.8	9	9
400	--	6.4	0.38	3.2	10	10
450	--	6.8	0.40	3.4	12	12
500	--	7.6	0.44	3.8	12	12
550	--	8.0	0.47	4.0	12	12
600	--	8.6	0.50	4.3	13	13
Cows nursing calves, first 3-4 months postpartum						
350	--	8.6	0.79	4.9	25	20
400	--	9.3	0.86	5.3	26	21
450	--	9.9	0.91	5.6	28	22
500	--	10.5	0.97	6.0	28	23
Bulls, growth and maintenance (moderate activity)						
300	1.00	8.7	1.21	5.6	23	18
400	0.90	10.0	1.33	6.5	19	18
500	0.70	12.0	1.60	7.1	21	21
600	0.50	11.6	1.42	6.9	21	21
700	0.30	12.7	1.41	7.2	23	23
800	0.00	9.9	0.99	5.6	18	18
900	0.00	10.7	1.07	6.1	19	19

1/ Nutrient requirements of beef cattle (3).

calcium requirement increases approximately 2½ times, as compared to a dry, pregnant cow. Other nutritional needs also increase during lactation.

The vitamin and micro-mineral requirement of beef cattle needs further research but adequate levels are recommended by the National Research Council (Table 3). Note that these requirements increase as the body weight increases.

It is vital that beef cattle have adequate water available at all time. The requirement is affected by temperature, body weight, rate of gain, lactation, type of diet, dry matter intake, activity and breed of animal. It is obvious that the need for water will vary greatly. However, a good rule of thumb is that 1.2 to 2.0 gallons of water are required per 100 pounds (45.4 kg) of body weight. Water comprises more than 60% of the animal body and is essential for normal functioning of the body. A body weight loss of 5 to 10 per cent due to insufficient water will reduce production.

Beef cattle in the Caribbean area obtain the majority of their nutrients from forage. Historically, the degree of success of beef cattle production in this area has been directly related to the efficency of forage in providing needed nutrients. For maximum production the periods of the life cycle of cattle requiring the most nurtients, such as the last two months of lactation and the first 3 or 4 months of lactation, need to be coordinated with the maximum peak in the forage growth cycle. Even when the optimum symbiosis occurs between cattle and forage, nutritional deficiencies can still occur in cattle because of inadequate forage or nutritional deficiencies within the forage. When this occurs it is necessary to provide supplemental feed to furnish the nutrients that the forage does not provide. Periods of the life cycle that need special attention are gestation, the first 4-5 months of lactation when the cow is nursing a calf and is expected to breed again and the first 6-12 months after a calf is weaned.

Table 3. Mineral and vitamin requirements of beef cattle (in percentage of ration dry matter or amount per kilogram of dry ration.1/

Nutrient		Growing and finishing steers and heifers	Dry pregnant cows	Breeding bulls and lactating cows
Vitamin A activity	IU	2200	2800	3900
Vitamin D	IU	275	275	275
Vitamin E	IU	15-60	--	15-60
Sodium	%	0.1	0.1	0.1
Magnesium	mg	400-1000	--	--
Potassium	%	0.6-0.8	--	--
Sulfur	%	0.1	--	--
Iodine	mcg		50-100	50-100
Iron	mg	10	--	--
Copper	mg	4	--	--
Cobalt	mg	0.05-0.10	0.05-0.10	0.05-0.10
Manganese	mg	1.0-10.0	--	--
Zinc	mg	10-30	--	--
Selenium	mg	0.05-0.10	0.05-0.10	0.05-0.10

1/ Nutrient requirements of beef cattle (3).

The major nutritional deficiencies found in the tropical areas of the Caribbean are energy, protein, phosphorus and cobalt. In the arid tropics or in areas where rainfall is seasonal there will also be periods when sufficient dry matter is not available. There are areas where copper, iron and other micro element deficiencies will be a problem and these need to be defined, but primary concern should be given to energy, protein, phosphorus and cobalt when designing a supplemental feed.

Nutritional Value of Tropical Forages

The nutritive value and chemical composition of tropical forages varies considerably due to type of forage, climate, forage species, soil fertility, and stage of maturity of the plant. Tropical forages range from native species, improved grasses, legumes and mixtures of grasses and legumes. They are subjected to intensive and extensive management procedures. Forage growth is seasonal in many areas such as Central America (4, 25, 50, 54), south Florida (28, 32), Puerto Rico where growth is slower in January and February (6) and other areas of South America. During the slow growing season the perennial grasses decrease in protein and digestibility and increase in fiber content. Many tropical soils are deficient in minerals required by cattle and this will affect the plant composition. Tropical species are reportedly relatively high in fiber (54) which will reduce dry matter intake and subsequently the intake of digestible energy.

All of the above factors are to emphasize the variability that can exist in tropical forages. More information is needed about the nutritive value and chemical composition of tropical forages. As mentioned earlier, the principle nutrients to consider in a supplemental feeding program are energy, protein, phosphorus and cobalt. Tropical forages are usually deficient in one or more of these factors. Energy is often the most limiting factor, although protein is also often deficient, particularly in native forages. Phosphorus is the most

common mineral deficiency in perennial forages but cobalt is also deficient, particularly in coastal areas or sandy soils such as found in south Florida.

Value of Supplemental Feed on Pasture

Studies in North Carolina (55, 56), South Carolina (37, 53), Georgia (39), Washington (31), Louisiana (7), and Florida (11, 19) have all shown that steers can be fattened with a limited amount of grain on pasture more economically than on pasture alone. The feed intake was generally limited to a maximum of 1% of body weight and energy supplements usually were of more benefit than protein supplements. Research in Florida over the last 20 years has consistently shown that supplying a limited amount of the proper supplement (1/2 to 1% of body weight daily) to steers being fattened on good quality pasture resulted in more economic return than from pasture alone and often more economical than feedlot gains.

Research in Brazil (48) has shown that supplemental feed significantly increased rate of gain of calves grazing Colonial Guineagrass (Panicum maximum Jacq.) during the dry but not during the wet season. Rate of gain of crossbred calves was significantly increased by both energy and protein during the dry season in the Pacific coastal area of Nicaragua (9) and a brewers grain - molasses supplement increased the rate of gain of slaughter bulls fed during the dry season on grass on the north coast of Honduras (12).

Supplemental feeds for good quality pasture should be high in energy and low in fiber. The crude protein of the total diet should be at least 10 percent. Preferably the pasture forage should contain 20% or more dry matter and the dry matter should contain at least .20% phosphorus and preferable .25 to .30%. Calcium should not exceed 2 to 3 times the amount of phosphorus. Supplemental feeds should be designed to provide the nutrients that are deficient.

The research in southeastern United States has utilized grains as the

energy source. In Latin America countries grains are too expensive to feed to beef cattle. Therefore other materials must be used. There are a number of local feedstuffs available in Latin America countries than can be used for this purpose. Most of these are byproducts of various agricultural and industrial businesses.

Feeding Byproducts to Beef Cattle

There are a number of factors that contribute to the increased interest in the use of byproducts for beef cattle production. Many of these byproducts have become pollutants and a means of disposal must be found; grains are more costly and are needed for human use; there is often a localized abundance of a byproduct that can be purchased relatively cheap; the nutritive value of many byproducts is excellent, providing good sources of energy, protein, minerals and vitamins; and beef cattle have a stomach that allows them to convert waste organic materials into useful products. Dried citrus pulp is an outstanding example of a waste product that was a pollutant but which has been converted to an excellent feed in Florida. There are many other byproduct materials available. A partial list is shown in Table 4.

Problems exist in the use of byproducts. Some of these are listed below:

1. Composition is quite variable. Ex. Cane molasses, citrus pulp
2. Supply is often seasonal. Ex. Cane product, vegetable, fruits
3. Byproducts are often high in moisture. Ex. Bananas, fresh vegetables
4. Possible bacterial contamination.
5. Will be deficient in some nutrients. Ex. Phosphorus is low in cane molasses and citrus byproducts.
6. Palatability will be variable.
7. Possible chemical residues. Ex. Animal wastes, wood products
8. Sometimes they will contain toxic substances. Ex. Wood products

Table 4. A partial list of by-product materials used in beef cattle production.

Crop residues
Rice straw
Wheat straw
Oat straw
Corn stalks
Sugarcane bagasse
Sugarcane tops
Cane molasses
Citrus molasses
Beet molasses
Starch molasses
Wood molasses
Wheat bran
Wheat middlings
Cottonseed hulls
Cotton gin trash
Coffee hulls
Copra
Rice hulls
Rice polishings
Peanut hulls
Corn cobs
Coconut oil meal
Vegetable and fruit wastes
Potatoes
Tomatoes
Celery
Brassica
Bananas
Citrus pulp
Beet pulp
Packinghouse residues
Feather
Hair
Offal
Meat and bonemeal
Blood meal
Sludge
Fishmeal
Pork lard

Table 4 continued.

Distillery waste products

- Wet distillers solubles
- Dried distillers solubles
- Citrus molasses distillers solubles
- Cane molasses distillers solubles
- Wheat distillers solubles
- Brews grain
- Press liquor

Industrial residues

- Whey
- Lignin sulfonate (NH_4, Ca, Mg)
- Fish solubles
- Miscellaneous liquid residues from the production of potable alcohol, enzymes, distilled vinegar, citric acid and amino acid.
- Wood wastes (sawdust, paper, pulp, etc.)
- Hatchery wastes (egg shells, infertile eggs, dead chicks, etc.)
- Feed screenings
- Garbage

Animal wastes

- Poultry manure
- Swine manure
- Cattle manure

Despite the problems inherent in feeding byproducts, these materials offer much potential for producing beef cattle more economically and at the same time converting pollution problems into additional cash income. These byproducts can be processed by ensiling, drying, treating with heat or chemicals and by pelleting in order to convert them into useful feeds for beef cattle. There are a number of byproducts available in the countries surrounding the Caribbean area.

Byproducts of the sugar industry. Sugar production is a major industry in south Florida and many Latin American countries. Sugarcane and its byproducts have been used in Florida beef cattle production for many years. There are two sources of waste materials, the field and the mill. Byproducts include surplus whole cane, sugarcane tops, bagasse, filter mud and molasses. Sugar can also be used in cattle feeds.

1. Sugarcane tops. In some countries this is a source of feed for workstock. Research in Florida (45, 46) and Brazil (24) have reported sugarcane tops to be a palatable feed but that protein was a limiting factor (Table 5). Dry matter intake and weight gains were improved when cane tops were supplemented with cottonseed meal. The main value of pelleted sugarcane tops was reported to be as a pasture extender or as a roughage source (46).
2. Whole sugarcane can be grazed or it may be cut and fed fresh, either chopped or whole. It may be ensiled but much of the sugar will be lost and more weight gain in cattle will be obtained from fresh cane than ensiled cane (16). Commercial varieties may not need to be chopped when fed to mature cattle but this will depend on the variety of cane. Sugarcane can be grazed but there will be variety preference

Table 5. Average composition of sugar cane tops.[1/]

Chemical composition	As fed basis	Dry matter basis
Dry matter	31.7	
Crude protein	1.91	6.03
Ether extract	0.54	1.72
Crude fiber	9.89	31.17
N.F.E.	17.07	53.73
Ash	2.33	7.35

1/ Pate et al. 1971. FAES-EES Mimeo Rpt. 71-5.

by beef cattle. Sugarcane is low in protein and cattle should receive a protein supplement when sugarcane is fed.

3. Filter mud is also referred to as filter cake or cachaza. It is the residue collected during the filtering of the cane juice. It has been fermented and used for a cattle feed, but has been less effective than dried citrus pulp in steer rations (16).

4. Bagasse is the fibrous residue remaining after the sugarcane stalk has been crushed and the juice pressed out. It has been shown in earlier studies to be a good source of roughage (34) but very bulky, requiring special mixing and handling equipment. Recent studies (18) have shown that 7½% to 10% of bagasse pellets compared faborably with cottonseed hulls as the roughage source in a complete cattle fattening rations. As shown in Table 6, bagasse is low in protein and high in fiber contents. Bagasse-containing supplements need to have protein, energy and minerals included.

5. Cane molasses. The byproduct of either raw sugar manufacture or refining, the composition of cane molasses will be affected by cane variety and maturity, climate and soil conditions, and clarification technics at the mill (40). Lack of uniformity exists in grades and definitions and care should be taken when feeding this material in order that it will be properly supplemented with other nutrients. Average composition for three different kinds of Florida molasses are shown in Table 7 (10). There are numerous research reports in the literature concerning the value of molasses in steer fattening programs. (5, 8, 14, 15, 41, 44, 50.) These and other studies have shown that molasses will significantly increase rate of gain during the dry season. Studies in Florida (36) and Cuba (47) have shown

Table 6. Average analysis of dried sugarcane bagasse pellets (per cent on air dry basis).1/

	1969-70	1970-71
Dry matter	93.8	94.6
Crude protein	3.1	2.6
Ether extract	.7	.6
Crude fiber	34.9	36.0
Ash	3.3	2.5
Nitrogen-free extract	51.8	52.9

1/ Chapman and Palmer. 1972. FAES Circular S-216.

