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# Potential to increase beef production



# in Tropical America



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Centro Internacional de Agricultura Tropical

# Potential to increase beef production in Tropical America



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## OBJECTIVES OF THE SEMINAR

1. To explore the roles of beef cattle enterprises in the agricultural and economic development of the lowland tropics

2. To evaluate factors influencing the development of the beef cattle industry in these areas

3. To identify techniques for increasing the productivity of beef cattle enterprises

4. To establish the bases for interchange of technology and information among institutions and individuals engaged in livestock and agricultural development programs

5. To assist CIAT and national agencies in establishing their own priorities for beef cattle research and training

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# THE ROLE OF BEEF CATTLE IN THE DEVELOPMENT OF LATIN AMERICA

*Roberto Meirelles de Miranda*

*"They landed. They brought with them some new animals looking very much like deer but taller, and they sat on the backs of those animals, which made them very swift. I saw some of them cross the plains in less time than it would take the best courier to run across my hall."*

Papantzin in "Corazón de Jade"
by Salvador de Madariaga

## THE HISTORY OF LIVESTOCK

At the time of discovery, the inhabitants of the new world were completely ignorant of the domestic animals of our day. Dogs for hunting, llamas and other cameloids, wild turkeys and capybaras were the only animals referred to by historians as having some connection with Indian life. Madariaga describes poetically what would have been the impression of the Indian princess Papantzin upon seeing horses for the first time. The Portuguese reporter from Cabral's fleet, in his first letter to his king, was precise in describing what he had found in the new land. Referring to the Brazilian Indians, he wrote, "They do not plow the land nor raise animals nor are there cows, goats, ewes, chickens or any other animal accustomed to living with men." (Pero Vaz Caminha, 1500).

The most advanced American Indians had already developed agriculture to the point of having efficient irrigation systems, but they knew nothing about livestock keeping, except for the Incas who had llama herds.

The history of the introduction of domestic animals in Latin America is not precise and facts are mixed with legend. Dates and species are quoted by historians in a vague way. Surprisingly enough, the few head introduced in the different countries reproduced rapidly, and herds were counted by the thousands in the century following discovery. When Buenos Aires was rebuilt in 1580, after having been abandoned by its founders, the new inhabitants found wild cattle and horses roaming through the pampas. The early Brazilian historians were startled by the rate of growth of the colonists' herds. One of them, Gabriel Soares de Souza, described the behavior of the herds in Bahia in an original way: "They freshen every year and continue reproducing even when they get older; heifers are mated with the bull when they are yearlings and give birth at two years of age, so in many cases we see calves suckling heifers who, in turn, are sucking their mothers; the same happens with mares, ewes and sows."

Today, we wonder at and perhaps tend to doubt those records, even when they are supported by historical data. In the XVII century, horses were exported to Portugal, and the Spanish colonies were suppliers of hides to their mother country. Cattle were slaughtered in large numbers for the hides, the meat going to waste in the absence of consumers. Dried jerked meat was developed later as an export item at the beginning of the XVIII century. More recently (1868), the discovery of industrial refrigeration by Charles Tellier opened the world markets to Latin American beef.

This short historical sketch clearly shows the importance of livestock in the settlement of Latin America. The sparsely populated colonies had their vast natural pastures filled with herds of cattle and horses, managed by a few colonists and a decimated Indian population. Even though mining was the main attraction for the white man, there were some cases when agriculture and cattle grazing developed considerably, and livestock populated immense regions of natural grassland and "consolidated the economic occupation of enormous areas in the hinterland," as Simonsen (1937) says when referring to Brazil. The same is also true for Argentina, Uruguay, Colombia, Venezuela, Mexico and many other countries.

## PATTERNS IN SOUTH AMERICA

Reading Roseveare's "The Grasslands of Latin America" (1948), we understand this historical development, and we can foresee that we will continue to depend on livestock for our well-being and economical growth. Natural grasslands predominate in many parts of Latin America, as for example the fine swards in the Argentine pampas, the coarse grasses in the Brazilian cerrados and the Colombian and Venezuelan llanos. Grasslands provide forage for sheep and cameloids in the high páramos, where people breathe with difficulty, and sustain water buffaloes in the marshy flatlands of Marajó Island.

FAO's (1971) map of South American soils shows how limited they are for modern agriculture, leaving the farmer the choice of forestry or livestock raising.

Only 10 per cent of the agricultural areas are free of serious limitations for modern agriculture: 50 per cent have low fertility, 20 per cent lack water, 10 per cent have drainage problems and the other 10 per cent are too steep. These limitations are not so serious for extensive beef production, and the cerrados and the llanos may be put into production simply by applying elementary technological procedures. Even looking at the Argentine pampas or the lands of Uruguay, where the limitations for agriculture are not so obvious, farmers' preferences are, by tradition or by natural inclination, for raising livestock. Campal's (1972) study of the Rio de la Plata basin indicates that raising livestock (beef and sheep) is the most common primary activity, using more than two thirds of the areas dedicated to agriculture and forestry.

Areas recently opened in the humid tropics of the Amazon basin leave small hope for subsistence agriculture. In these areas, the soil nutrients are retained only while they circulate through the vegetation. When trees are removed or debris burned, nutrients are rapidly leached, leaving behind a hardened, infertile soil for poor farmers. Another possibility for these areas may be livestock farming. Recent work by Falesi (personal communication, 1973) at the Instituto de Pesquisa Agropecuaria do Norte (IPEAN, Belem, Brazil) indicates that even the humid forest plains of the Amazon region may have a future potential as pastures. Surprisingly, Falesi has found that fertility indexes are improving in soils covered by grass swards. This gives new hope for the areas that are now being opened and which may be saved from subsistence shifting agriculture.

Taking a look at Latin America as a whole, we see there is enough land for livestock production and the lumber industry for the world. This still leaves enough farm land to produce crops to feed its own growing population and to supplement pastures during dry periods or for intensive breeding and fattening systems.

## THE GAMA OF CLIMATIC CONDITIONS IN LATIN AMERICA

Latin America extends from 30°N to 55°S. This, in combination with varied altitudes, gives rise to many kinds of climates. The largest land masses are found in the tropics, which have extreme variations in temperatures and rain conditions and which present many problems for livestock raising. For each climate combination, it is necessary to develop an appropriate new technology. Only the temperate areas of the southern tip of Latin America, northern Mexico and the high elevations were fortunate in being able to use the same breeds of livestock and forage plants European settlers used.

## LIMITATIONS FOR LIVESTOCK PRODUCTION

Early writers describe Latin America as a livestock paradise. Rapid animal population growth could be explained by unlimited grazing areas free from parasites and diseases. Certainly, the increased frequency of new introductions, without any quarantine measures, brought diseases and parasites which added to those peculiar to tropical environments. In a certain way, we were fortunate to remain free of so many diseases and parasites which even today hinder animal industry in Africa and Asia. Modern writers are very optimistic and forecast substantial increases in our indexes of productivity. In a recent series of lectures, Hutton (1972) states that "there is no reason why Venezuela cannot increase its cattle population from 8 to 24 million." We hear the same from many visitors from foreign lands.

We have to temper this optimism with reality, recognizing the limitations of our environment; creating the necessary research structure to tackle the problems; defining extension activities, credit and marketing systems; and developing land tenure organizations to absorb the technology generated by this research. The example of countries where research has progressed more than in Latin America demonstrates that scientific results are not the final objective of the efforts made to improve livestock productivity.

The Annual Report (1971-1972) of CSIRO's tropical pastures division in Australia states that only 4 per cent of the available natural tropical grasslands in Australia has been adapted to the known technology and may be classified as improved pastures.

What are our limitations? Our historical background, as well as the land and climate, can help us define them. Historically, there is a tradition of extensive livestock raising. Owners of large tracts of land and numerous herds are not prone to accept changes. The sheer exploitation of natural resources is enough to maintain their level of income. Without exerting pressure against this socioeconomic background, research alone will not lead to changes in productivity.

The level of soil fertility and seasonal rainfall shortages are serious limitations. Forage production is low and is not a continuous process. Fast-growing forages become woody and fibrous rapidly; and during the long dry periods, livestock eat the reserves accumulated during the rainy season.

Mineral deficiences can be identified wherever we look for them; however, the extent and intensity of this limitation are still unknown in the greater part of the continent.

To the diseases and pests brought in from the developed world, we add those of the tropical environment. Foot-and-mouth disease takes a big toll, and the variability of the virus limits movement of breeding animals from one area to another. Its mere presence raises barriers against our products in the world markets.

Rabies is widespread and continues as a permanent menace with the thousands of vampire bats living in caves in all mountainous areas. Farmers are so used to the presence of bats in these areas that they do not take into account the loss of blood and discomfort the bats' blood-sucking habits cause in their herds.

External parasites, especially ticks, are a permanent source of discomfort and reduction of animal vitality, even if we do not consider their secondary effects as vectors of hemoparasites. These, we know, exist and kill imported and weakened native animals, but production losses from this parasitizing have never been calculated precisely.

The world would be surprised to know how much is lost to ticks. A note published in the Australian Veterinary Journal (Vol. 44, p. 585, 1968) refers to estimates made at the Belmont Experimental Station, Queensland of average losses of 166 cc of blood/animal/day. Other estimates range from 107 to 154 cc. Farmers in Latin America and possibly all other tropical countries are so plagued by animal diseases that they are not impressed by those that do not kill promptly. This may explain why so little attention has been paid to the study of ticks.

I think this seminar would be a proper forum to raise the questions of research on ticks and to ask for an International Center for Research on Tick Control to be established. I do not see any subject more appropriate for an international center. We need basic, radical research no country is able to undertake alone. We need an international effort since no country has the staff to tackle all aspects of the problem nor to find solutions where nobody can see them now. Possibly through the knowledge gained from tick research, we might find solutions for controlling many other pests that plague humans and animals in the tropics.

Reproductive diseases are widespread in Latin America and the extent of their damage is not known. They also do not kill immediately; and of these, only brucellosis prompted some action in testing and vaccination programs.

UN-FAO (1961) made a study of the problems and potentials of livestock production in Latin America. The data on losses in Colombia caused by livestock diseases may be quoted here as an example of a general picture. In 1958, losses in Colombia amounted to 881 million pesos and 1,140,000 deaths. These losses are presented as percentages (Table 1).

Table 1. **Causes of livestock losses in Colombia, 1959.**

| | Percentage |
|---|---|
| Foot-and-mouth disease | 17.0 |
| Abortion | 13.0 |
| External parasites | 35.0 |
| Internal parasites | 15.2 |
| Tuberculosis | 1.8 |
| Paratuberculosis | 4.2 |

**Source:** UN–FAO, 1961

Tropical diseases place a permanent limitation on possibilities of exchanging genetic material. Zebus, buffaloes, bantengs and wild antelopes are sources of potential genetic material either to improve the adaptability of European cattle to our environment or, on the other hand, to replace them. But there are enormous risks of introducing new foot-and-mouth virus, rinderpest and many other diseases and parasites (Miranda, 1965) from Asia and Africa, where they are endemic.

In this list of limitations, the weakness of our research, teaching and extension institutions should be included. Animal research has lagged behind agronomic research and up to now only scratched the surface of the problems we have identified. Graduate teaching in animal sciences started just a few years ago, and the undergraduate programs have not emphasized production problems nor trained the men to solve them. Consequently, extension has not had a sound basis on which to develop.

## AVAILABLE RESOURCES

The list of so many limitations leaves us somewhat pessimistic as regards our livestock possibilities. Let us talk about our resources. The first of them is the vast amount of land with serious limitations for crop growing. Of the 20,559,000 square kilometers quoted by FAO as the total surface in Latin America, only 505,000 are considered permanent pastures, leaving large areas for development.

The second important resource is the existent large animal population. This is based on FAO figures shown in Table 2.

Table 2. **Latin American animal population, 1971 (millions).**

| | |
|---|---|
| Cattle | 248.5 |
| Horses | 24.2 |
| Swine | 103.2 |
| Sheep | 130.0 |
| Goats | 39.5 |
| Water buffaloes | 0.1 |

**Source:** FAO Production Yearbook, 1971

The Latin American animal population comprises a large and varied gene pool. In the past, we have tried to solve our problems by importing some miraculous breed and in doing so have introduced numerous breeds of livestock. For cattle in Brazil, we have established regular herd books for more than 16 breeds. In this century, we imported about 6,000 head of Indian cattle and numerous other breeds of *Bos taurus*, adding new genes to those brought in colonial times.

Recently, we have been reassessing the value of the genetic material brought in by the colonists. A number of papers (de Alba, 1955; Jordão, 1956; Domingues et al., 1959; and Bodisco et al., 1962, for example) describe the virtues of the criollo breeds: Blanco orejinegro, Romo sinuano, Costeño con cuernos, Lechero del Valle del Cauca, San Martinero, Caracu, Mocho nacional, Curraleira, Malabar, etc. Many criollo breeds have disappeared because of indiscriminate crossing with European or Indian breeds.

More recently, the cattle gene pool has been enriched by the introduction of new breeds from the United States (Brahmans, Santa Gertrudis, etc.) and Italy (Chianina, Romagnola and Marchigiana).

The interaction of land resources and genetic resources with our socioeconomic conditions has determined our present levels of productivity, with which we are not satisfied. Let us have a look at this situation by examining data published in the past, which have probably not changed much to date. Table 3 is a pool of information from many sources published since 1961. It represents what has happened in the major cattle producing countries; certainly the information may be extrapolated to the smaller producers.

Table 3. **Indexes of cattle productivity; variation in Latin America.**

| | | |
|---|---|---|
| Rate of extraction (%) | 7.2 | 26.5 |
| Average carcass weight (kg) | 164 | 220 |
| Beef per animal on hoof (kg) | 13 | 50 |
| Beef per hectare of pasture (kg) | 14 | 52 |
| Slaughter age (years) | 4 | 5 |
| Adult mortality (%) | 5 | 6 |
| Calf crop (%) | 40 | 60 |
| Milk per cow (kg) | 720 | 1920 |

Taken from various sources

Income levels from livestock are also quite low. Reproduced in Table 4 are some of the few data published on the subject. The data come from Campal's (1972) work and were taken from the Rio de la Plata basin, one of the best livestock areas in Latin America.

Tables 3 and 4 show low levels of productivity, and only the large farm areas explain how livestock farmers subsist. On the other hand, total production is considerable in view of the millions of hectares and the millions of livestock animals in Latin America, even though productivity per annual unit and per hectare is low.

Table 4. **Value of livestock production per hectare used as pasture in the Rio de la Plata basin (U.S. dollars). Prices in June, 1970.**

| | Highest total per ha | Lowest total per ha | Average per product | Highest values per product |
|---|---|---|---|---|
| Wool | 0.26 | 0.06 | 1.11 | 4.49 |
| Lamb | 0.09 | 0.05 | 0.40 | 1.58 |
| Milk | 25.83 | 0.17 | 2.63 | 25.83 |
| Beef | 11.89 | 2.12 | 6.97 | 18.63 |
| Total per ha | 38.07 | 2.40 | — | — |

**Source:** Campal, 1972

Table 5. **Livestock production in Latin America, 1971.**

| | (Thousands of metric tons) |
|---|---|
| Beef | 6,472 |
| Pork | 1,796 |
| Lamb and goat meat | 478 |
| Milk | 23,896 |
| Wool (unprocessed) | 322 |

**Source:** FAO Production Yearbook, 1971

The last important resource to mention in this paper is the genetic resource of the grass species. The tropical legume germplasm found in Latin America is still untapped by our researchers. Only those species studied by the Australians have received general attention. Tropical legumes provide the means to reduce soil fertility limitations, uneven rainfall distribution and protein scarcity for livestock feeding. The development of the potential of tropical legumes is considered by many scientists of the tropical belt of the world as the key to our livestock feeding problems (CIAT Beef Cattle Program Review Team, 1973; Granier, 1972; Hutton, 1972).

## RECENT DEVELOPMENTS IN LIVESTOCK PRODUCTION

Now that we have talked about resources, let us look at current performance and examine recent developments so that we may define what to do in the future. What has happened to livestock production in Latin America in recent years? Have production and productivity increased? Are we feeding our people better? In a recent paper, Jasiorowsky (1973) answers these questions. The following tables compare Latin America with the rest of the world.

Table 6. **Meat and milk production in Latin America and the world.**

| | | 1950 | 1970 | Average annual variation (%) |
|---|---|---|---|---|
| Meat, 1000 tons: | L. America | 6,185 | 10,183 | 2.5 |
| | World | 46,191 | 97,526 | 3.8 |
| Milk, 1000 tons: | L. America | 12,608 | 23,445 | 3.2 |
| | World | 256,302 | 398,498 | 2.2 |

**Source:** Jasiorowsky, 1973

Table 7. **Variations in per capita consumption of meat and milk in Latin America and the world.**

| | | 1950 | 1970 |
|---|---|---|---|
| Meat, total (kg): | Latin America | 38.2 | 35.9 |
| | World | 18.5 | 26.2 |
| Milk, total (kg): | Latin America | 77.8 | 82.7 |
| | World | 103.3 | 107.0 |

**Source:** Jasiorowsky, 1973

Total meat and milk production increased during the last years as shown in Table 6. For a continent with so much open space, the record is still a poor one, especially in meat production.

Table 7 shows how we are changing our consumption of livestock products, without taking into account what is being exported.

A small increase per capita availability of milk was registered, and certainly the decrease in meat consumption is higher than is shown, as exports were increased. Countries such as Argentina and Uruguay established meatless days to increase their exporting capacity, lowering their per capita consumption.

There is so much variation in per capita consumption in Latin America that the statistics given in Table 7 are meaningless in many cases. The high averages are produced by the extremely high levels of consumption in Argentina and Uruguay.

Productivity per animal varied as seen in Table 8. Small improvements noted in many cases are only signs of better measurements of output or population. In this table the much better figures for milk production are surprising, and there is a large decrease in pork output per head, for which there is no plausible explanation.

Table 8. **Variation in production per animal.**

| | 1950 | 1970 | Variation (%) |
|---|---|---|---|
| Beef (kg) | 28.5 | 29.4 | 3.2 |
| Lamb and goat meat (kg) | 2.7 | 2.7 | 0 |
| Pork (kg) | 20.5 | 17.6 | −14.1 |
| Milk (kg) | 77.8 | 95.0 | 22.1 |

**Source:** Jasiorowsky, 1973

## SUGGESTED ITEMS FOR FURTHER CONSIDERATION

We all admit that Latin America has an enormous potential for livestock production, but the data just shown may lead us to be discouraged because realization of the potential has not developed as expected. At this point, we should stop to think of some points which could be the key to our future.

First, let us look at our research; most research is not directed to the solution of previously defined problems. Nutrition and health limitations have been recognized as important, but we still dedicate more time and energy to breeding experiments. We have a tendency to study problems which are fashionable in the developed world. In Brazil, where mineral deficiencies are known, we have few results from research on mineral feeding; nevertheless, at the same time, stilbesterol implants were used in many experiments at a time when implants were forbidden by law in that country.

This brings us to the first matter that should be given further consideration. We should orient our research to our problems and look for solutions applicable under our conditions. It is useless to consider solutions leading to high investments if we do not have the capital, to huge amounts of fertilizers if we have to import them, and to sophisticated management practices if our field worker is illiterate.

In the first place, we should consider research which is almost demonstrative in nature, using the knowledge already available in literature, but which has not yet been proven to work under our conditions. This adaptive research should include simple management, feeding and health rules which, although they are not designed to produce big jumps in productivity, will make the difference we have been hoping for when applied to our millions and millions of hectares and heads of cattle.

Mineral feeding, proper vaccinations, changing of breeding season and weaning age, providing supplements during the dry periods, improving water facilities, and improving pasture management will certainly contribute to accomplishing the miracle. We need to determine which practices give the highest returns and then direct our limited extension capacity to make their use widespread, either as a package or singly.

Our research system should define simple practices which will result in small increases in productivity, but when applied to large herds and areas will result in large production increases. This kind of research will be feasible and easily performed with the small, unprepared staff we have at our institutions.

Research should also provide ways to convince people to use the results. Economic analyses of the results and the demonstration of the economic feasibility of the simple production systems devised by research will give the extension worker the necessary weapons to combat the difficulties of his task.

This brings us to the second matter to be considered. More than research, we need extension work. Because producers do not make use of available research results, we need different approaches for technology transference in our countries. We have efficient vaccines against most of the important diseases, but field surveys show that they are little used. We know that phosphorus deficiency is widespread and that phosphorus supplementation increases productivity of livestock, but we still rely on bone meal as the source of this element. The amount of bone meal available shows phosphorus supplementation is still an uncommon practice.

We should introduce these and other practices —such as those illustrated here— through extension, thereby increasing productivity. How to make farmers use these practices, though, is an important point for consideration if we want to fulfill the Latin American potential for livestock production. Should we direct our research capacity toward supporting the extension effort? Which actions are more effective: demonstrations of packages or isolated practices, studies on rural farm management, subsidizing the implantation of practices as we used to do with vaccination campaigns? These are questions to be answered after pondering the problem of technology transference in livestock production in Latin America.

In looking for other points to be considered, I think we should include studies on other species as sources for meat production. We have already introduced water buffaloes, and they look quite promising for areas under risk of flooding, such as the lower Amazon Valley. The species may also be considered for other areas similar to the Bahia (Brazil), where studies favored the water buffalo as compared with Zebus for milk production.

Horse meat has been produced in increasing amounts, and different scientists have also called attention to other species, such as the banteng (Camargo, 1957) and the chigüiro (a wild pig), or capybara (Ojasti, 1973).

Last but not least is the study of our forage species. We have always looked abroad, rather than paying proper attention to our own resources in legumes and grasses. These species have a long history of adaptation to our environment, and they should be carefully scrutinized to discover their real potential under traditional pasture management. The cases of **Stylosanthes** and **Siratro** are good examples of how to get the most out of our own natural resources.

In general we should think more about the rational use of our natural resources; but in many cases, we do just the opposite. Let us develop our livestock production on the basis of our land and pasture resources and our huge cattle population. By introducing small increases in the indexes of productivity and using more land, we will increase our livestock income and improve the level of nutrition of our people and the people of the world.

# A LOOK AT THE FUTURE OF THE LIVESTOCK INDUSTRY

Livestock has always contributed to the development of Latin America. We can see how it has contributed to the rapid occupation of our vast territory and how it provided food for the colonist and hides for various domestic uses and for export.

In spite of the low levels of productivity, livestock has been an important source of income in recent years; and in a few Latin American countries, it has provided high standards of nutrition for the people.

For the future we still have a great deal of untapped natural resources oriented for livestock production: the cerrados, the llanos, the savannas of Bolivar and the vast Amazon basin (CIAT, 1973). These will provide for large production increases. At the same time, scientists believe better technology will bring about large increases in productivity.

"The World Food Problem" (US President's Advisory Committee, 1967) estimates that foot-and-mouth disease reduces cattle production in South America by 25 per cent annually; this could be controlled if we put forth the necessary effort. The same source says "rabies reportedly kills more than one million cattle in Latin America each year." This disease may also be controlled with the new vaccines and methods to kill blood-sucking bats.

Raun (1968), in reviewing the production potential of the Colombian Llanos Orientales, calculates that the plains could produce as much as 3.49 times more beef in the short run and 22.8 times in the long run if improved management practices were used and some improved pastures were established. These increments are within the economic reach of cattle producers. Using the same approach, Raun also gives estimates for all of Colombia. In the short run, the country could produce as much as 2.72 times more beef and in the long run, 9.8 times more.

A recent paper by Severo et al. (1973) indicates that large increases in productivity have already been accomplished under experimental conditions in southern Brazil (Table 9).

In some of the projects accepted by international development banks for loans to the livestock industry in Brazil, it has been demonstrated that by introducing improved, viable technology, it was possible to raise calf crops to 70 to 75 per cent, increase our slaughtering rate to 21 to 22 per cent, lower slaughter age to three years, and increase beef production per hectare to 120 kilograms per year (Rocha and Aronovich, 1972).

These projections, with the exception of beef per hectare, agree closely with those

Table 9. **Increases in productivity reached in Rio Grande do Sul under specified conditions.**

| | From | To |
|---|---|---|
| Calf crop (%) | 50.0 | 74.8 |
| Weaning age (months) | 11.0 | 7.0 |
| Age of slaughtering (years) | 4.5 | 2.5 |
| Extraction rate (%) | 12.5 | 26.0 |
| Beef per hectare (kg) | 45.2 | 113.0 |
| Net income per hectare (Cr$) | 40.0 | 79.0 |

**Source:** Severo et al., 1973

made by the team that defined the Brazilian National Cattle Research Project (Table 10) after a detailed study of the available information.

If we consider these projections to be valid for Latin America as a whole, we can visualize the livestock production potential of the continent. The realization of this potential will contribute directly to agricultural development of vast areas and consequently to better nutrition for the people of the world. It is our task as researchers, extension workers, professors and other professionals to unite our efforts in order to make full use of this potential. We are fortunate to have CIAT contributing the expertise of some of the world's best scientists to our effort. This meeting is CIAT in action, establishing communication between its scientists and its Latin American colleagues. This integration of efforts will lower our technological barriers; and in the near future, the projections of productivity indexes will become reality.

Table 10. **Increases in productivity expected in the Brazilian cattle research project.**

| | Present values | Goals |
|---|---|---|
| Slaughter rate (%) | 11-12 | 20-22 |
| Reproduction rate (%) | 40-50 | 70-80 |
| Slaughter age (years) | 4-5 | 2.5-3.5 |
| Beef per hectare (kg) | 20 | 40 |
| Milk production, per lactation (kg) | 705 | 1450 |
| Milk per ha/year (kg) | 200 | 1100 |

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# NUTRIENT REQUIREMENTS FOR THE ESTABLISHMENT OF IMPROVED PASTURES

*R. K. Jones*

In evaluating the potential of a particular region for animal production, we must consider both the quantity and the quality of pasture available to the grazing animal throughout the year. Maximum animal production in a given environment, of course, can only be achieved if the production of adequate-quality pasture is maximized.

The quantity factor is usually influenced most strongly by rainfall (or more precisely, the duration of adequate soil moisture) and the soil nitrogen supply. (In some cases, other plant nutrients such as phosphorus must be added to this list if they are extremely deficient.) Although we can manipulate the quantity factor to some extent by introducing more productive plants and by conserving fodder from one year or a part of the year for feeding out in another, these factors are generally much less important than water and nitrogen supply.

The quality factor, on the other hand, is influenced mainly by the supply of nutrients from the soil, acting either directly on the chemical composition of the pasture or indirectly on its botanical composition. By correcting the nutritional problems of a soil, we can often encourage a legume to grow in a native grassland, thereby markedly changing the quality of the pasture. The fertilizer applied, of course, has a direct effect on the chemical composition of both the grass and the legume, but sizable changes also result from the fact that legumes generally have higher concentrations of protein and mineral elements, such as sulfur calcium, magnesium and phosphorus (in seed), than grasses. To some extent, direct mineral supplementation of animals with nonprotein nitrogen, phosphorus and/or sulfur can offset the effects of poor-quality pastures by overcoming deficiencies of particular nutrients or by increasing food intake and sometimes the efficiency of digestion of dry matter. The major changes in animal liveweight production, however, are generally brought about by fertilizer effects on the botanical and chemical composition of the pasture.

To illustrate some of these points, I refer to the work of Edye et al. (1971), Ritson et al. (1971) and others in northeastern Australia. Their starting point was an unfertilized native grassland with some Townsville stylo *(Stylosanthes humilis)* with one cow to five or six hectares. The soils were known to be deficient in phosphorus so they imposed three superphosphate treatments (0, 126, or 377 kg/ha/year) as well as two stocking rates (one cow to 1.2 ha and one to 2.4 ha) and a fodder conservation treatment. The effects, particularly of the superphosphate treatments, on the quantity and quality of the pasture were quite striking. Superphosphate increased both the yield of total dry matter and the nitrogen, phosphorus and sulfur contents of the legume, as well as the phosphorus and sulfur contents of the associated annual and perennial grasses. These effects were presumed to be responsible for the greatly increased liveweight production and conception rate of the cows, and weaning weights of the calves.

Provided that the technical knowledge is available, the extent to which the quantity and quality of pastures can be increased will depend largely on economic factors. Improving pastures means expenditure not only on seed and fertilizer, but also on clearing or perhaps poisoning of timber and on additional watering points, fencing, labor, cattle, etc. Nutritional limitations to plant growth, in general, can be completely overcome only with high-value crops such as tobacco and sugar cane. We often have to be satisfied with partial solutions when dealing with beef cattle on pastures. In Australia, the application of nitrogenous fertilizers in tropical grasslands is not economical except in special cases such as dairying; hence this paper emphasizes the nutritional value of the legume.

In formulating a fertilizer program for the establishment of improved pastures, we must first obtain information on two main topics; viz., the nutrient status of the soils on which we wish to establish the pasture and the nutrient requirements of the various pasture species available.

## THE NUTRIENT STATUS OF SOILS

A considerable amount of this type of investigation has been done in tropical Australia. A typical program is that described by Isbell and Gillman (1973) and Jones (1973). References to other work are also given (Andrew and Bryan, 1958; Teitzel and Bruce, 1971).

### Soil morphology and chemistry

The region is first mapped by a soil surveyor and the most important soil or soils selected for detailed study. The morphology of these soils is described and any variations over the region are noted. Profile samples are then taken to encompass the range of variation encountered. After examining numerous profiles, Isbell and Gillman (1973), for example, finally sampled eight profiles to a depth of 2.5 meters from an area of granitic sands estimated to cover 720,000 hectares. More intensive sampling can, of course, be done if it is warranted. To supplement these profile samples, a larger number of surface (0 to 10 centimeters) samples are usually collected.

The soil samples are analyzed by standard methods for pH, organic carbon, total N, P, S, K, Cu and Zn, available P and exchangeable Na, K, Ca and Mg. Determinations of particle size and of the mineralogy of the clay fraction are also made. The variability of each of these parameters, both within the sampling site (i. e., distances of 10 to 50 meters) and between sites (up to 200 kilometers), is estimated. This information is of great assistance when one wishes to extrapolate results from a limited number of field experimental sites to the area as a whole.

The morphological and chemical description of the soil is essential background information to subsequent studies using plants. In some cases, it is possible to make a recommendation about the fertilizer requirements of the soil from this information alone; this requires a knowledge of the relation between soil parameter and plant growth.

### Glasshouse experimentation

The next step is to do glasshouse experimentation on eight or ten samples of the surface soil from the area. Jones (1973) used fractional-factorial experiments, the factors being the presence or absence of each of ten plant nutrients. It is most important that all nutrients be tested at this stage, even if nutrients which are probably not deficient have to be grouped for economy in experimental treatments. Experiments using rates of important nutrients such as phosphorus can also be included in this phase to give information on the shape of the response curve. As a test plant, it is desirable to use a species which is likely to be used in commercial pastures. We normally use a pasture legume since this is generally the key to the productivity of the plant/animal system.

Glasshouse experimentation is reasonably fast and enables one to experiment on a much larger number of soils than can be handled in the field. It is ideal for highlighting trace-element deficiencies and for studying the interactions of lime with nutrients such as sulfur, molybdenum and zinc.

### Field experimentarion

The third and final step is to confirm the results of the soil analyses and glasshouse experimentation by doing field experimentation at a few sites chosen to be representative of the entire area. The results of the soil analyses and pot experiments are generally of great assistance in designing field experiments, since they enable the experimenter to concentrate on particular nutrients and to group others which have been found to be unimportant into "miscellaneous" treatments.

Sulfur and molybdenum are two nutrients, which in field experiments may give results in conflict with those from the glasshouse experiments. It is quite common for soils to respond to additions of sulfur in glasshouse experiments but to be nonresponsive in the field because of an accumulation of available sulfur at depths in the profile (Jones et al., 1974). In some cases, however, the response to sulfur may be greater in the field because of leaching of sulfur from the root zone (Isbell, 1973). Responses to molybdenum in legume-based pastures may take longer to appear in field experiments than in glasshouse experiments because nitrogen, mineralized from the soil after cultivation, may mask the reduced fixation of nitrogen in the root nodules of molybdenum-deficient legume plants. The experiments should, therefore, continue for several seasons.

Field experiments are often used to examine aspects such as responses to various rates and forms of fertilizer and leaching of nutrients and for correlating plant response with soil or plant analytical values. They have the advantage over glasshouse experimentation in that they can be carried out under conditions similar to those in a commercial pasture (e. g., with minimum cultivation, without clearing of timber, and under the same environmental conditions).

## NUTRIENT REQUIREMENTS OF THE PASTURE SPECIES

Although all plants require supplies of the same essential nutrient elements, they may differ in their quantitative requirements for these nutrients and in their ability to tolerate particular soil conditions. The work of Andrew and Norris (1961) illustrates this point well. They grew five tropical and four temperate pasture legumes in a soil of pH 5.5 and added lime at a wide range of rates. All other nutrients were adequately supplied. Most of the tropical species were well nodulated in the absence of lime and had dry matter yields in excess of 40 per cent of their yield with optimum lime additions. On the other hand, the temperate species were either not nodulated or were poorly nodulated at zero lime and had dry matter yields less than 6 per cent of the maximum. The authors attribute the differences to a differential ability in extracting calcium from the soil. Having evolved in the wet tropics on soils of low base status, they consider that the tropical species selected for the experiment were better adapted to the low calcium supply than the temperate species selected. However, the differences are not solely tropical versus temperate species effects since they found that silver-leaf desmodium *(D. uncinatum)* and white clover *(Trifolium repens)* were somewhat intermediate in their response. Moreover, in recent unpublished work, Jones and Andrew have found large differences in tolerance of a wide range of calcium x pH treatments within the tropical genus *Stylosanthes*.

Differences between species in their tolerance to other nutrients of soil factors have also been found with respect to low copper (Andrew and Thorne, 1962), low and high phosphorus (Jones, unpublished), high manganese (Andrew and Hegarty, 1969), and high aluminum (Andrew et al., 1973)

Apart from nitrogen, the nutrient requirements of tropical grasses have received less attention than those of the legumes. However, Smith (unpublished) has done some interesting work recently on cation interactions in a range of tropical grasses. He found that Green Panic (*Panicum maximum* var. Trichoglume), Rhodes grass (*Chloris gayana*) and Pangola grass (*Digitaria decumbens)* were able to accumulate sodium when potassium was in short supply and sodium was available. Thus, sodium tended to substitute for potassium when it was deficient. This characteristic was not present in the other six grasses studied.

Clearly there is a great deal more to be learned about the nutrient requirements of tropical pasture species. I think it is also clear, however, that an understanding of these requirements can greatly assist in the selection of species to plant in a given situation and in minimizing expenditure on fertilizers for the establishment and maintenance of pastures. As pasture workers in the tropics are still actively engaged in collecting pasture plants from tropical Africa and South America, it may well be fruitful for them to pay more attention than in the past to collecting from specific soil situations

## WAYS OF OVERCOMING NUTRITIONAL PROBLEMS

Once it has been established that a nutrient is required for the growth of a particular group of pasture species on a soil, then it is a relatively simple matter to fertilize with the cheapest available form of that nutrient. Phosphorus is very deficient in many tropical soils and the choice of fertilizers is usually between a single and a more concentrated form of superphosphate. In using concentrated superphosphate, however, the possibility of sulfur deficiency must always be kept in mind (Jones et al., 1974).

During the last five years, a rather unusual phosphatic fertilizer has been developed to the pilot stage in Australia by R. J. Swaby (personal communication). It is known as Biosuper and consists of an intimate mix of finely divided elemental sulfur (one part) and rock phosphate (five parts). During granulation, a small amount of water containing the bacteria *Thiobacillus thio-oxidans* is sprayed on the mix. The fertilizer can be stored dry for up to six months, but when it is applied to the soil and becomes moist, the **Thiobacillus** slowly oxidizes the sulfur to sulfuric acid, which acts on the rock phosphate, thus releasing soluble phosphates.

The results to date indicate that Biosuper is comparable to superphosphate as a source of P in tropical areas with annual rainfalls in excess of about 1,000 milimeters. It is, of course, a better source of sulfur than superphosphate. Biosuper may well be the cheapest phosphatic fertilizer available to countries with their own rock phosphate supplies and limited manufacturing facilities.

Lime or dolomite may be required on some tropical soils to modify the calcium and/or magnesium status, the pH or exchangeable aluminum levels of the soil. The appropriate rates of application, however, should be determined in the field with the pasture species to be used since, as mentioned previously, many of the tropical species are quite tolerant of low calcium/high aluminum situations. If trace elements are required, they are normally mixed with the superphosphate. Care must be taken to ensure that the mixing is thorough to avoid problems of uneven distribution. This is particularly important when molybdenum compounds are added because of the very small quantities involved.

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# MANAGEMENT AND UTILIZATION OF NATIVE TROPICAL PASTURES IN AMERICA

*Osvaldo Paladines*

## CHARACTERISTICS OF THE NATIVE TROPICAL PASTURES

It is necessary to define what is understood by a native tropical pasture and to establish certain limits to it in order to circumscribe its area and to determine, in one way or another, its characteristic conditions. Native tropical pastures are also known as tropical savannas; Blydenstein (1967) feels that the expression of savanna already implies the concept of being tropical.

Savanna, then, can be defined as a large area of short native Gramineae which also contains limited and variable quantities of bushes and short-growing trees. A more dynamic definition of savanna must include the presence of grasses and their degree of suitability for livestock production above all.

In Latin America, tropical savannas are found in Bolivia, Brazil, Colombia, Guyana and Venezuela. In the subtropics we find native pastures in Paraguay.

In accordance with the previously established definition, all tropical savannas are characterized by large land extensions dominated by native grass species and reduced amounts of trees. Trees, when present in the open savanna, are small and have twisted stems (Rizzini, 1964; Ramia, 1967). There is no uniform type of savanna for all countries, not even within one country. Nevertheless, American tropical savannas have two characteristcs in common: (1) low soil fertility and (2) a marked seasonal dry period in spite of the rather high total yearly rainfall.

It should be pointed out that in determining these two characteristics in common, the savanna was considered from the point of view of its value for animal production rather than for its ecological characteristics.

A fairly good quantity of work has been published in relation to tropical savannas of America. Mention should be made of the work published by Blydenstein (1967) about Colombia; Ramia (1967), Bonazzi (1962), Comerma and Luque (1971), Blydenstein (1971), and Fontana (1961) in regard to Venezuela; Rizzini (1964) about the Brazilian Campos Cerrados of Minas Gerais; and Stevenson and Goodland (1966) about Guyana. All of them, however, are either of a purely ecological or descriptive nature.

The lack of information and research on the productivity of tropical savannas of America makes it necessary to use information available from Africa and Australia although at times their savannas fall more within the subtropics rather than the tropics.

Of particular interest is the research conducted in South Africa and Rhodesia for more than 70 years. Information is also available from Zambia, Uganda, Tanzania and Nigeria.

However, before analyzing this information and trying to determine to what extent it applies to the savannas of tropical America, it is essential to determine their differences, which in turn establishes the transference limitations between the two types of conditions.

In our opinion, there are three main differences between the tropical savannas of America and Africa:

1. The vegetation of African savannas is regarded as subclimax, created by low rainfall and fire from a climax vegetation represented by bush and small trees. In other words, if the savanna were left undisturbed and by some means fire were kept out, vegetation would eventually revert to its original bushy nature. In America there are large areas of tropical savanna in which short grasses appear to be the climax vegetation. This vegetation was apparently caused by low soil fertility, which has also been maintained with the aid of fire. However, there are areas of the Llanos of Venezuela (Ramia, 1967; Comerma y Luque, 1971) and Cerrados of Brazil (Rizzini, 1964), where the bushy, xerophyte-type savanna is found extensively. The same reverting tendency towards bush and trees is found in these savannas.

2. The great majority of grasses of the African savannas are well accepted by cattle during their period of active growth, while in the American tropical savanna much of the species are not consumed by cattle at any time. This creates a great difference in the levels of pasture utilization from one case to another.

3. African savannas are highly influenced by low rainfall. Rains fall during four to six months of the year only, with a total of around 750 milimeters; whereas in America the rainfall in the savanna is over 1,000 milimeters and falls during seven to ten months of the year.

# MANAGEMENT OF THE TROPICAL SAVANNAS

Large amounts of literature are found in relation to the subtropical savannas of South Africa and Rhodesia, which bear some degree of similarity to the tropical savannas of the rest of Africa, in that some of the most common grass species, such as *Heteropogon contortus* and **Hyparrhenia** sp., are common to both. Other factors in common are the low rainfall with long dry seasons and soil fertility, which if not considered the best for crops, can maintain a useful grass cover for animal feeding, provided moisture is available. In contrast, the amount of research work done on tropical African savannas is considerably lower. The summaries presented by de Leeuw (1971) on northern Nigeria and Crowder and Cheeda (1973) on West Africa are important contributions to the understanding of the problems of that region.

Research information on the management and utilization of tropical savannas of America is practically nonexistent.

Three concepts are considered to be the bases for good management of tropical savannas in Africa (Kennan et al., 1955; Plowes, 1955; West, 1958; Edwards, 1942; Naveh, 1966; and Kennan, 1969):

1. Adequate stocking rate in relation to the production capacity of the savanna, taking into account seasonal variations

2. Resting of the savanna pastures after heavy grazing to allow useful species to recover

3. Weed control of bushy species and tree saplings

A short discussion of each of these factors, with inferences concerning the application of each to American conditions, is worthwhile.

## Stocking rate

Table 1 presents all information available to the author in relation to the animal productivity of savannas in America, Africa and Australia. Stocking rate has been included when available. Invariably, an increase in stocking rate produces a decrease in the gain per animal while per hectare gain increases. When very high stocking rates are reached, useful species tend to disappear and are replaced by others of less acceptability to cattle (Kennan, 1962); where bush and trees are predominant, their propagation is stimulated (Kennan, 1969; West, 1958). This same tendency may possibly be found in areas of the Cerrado and Cerradao of Brazil (Rizzini, 1964), in the **Trachypogon** savannas of Venezuela (Ramia, 1967), and in some of the Rupununi savannas of Guyana (Goodland, 1966). On the other hand, there are areas of savanna in America, where the abuse of pastures due to overgrazing stimulates the introduction of very short growing species such as *Paspalum conjugatum* and *Axonopus compresus* (personal observations in Carimagua, Colombia) and of *Paspalum notatum* (Grossman et al., 1966).

Kennan (1969) points out that short-term weight gains should not be accepted as indicative of the productivity of the savanna, particularly in relation to stocking rate, because it is not until the savanna is near the point of being overgrazed that the situation is reflected in animal gains. A proportionally similar effect is found in understocked areas of savannas with grasses well eaten by cattle, in which limited areas of overgrazing are formed. In these cases, overgrazing symptoms and invasion of the savanna by undesirable species are found (Tainton, 1972).

**After-grazing rest**

The South African grassland management philosophy of rapid grazing, rest and periodic burning of the savanna (Joubert, 1971, 1972; and Booysen, 1972) implies that all species present in the savanna are well accepted by cattle and that consumption is fairly uniform. When reference is made to African savannas of **Heteropogon**, **Hyparrhenia**, **Cynodon**, **Digitaria**, and other palatable species or even to American savannas of *Paspalum plicatulum*—such as those reported by Corrales and Gonzalez (1973) in Barinas or by Chicco et al., (1972) in Calabozo, Venezuela—this principle may apply, but it is hard to visualize in savannas of **Trachypogon** of such low consumption by cattle that large differences in stocking rate are not reflected equally by differences in forage availability (CIAT, 1972).

It is difficult to obtain really convincing evidence in favor of rotational grazing of the tropical or subtropical savannas (which implies a periodical rest), including South African savannas. As an example, Joubert (1971) found that a simple four-camp system gave better results than a more sophisticated 27-camp rotational grazing system. In a 12-year trial in southern Rhodesia (Kennan, 1969), continuous grazing produced more animal weight gain per hectare every year of the trial. West (1952) had found something similar in another type of savanna in Rhodesia.

With moderate stocking rates, continuous grazing produced more animal weight gain per hectare in northern Nigeria (de Leeuw, 1971). In one year of observations at Carimagua, Colombia, a four-paddock rotational grazing system produced slightly less gain than continuous grazing. The advantages of resting the savanna, then, must be looked upon in terms of other secondary effects.

Periodic rest is apparently more related to the possibility of accumulating sufficient grassy fuel for a good burn of the savanna for periodically destroying the bushy and weedy vegetation, which tend to return (Roberts, 1969; Kennan, 1969; West, 1969; Tainton, 1971). De Leeuw (1971) considers that at least 1,000 kilograms of grass dry matter is needed for a fire to be good enough to kill bush and tree saplings.

Roberts (1969) discusses at length the advantages and disadvantages of multicamp systems for Rhodesia; and even though he concludes that for their local conditons rotational grazing is beneficial, he explains it in terms of the need for weed control through fire.

**Burning of the savanna**

The terms burning and savanna seem to be almost synonymous. Many authors have speculated about the role which fire has taken in the formation of the savannas, and West (1969) refers to evidence of fire being used in Africa during the Stone Age 53,000 years ago. At that time, men apparently used fire, not for agricultural but for hunting purposes; but in doing so, they aided in the formation of the savannas. Blydenstein (1967) makes reference to the observations of the first Jesuit missionaries in the Colombian Llanos, which indicate that the present large savannas were already formed at that time. Indigenous people apparently burned the savannas every year to facilitate hunting and to make walking through the grassy vegetation easier.

One can argue extensively about beneficial and detrimental effects of fire on soil and vegetation, but the real fact is that under present extensive, totally extractive systems of production in tropical savannas, fire is the only management tool available. Its use obviously should and does change in accordance with the ecological conditions of the area.

Fire can fulfill two functions in the savanna: (1) It can control bushy and tall weeds, and (2) it can destroy old and unpalatable grass tussocks which are remnants from grazing, allowing young, more nutritious growth to come up. In Carimagua, Colombia, for instance, the **Trachypogon** savanna decreases in crude protein content from approximately 10 per cent at 10 centimeters height to 2 to 3 per cent at 50 centimeters or more (Table 5); and Cunha et al. (1971) found that **Trachypogon** savannas of Venezuela dropped in crude protein content from 8.11 per cent at 15 days of growth (less than 10 centimeters high), to 5.66 per cent at 50 days, and to 4.66 per cent at 105 days of growth. Cellulose digestibility of the same grasses dropped from 51.51 per cent, to 30.37 per cent, to 25.30 per cent at 15, 60 and 105 days of growth.

The figures cited indicate immediately that the **Trachypogon** savannas are of extremely poor nutritive value at any stage of growth above 15 days or 10 centimeters, which explains the very frequent use of fire by the local farmers.

Table 2 presents partial results of a trial in Carimagua, Colombia designed to measure the productivity of the **Trachypogon** savanna (CIAT, 1972, 1973; ICA 1972, 1973), which would serve to illustrate the effect of fire for removing the uneaten grasses. Results refer to two consecutive years of grazing. The entire area was burned in July, 1971, four months prior to receiving the animals. Grazing started in November, 1971 when grass was 35 centimeters high. The same area was burned the following year; this time the animals remained in their paddocks; and for this reason, half the area was burned 15 days after the other half. When this burning took place, the savanna was approximately 60 to 80 centimeters high, protein content had decreased to 2 to 3 per cent and phosphorus was 0.04 per cent.

The large differences found are not associated with rainfall, which was higher in 1971-1972. They can be explained on the basis that **Trachypogon** at 35 centimeters is already so low in nutritive value that animals have a difficult time selecting a diet sufficient for good growth. In 1972, on the other hand, animals had access to very young regrowth, which was eaten as soon as it could be reached. In this case, higher gains in the lower stocking rates are associated with more area of young growth available for consumption.

An additional treatment in the same trial seems to indicate that a sequential burning system throughout the year may be more advantageous than burning the whole area at one time (Table 3). If burning is that important in this area, as preliminary results seem to indicate, then stocking rate will also become very important since there must be a point in animal density where the savanna cannot be burned every year because of a lack of fuel material.

In the case of fire being used to control taller weed species that decrease the available space for grass growth (West, 1969), the most important point to take into account will be the amount of uneaten residual grass left on the savanna and the size and density of the bushes to be destroyed. Accumulation of grassy material will depend on stocking rate and the length of rest given the savanna before the burn. Rizzini (1964) points out the existence of bush and tree species in the Llanos of Venezuela with vegetative reproduction organs that grow underground, thus assuring their survival after a fire. The mechanism which has maintained the ecological balance between this species and grass species in the savannas is not known.

Experiments in which the savanna has been protected from the action of fire for several years indicate that many of the present grass species of the savanna are remnants of an original herbaceous cover of these areas, which has been maintained through the action of fire. A series of experiments conducted at the Biological Station on a **Trachypogon** savanna of the Venezuela Llanos (Blydenstein 1962, 1963; and Eden, 1967) indicates that the prevalence of this genera is directly associated with recurrent fires. In those areas that were burned every year, **Trachypogon** predominated, while **Axonopus** species increased after four years of protection from fire.

An interesting occurrence which appears to repeat itself under varied savanna conditions is the complete destruction of many of the grass species as a result of fire following several years of protection from it. It would appear that as a result of accumulation of grass material at ground level (mostly dead leaves and stems), the reproductive organs of the plants —sexual and asexual— come up above ground level and are destroyed by fire (Eden, 1967; Aristeguieta and Medina, 1965; Van Rensburg, 1952). Kennan (1969) points out the destruction of **Heteropogon** and **Themeda** savannas in Africa as a result of animals pulling the plants completely out when grazing. This occurs after some years of protection from fire.

When fuel material is sufficient, it is possible to burn tropical savannas at any time of the year. Obviously, the burning operation is easier and more effective from the standpoint of destruction, when carried out during the dry months. All research done in Africa appears to indicate that burning should be done at the end of the dry season, just before the first effective rains. At this time, grasses are still dormant, but bushes and tree saplings are in active vegetative stage, so that fire removes the dry and useless grass material, but roots are saved and have enough reserves for active growth when rain comes (West, 1958; Plowes, 1955; Edwards, 1942; de Leeuw, 1971; Tainton, 1971; Naveh, 1966).

The standard recommendation in Africa is to burn every four years, allowing for a rest of several months before the burn in order to accumulate fuel material to get a "fierce" (Edwards, 1942), rapid and complete fire, capable of destroying bushes and small trees up to 2 or 3 meters high. It should be pointed out that this practice implies a high normal intake of savanna pastures and a relatively low selectivity of this vegetation by grazing animals.

Blydenstein (1963) measured the growth of a **Trachypogon** savanna in Venezuela after burning at different times of the year. Differences were not too great, but he concluded that best growth is obtained when burning takes place at the end of the rainy season in December. In practical terms of grazing management, burning at this time of the year allows for the use of the limited regrowth of the grasses during the dry season. (Blydenstein, 1963, measured growth of 560 kg/ha from November to February.) In Carimagua, Colombia, burning at the beginning of the dry season changed weight losses occurring from November to January to weight gains, but losses for the rest of the dry season (January to March) could not be prevented (Paladines et al., 1973). These results are for only two years and do not give any indication of the effect of burning at this time of the year for consecutive years, since changes in morphology and physiology of the savannas are not evident in the short term (Norman, 1963).

## MANAGEMENT OF THE TROPICAL SAVANNA DURING THE CRITICAL MONTHS

By definition, tropical savannas should be described as native pastures, strongly seasonal in nature. Based on the severe dry period common to all savannas of tropical America, Blydenstein (1972) characterized them as semiarid and assigned most of their morphological and floristic characteristics to the severe moisture stress of the dry period.

The effects of the dry period during the year on animal performance are of such importance that there are tropical savannas where, in normal years, animals would not survive without some sort of supplementation during this period (Zemmelink, personal communication). To illustrate this point, Table 4 was assembled with a sample of tropical savannas from various parts of the world. There are cases included in Table 4 where animals lost all the weight gained during the wet season. In general terms, losses appear to be from 30 to 60 per cent.

Looking at this table, there would seem to be a negative relationship between losses during the dry period and gains during the wet period; and as expected, losses should be higher as stocking rate increases. Because of variations in stocking rate, it is difficult to compare results from different places. Furthermore, Smith (1966) found that the greater the weights of the animals at the beginning of the wet season, the greater the losses during the dry period.

Three factors should be studied with relation to the dry period in order to make some generalizations about its effects on animal productivity and to advance possible solutions: (1) severity of losses and subsequent compensatory growth, (2) supplementation during the dry period, and (3) management of the savanna to minimize losses. There is not a great deal known about these factors in relation to tropical savannas.

Compensatory gains have been carefully determined under many different feeding and grazing conditions so that there can be no doubt as to the results obtained. In terms of the productivity of the savanna, it is important to determine to what extent an animal can lose weight without impairing its capacity to grow and reproduce. In northern Rhodesia, Smith and Hodnett (1962) measured the compensatory growth of animals grazing the **Hyparrhenia** veld typical of this area. They were able to observe possible effects of animal age and level of restriction during the dry period in relation to gain during the wet season on the same savanna. Their conclusion was that animals can recover from 57 to 68 per cent of the dry period loss; that is, rainy season gains were superior by 570 to 680 grams per kilogram of weight lost during the dry period. Compensation took place during the wet season. In a more productive type of savanna in Venezuela, Chicco et al. (1972) found that unsupplemented animals during the dry period recovered all of the weight difference as compared with animals supplemented with 0.5 kg/day of a mixture containing 42.5 per cent crude protein.

Forage during the dry period can be deficient in quantity, quality or both. Experience obtained in Africa appears to indicate that dry season shortage is mainly a protein deficiency and that unless this deficiency is corrected, little can be expected from energy supplementation (Smith, 1961, 1962; Zemmelink, 1973).

In some interesting trials run in northern Rhodesia and Nigeria, the possibility of conserving savanna grass either as hay or as standing hay (deferred grazing) was investigated. The results were discouraging in all cases because hay in either form was unable to prevent weight losses during the dry period (Smith, 1961; de Leeuw, 1971). Only when urea was added to the savanna hay did losses decrease. Even more interesting was another trial in Rhodesia (Smith, 1961), in which continuous grazing of the savanna was compared to grazing in which different parts of the same area were cut for hay and fed during the dry season. Half the animals received two pounds of groundnut cake per head/day. Figure 1 was taken from Smith (1961), as it clearly shows the effects of protein supplementation and the ineffectiveness of conservation under savanna conditions.

It would be incorrect to assume that a similar situation will be found in the savannas of tropical America, but the protein content of the grasses is low at all times and well below the requirements of the animals during the dry period (Cunha et al., 1971; French and Chaparro, 1960).

Table 5 was prepared based on information collected at Carimagua, particularly from a small cutting trial in which the effects were studied of burning and hand cutting on yield and chemical composition of the savanna. The last line contains an average figure of many analyses of the savanna during the dry period.

Looking at the problem of weight losses during the dry period from a purely biological standpoint, there seems to be a need of supplementing the diet with a nitrogenous element during this period if the purpose is to reduce or eliminate weight losses. By doing so, the animals will not need to recover as much weight during the rainy season. Unfortunately, there is no generalization known for these relationships, and they must therefore be tested under all different ecological conditions.

For most of the tropical savannas of the world, the use of urea represents one of the few economical and easy means of providing for protein shortage during the dry season of the year (Pieterse, 1969).

A great deal of literature is available on the use of urea as a feed for ruminants, as well as its practical application for grazing animals. South African research has clarified the way in which it can be used and has pointed out some of its practical limitations. In this context, a long argument has been going on concerning the usefulness of adding a carbohydrate source to aid the beneficial effects of urea (Hart et al., 1939; Bell et al., 1953; Belasco, 1954). This question has not been totally answered since the action of carbohydrates does not seem to be associated with urea only but also with the type of pasture used. In any case, it would appear that in some areas of savanna, a carbohydrate source is not needed for urea to work (Pieterse and Lesch, 1963). In other areas the use of carbohydrates has been reduced to very small quantities (Beams, 1960; Winks).