Table 7. Average composition of millrun blackstrap molasses, cane molasses for feeding and citrus molasses (%).1/

	Millrun blackstrap molasses	Cane molasses for feeding	Citrus molasses
Dry matter	81	74	71
Crude protein	8-10	6-7	4
Total sugars	54	48	45
Phosphorus	0.10	0.08	0.06
Calcium	0.90	0.66	0.80
Total digestible nutrients	61	54	51
Digestible protein	4.7	4.3	1.4
Level for fattening rations	0-45	0-45	0-35
Relative value to #2 corn			
Limited fed	78-98	75-95	70-85
Overfed	45-55	40-50	40-45

1/ Chapman et al. 1972. FAES Bulletin 751.

that additional starch will increase gain of steers on a molasses-base ration. Excellent results have also been reported from feeding a combination of molasses and fish meal (47). It appears that the relative cost of molasses is the decisive factor regarding its use for fattening cattle. Molasses is an excellent energy feed, usually low in protein and phosphorus content.

Relatively little work has been done to evaluate cane molasses for beef cows. A three year study in Florida (17) has shown that cane molasses will increase pregnancy rate, weaning per cent, weaning rate and annual production per cow (Table 8). Again, relative cost was the determining factor in feeding this material.

6. Raw Sugar. Research in Hawaii showed that 16% and 32% of sugar could be added to cornmeal- or molasses-base feeds with good results (43). A sugar-urea supplement was fed up to 40% in Florida, replacing cornmeal with no harmful effects (3). Gains were higher on the sugar rations and feed utilization was improved linearly with increased level of sugar. Raw sugar is currently too expensive to feed, but more research is needed in case the relative cost improves.

Byproducts of citrus production. Some tropical areas have citrus production. Depending on how the citrus in marketed, there can be a number of residual materials that are excellent cattle feed. These include citrus pulp (either wet or dried), dried citrus meal, citrus seed meal and citrus molasses.

1. Citrus pulp. This is comprised of the peel, rag and seed of the citrus fruit. For many years it was fed fresh in California and Florida as a winter supplement to pasture. It is a carbohydrate feed low in both crude protein and crude fiber and relatively high in moisture. It should be fed in combination with protein and minerals. Intake is increased if the material is dried. When the peel, rag and

Table 8. Average production of cows fed different amounts of millrun molasses in conjunction with pasture.[1,2]

	Molasses treatment		
	None	Seasonal	Continuous
Molasses/cow/year (kg)	0	287.7	579.1
Pregnancy rate (%)	86.9	93.9	94.1
Calf survival (%)	93.6	94.3	96.4
Weaning (%)	87.9	92.6	94.6
Weaning weight (kg)	153.2	167.7	169.1
Production/cow/year (kg)	134.5	155.5	160.0

1/ Chapman et al. 1965. FAES Bulletin 701.

2/ Each figure an average of 100 cows, for 3 years.

seed is dried, it makes a bulky feed that is high in energy and has been used for many years in beef and dairy cattle rations. The chemical composition and physical appearance of dried citrus pulp varies a great deal depending upon the citrus fruit being processed and the procedures used by the processing plant. The average composition of commercial dried citrus pulp is shown in Table 9. Citrus pulp has been commercially dried in Florida for over 40 years. There have been many studies made of the material and these have been summarized (10). Good quality dried citrus pulp is a bulky concentrate comparing favorably to corn when fed as a supplement to pasture (14, 15). It should be supplemented with protein and minerals, especially phosphorus. Forty per cent of feedlot rations can be comprised of dried citrus pulp with good results and pasture supplements can use larger percentages.

When dried citrus pulp is pelleted it increases intake and rate of gain, but reduces the bulky quality of citrus pulp that may be of value in the rumen.

2. Dried citrus meal. This is the small particles of peel, pulp and seeds that pass through seives. Its chemical composition and appearance varies widely but is not greatly different than dried citrus pulp. It is often pelleted and added back to the pulp. Good quality dried citrus meal can be used up to 40% of a concentrate. Some cattlemen have used it as the sole pasture supplement when it was economical to buy.
3. Citrus seed meal. Very little is produced. It contains from 20-40% protein and is often also high in fat. It was equal to cottonseed meal in feeding tests but current recommendations are that it replace no more than one half of the protein meal.

Table 9. Average nutrient composition of dried citrus pulp (4).[1/]

Nutrient	Number of samples analyzed	Content
Moisture, %	1728	8.58
Ash, %	1728	4.68
Ether extract, %	1728	3.74
Crude protein, %	1728	6.16
Crude fiber, %	1728	12.28
N.F.E., %	1728	64.56
Calcium, %	82	1.43
Phosphorus, %	82	0.11

1/ Fla. Dept. Agriculture, Tallahassee.

4. Citrus molasses is manufactured from the press liquor obtained from the peel and pulp residue. It has been fed in Florida for over 30 years and the extent to which it is used depends upon its relative cost. Its composition as compared to cane molasses is shown in Table 7. Many producers dry the molasses and add it back to the citrus pulp. It is a very satisfactory supplement to permanent pastures. It is a high energy feed that should be fed in combination with protein and phosphorus.

Vegetable and fruit byproducts. Tropical areas have a great deal of vegetable and fruit production. If these materials are processed for marketing, there will usually be a large amount of cull material, trimming and other redidual materials that must be disposed of. Many of these make excellent cattle feed. Some are very high in moisture and need to be dried if they are transported for a very long distance. Examples of good feed materials are carrots, potatoes, tomatoes, celery, bananas, brussel sprouts, cabbage, cauliflower and many others. A few are briefly discussed.

1. Bananas. The workers at Turrialba and Cali have done considerable research using green bananas as a supplement to pasture and recently summarized the value for beef cattle (2, 51). Green bananas are an energy feed but are high in moisture. They will spoil easily and this may limit their use to areas close to banana packing plants. They should be supplemented with protein and possibly a supply of roughage.
2. Celery wastes. This material, which contains about 90 to 95% moisture, has been used as a feed in Florida, both fresh and dried. The dried material contains about 25% crude protein, 3% fat, 15% crude fiber and 11% ash. Research (29) has shown the dried material to be highly

digestible containing about 79% total digestible nutrients and as much as 30% was used in a feedlot ration with good results. The primary limitation is the economics of removing the water.

3. Brassica wastes. Brussel sprouts, cabbage and cauliflower reportedly can be fed to cattle on a limited basis (25). These materials are high in moisture (Table 10) and should be supplemented with a dry roughage, energy and phosphorus. More research is needed regarding the use of these materials for beef cattle. However, they have been successfully used as a livestock feed and offer a possible means for utilizing a potential pollutant for a useful purpose.
4. Tomato pulp. This is comprised of whole cull fruit. Disposal became a major problem in south Florida and it was studied to see if it would be a good livestock feed. Here, again, this material contains a very high moisture content (around 95%) and the production of the material depends on the economics of removing the water. However, when dried, the tomato pulp is high in protein, fat, and minerals and is an excellent feed for beef cattle (1, 13).
5. Others. These have been examples, but there are many other vegetable and fruit residues that can be used for cattle feed. Any area having a supply of these waste materials should investigate the potential of this means of disposal.

Industrial waste materials. As shown in Table 4, there are a large number of these materials available. They are all potential beef cattle feeds. A few of them are briefly discussed below:

1. Wood byproducts. These have been studied for many years but interest has increased lately because of the need to alleviate pollution problems

Table 10. Chemical composition of brassica waste (% drymatter basis)[1/]

	Brussel sprouts	Cabbage	Cauliflower
Dry matter	13.2	12.3	9.2
Crude protein	24.6	19.0	23.1
Crude fiber	13.4	10.8	14.5
Ether extract	2.4	2.9	3.3
Ash	10.7	13.8	17.7
Ca	0.72	2.01	2.43
P	0.46	0.36	0.49
K	3.51	3.33	4.30
Soluble CHO	49	36	57

1/ Fairbairn et al. 1971. A. D. A. S, Edinburg. p. 134-140.

and because some areas need a new supply of roughage. The use of wood wastes for cattle has been recently reviewed (22). Waste wood materials should be supplemented with vitamins, protein and minerals. Also, they should be checked closely for toxic materials such as heavy metals. A byproduct of paper production is lignin sulfonate. This material is neutralized with ammonia, calcium and sodium and has been wisely used in liquid feeds. A recent study (57) with yearling crossbred heifers showed a linear decrease in the rate of gain as the level of ammonium lignin sulfonate was increased from 0 to 25%. All byproducts should be thoroughly tested before their widespread use.

2. Whey. This material has been of much interest in recent years and considerable research has been done in the midwest, northeast and southeast portions of the United States. It is a byproduct of cheese production and new environmental regulations prohibit further discharge into sewers and streams. Whey contains 94% water. However, it can be refermented to build up the solids, treated with anhydrous ammonia and it makes a very good protein source for beef cattle. The degree of utilization will depend upon production economics and environmental control legislation. It can be made into a very palatable, digestible protein source.

3. Bakery wastes. Made from bakery products, it can be used as an energy source in cattle feeds. The composition will be variable depending on the waste material. As much as 10 to 20 percent of bakery wastes have been used in beef cattle rations with good results (35).

4. Miscellaneous. There are a number of other [illegible] wastes listed in Table 4 that are used in animal feeds. These include fish solubles, feed screenings, a wide variety of liquid residues that are used in

liquid feeds and a number of other materials. Many of them are excellent feeds for beef cattle.

Packinghouse residues. This is a source of byproducts that appears not to be fully utilized in many of the Caribbean and some of the developing countries of Latin America. Animal offal, blood, bones, etc. are a potential source of excellent protein and minerals for cattle and their use should be maximum as many of these areas are deficient in phosphorus. Another potential byproduct in some areas is animal fat which could provide a source of energy. Further research is needed to verify earlier results (8) that indicated rate of gain could be increased by adding fat to molasses. Also the fat could be processed and utilized in other livestock rations.

Crop residues. There are many examples of these types of materials in Latin America. Rice straw, corn stalks, cottonseed hulls, cotton gin trash, rice hulls, rice polishing, coffee hulls, coffee pulp and many other materials are available that are potential feed for beef cattle. More information is needed to show the best way to use these byproducts. For example, it has been reported (49) that the nutritive value of these materials can be increased 2 or 3 times by treating them with alkali materials such as sodium hydroxide. The procedure has disadvantages such as corrosiveness, cost, possible danger in using, etc. but these possibilities should be investigated as these byproducts are abundant in many areas.

Animal wastes. These wastes have received much attention in recent years. In the United States this interest has been precipitated by antipollution legislation, but the materials are an excellent source of nutrients. Recent research has been summarized for poultry (21), swine (30) and cattle (27) manure. In addition the use of animal waste for protein sources was discussed at a symposium which was recently sponsored by the National Research Council (52). These

materials do not have clearance for use in livestock rations in the United States and more research will be necessary before they are approved for this use but they are a large potential source of good quality feed for beef cattle. The poultry and swine industries in some Latin America countries may provide a source of these materials in the future.

Distillery byproducts. There are a number of distilleries and breweries throughout the Caribbean and Latin American countries. The grains used are fermented with yeast to produce alcohol or beer. The residues are distillers grains, distillers solubles, brewers grain, and press liquor. During the fermentation process the carbohydrates in the grains are converted to alcohol, carbon dioxide and other carbohydrates, while the proteins, minerals and vitamins are concentrated. The residue also contains the yeast cells and unidentified factors that are produced during the fermentation process. The residue is still disposed of in the wet form in some places. However, when dried they make an excellent feed for cattle, as well as for other forms of livestock. These feeds are high in protein, fat, minerals and vitamins and low in fiber. There will be some composition variability depending on the grain used in the process, but these products are excellent feeds. The main limitation in their use for cattle may be cost.

Summary

Beef cattle production in tropical areas will be based on pasture forage and locally available byproduct feedstuffs for many years to come. There are a large number of these byproducts available in most tropical areas. In order to use forages and byproducts to maximize beef cattle production it will be necessary to combine the two together to best furnish the nutrients needed for optimum beef cattle production. Continued efforts are needed to find economical ways to

convert the byproducts to useful feeds and to evaluate their use for beef cattle. Ways need to be developed to standardize the value of feedstuffs and to develop uniform supplies throughout the year. The use of these materials as a supplement to different kinds of pasture needs continued study. However, there is ample information available to conclusively show that beef cattle can utilize byproducts for much of their nutrition. It is simply a matter of bringing forage, byproduct and beef animal together in the proper symbiosis to produce the best product at the most economical cost.

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Seminar on
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RUMINANT NUTRITION: DAIRY CATTLE

J.K. Loosli
University of Florida
Gainesville, Florida

The efficient utilization of feeds by animals is governed not only by the nature and composition of the feed ingredients, but also by the ability of the animals to consume and digest the feeds and their genetic merit for meat or milk production. The animal's specific nutrient requirements must be fully met to achieve satisfactory growth and productive efficiency.

Nutrient Requirements of Dairy Cattle

After dairy calves are weaned from milk or milk replacers and are eating dry feeds, they can be fed the same feed ingredients as mature cattle, but the mixture should be richer in protein, energy, and certain minerals during the first year. The data in table 1 illustrate the requirements during growth. The values are considered to be the minimum amounts which will produce satisfactory growth responses. Larger intakes of protein and energy will result in more rapid growth, greater fat deposition, and earlier maturity of heifers, but not in larger mature size or higher milk yields. After about one year of age (250-300 kg), heifers can make normal growth on good quality forage without any concentrates if the forage is high enough in protein. Mineral supplements should always be fed, since even good forages may be deficient.

The major nutrient requirements of cows for maintenance and milk production are shown in table 2. There is some evidence that slightly higher levels of protein and energy than listed will increase the milk production of high yielding cows, especially in early lactation. The ARC (1965) values may be followed with results equally as satisfactory as the NRC data in tables 1 and 2.

Broster and Bines (1974) recently summarized various estimates of the protein requirements for milk production as follows:

Crude protein requirements (% of dry matter)

Milk yield (kg/day)	0	10	20	30
ARC (1965)	9.9	12.2	13.5	13.6
NRC (1971)	12.3[a]	14.7	16.4	16.7
Evans	8.9	13.1	14.4	14.5
Miller	11.3	13.3	14.4	14.5

[a] A level of 8.5% of crude protein is adequate for non-pregnant mature cows.

Drori and Folman (1970) reported that a concentrate having 11.5% crude protein fed with corn silage supplied adequate protein for high milk yields with high energy, high concentrate diets at all levels of production.

Highest yielding cows are unable to consume sufficient feed to prevent a negative energy balance and weight loss in early lactation even with ad libitum allowances of concentrates. A marginal or slightly deficient protein intake accelerates weight loss and decline in milk production. Thus, it is advisable to be generous with protein allowances to high producers in early lactation.

Composition of Feeds

It is necessary to know the composition and availability of nutrients in feeds in order to formulate feed mixtures that will supply the needs of animals. The composition of selected feeds is shown in table 3. Values are listed only for protein, energy, calcium, and phosphorus in the feed composition and requirement tables because these are the only nutrients which always need to be considered in formulating an adequate ration for dairy cattle. A trace mineralized salt mixture should always be provided to supply other essential minerals unless they are known to be fully adequate in the feeds. Extra vitamin A is unnecessary if ample fresh, green or ensiled forages are available. Otherwise, vitamin A can be added to the concentrate mixture. Vitamin D is usually combined with vitamin A supplements, and it costs very little. Cattle that are exposed to sunlight may not need extra vitamin D unless parturient paresis is a problem.

Formulating Adequate Rations

Protein sources are usually more expensive than energy-rich concentrates. Urea or ammonium compounds can often be used profitably to spare true protein sources such as the oil seed meals. The crude protein content of concentrate mixtures should be planned to supplement the protein in roughage without allowing wastage. The roughage supply and quality is the starting point in formulating an adequate, low cost, dairy concentrate mixture.

Urea and NPN utilization. Many studies have shown that urea can successfully replace high protein oil seed meals in up to one third of the nitrogen in dairy cattle diets. Less milk is usually obtained than with true protein, but the difference is very small, and economics usually favor NPN utilization (Loosli and McDowell, 1968). Bines and Broster (1974) reported data suggesting that the microbial amino acid synthesis in the rumen would cover maintenance and 10 kg milk daily. Additional milk must come from supplementary protein. Urea should never be added to mixtures already adequate in protein.

Meeting the roughage requirement. Young calves do not need roughage for normal growth the first few months, but mature-type rumen function develops by 2 to 3 months of age when pasture, hay or silage is fed along with limited milk and a concentrate feed. Young cattle finished for slaughter thrive on very low-roughage, high-energy rations. In contrast, dairy heifers developed on high-roughage rations that avoid over-fatness produce more milk and have longer productive lives than heavily-fed heifers.

Milking cows need 15 to 18% of fiber in their rations to maintain normal fat levels (Rock *et al.*, 1974), and much of the fiber source must be coarse enough to promote normal rumen fermentation. Ground and pelleted hay is not suitable since it moves through the rumen too rapidly for normal cellulose fermentation. Such bulky feeds as citrus pulp, brewer's grains, cottonseed hulls, soybean hulls, and perhaps coffee hulls can replace much of the hay, silage or pasture. Small amounts of coarsely ground corn cobs, bagasse, cereal straw or rice hulls can replace part of the forage. Sawdust and bark from trees have also been used.

There are fewer problems in maintaining high and efficient milk production when ample pasture or forage crops for hay or silage are available. When cows

have all of the good forage they can eat, the roughage requirement will be satisfied, and consideration is needed only to supplying protein, energy, and minerals. Good forage alone can suffice for maintenance and up to 10 kg of milk per day. In areas where crop land is scarce and expensive, production of suitable forage can be a major problem. It is reported that in Taiwan one hectare will produce enough Napier grass fed as green chop for 20 milking cows. The fresh or ensiled grass or sugar cane tops supplemented with molasses, urea, and minerals allows marketing 400 kg cattle at 14 months of age. In Cuba and Mexico, Preston has shown that sugar cane fed fresh will produce more forage and total energy for cattle feed per unit of land than any other crop.

Sources of energy for high milk yields. In addition to the cereal grains and their byproducts, sugar cane molasses, citrus molasses, citrus pulp, whole cottonseed, sweet potatoes, cassava roots, bananas, potatoes, beans, cowpeas and other legume seeds, brewery and distillery byproducts, and cannery wastes are good sources of energy. The wet byproducts can be stored in silos, but some dry feed should be added to prevent excess moisture run-off.

Molasses is a cheap source of energy, and some is wasted in tropical countries. Calves can be fed up to 1.0 kg molasses a day after 6 months of age. Mature cattle will eat 2.0 to 2.5 kg daily with ad lib feeding. Excess molasses lowers cellulose digestion in the rumen. Pigs do well on diets with 60 to 75% molasses. Molasses makes an excellent carrier for urea, whether self-fed or added to other feeds. The following amounts of molasses can be absorbed to make dry feeds: bagasse 1 part to 2.5 parts molasses, corn cobs 40%, coconut meal 33%, wheat middlings 19%, corn meal 15%, cottonseed meal 15%, and dried brewer's grains 10%.

Because byproduct feeds vary in cost and availability, it is useful to know how much of any one feed can be included in a dairy concentrate without depressing intake or production. The following amounts have been used: citrus pulp 50%, coconut meal 50%, wheat middlings 50%, and dried brewer's grains 30%. Citrus pulp is palatable when cattle become adapted to it and can be fed alone in any desired amount. In a test at Cornell University, pelleted wheat middlings, fortified with limestone to balance the phosphorus, was fed as the only concentrate to milking along with grass hay and corn silage. Milk production was equal to a 16% protein mixed concentrate.

Complete feeds. There is much interest and considerable recent research with complete feeds for milking cows. The problems of feeding correct amounts of concentrates to individual cows in milking parlors or stanchion barns are eliminated, and production appears to be as good as for individually fed cows.

Gohl (1970) cited the results of a study in Puerto Rico in which 20% of treated bagasse replaced 20% of corn grain in a complete feed. The control feed was 20% ground bagasse, 40% corn grain, 20% molasses, 16% soybean meal, 2% urea, and 2% minerals and vitamins. It contained 21.3% crude protein and 13.3% crude fiber on a dry matter basis. The other feed consisted of 20% treated bagasse, 20% corn grain, and the same amounts of the other ingredients, and it contained 17.1% crude protein and 28.9% crude fiber. The cows consumed 16.4 kg of the control and 20.5 kg of dry matter in the test feed, and the milk production was not significantly different on the two feeds.

Other examples of recent research illustrate the flexibility which complete feeds offer in dairy cattle management. Bath et al. (1974) offered ad libitum alfalfa wafers and a concentrate mixture in proportions to vary the energy supplied by hay from 20 to 80%. The results were as follows:

ENE from hay, %	80	65	50	35	20
Intake/day, Hay, kg	13.2	13.3	11.7	9.3	7.8
Concentrates, kg	2.1	3.7	5.4	6.2	8.7
Milk yield/day, kg	13.8	14.6	16.3	14.2	16.8
Fat, %	3.46	3.71	3.18	3.07	2.32

Each 1.0 kg of extra concentrate lowered the hay dry matter intake by 0.78 kg. Milk fat percentage was depressed in high yielding cows receiving 50% or more of estimated net energy (ENE) as concentrate, but the fat test was normal at all levels for low producing cows.

Good results have also been obtained when concentrates are mixed with silage at feeding time. Smith and Coppock (1974) fed Holstein cows corn silage as the only roughage throughout the year to supply 55% of the dry matter. A 25% protein concentrate mixture was added at feeding time to provide 45% of the ration dry matter. In Group 1, the lactating and dry cows were given the same ration ad libitum throughout the year. Group 2 cows, selected to be equal at the start of the study, were divided into high and low subgroups. Cows in

the first half of lactation were given the same feed and managed similar to Group 1. Low producers and dry cows were fed in a separate subgroup mixed corn silage 84% and a 45%-protein concentrate mixture 16%. The results are shown below:

	Group 1	Group 2 High	Group 2 Low
Ration:			
Corn silage, % DM	55	55	84
25% protein concentrate, % DM	45	45	--
45% protein concentrate, % DM	--	--	16
Daily DM intake, kg	19.6	20.8	17.0
Daily concentrate DM, kg	8.9	9.3	2.7
Daily milk, kg/cow	19.4	18.9	

The lower concentrate intake for Group 2 cows reduced the feed cost for the two group system.

Coppock *et al.* (1974) compared the energy intakes and requirements of cows group fed rations consisting of four different proportions of forage to concentrate dry matter during full lactations. The energy intakes and milk production of the groups are summarized below:

Thirds of lactation period	Forage: Concentrate Dry Matter 75:25		60:40		45:55		30:70	
	Digestible energy Mcal/day							
	Intake	Req.	Intake	Req.	Intake	Req.	Intake	Req.
1	48.7	55.1	48.0	50.8	56.2	55.6	61.0	53.8
2	49.6	47.5	53.7	46.3	66.4	50.0	64.4	49.1
3	45.5	40.8	49.6	41.7	61.7	43.4	61.2	42.2
	Milk, kg/day							
1	25.1		21.6		25.5		25.1	
2	20.7		19.5		22.4		22.3	
3	14.8		14.7		16.9		16.2	
Mean	20.2		18.6		21.6		21.2	

The results confirm earlier observations that good cows cannot consume enough to balance their requirements in the early weeks of lactation and they loose weight. They attain energy equilibrium sooner on higher concentrate diets.

In later lactation, all cows consumed more energy than needed to recover early weight losses on ad libitum group feeding, and the over-consumption was greatest on the higher concentrate feeds.

Some of the feeding and management systems are applicable to tropical conditions, but applied research is needed to determine the best ways of utilizing some of the local feeds.

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Table 1. Daily nutrient requirement for growth of heifers.

Body Weight kg	Dry Feed kg	Crude Protein g	Crude Protein %	Energy DE Mcal/kg	Energy ME Mcal/kg	Energy TDN kg	Energy TDN %	Calcium g	Calcium %	Phosphorus g	Phosphorus %
40	0.5	110	22	2.2	1.8	0.5	95	2.2	0.44	1.7	0.34
100	2.9	370	13	8.8	7.2	2.0	69	10.9	0.38	8.4	0.29
200	5.3	500	9.4	15.0	12.3	3.4	64	18.0	0.34	14.0	0.26
400	9.3	800	8.6	22.9	18.8	5.2	56	26.0	0.28	20.0	0.21

Source: U.S. N.R.C. (1971).

Table 2. Daily nutrient requirements of milking cows.

Body Weight kg	Total Feed kg	Crude Protein g	Energy DE Mcal	Energy ME Mcal	TDN kg	Ca g	P g
			Maintenance requirements				
450	6.0	585	15.0	12.3	3.4	18	14
550	7.0	691	17.6	14.4	4.0	21	16
650	8.0	776	19.8	16.2	4.5	23	18
			Per kg of milk				
Fat %							
3.0		70	1.23	0.99	0.28	2.5	1.8
4.0		78	1.46	1.13	0.33	2.7	2.0
5.0		86	1.68	1.28	0.38	2.9	2.2
6.0		94	1.90	1.43	0.43	3.1	2.4

Source: U.S. N.R.C. (1971).