The interest in trying to reduce to a minimum the amount of carbohydrate to be

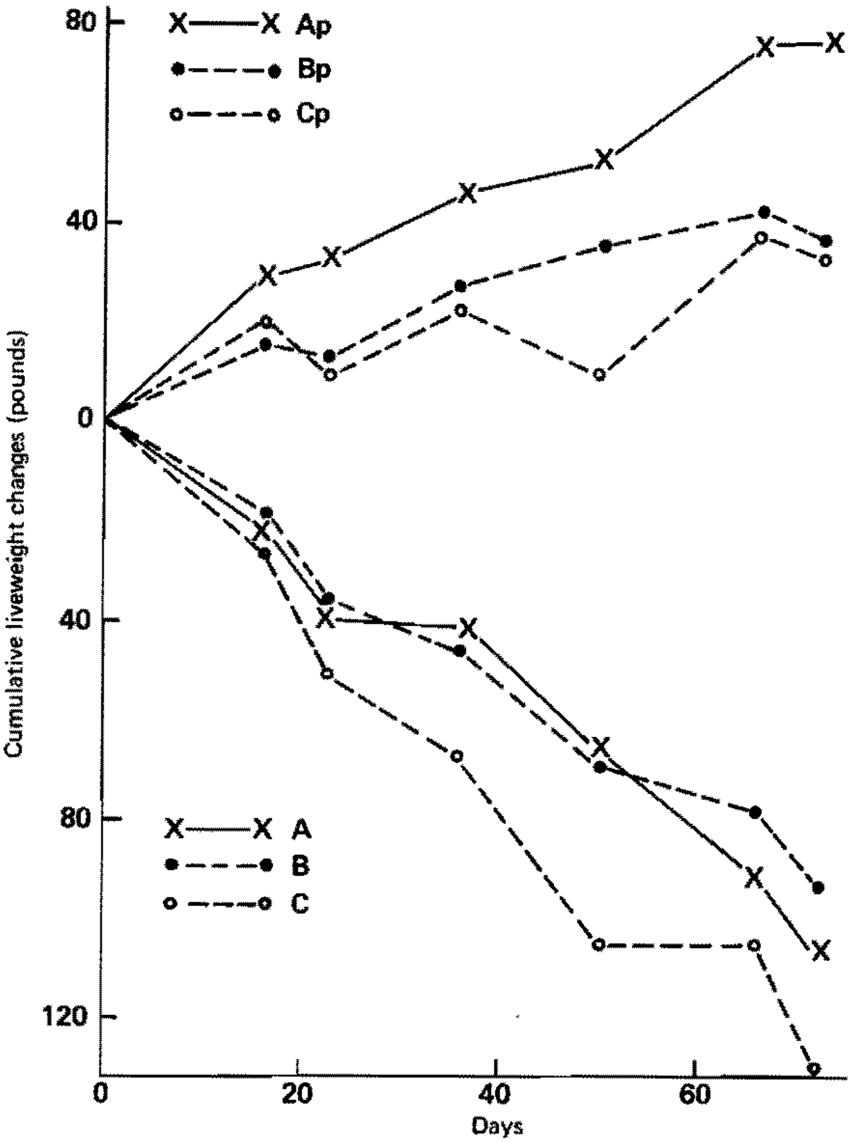


**Figure 1.** Liveweight changes of unsupplemented and protein-supplemented animals (taken from Smith, 1961).

A = total area cut for hay; hay provided during dry season while grazing their assigned plots
B = 50% of the area cut for hay
C = area used for deferred grazing
p = animals received two pounds of groundnut cake per day

mixed with urea is not merely of an academic and biochemical nature, but also one of vital economic importance for its use as a dry period supplement since the carbohydrate is the most expensive portion of the mixture. At present Colombian prices for an animal's daily supplement containing 60 grams of urea would cost US$ 0.172, 0.092, 0.052, or 0.012 if it also contained 1.0, 0.5, 0.25, or 0 kilograms of corn. Because of the high price of grains on the world market, tropical countries are trying to use molasses as a carbohydrate supplement. The use of molasses in savanna areas is often limited because of the high cost of transportation from distant producing areas, plus the fact that the price of molasses is also rising rapidly. Molasses is also preferred because techniques have been developed for its use under field conditions in drum-lickers of simple construction (Moore, 1968). One possible solution could be to look for substitutes which can be grown locally. Cassava may have a place in this context.

There is no clear indication of the minimum amounts of urea which should be fed. In a savanna of **Heteropogon**, Winks found a positive response to 56 grams of urea and 250 grams of molasses supplement per day. A higher level of urea (84 grams) had no added effect although some of the information obtained suggested that Shorthorn animals, adapted to better nutritional levels, also responded to higher levels of urea supplementation than Brahmans. Also, Brahman x Sahiwal crosses needed only 28 grams of urea per day. Although nonsupplemented animals made compensatory gains during the following rainy season, compensation was not complete.

Supplementation of the beef herd during the dry season is a complex and many-sided problem. In the case of steers, the simplest of all groups in the herd, the level of decision required may not be more than balancing compensatory gain against investment in supplement. But with the breeding herd, the problem is not so simple because the breeding season can be adjusted to the time of the year best for reproduction but still good for calf growth. One can accept a certain degree of weight loss of the cow as long as its future reproduction ability is not impaired. In this way the supplement given to the cow has to be balanced against the cow's own reproductive capacity (if supplementation prevents damaging losses), the growth of the lactating calf and the cow's capacity to rebreed.

## IMPORTANCE AND VALUE OF MANAGEMENT PRACTICES OF THE SAVANNA

In the preceding pages an attempt has been made to give a broad view of the production capacity of the savannas of tropical America. Because of lack of local information, data from Africa had to be used much of the time. At this point, it is necessary to indicate the form in which these management practices can influence the production of the tropical savannas. However, in doing so, two additional factors should be kept in mind: (1) The need to introduce "large" changes of great significance in production and (2) the need to do this with a minimum of capital investment.

If soil fertility rather than climate is the factor which determines the productivity of the tropical savannas of America, it would seem clear that with high enough levels of fertilizer application, production could be as high as in areas with better soil. This possibility was explored by the IRI Research Institute in Cerradao soils of Brazil (Quinn et al., 1970; Mott et al., 1967; Bisschoff et al., 1967) and is presently being explored by an extensive series of trials in the Cerradao of Minas Gerais (PIPAEMG, 1973) and other areas of Brazil.

Although there have been large increases in the world price of beef, prices of fertilizers have increased markedly also (Montes y Valdés, 1974). Taking this situation into account, we feel that in order to put the needed changes into effect, other methods have to be found.

The first question to be asked is, "What can be achieved by the application of classical methods of management?"

To answer this question, reference can be made to Table 1, which shows present levels of production and possible improvements through increasing stocking rate (where possible). Productivity of tropical savannas seems to run between 10 to 30 kg of weight gain/ha/year. In places of low stocking density, a well-planned increase in stocking rate may bring an improvement of 20 to 30 per cent.

Other management alternatives —such as rotational grazing, conservation as hay or deferred grazing— have been unable to produce any increase in production. Even urea supplementation does not produce global increases over 10 per cent, although much more information is needed for real quantification. Even if overall increments of 50 per cent in production per hectare are achieved, production would have increased only by 10 to 15 kg/ha.

**Which, then, are the alternatives?**

The basic alternative was recognized in Australia some years ago (Norman, 1966) and is beginning to be recognized in Africa (de Leeuw, 1971) and even in those countries where research in systems of management of the savanna has been a tradition of many decades (Birch, 1972).

The general conclusion can be expessed in the following terms: In order to obtain significant progress, it will be necessary to change the vegetation of the savanna from its native grass species to others of higher productivity and feeding value, which should also be capable of persisting under prevalent ecological conditions. For the latosol savannas of tropical America, it means using species capable of withstanding low soil pH and low phosphorus levels which would also maintain sufficient growth during the dry season.

Fortunately, tropical savannas of America are rich in forage legumes adapted to these conditions. Among these plants, the genera **Stylosanthes** offers great promise. **Stylosanthes** are found native from Mexico to Argentina. It would be highly advisable to take full advantage of these forage legumes. (CIAT, 1971, 1972, 1973).

Possible levels of production which can be reached with legumes are known for some environments. The experiment of Norman and Stewart (1964) demonstrates the great advances which can be obtained by the use of a tropical legume. Table 6 was adapted from the paper by Norman (1966) to illustrate this point. Another example is contained in the experiment of Shaw and Mannetje (1970), where they obtained an increase in liveweight gain from 25 kg/ha in the native pasture to 94 kg/ha when *Stylosanthes humilis* was introduced. This rose to 150 when the pastures including *S. humilis* received the following quantities of fertilizer over a seven-year period: 1,200 kg of superphosphate, 170 kg of potash, and one application of 0.375 kg of sodium molybdate.

Increases in production are around 400 to 600 per cent. Comparing these changes with the maximum 50 per cent improvement which can possibly be expected in traditional management systems, it is easy to see where the major changes will come from.

There should be no need for more proof to concentrate research and development efforts in the introduction of more productive species, especially legumes, in the tropical savannas of America.

The rate of progress to be achieved will be directly related to the identification and testing of these species and, of course, to provision at local and national levels of the structure which will permit the new technology to be used with economical success.

Table 1. **Productivity of a sample of savannas from America, Africa and Australia.**

| Location | Stocking rate animals/ha | Weight gain, kg animal/year | | Weight gain, kg ha/year | | Reference |
|---|---|---|---|---|---|---|
| Southern Rhodesia | | | | | | |
| *Heteropogon contortus, Bothriochloa* | .13 | 77 | | 11 | | Kennan, 1969 |
| *insculpta* | .20 | 66 | | 13 | | |
| | .24 | 64 | | 15 | | |
| | .31 | 62 | | 19 | | |
| Zambia, dry savanna | .12 | 74.0 | | 8.9 | | Smith, 1966 |
| | .20 | 64.7 | | 12.9 | | |
| | .32 | 50.0 | | 16.0 | | |
| | .74 | 33.6 | | 24.9 | | |
| Zambia, drainage savanna | | | | | | |
| *Hyparrhenia filipendula, Heteropogon* | .31 | 95.0 | | 29.7 | | Smith, 1966 |
| *contortus, Setaria sphacelata, Cynodon* | .63 | 89.6 | | 56.0 | | |
| *dactylon, Eragrostis* spp. | 1.25 | 78.4 | | 98.0 | | |
| Nigeria and Northern Guinea, savanna | | | | | | |
| *Loudetia simplex, Trachypogon spicatus,* | .42 | 21 | (203 days) | 9 | (203 days) | de Leeuw, 1971 |
| *Andropogon ascinodis, Monocymbium* | .50 | 26 | " | 12 | " | |
| *ceresiiforme* | .62 | 24 | " | 16 | " | |
| | .83 | 19 | " | 15 | " | |
| | 1.25 | 1 | " | 3 | " | |
| Queensland, Australia | | | | | | |
| *Heteropogon triticeus, H. contortus,* | .25 | 37 | | 9 | | Alexander, 1968 |
| *Bothriochloa intermedia, Themeda australis* | .41 | 25 | | 11 | | |

Table 1. **(continued)**

| Location | Stocking rate animals/ha | Weight gain, kg animal/year | Weight gain, kg ha/year | Reference |
|---|---|---|---|---|
| Rodd's Bay, Central Coastal Queensland | | | | |
| *Heteropogon contortus, Crysopogon* | .05 | 83 | 25 | Shaw y Mannejte, 1970 |
| *fallax, Eragrostis* sp. | .21 | 47 | 30 | |
| Calabozo, Venezuela | | | | |
| 50% *Paspalum plicatulum,* 30% *Leersia hexandra,* 20% *Sporobolus indicus and Panicum laxum* | ? | 118 (8 months) | ? | Chicco et al., 1972 |
| Barinas, Venezuela | | | | |
| 90% Native pasture | .21 | 225* | 47 | Corrales y González, 1973, b. |
| 83% " " | .23 | 230* | 52 | |
| 62% " " | .46 | 264* | 120 | |
| *Paspalum plicatulum, Leersia hexandra, Andropogon bicurnis, Trachypogon* sp. *Axonopus purpussi* | | | | |
| Carimagua, Meta, Colombia | | | | |
| *Trachypogon vestitus, Leptocoryphium* | .20 | 28 | 5 | CIAT, 1972 |
| *lanatum, Paspalum pectinatum, Axono-* | .35 | 38 | 12 | ICA, 1972 |
| *pus pulcher, Andropogon* sp. | .50 | 2 | 1 | |

* Calculated from the data given by the author

Table 2. **Weight gain of steers on the *Trachypogon* savanna of Carimagua, Colombia.**

| | Stocking rate, steers/ha | | |
|---|---|---|---|
| | 0.20 | 0.35 | 0.50 |
| | kg/animal/year | | |
| 1971-1972 (no burning) | 28.3 | 38.2 | 1.5 |
| 1972-1973 (with burning) | 92.0 | 94.0 | 74.0 |

Adapted from CIAT,1972, 1973; ICA, 1972, 1973

Table 3. **Productivity of the native savanna at Carimagua with two systems of burning.***

| Stocking rate animal/ha | Average yearly weight gain per animal, kg | | Advantage of sequential burning | |
|---|---|---|---|---|
| | One burning** | Sequential burning*** | kg/animal | % |
| 0.20 | 92 | 119 | 27 | 29 |
| 0.35 | 94 | 110 | 16 | 17 |
| 0.50 | 74 | 78 | 4 | 5 |

* Table taken from CIAT, 1973; ICA, 1973

** All the area was burned in November, 1972.

*** The area was divided by fireguards into eight plots of disked land and one plot burned at eight different times throughout the year, beginning November, 1972 and ending September, 1973.

Table 4. **Effect of the dry season on the body weight of animals on tropical savannas.**

| Location | Stocking rate animals/ha | Dry months of the year | Weight loss during dry season as percentage of yearly gain | Weight loss kg/animal | Reference |
|---|---|---|---|---|---|
| Southern Rhodesia | | | | | |
| *Heteropogon contortus, Both-* | .19 | 7 | 45 | 71 | Kennan, 1969 |
| *riochloa insculpta* | .31 | | 45 | 72 | |
| | .47 | | 54 | 81 | |
| Zambia, Dry savanna | .12 | 7 | 22 | 21 | Smith, 1966 |
| | .20 | | 29 | 26 | |
| | .32 | | 45 | 41 | |
| | .74 | | 65 | 61 | |
| Zambia, drainage savanna | | | | | |
| *Hyparrhenia filipendula, Hete-* | .31 | 7 | — | + 2 | |
| *ropogon contortus, Setaria* | .63 | | 6 | 9 | |
| *spahacelata, Cynodon dactylon,* | 1.25 | | 12 | 18 | |
| *Eragrostis* spp. | | | | | |
| Nigeria, northern Guinea savannas* | | | | | |
| *Loudetia simplex, Trachypogon* | .31 | 4-5 | 39 | 25 | de Leeuw, 1971 |
| *spicatus, Andropogon ascinodis,* | .62 | | 39 | 22 | |
| *Monocymbium ceresiiforme* | ? | | 83 | 51 estimated | |
| Katherine, N. T., Australia | | | | | |
| *Themeda australis, Sorghum plu-* | .5-0.08 | 8 | 54 | 50 | Norman, 1966 |
| *mosum, Chrysopogon fallax and* | | | | | |
| *Sehima nervosum* | | | | | |

* Stocking rates of 0.62 and 0.31 received 58 kg of cottonseed/animal during the dry period. Figures of the third line were not given by de Leeuw, 1971 and are extrapolations.

Table 4. **(continued)**

| Location | Stocking rate animals/ha | Dry months of the year | Weight loss during dry season as percentage of yearly gain | Weight loss kg/animal | Reference |
|---|---|---|---|---|---|
| Queensland, Australia* | | | | | |
| *Heteropogon contortus, Heteropogon triticeus, Themeda australis, Bothriochloa intermedia* | .25<br>.41 | 8 | 53<br>68 | 32<br>53 | Alexander, 1968 |
| Carimagua, Meta, Colombia | | | | | |
| *Trachypogon vestitus, Leptocoryphium lanatum, Paspalum pectinatum, Axonopus pulcher, Andropogon* spp. | .20<br>.35<br>.50 | 4 | 40<br>37<br>89 | 21<br>25<br>33 | CIAT, 1972<br>ICA, 1972 |

* Animals were supplemented for 77 days.

Table 5. **Crude protein content of the savanna at Carimagua, Colombia.**

| Cutting height (cm) | Burned savanna (%) | Savanna cut by hand (%) | Days of growth |
|---|---|---|---|
| *Trachypogon vestitus* | | | |
| 10 | 10.5 | 10.3 | 28 |
| 20 | 8.0 | 7.5 | 49 |
| 35 | 6.4 | 5.8 | 79 |
| **Whole savanna** | | | |
| 10 | 10.0 | 10.3 | 28 |
| 20 | 7.5 | 7.0 | 49 |
| 35 | 5.8 | 5.7 | 79 |
| 50 — 80 | 2.7 | — | Dry period |

Table 6. **Animal growth during the dry period in native pastures with varying levels of grass and legumes.**

| Pasture composition | | | Protein content of pastures at beginning of grazing (%) | Weight gain per animal (kg) | Period of weight gain (weeks) |
|---|---|---|---|---|---|
| Perennial grass (%) | Annual grass (%) | *Stylosanthes humilis* (%) | | | |
| 51.1 | 25.7 | 22.8 | 4.69 | 9 | 8 |
| 9.9 | 45.4 | 44.7 | 7.00 | 45 | 20 |
| — | 37.4 | 62.6 | 8.38 | 89 | 22 |

Adapted from Norman, 1966

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# LEGUME–BASED IMPROVED TROPICAL PASTURES

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The legume is the backbone of the animal industry in the temperate parts of the world, where it produces the cheapest form of protein for animals and nitrogen for the growth of the associated grasses. Whether the grass is **Lolium** or one of the many others, **Trifolium** (clover) and **Medicago** (alfalfa) are always present. Tropical pastures are also deficient in protein. In 1953, Whyte et al. expressed pessimism on the prospects of animal production from legume-based pastures in the tropics.

At about the same time, the late Dr. J. Griffith Davies, with characteristic British tenacity, was organizing the now well-known CSIRO Division of Tropical Pastures (now Agronomy) in Australia. Barely 20 years later, Dr. Davies' successor, Dr. Hutton (1970), was able to state that "reliable tropical legumes and grasses are available as well as knowledge of their fertilization, management and productivity." Another co-worker, Dr. Jones (1972), has written that "tropical legumes hold a primary place in the development of pastures in the tropics."

## IDENTIFICATION OF THE CLIMATIC TYPES IN THE TROPICS

The geographic boundaries of the tropics are well known. Within these, climatic and soil conditions vary. There are also some areas beyond these latitudinal limits where for some part of the year, temperature (summer months of the subtropics) and rainfall are capable of supporting growth of tropical plant species. Thus, the following climatic types of tropics may be identified:

1. **Wet tropics** have uniform high temperatures and rainfall with forest vegetation in general. Soils are leached and acidic, generally residual or alluvial; some are volcanic or littoral. The wet tropics are mainly unexploited except for some extraction of timber, cultivation of tree crops and grazing of cattle on ground vegetation under these crops. Proper management would increase crop yield and permit animal production (Santhirasegaram, 1965). This type of tropics covers approximately 10 per cent of the earth's land surface. Pasture growth is almost continuous, promoting continuous animal growth.

2. **Monsoonal tropics** have uniform high temperatures, but rainfall is restricted with one or two dry periods in the year. Regions with two dry periods (bimonsoonal) are almost similar to the wet tropics in effective growth of plant species, as the dry periods are not generally sufficient to cause severe shortage of animal feed. Such dry periods are of benefit to animals and facilitate seed harvesting of pasture species. In regions with one monsoon, the dry period may extend from nearly three months up to nine months. With an increase in the dry period, feed shortage becomes a limiting factor in animal growth. Soils become less leached as calcium content increases.

Much of the world's cattle population is found in the monsoonal tropics, and most of the area is cultivated for human food. Nearly all of the tropical grass species in use also come from this area. The vegetation changes from forest through savanna to grassland, depending on the length of the dry period. The monsoonal tropics cover nearly 15 per cent of the earth's land surface.

3. **Dry tropics** include tropical deserts and surrounding areas with a short rainy period, generally insufficient to support animal growth on pastures, even for a short period of the year.

4. **Seasonal tropics** are usually referred to as subtropics. They have high temperature and rainfall for varying periods (both decrease with an increase in latitude and altitude) during the summer months. Soils are weakly acidic to alkaline with high calcium content. Vegetation is open woodlands to grasslands. Cropping is widespread with considerable utilization of natural and sown pastures. Seasonal tropics occupy nearly 5 per cent of the world's land surface.

The wet, monsoonal and seasonal tropics which cover nearly a third of the world's land surface possess distinct potential for increased cattle production. The soils vary from alkaline littoral with high calcium to acidic continental with high aluminum in the cation complex. Most tropical soils are deficient in nitrogen and phosphorus, and many are deficient in sulfur. Deficiencies of other major and minor nutrients are to be expected in many types. There is a relationship between degree of nutrient deficiencies and amount of rainfall (past and/or present) and/or content of sand fraction in the soil, mainly because of increased leaching.

# PASTURE LEGUMES

A great deal is generally known about grasses and their use in pastures, whereas the use of legumes is rather new; and except for one or two instances (e.g. *Macroptilium atropurpureum* and *Glycine wightii*), selection and/or breeding is unknown. However, the natural forms of many legumes are making valuable contributions to animal production under many circumstances. Some of the important members include:

1. **Centrosema** spp. are native to South America and adapted to the wet tropics. They are perennials, capable of tolerating acidity and aluminum content. *C. pubescens* is widely used in the old world as a cover crop under plantations. Its critical P and K contents are 0.16 and 0.80 per cent in dry matter, respectively. The symbiotic **Rhizobium** requirement is specific. Seed innoculation is unsatisfactory because of the presence of toxic substances in the seed coat. It is usually scrambling or twining, but is capable of spreading on the soil surface with rooting at nodes. Flowering and seeding are spread across a period of time and pod shattering is a disadvantage. Good seed yields under hand harvesting in monsoonal areas have been obtained. Considerable genetic variation exists, and breeding and selection are possible.

2. **Desmodium** spp. are of American origin and range from short, prostrate types (*D. triflorum*) to tall, bushy types (*D. distortum*), and from perennials (*D. intortum*) to annuals. Thus, the genus is useful from the wet to monomonsoonal and seasonal tropics. *D. canum* is used in Hawaii in association with *Digitaria decumbens.* In Surinam, *D. ovalifolium* is used with *Brachiaria decumbens. D. intortum,* a perennial, is tolerant to acidity and aluminum and is capable of growing in altitudes up to 2,000 meters. Its critical P and K contents are 0.23 and 0.72 per cent, respectively. It requires **Desmodium-type Rhizobium** and is capable of scrambling or spreading with rooting at nodes.

Flowering is during a short period and seed harvesting with machinery is possible with no shattering. There is wide genetic variation, and some have high tannin content.

*D. uncinatum* is almost similar in character to *D. intortum* but is less hardy. Critical P and K contents are 0.24 and 0.60 per cent, respectively. It may require a lime application in extreme cases. **Rhizobium** is specific as in other members of the genus.

There are at least 20 species in the genus with potential use for pastures.

3. **Macroptilium** spp. are a genus of American origin, with annuals (*M. lathyroides*) and perennials *(M. atropurpureum).* The latter has been selected and bred in Australia (cv siratro) for the monsoonal and seasonal tropics. It is susceptible to fungus attack with severity increasing as wetness increases. Critical P and K contents are 0.24 and 0.75 per cent, respectively. The **Rhizobium** requirement is the cowpea type. It is capable of rooting

at nodes and scrambling. Flowering and pod shattering are factors to be improved by breeding and selection. This genus was formerly referred to as **Phaseolus.**

4. **Stylosanthes** spp. are another genus of American origin, with annuals *(S. humilis)* and perennials *(S. guyanensis)*. It is a rather erect-growing type, and the perennial develops a crown about 15 centimeters above soil surface under repeated grazing. This is an indication of lack of dormancy and also resistance to grazing. Tolerant to acidity and aluminum contents, it is definitely intolerant to alkaline soils. Low in P content, it is specific in **Rhizobium** requirement. It flowers during the dry season, and harvesting is possible with machines. Most cultivars shed the one-seeded pods on ripening. Large variation in genetics exists, with potential for selection and breeding. Many strains are susceptible to anthracnose. The annual, *S. humilis,* is widely used in the monsoonal tropics of Australia with good results. Critical P and K contents are 0.17 and 0.90 per cent, respectively, with the cowpea-type **Rhizobium.**

5. **Glycine** spp. are of African origin. *G. wightii,* a perennial, is used mainly in the seasonal tropics of Australia. It requires mildly acidic soils (pH $>$ 5.5). It is slow to establish, possibly because of slow nodulation and symbiosis. Critical P and K contents are 0.23 and 1.20 per cent, respectively. Flowering and seed production take place in a short period, and mechanical harvesting is possible.

6. **Lotononis** spp. include *L. bainesii,* a perennial of African origin, which is capable of tolerating aluminum and is particularly useful in light soils where it roots at the nodes with a growth habit resembling that of clovers. Its critical P and K contents are 0.17 and 0.75 per cent, respectively. It is highly strain specific in regard to **Rhizobium.**

7. **Pueraria spp.** include a perennial from Asia, *P. phaseoloides,* which is well suited to the wet tropics as a pioneer legume. It usually grows as a scrambler but is capable of spreading with rooting at nodes. It is generally used under plantations as a cover crop. It flowers for a long period of time, but the flowers are subject to fungus and bacterial attacks in wet weather. Seed setting is low and pods shatter easily; therefore, mechanical harvesting is difficult. In areas with a marked dry season, good yields have been recorded when harvested by hand. There is considerable diversity of opinion as to its palatability; it is suggested that palatability decreases with an increase in precipitation. There is also some discrimination by Zebu-type animals. Genetic variation has not been reported, but the possibility cannot be discounted.

8. Other genera include hosts of pasture legumes which are being examined in different parts of the tropics, some of which are **Aeschynomene** spp., **Arachis spp., Dolicus** spp., **Indigofera** spp., **Leucaena** spp., **Vigna** spp. and **Zonia** spp.

It may be noted that while tropical Africa has provided the bulk of grass species, tropical America is rich in legumes. The genera **Desmodium** and **Stylosanthes** would provide sufficient species and cultivars necessary for nearly every ecological niche that could be encountered in the tropics.

**Nitrogen fixation by tropical legumes**

The amount of nitrogen fixed by the various legumes in use has not been determined; however, some information is available to show that the rates are comparable to those fixed by temperate types. Table I summarizes some of the information available. Bryan (1970) showed that a pasture with 30 per cent legume content was almost equal to grass with 400 kg/ha application of nitrogen in terms of liveweight gain of animals. Jones (1972) demonstrated from various experiments that there is a linear relationship between dry matter yield of the legumes and the amount of nitrogen fixed by them. Norman (1970) showed that animal performance was linearly related to the content of legume herbage in the feed.

In Uganda (Jones, 1972), grain yield was superior from plots that had been previously under grass/legume pasture, as compared to those under grass only. It must be pointed out, though, that under the high tropical temperatures and alternate wetting and drying of the soils, animal excreta are the main form of nitrogen return from the legume to the soil. There would be considerable loss of nitrogen through volatilization and leaching. A steady supply under continuous grazing would be an efficient form of utilizing the legume nitrogen. Such a system of grazing is advocated by Jones (personal communication) for the persistence and growth of tropical legumes.

Table 1. **Amount of nitrogen fixed by tropical legumes in different parts of the world.**

| Legume sp. | Area | kg/ha/year N | Source |
|---|---|---|---|
| *P. atropurpureum* | Australia | 70-130 | Jones et al., 1967 |
| *D. canum* | Hawaii | 97 | Whitney & Green, 1969 |
| *D. intortum* | Hawaii | 264 | Whitney & Green, 1969 |
| *D. intortum* | Hawaii | 300 | Whitney, 1970 |
| *D. uncinatum* | Kenya | 61-159 | Thairu, 1972 |

**Selection, establishment and fertilization of legume-based pastures**

The key to success depends on the selection of legumes which are adapted to the environment and which are capable of persisting under grazing with associated grasses. Most tropical soils, particularly in the wet equatorial regions, are acidic and many are high in aluminum content. Santhirasegaram (1974) has reviewed the existing information and showed that tropical legumes would not require increased pH and that they are tolerant to aluminum, generally encountered in these soils. In calcareous soils, many of the legumes will not grow satisfactorily, but species are available for them too. *Glycine wightii, Leucaena leucocephala* and **Arachis** spp. are well adapted to these conditions.

The selection of grasses to be associated with the legumes is also an important factor. It has been shown that erect-growing grasses will not generally offer severe competition to the legumes (Reyes, 1974). However, persistent swards of *D. intortum* and *D. canum* with *Digitaria decumbens,* a prostrate type with grass rooting at nodes, have been maintained in Hawaii (Younge et al., 1964). Here, the determining factors appear to be grazing pressure and relative palatibility of the forage.

It is well recognized that tropical grasses grow faster than legumes and are therefore potentially capable of shading the latter, causing their elimination from the sward. For this reason, Hutton (1970) suggested that it may be necessary to breed tropical grasses with slower growth rates. However, it must be pointed out that relative palatability of the grasses is better than the associated legumes under most circumstances, particularly at the early stages of growth of the species. In the early life of the pasture, the amount of nitrogen available to the grass from the legume would be a limiting factor for its growth. Thus it would appear that under grazing conditions the existing circumstances would be complementary rather than competitive. The improvement of the growth rate of the legume, rather than the retardation of that of the grass, appears to be the more logical approach.

Tropical legumes would require less phosphorus and calcium as compared with their temperate counterparts, but they are characteristically high in their requirement of magnesium (Norris, 1959). Apart from requiring less P and Ca, tropical legumes have the ability to extract these two nutrients from soils which may be considered deficient in them.

Legumes and grasses adapted to the acid tropical soils appear to be low in P content ($<$ 0.20 per cent) and in many instances insufficient for the proper performance of the grazing animals. Santhirasegaram et al. (1972) have shown that for many species adapted to the ultisol in Pucallpa, Peru, an application of 100 kg/ha superphosphate would be optimal for establishment and early growth. When animals were grazed in such pastures, response to the added phosphate lasted for only six months (Echevarría and Santhirasegaram, 1974); and an application of 500 kg/ha superphosphate retarded the growth of animals during the same period.

Working in the dry monsoonal tropics of Australia, Ritson et al. (1971) recorded P content of 0.20 per cent on one occasion with *Heteropogon contortus* and on three occasions with *Stylosanthes humilis* (out of 22 and 20 determinations, respectively, in plots receiving 126 and 377 kg/ha/year superphosphate).

It is highly unlikely that the P content of these species could be increased to sufficient levels through the application of higher quantities of phosphate fertilizers, and it is even more questionable whether such levels would be economical. It would appear that phosphorus fertilizer should be applied to keep plants at or above their critical requirements and that the further requirements of the animal should be met through mineral supplementation.

The data of Echevarría and Santhirasegaram (1974) suggest that even applications of 100 kg/ha superphosphate every six months would not give a growth rate equal to that of animals supplemented with minerals. While it is possible that applications of 200 kg/ha superphosphate every six months can produce the same growth rate as mineral supplementation, the system would be uneconomical. Table 2 gives estimated costs and liveweight gains (LWG) to be expected from various combinations of phosphate fertilizer and direct mineral supplementation to the animal.

Table 2. **Liveweight gains and cost of production from *Pueraria phaseoloides/Hyparrhenia rufa* pasture with different rates of superphosphate application to the soil and direct supplementation of mineral phosphate to yearling Nellore heifers stocked at 2.0 animals/ha.***

| Treatment | LWG kg/ha/year | Cost of fert. (US$) | Cost of supp. (US$) | Cost/kg LWG (US cents) |
|---|---|---|---|---|
| A. Grass + legume | 120.2 | 0.00 | 0.00 | |
| B. Grass + legume + 100 kg/ha SP | 159.0 | 10.00 | 0.00 | 6.3 |
| C. Grass + legume + mineral supp. | 320.8 | 0.00 | 6.00 | 1.9 |
| D. Grass + legume + 100 kg SP + m. supp. | 352.4 | 10.00 | 4.00 | 4.0 |
| E. Grass + legume + 100 kg/6 months SP | 230.8** | 20.00 | 0.00 | 8.6 |
| F. Grass + legume + 100 kg/6 months SP + mineral supp. | 372.8*** | 20.00 | 4.00 | 6.4 |
| G. Grass + legume + 200 kg/6 months SP | 438.0**** | 40.00 | 0.00 | 9.1 |
| H. Grass + legume + 200 kg/6 months SP + mineral supp. | 438.0**** | 40.0 | 2.00 | 9.6 |

* Echevarría and Santhirasegaram, 1974
** Estimated by doubling the LWG during the first six months of Treatment B
*** Same as ** in Treatment D
**** Estimating maximum daily growth rate of Nellore heifers as 600 g

It would appear that the relationship between fertilization and LWG is curvilinear and an animal's response is soon limited by its capacity to grow. Further increase in LWG/ha could be achieved by increasing the stocking rate. It has already been established that 100 kg/ha application of superphosphate is optimal for plant growth. Under grazing conditions, however, there may be some further response to higher levels of phosphate application. It is suggested that applications of 100 kg/ha superphosphate every six months would be about the maximum required and perhaps even smaller quantities may be optimal. From the point of view of economics, there appear to be two factors: direct phosphate supplementations to the animal and limited, but frequent fertilization to the plants. Under this phosphate regime, optimum stocking rate would produce maximum LWG/ha.

Echevarría (personal communication) has found evidence that *Hyparrhenia rufa* pasture (without legume) with direct supplementation of mineral phosphate to the animal produced 318.6 kg/ha/year at a stocking rate of 1.5 beasts/ha of yearling Nellore bull calves. Thus it may appear that supplementation of phosphorus alone is sufficient. It must, however, be pointed out that these experimental pastures are young (four years old), with a history of light grazing. Continued use at high stocking rate without fertilization would result in loss of pasture growth and gradual reduction in carrying capacity. This is the state of much of the pasture in the Pucallpa region of Peru.

Thairu (1972) studied the decline in dry matter produced from grass only and grass/legume pasture during a four-year period. The grass-only pasture produced only 25 per cent of the dry matter in the fourth year, as compared with the first year, while the grass-legume pasture declined to only 50 per cent. Similar results were obtained by Horrel (1964) with *Panicum maximum* and *P. maximum/S. guyanensis* pastures in Uganda.

**Carrying capacity of legume-based pastures**

Early work by Shaw (1961) in northeast Australia showed that on natural pastures, weaner steers required 3.6 ha/head to reach slaughter weight at four to five years of age. Introduction of *Stylosanthes humilis* and molybdenized superphosphate reduced the area required per steer and age at slaughter to 0.8 to 1.2 ha and three years, respectively. Similarly, Norman (1968) in northern Australia showed that on natural grass pasture, animals lost weight even at 40 ha/beast. But when *S. humilis* was introduced and phosphate applied, animals reached slaughter weight at three years of age with only 1.2 ha/beast.

Riesco and Santhirasegaram (1974) recorded optimum stocking rates of 1.8 and 3.0 Nellore-type yearling bull calves on *H. rufa* and *H. rufa/S. guyanensis* pastures, respectively, in Pucallpa. The real potential in these pastures was not realized because of inadequate phosphate nutrition of the cattle. They have further shown that on legume-based pastures all cows were pregnant during the first three months after introducing bulls; while in grass-only pastures, only 50 per cent of the cows were pregnant even at the end of 12 months. Both groups of cows had access to mineral phosphate ad libitum while the legume-based pasture received 100 kg/ha superphosphate at commencement. The poor fertility of cows in the grass-only pasture with ad libitum mineral phosphate may have been due to estrus, conception or retention problems, or a combination of these factors. This effect of grass-only herbage on cow fertility was observed by Koger et al. (1961) and was considered to be caused by lack of estrus in young cows by Witt et al. (1958).

In another observation, Santhirasegaram et al. (1972) showed that when *S. guyanensis* was sown and 100 kg/ha superphosphate applied to *H. rufa* pasture, the dry matter content in the improved pasture was nearly 2.5 times greater compared to unimproved grass pasture.

The experiment of Riesco and Santhirasegaram (1974) suggests that improved grass/legume pasture would carry three yearling bull calves per hectare. The experiment of Echevarría and Santhirasegaram (1974) showed that at 2.0 yearling heifers per hectare, an annual LWG of 355.4 kg could be recorded. In these experiments animals were not receiving adequate amounts of phosphate. Furthermore, in the latter case, available feed at all times was high, sufficient to increase the carrying capacity to three beasts/ha. Thus an annual LWG of 528.8 kg/ha could be achieved. The consumption of legume (*P. phaseoloides*) by the Nellore heifers was very poor.

With species such as *S. guyanensis* and *C. pubescens*, where consumption would be good, another 10 per cent increase in LWG amounting to 581.7 kg/ha could be achieved. It is well known that male calves would make at least 10 per cent better growth than females. Thus an estimated 640 kg/ha/year LWG appears to be the potential of legume-based pastures in the Pucallpa environment, with adequate phosphate fertilization to the plants and direct supplementation to the animals.

The unimproved grass-only pasture produced an average of 130 kg/ha/year LWG from a number of experiments at Pucallpa. It must be stressed that the experimental pastures were all less than five years old and are much more productive than other grass pastures in the Pucallpa region, which are reported to carry less than one animal per hectare and produced less than 50 kg LWG per hectare per year.

The estimated liveweight gain of 640 kg/ha/year is far below the 850 to 900 kg, which Nuthall and Whiteman (1972) consider attainable under experimental conditions in the monsoonal and seasonal tropics of Australia. It must be pointed out that in Pucallpa, animal growth is continuous with almost continuous pasture growth. Thus it is possible to double the stocking rate, double the calving rate, quadruple the growth rate and half the slaughter age of cattle by the introduction of a suitable legume, along with applying adequate phosphatic fertilizer to the existing grass pastures and supplementing phosphate licks to the animals in Pucallpa. No doubt similar potentialities await exploitation in other tropical regions too.

# GRAZING SYSTEMS

All pasture utilization experiments at Pucallpa are being conducted under continuous or set stocking systems. Much has been written about grazing systems in temperate environments. It is generally believed that with improved sown pastures, sophisticated grazing systems would permit higher stocking rates, "even though experiments on sown pastures have not confirmed these beliefs. On present evidence, lucerne excepted, the only surety attached to the adoption of most grazing management practices is the extra cost they incur." (Willoughby, 1970).

There are few, if any, studies on grazing systems in the tropics. Walker (1968) compared continuous versus rotational grazing of unimproved natural pastures in Tanzania and concluded that at a high stocking rate, the latter is advantageous.

Table 3. **Animal productivity from continuous and rotational grazing at three stocking rates (Walker, 1968).**

| Stocking rate (beasts/ha) | Liveweight gain (kg/ha/year) | |
|---|---|---|
| | Continuous | Rotational |
| 1.0 | 182 | 177 |
| 1.2 | 192 | 177 |
| 1.6 | 213 | 265 |

It is, however, an accepted fact that in the tropics the primary concern should be to improve the pasture, which in many instances would result in a five- to tenfold increase in productivity. Once this is achieved, the lower remunerative factor of grazing systems may be considered. Controlled grazing may help in reducing selectivity by animals and thus check undesirable species dominating pastures. Walker (1968) showed that erect-growing types such as **Panicum** and **Hyparrhenia** spp. would persist under rotational grazing. However, Jones (personal communication) is of the opinion that rotational grazing, which causes severe defoliation, is detrimental to tropical legumes.

As in the temperate areas, farms are subdivided in the tropics for various reasons, but mainly for stock handling and saving labor. It is believed that in subdividing farms, a compromise should be reached between pasture utilization, stock management, labor efficiency and infrastructure investment; otherwise, gains from one aspect will be offset by losses from others.

# NITROGEN VERSUS LEGUME–BASED PASTURES

It may be said generally that under optimum management, liveweight gain from nitrogen-fertilized pastures would be double that of legume-based pastures in any given environment. While growth rates of animals from both systems are almost equal, the higher productivity from nitrogen is obtained from higher stocking rates. The economics of nitrogen-fertilized grass pasture for liveweight gains depends on the cost of nitrogen and market value of the beef produced. The general conclusion is that where the price of liveweight is twice the cost of nitrogen, the system is at a break-even point.

Liveweight gain is, however, only one aspect of cattle production. Producing, raising and maintaining breeding cows on the one hand and producing to weaning age of fattening stock on the other are factors that are generally overlooked by those who attempt to evaluate the economics of beef production from these two pasture systems. Nuthall and Whiteman (1972) made an extensive study of the possible economics of beef production from these two systems, where the whole herd is considered (cow/calf). They established that where the grass/legume system could produce 350 kg/ha/year LWG, the break-even yield required with 100 kg/ha nitrogen applied to the pasture is 517 kg LWG; and at 400 kg nitrogen the value would be 1,013 kg. The actual levels of LWG recorded in experiments at these two levels of nitrogen application are 360 and 923 kg. Thus, only at high levels of nitrogen application would the system be competitive with grass/legume pastures.

From the point of view of fattening alone, the more recent techniques of stall feeding by-products of sugar cane and other tropical crops will be competitive compared to grass/nitrogen pastures under grazing. If one may speculate, the tropics will produce weaners from grass/legume pastures; and others will produce the beef from processed feed, where the digestion in the animal's rumen may be by-passed.

In conclusion, nearly a third of the world's land surface is tropical with distinct potential for increased cattle production. Inclusion of a suitable legume with correction of mineral deficiencies in the nutrition of plants and animals would help to accomplish this potential. Many of the tropical legumes now in use are of American origin, tolerant of soil acidity with low phosphorus content and requirements. They have to be selected and bred to incorporate desirable agronomic characteristics, such as improved growth rate, persistence under grazing and ease of seed harvest.

Even in their natural state, these legumes contribute comparable quantities of nitrogen as do their temperate counterparts, having increased animal productivity five– to tenfold under simple grazing systems. At present, nitrogen fertilization of grass pastures rather than the use of legumes appears to be uneconomical and is beset with physiological problems in animals.

In the future, while breeding and weaner stocks are maintained and produced on legume-based pastures, beefing animals may well be raised in confinement on processed feeds.

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# INFLUENCE OF MANAGEMENT PRACTICES ON PRODUCTIVITY

*H. H. Stonaker, Juan Salazar, D. H. Bushman, Juvenal Gómez, Jaime Villar and Gustavo Osorio* *

We agree with many that the human element, the person, is the most important single factor in explaining variations in the productivity of cattle enterprises since a man's inherent ability, his education, his experience and his reputation all contribute to the process involved in making changes. We also agree upon the importance of the work of those who are helping other people become better managers.

Accordingly, we would like to proceed by adding a few particulars on available information and concepts, many of which are preliminary but which can help cattlemen by contributing to the storehouse of information on cattle production in tropical Latin America, a land of varied resources and opportunities.

Research on management systems can provide guidelines for the manager in finding valid prediction results for adequate appraisals in cattle operations relative to feeding, breeding, health, capital, use of land, labor and marketing. However, the individual manager is never free from the likelihood that conditions on his farm invalidate or modify the application of some practices which are usually economical for others. Farms, like their operators, are unique; thus, trial and error or research activities are essential ingredients of farm operations, informal as they may be.

Thus, systems of management are, in effect, the product of the unique characteristics of the manager interacting with his own unique ecosystem, his farm. Lest we over-emphasize individuality, there are large areas with characteristics in common. For example, in the tropical savannas of the world, the breeds from India predominate. One also finds,

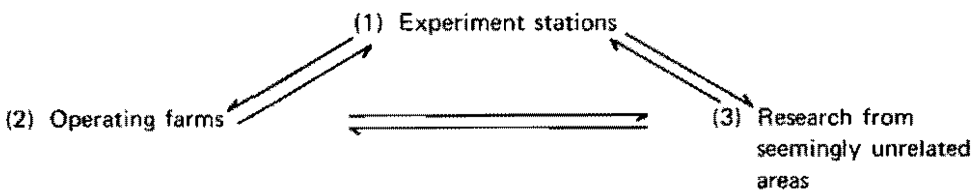
* **The work of Dr. N. S. Raun and Dr. Hemerson Moncada in establishing the herd system project and the contributions of Dr. Joaquín Cortés and Mr. Jaime Fajardo to the Fondo project are especially recognized.**

particularly in improved pastures, great similarity in the species and varieties of grasses. It has been said that just as tropical cattle come from India, the tropical grasses come from Africa and the tropical legumes from Latin America. Periodic drought and seasonal monsoons, soil characteristics, and problems of nutrition, health and genetics may be very similar for large areas. These common characteristics give those of us working in international research and development programs reasonable assurance that there can likely be a broad use of many technological improvements.

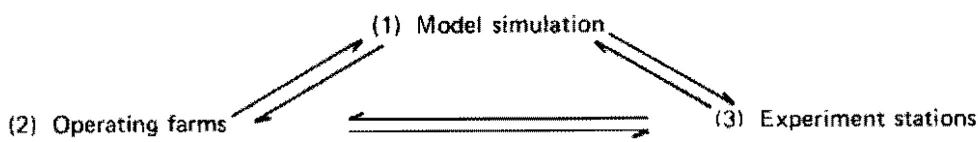
We know that conditions are currently critical for beef production, mainly because of a doubling of prices in the last two years. What may not have been historically an economically viable input may now produce good earnings on the investment. The market for good management and new technology is and will continue to be bullish. Innovations of all types are expected to contribute greatly to the process of change. How to undertake studies of herd management systems and apply the results has been a challenge to us here. Different approaches are needed to obtain the different results desired. If innovations such as the development of new legumes, vaccines, nutrients or breeds are required, the approach should be slightly different from interrelating known biological inputs into varying economic or ecological systems.

The universities, experiment stations and private and public research centers will lead in the development of innovations and in the creation and testing of new inputs. Operating farms may also contribute with new inventions or new breeds or varieties. In contrast, innovation does not easily stem from model simulation based upon historical evidence. More likely it will chart combinations of existing materials or conditions that may carry the industry into new peaks of productivity. We would suggest that these relationships are, in order of importance, as follows:

**Sources of innovation**




**Changing economic or ecological relationships**




The amount and kind of information which can be gained from each source would be as follows:

**Formalized experimentation, as on a government research farm**

| Limits in one cattle experiment: | | Maximum isolated comparisons | Minimum |
|---|---|---|---|
| | Main effects | 3 | 1 |
| | Interactions | 7 | 0 |
| Operating farms | | 0 | 0 |
| Model simulation | | 0 | 0 |

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| Effects of varying levels of input or activity as in regression statistics | Number of observations | |
|---|---|---|
| Operating farms | 100 to several thousand | 2 |
| Experiment stations | 70 ± | 2 |
| Model simulation (completely dependent upon estimates from the preceding) | | |

From changing economic relationships among know production inputs, it seems to us that the model simulation method is the most inclusive aid for making rapid decisions and predictions based on historical information. The traditional method would be observing changes in operating farms as independent operators gradually adjust to changing times and conditions.

Ordinarily with cattle, we would not expect a designed experiment to exceed information on four types of variables at two inputs or about eight lots involved in characterizing major effects. Thus, a 2 X 2 X 2 X 2 experiment could provide information on four main effects and their interactions. The great body of information continually being recycled by this type of research leads to new information for solving the unknown and for creating new opportunities.

Farm surveys and in-depth analyses of data from farms also bring out data complementary to those arising out of formal experiments. There are variables within the herd environment dealing mostly with differences in animal-to-animal production and the influence of age, genotype, castration, inoculation and a host of other management inputs. Constant management and nutrition are desired. Large populations are often necessary for ascertaining effects. The sire index in dairy breeding, for example, is one of the most highly developed applications of this technique.

Concepts and their interrelationships may be clarified or utilized to predict the effects of combinations of old and new situations through model simulation exercises using present-day computer methodology. Model simulation is based on historical events. The ever-present worries are the restrictions in deciding upon the data to be included and how reliable the basic input data are. Both of these factors may greatly affect the regressions produced.

An example of this kind of work is that conducted by an Oregon State University team in Venezuela (Miller and Halter, 1973). Using the best data available to them, predictions were made in this study as to the effect of price control and government policies on the intensification of beef production, amount of beef produced, etc., for the next 25 years.

The Oregon-Venezuela study was based on farm surveys. A different approach would be that of applying experimental results to the varying economic conditions on farms where they might be likely to occur, as was done in another Venezuelan study. In this case, levels of nitrogen and different prices for nitrogen were used to predict effects on the income on different-sized farms. Again, if the basic inputs are faulty, the conclusions or predictions will be erroneous.

In general we can classify the manner in which different inputs influence production as:

1. **Threshold inputs.** For example, one needs to know the minimum levels for various requirements, such as the minimum needed to maintain an animal alive during a dry season or to produce a calf. This is particularly interesting, for one more or less blindly explores various increments of input, not knowing whether one has under- or overinvested by a large or small margin in the inputs needed to produce the calf.

2. **Additive weight changes.** In contrast, these are easy to study, for there can be an almost daily reading on degree of response to inputs. An example of the additive nature of some production characteristics is weight gain of a calf while nursing + weight gain after weaning = market weight.

3. **Multiplicative increases.** The total product sold may be the product of the multiplicative nature of increases. For example, cattle raised X cattle weight X cattle grade X price = gross product of the cattle farm.

Other features of the production process of interest to cattlemen and other planners are the conceivable upper and lower limits to the process and what kind of costs or conditions seem necessary to achieve these limits. We have listed what seem to us to be presently acceptable average biological and economic limits (Table 1).

Table 1. **Estimated biological and economic limits in beef production (US$).**

| | Upper limits | Lower limits |
|---|---|---|
| Calving rate* | 109% | 40% |
| Survival (birth) | 99-100% | 40% |
| (Breeding or slaughter) | 100% | 40% |
| Growth | 363 kg | 90.8 kg |
| 8 months to 2 1/2 years | 1.82 kg/day | .11 kg/day |
| Time to market (about 454 kg) | 10 months | 7 years |
| Age at first calf | 18 months | 4 years |
| Age at last calf | 20 years | 9 years |
| Calving interval | 11 months | 2 1/2 years |
| Cost or price per kg of live cattle (Cost assumed to equal price over long term) | $ 1.32 | $ .10 |
| Labor costs/hour | $ 4.00 | $ .04 |
| Marketing cost | | |
| Transportation costs $/mile/400 kg | $ .13 (airplane) | $ .002 (on foot) |
| Shrinkage | 15% | 2% |
| Selling | 6% | — |

* Eleven-month calving interval

The foregoing discussion summarizes how our various activities concerned with improving cattle production are managed and interrelate. This should give a general idea of what we may expect from given kinds of activities. At this point, we would like to review a short period of activity here in Colombia (relative to surveys and research) undertaken at CIAT, with the essential collaboration and assistance of ICA and the Fondo Ganadero (Meta).

We will review some of the information we have been able to accumulate recently in our collaborative activities with ICA at Carimagua in the Llanos Orientales of Colombia and show how we might interpret these data so as to make broader generalizations for field application and production improvements. In addition, we will refer to a study of Llanos cattle farms conducted by a team of professionals and technicians from the Fondo Ganadero (Meta), ICA and CIAT.

# SURVEY OF FONDO GANADERO FARMS IN THE LLANOS*

All farmers had cattle on lease from the Fondo Ganadero. There were 19 farms on the southern side of the Meta between Puerto López and Puerto Gaitán. There were 20 farms in the Piedmont in the San Juan de Arama, Granada and San Martín-Acacías-Cumaral areas.

Llanos cattle farms are typically small (Brunnschweiler, 1972). On an average they would market fewer than 12 head per farm per year. Only 8 per cent of the cattle farms in the Meta area would have 50 to 60 head of cattle to market annually, a gross product equivalent to a salary of Col$ 10,000 to $ 15,000 per month.

In the Fondo study, the inventories would suggest an average extraction rate for the Meta of about 10 to 12 per cent per year. This would provide a gross cash annual income per family equivalent to about two laborers, or about Col$ 2,000 monthly, assuming little or no out-of-pocket costs for the cattle enterprise.

Obviously at present there is little wealth being produced in this vast area for either the country or the inhabitants. This lack of productivity in such a large area provides an enormous challenge.

The rainfall and temperature are approximately the same for all the areas: 1,800 millimeters rainfall, unevenly distributed; altitude 150 to 300 meters; mean temperature 26°C to 27°C. However, soil fertility is evidently much higher in the Piedmont. Soil-plant surveys have been made by FAO (1964).

The Fondo generally had three-year renewable leases with the cattlemen. The increase in the value of the herd and in progeny were divided so that the cattlemen received 60 per cent of the increase. It seemed to be a favorable contract; many farmers asked the Fondo if more cattle were available for lease or if friends or neighbors could obtain cattle. The consistent desire was for expansion because the farms were generally considered to be underpopulated and undergrazed.

There were distinct differences, apparent to the visitor, between the Piedmont and Llanos areas that were revealed to some extent in the survey. In the Piedmont, farms were much smaller but probably much more productive per hectare; and cattle and horses appeared to be in better condition. In working the cattle herds, the farm owners routinely cooperated in cattle work whereas in the Llanos, mostly extra hired labor did the work. Actual differences in farm size probably reflect about the same capacity for cattle raising.

* Stonaker et al., 1975

The number of Fondo cattle was about the same in the two areas, which implies a greater tendency to lease cattle in units of about this size. Almost without exception, there were few division fences. We saw little evidence of consistent vaccination or mineral feeding programs being followed. Even though these were contract requirements, our impression was that anything requiring cash outlay would be beyond the capacity of many of these farmers' management programs.

Preliminary information indicates a surprising similarity in cow productivity in the two areas. There are different breeding seasons for the cattle even though bulls are not separated from the cows. Perhaps the most important failure in the production cycle is due to the inability of cows to rebreed while nursing calves. This narrows the focus on what has been the main research objective in herd systems at Carimagua—to increase the calf crop.

Estimated ages of calves and fetuses (through palpation) indicated a marked breeding season in the two areas. This was toward the end of the rainy season and early dry season in the Llanos but in the middle to late dry season and early rainy season in the Piedmont. This will be commented upon later.

We consider the most consistent and pertinent single piece of information from this study to be the extremely low percentage of nursing cows that were found to be pregnant.

One can almost say axiomatically that wet cows do not breed in the Llanos. Most of the pregnant cows are dry; this, however, does not imply that all dry cows are pregnant (Table 2).

A calving rate of 40 per cent has often been indicated to be more or less typical of the Llanos. However, on these farms one may deduce that it is probably higher. At least for 1972-1973, it was 55 per cent and 52 per cent, as shown in Table 2.

Trying to deduce total annual production from one day's examination of a herd requires combining elements from two sources of information; namely, the number and estimated ages of calves and the number of cows found pregnant along with estimated age of fetuses. At least the following errors may enter into such calculations: biased errors in estimation of calf age and in the ages of the fetus and lack of information relative to calf losses and abortion. It was hoped that these errors would be minimized if one counted calves at the age of five months or more and fetuses estimated to be two months or more of age.

Table 2. **Preliminary material from cooperative Fondo, ICA–CIAT Projects (1973).**

| | Piedmont | Meta |
|---|---|---|
| Contracts | 20 | 19 |
| Years occupancy | 9.8 years | 8.7 years |
| Owners in residence | 16 | 10 |
| Hectares | 456 | 1,816 |
| Cattle (Fondo) | 98 | 95 |
| Heifers and cows palpated | 999 | 787 |
| Nursing | 43% {13% pregnant; 87% open} | 37% {9% pregnant; 91% open} |
| Dry | 57% {54% pregnant; 46% open} | 63% {51% pregnant; 49% open} |
| Total pregnant | 36% | 35% |
| Annual estimated calving rate | 55% | 52% |
| Breeding season | Late February-May | November January |

For computing the calving rate on an annual basis, we used the following classfications of cows:

| Condition of the cow | Dry | Nursing to six months | Nursing six months and over |
|---|---|---|---|
| Open | a | b | c |
| Pregnant under two months | d | e | f |
| Pregnant two months and over | g | h | i |

$$\text{Calving rate} = \frac{\text{Number of calvings in one year}}{\text{Number of cows}} = \frac{b+e+g+2h+i}{a+b+c+d+e+f+g+h+i}$$

Total cows and heifers palpated = $a+b+c+d+e+f+g+h+i$

Calves due in one year = $g+h+i+b+e+h = b+e+g+2h+i$

The "h" group could produce two calves in one year, and thus it is correct to count them twice, which was done.

While the palpation data were used for cattle estimated to be two months' pregnant, it would not have made much difference if calves estimated to be six months of age had been substituted. The total count for the Llanos and Piedmont was approximately 140 cows that were two months' pregnant versus 150 calves six months of age, giving about the same results as different data sources.

**Seasonality of breeding**

At this latitude and altitude with slight variations in day length, it is likely that seasonality in breeding will reflect a nutritional cycle. On irrigated pangola pastures in the somewhat higher Valle del Cauca (1,000 meters versus 250 meters), the seasonality of breeding is quite reduced in comparison with the two areas surveyed. This is indicated in Figure 1, based on data from the Lucerna dairy herd at Bugalagrande. The ratio of breeding in high versus low months for Lucerna was 1.44; for the Llanos, 12.60; and for the Piedmont, 12.7. The month of most frequent breeding was March for Lucerna, December for the Llanos, and May for the Piedmont, months of lowest breeding incidence were May, September and November, respectively (Fig. 1, 2 and 3).

**First steps towards increased calving rates in the Llanos**

Reviewing the Fondo data, we find that

1. Wet (nursing) cows are nearly always open.

2. Weaning pastures do not generally exist; thus, it is difficult to shorten the nursing period.

3. Breeding is seasonal even though bulls are always with the cows. This seasonality is almost certainly nutritionally induced.

4. Financial limitations or lack of conviction discourage farmers from buying minerals, salts and vaccines.

5. Higher carrying capacity of better grass pastures has little influence on total calving rates or on the seasonality of calving.

Our interpretation of these data would be that the typical life cycle of the Llanos cow is something like that shown in Figure 4.

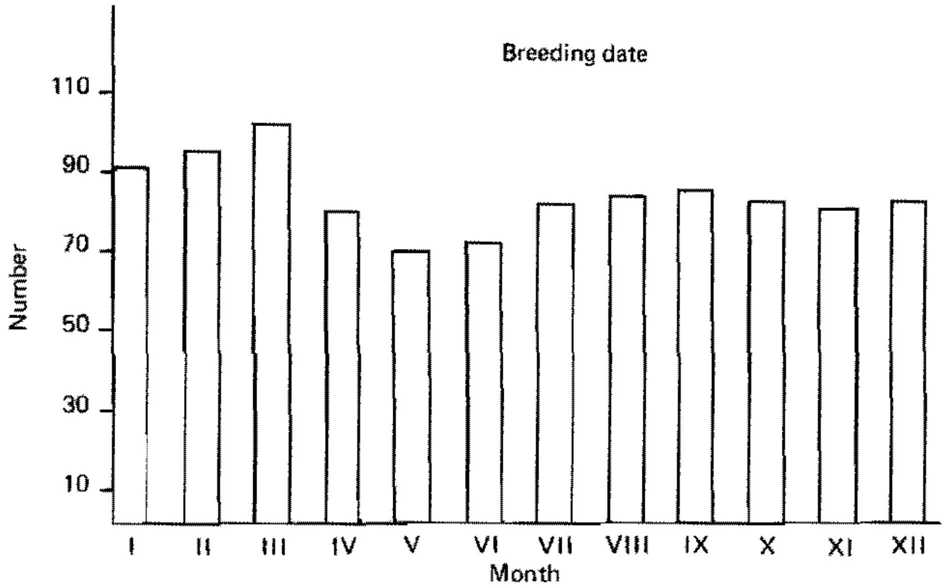



**Figure 1.** Distribution as per 1,000 cows based on 6,926 calving in the Lucerna herd (1966–1970).

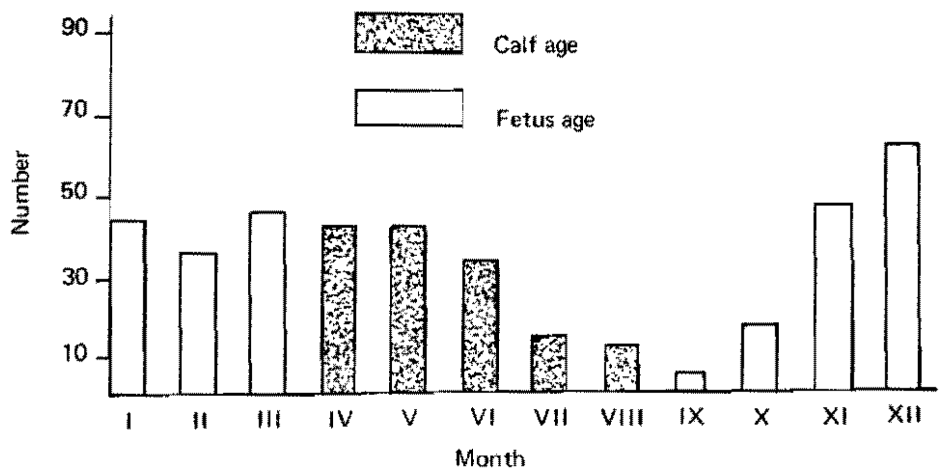



**Figure 2.** Llanos conception dates estimated from calf age and fetus age.

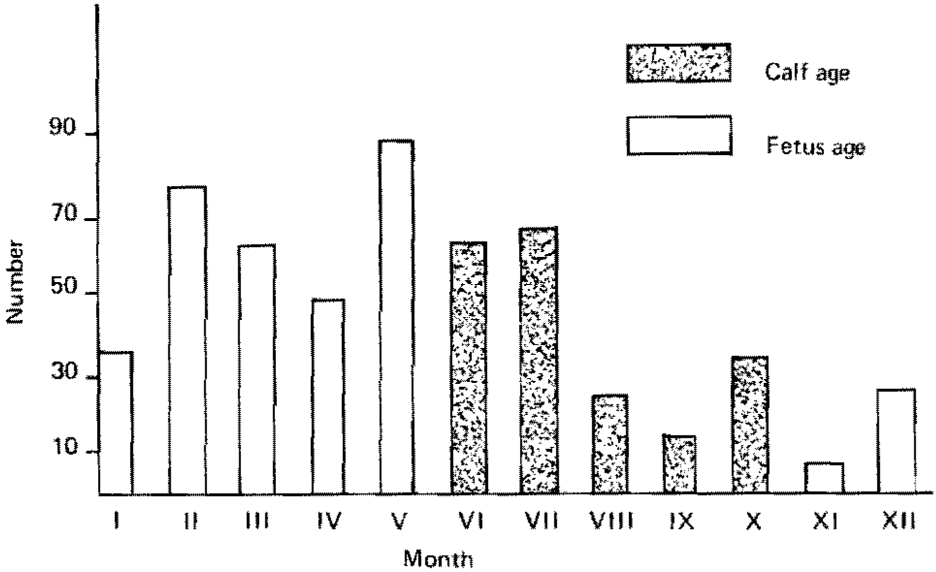


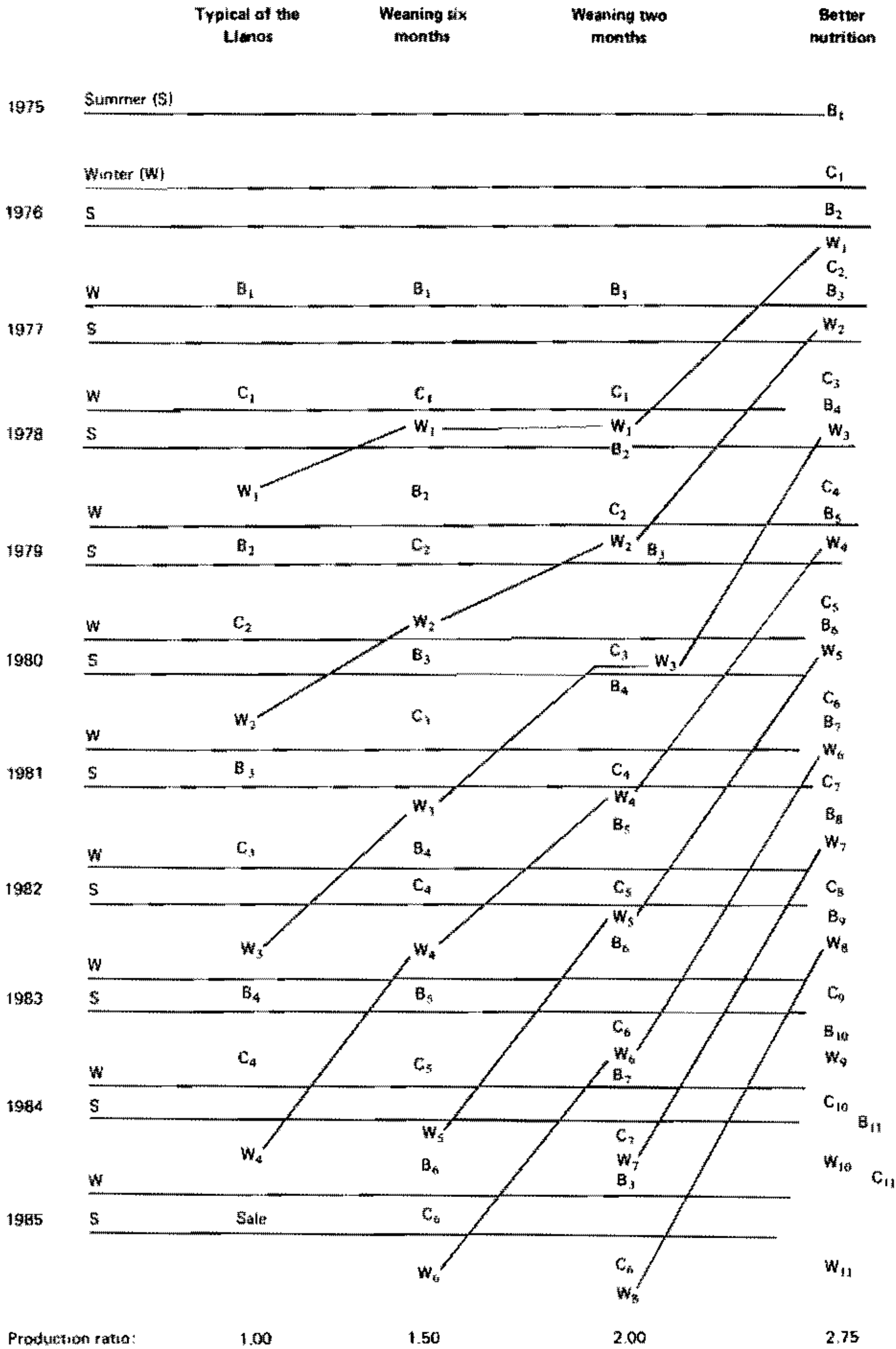

**Figure 3.** Piedmont conception dates estimated from calf and fetus age.

In eight years a typical cow produced four calves. Assuming minerals are used, the first step toward low-cost changes would be a weaning program. This would shorten the interval between calvings, as also indicated in Figure 4. The cow would have an opportunity to wean six rather than four calves, an increase of 50 per cent in the lifetime production of the cow.

The requirement would be a weaning pasture. The cost would be variable. One kilometer of five-wire fence costs Col$ 4,000; and $ 800 per year for 25 calves produces a return investment of 11 to 1.

A second step of intensification would be weaning at two months with supplementation of calves to six months of age (Fig. 4). We have estimated that the calf production of the typical cow would be doubled in this way.

This assumption is based on the estimated value of a two-month-old calf and the cost of raising that calf to six months of age. The most important assumption is that it would induce annual breeding.




**Note:** C = Calving, B = Breeding, W = Weaning

**Figure 4.** Production cycles in cows

Estimating value of two-month-old calves:

| | |
|---|---|
| Three-year-old steer weighing 180-200 kg | Col$ 3,500 |
| Less pasture for 27 months ($70/month) | –1,900 |
| Value of nine-month-old weaner | 1,600 |
| | |
| Additional grain cost for four months of feeding calves weaned at two months (.75 kg/day at $ 4/kg; i.e., $ 3/day X 120 days) | – 360 |
| Pasture and labor cost ($1/day) | – 120 |
| Approximate value of two-month-old calf | $ 1,120 |

For a 100-cow herd, the increase in weaning rates necessary to offset early weaning costs are indicated as follows:

| Nine-month weaning | No. | Individ. value | Total value | To sell | Individ. value | Sales | Heifers to sell |
|---|---|---|---|---|---|---|---|
| 40% | 40 X | 1,600 | 64,000 | 20 X | 1,600 | 32,000 | 0 |
| 50% | 50 X | 1,600 | 80,000 | 30 X | 1,600 | 48,000 | 5 |
| 60% | 60 X | 1,600 | 96,000 | 50 X | 1,600 | 64,000 | 10 |
| Two-month weaning | | | | | | | |
| 70% | 70 X | 900 | 63,000 | 50 X | 1,120 | 56,000 | 15 |
| 80% | 80 X | 900 | 72,000 | 60 X | 1,120 | 67,200 | 20 |
| 90% | 90 X | 900 | 81,000 | 70 X | 1,120 | 78,400 | 25 |

As can be seen, the feasibility of early weaning clearly relates to present calving rates and to the calving rates that can be anticipated from early weaning. If the typical weaning rate is 50 per cent, an increase to 70 per cent by early weaning would give a somewhat greater gross income above feed and labor costs. A more important factor would be a great increase in the availability of heifers for sale. Assuming 20 heifers are necessary to maintain herd size in a 100-cow herd, the shift would increase heifers available for sale.

Certainly, it gives validity to experimenting with early weaning under Llanos conditions. It would have the advantage of developing a more specialized and intensified use of the region for cows, with less emphasis on growing steers. Little investment would be needed if calves were taken elsewhere for growing.

As indicated in Figure 4, the ultimate management system for increasing cattle reproduction in the Llanos would be to provide ample nutrition throughout the entire year, preferably with an improved pasture program.

The present aspiration is to adapt the legume system, particularly well known in Australia, to the Colombian Llanos. Plans are to undertake this in the near future with a cow herd. There are **Stylosanthes** grazing trials under way at CIAT (1974); and at the present time, there is a great deal of optimism about the outcome.

Other alternatives may exist as well. Irrigation could be developed in the Llanos, and presumably climatic and soil factors are such that technically almost any level of pasture production is conceivable with indicated water and soil corrections. Biologically speaking, the obstacles do not seem to be insurmountable, but what would the economic implications be?

## THE PRELIMINARY IMPLICATIONS OF THE ICA—CIAT HERD

The early and currently operating strategy in the ICA—CIAT Herd Systems Project has been to introduce, under the challenge of an inhospitable environment, a series of existing inputs to increase beef production economically. The opportunity to study a wide range of interactions of inputs has been provided.

With grade Zebu heifers purchased in the Carimagua area by ICA, effects of several variables on reproductive rate, growth, mortality and disease, and total beef produced are being investigated. These variables are complete mineral supplement, improved molasses grass pasture and urea-molasses supplementation. On a hierarchical basis, it will be possible to study the effects of early weaning and crossbreeding within the groups. Thus several variables in the project are concurrently being examined at two levels: the prevailing or existing level versus an estimated or improved level.

### Salt and mineral supplementation

Complete mineral supplementation has been proven to affect reproductive capacity markedly, increasing reproductive rates across a wide range of soil and climatic conditions. The prevailing question is why this mineral supplementation is not widely used in the Llanos. Current indications are that pregnancy rates in first-calf heifers may be greatly increased by mineral supplementation (CIAT Annual Report 1973). The effect on nursing cows is almost certain to be less; ICA data indicated that except for the North Coast station at Montería, wet cows are not bred, even though they receive minerals.

The increased reproduction of first-calf heifers alone will more than pay for mineral supplementation of the entire cow herd (Tables 3, 4 and 5). The mineral response in cows at Carimagua is not yet known, but it will probably be less than in others because of other more limiting stress factors for the nursing cow.

An additional advantage is that these heifers reach a breeding weight at least four months sooner than those that do not receive mineral supplementation.

### Improved pastures

The effect of seasonality on the nutritive value of native and improved pastures (molasses grass) can be demonstrated in Figure 5, which illustrates weight gains or losses during different seasons. At the end of one year, heifers on native pasture exclusively versus those exclusively on molasses grass were essentially equal in weight. The pregnancy rate was 80 per cent on molasses grass versus 70 per cent on native pasture during four months of breeding. By the end of eight months of breeding, the pregnancy rate was only slightly different for native pasture versus molasses grass groups: 84 per cent versus 88 per cent (Table 2).

Molasses grass pastures, as we now use them, would need to produce about 13 per cent additional calf crop to be economically feasible in comparison with native savanna. Our

Table 3. **Preliminary results from ICA–CIAT Herd Systems Project (1972-1974).**

| | Herd | Heifer Weight (kg) | | Percentage Pregnant | | | |
|---|---|---|---|---|---|---|---|
| | | Dec. 73 | Feb. 74 | Oct. 73 | | Feb. 74 | |
| Native | 1 | 307 | 316 | 63 | | 66 | |
| Savanna-salt | 2 | 289 | 289 | 31 | 24 | 57 | 50 |
| Savanna-salt | 3 | 270 | 275 | 17 | | 43 | |
| Savanna-minerals | 4 | 334 | 343 | 68 | 70 | 88 | 84 |
| Savanna-minerals | 5 | 332 | 335 | 71 | | 79 | |
| Savanna-molasses grass-minerals | 6 | 325 | 338 | 58 | 60 | 89 | 86 |
| Savanna-molasses grass-minerals | 7 | 326 | 347 | 63 | | 83 | |
| Molasses grass-minerals | 8 | 328 | 333 | 78 | 80 | 86 | 88 |
| Molasses grass-minerals | 9 | 335 | 333 | 81 | | 89 | |

Table 4. **Summary of salt and mineral consumption (kg) per cow at Carimagua (1973).**

| | Salt only | | | Salt – mineral mix* | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Herds | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | 8.9 | 6.6 | 13.4 | 17.0 | 18.2 | 28.8 | 25.2 | 27.0 | 27.0 |
| Avg consumption | | 9.6 | | 17.6 | | 27.0 | | 27.2 | |
| Cost/year (Col$) | | 9.65 | | 70.48 | | 108.00 | | 108.80 | |

* Salt 47%, dicalcium phosphate 47%, trace minerals 6%; approximate cost Col$ 4 per kg, salt only, $ 1 per kg

first year of results indicates that it will be difficult to find an improved pasture for heifers that will be economically advantageous. It remains to be seen how cows under the stress of lactation will rebreed while grazing molasses grass. Seasonal variations in available nutrition, as measured by weight changes in heifers, are shown in Figure 5.

While gain data were not available from the Fondo farms, better pastures, as indicated by heavier carrying capacity, did not appreciably increase the calf crop (Table 2). Interestingly, the savanna and molasses grass appear to complement each other to some extent; for during the rainy season, gains were much higher on molasses grass. During the dry season, cattle on native pasture (savannas and wet lowland) gained whereas those on molasses grass lost. The use of molasses grass during the rainy season and the wet lowland during the dry season appear to be promising systems.

This brings up the question of how to reach an economical nutritional threshold that permits rebreeding wet cows and lowers the age of heifers at first calving. In the Herd Systems Project, we are attempting to attain this threshold immediately

1. By shifting herds from molasses grass to native savanna during the dry season

2. By supplementing with urea and molasses during the dry season

3. By conserving condition and weight of the cow for early rebreeding through early weaning at two months

4. By using pasture legumes in the future to supplement native and/or improved pasture

We are hopeful that some economical combination of these additions will permit a sustained annual birth rate in excess of 70 per cent.

Table 5. **Projected returns from mineral supplementation in herd of 80 cows and 20 heifers.**

| Herds | 2–3 % | Nb* | 4–5 % | Nb* | 6–7 % | Nb* | 8–9 % | Nb* |
|---|---|---|---|---|---|---|---|---|
| Calf crop from heifers | 50 | 10 | 84 | 17 | 86 | 17 | 88 | 18 |
| Assumed calf crop from cows | 50 | 40 | 50 | 40 | 50 | 40 | 50 | 40 |
| Total calves | | 50 | | 57 | | 57 | | 58 |
| Value of calves at Col$1,600 | | $ 80,000 | | $ 91,200 | | $ 91,200 | | $ 92,800 |
| Increase in calf value from minerals | | — | | $ 11,200 | | $ 11,200 | | $ 12,800 |
| Salt or mineral cost | | $ 965 | | 7,048 | | 10,800 | | 10,800 |
| Increased value of minerals | | — | | 6,083 | | 9,835 | | 9,835 |
| Net increase from minerals | | | | $ 5,117 (84%) | | $ 1,365 (14%) | | $ 2,965 (30%) |

* Nb = number of births

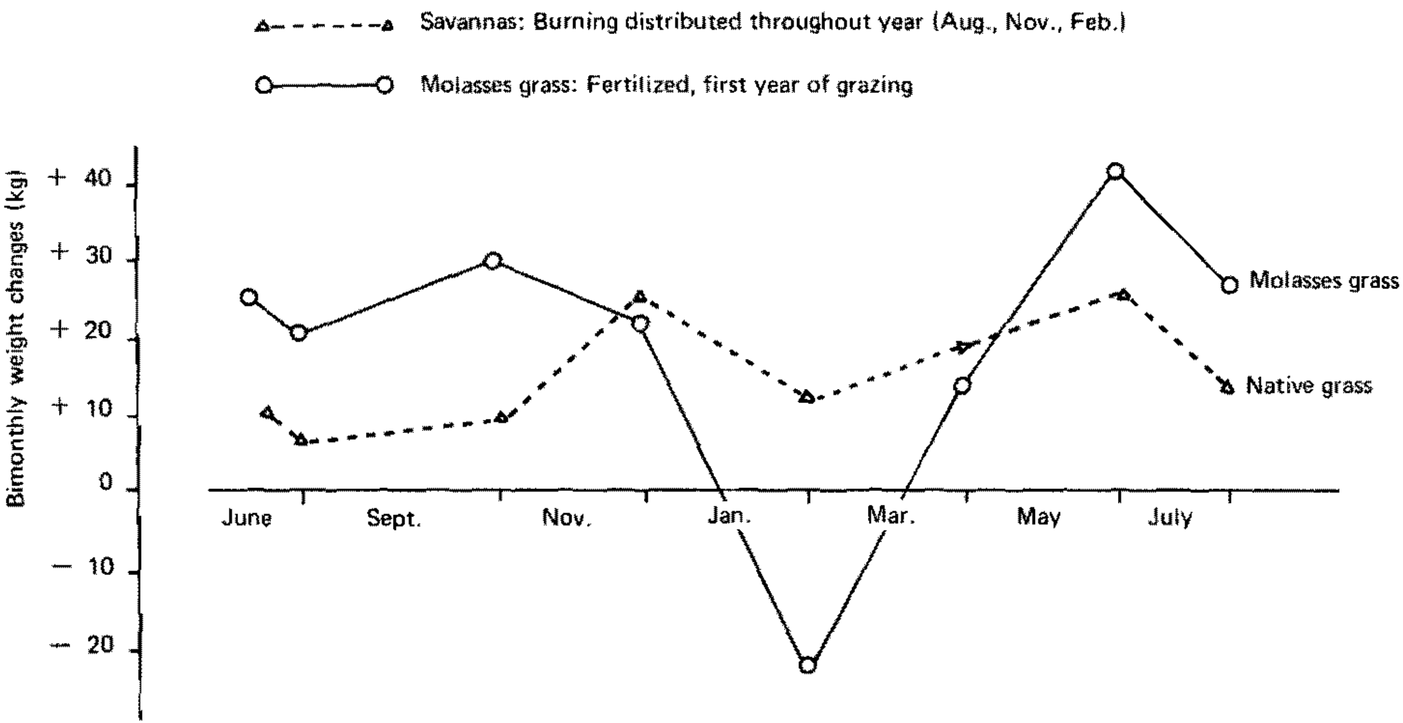



**Figure 5.** Seasonal variations in available nutrition as measured by weight changes (calculated bimonthly from base zero 1972-1973) in heifers at Carimagua.

**Bull management**

Conditions for handling breeding bulls at Carimagua have been arrived at empirically. Bulls were used for two weeks, then rested for two weeks. One bull was used with 35 cows. A chin ball harness marking system was used, thus good indications of the number of heifers bred were obtained. Bulls were given a ration supplemented with cottonseed meal during the first four months of the year when much of the breeding took place. The bulls were also supplemented while being rested. Bull fertility testing is being used on the ranch.

Under commercial Llanos conditions, it is difficult to assess limitations in calf crops as related to the bulls. The animals are generally run together without respect to age or sex. Bull calves are not castrated, and ordinarily they are not marketed before three of four years of age. Occasionally outside bulls are purchased; thus cows are exposed to a number of bulls.

In conclusion, it can be said that the problems of the Colombian Llanos are doubtlessly distinctive; but if it can be demonstrated that the thresholds for increasing calving rates are not excessively costly by current price standards, a tremendous increase in productivity of the area will follow.

It already seems evident that new disease-resistant legumes will have to be found. These may be the key to low-cost beef production, but it is not certain that satisfactory ones yet exist. If not, there are other alternatives, possibly at greater costs, some of which have been mentioned here. Hopefully, a greater interchange of material and methodology with other areas of the tropical savannas will be forthcoming. If not, economic breakthroughs in one location can stimulate similar approaches elsewhere.

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# SUPPLEMENTATION OF GRAZING CATTLE

*B.D.H. van Niekerk*

Beef production in many parts of the world depends almost exclusively on the extensive natural range lands found in the major beef producing countries. These areas are often unsuitable for purposes other than pastural use because factors such as topography, poor soils and low or variable rainfall do not favor agricultural crop production under present economic circumstances.

Animal production in such environs is, however, often seriously limited because of deficiencies of essential nutrients in the pastures during various seasons of the year. Thus, if this vast source of food for animal production is to be exploited fully, it is of utmost importance that these deficiencies should first be identified. It is of equal importance that supplementary feeding of range animals should not be a haphazard procedure, as is often the case in practice. In order to make full economic use of natural pastures, it is necessary to supplement only those nutrients which have been shown to limit the performance of various classes of livestock during the different seasons of the year.

The purpose of this paper is to summarize the most important findings to emerge from more than 50 years of investigation into the problems of supplementary feeding of grazing ruminants in southern Africa.

## CLIMATIC AND PASTURAL CONDITIONS

Approximately one third of the African continent consists of open grassland or savanna. Rainfall in these areas is strictly seasonal and very erratic, resulting in a prolonged and variable dry season which coincides with the winter period and which normally lasts from May through October or even November in areas nearer the tropics. Periodic droughts, during which less than half the normal annual rainfall might fall, are not uncommon.

A characteristic feature of the grazing in these areas is the almost complete absence of natural legumes. Therefore, cattle are almost exclusively dependent upon grass for their nutrient intake, with the leaves or pods of trees forming only a small fraction of the daily food intake in the bushveld areas. The nutritive value of the grass in a given area varies considerably from season to season. Following the first rains, there is a rapid increase in the nutritive value of the grazing which enables animals to gain weight for four to six months of the year. With the onset of the dry season and particularly after the first frosts in high-lying areas, the nutritive value of the grazing drops precipitously. This variation in nutritive value is less marked in the warm and drier, low-lying or so-called "sweet" grassveld areas but is very pronounced in the higher-lying or so-called "sour" grassveld areas, where the annual precipitation generally exceeds 700 milimeters. During the dry season cattle might lose weight for six to eight months of the year. In the sour grassveld this loss can amount to 25 to 30 per cent of the maximum summer liveweight. Under these conditions, unsupplemented animals show a net yearly weight gain of only 40 to 70 kilograms and require six to ten years to reach a marketable weight. Mortality is high, and heifers invariably do not calve for the first time until they are 3½ to 4 years of age. Recalving percentages are poor and the average calving percentage in much of Africa is less than 50 per cent. The final result is an extremely poor rate of meat production with low average herd turnover rates, varying from 5 to 26 per cent for the various countries in southern Africa.

## WINTER OR DRY SEASON SUPPLEMENTS

### Phosphorus supplements

Since loss of weight during the dry season is such an obvious cause of productive and reproductive failure, research work on supplementary feeding has been devoted almost exclusively to the question of winter weight loss. Analysis and digestion experiments show that dry grassveld is an exceptionally poor source of available energy, protein, carotene, phosphorus and other elements (du Toit et al., 1940; van Wyk et al., 1955).

It was, however, the extreme deficiency of phosphorus in South African soils and grasses and the widespread incidence of botulism caused by cattle eating the bones of dead animals which first stimulated interest in supplementary feeding in South Africa. In the now classical studies of Theiler et al., it was found that bone meal supplements fed throughout the year not only prevented the occurrence of botulism but also resulted in improved growth rates, milk production, weaning weights and calving percentages (Theiler et al., 1924).

Only in recent times has it become obvious that there is in fact no liveweight response to phosphorus fed during the dy months of the year when the animals are normally losing liveweight. This fact is clear not only from the original work of Theiler et al. (1924), but

Table 1. **Average month-end herbage analysis on a dry matter basis at Matabeleland, Rhodesia from 1961 – 1968.**

| | Crude protein | Ether extract | Crude fiber | N.F.E.* | Ash | Ca | P |
|---|---|---|---|---|---|---|---|
| November | 8.1 | 1.7 | 35.9 | 43.3 | 11.2 | 0.27 | 0.08 |
| December | 6.4 | 2.0 | 34.1 | 45.0 | 12.5 | 0.25 | 0.13 |
| January | 5.6 | 2.0 | 39.1 | 44.6 | 8.7 | 0.29 | 0.13 |
| February | 5.4 | 1.5 | 39.1 | 44.8 | 9.3 | 0.24 | 0.14 |
| March | 3.9 | 1.6 | 40.0 | 45.9 | 8.6 | 0.25 | 0.09 |
| April | 3.3 | 1.7 | 38.6 | 47.3 | 9.1 | 0.25 | 0.09 |
| May | 2.7 | 1.5 | 41.1 | 46.0 | 8.7 | 0.27 | 0.09 |
| June | 2.4 | 1.3 | 38.5 | 49.0 | 8.8 | 0.28 | 0.08 |
| July | 2.3 | 1.7 | 37.8 | 49.1 | 9.1 | 0.32 | 0.06 |
| August | 2.3 | 1.2 | 38.7 | 49.5 | 8.3 | 0.29 | 0.07 |
| September | 2.2 | 1.3 | 40.9 | 47.7 | 7.9 | 0.26 | 0.06 |
| October | 2.8 | 1.2 | 40.0 | 47.6 | 8.4 | 0.31 | 0.06 |

* Nitrogen-free extract
**Source:** Bemridge (1970)

also all subsequent studies using phosphorus as the sole winter supplement confirm this finding (Bisschop and du Toit, 1929; Murray et al., 1936; Murray and Romyn, 1937; Kotze, 1948; Rhodes, 1956; Skinner, 1963; Bisschop, 1964; Schur, 1968, Ward, 1968; van Schalkwyk and Lombard, 1969).

Thus, in spite of the poor status of phosphorus in dry grassveld, it is obviously not the primary limiting nutrient in winter grazing. Under conditions of maintenance and submaintenance, sufficient phosphorus of endogenous origin must reach the rumen so that microbial digestion is in no way impaired by periodic deficiencies of phosphorus in the diet.

**Energy supplements**

Digestion studies led early research workers to conclude that the digestible energy value of winter grassveld is so poor that it is almost valueless as a source of energy and that it would be futile to supplement such grazing with protein alone (Smuts and Marais, 1940; Louw and van der Wath, 1943). This belief led to the widespread use of energy-rich feeds—particularly maize grain and molasses—as winter supplements. Subsequent studies have, however, shown that such energy-rich but protein-deficient feeds not only give poor or even negative responses in animal production (Rhodes, 1956; Verbeeck and von L

Table 2. **Average weight change (kg) and total weight gain (kg) of cattle fed phosphorus (P) supplements during different seasons of the year.**

| Period | Season | Negative control | "Winter" P | "Summer" P | "Winter" & "Summer" P |
|---|---|---|---|---|---|
| January-March | "Summer" | + 35.2 | + 41.6 | + 61.6 | + 57.1 |
| April-June | "Winter" | + 5.3 | + 18.1 | + 14.1 | + 6.8 |
| July-September | "Winter" | − 29.8 | − 30.3 | − 36.3 | − 30.6 |
| October-December | "Summer" | + 45.7 | + 61.6 | + 77.5 | + 88.1 |
| Initial weight (kg) | | 314.9 | 307.7 | 305.4 | 311.8 |
| Total weight gain (kg) | | + 56.3 | + 91.8 | + 116.8 | + 121.4 |

**Source:** van Schalkwyk and Lombard (1969)

Chevallerie, 1958; von La Chevallerie, 1965; van Niekerk et al., 1968b; Winks et al., 1970; Nel and van Niekerk, 1970), but they also depress pasture intake by the grazing animals (von La Chevallerie, 1965; van Niekerk et al., 1968a; Nel and van Niekerk, 1970; Winks et al., 1970).

This lack of response to energy-rich feeds fed as sole supplements to winter grazing is attributable to the fact that such supplements encourage the proliferation of the fast-growing sugar— and starch-digesting bacteria at the expense of the slower cellulose and lactic acid utilizers, which are deprived of what little nitrogen is available in the rumen (Gilchrist and Schwartz, 1972). The result is a lowering of digestibility, rate of passage

Table 3. **Effect of molasses and molasses plus urea supplements on liveweight and estimated pasture intake of cattle during 141-day period on winter grassveld grazing.**

| | Negative control | Molasses (0.9 kg/day) | Molasses & urea (20:1) (0.9 kg/day) | Molasses & urea (10:1) (0.9 kg/day) |
|---|---|---|---|---|
| Initial weight (kg) | 273.50 | 280.80 | 279.20 | 278.70 |
| Weight gain (kg) | − 37.00 | − 41.70 | − 22.20 | − 0.20 |
| Grass intake (kg) | 3.62 | 1.84 | 2.64 | 4.29 |

**Source:** von La Chevallerie (1965)

and intake of the fibrous veld grasses. Therefore, energy is clearly not the first limiting nutrient in dry grassveld so there is little point in using energy feeds such as maize grain, molasses or maize silage as winter supplements unless other more important nutrient deficiencies have first been corrected.

**Protein and protein-energy supplements**

The crucial role of protein as the major limiting nutrient in winter grassveld was only fully appreciated by stock farmers once it was realized that urea can serve as a cheap and readily available source of protein. After the initial studies showing that urea could replace natural protein as a source of nitrogen (Murray and Romyn, 1939; Smuts and Marais, 1940; Groenewald and van der Merwe, 1940), practical feeding trials—first with urea-molasses mixtures and later with other combinations of urea—showed that winter weight loss could be significantly reduced by providing grazing ruminants with their minimum crude protein requirements (Bishop, 1957; Nel, 1960; Pieterse, 1967; Lourens, 1968; van Niekerk et al., 1968a and b; Nel et al., 1970; Bishop and Grobler, 1971; Topps, 1971). Simultaneous work using more expensive natural protein sources, such as cotton or groundnut oil cake and later fish meal, produced similar and sometimes superior results, particularly in the case of sheep (Murray et al., 1936; Rhodes, 1956; Kemm and Coetzee, 1967 and 1968; Bishop and Grobler, 1971). However, it was the low cost and free availability of urea and biuret as protein sources which led to the widespread use of protein winter supplements as a method of combating dry season weight loss in grazing cattle.

An observation of great significance to emerge from these experiments was that NPN and protein supplements greatly improved pasture intake and encouraged animals to consume even the most unpalatable grasses (Bishop, 1957; Nel, 1960; van Niekerk et al.,

Table 4. **Average liveweight loss and lick intake in cattle supplemented with fish meal and urea licks during a five-month period on winter grassveld grazing.**

| | Salt (40%)<br>Bone meal* (60%) | Fish meal (40%)<br>Salt (60%) | Urea (15%)<br>Maize meal (30%)<br>Bone meal* (25%)<br>Salt (30%) |
|---|---|---|---|
| Initial weight (kg) | 291 | 291 | 291 |
| Weight loss (kg) | 35 | 3 | 4 |
| Lick intake (kg/day) | 0.25 | 0.65 | 0.36 |
| Crude protein intake (g/day) | 0 | 166 | 166 |

* Degelatinized bone meal
**Source:** Bishop and Grobler (1971)

1968b; Nel et al., 1970; Winks et al., 1970). This finding is of great importance because the use of such supplements, coupled with sufficiently high grazing pressures, makes it possible to fully exploit the vast quantity of fibrous and unpalatable grass which, at least in Africa, normally goes to waste and is burned during or at the end of each dry season. Although the practice of veld burning is sometimes warranted as a tool in veld management, it invariably has an adverse influence on the vigor of grass; and it remains a major cause of soil erosion in southern Africa. It is, however, the tremendous waste of animal food which ultimately makes it difficult to justify this practice.

As far as the grazing ruminant in the sour and mixed grassveld areas is concerned, there can be little doubt that protein is the chief limiting nutrient. Since a regular daily supply of ammonia is essential for the normal functioning of the cellulolytic micro-organisms in the rumen, insufficient ammonia retards the activity and multiplication of these organisms. Digestion of feed, rate of passage and feed intake are consequently impaired. Under these conditions, therefore, the grazing animal not only suffers from a lack of protein but, as a result of this, also suffers from a lack of energy. The lack of energy, although secondary to that of protein, plays a vital economic role since it is more expensive to meet the grazing animal's energy requirements through supplementation than it is to supplement its much smaller protein requirements. Thus, by supplementing NPN or protein (in the presence of sufficient grass), it is possible to overcome not only the primary protein deficiency, but it is also possible to meet all or practically all the animal's energy requirements through increased intake of pastures.

Although the reduction in dry season weight loss through protein supplements is an important finding, it is the influence of these supplements on reproductive performance that is of greatest interest to the stock farmer. An important outcome of all the long-term experiments on supplementary feeding has therefore been the considerable improvements in calving and recalving percentages which have been recorded to date (Bouer, 1965; Bembridge, 1963; Elliott, 1964; Schur, 1968; Ward, 1968; Lesch et al., 1969; Steenkamp, 1971).

Table 5. **Effect of winter protein supplements on average liveweight and calving performance of Sussex-type cows fed during three seasons from 1958 – 1961.**

| | Negative control | Cottonseed oil cake* |
|---|---|---|
| Winter weight loss (kg) | 70.0 | 30.4 |
| Summer weight gain (kg) | 86.8 | 51.8 |
| Calving percentage (three-year avg) | 63.3 | 76.3 |
| Calving percentage (last two years) | 57.0 | 74.5 |
| Average calf weaning weight | 153.4 | 176.6 |
| Average annual mortality (%) | 9.6 | 0.6 |

* Cottonseed oil cake fed at rate of 0.45—0.91 kg/day during winter only
**Source:** Bembridge (1963)

A problem which has still not been fully resolved is the role of energy fed together with or in addition to protein as a supplement. Unfortunately, the results of many grazing experiments are confounded by the lack of control over energy and protein intake which makes the interpretation of these results difficult. Where the purpose of supplementary feeding is merely to get animals through the dry season as cheaply as possible and without excessive weight loss, the use of NPN or protein supplements without additional energy (except that which serves as a carrier for NPN or that fraction of energy which forms an inseparable part of any true protein) is invariably the most economic approach to follow. Experiments show that although additional energy does give an added response in liveweight, this response is often small so that the added costs can seldom be justified in terms of economic returns (Nel et al., 1970; du Plessis and Venter, 1971). The additional energy furthermore results in poorer utilization of the natural grazing (Nel et al., 1970).

It is, however, important to point out that this conclusion does not apply under all conditions. Practical experience acquired by farmers and the results of some unpublished experiment station trials show that in spite of NPN or protein supplements, growing animals and lactating beef cows are not always able to satisfy their greatly increased energy demands. This applies particularly to areas such as the sour grassveld where the nutritive value of grazing in winter is very poor. Under these conditions, protein supplements can be used to prevent weight loss during pregnancy; but during late pregnancy and particularly during lactation, it is essential to feed some form of additional energy such as maize grain, maize silage or good-quality hay. Without such supplements, cows lose too much weight; and as a consequence, reproduction suffers.

**Other supplements**

Chemical analysis of dry grassveld shows that it is also deficient in other nutrients such as $\beta$-carotene, sodium and sulfur. Relatively little research work has, however, been devoted to these and other possible limiting nutrients.

There is some evidence that animals may require supplemental salt in sour and mixed grassveld areas (Murray et al., 1936; du Toit et al., 1940; Rhodes, 1956; Bisschop, 1964), but this probably does not apply to the sweet grassveld areas (Skinner, 1964) and certainly not to areas with saline drinking water. Since salt is invariably used to control the intake of protein or phosphorus supplements, this question is, in any case, of academic interest only.

It is widely assumed that sulfur is an essential ingredient of dry season supplements, particularly those based on NPN, but few attempts have been made to test this hypothesis with grazing animals. Evidence in support of the inclusion of sulfur in dry season supplements for grazing cattle is therefore still lacking at this stage.

The crucial role of certain branched—chain fatty acids in promoting the activity of the cellulolytic bacteria in low-protein diets has been clearly demonstrated by van Gylswyk (1970). In practice, however, the requirement for these nutrients is probably met by being derived either directly from protein supplements (El-Shazle, 1952) or indirectly from NPN-starch supplements (Schwartz, 1968).

Although $\beta$-carotene is deficient in dry grassveld for many months of the year (du Toit et al., 1940; Skinner, 1963), attempts to demonstrate liveweight responses to vitamin A in grazing animals have not met with success so far (Skinner, 1963; Elliott, 1964; Ward, 1968; van Schalkwyk and Lesch, 1970). This failure may, however, be due to the lack of protein or other more limiting nutrients in the diet. In order to evaluate the role of $\beta$-carotene, phosphorus or any other nutrient in winter grazing, research workers in the future must ensure that other major nutrient deficiencies have first been alleviated.

## SUMMER SUPPLEMENTS

Superficially, the problem of improving the low productivity in beef cattle in southern Africa appears to be a matter of preventing the severe weight losses characteristic of the dry season. However, even when pastures are at their best, weight gains on natural veld leave much to be desired (van As, 1972). Only recently have research workers started to pay attention to the question of improving summer weight gains through supplementary feeding.

### Phosphorus supplements

In their original studies on phosphorus supplements of grazing animals, Theiler et al. found that bone meal supplements fed throughout the year had a marked influence on the productivity of beef cows in terms of milk production and in numbers and weight of calves weaned. This finding led to the almost universal acceptance of phosphorus as a supplement for grazing animals in southern Africa.

In practice, phosphorus supplements are fed mainly during the dry season when farmers are acutely aware of the need of some form of supplementary feeding. Only in recent years has attention been focused on the fact that the benefits derived from phosphorus supplementation are almost exclusively associated with the summer period when the animals are gaining in liveweight and when the phosphorus content of the pasture is at its best. This fact is reflected not only in the original work by Theiler et al. (1924) but also in all subsequent work that has been published in southern Africa (Bisschop, 1964; Ward, 1968; Schur, 1968; van Schalkwyk et al., 1969). It is also of interest to note that sheep on sour grassveld not only respond to phosphorus supplements (Kotze, 1948), but also that the response pattern—i.e., a large positive summer gain followed by an apparent negative response during the dry season—is identical to that observed in cattle.

Table 6. **Seasonal liveweight (kg) response to year-round phosphorus supplementation in grazing cattle.**

| Season | Negative control | Phosphorus* at 3.6 g/day |
|---|---|---|
| 1st winter | — 16.4 | — 18.6 |
| 1st summer | + 97.7 | + 119.1 |
| 2nd winter | — 37.7 | — 50.0 |
| 2nd summer | + 108.6 | + 120.9 |
| 3rd winter | — 61.8 | — 69.1 |
| 3rd summer | + 174.5 | + 187.3 |
| Final weight at 3½ years | 424.5 | 450.0 |

* Applied by dosing monosodium phosphate twice weekly
**Source:** Schur (1968)

It is therefore evident that phosphorus is an important and probably the major limiting nutrient in the diet of animals on natural pasture during the summer months in many areas of southern Africa. This conclusion obviously does not apply to those areas where no response to year-round phosphorus supplementation can be demonstrated.

**Protein supplements**

Chemical analysis of grassveld in many regions of southern Africa strongly suggests that protein may be a further limiting nutrient during much of the summer grazing period when pastures are most nutritious. Several studies with both sheep and cattle (Kreft, 1963 and 1966; van Niekerk and Muir, 1970) fed either NPN or NPN-protein supplements failed to illustrate any response during the early summer months. More recent experiments conducted by Bredon et al. (1970 and 1972) with protein supplements produced small but significant improvements in summer weight gains. These results do not appear to be of economic significance. Of interest, however, is the finding that the response to protein supplements sets in much earlier in autumn than is generally thought. There is also some evidence to suggest that animals respond to protein supplements during exceptionally dry summers (Bishop, 1964; Bredon et al., 1970).

**Energy supplements**

The role of energy as a possible limiting nutrient in the diet of animals on summer pasture has been examined in only a few experiments to date. Bredon et al. (1972) failed

Table 7. **Comparison of seasonal effect of urea licks on liveweight (kg) and carcass gain (kg) in grazing cattle from November, 1962 to February, 1965.**

| | Negative control | Urea lick winter only | Urea lick winter & summer |
|---|---|---|---|
| Initial liveweight | 234.5 | 233.6 | 255.0 |
| Avg summer weight gain (1962-65) | 135.9 | 131.8 | 135.0 |
| Avg winter weight loss (1962-65) | – 43.2 | – 22.7 | – 27.3 |
| Final carcass weight | 235.0 | 253.2 | 256.8 |

**Source:** Kreft (1966)

to measure significant differences in liveweight between groups of cattle fed isonitrogenous diets which varied in energy content. On the other hand, Pieterse and Preller (1965) produced statistically and economically significant results by feeding 1.5 kilograms maize grain per day to grazing cattle on summer veld. There may also be a case for feeding extra energy to lactating cows which calve during lush spring grazing. Bishop and Kotze (1965) demonstrated that recalving percentages and weaning weights could be considerably improved by feeding 2.75 kilograms of maize grain per cow per day for a period of about two months following calving in spring. This response was attributed to an inadequate intake of energy by cows grazing lush, but short spring grassveld.

## SUPPLEMENTARY FEEDING PROCEDURES

The following are the most important procedures that have been used to provide supplements to grazing animals in southern Africa:

### Spraying of veld grasses

One of the earliest attempts at supplementary feeding and improving the intake of dry grassveld in South Africa consisted of spraying veld grass in situ with mixtures of molasses and urea. The mixture used usually consists of ten parts by weight of molasses, ten parts by weight of water and one part by weight of urea. The area of grass sprayed is limited to what the animals will clean up in one day.

This system is seldom applied today because it is too laborious, because too much liquid is wasted on sparse grazing, and because it cannot be applied mechanically in inaccesible areas. Nevertheless, the method gives good results and good veld utilization, and it is a safe way of supplementing urea.

## Liquid supplements

Wheel or drum feeders as described by Moore (1968) are commonly used—particularly in areas where molasses is cheap—to supplement mixtures of urea and molasses. The mixture used is identical to that required for spraying veld grass as described above. Sometimes phosphoric acid is also added. Intake is controlled by increasing or decreasing the amount of water in relation to the other ingredients. This is a relatively safe method of feeding urea, and intake is readily controlled. Excessive molasses intake in relation to urea should be avoided, as this not only increases costs but can also result in poor pasture utilization.

## NPN blocks

Solid blocks based on molasses or molasses by-products and containing 10 to 40 per cent urea or biuret, together with salt and a source of phosphorus, are used extensively in practice. This method of feeding is attractive to farmers because of its easy application. Disadvantages include inability to regulate intake to the desired level, danger of toxicity where more than 10 per cent urea is used, and low energy value of the supplement in relation to its nitrogen content.

## NPN licks

Dry mixtures of urea or biuret (10-25 per cent), salt (20-30 per cent), maize meal (25-35 per cent) and dicalcium phosphate (25 per cent) are widely used as supplements. Such mixtures are more versatile than blocks since the intake of essential nutrients can be controlled by manipulating the ingredients. Intake of the lick is regulated by varying the salt concentration of the mixture. Molasses (5-10 per cent) is sometimes added to prevent losses due to wind since the mixture is usually fed in halved 200-liter oil drums. A disadvantage of this method of supplementary feeding is that it is more complicated than block supplements. Toxicity may also be a problem where urea is used as a source of NPN.

## Protein licks

Salt is often used to control the intake of oil cakes or fish meal. Salt (40-60 per cent)-fish meal mixtures are particularly popular among sheep farmers in South Africa. Various combinations of NPN, salt, phosphorus and one of the natural protein sources are also commonly used. In such cases, oil cake or fish meal is used in the place of maize meal as an energy source and as a palatability factor to encourage intake.

**Poultry manure**

The use of broiler or layer manure as a winter supplement is becoming increasingly common. Grazing cattle given free access to poultry manure will normally consume about 2 kilograms per day. It is seldom necessary to control the intake with salt. Poultry manure has the advantage of being cheap and safe. Because it is also a fairly good source of energy, it is often ideal for supplementing lactacting cows. Its disadvantages include spoilage during storage and excessive bulkiness which complicate feeding under extensive ranching conditions.

In all the above systems, the aim is to supplement grazing animals with 150 to 200 grams of crude protein (N x 6.25) and 6 grams phosphorus (P) for maintenance purposes on dry winter grazing. The optimum level naturally depends on environmental conditions. Lactating cows may require supplements of 400 grams crude protein and 12 grams phosphorus. This higher protein requirement of lactating cows restricts the amount of NPN that can be used in winter supplements for this class of animal Dry and lactating cattle require 6 and 12 grams of supplemental phosphorus, respectively, during the summer grazing period. This is normally provided by mixtures of salt (50 per cent) and dicalcium phosphate (50 per cent), or salt (35 per cent) and bone meal (65 per cent).

In conclusion, experiments conducted with grazing animals in southern Africa during the past 50 years have succeeded in identifying the major limiting nutrients in natural pastures during the various seasons of the year. By supplementing only those nutrients which are known to limit animal production, it has been demonstrated that it is possible to increase markedly the productivity of range animals while at the same time making better use of available grazing. Such a system of strategic supplementation not only minimizes supplementary feeding costs but also makes it possible to exploit this vast natural resource which without supplementation cannot be efficiently or fully utilized by grazing animals.

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# GENETIC SYSTEMS FOR THE IMPROVEMENT OF PRODUCTION IN THE TROPICS

*Dieter Plasse*

The severe beef shortages in the world market demand make it more and more essential to make full use of the vast tropical savannas in Latin America for the production of meat.

At present, the level of production in these areas is extremely low; Table 1 shows the estimated average values. Many factors contribute to this low level of productivity, and each one should be considered of importance if production is to be increased and if the cattle industry is to become a more profitable enterprise. It is risky to establish priorities for the factors influencing production at the national level even though this may be the right course of action when dealing with specific zones or individual ranches.

At the present time, the main problem seems to be of a socioeconomic nature, which can only be solved through a sound agricultural and livestock policy and through an extension service that can make good use of the results of research conducted within the country itself. Both the extension and research teams should be staffed by specialists in every field related to beef cattle. The failure to integrate a team of technicians from different fields as a result of professional jealousy, policies of professional societies or organizations, or the administration's reluctance (both at the government and university levels) to understand this problem has been the main reason for the failure to unite the efforts of agronomists, veterinarians, animal husbandrymen, economists, etc., for the integral evaluation and improvement of the cattle industry.

Too often, researchers do not leave their laboratories, and cattle growers do not visit the experiment stations; therefore, there is no contact between these two groups. Also, many times researchers are consulted by agricultural policy makers only after a certain policy has failed. This is obvious in the agrarian reform programs.

Table 1. **Estimated values of the level of production in the Latin American tropics.**

| Characteristic | Present level of production* |
|---|---|
| Calving percentage | 35-60% |
| Percentage of deaths to age of first service | 10-25% |
| Weaning weight (7 months)** | 120-150 kg |
| Age at first calf | 3-4 years |
| Slaughter age (males) | 3.5-5 years |
| Slaughter weight | 350-450 kg |
| Extraction rate | 8-15% |

* Does not indicate the range of variation but the limits that include the means of the principal zones

** Systematic weaning is not practiced in most herds; but it is assumed that on the average, natural weaning occurs in this period of time (seven months).

**Sources:** Bauer, 1968; Carrera; Estrada, 1966; Hill, 1967; Mayobre, 1966; Tundisi, 1970. (UCV/FCV, unpublished data).

## INTEGRAL IMPROVEMENT OF THE HERD

Beef production is influenced by two main groups of factors: the genetic potential of cattle and the environment in which production takes place (Fig. 1). Genetic potential can be subdivided into additive and nonadditive potential; this subdivision is a result of the way in which the genes act. The environment includes all those factors that are not determined by the genotype of the animal, such as climate, feed, diseases, management, factors inherent to the animal such as age and sex, and the entire complex of socioeconomic factors, which are of utmost importance in Latin America.

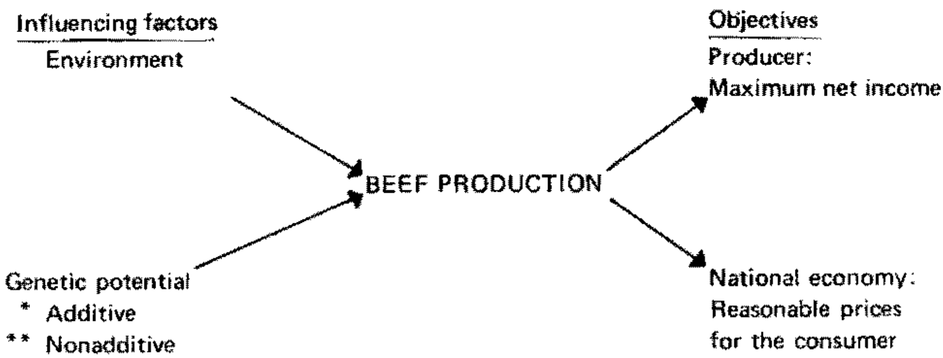


**Figure 1.** Influencing factors and objectives of beef production.

For the cattle producer the main objective of production is to obtain the highest possible net income. From the standpoint of the national economy, however, the main objective is the availability of reasonably priced, good-quality products for the consumer.

For that reason, the improvement of livestock productivity should include all the fields of agricultural and livestock science, and each one should be of equal importance. If, for instance, geneticists are able to produce animals with inheritable traits for superior weight gains, these animals will also require better feed and an improved health and management program in order to be able to express their genes in a better phenotype; that is, in better production. If, on the contrary, an animal of an inferior genotype is placed in an improved environment at a high cost, production will not increase as expected because the animal does not have the genotype that can profit from environmental level.

Normally, the Latin American tropics have animals of low genetic potential in an unimproved environment. Higher levels of production will be possible only when the genotypes and the environment are improved simultaneously. Perhaps the highest biologically feasible level will not be the most economical; and for this reason, breeding and environmental improvement must be balanced at a level where maximum economic returns can be obtained (Fig. 2). Therefore, it is important that research, extension and production improvement programs be economically oriented.

This paper deals with genetic systems aimed at increasing productivity; it should not be forgotten that they will have favorable results only when they become part of an integral development program for the herd.

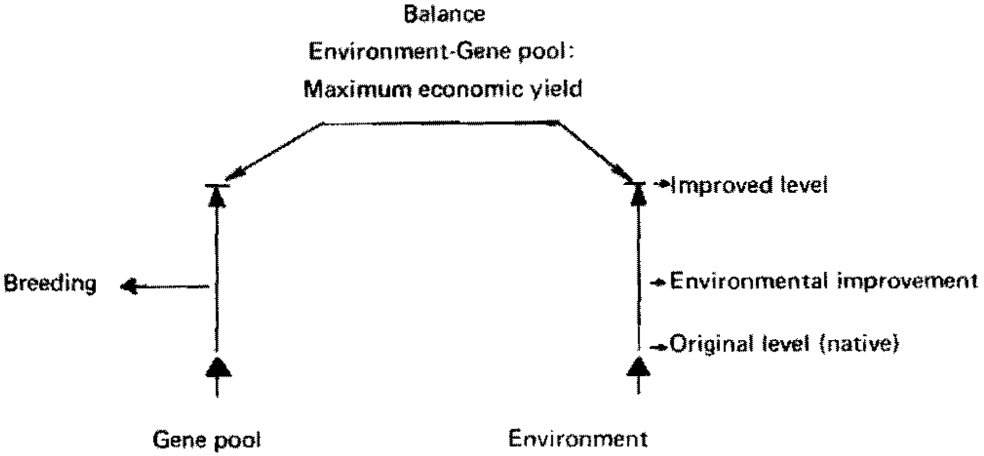


**Figure 2.** Breeding and environmental improvement under different economic conditions. (Please read from bottom to top.)