Table 3. Composition of Selected Latin American Feeds

Feed	DM %	Moisture-free Protein %	Fiber %	DE Mcal/kg	TDN %	Ca %	P %
Ananas comosus, pineapple tops, ensiled		7.5	28.4	2.48	56.2		
Animal blood, dehyd.	88	84.5	--	2.80	63.5	0.62	0.38
Animal bones, dehyd., steamed	95	21.4	--			26.44	11.78
Animal carcass residue, dry rendered w/ bone	94	52.6	--	2.43	55.0	8.50	4.43
Arachis hypogaea, peanut seeds, extr.	91	53.5	16.8	3.21	72.8	0.26	0.77
Bos, cattle, whey, dried	93	13.6	--	3.44	84.2	1.05	0.82
Bos, cattle milk, skimmed, dried	94	33.6	--	3.42	77.6	1.34	1.06
Brassica, rope seeds, extr.	93	43.8	13.7	3.27	74.1	0.61	1.07
Brevourtia, fish, dried, extr.	91	66.1	--	2.84	63.7	5.58	3.15
Calcium carbonate, limestone	94	--	--	--	--	36.79	--
Calcium phosphate, dicalcium phosphate	97	--	--	--	--	24.29	18.92
Carthamus tinct, safflower seed, extr.	92	25.9	37.8	2.19	49.7	0.26	0.70
Citrus, orange pulp	36	8.7	13.3	2.62	62.5	2.00	0.01
Citrus, orange syrup	67	7.7	--	3.36	76.1	1.83	0.17
Cocos nucifera, coconut, extr. gr.	92	28.7	9.9	3.48	78.9	0.16	0.49
Coffee, hulls	83	9.1	17.7	2.33	52.8	0.41	0.97
Coffee, pulp	47	10.4	19.4	2.81	63.6	1.34	0.28
Coffee, grounds, extr.	--	15.0	22.0	--	--	--	--
Elaeis guine., oilpalm, kernels, extr.	95	21.4	24.2	3.26	74.0	0.21	0.73
Glycine max., soybean, hulls	92	13.5	36.4	2.48	56.3	0.50	0.23
Glycine max., soybean, seeds, mech. extr.	85	48.4	6.7	3.50	79.5	0.35	0.64
Glycine max., soybean, seeds, solv. extr.	89	54.2	5.3	3.53	80.0	0.31	1.11
Gossypium, cottonseed, extr.	93	44.1	11.6	3.23	73.2	0.22	1.13
Gossypium, cottonseed, whole	92	22.9	20.5	3.38	76.6	0.15	0.73
Gossypium, cottonseed, hulls	87	7.0	51.6	2.37	53.7	0.28	0.09
Gossypium, cottonseed, stems	92	5.7	43.8	1.76	39.9		
Grains, brewer's	92	27.6	16.7	3.07	66.4	0.32	0.57
Grains, brewer's yeast	94	45.0	2.7	3.24	73.0	0.10	1.40
Grains, spent hops, dried	92	17.0	27.7	1.46	33.0	--	--
Helianthus annu, sunflower seed, extr.	93	48.9	13.1	2.88	65.3	0.50	0.81

Table 3. (cont'd)

Feed	DM %	Moisture-free Protein %	Fiber %	DE Mcal/kg	TDN %	Ca %	P %
Hordeum vulgare, barley grain	90	11.3	6.3	3.31	75.0	0.09	0.39
Ipomoea batatas, sweet potatoes, roots	32	3.9	3.8	3.75	85.1	0.28	0.23
Ipomoea batatas, sweet potatoes, aerial part, vines	25	11.8	28.8		52.4	--	--
Linum usit., linseed, seeds extr.	91	37.3	9.5	3.51	79.6	0.43	0.93
Manihot, cassava, roots	37	3.5	4.3	3.76	85.3	0.26	0.16
Manihot, cassava, leaves	26	25.5	15.3			2.62	0.22
Manihot, cassava, peelings	88	5.5	6.6	3.32	75.2	0.36	0.14
Manihot, cassava, pomace	84	1.8	22.5			0.57	0.04
Musa parad., banana, fruit	30	4.7	2.0	3.85	87.4	0.07	0.08
Musa parad., banana, leaves	100	16.6	19.2	2.89	5.6	0.58	0.21
Musa parad., banana, aerial part	8	6.5	22.5	2.89	65.5	1.93	0.10
Orbignya cohune, palm kernels, extr.	91	22.0	19.7	3.12	70.7	0.23	0.78
Oryza sativa, rice, bran w/ hulls	91	8.3	27.9	2.08	47.1	0.30	1.08
Oryza sativa, rice, hulls	91	4.5	42.1	1.76	40.0	0.32	0.21
Oryza sativa, rice, bran s/ germ	91	14.7	12.4	3.80	86.2	0.08	1.65
Oryza sativa, rice, bran, extr.	89	19.9	11.6	3.09	70.0	0.15	1.24
Oryza sativa, rice, crude rice	89	11.1	8.4	3.30	74.8	0.08	0.39
Oryza sativa, rice, rice straw	89	5.4	35.7	2.04	42.3	0.29	0.36
Pennisetum maximum, 15-28 days gr.	19	12.2	30.9	2.61	52.4	0.86	0.36
Pennisetum purpureum, Napiergrass, 57-70 days gr.	28	7.4	30.3	2.42	54.8	0.39	0.13
Phaseolus vulgaris, bean, kidney	90	24.0	5.0	3.29	74.5	0.46	0.37
Saccharomyces, brewer's yeast	93	48.0	2.9	3.41	71.4	0.27	1.51
Saccharum offi., sugar cane, Caribbean	68	9.0	30.5	2.54	57.5	0.40	0.17
Saccharum offi., crude sugar	--	0	0	3.90	88.0	0	0
Saccharum offi., tops	26	3.5	30.4	2.91	65.9	0.47	0.51
Saccharum offi., molasses	77	5.4	--	4.23	96.0	1.09	0.11
Sesamum indicum, sesame seed extr.	93	46.7	7.6	3.21	72.9	2.68	1.46
Setaria, millet grain	90	13.5	7.2	3.41	77.3	0.06	0.31
Solanum tuber., potato, root	24	9.6	3.1	3.22	73.1	0.05	0.24

Table 3. (cont'd)

Feed	DM %	Moisture-free Protein %	Fiber %	DE Mcal/kg	TDN %	Ca %	P %
Sorghum vulg., milo grain	89	11.4	2.6	3.55	80.4	0.03	0.39
Torula yeast	93	48.7	3.0	3.33	75.6	0.63	1.80
Triticum, wheat bran	88	17.6	10.4	2.99	67.9	0.46	0.88
Triticum, flour byproduct	88	18.7	7.7	3.49	79.2	0.18	0.96
Vigna, cowpea, seeds	89	26.8	5.6	4.35	98.6	0.10	0.44
Zea mays, corn (maize), aerial part, w/o ears	88	5.5	36.3	2.14	48.5	0.47	0.16
Zea mays, corn, cobs, grnd.	88	3.3	36.0	2.50	56.5	0.30	0.19
Zea mays, corn, aerial part, ensiled	26	10.0	28.9	2.68	67.0	1.06	1.71
Zea mays, corn, ears, grnd.	86	8.5	9.2	3.28	74.5	0.10	0.26
Zea mays, corn, grain, grnd.	89	10.0	2.8	3.47	78.7	0.13	0.41
Zea mays, corn, grits, hominy feed (bran & germ)	89	18.4	5.6	4.16	94.5	0.49	1.31
Zea mays, corn, distiller's grains	93	29.4	9.8	3.40	77.1	0.18	0.79
Zea mays, corn, gluten feed	90	27.3	10.3	3.63	82.4	0.37	0.79

The data were largely taken from the Latin American Feed Tables (1974) with some additions from other sources.

Seminar on
Utilization of Local Ingredients in Animal Feeds
Non-Ruminant Nutrition - Pigs
Jamaica, April 14-18, 1975

Joe H. Conrad
University of Florida
Gainesville, Florida

A dynamic or stable swine industry is based on the local availability of an economical supply of energy feeds. Feed represents 70-80% of the cost of producing pork, but at least 75% of the feed cost is the cost of energy feeds. Therefore, the geographic areas which have energy feeds available in large quantities at reasonable prices have the best potential for economical swine production. Examples of these are Denmark with barley, north-central United States with corn, and southeast Asia with rice by-products.

Men and pigs are both considered to be non-ruminants. As such, they both have similar digestive systems and nutritional requirements. Many demographers and planners are saying that the pig competes directly with man for available food supplies and that pork production will decrease as population pressures increase. In theory, this is basically true; however, in practice, we find the pig converting large quantities of inedible, undesirable and fibrous by-products, with low nutritional value for humans, into highly nutritious and delectable meat. The pig is by far the most efficient among farm animals in conversion of feed energy to body energy and ranks only behind the chicken and fish in efficiency of conversion of feed energy to body protein.

Geographic areas which have energy feeds available in large quantities at reasonable prices will have a definite advantage in swine production. Increased swine production in the tropics is dependent on increased production of feedstuffs and maximum utilization of locally produced feedstuffs. Several research groups have been concentrating on various aspects of both these problems. The challenge to the swine producer is maximum utilization of locally produced and locally available feedstuffs. Much progress has been made on this topic recently and many research results have been published. The best single reference is a recent book by W.G. Pond and J.H. Maner entitled *Swine Production in Temperate and Tropical Environments*.

A few pertinent statements will help to focus on the topics of utilization of feedstuffs available in the tropics.

1. There is no single nutritionally balanced feedstuff. Every feedstuff has nutritional limitations, and these deficiencies must be corrected for most efficient gains. For example, Opaque-2 corn supplies a good nutritional balance of amino acids and energy for pigs over 50 kg liveweight, but it is extremely deficient in minerals. The more that is known about the nutrient composition of a feedstuff, the easier it is to correct these deficiencies.

2. Many feedstuffs contain toxic materials which greatly limit their use. Some processing or special treatment is necessary to detoxify or reduce the level of toxicity. Properly heat-treated soybean meal contains an excellent balance of the essential amino acids. However, raw or poorly processed soybean meal contains digesting enzyme inhibitors (trypsin) and the availability of some of the amino acids is greatly reduced. Other examples are gossypol in cottonseed meal and hydrogen cyanide in cassava. More information is needed on the toxic principles which limit utilization of feedstuffs produced in the tropics.

3. A mixture of two or more energy sources often produces better results than single sources alone. Frequently, the ingredients are deficient in different nutrients, so they tend to complement each other.

4. The nutritional value of a single feed ingredient varies widely and is dependent on many factors. In general, high levels of fiber reduce the energy level which is especially true of cereal by-product feeds. Increasing the bone level in meat by-products reduces the protein level, and higher than normal silica levels in fish meal, rice by-products, and mineral mixtures indicate contamination. Feedstuffs must be traded on the basis of a guaranteed content and analysis.

5. The nutrient requirements of swine vary greatly during the life cycle. Low energy and fibrous feeds which have little value for young pigs may be highly recommended for sows during gestation. Forage and green chopped material has little energy value for young pigs, but can be used as a major source of energy for sows during gestation.

These points also indicate that, in formulating nutritionally balanced swine diets, it is necessary to know the nutrient requirements of swine, the

nutrient composition of the feedstuffs, the level of toxic materials which may limit their use and maximum levels of feedstuffs for optimum performance.

Nutrient Requirements of Swine

Tables 1 and 2 give the nutrient requirements of swine as recommended by the United States National Research Council Committee on Nutrient Requirements of Swine. These levels are based on the experimental evidence available and the best judgment of the committee in summarizing all the experimental work. Therefore, these figures are close to the actual nutrient requirements of the pig, and they are recommended for use as guides in formulating rations and feeding swine. A more detailed explanation can be found in "Nutrient Requirements for Swine" which can be obtained by writing to: National Academy of Sciences, Printing and Publishing Office, 2101 Constitution Avenue, Washington, D.C. 20418, and enclosing $2.50.

Supplying these levels of nutrients to healthy pigs with the inherited ability to grow should result in optimum performance and feed conversion. The recommended levels do not contain a margin of safety. In some cases, it may be desirable to increase the level of nutrients whenever storage conditions may cause some deterioration or when higher levels might be desirable for other reasons.

If nutrients are supplied at levels below those recommended in the tables, adverse changes in performance and feed conversion can be expected. A number of frequently occurring nutritional deficiencies are found in practice. Among these are water, energy or dry matter, protein or amino acids, calcium, phosphorus, iron, zinc, and multiple vitamin deficiencies.

Nutrient Composition of Feedstuffs and Some of Their Limitations in Swine Diets

Tables 3 and 4 give the nutrient composition of some feedstuffs commonly used in swine feeds. Only a limited number of feedstuffs have been listed for comparative purposes. More detailed information can be found in the Latin American Tables of Feed Composition published by the University of Florida and in other references cited at the end of this paper. These tables show that the nutrient composition of energy, protein, and vitamin feeds varies widely. Ripe bananas contain approximately 870 kcal of digestible energy per kilogram compared to corn which contains about 3,300. Similar contrasts can be pointed

out between the nutrient composition of all feedstuffs. The swine producer is urged to learn more about the nutrient composition of feedstuffs, variations in composition that can be expected, and how these feedstuffs can be combined for most efficient and economical production.

Protein supplement for use with tropical feedstuffs. Protein requirements for growing-finishing pigs vary between 18 and 13%, depending on age and weight. Sorghum contains approximately 9% protein, molasses contains 3% protein, cassava contain 1 to 2% protein, and bananas about 1% protein. Most all energy feedstuffs available in the tropics contain low levels of poor quality protein. Additional protein is always required and can best be supplied from a nutritionally balanced protein supplement.

In Table 5 are listed five protein supplements. The first four have been formulated with protein feeds which are frequently available in the tropics. Formula 5 is listed for comparative purposes and indicates how soybean meal could be used if available. In formulating these protein supplements, consideration was given to research results, level of nutrients, availability of ingredients and nutritional deficiencies of tropical feedstuffs. Formulas 1 and 3 contain cottonseed meal which often contains gossypol. Nutritional value of these could be improved by the addition of up to 2.5 grams of iron per kilogram of protein supplement.

These protein supplements are formulated to furnish adequate levels of protein, minerals, trace minerals, vitamins, and antibiotics when used with locally available energy feedstuffs. Thus, a properly formulated protein supplement should supply all the nutrients needed to correct the nutritional deficiencies of the energy feeds.