# BREEDING METHODS TO INCREASE PRODUCTIVITY

There are two breeding methods: selection, which increases the additive potential, and crossing, which influences the nonadditive potential.

## Characteristics to be considered

A low reproduction efficiency and a deficient growth rate demand the establishment of a breeding program in order to improve these characteristics. Efforts should be channeled in this direction because the larger the number of traits included in a selection program, the less progress that is made with each one of them.

At present, too much emphasis is placed on folkloric characterictics, which do not contribute anything to productivity. Recent emphasis on size per se is also harmful. It is difficult to understand the reason why cattle growers prefer to have cows that weigh 600 kilograms and bulls that weigh 1,200 kilograms when the objective is to raise a sufficient number of steers under good grazing conditions that weigh 450 kilograms in two or three years. It has been proven in other ecological zones (although under different economic conditions) that cows of average size and weight are the most efficient producers (Cartwright et al., 1964; Singh et al., 1970; Long et al., 1971).

The main problem existing in tropical herds is their low reproductive efficiency. This not only results in a low number of animals for market but also hinders any genetic progress. Low weaning weights and deficient postweaning growth result in slaughter animals of advanced age. These characteristics can be improved through selection and crossing, and the high mortality rates can be controlled primarily through improved management practices and a sound health program.

## Selection

When discussing the selection programs, differentiation should be made between males and females because, under the present conditions, different production characteristics should be taken into account.

### Females

Theoretical and practical considerations lead to the conclusion that it is advantageous to have all normally developed heifers, free of genetic defects, served during the mating season when they are approximately two years old. All those that fail to conceive and those that have inferior offspring should be rejected. Those cows that have not conceived for two consecutive years and those that have yearling calves with low weaning weights should also be rejected. Thus, females should be selected for high reproductive efficiency and good maternal ability, measured by the weaning weight of their calves.

**Bulls**

Replacement bulls must be selected for high reproductive efficiency and good postweaning gains. This last characteristic has a moderate heritability and can be easily improved on the sire's side. Conformation should not be emphasized because despite its commercial value, it is not a good indicator of the quality of the carcass. In the future, where a high-quality carcass is demanded, this characteristic (which is an inheritance index) should be taken into consideration in the male selection program.

These selection systems are explained in detail in another paper (Plasse, 1969).

**Results**

The previously mentioned selection systems, along with good management, have given good results in experiment stations and in private cattle operations.

In a large herd in the tropics of Bolivia, reproductive efficiency increased from less than 50 per cent to 89 per cent in eight years (Plasse et al., 1973c). In four private herds that were included in a research and extension project in Venezuela, the average calving percentage of 3,700 cows was 51 per cent before the improvement program was begun. In the second year—after the establishment of a mating season, a management program, and the culling of those females that failed to conceive—pregnancies reached 62 per cent, which represented an improvement of 20 per cent in one year (UCV/FCV, unpublished data).

In a selection program based on a production test in a Brahman herd at La Cumaca Experiment Station in Venezuela, reproductive efficiency improved 46 per cent during the first five years of the program; the percentage of weaned calves improved 68 per cent; preweaning growth improved 15 per cent and post-weaning growth, 22 per cent (UCV/FCV, unpublished data). Progress was less in the following years, but there was a gradual increase in total production.

Based on the data obtained in Venezuela, a model has been established for a herd of 100 cows, where improvement of productivity per cow can be observed during the first five years of a selection and organized management program (Table 2). From this table it can be deducted that through selection and good management, production can be doubled in any tropical herd in the first six years of improvement.

Table 2. **Possible increase in productivity through selection and environmental improvement for 100 cows.***

| Characteristic | Production level: Beginning Year 1 | Production level: End Year 5 | Index Year 1 = 100 |
|---|---|---|---|
| Pregnant cows (No.) | 55 | 75 | 136 |
| Calves born alive (No.) | 52 | 72 | 138 |
| Weaning | | | |
| Animals (No.) | 46 | 68 | 148 |
| Weight/animal (kg) | 140 | 160 | 114 |
| Total weight (kg) | 6,440 | 10,880 | 169 |
| Weight/cow in herd (kg) | 64.4 | 108.8 | 169 |
| Eighteen months | | | |
| Animals (No.) | 44 | 66 | 150 |
| Weight/animal (kg) | 230 | 280 | 122 |
| Total weight (kg) | 10,120 | 18,480 | 183 |
| Weight/cow in herd (kg) | 101.2 | 184.8 | 183 |

* The parameters used were obtained in experiment stations and in private herds in Venezuela. The following data were used in the calculations:

| | Year 1 | Year 5 |
|---|---|---|
| Abortions and stillbirths (%) | 6 | 4 |
| Deaths until weaning (%) | 12 | 6 |
| Deaths until 18 months (%) | 15 | 9 |

**Source:** UCV/FCV (Unpublished data)

## Crossbreeding

### Results

When *Bos taurus* breeds (of European origin) are crossed with *Bos indicus* breeds (Zebu native of India and Pakistan), their offspring have a higher reproductive efficiency, viability and growth than the average purebred parents. This is known as heterosis, and the author considers that the inducement of heterosis is the main objective of crossing in the Latin American tropics.

Table 3 summarizes the percentage of heterosis reported in crosses of *Bos taurus x Bos indicus.* A moderate increase in several characteristics of production contributes to improved productivity of 20 to 40 per cent per cow.

The maximum degree of heterosis in reproductive efficiency, in maternal ability and in postweaning growth can be observed in $F_1$ animals. Undoubtedly, the highest total productivity is observed in $F_1$ cows, but crossbreeding systems that take advantage of this fact are not functional under the conditions presently existing in the Latin American tropics.

The only crossbreeding system known to induce adequate levels of heterosis through generations and known to be functional is rotational crossbreeding with two or more breeds.

In Latin America there are several experimental programs to test the crossbreeding systems and the available data related to the first and, in some cases, to several generations. In a crossbreeding program among Criollo, Brahman and Santa Gertrudis breeds in Costa Rica (Peroz et al., 1971), cows produced 22 per cent more kilograms of weaned calves when these were the offspring of bulls of another breed,as compared with purebreds.

Published data of a crossbreeding program in Venezuela (Frómeta et al., 1973; Borsotti et al., 1973; Plasse et al., 1973a and b) show that calves ($F_1$) of Criollo cows and Brahman and Santa Gertrudis bulls and of Brahman cows and Charolais, Red Poll and Brown Swiss bulls have birth, weaning and 18-month weights 11, 10 and 14 per cent higher, respectively, than the average Criollo and Brahman purebred calves (Table 4).

Table 3. **Heterosis in crosses between** *Bos taurus* **and** *Bos indicus*

| Characteristic | Heterosis (%) |
|---|---|
| Reproductive efficiency | 10-20 |
| Viability | +? |
| Preweaning growth | 8-20 |
| Postweaning growth | |
| USA | ± 10 |
| Latin America | 10-20 |
| Productivity per cow | 20-30 |

**Sources:** Cundiff et al., 1970, Cunha et al., 1972; Plasse et al., 1973b; Muñoz and Martin, 1969; Peroz et al., 1971; Salazar, 1971; Stonaker, 1971

Table 4. **Adjusted weight averages of Criollo, Brahman and crossbred ($F_1$) yearling calves at the experiment station in the Llanos (MAC–UCV projects).**

| Sire | Dam | Birth weight (kg) | Weaning weight (kg) (205 days) | 18-month-weight (kg) |
|---|---|---|---|---|
| C | C | 26 | 153 | 208 |
| B | C | 31 | 170 | 263 |
| SG | C | 31 | 175 | 256 |
| C | CL | 25 | 146 | 211 |
| B | CL | 29 | 173 | 253 |
| B | B | 25 | 161 | 236 |
| CH | B | 28 | 173 | 258 |
| RP | B | 24 | 160 | 240 |
| BS | B | 27 | 172 | 262 |
| B | B | 26 | 161 | 237 |
| Total | | 27 | 165 | 243 |
| Purebred | | 25.5 | 155 | 223 |
| Crossbred | | 28.3 (+11%) | 166 (+10%) | 255 (+14%) |

C = Criollo Río Limón
CL = Criollo Llanero
B = Brahman
CH = Charolais
RP = Red Poll
BS = Brown Swiss

Number of observations:

| | |
|---|---|
| At birth | 1,208 |
| At weaning | 1,119 |
| At 18 months | 958 |

**Source:** Borsotti et al., 1973; Plasse et al., 1973a; Frómeta et al., 1973

Unanalyzed data (MAC-UCV, unpublished data) from the same project indicate that calves of $F_1$ heifers ( ¾ Zebu or ¾ *Bos taurus*) weigh 16 per cent more at weaning and 11 per cent more at 18 months as compared to purebreds (Brahman and Criollo). The crossbred heifers reach puberty at an age that is 9 per cent earlier than in purebreds (Linares et al., 1973b; Ordoñez et al., 1973). Unpublished data for 381 heifers and 272 first-lactating cows indicate that the advantage of the crossbreds over the purebreds (as regards conception) is of 61 and 11 per cent, respectively. The percentage of heterosis for pregnancy in Criollo x Brahman females compared to purebreds is estimated at 19 per cent for heifers and at 91 per cent for first-lactating cows. This advantage in the reproductive efficiency of first-lactating cows indicates that crossbreeding is the most efficient method to solve the problem of low conception rates, especially during the first lactation period (Linares et al., 1973a; Plasse et al., 1972).

If the data on the reproductive efficiency of $F_1$ and purebred heifers and the weight of their offspring at weaning and at 18 months are used to estimate weight production per cow in the herd, the following results are obtained: $F_1$ cows produce 33 per cent more kilograms of calves at weaning and 26 per cent more at 18 months. However, the values are expected to be lower for future generations.

Considerable improvement in reproductive efficiency was also observed in the material of 23,413 palpations corresponding to Criollo and Zebu cows and their crosses in a herd in the Bolivian tropics (Table 5).

If a small group of "selected Criollo cows," raised under better breeding and management programs in comparison to others, is excluded from the discussion, the performance of the crossbred cows is 11 per cent higher as compared to that of the purebred (Plasse et al., 1973c). In the same herd, the data corresponding to 15,838 steer carcasses (Table 6) showed that the crossbreds rendered 15 per cent more meat than the purebred Criollo steers (Bauer et al., 1973).

Data from Colombia (Salazar, 1971; Stonaker, 1971) related to the growth of Criollo x Zebu crosses confirm the results reported in Costa Rica, Venezuela and Bolivia, which indicate high percentages of heterosis, especially in postweaning growth and in reproductive efficiency.

Table 5. **Percentage of pregnancy in Criollo and Zebu cows and their crosses at El Beni, Bolivia (adjusted averages).**

| Breed | Pregnancy (%) |
|---|---|
| Number | 23,413 |
| $\bar{x}$ nonadjusted | 75 |
| $\bar{x}$ adjusted | 82 |
| Selected Criollo cows | 95 |
| Commercial Criollo cows | 76 |
| ¼ Zebu | 80 |
| ½ Zebu | 86 |
| ¾ Zebu | 80 |
| Zebu | 72 |
| Crossbreds vs. purebreds (excluding selected Criollo cows) | 11 |

**Source:** Plasse et al., 1973c

Table 6. **Carcass weight of Criollo steers and of crosses with Zebu at El Beni, Bolivia (adjusted averages).**

| **Breed** | **Carcass weight (kg)** |
|---|---|
| Number | 15,838 |
| Age x (months) | 48 |
| x nonadjusted | 215 |
| x adjusted | 230 |
| Criollo | 207 |
| ¼ Zebu | 220 |
| ½ Zebu | 240 |
| ¾ Zebu | 238 |
| Crossbred vs. Criollo (%) | 15 |

**Source:** Bauer et al., 1973

The only data published to date on alternate crossing (rotation of two breeds) between *Bos taurus* and *Bos indicus* for several generations were reported in Florida (Botero et al., 1973), and they show a percentage of heterosis for weaning weight per cow in the herd of 34, 25 and 16 per cent for $F_1$, ¾ and ⅝ cows, respectively.

**Beginning of a crisscross breeding program**

Here, two alternatives for starting a program that will truly adjust to the conditions of the Latin American tropics will be discussed.

1. Many herds are made up of an indiscriminate mixture of genes of the *Bos taurus* and *Bos indicus* breeds. In this case the herd should be subdivided into one group where *Bos taurus* predominates and into another where *Bos indicus* predominates; and bulls of the other breed should be used in each group of cows (Fig. 3). The heifers born in one herd can serve as replacements in the other. It would be advisable to have a third herd to produce bulls of the better adapted breed to be used in one of the crossing herds. The other breed of bulls would have to be purchased.

2. The other alternative would be herds that have been upgraded to Zebu (Fig. 4). Under these conditions, it is recommended to select 10 per cent of the best cows (herd II) for the production of Zebu bulls for crossbreeding and to buy the *Bos taurus* bulls. The other 90 per cent of the cows are subdivided at random into two

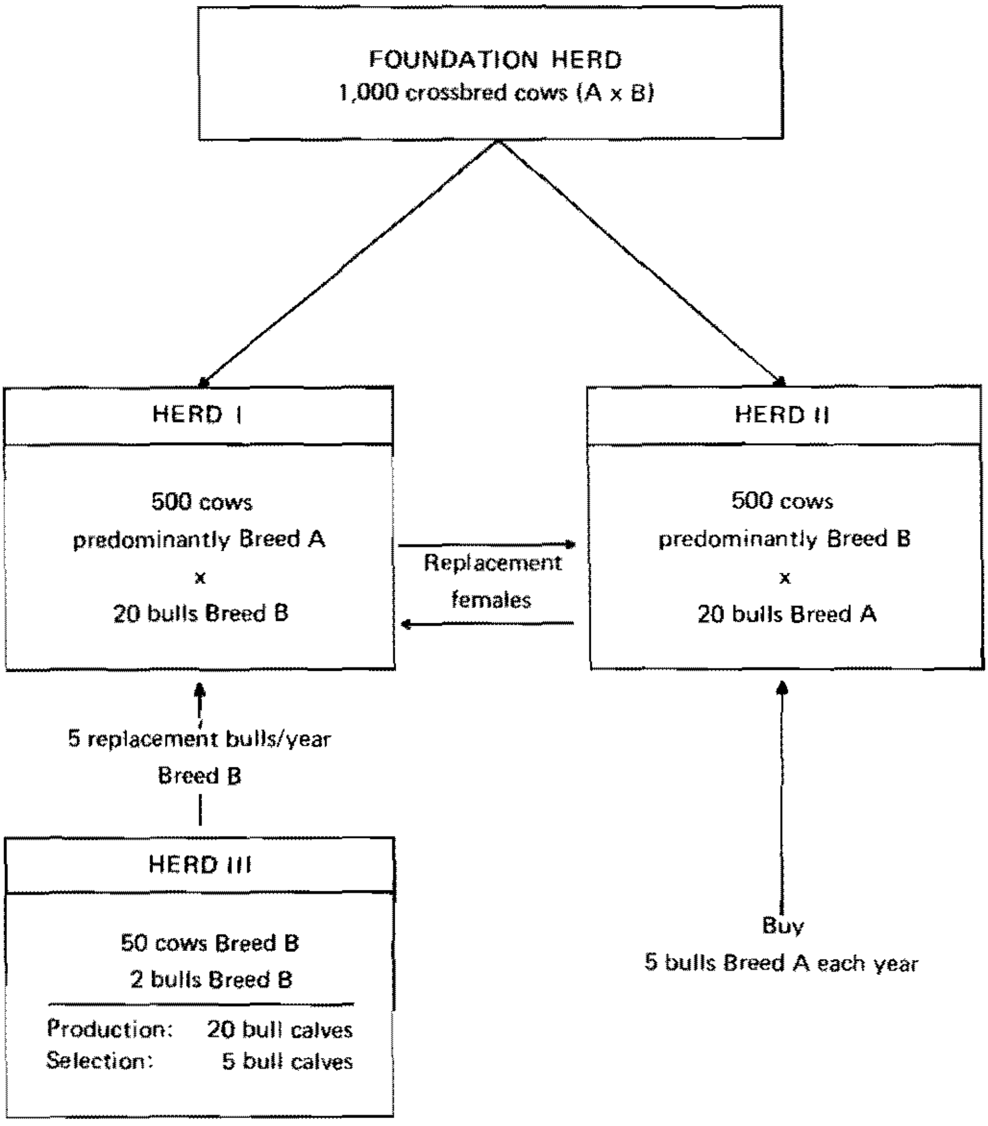


**Figure 3.** Beginning of a crisscross breeding project in a herd of crossbred cows (breeds A and B).

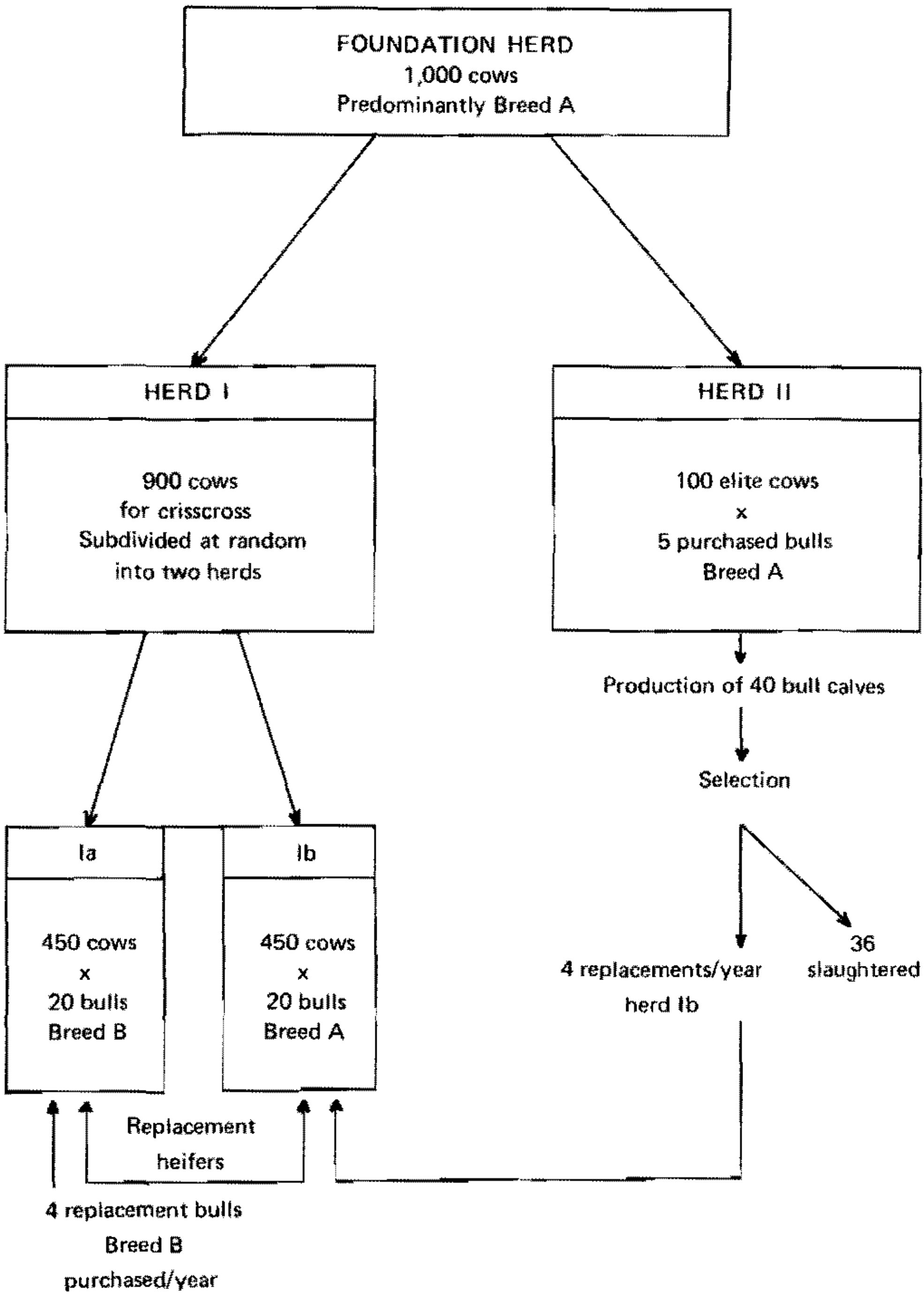


**Figure 4.** Beginning of a crisscross breeding program in a herd upgraded with Zebu.

groups, using *Bos taurus* bulls in one herd and *Bos indicus* in the other. The replacement heifers will always be served by bulls that do not belong to the same breed as their sire.

### Selecting the breed of the bull

The *Bos indicus* breeds present no problems when deciding which to use because each one has advantages and disadvantages, but all of them adapt well to the Latin American tropics.

Nevertheless, the selection of *Bos taurus* bulls presents problems. The data cited in this paper have proved clearly that the Criollo breed is very useful in crossbreeding programs with *Bos indicus;* their adaptability to the tropical environment is a great advantage.

Other breeds of *Bos taurus* that are not well adapted have been tested, and they will continue to be studied. If the *Bos taurus* bulls work well during the mating season and their hybrid offspring are superior to the *Bos indicus* breeds, the problem of adaptability is only academic. The same will be true once an artificial insemination program based on estrus synchronization has been developed. Noncriollo *Bos taurus* bulls normally involve high costs, and it is hoped that in the future, functional and economical artificial insemination programs will be developed.

### $F_1$ bulls and the concept of the gene pool

In the future, in those areas where purebred *Bos taurus* bulls present too many problems, $F_1$ *Bos taurus x Bos indicus* bulls could be used. If this type of bulls— representing several breeds that can contribute good characteristics— is used in a native population and then this population is closed and placed under a strict selection program for production characteristics (Fig. 5), it should be possible to establish a population with favorable genes and with some degree of heterosis.

This concept of establishing a gene pool and the selection from it should be technically reassessed under the conditions prevailing in the Latin American tropics. Most likely, these populations will lose some degree of heterosis as compared to those resulting from crossbreeding among purebreds. However, if they produce more than purebred *Bos indicus* populations, this system will be justified.

## OUTLOOK

The genetic methods discussed in this paper can be used in herds of a certain size and in cooperative agrarian reform programs (Plasse, 1973).

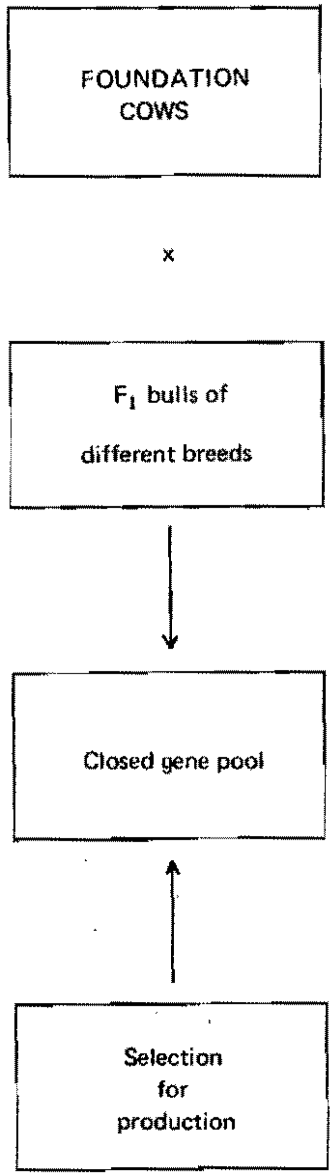


**Figure 5.** Concept of the gene pool.

Selection and crossbreeding should be combined in order to obtain maximum results in a breeding program. These methods should all be associated with different aspects of environmental improvement. If this is accomplished, the results summarized in this paper could bring about an increase in productivity of over 20 per cent per year in the first stage of improvement. This means that the tropical areas of Latin America could make a considerable contribution to the solution of the problems caused by beef shortages in the world and, through more efficient production, to the improvement of the living standards of their own populations.

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# ANIMAL HEALTH HAZARDS IN DEVELOPING NEW BEEF CATTLE PRODUCTION AREAS

*Eric Wells*

Before talking about specific hazards in developing new beef cattle production areas, I want to put the subject in context. First, the wording infers that there is a need to develop new beef cattle production areas. I have no doubt there is such a need, and I equally believe in the necessity for planned colonization and not exploitation. Animal health forms part of this planning, inextricably mixed with nutrition, breeding, management and economics. Veterinarians, therefore, have to be part of a team working towards a common end. This grouping of disciplines eliminates the arguments which can arise concerning the spheres of influence of different disciplines on the agricultural scene; or if there are arguments, the commodity approach helps to solve them quickly.

I think that veterinarians gain in another way. I think that the commodity team approach makes us reassess the contribution that a veterinarian can make towards developing livestock industries. Furthermore, we can assess whether veterinary schools in the world are teaching the attitudes and skills relating to animal disease necessary for a veterinarian to contribute to an animal commodity team. Most schools teach clinical medicine; that is, there is an emphasis on the individual animal. In a commodity team approach, however, we need an appreciation of ecology and epidemiology. That is, we need an appreciation of all the factors which contribute to the presence or absence of disease in an animal population. The two animal health subjects chosen for this seminar reflect this attitude.

The kind of animal health hazard that I am going to talk about will relate to pathogenic agents and not to nutrition. Protein deficiency, mineral deficiencies or toxicities are clearly hazards in themselves. I am sure that they have been or will be dealt with elsewhere in this seminar. Here we merely confirm in passing that the importance of any single pathogen can be influenced by the nutritional status of the animal.

I want to approach the subject in general terms but then, wherever possible, I want to draw examples from our own work in the Llanos Orientales of Colombia. In the Llanos we collaborate with the Department of Veterinary Science of the Instituto Colombiano Agropecuario (ICA). Since we cannot separate human and animal disease, we also collaborate closely with the International Center for Medical Research and Training, Tulane University, based at the Universidad del Valle, Cali (ICMRT).

The development of new beef production areas infers that either cattle are being taken into virgin areas for the first time, or addition is being made to an already existing, undermanaged, sparse population. In either case, we are taking cattle and people into an area where an ecological equilibrium probably exists. For good or for bad, we are disturbing this equilibrium in one of two ways: First, man or his animals may intrude on existing harmless transmission cycles and become infected by an organism which to them is pathogenic. Second, man or his animals may bring organisms with them. These may infect the soil and form reservoirs of infection in wild animals, or the introduced cattle themselves may form reservoirs of infection for others.

In the first case, the most dramatic example in the world probably relates to the tsetse fly—trypanosome—wild animal balance in immense areas of savanna country in Africa. Ecologically, the balance is beautiful to see and study. Then clumsy man enters the scene with his clumsy domestic animals. The tsetse species that exist in these savanna situations feed on these new hosts. The trypanosomes they transmit are pathogenic to cattle and sometimes to man himself. In this extreme case, man has to withdraw, leaving large areas of land unused. At the ICA/CIAT station at Carimagua in the Colombian Llanos, we are finding examples of biological cycles into which we may intrude. Two I want to mention relate more to human than to animal disease.

The first one is again a trypanosomiasis problem. We have been culturing the blood of the wild animals we have captured and passing the cultures to a Ph.D. student at ICMRT. Among many positive trypanosome cultures, two trypanosome species have been revealed which are infective to man. One is the pathogenic *Trypanosoma cruzi,* the cause of Chagas' disease; the other is the nonpathogenic *T. rangeli.* For both, the natural cycle in the Carimagua area appears to be between reduviid bugs and the common oppossum (*Didelphis marsupialis*). The likelihood of human infection at Carimagua is small or nonexistent as long as present standards of cleanliness are maintained. We certainly need to know, however, that we are living in an endemic Chagas' disease area.

The second example is echinococcus. So far, we have found 25 per cent of the common agouti (*Cuniculus paca*), a large rodent, infected with echinococcus cysts. We are currently investigating the species to determine whether it is one known to be infective to man. **Echinococcus** spp. are tapeworms normally infecting carnivores. The eggs are passed out in the feces, and livestock and wild animals can be infected from contaminated grazing or water. In these intermediate hosts, the echinococcus takes the form of multiple cysts. The carnivore is reinfected when it feeds on the secondary host and ingests the cysts. Man can be involved as a "dead-end" intermediate host through fecal contamination on his hands and not washing before he eats. Likewise he could be infected from contaminated water or from soiled vegetables. The potential of an echinococcus problem can be seen from figures available from elsewhere in South America. In 1962, for example, the Argentinians reported 229 human cases. They also reported 484,075 domestic animal carcasses rejected in slaughterhouses for this cause.

One important vector of disease that we have looked for at Carimagua but have so far failed to find is the common vampire bat (*Desmodus rotundus*). Bat-transmitted rabies is a dramatic cause of cattle deaths in some areas of South America. Death rates of up to 50 per cent have been recorded in some herds. The presence or absence of this creature should certainly be known in any area to be developed. In experimental situations, at least, the vampire bat is also a vector of *Trypanosoma evansi*, a trypanosome which can be the cause of periodic epidemics associated with high mortality in the horse population.

These are sufficient examples to illustrate the first way in which we may upset an ecological balance. We will now consider the second way; that is, examples of cattle bringing new organisms with them to the area. One notable example is the spreading throughout the world of the tick *Boophilus microplus*. According to Hoogstraal, this tick originated in Asia as a parasite of wild bovidae, domestic animals and deer. Man's interest in Zebu cattle has been the means of the tick's spreading in vast regions of the world. The principal areas have been Australia, New Guinea, South Africa, Central and South America. The parasite causes losses not only because it is a blood-sucking parasite, but also because it transmits diseases. We have this problem of disease transmission in South America. The most important group are the so-called tick-borne hemoparasitic infections; i.e., *Babesia bigemina, Babesia argentina* and *Anaplasma marginale.* The basic points concerning the epidemiology of these infections are well known. For the sake of completeness, however, I will give a brief description and then describe what can happen after cattle from an endemic situation colonize a new area.

The two **Babesia** spp. are tick transmitted, particularly by *Boophilus microplus,* the most common cattle tick in South America. The infection can pass through the egg from one generation of tick to the next. *Anaplasma marginale* can be transmitted by some ticks although recent attempts to transmit it using *Boophilus microplus* have failed. Noncyclical transmission by various genera and species of biting flies does occur however. Common to both the **Babesia** spp. and to **Anaplasma** is the fact that calves on good nutrition can survive infections and acquire an immunity which extends into adult life. This immunity can be enhanced by subsequent infections. The immunity is characterized by a few organisms remaining in the blood of the immune animal; the animal therefore remains a carrier of infection. On the other hand, an animal first obtaining infection as an adult will most probably die without therapy.

If a herd from an endemic area, where all calves are infected and the adults are immune, is taken to a tick-free area, a dangerous situation can arise. The intensity of grazing may prove inadequate to maintain the tick population. All subsequent calves may not be infected with **Babesia,** necessary for acquiring immunity; therefore, a population of highly susceptible adult animals may evolve.

Fatalities could therefore occur from babesiosis if susceptible animals from this herd are moved back to an endemic area. Likewise, fatalities could occur if another herd moved in from an endemic area, giving sufficient population density to maintain a permanent tick population and thus restore transmission cycles. What happens with anaplasmosis cannot be so clearly projected because of the current doubt concerning the means of transmission.

I had one traumatic experience in Africa with deaths occurring from tick-borne disease on a large scale in a situation where we colonized an empty area of country. This was an area in Uganda, north of Kampala, which had been cleared of tsetse. The tsetse had invaded the area some ten years previously. Based on probability, we decided that if we stocked the area to capacity as quickly as possible, then the tick population would quickly establish to a level where transmission cycles would resume with hardly a break. In that situation we were not only dealing with anaplasmosis and babesiosis but also with two other tick-borne diseases as well: East Coast Fever (*Theileria parva* infection) and heartwater (*Rickettsia rumenantium*). We were wrong in our supposition. It took three years for transmission cycles to resume, by which time there were many susceptible animals. We had a short period of months when there was almost 100 per cent mortality in two- and three-year-old animals.

Similar catastrophes have perhaps already happened in Colombia. The Jesuits, for example, took herds of cattle to their early mission settlements in the Llanos at the end of the 16th century. Although the herds flourished and multiplied when first introduced, there is some indication of large herds being completely destroyed by disease later. That this was babesiosis can only be conjecture based on available evidence. More solid information is currently available. The few herds in the Colombian Llanos, for which we have readings on immune status judged by complement fixation, indicate different levels of transmission in different localities. This needs to be looked at in detail. We may already possess the ingredients for tragedy.

I would like to mention two other situations at the ICA/CIAT station in Carimagua. One is the apparently recent introduction of "nuches" *(Dermatobia hominis* infection) into the area, probably by infected cattle. The incidence of infection in some groups of cattle under ICA/CIAT experimentation is being noted. The increasing incidence based on certain specific grazing areas within the Carimagua farm could be explained by recent introduction of the parasite and slow colonization.

My last example is a potential situation. We have noticed at Carimagua that the paramphistome fluke is present. This comparatively nonpathogenic fluke inhabiting the rumen gives us an important warning. It frequently has the same intermediate snail host as the more pathogenic fluke *Fasciola hepatica;* therefore, cattle infected with fascioliasis introduced to Carimagua could possibly establish infection.

I think that these are enough examples. Let me just summarize what I have said. I have favored the commodity team approach to agricultural research and in this case specifically to beef. I have indicated that participating veterinarians need to be epidemiologists and not primarily clinicians. I have discussed two principal ways in which the equilibrium of an undeveloped area of land can be disturbed by the introduction of man and his cattle. I have given examples mainly from our own collaborative work in Colombia.

How a veterinary service meets this challenge is an interesting study in logistics. Clearly, a commodity team—including its animal health input—has to be in an area long before cattle arrive.

I hope I have been controversial enough to stimulate discussion. I am always aware that my experience has been mainly African and not South American. I look forward to hearing the comments and experiences of others.

# INFLUENCE OF POPULATION DENSITY ON ANIMAL HEALTH

*Carlos Pijoan and Pedro Solana*

Because of the increase in human population, it has become necessary to intensify animal production; this intensification, however, implies a larger concentration of animals per unit of land.

In order to illustrate health problems related to animal concentration, we believe it is useful to analyze first the systems nature uses to control wild animal populations.

Natural control of these populations appears to be exerted through exogenous and endogenous factors. Among the external factors we find (1) climate, which mainly affects insect control; (2) predators which control all animal populations; (3) feed, which is important because it is the most limiting factor in population growth; and (4) diseases, which exert control not only over wild populations but also over domestic ones. For instance, on Cyprus Island the combined number of sheep and goats reaches approximately 500,000; and although there have been variations in the ratios per species, every time these populations go above this figure, an epidemic occurs, reducing the population to the natural ceiling level (Schwabe, 1969).

The majority of wild populations exert control over their own populations for ecological reasons and for self-preservation. Fish bowl trials show this kind of control. If the adult fish population is frequently reduced, young fish are allowed to grow; but if adults are not taken out, young fish are exterminated by cannibalism, thus maintaining a constant population in the fish bowl.

Under natural conditions, the territorial and hierarchical systems maintain constant populations by limiting the number of animals reproduced. Occasionally, weak adults must migrate. Population is limited either by controlling the number of adults reproduced or by limiting the number of births per couple (Wynne-Edwards, 1965). In insects, this control is exerted occasionally by genetic mutations in the population. An example is the case of the locust migration in Africa, which occurs when the sedentary locust population undergoes a genetic mutation. The new nomadic locust (migratory phase) is much more active.

Thus, we can see that all wild populations maintain a certain number within the limitations of their habitat. In other words, they establish a ceiling population; that is, the number of animals that can survive in a given environment.

We believe that if we allow a given bovine population to establish its own ceiling population density within a given area, the number would be inferior to what is considered commercially viable for an extensive operation, not to say for an intensive one.

Man has already been able to deal with some of the aforementioned factors limiting population growth better than others. Endogenous factors are generally controlled by not allowing the free mating of animals or the ritual fights between males; however, this control is not always exerted. Such was the case of "peligüey" lambs, a species with little wool, well adapted to the tropics. When these animals were raised on family farms, several males stayed with the females. This situation has changed now that these animals are under intensive operational systems on our institute's experimental farm.

In regard to exogenous factors, climate is limiting. For instance, when European milk-producing bovine breeds are introduced to the tropics, they are affected by temperature and humidity. Predators do not usually constitute a problem; nevertheless, only one example will suffice to demonstrate the care that must be taken not to produce an ecological imbalance. In northern Mexico, coyotes caused great losses in the calf herds so it was decided to eliminate a great number of these predators. This, in turn, brought about a population explosion of hares and other wild rodents that competed with the cattle for forage.

As regards the established constraints of nutritional requirements, we shall mention here only a few examples related to overgrazing. Overgrazing favors not only the predominance of annual grasses in the pasture lands, but it can also produce genetic mutations in the improved pastures submitted to great ecological stress (Pimentel, 1968). Another problem is that the majority of diseases increase when animals graze on protein-deficient pastures (Schwabe, 1969). For these reasons, it is important that only optimal stocking densities be kept in each area.

Next, we have health problems. It is quite obvious that placing greater stocking rates within smaller areas will increase the incidence of many diseases because there is greater possibility of contact among the population, thereby facilitating transmission of diseases.

Many factors, not all of which are well understood, regulate the epidemic spread of a disease. One of the most important is that of social distance (Schwabe, 1969), the term used to describe the frequency of contact between animals —especially among those of different ages—since this is when the transmission of diseases increases.

However, not every disease is intensified in the same way. Sporadic diseases that present signs of being of exogenous origin will intensify or not, according to the transmission pattern within the herd. Endemic diseases will probably maintain a constant level unless new animals are introduced into the herd since the population is under a state of immunity to those diseases. On the other hand, in the case of epidemic diseases, when the number of affected animals is above that expected, the diseases will probably intensify upon increasing the possibilities of transmission. Vertical disease transmission (mother to son) will not be intensified, but horizontal transmission (between members of a population) will intensify or not, according to the transmission mechanism.

When the disease is transmitted by direct contact among the members of the population (e.g., dermatomycosis), it is almost certain that there will be a considerable increase in the incidence of the same. Disease transmission via the respiratory tract will probably increase when the members of a population find themselves in closer contact. Nevertheless, the degree of intensification of these diseases will vary from region to region according to the degree of humidity since in this case transmission is dependent upon aerosol emission or discharge and the characteristics of the latter have considerable variations caused by extrinsic factors such as the relative environmental humidity.

In vector-transmitted diseases, the possibilities for intensification are less predictable since there are two main variables involved: One is the dynamics of the animal population available to the vector; the other is the dynamics of the vector populations. This process was clearly observed in Mexico during the recent outbreak of Venezuelan equine encephalomyelitis (VEE). There was a greater degree of intensity in those places where there was a large, susceptible horse population and where at the same time the climatic conditions favored large populations of the vector mosquitoes. The disease was not present in the regions of Yucatán and Quintana Roo despite the existence of adequate ecological and population conditions, perhaps because the horses had already been exposed to the disease so there was a considerably high immunity in the population.

On the other hand, in regions such as San Luis Potosí and northern Tamaulipas, which have a dryer climate, considerable damage was caused by the disease because of the fact that rainfall was heavier than normal that year and also because of the greater susceptibility of the horse population. In geographic areas at altitudes over 2,000 meters above sea level, no outbreaks of the disease were expected since the traditional vectors are not found there. However, mosquitoes that were not believed to be vectors did transmit the disease, producing a few outbreaks. Therefore, we can see that the intensity of the disease depends not only on the host population but also on that of the vector.

Consideration should also be given to the fact that in situations where there are no vectors, some of these diseases are kept in animal reservoirs. Such seems to be the case with rodents and birds in connection with equine encephalomyelitis (Downs et al., 1962). This is also the case of vampire bats in relation to rabies in bovines. However, under conditions in which the vector population is constant or has a periodic fluctuation every year, it is possible that an increase in number of animals per hectare will facilitate disease transmission.

Another interesting example of the interaction of the host population and its vectors is found in the case of myxomatosis of rabbits, introduced in Australia and New Zealand. In Australia, it caused 98 per cent mortality during the first year, but mortality decreased yearly until the sixth year when it reached a level of 25 per cent (Pimentel, 1968). This decrease was probably caused by two factors: On the one hand, less resistant strains of the virus were selected because the mosquito vectors only feed on live animals and so the strains that took a longer time in killing the animal had a better chance of transmitting themselves. On the other hand, rabbits developed greater resistance to the agent. Thus, we can see that within a stable population of hosts and vectors, an epidemic disease rapidly becomes endemic and establishes a climax within that ecosystem. There was less mortality in New Zealand because of the lack of vectors (Schwabe, 1969).

It could be argued that eliminating the vector in these cases is enough to eliminate the disease, independent of the animal concentration. This has been achieved when there is only one vector and when the cycle of the vector in the animal is long. Such is the case of the ticks *B. annulatus* or *B. microplus* in regard to piroplasmosis. Yet many of these diseases have different vectors including mosquitoes, and control is virtually impossible, which is the case of anaplasmosis.

Another serious problem to be faced when moving into intensive production systems is the outbreak of new diseases. Two cases will illustrate this. In Mongolia, where there is a low animal population per hectare and where nomadic herd systems prevail, tuberculosis is rarely found. However, during recent years, tuberculosis has increased simultaneously with the introduction of the system of confining herds. Without a doubt tuberculosis is more common all over the world in cattle under confinement than under extensive operations. The increase in concentration of bovine populations in order to intensify productivity per hectare will most probably be accompanied with increases in the incidence of this disease unless specific measures are taken to prevent it.

The second case is found in the United States, where the practice of concentrating animals in small lots has brought about respiratory problems caused by three viruses: infectious bovine rhinotracheitis (IBR), bovine viral diarrhea (BVD) or mucosal disease, and parainfluenza 3 (PI-3) (Baker, personal communication). These viruses are practically unknown in tropical America, but it is probable that they exist at low levels in the populations. This is the case in Mexico, where the IBR virus has been detected in cattle under extensive systems and to a greater extent in those under confinement (Martell, personal communication). The level of this disease could increase considerably upon concentrating population densities, thereby facilitating transmission.

Certain diseases are closely related to others. Such is the case of fascioliasis and liver necrosis in lambs and verminous pneumonia, influenza and cholera in swine. Expected increases in a disease because of population density may result in unexpected increase in another.

The possibility of finding new diseases as a result of a change in the environment should also be considered. These new diseases, whose presence was not caused by a population increase, will find greater transmission facilities.

The reduction of social distance, in addition to increased contact among animals, produces an increase in the "stress" of the herd which, as is well known, weakens the animal, thus allowing agents that are usually commensal to become pathogenic (e.g., **Pasteurella, Bordetella**). This is due to the interaction between the host and the environment and the interaction between the agent and the host. These diseases are not new, but they can produce serious losses unless control is exerted.

In tropical climates the serious problem of wild reservoirs of diseases should be taken into consideration because this makes disease control tremendously difficult. I have already mentioned that equine encephalomyelitis seems to have reservoirs in birds and rodents (Hammond, 1942*; Batalla, personal communication). Another example is malignant catarrhal fever in cattle, which is asymptomatically carried by wildebeest and lambs (de Kock and Neitz, 1950).

Many diseases affecting cattle in the tropics are found in a state of ecological balance in the wild fauna; this is what Soviet authors call a state of nidus. In addition to those mentioned previously, disease transmission from the wild fauna to the domesticated population depends on the wild population, on the vector population (insects, birds, rodents, etc.), and logically, on the domestic animal population. Transmission of diseases increases when any one of the previously mentioned populations increases, provided that the other two remain stable.

Increase of diseases under intensive management systems has already been observed. In England, this has been the reason for the higher incidence of foot rot, Johne's disease, mycotic abortions, infertility, photosensitivity, mineral deficiencies and parasitosis (Gould, 1966). Other authors have found that in animals under strict confinement, an increase occurs in traumatic reticulitis, parasitosis and plant poisoning (Ekesbo, 1966). In Mexico, the change from extensive to intensive systems in poultry brought about increases of diseases, mainly respiratory, and also led to the outbreak of diseases that had not been previously detected, such as Gumboro disease. Likewise, a considerable increase in swine diseases, such as cholera and contagious gastroenteritis, has been observed upon changing from an extensive family operation to an industrial intensive system. It has been our

* The complete reference was not supplied by the author (Editor's note).

experience that an increase in the number of animals per unit of land brings about a considerable increase in diseases. These diseases have become so epidemic that their solution has been based upon protection of the whole population rather than individual treatment of the sick animals.

An increase in bovine population per unit of land is usually caused by the introduction of new animals into the herd. Problems arise because animals of one region are immune to many of the diseases prevailing in that area. Even without artificial immunity, a herd establishes a cyclic resistance at the population level. Upon introduction, new animals become infected with local diseases, frequently to a greater degree than local animals. These new animals might become infected by agents that have not been previously detected since because of infections in utero or injections applied to young animals, they become established in the original herd as tolerated (immune tolerance) or subclinic infections. A good example of this is the original research on piroplasmosis carried out by Salmon.* He observed that those animals that lived in affected areas rarely had the disease; and if they did, it was of a chronic nature. On the other hand, where there were no vectors during the winter, animals living at the geographic boundaries of the disease had serious cyclic outbreaks of the disease every spring.

Another unavoidable problem accompanying population increase is the contact among different age groups of animals. This is a source of many serious infections in young animals (e.g., poultry mycoplasmosis) and streptococci in young school children. This problem arose in intensive poultry farming in Mexico, and solutions were not reached until different age groups were segregated in different farms and an "all in-all out" technique was used. This consisted in having all animals taken out after each fattening or egg-laying cycle ended; then the place was disinfected and the new cycle introduced.

We have briefly sketched the multiple problems related to population increases; we shall now mention some solutions. In general terms, two solutions have been proposed to keep an animal population free of disease. The first is to produce specific pathogen free (SPF) animals. This has given good results in the poultry industry in the United States and in the swine industry in England. The second solution is to produce populations immune to the diseases prevailing in the region.

It is our opinion that the second solution is more feasible for producing good results in tropical environments. In the first place, the cost of producing and maintaining SPF animals is very high, mainly because of the installations needed. SPF animals require confinement in installations with the least possible external contact, for bovines in tropical climates, this is nearly impossible. It is also necessary to have skilled personnel who understand the need of desinfecting boots, overalls, etc. The other problem would be the wild reservoirs that are beyond control; these conditions would produce a totally vulnerable SPF population, which would be suicidal.

* The complete reference was not supplied by the author (Editor's note).

It is more logical and easier to establish herd immunity. In wild populations, herd immunity is, in many cases, brought about by the constant presence of an infection affecting younger animals which are usually much more resistant to diseases. In these populations, herd immunity depends on many factors, such as degree of concentration, population migration and contact with outside animals. The greater the contact between immune and vulnerable animals, the greater herd immunity will be.

This rule is also applicable to domestic populations. Here herd immunity is achieved through regular vaccination for all diseases prevailing in the region, trying to vaccinate animals at an early age (around three to four months). Animals must be separated according to age, in homogenous groups, in which an adequate immunization level has been achieved. Anthelmintic treatments and periodic antitick baths or spraying are useful in shortening the cycles of many diseases because of the reduction of the vector populations.

We will finish by stressing the concept that in extensive cattle operations, we must not be concerned so much with the medical treatment of individual animals but must strive toward total herd immunity since only an adequate level of immunity will allow us to move from extensive to intensive cattle operations under tropical conditions.

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# INTENSIVE CATTLE FEEDING UNDER GRAZING SYSTEMS

*Gustavo Cubillos, Karel Vohnout and Carlos Jiménez*

The problem of the availability of high-quality protein has been aggravated by the constantly growing population of the world. One solution lies in the increased production of beef. Because of the abundance of adequate resources for cattle raising, the tropics have a great potential for reaching this goal.

The fattening of cattle for meat production is the final stage in a complex process involving various biological, as well as socioeconomic factors, which should be studied in order to obtain integrated production systems that can be adapted to the different conditions found in the tropics. An animal production system must consider the various aspects affecting it, including the animal s physiological response to its environment. In addition to feeding, this environment includes genetic potential, health and general management factors.

Beef production is only one means of utilizing resources that man cannot consume directly. This is not a simple process since, in addition to the factors already mentioned, the animals come from various sources and have belonged to different owners prior to the final fattening stage.

In order to contribute to the formulation of forage feeding systems and to determine the potential of these systems for tropical conditions, research work relevant to the fattening stage will be discussed.

## GRASS AS A COMPONENT OF THE SYSTEM

Grass is the most abundant and the least expensive source of cattle feed. However, there are several factors affecting its production and quality, which we will discuss briefly.

The tropical zones of America are quite variable ecologically. Rainfall distribution determines grass growth to a great extent, thus affecting the yielding potential of a zone. Figures 1 and 2 present the variations in the grass growth rate in the humid and dry tropics. Figures vary according to the region and the species but generally follow the tendency described.

In a production system based on pastures, the seasonality of grass production will cause variations in the quantity and quality of cattle feed. Even in regions where there is abundant rainfall, grass growth is seasonally reduced, thus affecting the availability of feed. These variations can reduce growth rates to 20 to 30 per cent of the maximum yields.

The growth rate of grass is not a synonym for feed availability since this also depends on the grazing pressure exerted on the pasture. For this reason, especially in those areas with a well-defined dry season, grass availability during the critical season fixes the yield that can be obtained per unit area. As production is intensified, it is necessary to utilize the resources available to the animal more efficiently and to search for alternative sources of feed for periods of low grass production. At the same time, forage utilization should be improved during the rainy season.

Some alternative solutions would be

1. The utilization of low or more humid areas for grass production during the dry season and the efficient use of the forage produced

2. The irrigation of part of the pastures during the dry season (not always feasible or economical)

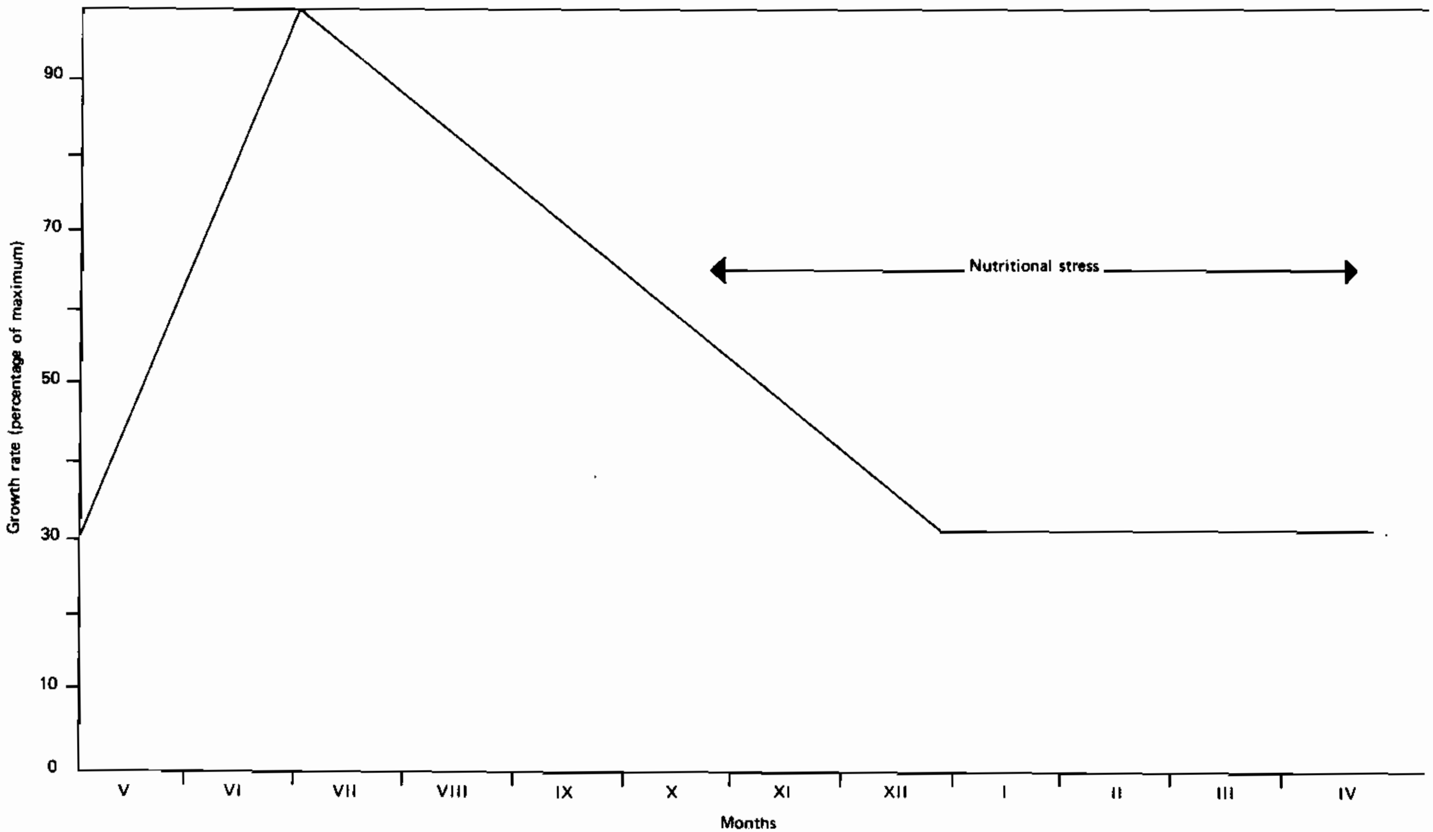
3. The conservation of surplus forage produced at the beginning of the rainy season (involves improvement in pasture management during the rainy season in order to increase the availability of forage for conservation)

4. The production of standing hay, a practice also known as deferred grazing

5. The production of supplementary crops to be used as feed during the dry season

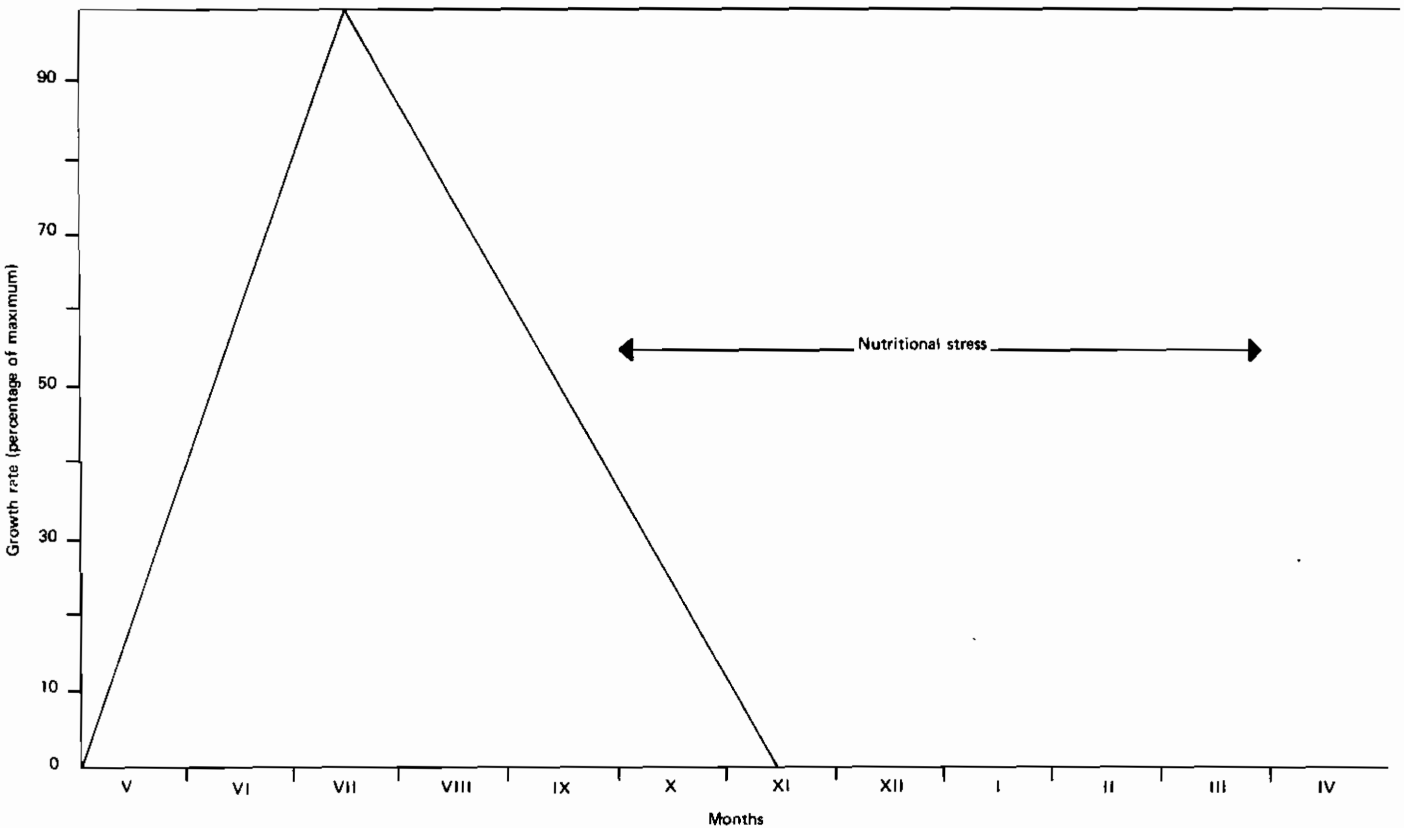
6. The feeding of concentrates or supplementary feeds based on locally available products or by-products

Any of the aforementioned solutions may be a total or partial approach, depending upon the region and the economics of production; they should always be considered in terms of the efficiency of the utilization of available resources.




**Source:** Catie, Turrialba, Costa Rica

**Figure 1.** Seasonal growth of grass in the humid tropics in Central America.




Source: Catie, Turrialba, Costa Rica

There are several factors in grazing that affect animal production. It has been said that grass availability varies during the year and that the number of animals found on one farm is relatively constant. Therefore, it is important to know to what extent forage availability affects the production of the individual animal. Figure 3 shows the results obtained in tropical and temperate zones in relation to stocking rate and cattle weight gains (Alpizar and Vohnout, 1963; Cubillos and Mott, 1968).

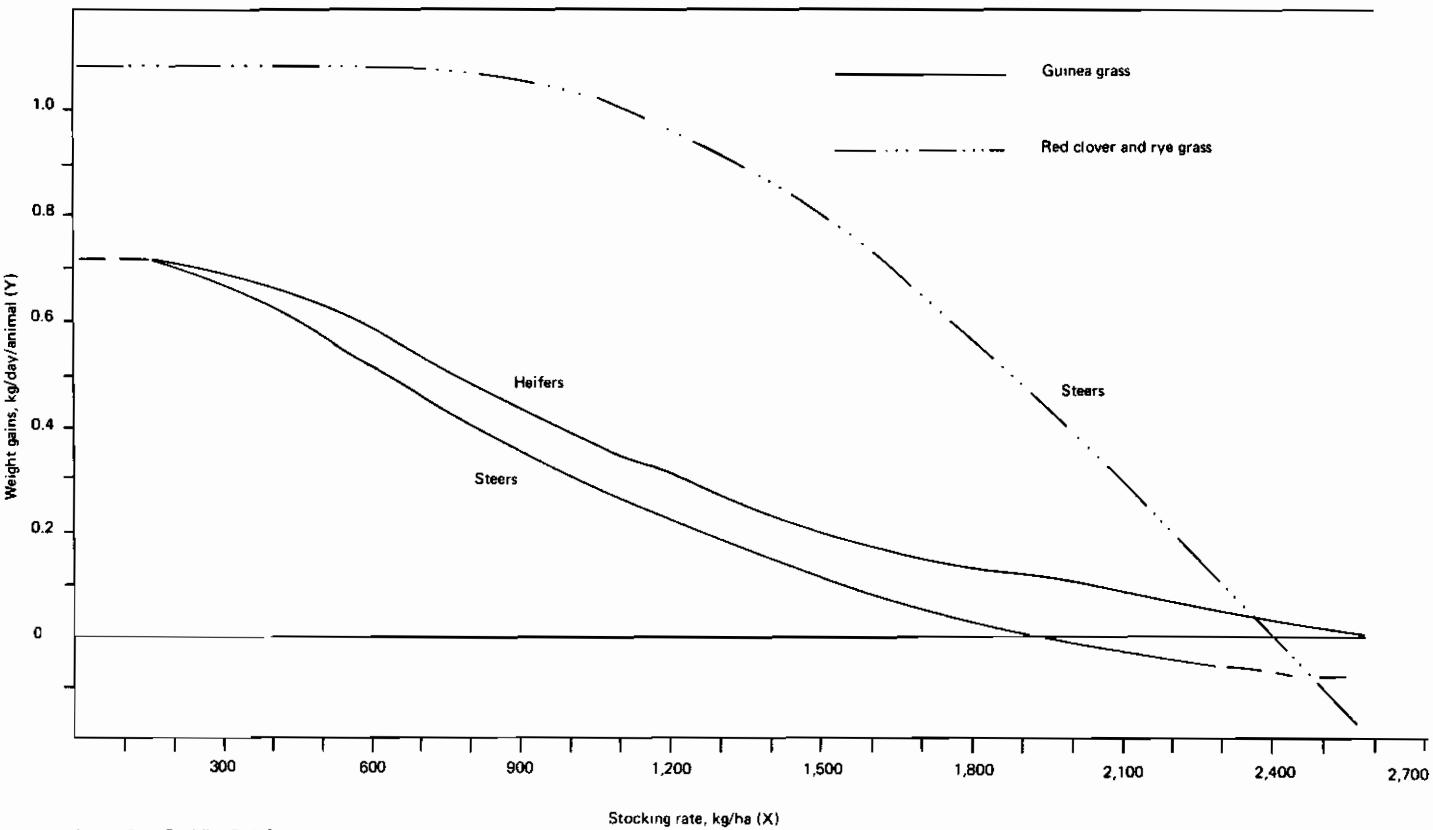
Pastures in temperate zones produce more weight gains in animals at similar stocking rates; production is also greater at higher stocking rates. This indicates better-quality pastures in these zones. Figure 4 shows the per hectare yields obtained with the same pastures. In accordance with the work presented by Mott (1960), maximum production per unit area was obtained at levels where individual production decreased. This is an important aspect in regard to the efficiency of a cattle operation since maximum biological production does not always lead to maximum economic production (Bryant et al., 1965). This has been confirmed for tropical conditions in recent work conducted in the humid tropics of Costa Rica (Ettinger, 1972; Jiménez, 1974; Vohnout, 1973).

The aforementioned figures show that under grazing conditions, the maximum individual production in the tropics would be approximately 0.70 kilograms per animal per day. Data from temperate zones (Bryant et al., 1965; Cubillos and Mott, 1969; Hull et al., 1965) show similar increases for relatively long grazing periods. In contrast, increases of 1 kilogram per day, obtained with Holstein steers on pastures of rye grass (*Lolium perenne* L.) and red clover (*Trifolium pratense* L.), show that the maximum gains are high and similar to those obtained in confinement (Isidor, 1973).

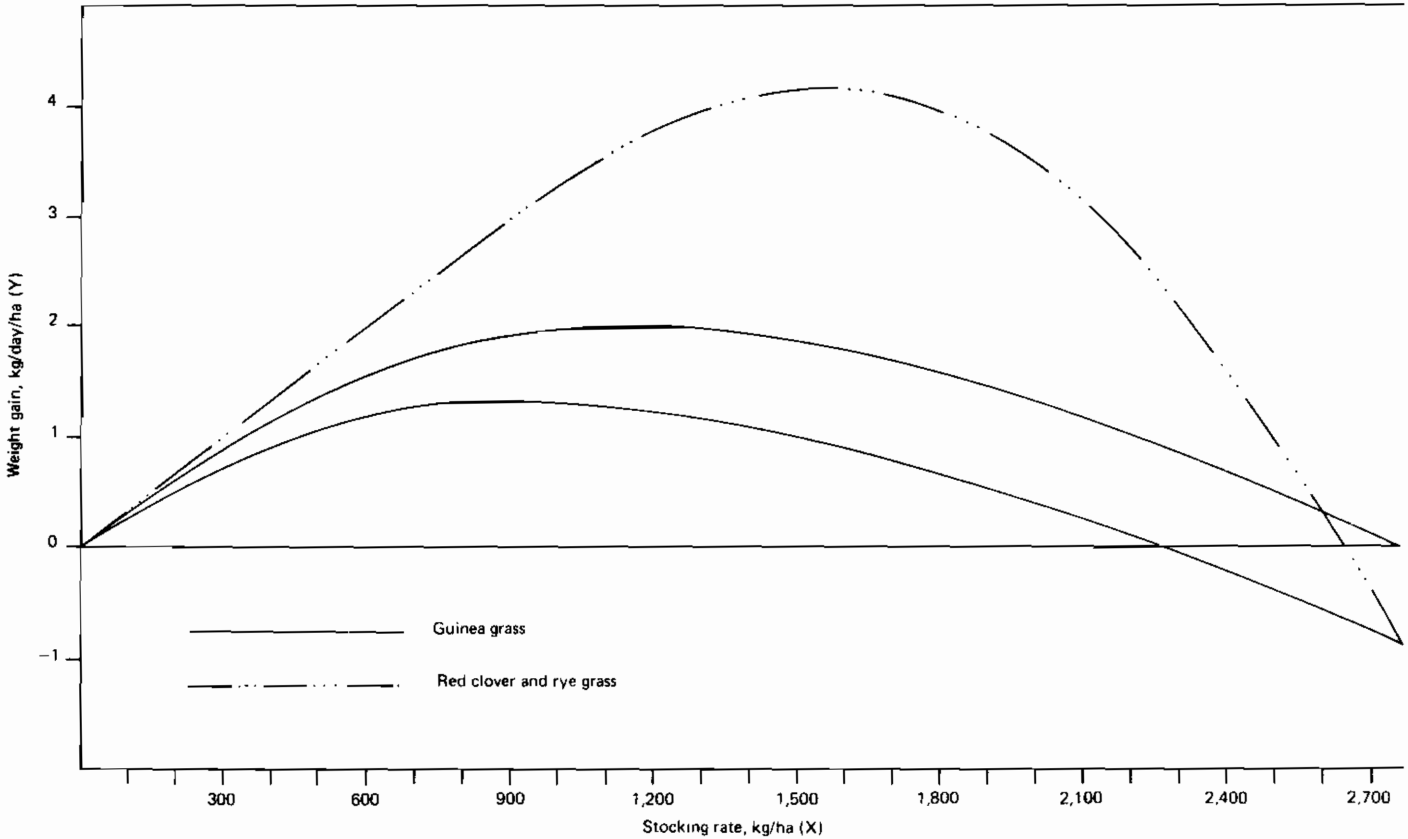
This shows that under adequate management conditions, pastures can constitute the total diet for cattle. However, because of uncontrollable factors, the quality of the forage is variable, which means that the nutritive value of the grass varies, as does the level of productivity.

Protein content can be a major limiting factor because of its direct effect on the animal and its indirect effect through the microbial activity of the rumen (Hungate, 1966). For this reason, nitrogen fertilization of pastures before the onset of the dry season increases both pasture protein content and daily weight gains of steers on guinea grass (*Panicum maximum*) (Mott et al., 1969). However, as a result of the animal's compensatory growth, this advantage disappears during the next rainy season. Consequently, this alternative should be considered only when animals are to be sent to the market at the end of the dry season.

Fundamentally, nitrogen fertilization during the rainy season means an increase in the amount of available forage. This should be associated with an increase in stocking rate and in the efficiency of pasture utilization. Nevertheless, fertilization with nitrogen at the beginning of the rainy season may increase the rate of forage growth more, making the pasture management problem more difficult. Furthermore, forage quality during the dry




Source: Catie, Turrialba, Costa Rica




**Source:** Catie, Turrialba, Costa Rica

**Figure 4.** Effect of stocking rate on beef production per hectare

season may substantially decrease in species commonly used in the tropics, such as *Hyparrhenia rufa* (Blue and Tergas, 1969; Vohnout, 1973).

## FEEDING SUPPLEMENTARY TO GRAZING

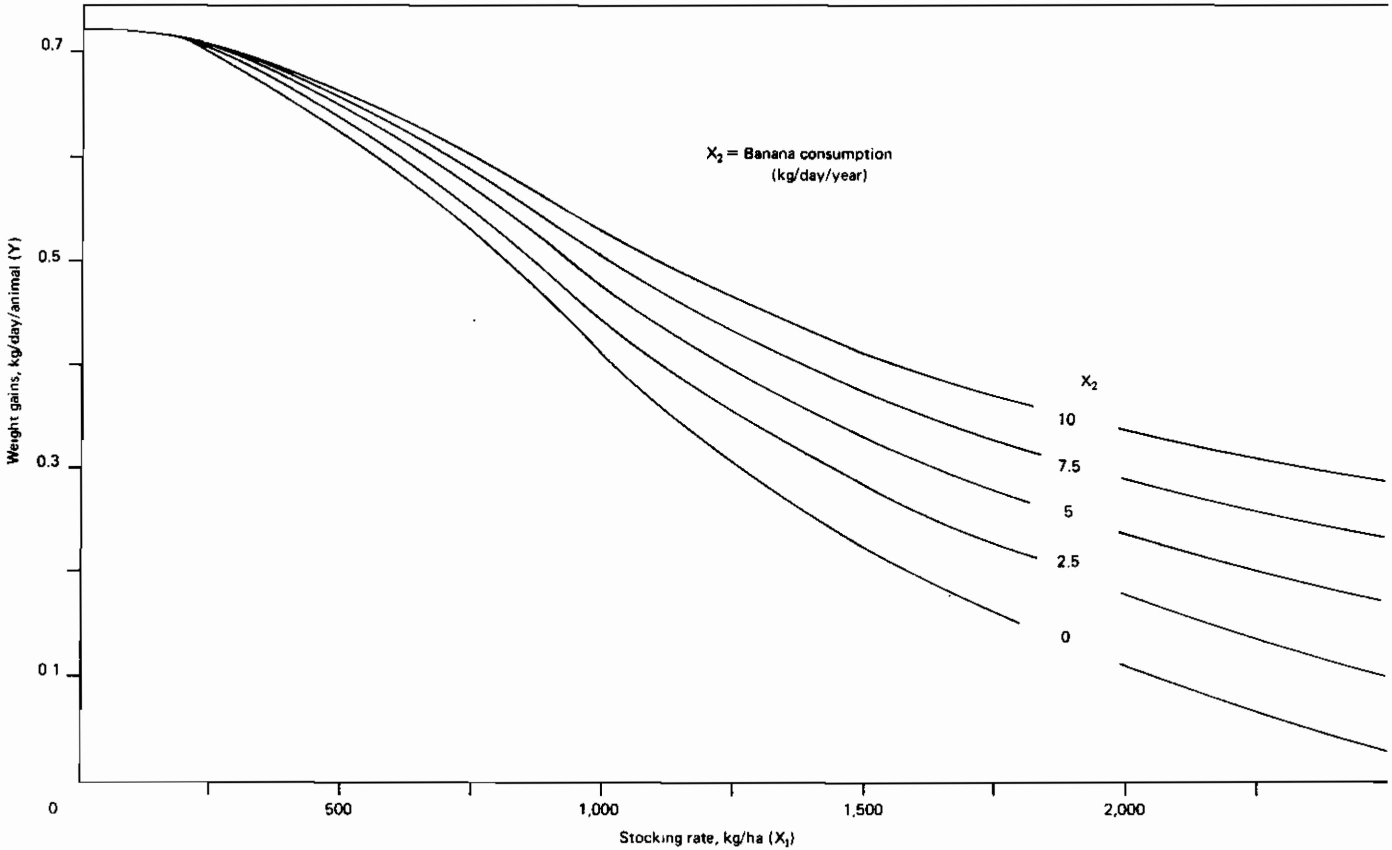
The seasonality of grass production has led to a search for alternative feed sources for the dry season. The tropics have a series of resources that can be used for cattle. Among them are molasses, sugar cane bagasse and leaves, reject bananas, cacao hulls, coffee pulp, etc. Table 1 shows the amounts of molasses and sugar cane bagasse that could be used for cattle today. These are not permanent resources since their market prices can rise and they will no longer be available for cattle feeding. Since the maximum utilization of available resources is sought, results obtained with feeding supplementary to grazing are presented. Bananas have been used as an example, but this application may be similar to other products or by-products.

Experience with supplementation under grazing conditions at Turrialba (Jiménez, 1974; Ruíz, 1973; Vohnout, 1973) shows several important factors, such as the relationship between stocking rate and the effect of supplementing with reject bananas (Fig. 5). With a low stocking rate and no supplementation, the maximum daily weight gain of heifers on guinea grass was 0.716 kilograms. At these stocking rates, the effect of supplementation was nil; but as grazing pressure increased, forage availability per animal decreased, resulting in lower weight gains. Under these conditions, supplementation with bananas increased animal weight gains. Thus, an increase in stocking rate from 250 to 500 kilograms of liveweight per hectare may result in slight variations in the daily

Table 1. **Approximate annual production of molasses and sugar cane bagasse in some Latin American countries (1969–1970).***

| Country | Millions of tons | |
|---|---|---|
| | Molasses | Bagasse |
| Argentina | 0.43 | 2.67 |
| Brazil | 3.01 | 18.81 |
| Cuba | 2.56 | 16.00 |
| Colombia | 0.62 | 3.90 |
| Costa Rica | 0.08 | 0.50 |
| Ecuador | 0.36 | 2.25 |
| Mexico | 1.20 | 7.50 |
| Peru | 0.32 | 2.00 |
| Dominican Republic | 0.32 | 2.01 |

* Based on sugar cane production data published by FAO, Production Yearbook, 1970




Source: Catie, Turrialba, Costa Rica

**Figure 5.** Effect of stocking rate on weight gains of heifers supplemented with different levels of bananas

increase; but as the stocking rate increases, the effect of supplementation is stronger. At rates of 1,500 kilograms, supplementation with 10 kilograms of bananas produces weight gains that are practically double those obtained without supplementation.

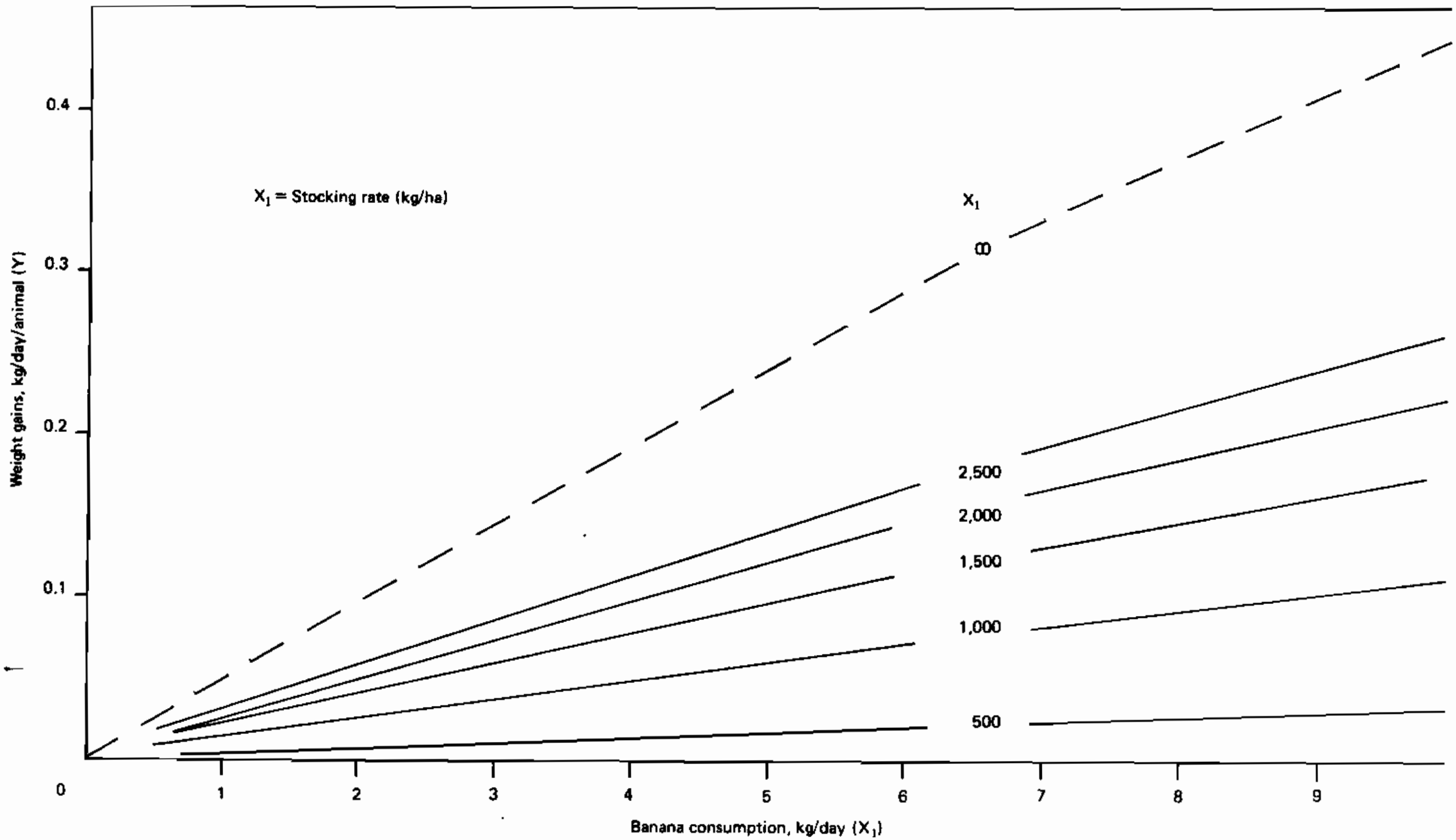
An "additive" effect takes place; that is, the energy or protein of the supplement is added to that of the grass. This effect is greater when grazing pressure is high because forage availability per animal decreases substantially at these levels. Figure 6 shows the additive effect of supplementation with bananas in heifers on guinea grass at different stocking rates. At low stocking rates, the weight gain was low; however, as the rate increased, the gain produced by supplementation with bananas was greater.

Figure 7 shows the effect of substitution on weight gain in supplementation with bananas; that is, the replacement of forage with bananas. As the stocking rate decreases—that is, when the grazing pressure decreases—the substitutive effect increases. As grazing pressure increases, the possibility of replacing forage with bananas decreases, thereby lessening the substitutive effect.

Figure 8 shows the effect of banana consumption on the weight gain of heifers at different stocking rates. At low grazing pressures, animal performance is not affected by the level of banana consumption. As a result of the substitutive effect, the weight gain per animal is similar at any level of banana intake. However, when grazing pressure increases, animal response increases in relation to the greater intake. This implies that the contribution of grass to the animal's maintenance is less and less. Maximum consumption of supplements under grazing is lower than under confinement, where consumption of bananas on a dry basis has reached up to 5 per cent of the liveweight (Isidor, 1973). Similar results have been obtained with molasses, where animals confined for short periods increased their consumption of molasses, as compared with those receiving supplementation while grazing (Vohnout et al., 1973a and b).

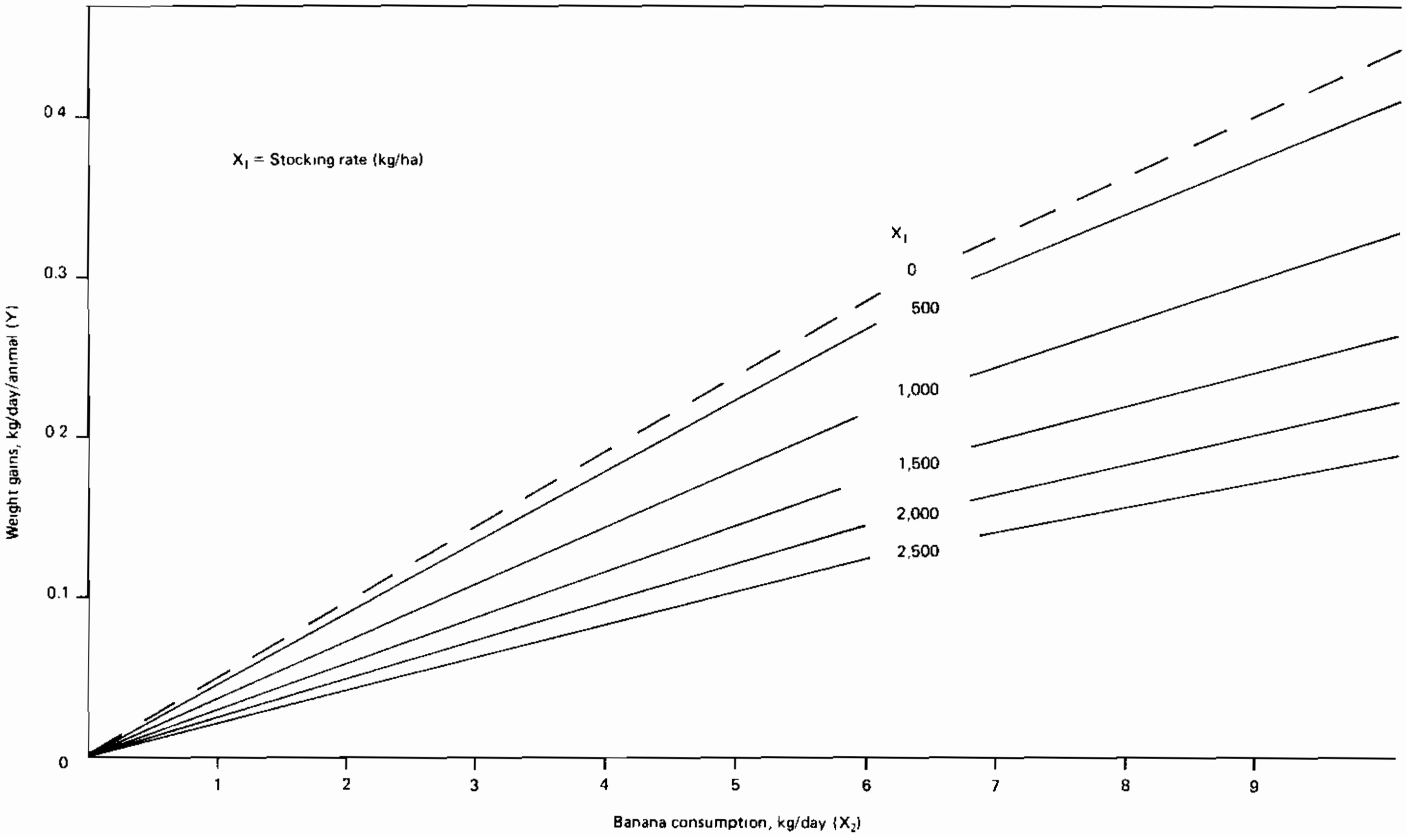
As production is intensified, output per unit area should be assessed (Hutton, 1970). This is the reflection of individual animal response and the number of animals per unit area (Mott, 1960). Figure 9 shows how stocking rate and supplementation with bananas affect beef production on guinea grass. As the stocking rate increases, so does production per hectare, up to a maximum of approximately 1,000 kilograms of liveweight per hectare. Then this gradually decreases up to a stocking rate of 2,500 kilograms of liveweight per hectare, where production is nil. However, the effect of supplementation is a very important aspect. Figure 9 also shows that production curves have a less-pronounced decline with higher banana intake. For example, at limited levels of banana consumption (2.5 kg/day/animal), production per hectare increases from 2.0 to 2.2 kg/ha/day; and maximum increases are obtained at stocking rates of 1,300 kilograms of liveweight per hectare. Similarly, the curves are altered by the increase in banana intake, which results in greater production per unit area.

This means that when sufficient grass is available, stocking rates should be increased if supplementation levels are raised; that is, if productivity per hectare is to be increased.




Source: Catie, Turrialba, Costa Rica

**Figure 6.** Additive effect of banana consumption on weight gains of grazing heifers.

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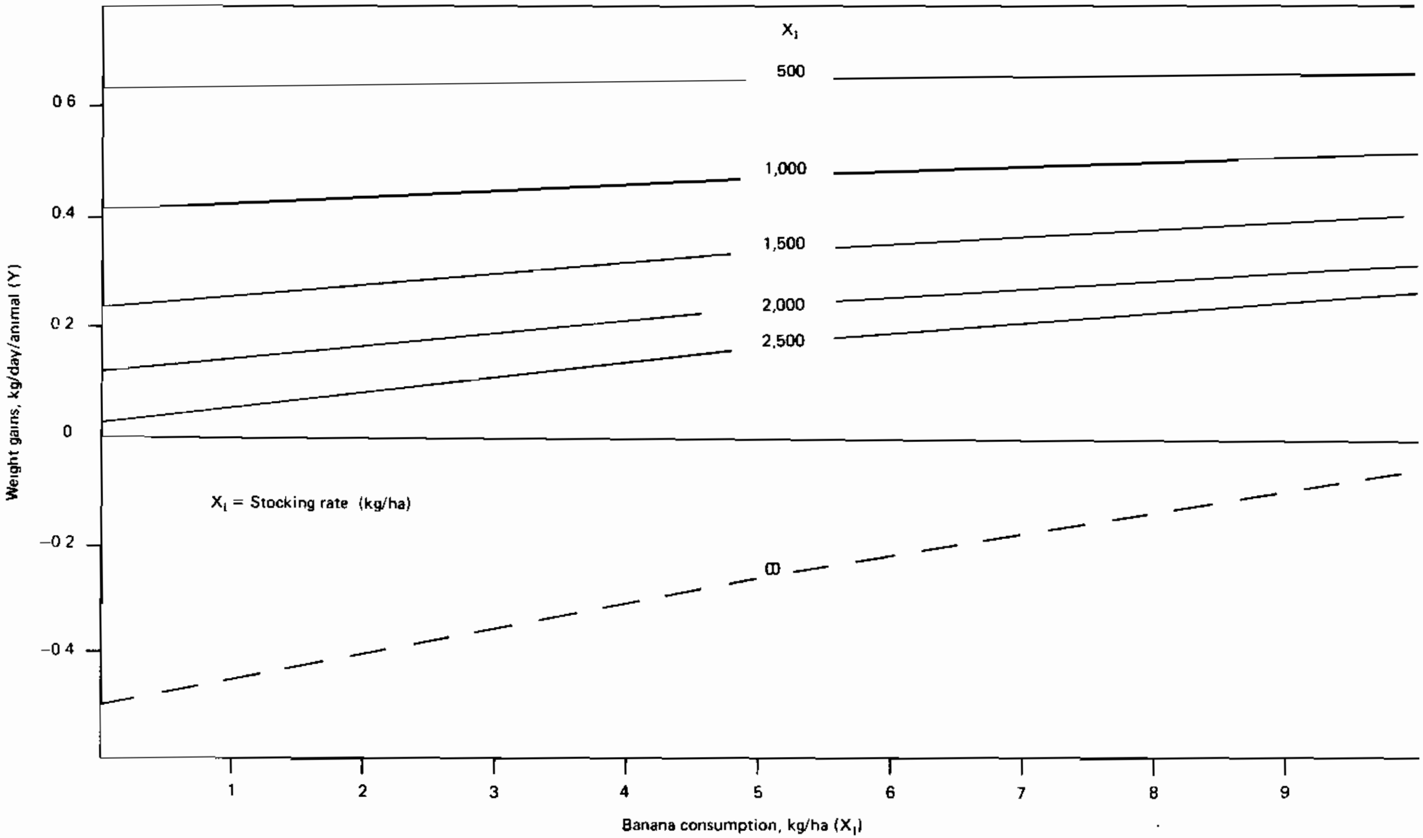
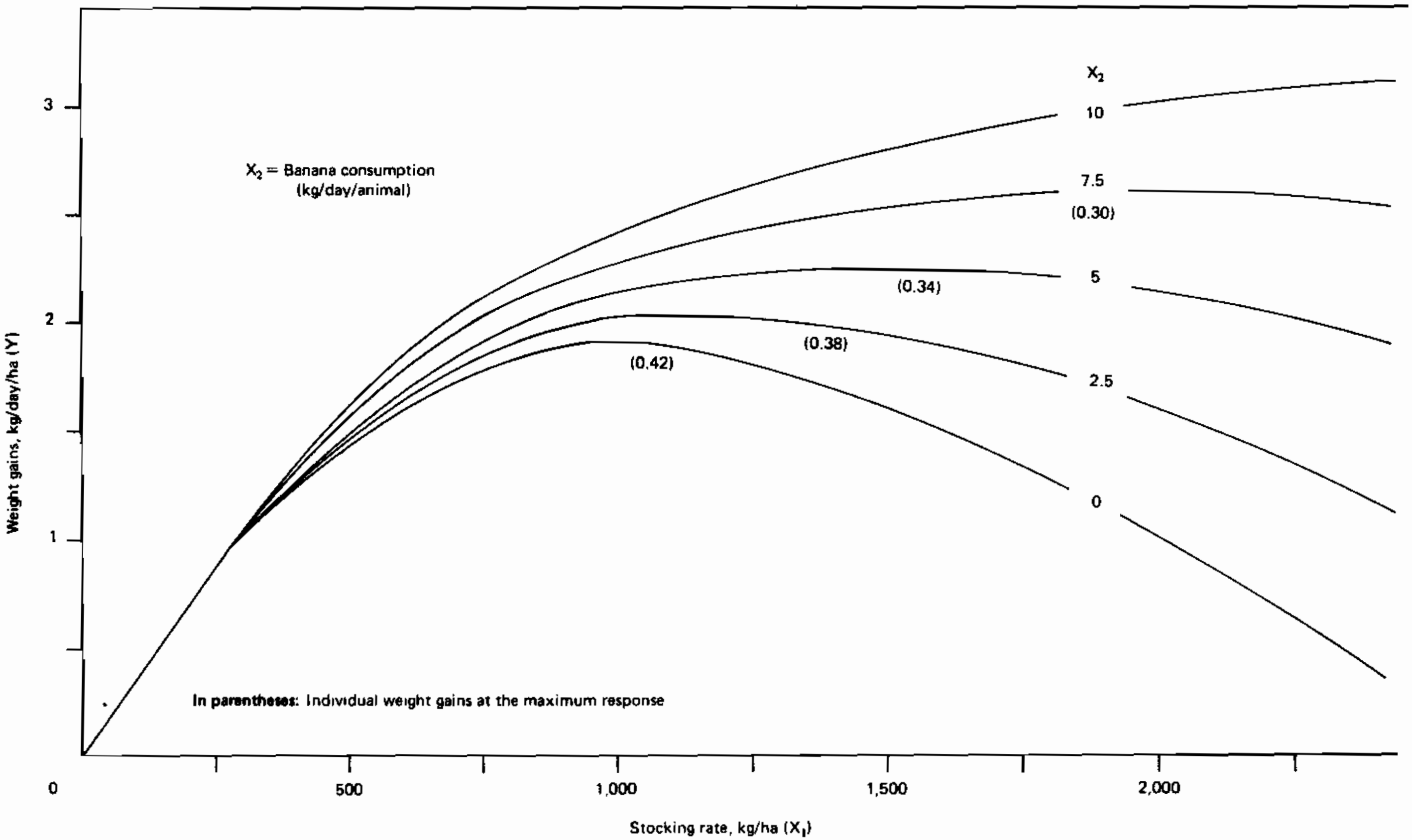



Source: Catie, Turrialba, Costa Rica

**Figure 8.** Effect of banana consumption on weight gains of heifers at different stocking rates




Source: Catie, Turrialba, Costa Rica

**Figure 9.** Effect of stocking rate and banana supplementation on beef production on guinea grass.

When a constant stocking rate is maintained and bananas are supplied, the substitutive effects of bananas—as opposed to grass—consumption are increased, which means a loss of the least expensive resource, forage.

In the formulation of feeding systems, this relationship becomes important if grass production is seasonal since it is possible to increase supplementation as forage availabillity decreases and still maintain high production per unit area.

## THE FUTURE OF INTENSIVE SYSTEMS

In the future, intensive feeding systems should be based upon the use of resources such as grass or agro-industrial by-products, as available. Cattle will continue to be the means that transforms them into high-quality protein.

Results obtained in the humid tropics show that it is possible to increase yield per unit area, supplementing pasture with local waste products or with other products not used effectively. Research must continue to develop feeding systems based upon the use of available products as alternatives to correct forage shortages during the critical periods. In any case, the utilization of forage resources should be the basic element in the increase of yield per unit area.

Deferred grazing during critical periods seems to be inefficient if *Hyparrhenia rufa* is used because of the rapid decrease in its protein content, as shown by work done in the monsoon area of Costa Rica (Blue, 1969; Tergas et al., 1971). In view of the large areas covered with this grass, protein supplementation of animals during this period should be considered. For these areas, it is necessary to study the use of better quality species that will retain their nutritive value during the dry season. Forage conservation under pastoral systems is unlikely at present because of the expenses involved and the losses entailed. Hutchinson's work (1971) shows that in production systems for grazing animals, it is important to consider the efficiency of the utilization of energy provided by the consumption of either fresh or conserved forage.

One important aspect that is sometimes overlooked is the physiological capacity of the animal to utilize its own reserves. Under tropical conditions, the possibilities should be studied of submitting animals to nutritional stress during a period of their lives so that there will be compensatory growth later. However, in order for this compensation to occur it is necessary to have high-quality grasses or adequate supplements.

It is not a simple matter to determine which is the most adequate production system. The fattening phase is just one stage within a system, and it is not always easy to define clearly which animal is the beef producer. There are instances when the animal is the by-product or co-product of milk production. Also, since animals to be fattened have been submitted to different treatments, their potential for producing an adequate carcass may be affected by nutrition, as well as by other factors (Baker, 1966). In any case, forage must constitute the basic feed, and the most adequate fattening system would be the result of the efficient utilization of resources throughout the year.

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# INTENSIVE BEEF FATTENING SYSTEMS FOR THE TROPICS

*T. R. Preston*

Not so long ago, it was accepted that there was no place in the humid tropics for intensive cattle fattening systems. The argument was that such procedures were extremely costly in terms of feed requirements and fixed overheads and could not compete with simple feeding on pasture, which is still considered to be the cheapest feed resource in the humid tropics.

However, in the last two years this situation has changed. Not only is there increasing interest in the possibility of intensive fattening in tropical countries, but it has been demonstrated that there are intensive feeding systems which are economically feasible. An even more important consideration is that in the light of recent developments the potential for intensive fattening in the tropics promises to be greater than anywhere else in the world. One can even predict a situation when the major beef producers in the world of tomorrow will be found in the humid tropics.

To some extent, the place of intensive feeding in the tropics can be better understood by considering some of the constraints to beef production in these regions. One of the most important factors is the seasonality of rainfall, which results in a marked disparity in natural pasture production between the rainy season and the dry season. The exact relationship of these two periods differs slightly according to region, but in general the situation is somewhat similar to that presented in Figure 1. In certain regions, temperatures in the dry, winter season may fall to the point of limiting plant growth to some extent, but in general, the major constraint is water. If animal production systems are based on the natural availability of pasture growth, the stocking rates must be adjusted to the levels of herbage production in the dry season. This, in fact, is the traditional method in much of tropical America, usually resulting in stocking rates expressed in terms of hectares per animal rather than animals per hectare.

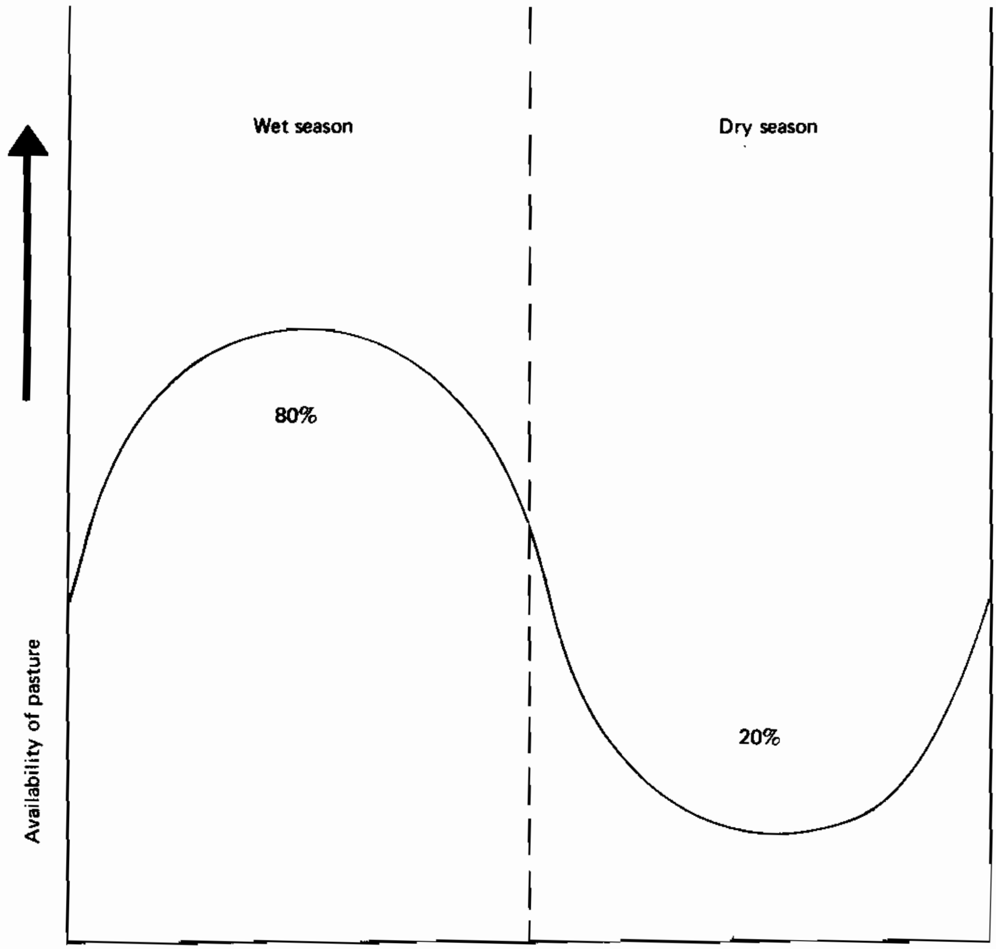



**Figure 1.** The availability of pasture in the tropics according to season.

One approach to intensification is to adjust the stocking rate according to the rainy season, so as to utilize the available pasture to the maximum, and then to provide supplementary feeding in the dry season so that the same stocking rate can be maintained throughout the year. This kind of feeding system will be discussed later.

Another important consideration is to examine the economics of cattle fattening in relation to present financial constraints, principally the high cost of feed ingredients and the high interest rates on money invested in livestock. Taking Mexico as an example, the present interest rate on bank loans for livestock is 12 per cent yearly. If the animal purchased for fattening costs US$ 0.80/kg liveweight and weighs 300 kilograms, then the interest rate per month is US$ 2.40. If the rate of gain is 1kg/day, this is equivalent to a cost of US$ 0.08/kg of gain. If, however, the rate of gain is only 0.5 kilogram daily, then the interest cost per unit gain is US$ 0.16. In Mexico, the sale value of liveweight is US$ 0.80/kg; thus the interest cost between 0.5 and 1 kilogram daily liveweight gain is equivalent to 20 and 10 per cent, respectively, of the final sale value of the liveweight produced.

The other important factor in relation to the use of supplementary feed for fattening is the relationslhip between feed conversion rate and profitability. From 50 to 70 per cent of the total cost of fattening is accounted for by the cost of the feed. It is therefore imperative that the feed conversion rate be kept as low as possible in order to minimize the feed cost of liveweight gain. Since there is a close relationship between the rate of liveweight gain and the feed conversion rate, this is yet another argument in support of maximizing the rate of liveweight gain per animal. As will be shown later, this is most easily achieved under conditions of confinement feeding.

The final consideration to justify increasing intensification in cattle fattening is carcass quality. When systems of fattening are extensive and the product is mainly for local markets, carcass quality is of little importance. At the present time, however, beef is an important basic commodity on world markets and is in ever-increasing demand; therefore, prices are constantly rising. There are many advantages that accrue from applying the concept of exporting high-quality cuts at relatively high prices and consuming the second-quality cuts locally at reduced prices made possible by the exportation of the best cuts. If we accept the fact that there is an enormous potential for beef production in tropical America, it is equally obvious that a considerable part of such production should logically be directed at the export market as a means of earning foreign exchange.

Under these circumstances, carcass quality becomes important. Since sale and transport costs are based on weight, obviously the higher the unit value of the weight that is sold, the lower (proportionately) the overhead costs of the selling operation are. In this context, quality is an important constraint for any livestock fattening operation that intends to export; and the only way to control quality efficiently is by confinement feeding.

On the one hand, the greater control which is possible in the feedlot allows better selection at time of slaughter. On the other hand, conditions of intensive feeding with high rates of liveweight gain are conducive to improved carcass quality in terms of reducing the age at slaughter and decreasing the relative proportion of bone and inedible components in the carcass. There is also the argument that beef from intensively fattened cattle have a greater proportion of intramuscular fat and is thus of better eating quality. However, this trait is considered to be less important than youth and percentage of lean meat, which are the main prerequisites for most importing markets—at least for those in Europe.

## PASTURE

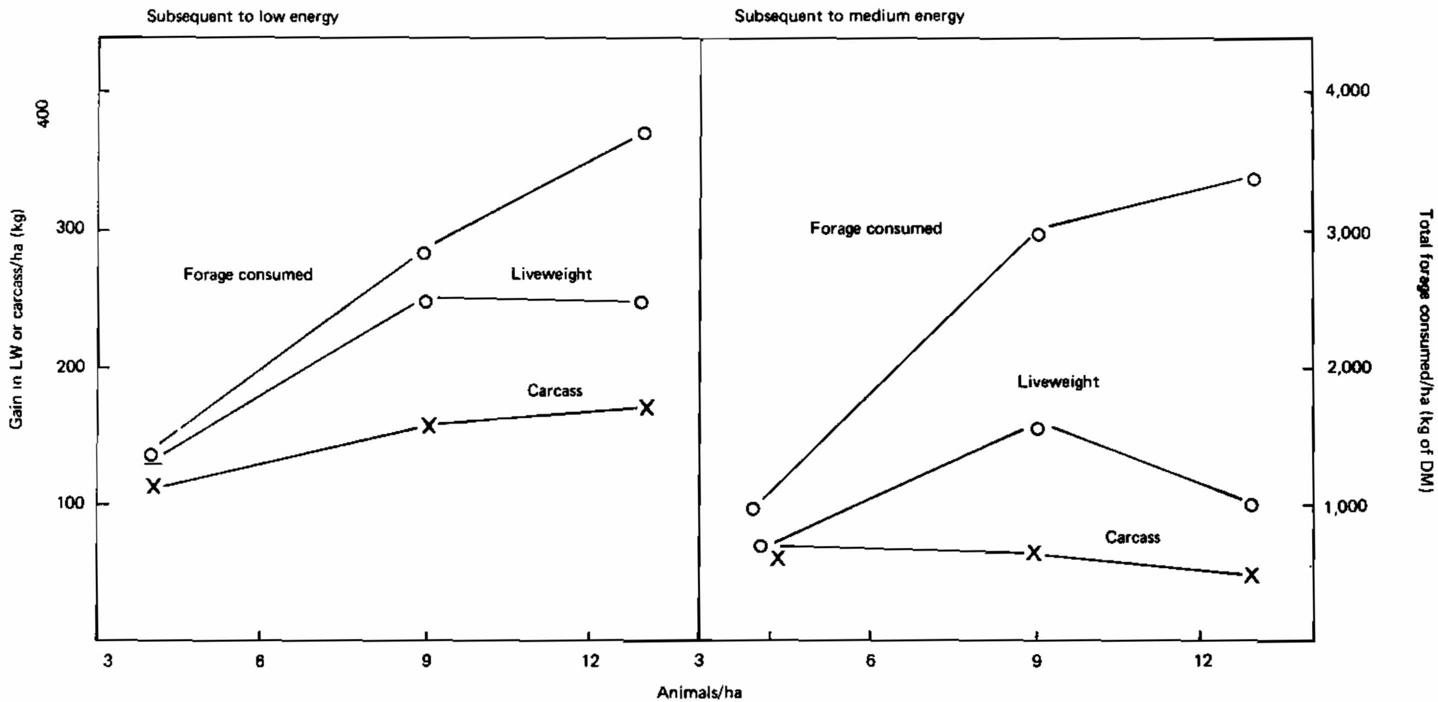
The problem of the seasonality of pasture production has been mentioned in the introduction. It is also relevant to consider other constraints to fattening on pasture so that the advantages of confinement feeding can be better appreciated. The main problem is the interaction which occurs between productivity per animal and pasture utilization. The data presented in Figures 2 and 3 describe this interaction, which is basically the incompatibility between productivity per unit area and productivity per animal.

In pasture utilization, investment and operational costs are expressed per unit area, whereas the costs of cattle fattening are a function of the individual animal. As stocking rate increases, productivity per hectare increases; and as a result, so does return on costs invested in the pasture. However, at the same time there is a decrease in productivity per animal and therefore in the return on the investment in the animal itself.

The physical condition of the animal at the start of fattening on pasture is another important factor since rate of liveweight gain on pasture is negatively related to the initial condition as a result of the effects of compensatory growth. In other words, with grazing systems it is impossible to have maximum productivity per animal and at the same time maximum productivity per unit area. This does not mean that there is no place for fattening on pasture, but simply that this interaction is an important constraint on this system and one which does not apply under conditions of confinement feeding, where feed is transported to the animals.

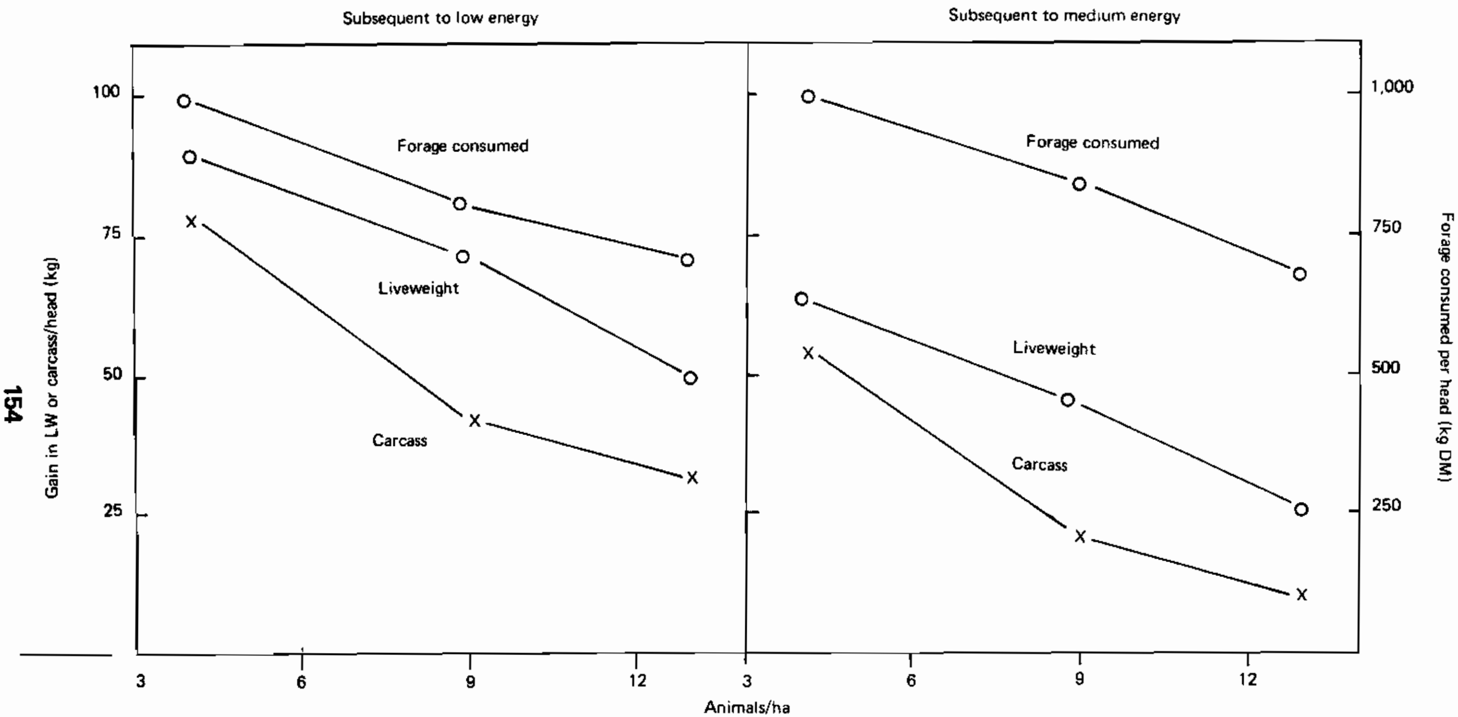
## CEREAL GRAINS

The principal feed used in intensive fattening of cattle in North America and Europe is cereal grain. Many of the intensive feedlots set up in the last decade in Central and South America have also used the same principle, but only rarely have they been profitable. In fact, disused feedlots in Mexico outnumber those still operative, which is evidence of the economic weakness of this particular system. One reason for the failure of this feeding method has been the combination of high prices for cereal grains, low beef prices on local markets, and genetic unsuitability of the cattle employed. It has been well documented that Zebu-type cattle, which are predominant in tropical America, are at least 20 per cent




Source: Hull et al., 1965

**Figure 2.** The effect of stocking rate on productivity per hectare in response to previous periods of low or medium energy intake.




Source: Hull et al., 1965

**Figure 3.** The effect of stocking rate on individual animal productivity in response to previous periods of low or medium energy intake.

inferior in feed conversion to the improved European breeds, which are the basis of intensive fattening in North America and Europe.

Besides these strictly economic considerations, there are other more pressing reasons why grains should not be used as a basis of intensive feeding systems in tropical America. One of these is the relationship between the expanding human population and available feed supplies and the important role that cereal grains play in human nutrition. In this respect, there is direct competition between man and cattle for the same food; and all the predictions indicate that this competition is likely to intensify, particularly within the developing countries. Still another factor is the high cost of cereal grains on world markets, which places an even greater premium on the efficiency of liveweight gain and feed conversion if profits are to be made with these raw materials.

Finally, the most important reason of all is the relatively low productivity of cereal grains in the humid tropics as compared with other crops more adapted to these regions ecologically. The comparisons set out in Table 1 show that what might be considered as unconventional crops in terms of cattle feeding—namely, cassava and sugar cane—are much more productive in the tropics than cereal grains are.

Part of these yield differences represents direct climatic effects. For example, it has been shown that sugar cane, as well as other tropical grasses, possesses a more efficient enzyme system for converting solar energy into carbohydrate than the typical temperature crops have (Hatch and Slack, 1966). Another factor is the greater degree of technology required to achieve high productivity with cereal grains and the fact that lack of this technology is a major constraint in the developing tropical countries. Taken in general, the above arguments are weighty enough to discount the use of cereal grains as the basis of cattle fattening in the tropics. At the most, their application must be confined to supplementary usage only.

## FORAGE CROPS

**Maize and sorghum**

In tropical Africa it has been established that economically feasible feedlot systems can be based on ensiled maize forage, supplemented with molasses/urea, maize milling by-products and minimal amounts (less than 5 per cent) of protein supplement (Creek, 1972). The feeding problems with this system are minimal and the principal constraints are of an agronomic nature, associated with crop establishment and development. Conventional forage sorghum is another possibility although research in progress (Preston, unpublished data) indicates that the sweet (or sugar) sorghums offer much more potential.