A 30% protein supplement is recommended when an additional source of energy is required. In addition, a 30% protein supplement can easily be made by mixing the following ingredients:

70 parts of a 40% protein supplement and
30 parts of a 10% protein energy feed

or

60 parts of a 40% protein supplement and
40 parts of a 15% protein energy feed.

The 10% protein energy feed could be sorghum and the 15% protein energy feed could be rice or wheat by-products.

A sorghum-protein supplement feeding program for growing-finishing swine is outlined in Table 7. This could be called a conventional feeding program. With this program, all ingredients are dry; they are ground and mixed together and fed in a self-feeder or trough. This program is based on complete mixed rations, but is not suitable for use with feeds containing high levels of moisture such as molasses, fresh cassava or bananas. Experience has shown that swine production can be greatly increased if feeding programs are designed specifically for maximum utilization of locally available feedstuffs. Recent research has shown that excellent and economical results can be obtained by feeding large quantities of molasses, cassava, and bananas when these products are economically available.

A molasses feeding program for growing-finishing swine. A series of feeding trials have been conducted at the University of Florida to study maximum utilization of molasses for growing-finishing swine. Details of these studies were reported by Combs and Wallace (1969, 1970, and 1972). Results show that 20% molasses can be successfully fed to pigs between 5 and 50 kg liveweight and 40% molasses can be fed to pigs over 50 kg. Levels of up to 60% molasses were fed, but gains were 8% slower than with 40% molasses. Therefore, research has indicated that a molasses feeding program as outlined in Table 8 can be used successfully for growing and finishing swine.

Approximate daily feed intakes are also listed in Table 8. There is no need to mix these ingredients together in a mechanical mixer. The liveweight of the pigs and the feed intake can be estimated. Twice daily, the ingredients can be spread in a trough by hand. For example, the required amount of protein supplement can be placed in the trough first, then the ground sorghum grain, and then the molasses. These ingredients can then be mixed slightly using a hoe or other suitable tool. Swine feeding programs must be adapted to locally available feedstuffs and to local conditions. Other ingredients can easily be substituted for the sorghum or corn in these rations.

A cassava feeding program for growing-finishing swine: Research conducted at C.I.A.T. in Colombia has clearly shown the value and potential of using cassava as a major source of energy for swine. Fresh cassava contains about 65% water, 35% dry matter, and about 1 to 2% protein. Yields are often low, between 3 and 20 tons per hectare, but, experimentally, 78 tons per hectare have been produced. About 4.0 kg daily of fresh chopped cassava supple-

mented with 0.75 kg of a 40% protein supplement has resulted in daily gains of 0.75 kg for growing-finishing swine.

In Table 9 is a suggested cassava feeding program for growing-finishing swine. Cassava can be fed as fresh chopped cassava or sun-dried cassava. Formulas and estimated daily intakes in Table 6 are based on research results. Where molasses is available, 5 to 10% is recommended to reduce dustiness and increase the palatability of diets containing high levels of cassava. When molasses is more economical than cassava, 20 to 30% molasses is recommended as outlined in Table 8.

Some varieties of fresh cassava contain toxic levels of hydrogen cyanide (HCN). It is recommended that high yielding varieties with non-toxic levels of HCN be produced. However, cooking in water, drying in the sun, or oven drying at 80°C have all been shown to reduce the level of HCN present.

Banana feeding program for growing-finishing swine is outlined in Table 10. The one percent level of protein and the 80% level of moisture in bananas requires that they be supplemented with both a high level of protein and additional energy. Based on recent studies conducted by I.N.I.A.P. in Ecuador, mature bananas with skins and a 30% protein supplement have produced excellent results with growing-finishing swine.

It is possible to obtain good results by free choice feeding of the mature bananas with skins and the 30% protein supplement. However, protein supplement intake can best be controlled by hand feeding the required amount twice daily and then providing all the mature bananas with skins the pigs will consume. The 30% protein supplement is recommended to supply additional energy and dry matter. It can be made from the 40% protein supplement as indicated in the discussion related to Table 3.

Rice by-products are available in many tropical areas and are widely used in swine diets. Rice is the most important food crop in many tropical areas. At times, the price of rice makes it competitive as a feed for swine, but, wherever rice is grown, its by-products are used extensively in swine diets.

Rough rice or paddy contains the hull which is high in fiber and poorly digested. Rough rice can be substituted for some or all of the corn in swine diets. It has been shown to have about 75 to 80% of the feeding value of corn.

Brown rice has a chemical composition and energy value similar to that of corn. The feeding value is equal to that of corn, and it can be substituted for part or all of the corn in a swine diet when the price is equal or less than that of corn.

Rice bran is usually a mixture of bran, polishings, and some hulls. Rice hulls have no nutritive value for swine, but are sometimes added as an adulterant. Rice bran often contains about 12% fat which easily becomes rancid when stored under the conditions of a tropical environment. A number of studies show that good quality rice bran can be used to replace 20 to 30% of the corn in growing-finishing swine diets. Results will vary with the quality of rice bran. Rice bran at levels up to 30% of the diet has approximately the same feeding value as corn. But when rice bran replaces half of the corn, its feeding value decreases to 80 to 90% of that of corn. Recent studies at the University of Florida (Campabadal, 1974) compared levels from 20 to 45% rice bran for growing-finishing swine. Higher levels of rice bran (35 to 45%) decreased daily gain, feed intake, and feed efficiency. Gastro-intestinal irritation was observed to increase as the percent of rice bran in the diet increased. The exact reason for the irritation is not currently known.

Wheat flour by-products are classified on the basis of fiber content as follows: bran more than 9.5%, middlings or mill run between 4 and 7%, red dog between 1.5 and 4%. A majority of these by-products are used in animal diets and, usually, the higher the fiber, the lower the price. Comprehensive information on the milling process, chemical composition, and nutritional value of wheat by-products for swine can be found in a recent publication by the Miller's National Federation. Wheat flour by-products contain many essential nutrients, but are considered primarily as sources of energy.

Wheat middlings and by-products with lower levels of fiber are usually considered as energy substitutes for corn. Wheat bran has often been included in farrowing rations, but its use in growing-finishing diets is limited because of the fiber content. Studies were conducted by Neufville and co-workers at the University of Florida to determine the effects of different levels of wheat bran on performance and carcass quality. A 27% level of wheat bran resulted in gain and feed efficiency comparable to a corn-soybean meal diet, but 39% wheat bran significantly affects gains. Although gains were depressed and more feed per unit of gain was required, the calories of digestible energy

per unit of gain were essentially the same with 0, 8, 20, 27, and 39% wheat bran.

Sweet potatoes contain about 30% dry matter, 1% protein, and are considered a relatively good source of energy. Sweet potatoes can be fed raw, but cooking increases consumption, protein digestibility, and rate of gain. Cooked sweet potatoes have been shown to have about 80% of the value of corn when compared on a dry matter basis. Dehydrated sweet potatoes on a dry matter basis could be expected to have about 5% higher value and raw sweet potatoes about 5% lower value than cooked sweet potatoes.

Protein feeds. Protein feeds should be selected primarily on the basis of cost per unit of quality protein, but consideration must also be given to the fiber, phosphorus and vitamin content.

Soybean meal. Properly heat treated, solvent, extracted soybean meal containing 44 to 49% protein is an excellent source of protein for all ages of swine. For young, growing swine, its balance of amino acids is excelled only by dried skim milk. Soybean meal has become the standard with which to compare other sources of protein.

Cottonseed meal. This is one of the most widely produced sources of protein and is often the least expensive. The high level of free gossypol and the low level of lysine have restricted the use of cottonseed meal in swine diets. Gossypol is found in the pigment glands of cottonseed and the level in the meal varies with the oil extraction process used. Prepress solvent extracted cottonseed meal contains relatively high protein quality and is usually low in free gossypol. Both expeller process and direct solvent process result in much higher levels of free gossypol.

Recent research has shown that cottonseed meal containing less than 0.04% free gossypol may safely serve as the only source of supplemental protein for swine. A level of 0.01% of free gossypol in the total diet has been suggested as a safe level. Research has shown that the addition of ferrous sulfate to the diet will bind the free gossypol so it will not be absorbed by the pig. If the level of free gossypol is higher than 0.01% in the total diet, iron should be added as ferrous sulfate in a 1:1 weight ratio up to a maximum of 500 mg/kg of added iron in the total ration. The addition of 1% of calcium hydroxide in the presence of recommended levels of iron also helps in the inactivation of gossypol.

The low lysine content of cottonseed meal can be improved by mixing with protein sources containing higher levels of lysine such as fish meal, blood meal or soybean meal. The addition of synthetic lysine should also be considered.

Peanut meal. Peanut meal contains a high level of protein, but the balance of amino acids limits its use. A swine ration based on corn and peanut meal is very deficient in lysine and is low in methionine and tryptophan. These amino acid deficiencies can be corrected by mixing the peanut meal with higher lysine supplements such as fish meal, blood meal, and soybean meal.

Peanut meal processed from peanuts heavily infected with the fungus *Aspergillus flavus* contains high levels of aflotoxin which have been shown to produce toxicity in swine. Production of aflotoxin can be controlled by rapid drying of the harvested peanuts to 8% moisture or below.

Coconut meal. Although coconut meal contains only about 20% protein, it is an important source of protein in many tropical areas. Nearly maximum performance can be expected with levels up to 20% in the diet. However, a 40% level of coconut meal has been shown to greatly reduce gains and cause a 30% increase in feed required per unit of gain.

Other sources of plant proteins. A number of varieties of peas and beans are being used to supply a part of the protein requirements for swine. Many of these sources contain between 20 and 30% protein. Some have fairly good amino acid balance, but are often deficient in methionine and cystine. It is expected that these will become more important in the future.

Protein feeds of animal and marine origin. The nutrient composition of these protein sources sometimes varies greatly. Quality of meat and bone meal and tankage tends to vary because the products are made from different proportions of carcass trimmings, inedible meat, and condemned carcasses. Methods of processing, including time, temperature, humidity, and the presence of contaminants, all influence nutritive value. Generally, animal proteins are of excellent quality, but their feeding value is usually improved when fed in combination with a good source of plant protein. Rations of corn and animal or marine proteins are usually low in tryptophan and may contain an excess of calcium. Animal and marine proteins often have a greater potential for rancidity and salmonella contamination than plant proteins.

Tankage and meat and bone meal produce good results when they are used to supply one half of the supplemental protein. Blood meal contains about 80% protein, but, because of its lower digestibility and taste, it should be used to supply not more than 25% of the supplemental protein.

Anchovy fish meal is one of the world's most important fish meals with the center of production located in Peru. In general, good quality fish meal is superior to meat and bone meal as a source of supplemental protein. Good quality fish meal can be satisfactorily fed as the only source of supplemental protein for swine of all ages and weights. Therefore, the relative price of fish meal protein as compared to other sources of protein will help determine the level of fish meal protein in swine diets.

Feather meal. Hydrolyzed feather meal can satisfactorily be used at the 5% level in growing-finishing swine rations. However, it should not be used as the only source of supplemental protein.

Poultry by-product meal. This by-product of poultry processing plants containing about 55% protein has been satisfactorily used at the Florida Station as the only source of supplemental protein in growing-finishing swine rations.

Shrimp meal contains over 45% protein of relatively good quality, but, because of its high mineral content, it should be used in combination with plant proteins.

Summary

A major factor limiting swine production in the tropics is the availability of energy and protein feeds. Research has clearly demonstrated that it is possible to use much higher levels of molasses, bananas, cassava, and cottonseed meal in swine diets than in the past. Correcting the nutritional deficiencies, proper processing, and removing or neutralizing the toxic materials present are necessary for maximum utilization of tropical feedstuffs. Energy feeds should be selected on the basis of cost per 1,000 kcal of digestible energy, but consideration must also be given to the levels of dry matter, protein, and fiber. Protein feeds should be selected primarily on the basis of cost per unit of quality protein, but consideration must also be given to the fiber, phosphorus and vitamin content.

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Table 1 NUTRIENT REQUIREMENTS FOR SWINE (PER KILOGRAM OF RATION)[a]

Nutrient	Starting, growing and finishing weight, kg. 5-10	10-20	20-35	35-60	60-100	Gestation	Lactation
Daily gain, kg.	0.3	0.5	0.6	0.75	0.9		
Digestible energy, kcal.	3,500	3,500	3,300	3,300	3,300	3,300	3,300
Crude protein, %[b]	20-22	18	16	14	13	14	15
Lysine, %[b]	1.0	0.8	0.7	0.6	0.55	0.5	0.5
Minerals:							
Calcium, %	0.8	0.65	0.65	0.50	0.5	0.75	0.75
Phosphorus, %	0.6	0.5	0.5	0.4	0.4	0.5	0.5
Salt, %	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Iodine, mg.	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Iron, mg.	80	80	80	80	80	80	80
Copper, mg.	6	6	6	6	6	6	6
Manganese, mg.	20	20	20	20	20	20	20
Selenium, mg.	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Zinc, mg.	50	50	50	50	50	50	50
Vitamins:							
B-Carotene, mg.[c]	4.4	3.5	2.6	2.6	2.6	8.2	6.6
Vitamin A, I.U.[c]	2,200	1,750	1,300	1,300	1,300	4,100	3,300
Vitamin D, I.U.	220	200	200	125	125	275	220
Vitamin E, mg.	11	11	11	11	11	11	11
Riboflavin, mg.	3	3	2.6	2.2	2.2	4.0	3.5
Niacin, mg.	22	18	14	10	10	22	18
Pantothenic acid, mg.	13	11	11	11	11	16	13
Vitamin B_{12}, mcg.	22	15	11	11	11	14	11

a. These requirements are based on U.S. National Research Council recommendations in which high energy diets were fed to swine for optimum performance. Energy and protein levels were derived primarily from corn-soybean meal type diets. Performance and feed conversion will normally be reduced with lower energy diets.

b. Approximate protein levels required to meet the essential amino acid needs. Lysine is one of the amino acids most limiting in swine rations. If cereal grains other than corn are used an extra 1 or 2 percentage units of protein may be required.

c. Carotene and vitamin A values are based on 1 mg. of B carotene equalling 500 I.U. of biologically active vitamin A. Vitamin A requirements can be met by carotene or vitamin A or both.