Table 1. **Yields of total digestible nutrients (TDN) from carbohydrate crops in selected tropical countries.**

| | Maize grain | Sorghum grain | Cassava tubers | Derinded whole sugar cane | Final molasses | Dry bagasse |
|---|---|---|---|---|---|---|
| | TDN (ton/ha) | | | | (ton/ha) | |
| Peru | 1.28 | 1.36 | 2.07 | 21.8 | 3.62 | 12.80 |
| Ethiopia | 0.88 | 0.56 | — | 21.6 | 3.59 | 12.70 |
| Uganda | 0.88 | 0.88 | 0.66 | 13.8 | 2.29 | 8.13 |
| Taiwan | 1.82 | 1.28 | 2.88 | 11.0 | 1.83 | 6 48 |
| Ecuador | 0.40 | — | — | 10.4 | 1.73 | 6.13 |
| Jamaica | 0.96 | — | 0.40 | 10.4 | 1.73 | 6.13 |
| Mexico | 0.96 | 2.00 | — | 9.4 | 1.56 | 5 54 |
| India | 0.80 | 0.40 | 2.35 | 7.2 | 1.20 | 4. [illegible]4 |
| Kenya | 3.44 | 0.64 | 1.17 | 7.0 | 1.16 | 4.12 |

**Source:** FAO, 1969 and Pigden, 1972

## Sugar cane

Management problems involved in growing both maize and sorghum increase in severity as rainfall increases (e. g., in excess of 2,000 mm/year), a constraint applicable to almost all annual crops in the humid tropics. In these situations, perennial crops such as sugar cane have considerable advantages. Another important factor is that harvest time, a critical constraint for maize and sorghum, is extremely flexible for sugar cane since its nutritive value varies little between 6 and 24 months of growth. The sucrose content changes, but this is compensated for by an inverse relationship in concentration of its constituent monosaccharides, both of which are equally available to the animal.

## Agro-industrial by-products

Often overlooked sources of feed for intensive fattening are the by-products from crops which are processed to supply edible foods and/or industrial raw materials. Some of the products which have potential in this respect are set out in Table 2, together with the forage crops which offer the most potential as a basis for intensive finishing programs. Almost all of these are extremely low in protein; and as a result, there is a greater requirement for protein in order to make balanced rations from such ingredients.

Table 2. **Feeds which can be used as the basis* for confinement finishing in tropical America.**

| Feed resource | Processing |
|---|---|
| Forages | |
| Maize | Silage |
| Sweet sorghum | Silage |
| Whole sugar cane | Derinding |
| Whole sugar cane | Grinding |
| By-products | |
| Final molasses | None |
| Citrus and pineapple pulp | Silage |
| Brewers' grains | Silage |

* Defined as being able to supply more than 50 per cent of the ration dry matter

Unfortunately, the availability of protein supplements is even more limited than cereal grains, and protein is more important than energy in terms of competition between animal and man. Thus, the only feasible procedure is to balance such feeds with simple nitrogen compounds (NPN) which, although suitable for rumen microbial growth, have no value in the human diet. In most cases the deficiency is such that the required rate of addition is from 50 to 70 per cent of the total diet nitrogen. Such high levels of NPN supplementation are never needed for commercial fattening systems in the temperate countries.

Final molasses, the principal by-product from sugar cane, is also different in composition from conventional feeds given to ruminants because of its high soluble sugar content. This provides yet a further constraint on the efficient use of this feed in animal production systems.

## FEEDING SYSTEMS

### Confinement or semiconfinement

The decision as to which of these two approaches should be adopted will depend upon the overall policy in a given situation. For example, if the aim is to establish a feeding system to be applied only during the dry season, direct grazing being the favored procedure during the rainy season, it would not be economical to construct a full confinement feedlot, as it would only be in use for six months of the year. In this situation, intensive feeding in semiconfinement, combined with periods of restricted grazing, is a more logical approach.

The facilities required for this kind of fattening are extremely simple. Since the system is used only in the dry season, there is no problem about disposal of manure or build-up of mud caused by excessive rains; thus, a simple enclosure is all that is required. In this kind of plan the aim is to have the animal harvest its own forage; and by controlling the number of hours spent grazing, stocking rate can be maintained at the same level as during the rainy season, with full access to grazing. Restricted grazing for some three to five hours daily can be expected to supply 20 per cent of the total dry matter needs of the animal, the remainder being given in the form of a supplement according to the kind of raw materials that are available.

Full confinement applies to these situations where the objective is not to take advantage of summer grazing, but rather to grow crops specifically for utilization under feedlot conditions. The design of this kind of confinement unit is critical, as it is necessary for it to be workable during the period of heavy rainfall in spring and summer. The typical feedlot pattern based on North American experience is not appropriate under such conditions, and systems of housing making use of partially slatted floors, associated with removal of manure in liquid form, have been found to be much more appropriate.

**Fattening on final molasses**

The experimental work leading to the use of final molasses as the major energy source in an intensive fattening system was carried out in Cuba. The development of the system and the constraints associated with the use of this material have been reviewed in detail elsewhere (Preston, 1972). Therefore, only the major factors associated with this feeding system will be summarized here.

The successful use of final molasses at high levels in cattle fattening requires an understanding of the following factors: (a) molasses is a liquid and thus has no roughage characteristics in contrast to other carbohydrate feeds, such as cereal grains and forages; (b) it contains less than 1 per cent nitrogen, almost all of which must be considered as nonprotein nitrogen; (c) it is a good source of calcium and of trace elements but is highly deficient in phosphorus and sodium; (d) the carbohydrate fraction is found entirely in the form of highly soluble sugars, which give rise to quite different patterns of rumen fermentation, as compared with either starch or the structural carbohydrates. To feed molasses to fattening cattle successfully, it is necessary to understand the need for and the effect of specific supplements; namely, roughage, protein, minerals and nonsugar carbohydrates.

### Roughage

The role of roughage in molasses feeding is primarily to ensure efficient functioning of the rumen. For example, if the rate of emptying the rumen is slowed down because of lack of rumen motility, there is a reduction in voluntary intake. A related, secondary effect is an atypical pattern of rumen fermentation, characterized by high levels of butyrate and low levels of propionate. This, in turn, can give rise to a metabolic disorder known as molasses toxicity, which in its final form causes cerebro-cortical necrosis.

Desirable attributes of a roughage to be used with liquid molasses are therefore (a) that it should have an adequate physical effect on the rumen wall and (b) that it should be sufficiently palatable to be consumed in the minimum amounts needed to maintain normal rumen function. This minimum amount will depend upon the physical characteristics of the roughage, thus both of these factors are interrelated. Some effects caused by roughage are summarized in Tables 3 and 4.

Elimination of roughage from the ration gave rise to 100 per cent toxicity, whereas a forage that was adequate in the freshly chopped state became inadequate after dehydration and grinding. In Table 4, the poorer results obtained with maize stover reflect, not so much its lack of roughage characteristics, but the fact that it was not eaten in sufficient quantities.

Experience indicates that the most suitable roughages for this system are stoloniferous grasses, such as pangola and African star grass, given either in the fresh state or as hay.

Table 3. **Effect of artificial roughage on voluntary intake of molasses and total diet by young bulls (basal diet was ad libitum molasses, protein supplement and the respective forage sources).**

| | No forage | Plastic roughage | Fresh forage | Dried, ground forage |
|---|---|---|---|---|
| Perón and Preston (1971) | | | | |
| Molasses (kg DM/day) | 2.32 | 3.17 | 4 92 | — |
| Total diet DM (kg/day) | 2.68 | 3.53 | 5.64 | — |
| Losada and Preston (1972) | | | | |
| Molasses (kg DM/day) | 1.53 | — | 1.91 | 1.32 |
| Total diet DM (kg/day) | 1.81 | — | 2 38 | 2.04 |

Table 4. **Liveweight gain and incidence of molasses toxicity in cattle (Zebu and Criollo) given high levels of molasses/urea and different sources of forage.**

| | Maize stover | Barley straw | Maize silage |
|---|---|---|---|
| No. of animals | 200 | 200 | 2,000 |
| Initial weight (kg) | 274 | 284 | 275 |
| Days of feed* | 29 | 29 | 29 |
| Daily gain (kg) | 0.510 | 0.710 | 0.910 |
| Molasses toxicity (%) | | | |
| Deaths | 2.0 | 2.0 | 2.0 |
| Sick** | 5.5 | 0.5 | 2.5 |

* Period of adaptation
** Recovered subsequently
**Source:** Losada and Preston, 1974 (Unpublished data)

Freshly cut forage sorghum appears to be particularly undesirable as a forage source because of the apparently high incidence of bloat associated with this particular feed. The reason why this particular metabolic disorder would be associated with forage sorghum is not known. The problem disappears when the forage is dried and given as hay, which would suggest that some factor in the fresh juices is responsible for causing the bloat.

## Nitrogen supplementation

Bearing in mind the excellent medium for the growth of rumen microorganisms offered by the high sugar content of molasses, it is obviously more economical to take maximum advantage of rumen microbial synthesis from simple nitrogen compounds to supply the major amino acid needs of the animal. In this respect, it is necessary to balance the digestible carbohydrate in the molasses with the simplest form of nitrogen that can be used by microorganisms; namely, a source of ammonia, which is most conveniently provided by urea.

Both on the basis of theoretical considerations and practical experience, the optimum level appears to be between 2 and 3 per cent of urea in final molasses of 80° Brix concentration. Because the extent of microbial protein production in the rumen is a function of energy supply and because anaerobic fermentations are relatively inefficient, it is to be expected that a source of amino acids in addition to those produced by rumen microorganisms will be needed to cover the overall amino acid needs for intensive fatterning.

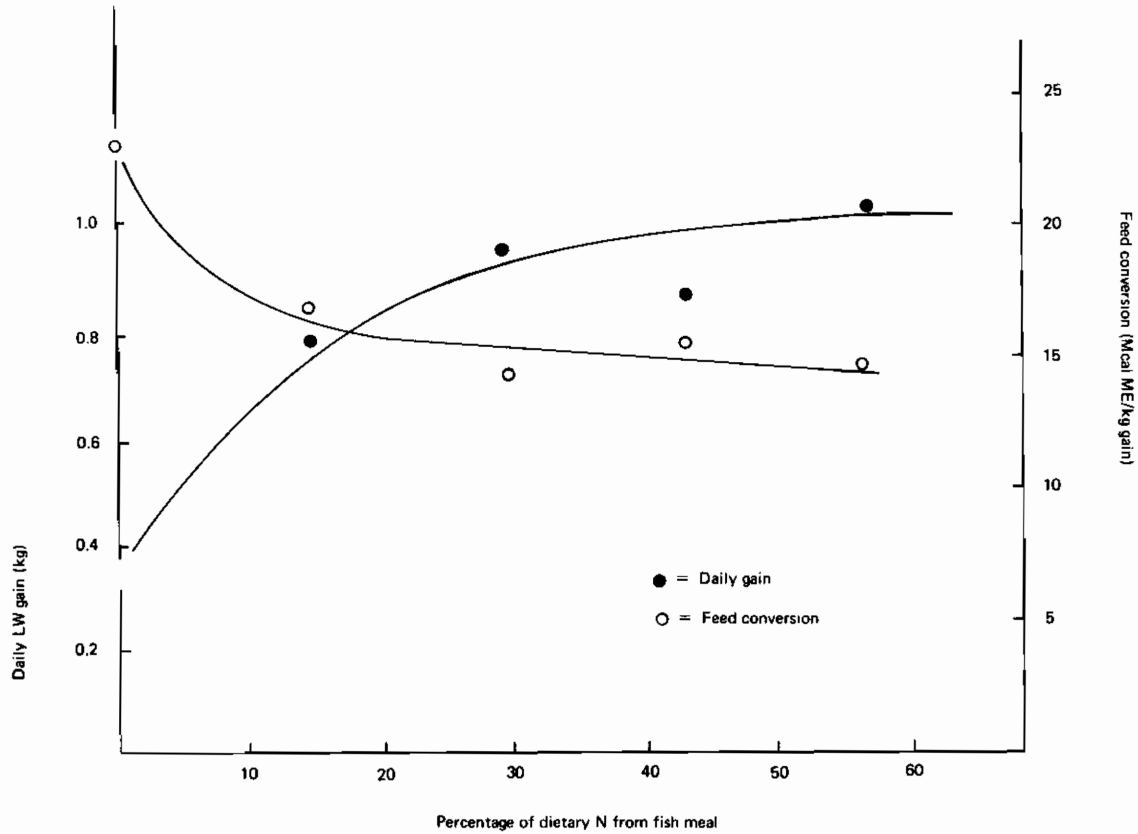
With an average molasses intake of 2.5 per cent of liveweight, the diet carbohydrate that is fermentable in the rumen will be sufficient to supply 60 per cent of total protein requirements as microbial protein according to the theoretical conversion rates for this process in a molasses-based diet, estimated in vivo by Ramírez and Kowalczyk (1971). Supplementary dietary protein would therefore need to be supplied to the extent of 40 per cent of total needs. Moreover, this should be "protected" or insoluble protein to avoid its being degraded upon passage through the rumen. Confirmation of this hypothesis is provided by the data given in Figure 4.

The experiment was carried out with a typical molasses-fattening ration, except that the composition of the nitrogen fraction, over and above that present in the forage and molasses, was varied between 100 per cent urea nitrogen and 100 per cent fish meal nitrogen, the latter being considered a naturally insoluble protein because of the heat treatment received in its processing. In view of the much greater cost of fish meal as compared with urea nitrogen, the economic optimum is closer to 20 per cent fish meal nitrogen; i.e., the equivalent of 4 per cent fish meal in the diet dry matter. A similar trial was carried out with yeast protein *(Torulopsis candida)* by Preston and Muñoz (1971). The nature of the response curve (Fig. 5) was broadly similar to that obtained with fish meal, the only difference being that a greater total amount of protein was needed to reach maximum animal performance, a finding possibly related to the lower level of sulfur amino acids in this particular protein source.

The importance of the insolubility of the supplementary protein is emphasized by results from an experiment (Table 5), where the supplementary protein for a molasses/urea diet was supplied by either solvent-extracted rapeseed meal, fish meal or a mixture of the two (Preston and Molina, 1972).

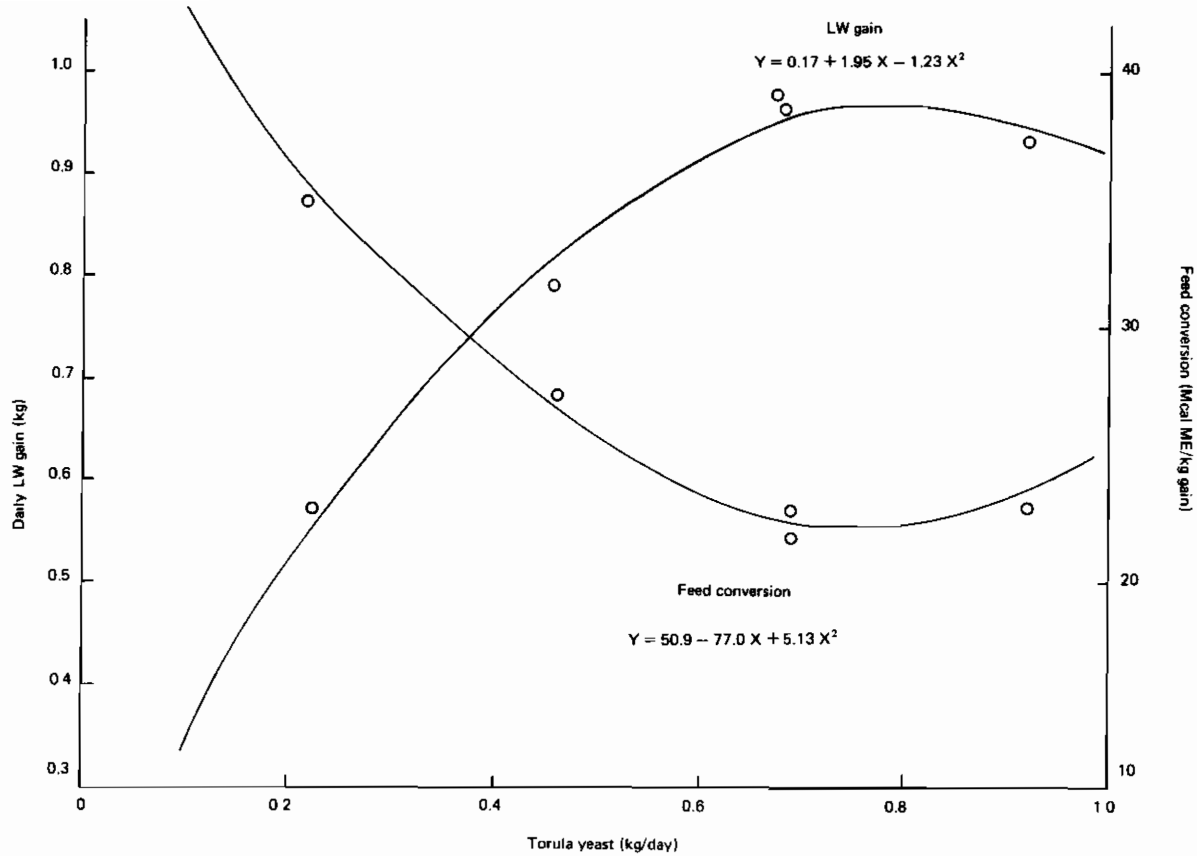
Animal performance on the rapeseed ration was no better than that expected from urea alone and less than half that recorded on the fish meal diet. The rapeseed meal was found to be 80 per cent soluble in rumen fluid and therefore likely to be degraded rapidly by rumen organisms. Subsequent trials have shown that expeller rapeseed meal, which is less soluble because of the heating received in the extraction process, is more suitable as a protein supplement for molasses/urea diets (Donefer, 1973, personal communication).

The importance of the solubility of the protein source seems to be a function of its level in the diet. Thus, Redferne (1972, personal communication) obtained good results with a mixture of maize germ and cottonseed meal in a molasses-based fattening diet; but in this case no urea was given, and all the supplementary nitrogen came from protein. Similarly, Preston (1973, unpublished data) found that gains of 0.9 kg/day could be obtained from a diet of 60 per cent molasses, 20 per cent forage and 20 per cent whole cottonseed. Again, at this level of supplementary protein (no urea was given), a relatively soluble source was acceptable.




**Source:** Preston and Martin, 1972

**Figure 4.** The effect of replacing urea N with fish meal N on growth rate and feed conversion in Holstein x Brahman bulls, fattened on a molasses-based diet.




**Source: Preston and Muñoz, 1971**

**Figure 5.** The effect of yeast protein on performance of bulls fed a molasses/urea ration.

Table 5. **Rapeseed meal as a supplement to molasses-urea diets for crossbred Brahman bulls.**

| | Fish meal* | Fish meal and rapeseed (50:50)** | Rapeseed meal*** |
|---|---|---|---|
| Initial weight (kg) | 135.6 | 133.6 | 134.8 |
| Final weight (kg) | 208.4[a] | 184.6[b] | 166.0[c] |
| Daily gain (kg) | 0.85[a] | 0.59[b] | 0.36[c] |
| Conversion (Mcal ME/kg gain) | 11.4[c] | 13.8[b] | 20.8[a] |

abc = Means without letter in common differ at $p < 0.05$.

* Basal diet of ad libitum molasses (with 2% urea), fresh forage (1.5% of LW daily), and minerals, plus 450 g fish meal daily

** Basal plus 200 g fish meal and 392 g rapeseed meal

*** Basal plus 785 g rapeseed meal

**Source:** Preston and Molina, 1972

Other data, relevant to the general hypothesis requirements for supplementary "protected" protein, refer to programming or phase feeding (Table 6). Supplying the protein at higher levels during the first month supported better animal performance and more efficient use of both the molasses and the protein. In some respects, such findings could be interpreted as indicating a period of adaptation to urea utilization. However, agreement is with Burroughs et al. (1970) that the implied adaptation is more likely to be related to the energy components of the diet, for which there is adequate documentation (Turner and Hodgetts, 1955; Marty and Sutherland, 1970), and that this, in turn, affects microbial growth in view of the energy-limiting nature of this process (Hungate, 1966).

Feed intake always increases after the transition period, thus providing for greater microbial synthesis, thereby reducing the requirement for supplementary protein. There is also the fact that protein requirement relative to energy decreases on feed with time because of the changing composition of the tissue being laid down.

### Nonsugar carbohydrates

It has been shown that the pattern of rumen fermentation on molasses-based diets is characterized by abnormally high levels of butyrate and low levels of propionate (Table 7). Such a situation could lead to low voluntary intakes and to decreased efficiency of energy utilization for fattening. Addition of a source of starch to a molasses-based ration would theoretically be expected to increase propionate levels; and in fact, this

Table 6. **Effect of programming the protein supplement supply for Holstein x Brahman bulls given ad libitum molasses-urea and restricted grazing.**

| | **Allowance of fish meal in successive months (g)** | |
|---|---|---|
| | **300:172:57:57** | **400:57:57:57** |
| Number of bulls | 700 | 700 |
| Liveweight (kg) | | |
| Initial | 270 | 262 |
| Final | 345 | 330 |
| Daily gain | 0.581 | 0.641 |
| Conversion (kg/kg gain) | | |
| Molasses | 9.640 | 8.800 |
| Fish meal | 0.275 | 0.231 |
| Mean daily intake of fish meal (kg) | 0.160 | 0.148 |

**Source:** Morciego et al., 1972

Table 7. **Molar composition of the volatile fatty acids (VFA) in rumen liquor from cattle given high levels of molasses compared with values from the literature for more conventional diets.**

| **Class and number of animals** | **Diet** | **Total VFA meq/liter)** | **Molar proportions (%)** | | | |
|---|---|---|---|---|---|---|
| | | | **Acetic** | **Propionic** | **Butyric** | **Others** |
| Dairy cows | | | | | | |
| 2 | Pasture | 131-148 | 65-67 | 18-19 | 11-12 | 3-4 |
| — | High-grain | 148 | 58 | 20-21 | 15-16 | 4-5 |
| 8 | High-molasses | 114 | 36 | 24 | 29 | 10 |
| Fattening cattle | | | | | | |
| 2 | Alfalfa hay | 107 | 74 | 18-19 | 7-8 | — |
| 5 | High-grain | 115 | 39 | 40 | 21 | — |
| 8 | High-molasses | 143 | 31 | 19 | 41 | 9 |
| Weaned calves | | | | | | |
| 4 | High-grain | 115 | 50 | 37 | 13 | — |
| 8 | High-molasses | 96 | 28 | 20 | 37 | 14 |

**Source:** Marty and Preston, 1970

hypothesis has been proven experimentally in dairy cows (Table 8). Although conclusive data are lacking for such effects on the rumen fermentation pattern in fattening bulls, there is evidence that supplementary starch has a nonadditive (i.e., stimulatory) effect on animal performance. A linear improvement in voluntary feed intake, liveweight gain and feed conversion to added maize grain was reported by Preston et al. (1973) for Zebu bulls fattened on a molasses-based ration in Mauritius (Fig. 6). A curvilinear response with increases in maize bran (including the germ) in a molasses ration was observed by Redferne (1972) in Kenya (Fig. 7).

Since in the early phase of supplementation with cereal grains the response appears to be in excess of the substitution value of the metabolizable energy of the starch source (there is also an increase in voluntary intake), it will usually be economical to include some cereal grain (or grain by-product) at low levels in a molasses-based ration, despite the higher price of the energy supplied by the cereal grain or by-product in comparison to that found in molasses. There is also the added advantage that inclusion of some grain product appears to give protection against molasses toxicity since this syndrome also seems to be caused by low levels of propionate production (Losada and Preston, 1973).

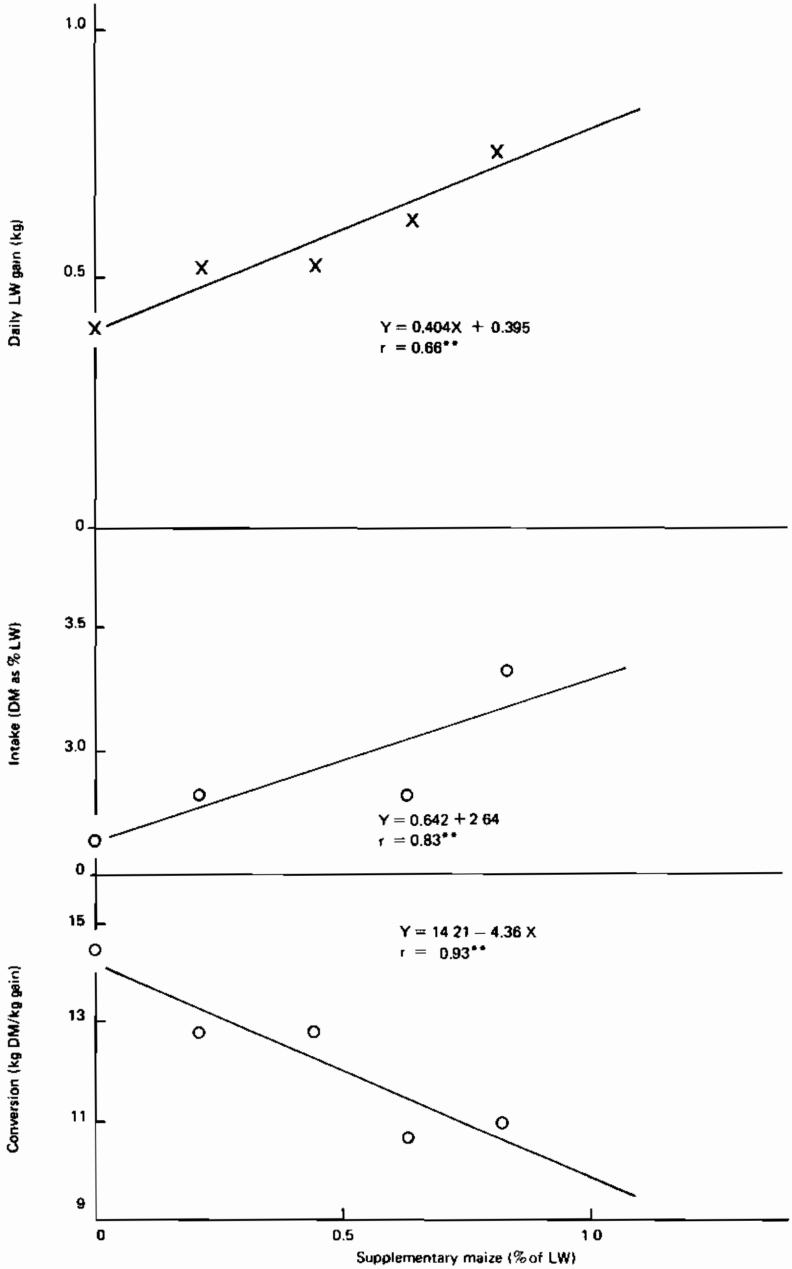
**Input-output data for fattening with molasses**

There can be no one formula or combination of ingredients applicable to all the varied situations where molasses is produced. For each particular region, input-output studies must be carried out in order to determine the most economical combination of inputs. The information given in the preceding part of this section aims to provide a guideline as to the nature of the responses to be expected, but it can be no substitute for experimental data using the actual raw materials available.

Table 8. **The effect on rumen fermentation of substituting maize with molasses in a low-forage diet given to dairy cows.**

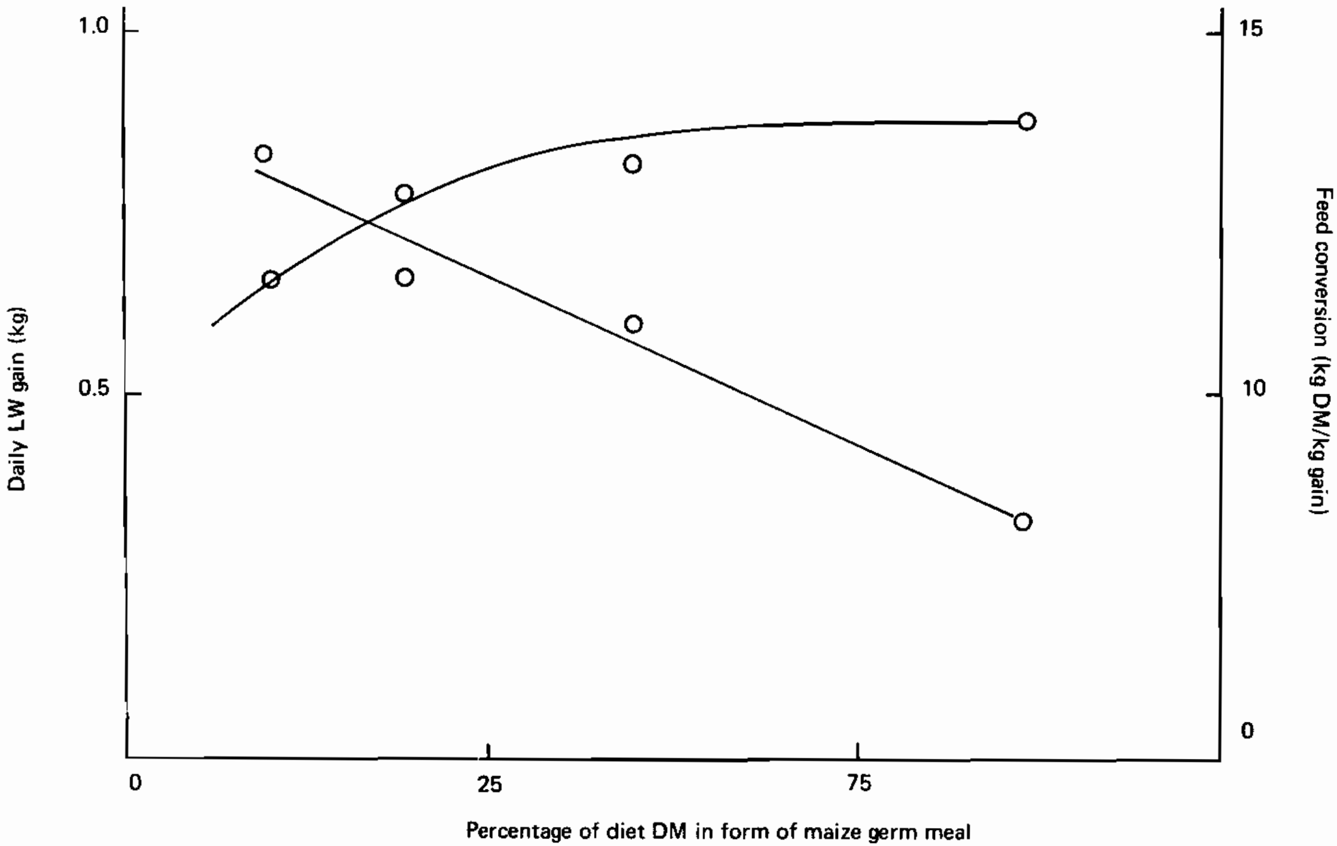
| | Maize (as percentage of diet DM) | | | |
|---|---|---|---|---|
| | **63.8** | **42.25** | **20.45** | **0.61** |
| VFA, molar (%) | | | | |
| Acetic | 57.4 | 56.8 | 55.8 | 51.9 |
| Propionic | 29.3 | 23.9 | 19.9 | 18.0 |
| Butyric | 10.7 | 17.4 | 21.1 | 25.8 |
| Valeric | 0.6 | 1.2 | 2.6 | 3.7 |
| Blood ketone bodies (mg/100 ml) | 4.6 | 3.9 | 4.9 | 7.0 |

**Source:** Clark, 1971




**Source:** Preston et al., 1973

**Figure 6.** The effect of supplementary maize grain on performance of Zebu bulls fed a diet based on molasses/urea.




**Source:** Redferme, 1972 (Unpublished data)

**Figure 7.** The effect of adding increasing amounts of maize germ meal on performance of Zebu steers fed a molasses-based diet.

In 1970 to 1971, the program of fattening with molasses in Cuba was based on fish meal as the only supplement to the basal diet of molasses/urea, minerals and forage. The data in Tables 9 and 10 refer to the input-output relationship obtained with these ingredients in a commercial 10,000-head feedlot and in a series of dry season fattening units employing the restricted grazing system. For the feedlot, comparative figures are given for the previous year when more conventional feeding systems were in operation, based on ad libitum forage supplemented with smaller quantities of concentrates and molasses. The information is self-explanatory, but it is relevant to draw attention to the considerably greater production which was one consequence of changing to the high molasses-low forage program. This simply reflects the considerable logistics problem involved in trying to cut and transport large amounts of green forage and how much easier it is to move liquid molasses.

The high mortality and emergency slaughter figures in the first year of the molasses program also merit some explanation. In part, they reflect management difficulties which are bound to arise when making a radical change in feeding systems. Nevertheless, it should also be pointed out that despite the greater losses, the overall economics of high molasses feed remained attractive since, in terms of all the major inputs—i.e., animals, labor machinery—feed output was considerably increased, inclusive of the losses.

There were no important differences in input-output relationships between the restricted grazing and the feedlot systems. In fact health problems were considerably reduced in the former, probably reflecting a better control over the forage input, since the animal under free-grazing conditions can more effectively select this portion of its diet.

**Sugar cane**

The concept of using sugar cane as a direct source of animal feed arose from a new technology developed in Canada by Miller and Tilby (See Dion, 1973). They invented a machine which splits the sugar cane stalk, scoops out and grinds the pith containing the sugars and discards the two strips of rind (Table 11). The coarsely ground pith is a creamy white, palatable feed that has the consistency of wet sawdust. It is readily eaten by cattle and is an excellent energy source for intensive beef production (Table 12).

Yet a further possibility is to use ground whole sugar cane including the rind. Simple machines for this process have been developed both in Brazil and Mexico. No reliable data for animals are yet available for this process although preliminary observations are encouraging (Preston et al., 1974). From the economic point of view, this system requires much less investment so it should be particularly suitable for use at the small farm level (Tables 13 to 15 and Fig. 8).

Table 9. **Input-output data (January to June inclusive) for fattening bulls on molasses-based diets (1970 and 1971), as compared with forage-based diets (1969) in a 10,000-head capacity feedlot.**

| | Forage-based | Molasses-based | |
|---|---|---|---|
| | 1969 | 1970 | 1971 |
| Total daily LW gain (kg) in the feedlot | 3,724 | 8,295 | 13,797 |
| Daily LW gain (kg) per | | | |
| Bull | 0.43 | 0.88 | 0.89 |
| Worker | 14.30 | 51.80 | 82.20 |
| Tractor | 85.60 | 420 | 282 |
| Conversion (kg/kg LW gain) | | | |
| Forage | 34.70 | 11.90 | 10.30 |
| Molasses | 3.10 | 10.00 | 9.62 |
| Urea | 0.23 | 0.32 | 0.31 |
| Concentrates | 3.84 | —— | —— |
| Fish meal | —— | 0.41 | 0.41 |
| Minerals | —— | 0.13 | 0.10 |
| DM | 15.40 | 10.80 | 9.82 |
| Mortality (%) | 0.10 | 1.00 | 0.21 |
| Emergency slaughter (%) | 0.40 | 3.04 | 1.31 |

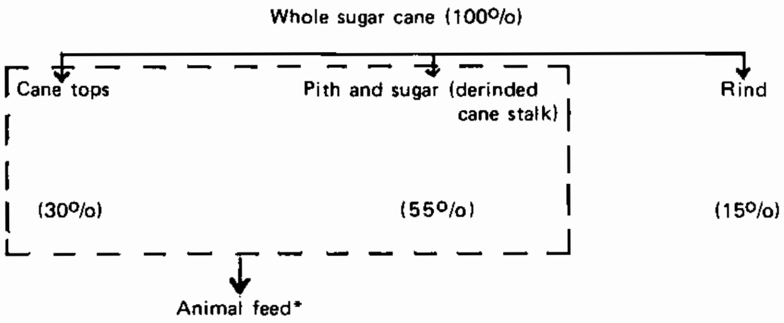
**Source:** Muñoz et al., 1970; Muñoz, 1971 (Unpublished data)

Table 10. **Input-output data for fattening bulls given ad libitum molasses/urea and restricted grazing and fish meal supplementation (3,500 bulls in 11 units).***

| | Best unit | Mean of all units | Worst unit |
|---|---|---|---|
| Daily LW gain (kg) | 1.04 | 0.83 | 0.74 |
| Conversion (kg feed/kg gain) | | | |
| Molasses | 5.90 | 9.10 | 14.70 |
| Fish meal | 0.32 | 0.45 | 0.54 |
| Urea | 0.19 | 0.29 | 0.47 |
| Mortality (%) | 0.00 | 0.38 | 1.33 |
| Emergency slaughter (%) | 0.00 | 0.44 | 1.33 |

* Mean initial and final weights were 313 and 403 kg; breeds were Brahman and Holstein x Brahman.
**Source:** Morciego et al., 1970

Table 11. **Derinding of sugar cane for animal feeding.**




* Both components combined can supply total diet needs for readily fermentable carbohydrate and roughage.

**Source:** Pigden, 1972

Table 12. **Average values (and range) for composition of derinded cane stalk alone and with the tops included.**

| | **Derinded cane stalk** | **Derinded cane stalk plus tops** |
|---|---|---|
| DM (%) | 30 (27 to 31) | 32 (30 to 33) |
| Composition of DM (%) | | |
| N X 6.25 | 1.9 ( 1 to 2.5) | 3.0 (1.8 to 4.2) |
| Cellulose | 18 (15 to 20) | 24 (21 to 38) |
| Total sugars | 50 (40 to 63) | 43 (40 to 48) |
| Digestibility of DM (%) | 70 (68 to 73) | 69 (68 to 71) |

**Source:** Pigden, 1972

Table 13. **Technical coefficients of two sugar cane processing machines for cattle feeding.**

| | Derinding machine* | Mill |
|---|---|---|
| Investment (US$) | 37,000 | 4.00 |
| Laborers (No.) | 3 | 7 |
| Productivity (ton/hr) | 3.93 | 0.56 |
| Electric power (KWH/ton) | 7.82 | 7.00 |
| Waste (%) | | |
| Leaf | 4 | |
| Rind | 14 | |

* Model C4, Canadian Cane Equipment, Barbados

Table 14. **Sugar cane processing for cattle feeding (US$).**

| | Derinding machine | Mill |
|---|---|---|
| Feedlot capacity (No.) | 1,600 | 1,600 |
| Investment | 37,000 | 3,200 |
| Ground cane (ton/year) | 14,244 | 11,680 |
| Processing cost | | |
| Per ton of product (fresh bagasse) | 1.33 | 1.35 |
| Per ton of product (dry bagasse) | 4.44 | 4.50 |
| Percentage as: | | |
| Interest and amortization in 10 years (12% yearly) | 40.4 | 3.4 |
| Electric power | 14.7 | 13.0 |
| Labor | 33.0 | 82.6 |
| Maintenance | 11.9 | 1.0 |

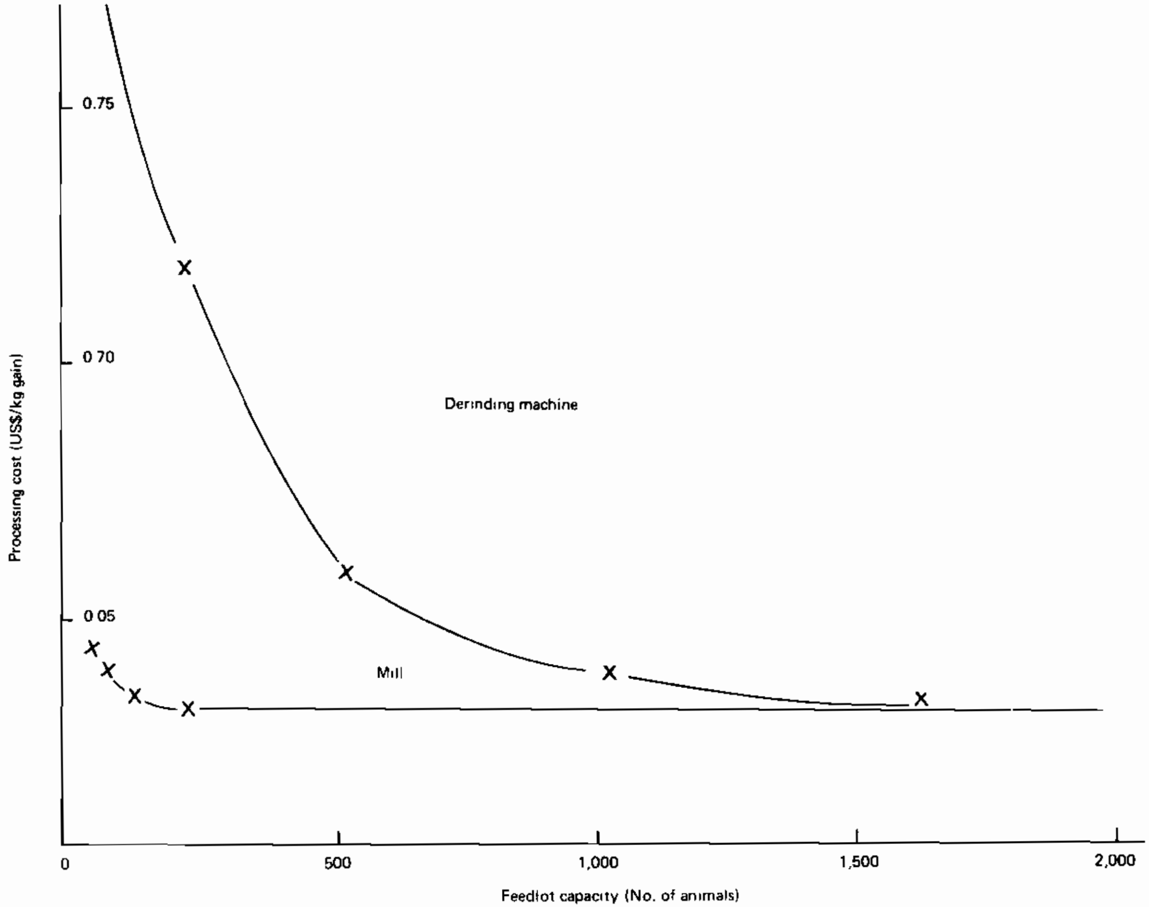



**Figure 8.** The cost of two methods for sugar cane processing in accordance with the scale of operation.

Table 15. **Cost of processed cane (US$).**

| | Derinding machine | Mill |
|---|---|---|
| Price of sugar cane in stalks | 7.01 | 7.01 |
| Price of sugar cane including tops | 4.91 | 4.91 |
| Cost of the product (fresh bagasse) | 5.99 | 4.91 |
| Processing cost (fresh bagasse) | 1.33 | 1.35 |
| Total cost (fresh bagasse) | 7.32 | 6.26 |
| Total cost (dry bagasse) | 24.41 | 20.87 |
| Total cost including mechanization* | 26 73 | 23.19 |

* Fork lift and pallet system

The development work on derinded sugar cane has been carried out exclusively in Barbados and mainly with Holstein steers, by-products of the local dairy industry. The research facilities available did not allow comprehensive evauation of the different inputs associated with this feeding method. Nevertheless, certain dietary variables have been studied; and in general, the results obtained indicate that in many respects similar constraints apply to derinded sugar cane, as well as to final molasses when used as the major component in a fattening program (Donefer et al., 1973).

## Forage

Although derinded cane obviously has better roughage characteristics than liquid molasses, animal performance seems to be improved by incorporating additional forage in the form of the cane tops (Table 16). As with molasses, supplementary forage seems to exert its major effect in increasing voluntary intake and as a result, rate of liveweight gain; but there is a slight reduction in the efficiency of feed conversion. The ratio of tops to derinded cane was fixed as that normally found in whole sugar cane. It is not known if slightly narrower rations—i.e., a lower proportion of tops—might not be more beneficial.

## Cereal grains

Two carbohydrate supplements, maize grain and molasses, were added to rations based on derinded whole sugar cane (Table 17). Both supplements, which were supplied at the

Table 16. **Derinded sugar cane as the basis for intensive feeding of Holstein steers.***

| | Derinded cane stalk | | Improvement because of cane tops (%) |
|---|---|---|---|
| | Alone | Plus tops | |
| No. of calves | 12 | 13 | |
| Liveweight (kg) | | | |
| Initial | 105 | 102 | |
| Final | 257 | 271 | |
| Daily gain | 0.59 | 0.66 | 12 |
| Feed intake (kg/day) | | | |
| Derinded cane stalk | 12.8 | 10.9 | |
| Cane tops | — | 4.3 | |
| Derinded whole cane | 12.8 | 15.2 | 19 |
| Protein supplement | 1.1 | 1.1 | |
| Total DM | 4.72 | 5.63 | 19 |
| Conversion (kg DM/kg gain) | 8.0 | 8.5 | –6 |

* It was considered that in this trial the liveweight gains were lower than would normally be expected because of the use of immature cane and effect of flooding on cane quality

**Source:** James, 1973

rate of 1 per cent of liveweight daily, brought about consistent increases in voluntary intake and in liveweight gain. Maize increased gain by more than 25 per cent, and there was also an important improvement in feed conversion (11 per cent on an average). Molasses increased gain by a lesser amount (about 9 per cent) and caused a deterioration in feed conversion. Data are not available on rumen fermentation on derinded sugar cane, but it is probable that it will show the same constraints as on molasses—i.e., propionate production will be limiting—since the beneficial effects of added maize grain are of the same magnitude on both feeds.

The level of maize supplementation in these trials was high (32 per cent of the diet DM) and would not be economical in most cases. It is probable that smaller amounts would be more appropriate since it can be expected that the response curve to maize supplementation will be curvilinear, with the greatest effect being observed in the early phase of substitution.

### Protein

In all the trials reported with derinded cane, urea was added to supply from 50 to 60 per cent of the total nitrogen requirements. However, the absolute quantities of protein/

Table 17. **Effect of added (1% of LW) maize or final molasses on performance of Holstein steers fattened on a basal diet of derinded sugar cane.**

| | Control* | Improvement over control (%) | |
|---|---|---|---|
| | | Molasses | Maize |
| Initial wt (kg) | | | |
| Trial 1 | 308 | | |
| Trial 2 | 322 | | |
| Trial 3 | 380 | | |
| Final wt (kg) | | | |
| Trial 1 | 459 | | |
| Trial 2 | 407 | | |
| Trial 3 | 426 | | |
| Mean daily gain (kg) | | | |
| Trial 1 | 0.99 | 9 | 27 |
| Trial 2 | 0.95 | 13 | 24 |
| Trial 3 | 1.02 | 3 | 32 |
| DM intake (% LW) | | | |
| Trial 1 | 2.40 | 29 | 17 |
| Trial 2 | 2.47 | 14 | 11 |
| Trial 3 | 2.47 | 7 | 4 |
| Feed conversion (kg DM/kg gain) | | | |
| Trial 1 | 9.1 | −16 | 8 |
| Trial 2 | 10.1 | 0.0 | 11 |
| Trial 3 | 9.9 | −15 | 15 |

* Control diet was (% DM basis): derinded cane stalk, 52, cane tops, 28; protein/mineral/vitamin supplement, 20.

**Source**: James, 1973

nitrogen in the diet were higher than those used in the work done with molasses in Cuba. This might account for the apparent absence of response to fish meal in comparison with the more soluble rapeseed meal (Table 18). Further trials are needed with more critical levels of protein before definitive conclusions can be made on this aspect.

Table 18. **The effect of the type of protein supplement on the performance of Holstein steers fed a basal diet of derinded sugar cane.***

| | Fish meal | Fish meal/ rapeseed | Rapeseed |
|---|---|---|---|
| Liveweight (kg) | | | |
| Initial | 146 | 148 | 147 |
| Final | 303 | 308 | 309 |
| Daily gain | 0.90 | 0.91 | 0.91 |
| Feed conversion (DM intake/gain) | 8.3 | 8.5 | 8.7 |

* The diets were (DM basis, %): derinded cane plus tops, 60; protein supplement, 12; and maize grain or molasses, 27, for the fish meal diet; and derinded cane plus tops, 54; protein supplement, 19; and maize or molasses, 27, for the rapeseed meal diet; the mixed-protein diet was intermediate in proportions of the two protein sources.

**Source:** James, 1973

### Ensiling

One disadvantage of using derinded sugar cane as animal feed is that because of its high moisture and sugar content, it ferments quickly so that it must be processed and fed daily. A similar problem exists with the feeding of whole crop maize, and this has been solved by ensiling the material. In this form maize stores easily and is well accepted by cattle. Unfortunately, the ensiling process appears to be much less suitable for derinded cane. The data in Table 19 show that when fresh derinded cane is replaced by the ensiled material, there is a serious fall-off in animal performance; that is, in gain and feed conversion. This effect can be related in great part to depression in voluntary intake of the ensiled material and to reduced efficiency of its utilization. Both these effects can be corrected by addition of either molasses or maize. The rate of gain on ensiled derinded cane plus energy supplement was comparable to that on fresh unsupplemented material. Nevertheless, both gain and intake remained below the levels reached when these energy supplements were added to fresh derinded cane.

### Input-output data for a feedlot using derinded sugar cane

Available data are summarized in Table 20. Caution must be used in interpreting this information since only limited numbers of animals were involved and the same group did not continue throughout the full feeding period. The overall level of performance is

Table 19. **The effect of ensiling derinded whole sugar cane on the performance of Holstein steers.**

| | Derinded whole sugar cane | | | | | |
|---|---|---|---|---|---|---|
| | No supp. | Molasses | Maize | No supp. | Molasses | Maize |
| | (Fresh) | | | (Ensiled) | | |
| No. of steers | 8 | 8 | 8 | 8 | 7 | 8 |
| No. of days | 95 | 95 | 95 | 42 | 95 | 95 |
| Liveweight (kg) | | | | | | |
| Initial | 322 | 310 | 336 | 290 | 325 | 325 |
| Final | 407 | 405 | 440 | 304 | 408 | 415 |
| Daily gain | 0.89 | 1.00 | 1.09 | 0.31 | 0.87 | 0.94 |
| Feed intake (kg DM/day) | | | | | | |
| Derinded whole cane | 7.45 | 5.86 | 5.31 | 4.45 | 4.45 | 3.22 |
| Protein supplement | 1.54 | 1.54 | 1.59 | 1.45 | 1.54 | 1.54 |
| Energy supplement | —— | 2.81 | 3.09 | —— | 2.86 | 3.04 |
| Conversion (kg DM/kg gain) | 10.1 | 10.1 | 9.1 | 18.8 | 10.1 | 8.2 |

**Source:** James, 1973

similar to that recorded on molasses-based rations. It should be remembered that the breed used was Canadian Holstein. Limited observations on Zebu steers (James, 1973) indicate that average gains on similar rations were 18 per cent poorer than for Holstein.

### Processing costs

Estimates are given in Tables 13 to 15 of the cost of processing sugar cane by derinding and simple grinding, based on measured productivity and power consumption in the two systems. The costs of a typical finishing system are derived in Table 21, and the projected economics for Mexican conditions for a 1,600-head capacity feedlot using derinded cane are given in Table 22. Expected animal performance is set at 0.8 kg/day. Confirmation of these projections will be possible when trials now in progress have been completed (Preston et al., 1974).

Table 20. **Input-output data for fattening Holstein steers given diets based on derinded whole sugar cane.***

| | | | |
|---|---|---|---|
| Days in feedlot | 446 | | |
| Liveweight (kg) | | | |
| Initial | 102 | | |
| Final | 459 | | |
| Daily gain | 0.80 | | |
| Feed intake (kg) | | **As fed** | **Dry matter** |
| Derinded cane stalk | | 5,620 | 1,713 |
| Cane tops | | 2,300 | 854 |
| Protein supplement | | 676 | 598 |
| Total | | | 3,165 |
| Conversion rate (kg DM/kg gain) | | | 8.87 |

* These relationships are calculated from data in Tables 18 and 19. The information relates to 13 animals over the first part of the growth curve to 271 kg; and only 6 animals from 308 to 459 kg. Performance from 271 to 308 kg was assumed to be at the average rate for the range 308 to 459 kg.

Table 21. **Intensive fattening ration based on sugar cane.**

| | | US$ | | |
|---|---|---|---|---|
| | (%) | Derinded | | Ground |
| Sugar cane (dry basis) | 78.33 | 26.73 | | 23.19 |
| Final molasses | 8.68 | | 40.00 | |
| Urea | 2.95 | | 136.00 | |
| Water | 2.21 | | | |
| Maize | 7.83 | | 104.00 | |
| Minerals | 1.00 | | 100.00 | |
| Cost ($/ton) | | 37.57 | | 34.79 |
| Feed cost ($/kg gain) | | 0.338 | | 0 313 |

Table 22. **The economics of intensive fattening in confinement with sugar cane (1,600 head).**

| | US$ | |
|---|---|---|
| Investment | | |
| Feedlots/management | 128,000 | |
| Equipment for molasses/urea | 2,833 | |
| Weight scales | 2,000 | |
| Other equipment | 1,000 | 133,833 |
| Operating costs* | | |
| Interest and amortization (16%) | 22,752 | |
| Labor (3 cowboys) | 3,942 | |
| Maintenance (5%) | 6,692 | |
| Interest on cattle (12%) | 37,210 | |
| Other costs (electricity, veterinary services, vaccines, etc.) | 5,000 | 75,596 |
| Cost per kg of gain** | | |
| Operation | 0.155 | |
| Feeding | 0.338 | |
| Losses (0.5% deaths, 0.5% slaughter) | 0 0107 | |
| Total | 0.600 | |
| Value of gains ($/kg)*** | 0 88 | |

* The machinery used to feed the cattle is the same used for mechanized sugar cane management.
** Assuming a gain of 0 80 kg/day
*** Plus the value of manure

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# APPLYING TECHNOLOGY AT THE LEVEL OF THE FARMER AND THE CATTLEMAN

*Ramón Claverán Alonso*

Economist Theodore Schultz (1965) maintained that the farmer who works the soil just as his forebears did cannot produce much food, no matter how rich his land is or how hard he works, and that any country depending on this traditional kind of agriculture will inevitably be a poor country. If he is right, modern technology and the necessary inputs for its correct application at the level of the farmer and the cattleman represent the major limiting factors in agriculture and livestock production.

In regard to those problems involved in the process of applying technology, I have some suggestions and possible solutions. I will first define, however briefly, the factors affecting production and their average status in tropical Latin American countries.

## FACTORS AFFECTING PRODUCTION

The land available for cattle raising is abundant but unfortunately of poor quality. It has been a tradition, handed down since colonial times, to use marginal or semimarginal lands for animal production. Such lands are deemed inadequate for growing crops because of their poor quality, topography and accessibility. For years, beef production has been looked upon as a "stepchild" of the other branches of agricultural production although this situation naturally varies from one country to another.

Nevertheless, during the last few decades, significant changes have come about, probably caused by increases in milk and meat prices —both nationally and internationally— and technological and economic problems involved in grain and fiber production. During the 50's in Mexico, for instance, beef production was replaced by cotton crops in many dry, unirrigated tropical lands. When cotton prices went down on the international markets, cattle raising returned to these lands. At present, the trend has been reversed once more as cotton prices have climbed rapidly during the last year. A similar phenomenon has occurred in northern Mexico with alfalfa destined for dairy cattle feeding and cotton crops in irrigated lands.

Landholding systems have also been an obstacle in the development of the cattle industry. In many Latin American countries, summer pasture lands have been traditionally held in huge estates by absentee landlords and placed in the hands of administrators who have been reluctant to incorporate progressive innovations. Obviously, serious socio-economic problems have arisen. It is not surprising, therefore, that a large number of developing countries have placed their hopes in agrarian reform programs.

Most countries where agrarian reform has been tried have not attained a significant level of efficiency in animal production. The only possible exception might be the Cuban experience, about which I unfortunately do not have sufficient information. The major causes for this, as seen by Edmundo Flores (1972), are (a) the inefficient application of the reform laws, (b) the mistaking of mere administrative and technical improvements for real agrarian reform, and (c) the conception of reform as though its objectives and the processes for achieving them could be identical for all countries, regardless of their cultural heritage and their economic and political idiosyncrasies.

Capital, an essential input for the development of the cattle industry in the tropics, has not been available in the past. Financial aid, through official banks and national development institutes, has been scarce likewise and its effects on the total economic balance of the country hardly visible.

Private banks, on the other hand, had an ancestral fear of investments in animal production and crops and therefore concentrated their funds in industry and commerce. Private lending institutions limited their investments in loans for agriculture and cattle raising to those enterprises capable of guaranteeing repayment and therefore not to the ones in greater need. Because of the risks involved, this policy is understandable —although not socially justifiable— from a financial point of view. Generally speaking, this situation still exists in some of our countries, but it has improved in the last decades. Today the percentage of capital investments in cattle raising and agriculture is still minimal in relation to other activities, but there is a greater volume of such investments in the private sector than formerly.

In the last 15 years, several international financing agencies have been created. Some of these are the International Bank for Reconstruction and Development (IBRD), the Interamerican Development Bank (IDB), the U.S. Agency for International Development (USAID), and the World Bank Association for International Development, dedicated to financing low-income enterprises in developing countries.

The World Bank has become the most important international financing agency for animal production. The bank made its first investment in agricultural production in 1948, and 15 years ago it began operating in this continent by granting financial assistance to Uruguay. Since then, its investments in agricultural development in Latin America have increased at such a rate that today they amount to several hundred million dollars. Mexico has been granted four loans totaling $ 275 million, destined for both national and regional cattle raising programs in definite ecological areas. Financial aid programs have been designed and carried out for both relatively developed commercial ventures and low-income livestock farmers. These programs cover the whole range of production, from primitive methods to different stages of industrialization.

The Interamerican Development Bank and the Agency for International Development have allocated funds amounting to $ 93.5 million for aid to low-income producers. These loans represent a third of the program's total investment; as customary, the remaining two thirds are contributed by the government, private national banks and the producers themselves.

The financing system currently used in Mexico is common in Latin America, and most of us are familiar with it. I have gone into it in detail in order to point out that financing for the development of the cattle industry is no longer a bottleneck situation. International aid agencies often assert that the major limiting factor at present is not the availability of financial resources, but the identification of viable regional development projects at the business level.

In identifying a sound development project, several factors must be taken into consideration. Some of these are ecological characteristics, adequate infrastructure, services, land-holding systems, the organization of the producers, the social situation, etc. At the end, the producers' actual technological levels should be defined, the means for improving these levels should be calculated, and appraisals of how fast new techniques can be absorbed should be made so that results begin to show.

The know-how of the cattle producer is a less tangible form of capital than machinery, livestock or bank accounts; and yet it is often the only capital remaining to him when everything else has been lost. This subjective aspect of capital ranges from the empirical methods of traditional cattle raising to the most sophisticated modern techniques, either those the cattleman already has or those that are or should be available to him as just one more production input.

Labor is usually abundant in tropical Latin America. Unfortunately, however, most laborers are not sufficiently skilled since schooling is alarmingly inadequate and illiteracy is widespread. In those ecological environments where animal production is the most convenient or the only possible use of the land, social problems become more serious because cattle raising displaces labor, especially in extensive or semi-intensive management.

Workers must then be relocated until the great industrialization process foreseen by experts comes to the area—if indeed it ever does.

Other important material inputs, such as machinery, fertilizers, insecticides, etc., have ceased to be a major problem even in those countries which do not produce them themselves. These inputs are scarce in our countries only when there are scarcities on the international market, as is now the case for fuel and fertilizers.

## FLOW OF TECHNOLOGY

In theory, the flow of technology should reach farmers and cattlemen through the agrarian extension programs of the countries' departments of agriculture. It is no secret, however, that these programs (with rare exceptions) have not worked efficiently. This is especially true of official programs for the cattle industry because they generally suffer from serious budget limitations and adequately trained personnel; unfortunately, even the motivation to make these programs work is often sorely lacking. If there are cases in Latin America where the situation is different from what I have described, I apologize for my ignorance.

Official agricultural extension programs, because of the poor state they were in, did not represent sound investment risks for international financing agencies or for the country's banking institutions or subsidiary agencies, who in the long run would be responsible for recovering or losing the invested funds. The banks were fully aware that technology was a basic complement for capital and that the recovery or loss of fixed and capital assets depended on it. Thus, mechanisms had to be created to provide the funds, diagnose the need for and establish priorities among the possible investments, program the process of repayment, define the profits to be obtained and decide whether the investment was financially sound. These mechanisms must be capable of checking and watching over the actual carrying out of the investments and, above all, have sufficient capacity to provide the technical assistance necessary through every stage of the process.

As a result of this, a new type of Latin American technician has appeared and increased in numbers in recent years. He spends most of his time on financial matters and technical counseling but has some time for promoting programs and making personal contacts.

Under this system, rather complex technical structures have emerged. One example is the Mexican Guarantee Fund (Fondo de Garantía de México), which has more than 450 technicians around the country, as well as specialists on regional and national affairs, training and demonstration programs, a public information service, etc. About a year ago, this technical assistance complex began to coordinate efforts with the government's extension system.

Official banks have similar technical structures in regard to number and organization of their technicians. Even private banks have agronomists and animal health experts on their staffs. This is a considerable improvement if one remembers that less than 20 years ago, private banks did not employ technicians, and their operations in the field of agriculture and cattle raising were very small. Similar organizations exist in almost all Latin American countries. In some countries the World Bank recommends hiring a foreign director for the cattle development program who will train a native technician so that he can eventually take over the program. In other cases, the banks work directly with the cattleman who has to employ officially registered, private consultants whose work is regulated by the bank. This was the type of operation set up two years ago for the control of Interamerican Development Bank funds invested in the cattle industry on the North Coast of Colombia.

Thus, technical assistance is being channeled through programs that have arisen out of the immediate need to develop the agricultural and cattle raising sectors; and I think the results have been positive. Unfortunately, as far as I know, no evaluation has been made of the results distinguishing the effects of financing from the effects of new techniques introduced by the professionals in charge of the programs.

In general, we can say that this dual system of financial and technical assistance has been successful in its initial stage. In the future, however, in order to continue its growth and increase its influence, the system will have to change considerably, keeping pace with the rhythm of development it has been responsible for establishing in the country's cattle industry. Experience has taught us that in the first stages of development, simple technical innovations in originally empirical and primitive operations yield quite significant results; but as the cattleman masters these, the technician's storehouse of techniques is finally exhausted and his importance diminished.

The technical adviser needs a continual flow of technical assistance in order to keep up to date. This assistance must be first rate, or the technician will lose the cattleman's trust. Sending the technician for studies abroad is only a partial solution. The technician may learn valuable new practices and ideas, but these may not have been tested for his own ecological and social environment. Obviously he cannot recommend them commercially. It is imperative for us to have adequate mechanisms for testing new techniques, whether original or derived from old ones, and for transmitting them to the technical adviser who, in turn, will see that they reach the individual farmer.

There have been some commendable efforts made in this respect. The Bank of Mexico Guarantee Fund, for instance, has a demonstration system involving the introduction and testing of tropical grasses and legumes, milk production in the tropics, systems for raising calves, etc. In Chile, specialists were sent from New Zealand, and later a group of 15 Chileans traveled to Australia and New Zealand in order to study, among other things, the possibility of establishing a winter grazing management system to replace the widespread practice of feeding cattle in mangers during the cold season. In view of the fact that no definite arrangements were made, more than 20 milk producers were chosen to travel to Australia and New Zealand. What they saw convinced them, and they in turn convinced their neighbors. Today many Chilean producers have switched to the winter grazing system, which is economically superior to the system formerly used in the area (Wagenen, 1972).

A few years ago, R. Milford started a program in Paraguay for introducing tropical legumes, using plots where it was possible to test all the grass-legume combinations. The following year the best combinations were planted in commercial plots. Similar programs are under way in several Latin American countries. Their design and execution might be subject to criticism from a scientific point of view, but they are eminently practical in nature, providing information for immediate application. Although these programs are a very positive approach, they cannot be expected to solve the great number of problems faced by the complex animal production system. We must turn toward the two essential sources for technical assistance: research and education.

**Research**

In the first place, I must admit that I am not familiar with the cattle research programs existing in all tropical Latin American countries. I know a few of them, however; and the exchange of ideas I have had over the years with Latin American technicians and researchers has convinced me that there are general characteristics which should be mentioned.

Research has been classified in many ways: basic research, applied research, speculative research, etc. For our purposes perhaps the most practical classification would be "useful" and "useless" research. In the first category we must class the type of studies which yield data and experiences applicable in reasonably short or intermediate terms. In Latin America we often indulge in the three types of research mentioned previously, or no research is done at all. We often encounter research projects without well-defined objectives or aimed at studying problems totally unrelated to the socioeconomic reality of the country paying for them.

Fortunately, researchers themselves seem to be reacting as they are finally becoming aware of the little regard cattlemen have for research, simply because they see no economical results coming from it. At the Fourth Convention of the Latin American Association of Animal Production last year, their president dealt with the problem in his opening speech. I think everyone there was motivated to think more about the practical usefulness of the papers presented from the cattleman's point of view.

Some scientists have a narrow view of the objectives of research, giving no thought whatsoever to the applicability of their findings. They consider themselves "men of science," whose basic objective is to publish articles in highly specialized journals in order to build up their professional reputation.

One of the most important technological contributions made by the World Bank to the Latin American cattle industry has been the know-how and discipline instilled in institutions and technicians. Our own institutions are now able to evaluate investments and make solid economic decisions using modern methods for determining indicators such as the cost-benefit ratio and profitability. It would be highly beneficial to train researchers in the same way so that they plan their research projects, taking into account the dollars and cents to be derived from this work. This does not mean that experiments should be planned and dealt with as mere financial investments, but there is a lot to be done to make research more pertinent.

The late Dr. McKeenan, a practical man and a great researcher, pointed out the scarcity of researchers and financial resources in developing countries (McKeenan, 1970). Dr. McKeenan saw the need for "adaptable" (as opposed to speculative) research in animal production in order to transfer the information obtained in more developed countries to our countries and put it to practical use. He felt that this type of research was not for second-rate researchers, but rather was just as difficult as basic research, for it required a great deal of intelligence, imagination, solid basic knowledge and a mastery of scientific methods.

It is a common error in Latin American for experiment stations to function independently of livestock farmers in the area. They underestimate the capacity of these men who may be uneducated and lacking in scientific training, but who generally possess a good deal of practical sense and intuition. Experimental programs where farmers and researchers have collaborated have proven quite successful in Australia.

An analysis of the causes of the recent development of the cattle industry in Mexico would show that the main inputs in commercial cattle raising have been introduced by the producers themselves. This is the case for several species of grass, such as pangola grass *(D. decumbens)*, African star grass *(C. plectostachyum)*, buffel grass *(C. ciliare)* and the coastal Bermuda cross No. 1 *(C. dactylon* and *C. nlemfuensis)*, to mention a few. It was also the farmer working in the humid areas of the tropics who tamed the so-called German grass *(E. polystachya)*, the only native grass in that area. Producers have also introduced Hereford, Angus and Charolais cattle, etc. The small milk producer in the tropics has preserved and selected cattle descended from the cattle originally brought by the Spaniards and adapted the animals to our environment by natural selection. All these valuable contributions made by the farmers have been empirical efforts, but we should not forget those who failed for lack of technical direction. It is, therefore, urgent to channel the great initiative shown by cattle raisers into a scientifically planned national structure.

**Education**

The educational system provides the human resources necessary for extension and research in beef and crop production. If this system is not adequately organized, the result will be deficiencies in personnel for these areas. Many Latin American schools of animal science still employ the scholastic educational philosophy and have not begun to take advantage of modern methods of dynamic or active education, combining physical work with intellectual effort (Costa, 1973). We have inherited a centuries-old tradition of underestimating practical experience in professional training. Quite often we see that extension workers or technical assistants are not trusted by the farmers because of this lack of solid practical training.

Academic preparation also leaves a lot to be desired. Few schools train their technicians in library skills and in those techniques they will need in order to keep up with new developments. It is commonly believed that once the student completes his thesis, which is supposed to be the highlight of his career, he will automatically be endowed with all these skills. It was also felt that these professional dissertations were valuable contributions to the scientific development of the country. Actually, the great majority of animal science schools that require the student to write a thesis in order to obtain his degree possess inadequate research facilities. The only other alternative, that of sending graduates out into the professional world to fend for themselves in writing their undergraduate theses, would be an irresponsible measure on the part of the educational institution. In developed countries,the prerequisite of a thesis for granting a professional degree has been abolished, but at the same time study programs have been radically changed.

As long as professional animal science education does not reach a higher level of efficiency, graduate study programs will lack a solid foundation. Since adequate graduate education is not available at the required pace in our countries, we are forced to obtain it abroad. Some countries, such as Venezuela and Mexico, have already sent large groups abroad for graduate studies in animal science and agronomy. Unquestionably, this practice has been favorable for the countries involved; and although these programs should continue to a greater or lesser extent, it would not hurt to evaluate the situation in depth. Training abroad is rather burdensome for the sponsoring country or international institutions. On his return, the technician tends to overestimate his abilities and generally moves toward better-paying jobs, not necessarily related to the institution or program that financed his graduate degree. An alarming percentage of the technicians finally go into administrative work.

A lot can be done to improve the quality of education and increase the number of people it reaches. A good example of such an endeavor is the professional training program developed at CIAT. There is also a modest, but extremely interesting program initiated by de Alba and Preston in Mexico. Exploring a new approach different from orthodox graduate programs, they are training students through work in field projects, some of them even in commercial ventures —as is the case with Dr. Preston's students— or through a project of organizing their own research and training centers, as in the case of Dr. de Alba's trainees.

The basic idea of these programs is to give future technicians intensive practical experience in addition to orientation in the basic disciplines and library skills. Finally, they will be involved in intensive courses taught by national and international specialists in their field. This will hopefully produce a qualified technician, familiar with the problems of his own country and able to handle research, education or extension projects. This program is still at the experimental stage, but it is flexible enough to be adapted to a given country's specific circumstances. Conventional graduate schools, along with programs such as this, could be an aid in training professionals for our specific situations, where human and material resources are scarce.

In conclusion, the application of technology at the level of the cattleman has become one of the major factors limiting production in Latin America. Other traditional constraints, such as the availability of financing and basic inputs at the level of the producer, infrastructure, commercial policies, etc., have been only partially solved.

Technical assistance in each country must be strengthened and reorganized into one well-planned, solid structure. It is imperative to coordinate further the efforts of official extension services, credit institutions and development agencies. Because of the economic situation of most of our countries, the government should not be the only institution paying for technical assistance costs, especially since this is a burden on taxpayers.

It is also necessary to strengthen the ties between researchers and producers. Research programs should be developed within an economic framework and geared to short-term problem solving. The only way to gain the cattleman's trust is to involve him in the planning and carrying out of research. In Latin America it is almost a crime to waste valuable time on research programs that have no practical application.

Education in animal science must adopt modern, dynamic teaching methods in order to acquaint a technician with the production process in detail, or he will also lose the cattleman's confidence. In order to eliminate our tremendous deficit in specialists and our dependence on training abroad, graduate study programs must undergo radical changes.

The aforementioned points are of basic importance in the production of food of animal origin in the 19 countries of tropical Latin America. This area, with a population of roughly 240 million (World Atlas, 1973) has an annual rate of population growth of 2.96 per cent. Some of our countries like El Salvador, Nicaragua, Mexico and Venezuela have a rate of population growth of more than 3.5 per cent, one of the highest in the world. On the other hand, Dr. Dieter Plasse informed us in his talk that the birth rate of cattle in Latin America is only from 35 to 60 per cent. In other words, in our underdeveloped countries, human births are inversely correlated to animal births. At present, the mean per capita gross national product, a conventional way to measure economic development, is only 460 dollars per year. These figures indicate that our present situation is unfavorable and the future even more uncertain unless drastic changes are introduced into our animal production processes.

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# MANAGEMENT AND ADMINISTRATION OF AGRICULTURAL AND LIVESTOCK ENTERPRISES

*Julio Rebolledo A.*

To obtain good results in the operation of an agricultural and livestock enterprise, it is essential to make an inventory of the existing resources first. This will allow careful planning for the type of operation to be established, taking maximum advantage of existing resources.

First, we should know what those resources are.

1. Human resources. I have divided them into three categories.

   a. Technical personnel. This category should include all the professionals connected with the enterprise as long as they carry out their different activities. There are those who are able to work full time and others who render contractual services to develop a certain type of work or for a specific consultation.
   b. Administrative personnel. They do not necessarily have to be professionals, but they should have had administrative experience.
   c. Trained specialized workers and common laborers. Unfortunately, the latter group have a high degree of illiteracy.

2. Location. In order to avoid future marketing problems, it is important to consider all access routes to the enterprise, such as highways, rivers, railways, roads, airports, etc., in order to plan the most advisable type of operation, depending upon existing transportation facilities.

3. Soils and climate. When the objective is to have an efficient operation and better results, an accurate knowledge of the different soil types is required, as well as knowledge of water available for irrigation and livestock, mean temperature, wind,

dry and rainy seasons, environmental humidity and all those factors that influence the life cycle of plants and animals. These environmental factors should be taken into account when looking for the most desirable type of forage, grasses, crops and cattle breeds in order to avoid the introduction of exotic plants or animals that will not grow or produce satisfactorily.

4. Economic resources. These are divided into fixed assets, saleable assets, owned capital, and short-, medium- and long-term credit. These will be discussed later.

5. Agrarian laws. This point is of utmost importance because the program of the agricultural enterprise must be based on the concepts of the agrarian laws, which by nature, are often stimulating factors to the agricultural and livestock industry such as those related to special credit for the area. However, at other times, these laws are limiting, especially those that reduce the size of the operations to a degree that hinders the introduction of adequate modern technology. In such cases, the state should provide needed technical inputs but the result has been completely negative in most cases.

There are other agrarian laws that discourage investment in agriculture, such as those that allow the government to expropriate without fair payments. These laws are a highly negative factor, hindering the introduction of permanent improvements which would otherwise produce great benefits.

## SELECTING THE LIVESTOCK ENTERPRISE

According to the previously mentioned inventory of resources, one should consider different types of operations that can be adjusted to the conditions of the farm itself. For example, we will make an analysis of the cattle farm. There are different types of operations, the simplest being a commercial cattle operation that can be developed based on Criollo breeds and improved bulls which may be Zebu.

1. This type of operation in the inexpensive savanna areas, such as the Eastern Plains (Llanos Orientales) in Colombia, requires good management practices but does not require higly advanced technology. It has the advantage of having a high percentage of the capital invested in easily saleable goods, very few fixed assets, and few pieces of machinery and equipment to depreciate.

2. A more advanced type of operation would be an upgraded commercial herd of good-quality cattle, where in addition to usual sales, high-grade bulls would be produced to be sold for use in commercial herds. In this case, higher fixed investments are required, especially in pastures, fencing, buildings, equipment, etc. At the same time, there will be higher expenses involved for technical and administrative personnel, as this type of operation generates more sources of employment than the system previously mentioned.

Management costs per cattle unit will also be higher, but this will be offset by higher selling prices for animals. This type of operation requires a more accessible location than those previously described.

3. The most advanced of all is the purebred or highly selected cattle operation. Since this type is the most important source of herd bulls for the national cattle industry, it is essential to work with breeds adapted to the tropical environment. Many industries of this type have failed because of the introduction of exotic breeds, not adapted to the tropical environment.

This type of operation should be developed under optimal environmental conditions; that is, it should have highly qualified administrative and technical personnel, qualified workers, an easily accessible location, good communications systems, a food transportation system, good or artificially improved soils, good pastures, and adequate economic resources because investment per surface area is higher than in other types of cattle operations. In summary, this type of operation is profitable only when optimal conditions exist.

4. Cattle fattening should be considered as an industry that transforms feed into meat and where breeding is not involved. For this type of operation, steers must be able to utilize forages common to the tropics.

For fattening operations, it is important to be near markets and to have good means of transportation. In relation to the technological aspect, agronomy plays an important role in pasture improvement. It is essential to have adequate programs for control of internal and external parasites in order to obtain higher productivity. This type of operation is easily managed, has a fast turnover of capital invested and has the highest rate of liquidity.

## ADMINISTERING THE ENTERPRISE

One of the most important aspects in the development of an agricultural and livestock enterprise is continuing communication between technical and administrative personnel. In my opinion, it is essential to have weekly meetings to discuss and analyze the different farm production programs being carried out.

Traditionally, we see farms that include both agricultural and livestock components. However, they are managed as if they were two separate enterprises, and the work is not coordinated. For this reason, I consider periodic meetings important because I believe that they are the only way to attain coordination of the technical, financial and administrative aspects.

The establishment of a central office with an adequate accounting and statistical department should be given priority. I believe that in order to manage an agricultural and livestock enterprise well, it is essential to have adequate statistical data that allow the analysis of the different units in the operation. Of course, it is not advisable to begin with completely separated production units, but rather with a system that groups units of the same kind and then, depending on the development of the enterprise itself, expand statistical data in order to be able to analyze each production unit individually. For example, let us consider the case of a farm with 500 commercial cows. Initially, we would have all the necessary data for the group. Then, conditions permitting, we would separate these into five groups of 100, in order to obtain information for each individual animal. This procedure applies to every field: pastures, agricultural areas, machinery and equipment, etc.

With good records, programming is easier. Many times, enterprises have failed because planning of the infrastructural work has not been organized or completed, or large investments have been made in areas whose location, soils and other factors are inadequate to achieve stated objectives.

Before beginning farm development, it is important to know all the factors involved in production, and development priorities should be established and implemented as soon as possible to avoid interest costs on idle capital.

The development program has been divided into three groups:

1. Partial work that benefits only a certain lot within the farm

2. Integral work that benefits a good part of the farm

3. Regional work which can be done in cooperation with the neighbors for the benefit of an entire region.

Another important factor which, to a certain extent, has been neglected by modern enterprises is the experimental aspect. A good development policy should include the allocation of about 10 per cent of the net profit of the enterprise for experimentation.

**Mixed enterprises**

Combination crop and cattle enterprises have a great potential in our country. At present, it is difficult to find straight cattle enterprises in the highly populated areas with good transportation services. Analysis of zones having these characteristics shows that mixed enterprises prevail in our country and are the best administered.

In this type of enterprise, crop production should be limited to a commercial scale; it is also important to make provision for production of food crops such as cassava, plaintain, etc. (in the warm areas) for on-farm consumption. At present, the price of these products is excessively high and they are scarce; therefore, the enterprise should produce them to feed their employees and their families.

Within this type of operation, it is easy and economical to produce supplementary feed for cattle —such as sorghum for forage— and ensiled maize and legumes, etc. for grain, taking advantage of the machinery and equipment required for commercial crops.

**Lumber**

The production of timber is an important factor. Every cattle enterprise needs lumber for fencing, corrals and other purposes. Unfortunately, poor conservation of natural resources, burning, and uncontrolled forest clearing have eliminated many extensive wooded areas.

An area must be set aside for reforestation; at present it is easy and profitable to do it with trees of early maturing varieties, which after three or four years can produce good-quality timber.

**Agro-industrial aspects**

I would like to comment on what should be called agro-industrial enterprises. This type of enterprise has a promising future in our country, especially in the overpopulated areas where labor is easy to get and new sources of employment must be created. Of course, this type of enterprise is harder to manage than crop or livestock enterprises. It requires more technological competency and the full-time dedication of technical and administrative personnel.

It is essential to have additional facilities such as electric power, without which industrialization would be inconceivable. There is a wide range of small industries that can be combined with the agricultural and livestock enterprise. For example, small feed manufacturing plants can be established, based on farm-produced crops and by-products. Another alternative would be to process farm-produced oil seed crops, obtaining meals rich in protein. These feeds are very expensive at present.

In accordance with the factors already analyzed, it is easy to develop programs to increase the productivity of each unit in the enterprise. These involve land, cattle, agricultural equipment, human and natural resources; in other words, all those factors influencing production. With good programming, there will be a constant increase in productivity; and with reliable statistical data, we will be able to determine which units are unprofitable or less profitable and how they might be improved.

In conclusion, I believe that the work of an administrator is based on the coordination of all available resources and all personnel in the farm enterprise; and to achieve this, a person must have time to think. An administrator cannot be expected to do all the administrative work; he must delegate responsibility in order to obtain better results, channeling all efforts toward the same objective, which is to increase productivity. And for this, I repeat, he must have time to think.

# SOME ECONOMIC ASPECTS OF THE CATTLE INDUSTRY IN LATIN AMERICA

*Alberto Valdés**

This past January, 20 economists from eight nations participated in a seminar at CIAT as part of an effort to achieve a greater interaction among economists working on problems of the livestock sector.

The objectives of the seminar were

1. To review existing research, both completed and in progress
2. To identify substantive areas for priority work
3. To identify personnel and institutions capable of participating in a collaborative research effort at the regional level

One of our premises was that research in economics is a necessary complement in the great task of accelerating beef production in Latin America. In the long run, the world and domestic market situation for beef products is quite favorable. Through research we could capitalize on the favorable conditions of world markets and contribute to increases in production and exports, thereby generating important changes in agricultural income, the supply of foreign exchange, nonagricultural employment and perhaps even nutrition.

The experience of this seminar indicates that there is a highly competent professional group in our area of the world, although the number of group members is limited in each individual country. It is our opinion that the combined efforts of group members, if organized professionally, could be more efficient than the total of individual endeavors. This seminar was but one first step in this direction.

* The author is indebted to Reed Hertford, Lovell S. Jarvis and Lucio Reca for their helpful comments.

In this report, I will not try to give a chronological account of the presentations or the comments of all seminar participants. Rather, I will attempt to summarize their observations and presentations, arranging them in rather loose categories as follows:

I. Production and consumption

II. Investment behavior and farmers' responses to economic incentives

III. Some options in economic policies

IV. Economics of beef production systems with special emphasis on location, farm size and productivity

V. Foreign trade and perspectives for exports

VI. Methodological considerations pertaining to the matters already mentioned

Finally, I will make some suggestions about a type of organization that coúld initiate collaborative research programs.

## I. Beef production and consumption in selected countries

Some valuable background statistics were presented in this seminar. Some of these have been compiled in Tables 1 through 3. We will first deal with some background information on production trends.

Table 1 shows that as regards cattle population, the four most important Latin American countries are Brazil, Argentina, Mexico and Colombia, in that order. In general, except for Argentina and Chile, increases in cattle inventories are relatively small, for five out of six countries the annual rate is close to 3 per cent.

When we compare the ratio of animals slaughtered for domestic consumption to those destined for exports, we see that Argentina has increased the amount destined for the export market although both have diminished. In Brazil, on the other hand, there have been increases in exports, but proportionately less than the increases in the total number of animals slaughtered.* The slaughter inventory ratios in Argentina and Brazil imply net increases in cattle population. On the contrary, the four remaining countries are literally eating up their capital; in fact, increases in slaughter are greater than increases in cattle stock.**

* Slaughter is considered on a larger basis than exports.

** Strictly, the comparison of slaughter to net production would be a more appropiate indicator of investment: $S = P + \Delta I$, where S = slaughter, P = production and $\Delta I$ = changes in inventory.

Table 1. **Cattle population, evolution of production and extraction rate.**

| Country | Cattle Population[1] 1970 (millions) | Annual compound rate of increase (1960-70) Stock[2] (%) | Slaughter[3] (domestic consumption) | Exports[4] | Extraction rate (%) |
|---|---|---|---|---|---|
| Argentina | 56[a] | 0.3[a] | –0.4[a] | –0.1[a] | 25 |
| Brazil | 78[b] | 3.5 | 2.3[b] | ≈2.0 | 15 |
| Chile | 3[c] | –0.1[b] | 4.1[c] | –3.0[b] | 28 |
| Colombia | 20[d] | 2.7 | 4.3 | 2.9 | 11-12 |
| Mexico | 26[e] | 3.3 | 4.1 | — | — |
| Venezuela | 8[f] | 3.0[c] | 5.1[d] | 13.2[c] | 10.7 |

[1] *Cattle population*

a. This figure corresponds to 1967 (Yver, 1972, p. 62).
b. Schuh and Lattimore (1974, p. 5)
c. This figure corresponds to 1965 (Barros, 1973, p. 56).
d. Hertford and Gutiérrez (1974, p. 6)
e. Silos (1974, p. 1)
f. Miller (1973, p. 425)

[2] *Stock*

a. 1957-67
b. 1955 65
c. 1961-70

[3] *Slaughter*

a. 1956-66 (Nores, 1969, p. 117)
b. Apparent beef consumption (Schuh, 1974, p. 4)
c. 1955-65
d. 1959-69

[4] *Exports*

a. 1956-66, beef exports in tons (Nores, 1969, p. 117)
b. Imports 1955-65 (Barros, 1973, p. 42)
c. Imports 1962-70

Why has the expansion of inventory been relatively slow? To what extent does this reflect an economic distortion at the level of cattlemen who, considering prevailing prices, may have underinvested in cattle? Or is this distortion rather caused by factors beyond the cattlemen's control, such as artificially lowered prices, insufficient investments in infrastructure, etc.?

In order to raise the rate of expansion in cattle population beyond 2 or 3 per cent, cattle productivity must be increased. The most common index for these comparisons is the extraction rate shown in Table 1. This rate varies greatly from one country to another. Chile and Argentina are clearly ahead, with rates twice that of Colombia and 2½ times that of Venezuela. But this rate also varies in different regions within a given country. The higher the land value, the more intensive the system of production tends to be.

In this presentation, Dr. Raun classified the Latin American ecosystems as (a) those prevalent in fertile alluvial soils, (b) allic soils with high pH and low fertility, characteristic of tropical savannas, and (c) low fertility soils covered by forest vegetation.

The greatest potential for expansion seems to be in areas of tropical savannas, where cattle productivity today is relatively low and where, coincidentally, there is the most elastic supply of land, as in the case of the "campo cerrado" region in central Brazil, in the Colombian and Venezuelan Llanos and part of Bolivia. On the other hand, in countries with alluvial soils—like Argentina, perhaps, and certainly Chile— the frontier lands are almost totally incorporated to agricultural production.* But the potential found in tropical zones can be fulfilled only if and when researchers succeed in designing an economically viable technology, making it profitable to introduce nutritional changes that could raise the calving rate, reduce the mortality rate and raise the average daily weight gained during fattening.

In relation to the structure of domestic consumption, the high weight of beef in the family budget was pointed out. In Table 2 we can see that in Brazil, for example, beef represents 25 per cent of the total food budget and almost 10 per cent within the general cost of living index. In Argentina, the latter amounts to 15 per cent. There is, therefore, great pressure to introduce beef price controls, as will be mentioned in the section on economic policies.

The studies by Schuh and Lattimore (Brazil, 1974), Andersen and Londoño (Colombia, 1972), Nores (Argentina, 1969) and Barros (Chile, 1973) indicate that the demand for beef is relatively price inelastic in the long run, reflecting scarce substitutions for beef.** Is Latin America a special base in this respect, giving beef a greater importance in the daily diet?

As a source of protein, the relative importance of beef is greater, as shown in the study for Colombia by Hertford and Gutiérrez (1974). It is possible that when produced under extensive grazing systems rather than on grain feeding, beef will be a cheaper source of protein than either pork or poultry. Its empirical comparison is complicated by the existence of price controls for beef.

* However, one ought not to underestimate the increases in production which might be gained from increased productivity in the temperate zones. As Jarvis correctly points out, Argentina uses almost no fertilizer, has less improved pastures than it could theoretically employ, has lower calving rates than the US does, and has few feedlot systems (L. Jarvis, personal correspondence).

** Including pork and poultry, as is shown for Brazil

Table 2. **Demand for beef in selected countries.**

| Country | Share of beef in total food expenditure (%) | Share of beef in total family expenditures (%) | Elasticities: Income High | Income Low | Income Average | Price Short term | Price Long term |
|---|---|---|---|---|---|---|---|
| Argentina | 25.0 | 15.0 | | | 0.41 | −0.3 | −1.0 |
| Brazil | 25.0 | 9.6 | 0.50 | 1.60 | | | −0.9 |
| Colombia | 23.0 | 13.1 | 0.47 | 1.50 | 0.84 | −0.8 | |
| Chile | 21.7 27.9 | 10.9 7.2 | 0.25 | 1.73 | 0.61 | −0.9 | |
| Income level | low high | low high | | | | | |

**Source:** Argentina: L. G. Reca (1973, p. 99 103), except for long term elasticity, obtained from Yver (1972, p. 44)

Brazil Schuh and Lattimore (1974, p. 17, Chapter II and Table 1, p. 56)

Colombia: Hertford and Gutiérrez (1974, p 35) for average income

Chile: Valdés and Mujica (1973, p. 36), except for price elasticity, which is due to Barros (1973)

In regard to income elasticities, there is a great difference between low and high income levels in Brazil, Colombia and Chile. In fact (as can be seen in Table 2) at a low income level, elasticity is always higher than 1.0, whereas at a high income level it is of 0.5 or less. It is estimated that the average income elasticity is lower than 1.0, which shows that beef can be classified as a basic rather than a luxury consumption good.

The relation developed by Hertford and Gutiérrez (1974) between the characteristics of consumption and growth in production and exports is an important contribution. They conclude that for Colombia, per capita consumption has not increased during the period of 1957-1970, which seems to be the result of relatively modest increases in per capita income, combined with an income elasticity lower than 1.0 and increases in the relative price of beef. These factors favored the rapid growth of exports.

The lack of information about the structure of beef consumption was pointed out, especially at the low income level. This could have a bearing on the fact that demand projections seem to have underestimated the increases in consumption because of a mistaken use of low elasticities for low-income groups.

As a reflection of our concern for obtaining better information, a benchmark study on cattle raising in Latin America was suggested as a starting point. The preliminary study on Colombia presented at this seminar is one such effort. On the basis of the information available, the following subjects are dealt with: (a) the evolution of the cattle population and production according to age, sex and regions, with emphasis on determining the coefficients of birth, mortality and length of the fattening operations, etc., (b) the identification of the sources of changes in production and determining the evolution of consumption and exports, (c) the quantification of the sector's contribution to the gross national product, exports, the fiscal budget, employment and distribution of income, (d) the description of policies and legislation relevant to the subject, (e) the characterization of landholding systems and the examination of the small-scale beef producer's economy, (f) the analysis of the principal limiting factors of an environmental and institutional nature (including government policies), (g) the revision of sectorial models and their implications for the same. The main objective would be to create, on the basis of a diagnosis for each country, an agenda for technical and socioeconomic research on the cattle industry.

## II. Investment behavior and farmers' supply response

Until recently, policy makers acted as though cattle sales would not be affected by price changes in the short or the long run. Previous empirical studies had found a negative supply elasticity in short-term sales, and from this they deduced that elasticity was also negative for long-term sales. Thus, they concluded that cattle raisers did not respond to economic incentives.

Looking back, the fact that production, when viewed properly, involves the sum of changes in inventory as well as changes in sales (slaughter), does not seem to have been well understood. Production in a given year can result in two situations that are mutually exclusive: retention of cattle as an investment versus putting them on the market. The price per unit remains the same in both cases. As Yver (1972) has accurately said, in this industry it is difficult to know when we are consuming the machinery and when the product.

In the last two or three years, important theoretical and empirical contributions have been made in the area of investment behavior in cattle raising. The excellent research done by Jarvis (1973) and Yver (1972), complemented by their econometric studies and the empirical studies of Nores in Argentina (1969), Barros in Chile (1973) and Schuh and Lattimore in Brazil (1974), has brought to light certain fundamental aspects of cattle supply. One of their most important conclusions is that the long-run elasticity of supply is clearly positive in all cases analyzed, and one of its most complex implications is the dynamics of the response of livestock farmers It was essential to differentiate clearly between short- and long-term responses and between sales and cattle stocks.

These studies show that when beef prices increase, the sale of animals will tend to diminish at first. The cattleman will prolong the optimum age for sales and adjust the composition of his herd.

In Table 3 it can be seen that when prices go up, the reduction in short-term sales* is greater for females than for male animals and that four or five years later (depending on the country) this negative response becomes positive, with values of 1 to 1.5 in the long run.**

The period of adjustment for achieving a new long-term steady-state equilibrium takes at least four or five years. During this period of transition, beef prices could become unstable, but they would tend to stabilize in approximately three to five years. If authorities intervene during this period of adjustment, it is possible that long-term expansion of sales will not materialize.

This analysis is complicated by the effects of inflation and the resulting imperfections in the capital market, so typical of many South American countries. A logical reaction on the part of many entrepreneurs would be to buy cattle as a hedge against inflation, investing more as inflation increases, with a reduction of sales in the short run, nevertheless, this effect would lead to an increase in sales in the long run.

* Without an empirical analysis, Professor Navas describes the same short-term phenomenon in Venezuela for 1972-1973. When official prices rose from $B 6.50 to $ 9.00 per kilo, he observed that cattle farmers retained their cattle for two or three months, thus raising the average slaughter weight from 170 to 210 kg. However, the latter could instead reflect changes in the composition of the age and sex of the animals being slaughtered.

** As Musalem (1973) has shown theoretically, it is important to keep in mind that the short-run elasticity of sales can be positive.

Table 3. **Estimates of elasticity of beef cattle supply.**

| Elasticity of: | Argentina | | | Brasil[2] | | Chile[3] | |
|---|---|---|---|---|---|---|---|
| | | | | Short term | Long term | Short term | |
| Inventory: | | | | | | | |
| Males | | | | 0.078 | 1.775 | 0.13 | |
| Females | | | | 0.046 | 0.788 | 0.18 | |
| Total | | | | — | 1.587 | — | |
| Sales (slaughter) | Females[1] | Males[1] | Total sales[1] | Females | Males | –0.108 | females |
| | | | | | | –0.227 | males |
| Period | | | | | | –0.117 | calves |
| 0 | –0.055 | 0.076 | 0.023 | –0.575 | –0.113 | | |
| 1 | –0.372 | 0.017 | –0.161 | –0.458 | 0.036 | | |
| 2 | –0.411 | 0.053 | 0.370 | –0.347 | 0.037 | | |
| 3 | 0.012 | 0.370 | 0.225 | –0.243 | 0.107 | | |
| 4 | 0.533 | 0.664 | 0.609 | –0.146 | 0.174 | | |
| 5 | 0.689 | 0.725 | 0.710 | –0.053 | 0.238 | | |
| Long term | 1.376 | 0.995 | 1.149 | 1.538 | 1.596 | | |

**Source:** [1] Elasticity of sales is measured in terms of beef prices and length of the period (Yver, 1969, p. 47, Table 8).

[2] Measures the "accumulated" elasticity of cattle sales with respect to the price of meat (Schuh and Lattimore, preliminary, 1974)

[3] Barros, 1973

It is interesting to note that a relatively similar theoretical model served as the basis for studies in Argentina, Brazil and Chile. We are well equipped for the study of this problem area since we have at our disposal sound theory and supply coefficients. Our task now is to use them effectively in economic policy making and planning.

In the future we must continue to study investment behavior in relation to technological changes, especially in the area of nutrition. The theory mentioned above gives us an excellent point of departure. In this context, risk considerations would be less important than they are in studies of crops. As illustrated by Schuh and Lattimore, we can relate the supply and demand of beef to government policies, including endogenously the political instruments currently used.

The final objective of investment analysis is to provide an empirical basis for the evaluation of national economic policies.

## III. Some options of economic policies for this area

The so-called "agricultural" policies have often had a lesser effect than general policies, such as exchange rates, interest rates, tax systems, tariffs, export quotas, etc. In other words, the economic key to the industry is almost exclusively in the hands of the central banks and ministries of economics, rather than being influenced by agricultural agencies; and the well-being of the consumers very often overrides the interest of producers.

This kind of policy making has not only limited the level of investments in cattle raising, as is deduced from the empirical studies available on Argentina, Brazil and Chile, but could also have had some effect on the diffusion of technology employed. The quick adoption of a specific technology often depends to a great extent on the economic policies in force.

This section will consider three aspects of the subject:

A. Exports versus domestic consumption

B. Instability and uncertainty in prices

C. Critical inputs and infrastructure

### A. Exports versus domestic consumption

In several countries, the government has and is intervening in the regulation of meat markets, lowering domestic prices below the international levels. These anti-inflationary measures have been caused by the high weight of beef prices in the family budget, as mentioned before. Almost without exception this has brought about greater foreign trade restrictions, as happened in Brazil, Argentina, Colombia and Chile. Frequently these restrictions have taken place through changes in export quotas and/or export duties and/or multiple exchange rates.

Government officials come up against complex dilemmas. In the short run, governments can either allow international prices to prevail in the domestic market, which increases the pressure on the cost of living indexes but results in export increases and a stronger balance of payments. Or they can favor the domestic consumer, with consequent reduction of investments and the risk of eventually having to import beef as has happened in Chile. Up to now, in virtually every country, it has been decided to reduce exports.* A key problem to be considered is whether or not high beef prices on the international markets are a transitory phenomenon.

There also seems to be a widespread distortion of milk prices in relation to beef prices in Latin America. Almost invariably milk prices are set at a low level. A quick estimate suggests that at present the milk-beef price ratios are in a proportion of 1 to 10 on the Colombian North Coast; whereas in the United States, for instance, the ratio is 1 to 5. What would happen in Colombia if the price of milk climbed to the 1 to 5 ratio?

If milk and beef were considered as joint products, technically speaking, the controls on the price of milk would be limiting the long-run expansion of beef production, resulting in a lower output of calves.**

## B. Instability and uncertainty in prices

In relation to this, three interesting types of problems arose. On the one hand, we have the so-called beef cattle cycles; that is, the annual fluxes in sales and prices. Countries such as Colombia are making an effort to reduce the instability of internal prices through adjustments in the export quotas. These measures are well grounded. Excessive instability makes the price mechanism less efficient and leads to smaller levels of investments. Econometric models show that the adjustment period takes many years. After an increase in expected prices, reaching a new long-term steady state of production takes around five years in the case of Argentina and even more in Brazil. This suggests that the existence of frequent ups and down in prices may have a negative effect in the expansion of the industry in the long run. But there is a risk in that the stabilizing of cyclical variability often results in a distortion of the domestic price level, which goes down below international prices.

* According to export-demand elasticities, a reduction of export volumes can lead to increases in expor prices. This is perhaps the situation in Argentina.

** L. Jarvis informs me that there is evidence for both Argentina and Chile that an increase in the price of milk leads to greater slaughter of animals in the short run. In the long run though, without the pasture constraint, higher milk prices may allow an expansion of the herd of dual-purpose animals, which would result in an increase in the availability of beef at constant prices.

Another aspect is that of seasonal variations, a problem better documented in the case of Brazil. According to da Leite (1972), a large subsidized investment was made in storage facilities in Brazil in order to reduce price variability between the dry and rainy seasons. Stocks were put in cold storage instead of keeping live cattle on the ranch. In the latter case, live cattle supply would have risen during the dry season as a result of higher prices. These are alternatives, but any variation of prices during the dry season will affect the cattleman's behavior in the rainy season as well. It was suggested that it was necessary to revise the policy in question.

C. **Critical inputs and infrastructure**

The process of increasing cattle productivity through technological changes may generate significant tensions on the markets which supply the cattle sector; we must therefore try to anticipate them.

Credits, fertilizer supply and road infrastructure are some of the inputs mentioned most often.

Unfortunately we could not find any study on the credit situation. There are only brief commentaries. Surprisingly, it was said that at least in two or three countries there seems to be more credit available than the cattleman wishes to utilize. This is surprising, especially when we remember that this credit is usually offered at a negative real rate of interest; in other words, loans are really handouts.*

The role of international credit per se was not discussed. We do not know its real effect on net investments, income distribution and on technological change. There was an impression in the past that in IBRD credit programs the problem of alleviating the balance of payments situation was given priority over the issue of the benefit derived from distributing loans according to size of herd and tenure.

A novel and important topic was the economics of animal health programs. A lot of international credit has been invested in foot-and-mouth disease and to other diseases; and as far as we know, there is no quantitative study of the costs and benefits derived from these investments.

The analysis of the situation is complicated further by the existence of "externalities" (e.g., foot-and-mouth-disease vaccination) which could bring about discrepancies between private and social benefits and the possible interaction between the management level and the incidence of a given disease.

* For example, at an annual interest of 12 per cent, when inflation reaches approximately 23 per cent per year, as in Colombia in 1973. One of the reasons given at least in Argentina, according to Jarvis, is that these loans require the submission of substantial information from the producer regarding his assets, income, etc.—information which many producers are unwilling to give for fear that it might fall into the hands of the tax authorities.

There are other issues we should also try to analyze, such as (a) costs and returns of alternative control methods (levels) at the level of the farm, (b) the social cost of diverse levels of incidence, and (c) the probable rate of return upon reducing incidence. This would allow us to examine problems, such as how much and to what degree the cattleman should be subsidized, what the optimum level of control for foot-and-mouth disease is, when attempts can finally be made to eradicate a disease rather than control it, etc. The veterinarian should know about relations involved in the incidence of foot-and-mouth disease, brucellosis, etc. and production parameters, such as birth and mortality rates, weight gains, probability of contagion according to age, etc. Unfortunately, this information is not yet available for the majority of diseases. It is a new area where a rigorous application of economic theory has not yet been made and where it is difficult to quantify the effects of these diseases.

In regard to the fertilizer market, the problem of phosphates in Colombia was analyzed in reference to its incidence on the costs of establishing and maintaining improved pastures in tropical savannas (Montes, 1974). Colombia depends on imports; approximately 85 per cent of the fertilizers consumed in the last five years was imported. The future of savanna legumes depends partly on the international prices for phosphates. Around 1971 prices climbed dramatically, increasing 200 per cent between 1971-1973. Future projections should be urgently studied.

Part of the problem is to know whether the supply of phosphates produced in Latin America would effectively reduce the price below international levels. It is relevant to look back and remember that in Chile and Argentina, two cases where for years the governments have protected the development of national fertilizer industries, the prices for domestic fertilizers turned out to be higher than those of imported fertilizers, resulting in the reduction of their consumption.* We must not generalize from these experiences, but they should serve as a warning. Colombia, on the contrary, sells at a price equivalent to the international level.

Roads and transportation in general seem to be crucial matters, above all in frontier areas, such as the Colombian and Venezuelan Llanos and Brazil's and Bolivia's interior. It is necessary to study the impact of different levels of transport infrastructure on net prices obtained by the cattleman in a given area and how this can influence the present specialization of the area in either breeding or fattening operations.

Clearly, the need arises for more research on economic policy for the cattle sector, including the role of public works. The emphasis on quantitative analysis may facilitate communication between researchers and the authorities in charge of designing and

* If the importation of nitrogen at international prices had been permitted, the increase—both in yield and consequently in national wheat production—would have permitted the lowering of wheat imports by such an amount that their value in dollars would have been greater than the value of the additional fertilizer imported (Valdés, 1974).

implementing economic policy. A good illustration is the sectorial model for Venezuela developed by Oregon and MAC–FAO, used in the process of setting prices for beef.

## IV. Economics of beef cattle production systems

We shall examine three issues: regional specialization, the relation between profitability and production technology, and finally the importance of dairy production.

Beef cattle raising tends to utilize residual lands in relation to crops and plantations.* It is very land intensive, as well as intensive in capital and in cattle, so it is logical that beef producers prefer areas where land is relatively cheap, such as frontier areas. Since larger proportions of land are needed for cow-calf operations than for fattening, the former activity tends to be located in places where land is relatively cheaper, as was seen to be the case in Colombia and Brazil. Besides, young animals travel better because the cost of recovering weight losses is smaller. The investment theory already mentioned serves as the basis for explaining regional specialization in cattle raising.

One issue we did not deal with, but which merits discussion on another occasion, is the feasibility of intensive fattening systems in areas with wide availability of agro-industrial products. The Cuban, Central American and Kenyan experiences are relevant in this respect. If they turn out to be feasible, surely regional specialization in the cow-calf operation would become even more widespread.

As far as the cattle are concerned—a very liquid asset—a rate of return no lower than the real rate obtainable on bonds and other nonagricultural investments of similar liquidity is expected.

What changes, if any, have taken place in the average cattle productivity in, let us say, the last 20 or 30 years? We know little about this. The study by Hertford and Gutiérrez (1974) for Colombia concludes that production growth is mainly brought about by increases in grazing land and in the number of operations. No significant increases in carrying capacity have come about. Da Leite Silva (1972) also studied the problem of production in Brazil and concluded that in spite of climbing meat prices, there has been no important growth in output. Some evidence though indicates that toward the end of the 60's, production was beginning to increase. This type of extensive-expansion might have been an "efficient" path in the past; we do not know for sure.

An interesting aspect is the interrelation among profitability, technological changes and whether or not livestock farmers live on the farm. This point was illustrated by Obschatko's study for Argentina (1971), which determined that given the technology prevailing in the

* This is not the case with wheat and meat in Argentina.

area, residence on the farm was not a factor affecting profitability. Nevertheless, those who do reside on their farms have subjective socioeconomic costs from living in isolated areas without educational, health and recreational facilities for their families.

The question is whether the new technology in tropical savannas, for instance, will demand significant improvements in management capacity. This new technology would have to raise the rate of return substantially in order to compensate competent administrators for taking their families to live in the country, with all the implications of such a decision. Competent administrators have a high opportunity cost. It should likewise be remembered that studies on the diffusion of technology have concluded that farmers do not readily switch to new technological practices when they mean increases in profitability of only 4 to 5 per cent.

In relation to development potentials of frontier areas, the perspectives of the beef cattle industry in the Peruvian jungle were examined. A feasibility study has determined that at present prices, beef production in the jungle would not be a successful operation, even at the most "probable" productivity rates for the area (Aldunate, 1973). The biggest problem is a financial one. It has been concluded that a farmer would have negative cash flows for many years, during the entire period for developing the pastures and the herd.

Another issue which came up repeatedly was the importance of milk production in beef cattle operations. A parallel might be established between cattle raising and crops. Mixed cropping is more common in the tropics than in temperate climates, which also seems to be true in the case of beef and dairy operations for tropical and temperate areas.

In areas traditionally classified as solely beef producing as shown in Rivas' (1973) study for the North Coast of Colombia, it was observed that milk production is responsible for an important share of the farmers' income. This is probably because of their need for cash. The proportion will vary, of course, as a function of the ratio between milk prices and the prices for calves destined for beef production, with milk sales decreasing when relative prices for calves go up. The relative importance of milk sales for small farms in Costa Rica was also pointed out by Vernon Smith (personal communication).

Detailed studies of the economics of production systems (those in progress as well as projected ones) seem to be a must in order to project the response of cattle supply in the short and long run, under different ecosystems. Why does the farmer do what he does? How homogeneous is the use of technology in the farms of the same area or from one area to another?

## V. Foreign trade and export perspectives*

Despite the cyclical situation in 1974, long-run projections regarding the international beef market forecast that rising prices would continue. The demand for beef exports

* This section is based mainly on the presentation by Mrs. R. van Haeften, but this version of her commentaries at the seminar is solely the author's responsibility.

increases rapidly and prices have more than doubled between 1966 and 1970. According to available information there are no risks of overproduction in the future but rather of underproduction, unless drastic changes occur in the commercial policies of the major importing countries.

Europe is the most important market for South American production, the main importer being Great Britain and Germany. In the future, after 1980, Japan may become a large importer. For Mexico and Central America, the United States constitutes the major market. These countries, because they are free of foot-and-mouth disease, receive preferential treatment over South America.

The largest export market at present is for fresh-chilled and frozen beef. Canned beef represents only 14 per cent of world exports and seems to continue declining. Most of the beef Europe imports from South America comes to the consumer in processed form, which is subject to lower tariffs than fresh meat. There is a tendency for the consumer in both the United States and Western Europe to favor lower-priced meats, which precisely benefits processed meats. Whether or not South America will be able to increase the exportation of processed beef (as Mexico did after eradicating foot-and-mouth disease) remains to be seen.

Aside from tariffs on unprocessed meat, the major restrictions for beef imports in Europe, as well as North America, are not tariffs but import quotas and health regulations. Of the two, the more flexible and negotiable for exporting countries are import quotas.

This year the United States Department of Agriculture will begin an extensive study on the international market, itemized by countries. They are developing a framework of analysis to study the impacts of alternative foreign trade policies on prices, consumption, production and future trade flows in both importing and exporting countries. Because of its nature and extension, this study will encompass a great number of national research projects on the economics of the cattle industry.

## VI. Some methodological considerations

We have already identified the two major difficulties in the economic evaluation of animal health programs. I would merely like to add that the econometric models of investment behavior could only be estimated by making considerable efforts to correct official statistics. It was shown that this handicap could be overcome through the use of a system of accountmg identities and by having at hand a good census and a time series of slaughter. Today we have good series of stocks and slaughter for Argentina, Brazil and Chile, classified by sex and age. The studies for Venezuela by Oregon with MAC–FAO and for Colombia by García and OPSA will present a revision of these data for the respective countries. The benchmark study we have mentioned is a good starting point in the identification of information sources and for the revision of pertinent technical coefficients.

The presentations by Miller and Halter (1973) and Anderson (1974) on the uses of simulation models at both macro- and microeconomic levels, were important contributions to this seminar. The sectorial model for Venezuela is relatively better known (Miller and Halter, 1973). The implications of changing from a traditional production system to a modern one are being studied by adapting part of the model designed by Michigan for Nigeria. This model stresses the animal nutrition subsystem and the price policy. The production coefficients used are not statistical estimates but rather represent the opinion of experts.

One of the main assets of the simulation-model approach, both at the micro- and macroeconomic levels, lies in the construction process itself. The methodology leads to the clear identification of crucial structural relations, even when the model cannot be totally validated. In this sense the sectorial model may be a great help to officials in charge of economic policy making and planning, by pointing out the trade-off between alternative policies. Halter illustrated important cases, such as the differential increases in slaughter and average weight after the price goes up by 2 per cent, both when complementary policies are and are not modified. He also measured the cost/benefit ratio of solving some animal health deficiencies.

It seems important to attempt to integrate analytical sectorial models, such as the model on investment and supply behavior, with the simulation models. This could help explain the "black boxes" in the latter when they bear an influence as decision variables and also aid in incorporating statistical estimates.

The discussion of production models (micro) was centered on identifying decisive factors in the selection of the structure and analytical method to be used in the construction of a production model for grazing beef cattle. There was no discussion on systems methodology per se.

In general, efforts are directed towards the study of the implications of changing prevailing traditional systems to alternative modern ones. The sequence to follow would be to construct the model at the microeconomic level first in order to identify key practices, then go to a regional model and finally to a sectorial one in order to examine the macroeconomic implications on the markets for inputs and final products. Among these stand out such factors as fertilizers, credit, transportation and prices.

The problem was illustrated in general terms for the case of tropical savannas. The potential impact that incorporating legumes in grazing pastures would have on cattle production and on the farm's financial situation, cash flow and rate of return needs to be examined in order to determine the optimum development rate for the grazing lands.

These results would help by orienting biological research because if the production system is found not to be sensitive to certain factors, why study them? These results would also aid in the task of designing landholding policies and the overall economic policies for the area. There is still a need to determine the minimum capital requirements per farm in order to provide an "acceptable" family income under alternative technological levels and different price ratios.

There are several techniques available. These are budget methods, linear (uni- and multiperiodical) and dynamic programming, and simulation. Anderson and Halter argued convincingly in favor of using computerized simulation models for grazing beef cattle production. This is the most adequate method for the study of the system's behavior, for it considers the importance of (a) flows in time (dynamic analysis), (b) variations on the scale of the operation, and (c) stochastic elements, as well as the system's sensitivity to changes in prices and in the technology used in the area.*

However, these models are expensive and their construction, verification and validation are time consuming. Research objectives, the availability of technological parameters, the computing facilities, and the time element—all bear an influence on the elaboration of models. It is basic to determine a priori the degree of structural detail to be included, otherwise model construction becomes an endless process.

Whenever possible, the effort should be made to adapt parts of models that have already been successfully applied in other areas and/or countries. The model designer must be brought in at the same time, for he is the only person thoroughly acquainted with the structure and handling of the original model.

One of the greatest difficulties in constructing production models arises from the fact that the information comes from several disciplines (agronomy, animal nutrition, soils, economics, etc.); and as Anderson has said, it is easy to underestimate the difficulties of interdisciplinary communications.