Table 2 NUTRIENT REQUIREMENTS FOR SWINE--AMOUNTS PER ANIMAL PER DAY[a]

Nutrient	Unit.	Starting, Growing and Finishing Weight, kg. 5-10	10-20	20-35	35-60	60-100	Gestation	Lactation
Feed intake (air-dry)	kg.	0.6	1.2	1.7	2.5	3.5	2	5
Digestible energy	kcal.	2,100	4,400	5,600	8,250	11,550	6,600	17,000
Crude protein	gm.	130	225	270	350	450	280	800
Minerals:								
Calcium	gm.	4.8	8	10	12.5	17.5	15	38
Phosphorus	gm.	3.6	6.3	8.5	10	14	10	26
Salt	gm.	3	6	8.5	12.5	17	10	25
Iodine	mg.	.01	.02	.03	.05	.07	.04	.1
Iron	mg.	48	96	136	200	280	145	400
Copper	mg.	3.6	7.2	10	15	21	11	30
Manganese	mg.	12	24	34	50	70	36	100
Zinc	mg.	30	60	85	125	175	90	250
Vitamins:								
Vitamin A	I.U.	1,300	2,200	2,200	3,250	4,550	7,900	16,500
Vitamin D	I.U.	130	250	340	315	440	500	1,100
Vitamin E	mg.	6.6	14	19	28	38	22	55
Riboflavin	mg.	1.8	3.8	4.4	5.5	7.7	8	16
Niacin	mg.	13	22	24	25	35	40	90
Pantothenic acid	mg.	8	14	19	28	38	32	70
Vitamin B_{12}	mcg.	13	18	18	28	38	27	55

These requirements are based on United States National Research Council recommendations. See Table 1 for details.

Table 3 NUTRIENT COMPOSITION OF FEEDSTUFFS COMMONLY USED IN SWINE DIETS.

Energy Feeds	Dry Matter %	Protein %	Lysine %	Fat %	Fiber %	Digestible Energy kcal/kg.	Ca %	P %	Riboflavin mg/kg.	Niacin mg/kg.	Pantothenic Acid mg/kg.
Corn, yellow	88	9.0	.2	4.4	2.0	3,300	.01	0.27	1	26	4
Sorghum	87	9.7	.2	3.4	3.6	3,250	.04	0.30	1	43	11
Rice bran	90	12.0	.5	12.0	11.0	3,250	.06	1.50	3	300	24
Wheat bran	90	15.0	.5	4.0	8.0	3,150	.10	1.00	3	120	15
Banana tree	8	0.5	--	0.1	2.0	-----	.05	0.02	-	---	--
Rice, polished	89	8.0	.2	2.0	0.4	3,600	.04	0.20	1	14	4
Brown rice	89	10.0	.3	1.2	1.0	3,600	.04	0.18	1	17	5
Brewers grains, wet	23	5.0	--	1.6	3.6	450	.06	0.12	-	10	2
Brewers grains, dried	80	25.5	--	6.0	15.0	1,800	.27	0.50	2	43	9
Sweet potatoes, fresh	30	1.0	--	0.5	1.0	1,250	.03	0.04	1	10	-
Sweet potatoes, dried	90	3.0	--	1.5	3.0	3,600	.09	0.12	3	30	-
Wheat grain	90	12.5	.3	1.5	2.4	3,500	.05	0.35	1	60	13
Molasses, cane	78	3.0	--	0.0	0.0	2,500	.86	0.08	3	31	39
Sugar cane, stalks	27	0.7	--	0.4	8.0	500	.13	0.05	-	--	--
Cassava, fresh	35	1.0	--	0.3	1.5	1,200	.04	0.05	-	--	--
Broken rice	89	8.0	.2	2.0	0.4	3,600	.04	0.20	1	15	5
Broken brown rice -	89	10.0	.3	1.2	1.0	3,600	.04	0.18	1	17	5
Paddy or rough rice	90	7.5	.2	2.0	10.0	2,500	.04	0.26	1	30	8
Banana fruit, whole ripe	20	1.1	--	0.2	1.0	870	.03	0.23	1	6	--
Cassava, dried	88	2.5	--	1.4	3.0	3,400	.09	0.25	-	--	--
Garbage	13	3.0	--	5.0	1.0	500	---	---	-	--	--

Table 4 NUTRIENT COMPOSITION OF FEEDSTUFFS COMMONLY USED IN SWINE DIETS

Protein Feeds	Dry Matter %	Protein %	Lysine %	Fat %	Fiber %	Digestible Energy kcal/kg.	Ca %	P %	Riboflavin mg/kg.	Niacin mg/kg.	Pantothenic Acid mg/kg.
Coconut meal	90	20	0.5	6.0	10.0	3,000	0.17	0.60	3	25	6
Cottonseed meal, solv. extd.	90	41	1.6	2.0	14.0	3,000	0.20	1.00	5	40	8
Fish meal, anchovy	90	65	5.0	5.0	1.0	3,000	4.0	2.5	6	60	10
Fish meal, menhaden	90	60	5.0	6.0	1.0	3,000	5.0	3.0	5	55	9
Fish, whole dried	90	50	4.5	12.0	1.0	3,200	5.0	3.0	6	60	10
Meat and bone meal	90	50	3.0	8.0	2.5	3,000	10.0	5.0	5	48	4
Peanuts	90	30	1.0	44.0	2.5	4,400	0.06	0.44	8	150	40
Peanut meal, solv. extd.	90	47	2.0	1.2	13.0	2,850	0.20	0.65	11	170	50
Soybean meal, solv. extd.	90	44	2.9	1.0	6.0	3,300	0.25	0.60	3	27	15
Soybean meal, solv. extd.	90	49	3.2	1.0	3.0	3,400	0.26	0.62	3	27	15
Soybean seed	90	36	2.3	18.0	5.0	4,000	0.25	0.60	2	18	10
Yeast, torula, dried	93	48	3.8	2.5	2.0	2,470	0.57	1.68	44	48	39
Vitamin Feeds:											
Alfalfa, fresh	22	4.0	---	0.8	6.0	350	0.40	0.6	3	12	8
Alfalfa meal, dried	92	17.0	---	3.0	24.0	1,400	1.30	0.24	12	46	30
Elephant grass, napier	22	1.1	---	0.3	9.0	350	0.08	0.07	--	--	--
Kudzu, tropical	22	3.5	---	0.8	8.0	350	0.90	0.07	--	--	--
Cassava leaves, fresh	15	4.0	---	0.8	3.0	250	0.12	0.08	--	--	--
Water Hyacinth	10	1.0	---	0.3	2.0	130	0.05	0.05	--	--	--
Sweet potato leaves & vines	12	2.0	---	0.5	3.0	200	0.12	0.10	--	--	--

Table 5 PROTEIN SUPPLEMENTS FOR USE WITH TROPICAL FEEDSTUFFS

Ingredients		Formulas 1	2	3	4	5
		%	%	%	%	%
Cottonseed meal	(40% protein)	45		50		
Coconut meal	(20% protein)				40	
Peanut meal	(45% protein)		40			
Soybean meal	(44% protein)					70
Meat and Bone meal	(50% protein)	40	40	20	30	20
Blood meal	(80% protein)			10	20	
Rice bran or wheat bran	(12% protein)	11	16	11	3	1
Bone meal				5	3	5
Salt		2	2	2	2	2
Vitamin premix		2	2	2	2	2
Antibiotic premix		+	+	+	+	+
Trace mineral premix	(.25% of protein supp.)	+	+	+	+	+
Total		100	100	100	100	100
Calculated analysis						
Protein , %		40	40	40	40	41
Lysine , %		2.0	2.1	2.1	2.3	2.6
Calcium , %		3.6	3.3	3.2	3.2	3.0
Phophorus, %		2.7	2.4	2.2	2.1	2.0

Table 6 COMPOSITION OF VITAMIN AND TRACE MINERAL PREMIXES

Vitamin premix 1			Trace mineral premix 2	
Vitamin	Per pound of premix	Per kilogram of premix	Trace mineral	Percent of premix
Vitamin A, I.U.	400,000	880,000	Copper	1.0
Vitamin D, I.U.	40,000	88,000	Iodine	0.04
Vitamin E, I.U.	2,000	4,400	Iron	10.0
Vitamin K, mg.	300	660	Manganese	4.0
Riboflavin, mg.	400	880	Zinc	10.0
Pantothenic Acid mg.	1,600	3,500		
Niacin, mg.	2,400	5,280		
B_{12}, mg.	2	4.4		

1 Add to protein supplements at the rate of 2%.
2 Add to protein supplements at the rate of 0.25%.

Table 7 SORGHUM-PROTEIN SUPPLEMENT FEEDING PROGRAM FOR GROWING-FINISHING SWINE

Liveweight, kg.	10-20	20-35	35-60	60-90
Sorghum, 9% protein	71	77.4	84	87
Supplement, 40% protein	29	22.6	16	13
	100	100	100	100
Percentage Units of Protein contributed by				
Sorghum, 9% protein	6.4	7.0	7.6	7.8
Supplement, 40% protein	11.6	9.0	6.4	5.2
	18.0	16.0	14.0	13.0
Daily feed intake, grams	1250	1700	2500	3045
% protein recommended	18	16	14	13
Daily protein requirement, grams	225	272	350	455
Sorghum consumed daily, grams	888	1316	2100	3045
Protein supplement consumed daily, grams	362	384	400	455
Daily feed intake	1250	1700	2500	3500
Average expected daily gain, kg.	0.5	0.6	0.75	0.90

Table 8 MOLASSES FEEDING PROGRAM FOR GROWING-FINISHING SWINE

Liveweight, kg.	10-20	20-35	35-60	60-90
% protein recommended	18	16	14	13
Formula of diet				
Sorghum or Corn, %	48	40	32	24
Molasses, %	20	30	40	50
Protein supplement, 40% protein, %	32	30	28	26
	100	100	100	100
Daily feed intake				
Approximate daily feed intake, grams	1250	1700	2500	3500
Sorghum or corn, grams	600	680	800	840
Molasses, grams	250	510	1000	1750
Protein supplement, grams	400	510	700	910
	1250	1700	2500	3500

Table 9 CASSAVA FEEDING PROGRAM FOR GROWING AND FINISHING SWINE

Liveweight, kg.	20-35	35-60	60-90
Fresh chopped cassava, kg. daily			
Cassava, fresh copped, kg.	4.1	5.2	6.5
Protein supplement, 40% protein, kg.	0.7	0.8	0.9
Sun dried cassava, kg. daily			
Cassava sun dried, 90% dry matter, kg.	1.8	2.3	2.8
Protein supplement, 40% protein, kg.	0.7	0.8	0.9
	2.5	3.1	3.7
Sun dried cassava and molasses, % of diet			
Cassava sun dried, 90% dry matter, %	48	46	43
Molasses, %	20	25	30
Protein supplement, 40% protein, %	32	29	27
	100	100	100
Sun dried cassava and molasses, Same formula as above but based on daily consumption			
Cassava, kg. daily	1.2	1.42	1.6
Molasses, kg. daily	0.5	0.78	1.1
Protein supplement, 40% protein, kg. daily	0.8	0.9	1.0
	2.5	3.1	3.7

Table 10 BANANA FEEDING PROGRAM FOR GROWING-FINISHING SWINE

Liveweight, kg.	10-20	20-35	35-60	60-90
Daily feed intake on as fed basis, kg.				
Bananas, mature with skins, kg.	3.125	4.250	8.250	11.500
Supplement, 30% protein, kg.	.625	.850	.850	1.200
Daily feed intake on air dry basis, 10% Moisture, kg.				
From bananas, kg.	.625	.850	1.650	2.300
From supplement, kg.	.625	.850	.850	1.200
Total and amount required, kg.	1.250	1.700	2.500	3.500
Protein recommended, grams	225	272	350	455
Protein furnished, grams	218	297	337	475

Note: From 10-35 kg. liveweight one half of the feed requirement is from bananas. From 35-90 kg. liveweight two-thirds of the feed requirement is from bananas.

APPENDIX D

Abstracts of theses completed during the past year which are directly applicable to the University of Florida's competence in tropical animal science and tropical forages.

Abstract of Thesis Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Agriculture

ESTABLISHMENT TECHNIQUES FOR PERENNIAL PEANUTS
(*Arachis glabrata* Benth.)

By

rtin Bani Adjei

June, 1975

Chairman: Gordon M. Prine
Major Department: Agronomy

Perennial peanut (*Arachis glabrata* Benth.) is a promising rhizomatous forage legume for the tropical and subtropical climates but its widespread use has been limited to its slow rate of establishment.

Field and greenhouse investigations were conducted to evaluate the effects of inoculation, nitrogen fertilization, rhizome fragmentation and dispersal, and chemical weed control of 'GS-1' peanuts grown on arredondo fine sand. Spreading of two cultivars, (GS-1 and 'Arb') were also compared. Field trials, covering a total area of 0.6 ha, were conducted from March 1974 to April 1975 using a split-plot design.

It was found that the soil area covered by peanuts at the end of one season was not influenced by inoculation, owing to the existence of effective native *Rhizobium* strains. The average area covered by peanuts following nitrogen fertilization at the rates 0 kg/ha, 168 kg/ha and 336 kg/ha was 1244 dm^2,

877 dm^2 and 590 dm^2 respectively. Soil coverage, from 3 x 3 dm rhizome mats divided into 6 or 8 hills, averaged 1780 dm^2 compared to 1415 dm^2 for those dispersed in 2 hills at the end of the first year of establishment. Herbicidal weed control significantly affected spread of peanuts only with simultaneous application of nitrogen. Cultivar GS-1 covered a ground area averaging 1276 dm^2 and Arb 1192 dm^2 in the first year.

In greenhouse experiments, total dry matter yield of shoots, rhizomes, roots and nodules was depressed from 33 gm per pot from native or inoculated soil, to 18 gm per pot from sterilized soil. The 56 kg/ha nitrogen application did not affect the dry matter yield of top growth. However, the application 56 kg N/ha and 112 kg N/ha reduced nodulation by 32% and 86% and nodule development was depressed by 15% and 39% respectively.

These studies indicate that significant improvement in the perennial peanut establishment was obtained by ensuring the presence of proper Rhizobium bacteria in the soil, by omitting nitrogen fertilization, by fragmenting and dispersing the rhizomes into small hills and by using the superior cultivar.

Chairman

Abstract of Thesis Presented to the Graduate Council of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Master of Science in Agriculture

EFFECT OF METHIONINE HYDROXY ANALOG OR CHOLINE CHLORIDE ON THE METABOLIZABLE ENERGY OF BIRD-RESISTANT SORGHUM GRAIN WHEN FED TO STEERS

By

Wayne Arthur Brommelsiek

August, 1974

Chairman: Dr. R. L. Shirley
Major Department: Animal Science

Two 3x3 Latin square design experiments were carried out to evaluate the effects of feeding supplemental methionine hydroxy analog (MHA) or choline chloride on metabolizable energy (ME) in a bird-resistant sorghum grain diet. In addition, total digestible nutrients (TDN), tannins and apparent ash absorption were determined. One experiment involved steers fed 5 g MHA or 5 g choline chloride per head per day as supplements in the sorghum grain diet. Steers in the other experiment were supplemented with 30 g MHA or 15 g choline chloride per head per day.

Diets containing 0, 15 g choline chloride or 30 g MHA per head per day yielded ME values of 2.21, 2.29 and 2.86 Mcal/kg dry weight, respectively. Metabolizable energy values in the grain were 2.25, 2.36 and 3.06 Mcal/kg dry weight for the control, choline chloride and MHA supplemented diets, respectively. These values were obtained by subtracting ME values given in the NRC (1970) composition tables for the sorghum silage and cottonseed meal in the diets from the ME values of

the total diet. MHA fed at the level of 30 g per head daily resulted in an increase ($P<.05$) in digestion of crude fiber and nitrogen. The 15 g choline chloride supplement had no effect on these two nutrients.

At the low level of MHA and choline chloride supplementation there was no significant effect on ME or digestibility of dry matter, organic matter, nitrogen, proximate analysis fractions, tannins or apparent ash absorption.

R. L. Shirley
Chairman

ABSTRACT OF THESIS PRESENTED TO THE GRADUATE COUNCIL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE

INFLUENCE OF NITROGEN AND ENERGY
SUPPLEMENTATION ON THE UTILIZATION OF LOW-QUALITY
BERMUDA AND PANGOLA HAYS BY RUMINANTS

By

Abelardo Bustillos C.

March, 1975

Chairman: Dr. C. B. Ammerman
Major Department: Animal Science

The influence of supplemental nitrogen in the form of feed grade biuret and energy (50% corn meal, 25% corn starch and 25% glucose) upon the utilization of low-quality bermuda and Pangola grass hays was studied with 30 sheep. Voluntary intake and nutrient utilization were determined. The two hays were fed with each of three supplemental treatments: 0 g nitrogen and 0 g energy; 10 g nitrogen and 0 g energy; 10 g nitrogen and 75 g energy. Voluntary hay intake, total organic matter intake and cellulose digestibility were not affected significantly by supplementation but voluntary hay intake was greater ($P<.01$) for bermuda compared with Pangola hay and cellulose digestibility was higher ($P<.01$) for Pangola than for bermuda hay. Organic matter digestibility was affected positively ($P<.01$) by energy supplementation for both hays. Nitrogen supplement alone had no effect on organic matter for bermuda nor for Pangola hays. Nitrogen digestibility was increased ($P<.01$) for both hays by nitrogen supplementation. Nitrogen

was more digestible ($P<.01$) in Pangola than in bermuda hay. Nitrogen balance was improved ($P<.01$) by adding only nitrogen to Pangola but not to bermuda. With both hays, the addition of nitrogen plus energy improved ($P<.01$) the nitrogen balance. Blood urea nitrogen for sheep consuming both hays was increased ($P<.01$) by nitrogen supplementation but to a lesser extent in the presence of supplemental energy.

Chairman

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

MICRO-HISTOLOGICAL CHARACTERISTICS OF THREE WARM-SEASON GRASSES IN RELATION TO FORAGE QUALITY

By

Raul A. de la Torre

August, 1974

Chairman: John E. Moore
Major Department: Animal Science

The first part of this study investigated several factors that limit quality in Suwannee bermudagrass (Cynodon dactylon). In experiment I, hays of 2, 4, 6, 8, 10 and 12 wk were fed to sheep in an intake and digestion trial. Organic matter (OM) intakes of the 2-, 4- and 6-wk hays were similar, but a large decrease ($P<.05$) occurred from 6 to 8 wk (64.8 to 51.4 $g/kg^{.75}/day$). OM digestibility was reduced from 2 to 4 wk (66.2 to 59.5%) and from 6 to 8 wk (56.4 to 49.3%).

In experiment II, the four oldest hays (6-, 8-, 10- and 12-wk) were fed with or without 75 g of soybean meal (50% crude protein) daily. The sharp drop in OM intake between 6 and 8 wk was not repeated and there were no differences between hay means. OM digestibility, on the other hand, was reduced from 6 to 8 wk as in experiment I. Protein supplementation did not affect intake nor digestibility even in hays with less than 7% protein. In both experiments, OM intake did not decline with maturity as rapidly as did digestibility. Further, small differences in composition were related to large differences in intake and

digestibility. Lignin was the structural component most closely correlated with OM intake and OM digestibility, and appeared as the primary inhibitor of quality.

During the second part of this study, the various micro-histological characteristics which may relate to microbial degradation of plant tissues and forage quality were investigated on leaf and stem samples of Pangola digitgrass (Digitaria decumbens) (4- and 11-wk), Suwannee bermudagrass (6- and 12-wk) and Pensacola bahiagrass (Paspalum notatum) (6- and 13-wk) hays of known in vivo intake and digestibility. In the first of three experiments, stem morphology was compared in terms of percentage vascular tissue (the fraction of the stem cross-sectional area representing the combined areas of all vascular bundles) and percentage lignified tissue (the fraction of the stem cross-sectional area representing the combined areas of sclerenchyma, epidermis and vascular tissues). Percentage vascular tissue was little affected by maturity, while percentage lignified tissue was significantly increased with maturity in bermuda and bahia but not in Pangola. Percentage lignified tissue gave higher r values with both OM intake and OM digestibility than the other anatomical parameter.

In experiment II, leaves and stems cut into 2 mm lengths were incubated in vitro for 48 h with microorganisms and examined microscopically. Digestion was not complete, but in all samples degradation was apparent in non-lignified tissues only, i.e. parenchyma and phloem. Stem parenchyma cell wall thickness (in microns) before vs after digestion were: 4-wk Pangola, 1.12 vs .67; 11-wk Pangola, 1.50 vs .56; 6-wk bermuda, 1.62 vs .81; 12-wk bermuda, 2.22 vs .85; 6-wk bahia, .81 vs

.54; and 13-wk bahia, .79 vs .54. In lignified tissues, i.e. sclerenchyma, xylem and epidermis (the latter containing cutin in addition to lignin), cell wall thickness did not change during digestion.

In experiment III, in vitro dry matter digestion (IVDMD), neutral detergent fiber digestion (IVNDFD) and acid detergent fiber digestion (IVADFD), and morphological changes were measured on cut sections of leaves and stems after 72 h incubation. Leaf IVDMD ranged from 43.9 to 88.8% and stem from 39.4 to 61.8%. Leaf IVNDFD ranged from 29.7 to 82.9% and stem from 23.4 to 44.5%. Leaf IVADFD ranged from 25.7 to 82.3% and stem from 12.6 to 36.1%. All the lowest values were for 12-wk bermuda and the highest for 4-wk Pangola. Within each hay, IVDMD, IVNDFD and IVADFD of leaves were significantly higher ($P<.01$) than of stems. Digestion of cellular contents was found to be nearly 100% in both leaves and stems. The contribution of digested NDF to the total DM digested amounted to approximately 60% in leaves and approximately 50% in stems. Microscopic examination showed that digestion of non-lignified tissues in stems was complete and that the decreased digestibility due to maturity within each species could be accounted for by a reduced ratio of non-lignified (digestible) to lignified (indigestible) tissue. In leaves, digestion of non-lignified mesophyll cells was complete in Pangola but only partial in both bermuda and bahia. Evidence suggests that cell walls of lignified tissues are totally indigestible and that degradation of non-lignified cell walls is not affected by presence of lignified structures. Differences in rates of cell wall digestion were more evident in leaves than in stems and may explain the incomplete degradation of mesophyll cell walls in bermuda and bahia.

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

EXPERIMENTAL LEAD TOXICITY IN SHEEP AND RATS

By

Karl R. Fick

December, 1974

Chairman: Dr. C. B. Ammerman
Major Department: Animal Science

Several experiments were conducted to study the effects of dietary lead level on animal performance and metabolism in sheep and rats.

Growth and balance trials were conducted to study the effect of graded levels of dietary lead on animal performance, lead deposition in tissues, nutrient digestibility and nitrogen and lead balance. In a growth trial, 20 wether lambs (36 kg body weight) were randomly allotted to five dietary treatments: basal diet and basal plus 10, 100, 500 or 1000 ppm added lead as lead acetate. Animals were individually fed for 84 days then euthanized and tissues removed for analysis. Feed intake (kg) and daily gains (g) were: 1.43, 169; 1.36, 161; 1.30, 158; 1.32, 168; and 1.21, 172. Lead levels were higher ($P<.01$) in liver, bone, brain and spleen when 500 or 1000 ppm lead was fed. The 1000 ppm lead level resulted in higher ($P<.05$) lead levels in kidney, heart and muscle. In a balance trial, six sheep (37 kg body weight) each were assigned to diets containing 50 or 1000 ppm supplemental lead. Sheep were offered 1 kg of diet per head daily and nutrient digestibility and nitrogen and lead balance were determined. Supplemental lead did not affect nutrient digestibility or nitrogen balance. Sheep on the

higher lead level absorbed and retained more ($P<.01$) total lead but the percent apparent absorption and retention were not different.

A radioisotope trial was conducted to study the metabolism of lead. Six sheep (37 kg body weight) each were fed a basal diet plus 50 or 1000 ppm supplemental lead and dosed with ^{210}Pb either orally or intravenously in a 2 x 2 factorial arrangement of treatments. Limited intestinal absorption of lead was demonstrated by the low values recorded for apparent absorption and net retention of stable lead. In addition, blood and tissue uptake of ^{210}Pb by those animals receiving oral doses of the radioisotope was very low. Excretion of ^{210}Pb administered orally was almost entirely by way of the feces, but intravenously injected ^{210}Pb was excreted in feces and urine in approximately equal amounts. Low dietary lead and intravenous administration of ^{210}Pb resulted in the greatest tissue retention. Tissue levels of stable lead were higher in sheep fed the high level of dietary lead.

A 84-day growth study involving 40 weanling rats (65 g body weight) was conducted to study the effect of dietary protein and lead level on performance and tissue lead deposition. A 2 x 4 factorial arrangement was used in which diets containing 20 or 30% protein were supplemented with 0, 10, 100 or 1000 ppm lead. The high level of dietary protein resulted in higher ($P<.05$) lead concentrations in liver but did not affect that in kidney or bone. Feed intake, performance, hemoglobin and hematocrit were depressed ($P<.01$) with the 1000 ppm supplemental lead level. Lead concentrations were higher ($P<.01$) in kidney and

bone when 100 or 1000 ppm dietary lead was fed. High dietary lead also resulted in higher ($P<.01$) lead concentrations in blood and liver.

Growth and balance trials were conducted with rats to evaluate the effects of providing lead in animal tissues (muscle and liver from sheep fed lead, growth study described previously) and animal tissue plus lead acetate on performance, lead balance and lead deposition in tissues. In the growth study 18 weanling male rats were randomly assigned to three dietary treatments: 50% laboratory chow plus 50% low- or high-lead muscle or 50% laboratory chow plus 50% low-lead muscle and 3 ppm lead.. Rats were individually fed for 56 days, then euthanized and tissues removed for lead analysis. Feed intake, growth rate and lead concentration in tissues were not affected by any of the treatments. In a 14-day balance trial four male rats were assigned to each of the following three treatments: 50% laboratory chow plus 50% low- or high-lead liver or 50% laboratory chow plus 50% low-lead liver and 8 ppm lead. Increased dietary lead supplemented in the form of lead in liver or as lead acetate increased ($P<.01$) lead absorption, excretion in the feces and retention. Rats receiving lead acetate deposited more ($P<.05$) lead in the kidneys than those on other treatments.

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

RESPONSE OF A COMPLEX TROPICAL PASTURE MIXTURE
TO DIFFERENT GRAZING MANAGEMENT SYSTEMS

By

Gerzy Ernesto Maraschin

August, 1975

Chairman: Dr. Gerald O. Mott
Major Department: Agronomy

A grazing experiment was conducted at the Beef Research Unit, University of Florida, at Gainesville, during the summer growing season of 1974, to study the effects of length of grazing, rest periods and grazing pressure, at five levels each upon a mixture of Siratro, Greenleaf desmodium and lotononis growing in association with Coastcross-1 bermudagrass.

The experimental site was developed and sown to the above mixture in 1973. The experimental design was a Central Composite to which extra points were added. Braford yearling heifers were used to graze the experimental pastures.

Visual estimates of botanical composition were compared against actual hand separation.as well as visual estimates of fresh forage yield against actual yield of fresh forage. The regression coefficients obtained were used to correct for yield of the not harvested samples.

The response parameters were estimated by a second degree polynomial.

Length of grazing was the least important factor. Rest period and

grazing pressure produced significant biological responses upon the pastures. Longer rest periods were required for higher grazing pressures to maintain high grass percentage and yield. The legume percentage and legume dry matter yield was increased by long rest periods. The negative effect of long periods of grazing were partially offset by lenient grazing pressure. High levels of both rest period and grazing pressure were required to reduce the weed component to a minimum.

Maximum total forage dry matter yield was obtained at all grazing pressures but in combination with different rest periods. The stocking rate was dependent upon the forage dry matter on offer. Maximum stocking rate occurred at high grazing pressures in combination with long rest periods.

The IVOMD of the grass and Siratro was reduced by increased residue after grazing. The IVOMD of grass, Siratro and Greenleaf desmodium showed a curvilinear relationship to rest periods. The nitrogen of the grass was reduced by increased residue after grazing. Nitrogen content showed a curvilinear relationship with rest period.

Abstract of Thesis Presented to the Graduate Council of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Master of Science in Agriculture

FORMALDEHYDE TREATED SOYBEAN MEAL AS A PROTEIN SUPPLEMENT FOR GROWING LAMBS

By

Jose Rafael Martinez

March, 1975

Chairman: Dr. C. B. Ammerman
Major Department: Animal Science

One hundred and twenty wether lambs with an average initial weight of 25.4 kg, were used to study the effect of formaldehyde-treated soybean meal (SBM) when used in the diet for finishing lambs. After an adjustment period of 14 days the lambs were randomly assigned to 15 pens of 8 animals each providing three pens for each of five dietary treatments. The diets contained 10% SBM treated with either 0.0, 0.2, 0.4, 0.6 or 0.8% formaldehyde and other major ingredients were corn, 67.5% and cottonseed hulls, 15%. Lambs were fed ad libitum as groups for 63 days and slaughtered at the end of the experimental period for carcass evaluation. Individual initial and final weights and feed intake by pen were recorded. Average daily gains (ADG) of the lambs receiving diets with 0.0, 0.2, 0.4, 0.6 and 0.8% formaldehyde-treated soybean meal were 192, 211, 210, 221 and 207 g/day, respectively, and feed per unit gain was 6.70, 6.43, 6.30, 6.09 and 6.49, respectively. The differences were not statistically significant. When the ADG (192 g) for control lambs was compared with that (212 g) for lambs receiving all levels of formaldehyde, there was a significant ($P<.05$)

response due to treatment. Carcass measurements were not influenced by dietary treatment.

Chairman

Abstract of Thesis Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Agriculture

EFFECT OF PELLETING AND OF FORAGE MATURITY ON
QUALITY OF PARAGRASS AND ST. AUGUSTINEGRASS

By

:ar Neri-Flores

June, 1975

Chairman: Dr. Samuel W. Coleman
Major Department: Animal Science

Two identical in vivo digestion and voluntary intake trials were conducted. Each experiment was a 2x2x2 factorial completely randomized design with two Angus-Brahman crossbred steers per treatment. The objective of this study was to examine the effect of processing (green chopped and pelleted) and forage maturity (4 and 8 weeks of regrowth) on voluntay intake, nutrient digestibility and rate of passage of digesta of paragrass and St. Augustinegrass. Rate of passage was estimated using Cr_2O_3 as a marker.

Pelleting 4- and 8-week regrowth resulted in a higher dry matter intake (DMI) of both grasses when compared to the corresponding green chopped regrowths ($P<.05$). The greatest increase as a result of pelleting was observed in the 8 week regrowths. At this age, DMI of paragrass and St. Augustinegrass increased ($P<.05$) by 25.4 and 19.7 percent, respectively. DMI of green chopped or pelleted paragrass and green chopped St. Augustinegrass decreased with maturity ($P<.05$). Digestible DMI of paragrass showed the same trend as did DMI with respect to maturity. However, digestible

DMI of St. Augustinegrass did not change ($P<.05$) with maturity in either physical form of forage.

In general, dry matter digestibility (DMD) was depressed by pelleting. The reduction in digestibility due to pelleting was most marked in the cell wall components of both grasses. DMD of paragrass and St. Augustinegrass showed similar pattern with maturity as did digestible DMI. Pelleting 4- and 8-week paragrass and 8-week St. Augustinegrass accelerated ($P<.05$) the rate of passage of Cr_2O_3 as measured by 5% excretion time and k (instantaneous excretion rate), which may be used as measures of rate of passage. DMI was significantly ($P<.01$) correlated with rate of passage.

S.W. Coleman

Chairman

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

NUTRITIONAL EVALUATION OF PENSACOLA BAHIAGRASS PASTURE BY ANIMAL AND LABORATORY TECHNIQUES

By

Enio Rosa Prates

August, 1974

Chairman: Dr. J. E. Moore
Major Department: Animal Science

Grazing and greenchop experiments were conducted simultaneously every 28 days during a six-month period (1) to estimate the seasonal variation in nutritive value of a Pensacola bahiagrass pasture, (2) to evaluate the performance of grazing steers on this pasture, (3) to compare estimates of intake by grazing animals with animal performance and (4) to compare sampling methods for estimating quality and quantity of pasture throughout the season. Measurements of live weight changes by grazing yearling steers and estimations of pasture organic matter (OM) intake by different techniques were made for each period. Calculated OM and total digestible nutrients (TDN) yield of the pasture and chemical composition of forage samples were also obtained. Results of an intake and digestion trial with greenchop were compared to the results obtained in the pasture trial.

Average daily gain (ADG) by grazing steers declined from May to September, then slightly increased in October.

It followed a trend similar to the general live weight pattern observed in the flatwood areas, i.e., high ADG at the beginning of the grazing season, rapid decline as the summer progresses through September, and a small increase in early fall. The low ADG by the steers during August and September was apparently independent of differences in the quantity of available forage and, thus, may have been caused by low OM intake. High rainfall, low forage palatability or low forage quality during late summer may have been the cause of the low OM intake.

Estimates of OM intake by grazing steers were lower than the actual OM intake by greenchop steers. This unusual situation may have been due to an underestimation of fecal output in the grazing experiment by the chromic oxide ratio. Fecal crude protein gave high estimates of OM intake while lignin ratio and greenchop OM digestibility gave low estimates. Correlations between OM intake estimates and ADG varied with each estimate. Estimates of OM intake based upon the agronomic difference technique were similar to stated requirements; however, these estimates were not correlated with ADG. Estimated OM intake from *in vitro* OM digestion (IVOMD) of esophageal-fistula, hand-plucked available-forage, and caged-forage samples were all lower than the requirements; however, these estimates were highly correlated with ADG.

The estimate of OM intake using IVOMD of hand-plucked samples was the most highly correlated with ADG. Therefore, hand-plucked samples would be preferable to any other technique to estimate chemical composition and OM intake of Pensacola bahiagrass pasture. Furthermore, this sample was the most easily obtained.

Organic matter and TDN yield/ha followed a pattern which was opposite to that of gain/animal and gain/ha. Fifty percent of the forage yield was produced in July and August. Residual forage OM was also measured and the results showed that the amount left uneaten in each period steadily increased.

The chemical composition data demonstrated that the quality of Pensacola bahiagrass decreased as the season progressed. Acid detergent fiber increased and IVOMD decreased. There was little change in neutral detergent fiber and lignin throughout the season. Crude protein percentage remained always high (above 11%). It was concluded that a light overgrazing of the Pensacola bahiagrass pasture under continuous grazing, or harvesting the excess grass to avoid accumulation of unpalatable forage, were management practices that could be used to increase production.

Abstract of Thesis Presented to the Graduate Council
of the University of Florida in Partial Fulfillment
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Master of Science in Agriculture

BLOOD AND RUMEN FLUID PROFILES IN
CARBOHYDRATE-ENGORGED CATTLE

By

Robert L. Suber

March, 1975

Chairman: Dr. J.F. Hentges, Jr.
Major Department: Animal Science

Effects of a force-fed high carbohydrate diet on blood and rumen fluid composition were determined at ten intervals during a 32-hour period. Six rumen fistulated steers were offered two dietary treatments, pasture forage offered ad libitum and a high carbohydrate diet given intraruminally at the rate of three and one-half percent of live body weight. Blood analyses included pH, hematocrit, histamine, acetylhistamine, plasma L-lactic acid, plasma glucose, plasma lactic dehydrogenase (LDH), serum protein, serum sodium and serum potassium. Rumen fluid analyses included histamine, acetylhistamine and L-lactic acid.

Analysis of variance showed differences between the two dietary treatments for blood pH ($P < .01$), plasma L-lactic acid ($P < .01$), plasma LDH ($P < .05$), serum sodium ($P < .01$), serum potassium ($P < .01$), rumen fluid

L-lactic acid ($P < .01$), rumen fluid histamine ($P < .01$) and rumen fluid acetylhistamine ($P < .05$).

A positive correlation of rumen fluid and blood acetylhistamine before ($R = 0.49$, $P = .0002$) and after ($R = 0.28$, $P = .0282$) forced engorgement of a high carbohydrate diet indicated that dietary components and microbial metabolism within the rumen may cause an elevated blood acetylhistamine during digestive disorders in cattle. Clinical symptoms of distress and feedlot founder were successfully induced within four to six hours after blood acetylhistamine attained a mean peak concentration, 2.9997 $\pm$ 1.7054 μg of histamine base/ml of sample.

Rumen fluid histamine was higher ($P < .01$) after steers were engorged than when forage-fed. A low correlation of rumen fluid and blood histamine indicated that dietary sources were not responsible for blood levels.

An increase in rumen fluid L-lactic acid apparently does not increase plasma levels because of a low correlation. Engorged steers became lethargic and had lower ($P < .01$) plasma L-lactic acid levels throughout the 32-hour study.

Mean plasma LDH was higher ($P < .05$) after steers were engorged and foundered than when forage-fed. A low correlation indicated that an increase in plasma LDH does not affect plasma glucose or L-lactic acid levels.

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Chairman

A SIMULATION STUDY OF THE PROFITABILITY AND EFFICIENCY OF BEEF BREEDING SYSTEMS

Hines Boyd[1] and Marvin Koger[1]
University of Florida, Gainesville 32601

Summary

A DYNAMO computer simulation model was developed to determine nutrient intake and costs for cow-calf and post-weaning production. Data were analyzed from 2 straight-bred and 3 criss-cross breeding systems maintained on clover-grass pastures and wintered on a corn silage ration at the Beef Research Unit at Gainesville. The straight bred systems were Angus and Hereford. Criss-cross systems were Angus-Hereford, Angus-Brahman, and Hereford-Santa Gertrudis. Calves were weaned at 9 months of age and immediately placed in the feedlot for 6 months. At weaning, net returns to land, management, and capital for each cow with a live calf were $161.35, 158.15, 156.37, 152.14, 143.45 for the Hereford-Santa Gertrudis, Angus-Brahman, Hereford, Angus-Hereford, and Angus breeding systems respectively. Net returns at slaughter were $171.55, 169.35, 167.07,164.97, 158.67. Efficiency measured as total kg TDN comsumed per kg calf produced was 12.23, 12. 20, 12.50, 12.59, 12.72 at weaning and 9.85, 9.71, 9.93, 9.78, 9.92 at slaughter.

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[1]Department of Animal Science.

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