## SOME REFLECTIONS ABOUT COLLABORATION IN THE FUTURE

I believe the seminar was an effective instrument in identifying specialists. It allowed a greater exchange of views on the subject of methodology, and it contributed to a wide exchange of research results and experiences, all at a cost of approximately US$ 3,500, which is low. Besides, as stems from this report, important topics for future research were identified.

There was a consensus that opportunities for regional collaboration should be explored, so they may support and complement national activities. This will result in strengthening both local and professional institutions.

* In the case of the Llanos, special emphasis would be given first to the relation between the basic system's behavior and the feed component and between the scale of the operation and tenure. Later on, other elements, such as commercial crops and animal health, could be incorporated.

There are several possible models of collaboration. My following statements are, I believe, consistent with the suggestions of several participants; but like any synoptic view of a seminar, they represent a personal view.

The talent for research in this problem area is at present scattered throughout the universities and government agencies in Latin America as elsewhere. For many of them, this area of research contains only part of their research interests.

One approach would be to form core groups centered around high-level researchers. The goal would be, at the end of 18 or 24 months, to have a set of relevant problems analyzed with a display of rigorous methodological excellence.

The final mechanism must permit the continuation of the process of identifying talent, and even more important, it must make the specialist's participation truly attractive to him. These objectives could be achieved by

1. Organizing small work groups around specific problems. These groups would meet frequently in workshops with few participants and for short periods of time. A total of two or three workshops could take place in 1974.

2. Providing direct support for research in some priority subjects. I suggest the following:

    a. A benchmark study for four or five countries (described in I)
    b. The economics of beef cattle production systems (described in IV and VI)
    c. The economics of animal health (mentioned in III)

3. Improving communication channels among Latin American researchers and between them and selected research centers in the United States and in other continents. Because of the nature of the topic, it is imperative to have their support in both the theoretical and methodological processes.

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# SYSTEMS ANALYSIS OF A BEEF CATTLE ENTERPRISE

*Blas Bravo*

In most of the cattle raising areas of Latin America, the predominance of a livestock operation similar to that of previous decades is caused by different biological and physical reasons on the one hand and socioeconomic reasons on the other.

The necessary increase in production for each region or country requires (1) the existence of a viable technology and (2) the introduction of adequate agricultural policies regarding land tenure, taxes, credit, trade and input-output prices.

Only if the two aformentioned points are accomplished will improved technology be feasible, thereby increasing production. It should be remembered that production is not an end in itself, but that it should be at the service of mankind; technology is not "neutral."

Technology originated and used in countries having a great deal of available capital and a shortage of rural labor is neither viable nor advisable in regions where the opposite conditions prevail: shortage of capital and abundance of manual labor. Changes must be geared not only to increase production but also to lower unemployment and improve the distribution of wealth. This implies that each of the regions and countries in Latin America must create its own technology, based on research performed within the production system in which it is going to be used or with those that could be formed.

For many years, agricultural and livestock research has been carried out in the majority of the countries of the world. However, no adequate mechanism has been developed which is geared to (a) evaluate and assimilate the information flow produced by research, whether one's own research or that performed by others, and (b) provide a more objective guideline for conducting future research.

One of the most important features in beef production is its immense complexity in the face of already complex agricultural production. In beef cattle production we find a large number of strongly interrelated variables that must be considered jointly. This fact explains the failures in trying to solve production and profitability problems of a region or of a producer by the modification of a few factors only. I quote as an example the experiences of many of my colleagues: the introduction of perennial grasses, pasture fertilization, the use of artificial insemination, etc. (each of which used as an isolated technique has in many cases not produced the expected results). However, these and other practices could be part of an organic and integrated whole that would constitute a successful production system.

An analytic approach is predominant in traditional agricultural research. The research worker analyzes some particular aspect of the complex bioeconomic system, which constitutes an agricultural and livestock operation. Aspects of soils, meteorology, botany, zoology, plant and animal physiology, health, genetics, etc. are studied in greater detail every time.

The great quantity of knowledge at the world level makes it necessary to have greater specializations within these disciplines. But on the other hand, the agricultural and livestock producer does not deal with the plant alone nor with the isolated animal; he deals with the whole enterprise and with all the biological complexities in an environment full of uncertainty in regard to bioeconomic factors.

Whereas the research worker is used to thinking in an analytical way—that is, from the whole to the parts—the producer and the extension worker must integrate information and synthesize variables to obtain the functional organic whole. It is, therefore, evident that a formal approach must be taken which allows the visualization of the enterprise as an organic whole. This formal approach—system research—can be defined as an integrating framework permitting the study of complex systems involving several disciplines.

By the use of systems methodology, the following goals are pursued:

1. To become more familiar with the system under study and to estimate the scope and structure of the result of the operation of the system as a response to the management strategies used and under the conditions of uncertainty resulting from the use of uncontrollable inputs

2. To assist in the identification of areas of knowledge in which there is little or no information, thereby determining research lines and the allotting of funds for the same

3. To promote interdisciplinary teamwork; integration is indispensable when a group of technicians from different disciplines faces a common problem.

# STUDY OF SYSTEMS METHODOLOGY

A system is defined as a set of elements having a given function and interacting within a real or conceptual limit.

There are hierarchies of systems, from the atom to the universe; therefore, what we are really concerned with are subsystems of a larger system. Traditionally, research regarding livestock production has had as a goal the biological system of the complex "animal-habit." More recently, it has been recognized that it is a bioeconomic complex with important interrelations between the biological and economic factors, which must be studied as a whole, respecting said interrelations.

Livestock and agricultural systems may be studied in different ways, but it is evident that their study through research with real-life systems is very costly in both time and money. However, although "experimental production units" do not lend themselves to research, they may be of great use. They not only serve demonstration purposes (on a commercial scale) for a given technological package for producers, but they also pinpoint flaws or lacks of information that should be corrected through more research of those variables that are part of the package. On the other hand, planning and implementing these production units is beneficial for the research center where these units exist since it becomes necessary to have an interdisciplinary team at work including soil scientists, agrostologists, nutritionists, breeders, veterinarians, management specialists and economists.

I said that to carry out research with more complex real systems is practically impossible. If one thinks about the number of factors intervening in the process and about the different levels each factor may have, a prohibitive number of units arises, making the replication of experiments more difficult. In the case of a factorial trial in which

$$U = N^F$$

where $U$ = number of experimental units
$N$ = number of levels for each factor
$F$ = number of factors

only the results of one replication for one year would be obtained. Obviously this would not be sufficient; several replications would be necessary during several years of experimentation.

In livestock and agriculture, as in many other fields, the study of model designs—that is, representations of real systems— is considered adequate. Whereas some fields use physical models (of great application in aeronautic and hydraulic engineering, etc.), we are interested in mathematical models. These can be of different types and complexity, going from a simple linear equation, passing through regression models and production function models, until we reach models involving a large number of equations that require the use of computers with large capacity and speed for a practical solution.

Although all methods based on the use of mathematical models may be considered simulation methods, a distinction must be established between (1) those based on models built to a somewhat rigid mathematical structure that permit one to obtain the optimum solution (i.e., linear programming) and (2) those using more dynamic models that are not restricted to set formats and that are usually not optimization models.

For the purpose of this discussion and without denying that both can be called simulation methods, I shall call the first "optimization methods" and the second "simulation methods." The optimization methods are adequate for problems of allocating scarce resources among several competitive activities, within a system whose goal is the maximization of profit or the minimization of costs. On the other hand, the simulation models are more adequate for representing dynamic systems, subject to exogenous stochastic factors, and where the interest is to prove the effect of different decisions taken in the face of different conditions.

**Examples and conclusions**

The examples presented are taken from work done by students in the Animal Production Course of the Graduate School at the I.N.T.A. Experimental Station in Balcarce, Argentina. It must be clarified that the authors have been able to perform this work after taking a programming course (in the FORTRAN language) and with a few orientation classes regarding systems methodology in a period of about six months, using an IBM 1130 computer at the station.

A. Optimization

Linear programming of an agricultural and livestock enterprise in a cattle breeding area in the province of Buenos Aires

B. Simulation

Simulation of steer fattening on pasture, based on a simulation model of a ruminant and on a growth model of perennial rye grass-white clover pasture

A. Sample of optimization

Simplified case (natural grasslands only) of a beef cattle enterprise in the Salado River Basin (province of Buenos Aires) without capital restriction

**Description of the activities**

1. One bull + pregnant or lactating cow + nursing calf

| | | |
|---|---|---|
| Requires: | Winter rations | 113 |
| | Spring rations | 131 |
| | Summer rations | 87 |
| | Fall rations | 90 |
| | Pregnant replacement heifers | 0.25 |
| | Variable costs | $ 12.60 |
| Producers: | Male calves | 0.50 |
| | Heifers | 0.50 |
| | Old pregnant cows | 0.03 |
| | Open cow | 0.15 |
| | Aborting cows | 0.05 |

2. Adult pregnant or lactating cow + nursing calf

| | | |
|---|---|---|
| Requires: | Winter rations | 108 |
| | Spring rations | 126 |
| | Fall rations | 120 |
| | Summer rations | 84 |
| Produces: | Male calves | 0.50 |
| | Heifers | 0.50 |
| | Sale value | $ 1,058.00 (net) |

3. Sale at weaning

| | | |
|---|---|---|
| Requires: | Calves at weaning | 1 |
| Produces: | Sale value | $ 720.00 (net) |

4. Heifers for first mating at 26 months

| | | |
|---|---|---|
| Requires: | Spring rations | 90 |
| | Fall rations | 42 |
| | Replacement heifers kept for 19 months | 1 |
| | Variable expenses | $ 5.00 |
| Produces: | Pregnant replacement heifer | 0.80 |
| | Open heifer | 0.15 |
| | Aborting heifer | 0.05 |

5. Maintenance of heifers for 19 months

| | | |
|---|---|---|
| Requires: | Winter rations | 126 |
| | Spring rations | 63 |
| | Summer rations | 42 |
| | Fall rations | 168 |
| | Weaned heifer | 1 |
| | Variable costs | $ 19.00 |
| Produces: | Replacement heifer kept for 19 months | 0.98 |

6. Sale of heifers at weaning

| | | |
|---|---|---|
| Requires: | Heifers | 1 |
| Produces: | (Per sale) | $ 600.00 |

7. Purchase of pregnant heifers on March 1

| | | |
|---|---|---|
| Requires: | Heifer price | $ 1,000.00 |
| Produces: | Pregnant replacement heifer | 1 |

8. Immediate sale of open cows upon palpation on March 1

| | | |
|---|---|---|
| Requires: | Open cow or heifer | 1 |
| Produces: | (Per sale) | $ 1,000.00 |

9. Sale of wintered open cows, July 1

| | | |
|---|---|---|
| Requires: | Cow or open heifer | 1 |
| | Fall rations | 120 |
| Produces: | (Per sale) | $ 1,215.00 |

10. Sale of cows on December 1, kept until March 1

| | | |
|---|---|---|
| Requires: | Aborting cow or heifer | 1 |
| | Fall rations | 120 |
| | Winter rations | 90 |
| | Spring rations | 60 |
| Produces: | (Per sale) | $ 1,215.00 |

11. Native grassland, well drained

| | | |
|---|---|---|
| Requires: | 1 hectare of well-drained land | |
| Produces: | Winter rations | 27 |
| | Spring rations | 117 |
| | Summer rations | 18 |
| | Fall rations | 96 |

12. Native grassland, poorly drained

| | | |
|---|---|---|
| Requires: | 1 hectare of poorly drained land | |
| Produces: | Winter ration | 9 |
| | Spring ration | 81 |
| | Summer ration | 18 |
| | Fall ration | 72 |

**Restrictions**

1. Winter rations
2. Spring rations
3. Summer rations
4. Fall rations
5. Male calves
6. Heifers
7. Heifers maintained for 19 months
8. Pregnant replacement heifers
9. Old cows
10. Open cows or heifers
11. Aborting cows or heifers
12. Well-drained land (1,157 ha)
13. Poorly drained land (1,850 ha)

**Results**

| Activity | Level |
|---|---|
| 1. Bull + cow + nursing calf | 397 units |
| 2. Adult cow + nursing calf | 12 units |
| 3. Sale of male calf at weaning | 204 units |
| 6. Sale of heifer at weaning | 204 units |
| 7. Purchase of pregnant heifers, March 1 | 99 units |
| 9. Sale of wintered open cows | 59 units |
| 10. Sale of aborting cows | 20 units |
| 11. Well-drained grassland | 1,157 ha |
| 12. Poorly drained grassland | 1,850 ha |

Objective function: $ 224,866

| | | |
|---|---|---|
| Surplus: | Spring rations | (230,572 rations) |
| | Fall rations | (197,629 rations) |
| | Summer rations | ( 18,620 rations) |

Shadow prices:

| | |
|---|---|
| For winter rations | $ 4.69 |
| Well-drained land | 126.78 |
| Poorly drained land | 42.26 |

In conclusion, it can be said that under the described conditions, objective function is maximized by selling all of the male calves and heifers at weaning and buying all replacement heifers already pregnant.

B. Simulation example

**Simulation of steer fattening on grazing**

The system represented by this model may be defined as follows: A perennial rye grass (**Lolium perenne**) and white clover (**Trifolium repens**) pasture, fertilized with triple superphosphate (0-47-0), and planted two years before on a Solod (Soloth) soil in the Balcarce area. On this pasture, divided into six plots, rotational grazing is given to young Aberdeen Angus steers that begin the fattening period after weaning at six months of age on the average.

In the simulation model daily estimates are made in terms of dry matter, the growth of the grass, the consumption by the animals, natural losses of the pastures and losses caused by the animals.

Steer fattening and pasture growth models were independently validated, finding in both cases a considerable similarity with the values found in real field trials.

Potential growth of the pasture, without soil moisture restrictions, is a function of fodder availability and of the time of the year. On the other hand, real growth is a function of potential growth and of the degree of restriction imposed by the soil moisture content. The values required to estimate the restrictions caused by soil moisture are calculated by the Thornwhite method, based on real rainfall and daily temperature data.

Losses pertaining to the pasture itself are estimated on the basis of availability; losses because of the animals are a function of the availability and of the instant stocking density. Both kinds of losses are estimated by empirical equations.

Potential fodder consumption by the animals is based on their liveweight, adjusting it by availability and digestibility. Daily gains are obtained through a simplified metabolic route, beginning with feed composition and consumption. Energy produced by every fraction is estimated. Once maintenance is attained, energy utilizable for production is divided by the caloric value of the gain (which is, in turn, a function of the liveweight), which gives the daily weight gains.

Within the model, decisions to be made are established for every possible situation; animal rotation in the plots and the decision of whether to slaughter or not are taken based on preestablished availability values that vary with the time of the year. If none of the plots has enough availability for grazing, the animals consume hay only until one of the plots reaches the point of minimal pasture availability to begin grazing.

To improve this model, it is necessary to have more complete information regarding several aspects, such as factors affecting pasture growth and losses (e. g., animals can affect growth and loss of forage as a result of trampling, feces, grazing habits, etc.) on the growth and losses of the root system and metabolic interchange with the aerial part of the plant. Better knowledge as to how the availability and structure of the forage affects the maintenance requirements is also needed.

It is important to highlight the fact that the modeling process could not exist without information based on traditional research and without the formulation of hypotheses about the real systems, based on direct observation. In no way is simulation to be considered an alternative to real experimentation. Both activities should be integrated in such a way that the task of building models becomes a real aid in research. In this way, the first may act as a guide for the experimental research program so the available resources will be used in areas having greater possibilities for producing significant impact in production.

| RESTRICTIONS | B | Bull + pregnant or lactating cow + nursing calf | Old pregnant or lactating cow + nursing calf | Sale of male calves at weaning | 1st-pregnancy heifer at 26 months | Maintaining heifers for 19 months | Sale of heifers at weaning | Purchase of pregnant heifers | Immediate sale of open cows, March 1 | Sale of wintered open cows, July 1 | Sale of aborting cows or heifers, December 1 | Well drained native grassland | Poorly drained native grassland |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Winter rations | 0 | 113 | 108 | 0 | 0 | 126 | 0 | 0 | 0 | 0 | 90 | – 27 | – 9 |
| 2. Spring rations | 0 | 131 | 126 | 0 | 90 | 63 | 0 | 0 | 0 | 0 | 60 | –117 | –81 |
| 3. Summer rations | 0 | 87 | 84 | 0 | 42 | 42 | 0 | 0 | 0 | 0 | 0 | – 18 | –18 |
| 4. Fall rations | 0 | 90 | 120 | 0 | 0 | 168 | 0 | 0 | 0 | 120 | 120 | – 96 | –72 |
| 5. Male calves | 0 | – 0.5 | –0.5 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6. Heifers | 0 | – 0.5 | –0.5 | 0 | 0 | 1.0 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7. 2nd-pregnancy heifers | 0 | 0 | 0 | 0 | 1.0 | – 0.98 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8. Pregnant replacement heifer | 0 | 0.25 | 0 | 0 | –0.8 | 0 | 0 | –1.0 | 0 | 0 | 0 | 0 | 0 |
| 9. Old pregnant cow | 0 | – 0.03 | 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10. Open cow or heifer | 0 | – 0.15 | 0 | 0 | –0.15 | 0 | 0 | 0 | 1.0 | 1.0 | 0 | 0 | 0 |
| 11. Aborting cow or heifer | 0 | – 0.05 | 0 | 0 | –0.05 | 0 | 0 | 0 | 0 | 0 | 1.0 | 0 | 0 |
| 12. Well-drained native grassland (ha) | 1,157 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13. Poorly drained native grassland (ha) | 1,850 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Value | 0 | –12.60 | 1,058 | 720 | –5.00 | –19.00 | 600 | –1,500 | 1,000 | 1,215 | 1,215 | 0 | 0 |

# DEVELOPMENT PROJECTS: SELECTION, DESIGN, IMPLEMENTATION AND THEIR ROLE IN TECHNOLOGICAL APPLICATIONS

*James Fransen*

This paper describes an international program for the improvement of beef production in tropical America. The approach is essentially that of combining capital resources and technical know-how, thereby making more effective use of land, animals and man in fostering economic development. The method permits the immediate use of these interrelated basic resources and provides man with the incentives and technology required to increase the productivity of both land and animals.

It is fitting that this session should be near the end of the seminar since it is concerned with attempts to increase food supplies from tropical America at the point where they originate—the farm and ranch. The views expressed are personal; they derive from some 20 years of direct involvement with international livestock research and development programs.

## BACKGROUND

Throughout tropical America, there are extensive areas of land, which in the foreseeable future can be used economically only for grazing pastures. These lands are generally unsuited for cultivation; or if they are suited for this purpose, there is no economic justification at present for their use for crop production. In many of these areas, which have been and still are the main "growth" areas for beef production, population pressure is low and infrastructure is almost nonexistent.

A major constraint to development of livestock production in these areas, as well as in others, has been the inadequacy of institutions to provide credit, research and extension services. This consideration, in addition to the fact that commercial lending systems have found it easier to lend to large-scale producers, has influenced governments to encourage development of beef production on medium- or large-scale commercial ranches which can operate as self-contained units. In all likelihood, beef production in these areas will continue for many years on an extensive system of development on existing ranches, above all those which are privately owned, or possibly on cooperative ranches comprised of several farms.

In livestock development in Latin America, bank policy has therefore been aimed at transferring technology and resources, encouraging a rational use of land by producing beef and milk in areas well suited to do so, emphasizing low-cost production, and helping improve the foreign exchange position of the recipient country.

## AGRICULTURE AND DEVELOPMENT

Let us turn to the importance of agriculture in development. In most developing countries, more than two thirds of the people live on the land. Once a contentious issue among development economists, it is now generally accepted that increasing the productivity of the agricultural sector is one of the most effective ways of contributing to capital savings and productive investment for economic growth. It also contributes to a better balance of payment. More basically—and more urgently under the present circumstances—it offers the only hope of providing enough food for growing populations.

Fortunately, the tide of development thought has been turning further. To evaluate the development process only by such gross indicators as rural or urban investment, per capita income, or the rate of increase in the gross national product is to ignore some of the more basic problems affecting the lives of people in developing countries. I refer to the fundamental issues of malnutrition, increasing unemployment, and the growing inequality in the ownership of resources and the distribution of income. To a large extent, these problems arise from an unabated, rapid population growth. Unless greater emphasis is given to these issues within a broader concept of development, the results of all efforts will be minimal indeed.

It is not my intention to dwell on these issues at any length but to point out that at the World Bank we are becoming more and more aware that the problems of unemployment and underemployment and unequal income distribution cannot be solved by economic growth alone. Nor can we expect to solve them by any fiscal measures designed to redistribute income. The income of the poorest groups of people, most of whom live in the rural areas, must be raised by somehow increasing the number of productive jobs available to them.

**Analysis of the agricultural sector**

In order to better account for all these factors of development, the bank has recently begun to undertake complete reviews of member countries' agricultural sectors in close cooperation, of course, with the governments concerned. These reviews are aimed at obtaining an overall perspective of the sector so that after identifying the many resource and institutional limitations, development and project priorities may be established. The bank and governments then use these reviews to guide investments in agricultural projects.

## THE ROLE OF LIVESTOCK

In view of the widespread protein deficiency, investment in livestock can play an increasingly important role in the field of nutrition. The demand for cheaper food of animal origin is urgent and can only be met on a permanent basis by increasing production within the developing countries themselves.

In a number of countries in tropical America, production from the livestock sector can be increased in sizable jumps. This is indicated by the low levels of productivity of existing herds, where it is often the case that from 5 to 20 acres are required per head of cattle. Reproductive efficiency, in terms of weaning rates, seldom exceeds an effective level of 50 per cent. Mortality rates of up to 10 per cent are common, and growth is so slow that it takes three to four years or more for steers to reach slaughter weight. The number of cattle slaughtered each year, expressed as a percentage of the national beef cattle herd, yields an average extraction rate of around 12 per cent; and this has not changed for many years. In other words, in these countries some 50 to 100 head of cattle must be fed and maintained to produce each ton of beef as compared with 12 to 14 head in the more advanced livestock-producing countries. There is clearly an enormous potential for using the large animal resources of tropical America more effectively through the application of existing technology suitably adapted to fit the needs of the local environment.

## THE BANK'S APPROACH TO LIVESTOCK PROJECTS

The bank's policy has been to make special expertise available, either from permanent staff or hired consultants, to help member countries draw up overall agricultural development programs and identify suitable projects which fit into the framework of these programs for bank financing. There are representatives in the audience today of at least three countries where projects were selected and designed in this way. Prepared projects are submitted to the bank for review. At this stage, further information may be sought before the project is considered suitable for appraisal.

## PROJECT APPRAISAL AND MANAGEMENT

### Project appraisal

The bank's lending activities are based on project appraisal. The team of evaluators for a livestock development project always includes professionals from several disciplines: livestock and pasture specialists, economists and financial analysts, as well as credit and marketing specialists. During appraisal, it is often necessary to make quite radical changes in the project originally submitted to the bank. In the interests of the borrower, the team of evaluators must ascertain that the project it recommends is the one most likely to contribute to the development of the livestock subsector and to the country's economy. For this purpose, it must establish priorities within the subsector and among the geographical areas that should be brought into the project. Consideration is also given to the problems of organization and management, including the availability of technical staff and other supporting services. The social implications of a project are, of course, also taken into consideration. (I referred to these earlier.) It may be more advisable to begin on a small scale, which if successful, can be further supported by one or more additional loans.

### Producer incentives

It is important to assess whether the economic climate in the country concerned is conducive to increasing production. For this purpose, it may be necessary to make the loan conditional on the government's instituting policies that will increase incentives for the producer, such as removing marketing and price controls or adopting more equitable tariffs and methods of taxation. In some cases, part of the loan is allocated to finance special studies on marketing or on technical problems, which are directly related to the project's success. These studies may enable the initiation of viable projects in geographical areas and with ranchers that had been previously considered uncreditworthy by commercial lending institutions.

### Technical aspects

On the technical side, in order to make more effective use of animal and land resources, it is clearly important to understand the reasons for the low levels of productivity before deciding what kind of inputs to finance. In most projects, funds are provided for physical inputs such as fencing, watering points and corrals. These rather simple inputs, which are essential for the control of stock and grazing management, have often produced considerable increases in production. An equally important physical input is improved pastures, particularly the introduction of legumes and fertilizers.

**Channeling of credit**

In most developing countries, the main factors limiting development of the agricultural sector have been the lack of medium- and long-term funds for productive investment and the failure to adopt modern technology. It is not surprising, therefore, that all World Bank livestock projects provide medium- to long-term credit for rancher subborrowers, linked closely with technical supervision.

When selecting suitable credit channels through which ranchers may obtain subloans, our general principle has been to use existing channels wherever possible and to improve them, if necessary, rather than establishing new ones. In this way, we try to involve both commercial and government banking and other credit institutions. Unfortunately, however, it is often the case that they have had little experience in long-term agricultural loans, particularly in those countries that have experienced chronic inflation.

A typical method we use is to channel World Bank funds through the central or reserve bank to commercial banks, which then pass the loan on to the participating ranchers. It is usual for both the central bank and the commercial banks to provide an agreed proportion of the total loan from their own funds; and the rancher himself also contributes. It is important to incorporate adequate incentives for the institutions responsible for disbursing the credit, as well as for the subborrowers themselves. In this context, interest rates and amortization schedules for the subborrowers and rediscounting procedures for the participating banks are of prime importance.

**Project management**

Probably the most critical part of project appraisal is to determine the most appropriate organizational and institutional framework required to ensure that a project functions as it is meant to. In our experience, the organization responsible for project management must be free from political pressures. Therefore, the most successful projects have been those where project management has been provided by a separate, independent department within an existing credit institution, such as a central bank, or where it has been provided under the umbrella of an "honorary project commission," created especially for the project. Such "commissions" usually include representatives from both the public and private farming and banking sectors. The management organization employs a technical director whose responsibilities include administration of the project and training of local technical staff who, in turn, assist ranchers to draw up viable ranch development plans.

No subloan may be granted without an approved development plan, which then becomes the basis for lending by the credit institution concerned. An individual ranch plan includes estimates of income and expenditures after accounting for the expected improvements in production performance.

Once the loan is made effective, the technical staff makes follow-up visits to each rancher to assess progress, to measure the loan's impact and to solve any problems that may arise. Needless to say, it is not possible to provide this assistance to all ranchers. Nevertheless, there is significant program diffusion as a result of these visits because those ranchers participating influence their neighbors to adopt similar techniques, which increases the overall impact of the project.

As far as the World Bank is concerned, during appraisal of each livestock project, a detailed estimate is prepared of the total project investment program and the rate at which the loan is expected to be disbursed to the borrower; that is, to the country involved. This includes capital expenditures for ranch development, working capital requirements and the cost of technical services. The financial and economic viability of a project is calculated and rates of return estimated for both the subborrowers and for the economy as a whole. In all cases a project should satisfy three broad criteria: It should be technically feasible, financially viable and economically sound.

## IMPACT OF BANK GROUP LENDING IN LATIN AMERICA

Of the 15 countries in Latin America that have received livestock development assistance from the bank group, only Uruguay, Chile, Paraguay, Colombia, Bolivia and Mexico have had projects operating long enough (five years) to warrant assessment on a project or national basis. In order to make such an assessment, it is necessary to quantify the production benefits arising from the investments made at the individual ranch level. Ideally, this should be done on the basis of the performance of individual subborrower ranchers, comparing actual with projected performance. To date, it has not been possible to do this on a general basis in any of these countries because project technical staffs have always had to give first priority to their basic development planning and supervisory functions, leaving insufficient time to collect necessary data. Indirect methods of obtaining these data by asking subborrowers to complete questionnaires periodically have also been unsuccessful, mainly because of the traditional reluctance of ranchers to divulge information that could be used for other purposes. This problem is being given serious attention in Mexico; and under the livestock loans, a provision has been made to employ an experienced group of consultants to help set up a mechanism for measuring results on participating ranches. If successful, this will provide, along with similar efforts being made in Uruguay, valuable guidelines for establishing systems in other countries.

In each bank group livestock project in Latin America, only a few individuals maintain adequate records from which it is possible to determine the results of their loans; and because of the paucity of such data, it is often tempting to use what is available to judge overall project performance. This, however, would lead to overoptimistic evaluations because the person with the initiative to maintain good records is invariably an above-average, progressive rancher. Such production achievements do, however, provide goals for other ranchers.

Until a simple mechanism is created for obtaining regular records from all subborrowers in the various countries, the measurement of project impact will of necessity depend largely on subjective assessments by experienced personnel and the interpretation of changes in cattle populations and beef production data obtained from national statistics. Unfortunately, cattle population statistics are not reliable in most tropical American countries. Furthermore, cattle populations per se are not a reliable index of production unless they can be interpreted in terms of take-off rates and animals slaughtered. In spite of the foregoing limitations, it can still be said that the bank group projects in the countries mentioned have had a positive impact to date.

## THE ROLE OF RESEARCH IN THE BANK'S APPROACH

Finally, let us turn to the role of livestock research in the bank's approach to economic development. As a bank, and principally as a development agency, we are especially interested in research that is carried out prior to making an investment and which deals with the ranch as a whole. Most livestock research in needy countries is based upon the way of thinking and the approaches of the developed world; seldom is it directed toward meeting a country's own immediate basic development needs. It rarely involves an effective unification of economics and technology, which brings serious consequences. Low-cost beef production is necessary to keep from being priced out of major world markets, but the application of science and technology to traditional farming has just begun to produce dramatic results with some food crops.

The rapid expansion of certain food grains in the developing world has been heralded as the "Green Revolution." But what does this current crop history have to do with advances in livestock production? We believe the answer to be self-evident: Ranchers, like farmers, respond to incentives that increase productivity and at the same time reduce unit cost. To the world's average producer, the success of research results is measured in the terms of financial returns rather than in terms of biological reactions. Although a new technological package like the "Green Revolution" has not yet been designed for livestock production, it is believed that the prospect of doubling earnings is the most effective means of stimulating production increases. The bank's comprehensive approach to ranch development assists in this effort.

In summary, let me say that although it is improbable that the bank's basic approach will differ from the three criteria mentioned earlier, we are presently evaluating and reevaluating additional considerations which are leading us to make major changes in our livestock development strategy and, in fact, in our development strategy as a whole. These changes have been brought about, in part, by recent acceptance of the view that by dedicating more attention to the poorer agricultural groups, we are not necessarily sacrificing economic growth. Moreover, coupled with various land reform programs carried out by the countries themselves, we are able to facilitate a more equitable distribution of productive resources and income.

In our livestock projects, more emphasis is being placed on the small livestock owner, including— in addition to beef cattle—sheep, dairy cattle, pigs and poultry. These changes present many new problems, particularly in regard to the appropriate technological package for the smaller producer and his financial and economic viability. These projects are already challenging the ingenuity of bank and project staff in the field; but with the fuller involvement of all the organizations involved, we are confident that these problems will be solved successfully.

# GOVERNMENT POLICY AND THE LATIN AMERICAN BEEF PRODUCER

*August Schumacher*

For producers of Latin American beef, 1973 was a volatile year. Governments throughout the world continued to extend their policy influences over the industry. Exporting countries increased their controls over exports; importing countries relaxed their restrictions on imports. At any rate, prediction of future trends has always been a hazardous occupation.

The Latin American beef producer, like producers of grain and dairy products, continues to be buffeted by national and external government policies. Many are contradictory, some are outdated, and others serve only a narrow producer or service segment. National policies (credit, exchange controls, tariffs, quotas, price controls, health regulations, taxes and subsidies), together with geographic conditions and external disease regulations, fragment the Latin American beef industry.

Unlike coffee and sugar, international agreements do not exist for beef. Government policies since World War II have largely originated at the national level although regional policies (EEC and to a lesser extent COMECON) have increased during the past decade. Regional groupings in Latin America (Andean Pact, LAFTA, Central American Common Market) have not been as influential in shaping the dynamics and structure of their beef industries as their European counterparts. With the exception of some of the multilateral development banks, international policy influences on the world beef system, as compared with national policies, have been minimal. International beef policies do not exist; each country seeks to obtain the most benefit from its advantages.

Consumer-oriented policy makers in both rich and poor countries are particularly sensitive to the effect rising beef prices have on their constituents, especially as beef consumption in many Latin American countries still accounts for more than 80 per cent of meat consumption. Because of the high proportion of beef in consumer price indexes, rises in consumer price indexes are created by rapid increases in beef prices, especially where they are related to middle- and high-income strata.

With this pervasive influence of government policies on the dynamics and structure of the Latin American beef system, no participant in the system, including the research segment, can operate without (a) a reasonable understanding of existing policies and (b) a "best guess" as to what policy changes are likely to occur during the next decade.

This paper focuses on the influence of government policy in shaping the dynamics and structure of the Latin American beef industry.

## THE SIGNIFICANCE OF BEEF IN LATIN AMERICA

**Animal protein* availability from Latin American animal and fish production (1970)**

As Figure 1 indicates, a significant segment (35 per cent) of Latin America's animal protein consumption is derived from beef.

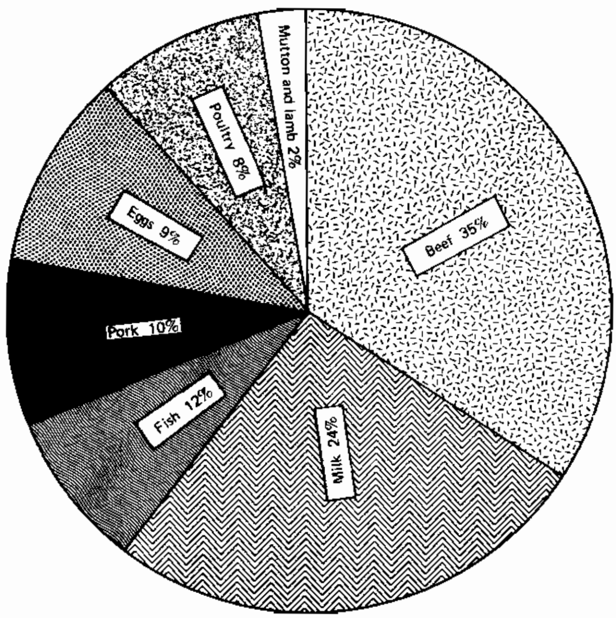



**Figure 1.** Animal protein consumption in Latin America.

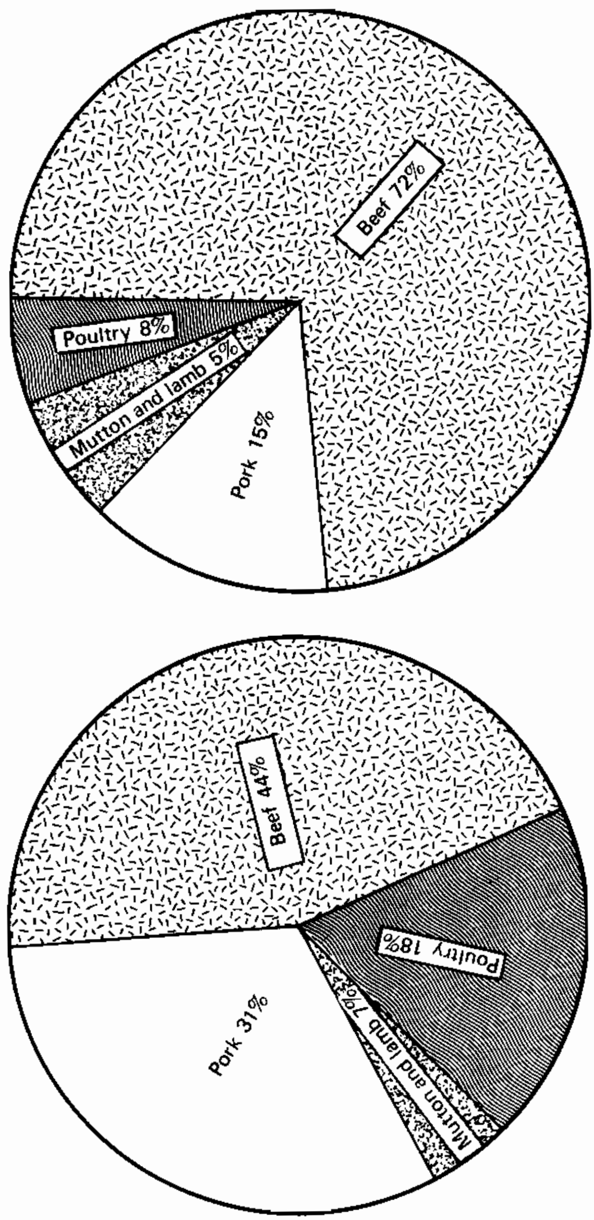
* Most protein is derived from crops, such as beans and other crops grown on subsistence farms, for which there are no statistics.

## Beef production as a share of Latin American and world meat production (1970)

Figures 2 and 3 indicate the importance of beef in Latin American meat production as compared with world, Australian and United States patterns. Taken as a region, beef production in Latin America is nearly 60 per cent more important in its meat economy as compared with its productive share in Australia and the United States.

Figure 2b. Latin America

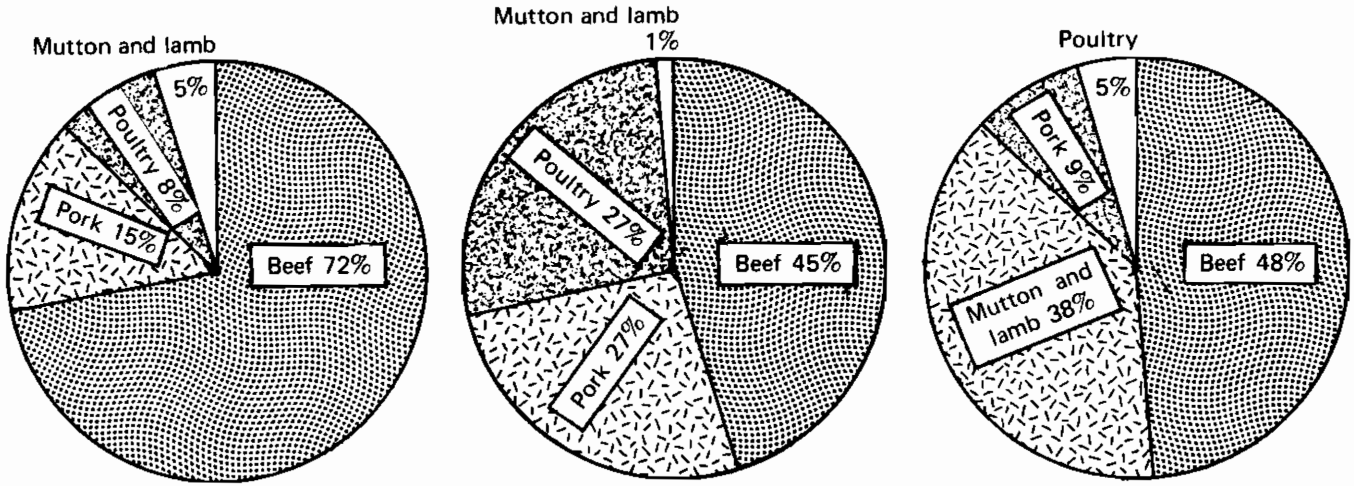
Figure 2a. World




Source: USDA and FAO

**Figures 2a and 2b.** The importance of beef in Latin American meat production as compared with world patterns.

**Figure 3a.** Latin America **Figure 3b.** United States **Figure 3c.** Australia

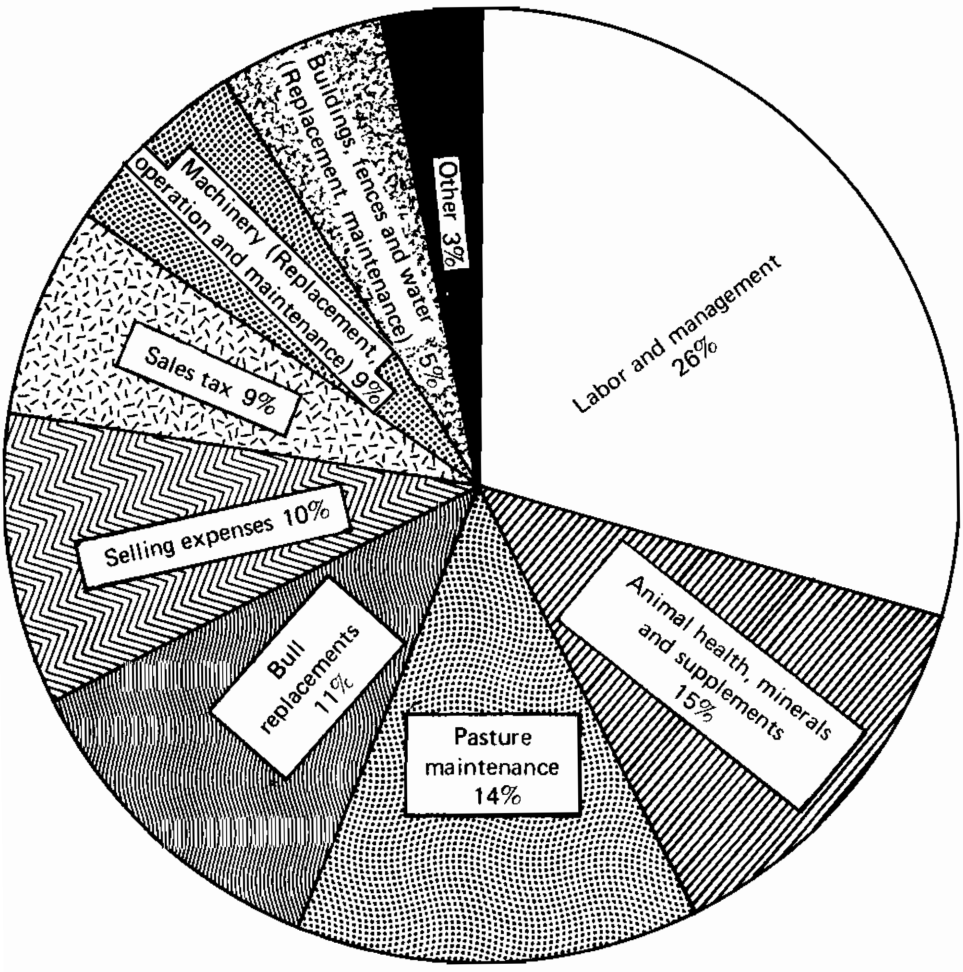



Source: USDA & FAO

**Figures 3a, b and c.** Comparative meat production in Latin America, the United States and Australia (percentage of shares in 1970).

**As a consumer of annual operating inputs**

Figure 4 provides an estimated breakdown of categories of inputs used by cattle ranchers in Latin America in 1970.

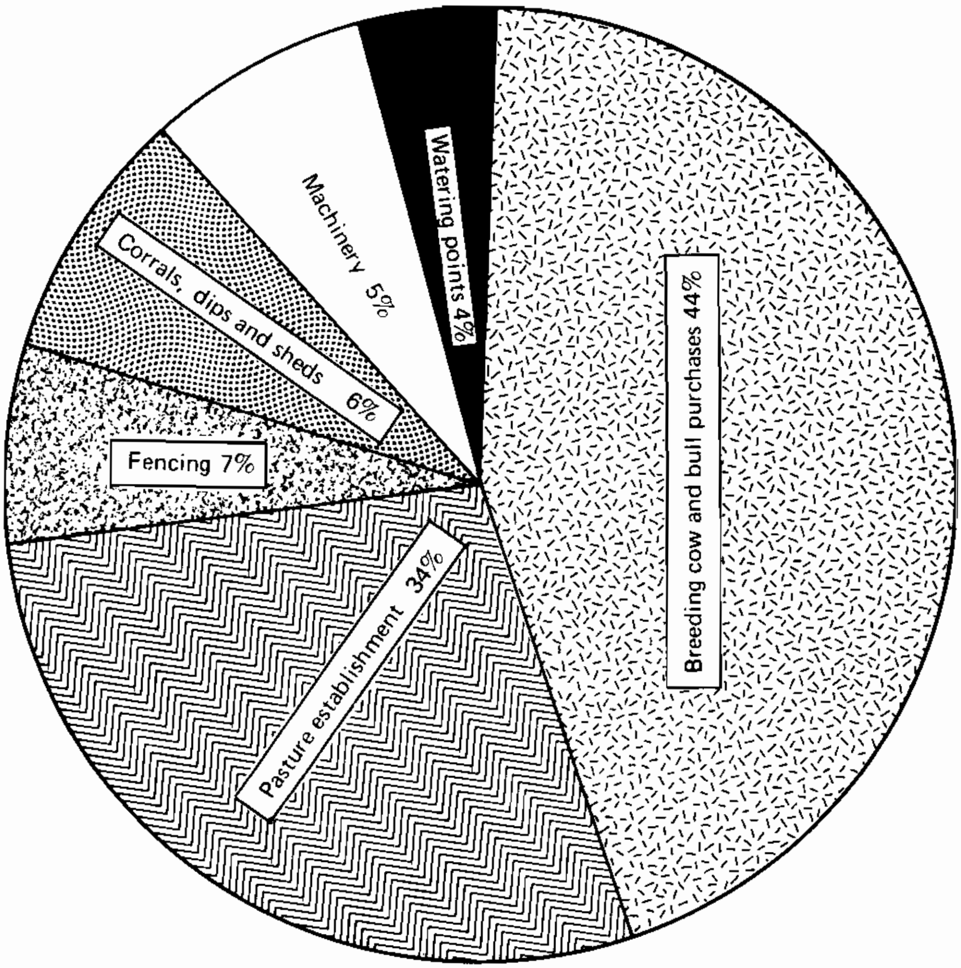



Source: Derived from IBRD appraised report estimates

**Figure 4.** Estimated breakdown of inputs on Latin American ranches in 1970.

**As a consumer of investment inputs**

During the 1969-1971 period, typical ranchers in Latin America who had IBRD-supported development loans used such credit to support on-ranch investments broken down into the following categories:




Source: IBRD appraisal data based on Table 2 in Annex 6

**Figure 5.** Breakdown of typical on-ranch investments in Latin America (1969-1971), using IBRD-supported development loans.

As Figure 6 indicates, productivity per head of cattle* in Latin America is 67 per cent and 32 per cent of levels in Australia and the United States, respectively. If cattle productivity in Latin America could be raised to 1970 levels in Australia, beef production would expand by 3.4 million tons by 1980, just from productivity increases of existing herds. This would imply a production increase of 5.5 per cent annually from productivity rises alone.

If, at the same time, these productivity increases were to be accompanied by a herd increase of 5 per cent annually during this decade; that is, approximately 385 million by 1980, beef supplies in Latin America would reach 16 million tons as compared with 6.8 million tons in 1970.

Figure 6 illustrates regional productivity differences in 1970.

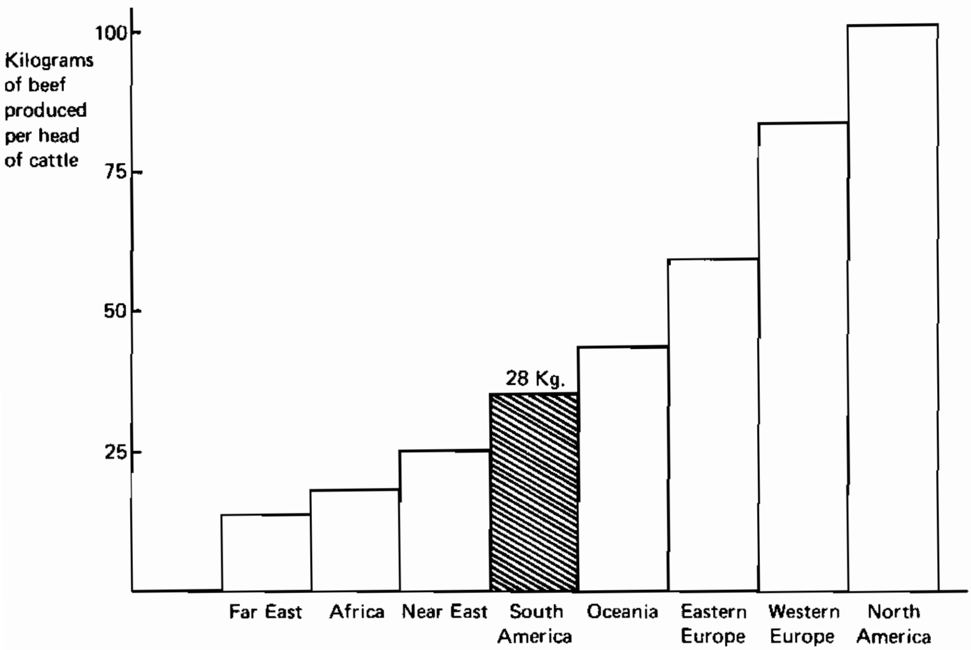



**Figure 6.** Regional productivity differences (1970).

* However, Frank Thomas pointed out to me that this measure (pounds of beef produced per head of cattle) may not be a relevant measure in the Australian context, a country which has 20 to 25 years of high-quality research, little price manipulation (until recently) and unlimited land resources. In Australia, Thomas believes, it is not important to develop high production per head or per unit of area; but it is important to develop output per unit of investment and per worker to take advantage of Australia's comparative advantage.

IBRD appraisal report data indicate that about US$55 of on-ranch investment is required to maintain an extra animal unit under Latin American conditions. This is an average figure with the range running from $35 to $84. Thus, to expand herd numbers to 385 million (285 million animal units) in Latin America by 1983, the investment required would be roughly the equivalent of US$5 billion (or US$500 million a year), exclusive of land costs. Current cash investment* in the beef cattle industry of Latin America is probably the equivalent of US$350 million: 25 per cent financed from foreign sources, 75 per cent domestically generated.

Most technicians will probably agree that these production possibilities are feasible (a) as ample pasture areas are available in the lowland areas of South America and (b) there is a reasonable knowledge of improved grasses and legumes. And just as important, management techniques are available to be used by existing beef producers. Much research remains to be done on both types of extensive and intensive production systems,** but few here at this conference will argue that insufficient technical knowledge is an investment in the short term.

On the contrary, most beef producers are likely to argue that the most immediate obstacle to beef production in Latin America is the lack of consistent and sustained government policies to support the long-term investments necessary to increase production. This paper attempts to analyze some of the policy conundrums the Latin American beef producer faces.

## NATIONAL AND INTERNATIONAL POLICY INFLUENCES ON THE LATIN AMERICAN BEEF PRODUCER

In the absence of beef commodity agreements, some of the international development agencies have emerged as a multilateral policy force capable of influencing the shape of the different segments of the Latin American beef system. The World Bank and Interamerican Development Bank are now lending annually some US$85 million for beef cattle development in 15 Latin American countries. These institutions currently hold an accumulated beef loan portfolio of about US$650 million. Since these agencies normally lend about 50 per cent of project costs, another half a billion dollars has been invested as a result of these projects during the past eight years. Emphasizing low-cost systems of production, these banks have been especially active in Mexico, Central America, Brazil, Uruguay, Colombia, Paraguay and Bolivia.

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* This refers exclusively to the value of heifers retained, which are counted, in theory, at the same rate the rancher is deprived of immediate cash income because he has retained the heifers to build up his herd. In view of the limited cash flow this system creates, some Latin American banks provide special lines of credit over a three- to four-year period in order to cover this period of cash shortage.

** It is recommended to investigate further rust-resistant strains of **Stylosanthes gracilis**, the utilization of the savannas for beef production, and techniques for disseminating the results of this research.

A recent (1973) Latin American development, which is very interesting in light of recent oil and mineral developments, is the attempt by three major producing countries (Brazil, Argentina and Uruguay) to organize meetings (International Congress of Meat Producers) with the express purpose of organizing a "more rational international market for beef." The first meetings of the congress did not go into these matters deeply as they were simply an attempt on the part of producers and purchasers to take a broadened look at some of the features of the world meat trade.

However, most of the important policy features affecting the Latin American beef producer are nationally, rather than multilaterally derived. A brief analysis follows of policies in countries representing nearly 80 per cent of the Latin American cattle herd and more often 90 per cent of the beef export.

**River Plate Region.** Traditional beef exporters to the United Kingdom (Argentina and Uruguay) have gradually diversified their external markets, besides altering substantially their internal policies toward their beef sectors. Unlike Australia*, a substantial portion of their domestic animal protein consumption is taken in the form of beef. Therefore, their governments have been increasingly torn between (a) keeping beef prices down domestically in the absence of alternative animal protein and (b) earning foreign exchange. During the past decade, domestic consumer considerations have prevailed; therefore, export availabilities have fluctuated.

In addition, these governments have relied on their beef sector for a significant portion of their fiscal revenues. In the late 1960's, for example, more than 40 per cent of the total value of Uruguay's beef export was siphoned off by a multitude of taxes and levies. Unlike Australia, which transferred a net US$7 per head into its beef sector in 1971, Uruguay took US$4 per head from its producers; a similar pattern prevailed in Argentina and in Brazil at US$3 per head in 1971. In the latter case, a 200 NC/ton export tax was levied in mid-1973, which was increased to 500 NC at the end of 1973, with the express purpose of diverting additional quantities of beef from the international market, thereby holding down domestic prices.

In these countries, the beef sector is affected by four types of taxes: export, sales, predial (continually rising) and income—by far the most important being export, predial, and sales taxes. In Argentina, export taxes are frequently changed on beef, varying from 5 per cent to 25 per cent. Their major effect, of course, is to keep domestic beef prices

* A note on Australia's beef policy is contained in the Annual Report (38) of the Australian Meat Board, June 30, 1973. "The Board is conscious of the need to contain (beef) prices in an attempt to stem inflation. . . . In a report to. . . the Minister of Primary Industry. . . in April 1973, the board explained in some detail the reasons for the meat price situation on the domestic market. Included in that report were the findings from the examination of a number of ways in which stabilization of meat prices on the domestic market might be achieved.
"We concluded that there appeared to be no method by which price stabilization could be achieved without damaging the long-term essential development of the industry, the national economy and the long-term interests of the consumer. Everything pointed to the need for increased production as the best means to contain prices."

5 per cent to 25 per cent below world levies. Producers and exporters in Argentina claim that the export retention system penalizes producers and deters exports when there is a sluggish market.

Sales taxes (state and federal) are applied to all cattle sold. They average 5 per cent of liveweight beef, or 10 per cent of carcass. Land and income taxes —unlike the United States and Australia, respectively— have a limited effect on the beef sector. The net effect is to tax production values rather than profits, thereby inhibiting production increases.

In recent years, Argentina has conscientiously persisted in a ban ("veda") policy of prohibiting beef consumption for two out of every four weeks in order to keep exports flowing. The evidence of the success of this type of policy in reducing beef consumption, increasing consumption of alternative meat, and maintaining or increasing exports is being closely watched by beef policy makers in other Latin American countries.

**Brazil.** Brazil's beef industry has not been as dynamic as other segments of the country's booming economy. Although the sheer size of Brazil has inhibited growth of the beef cattle industries because of transportation problems in the far interior, government policy has played a significant role in encouraging productivity increases in the more developed beef regions. The government has been torn between encouraging and restricting beef exports to hold down internal prices. With rapid rises in available urban income, demand for animal protein has skyrocketed. Beef production has not kept pace and prices have risen accordingly, compounded by rapidly rising international prices. In the short run, at least, the urban beef consumer appears to have won a significant policy change. Exports are to be tightly controlled to 80,000 metric tons per year; in addition, these exports have to bear a 500 NC-per-ton export tax on fresh and frozen beef and 250 NC on canned beef. Realistically, these policies exclude Brazil from the international market for the next two to three years.

In addition, a series of new measures has been introduced to keep prices to consumers closely controlled. Regulations have been put into force, directed not only at retailers and slaughterers, but also for the first time at the producing rancher (both breeder and fattener). In 1973, the government issued regulations actually enabling it to confiscate cattle from producers who refuse to sell their cattle to slaughterhouses at the controlled price.

Government economists have estimated that a price of 90 NC per arroba gives adequate returns to producers. The unofficial price in late 1973 was reported as high as 140 NC per arroba. The government has also indicated that it will cut lines of seasonal and development credit from official banks to those ranchers who refuse to sell at official prices. Sales are to be monitored by new schedules on annual income tax statements. The schedules will provide forms for reporting purchases, sales and on-farm cattle slaughter. For the Brazilian beef producer, these measures introduce a period of uncertainty.

**Mexico.** Currently, the largest exporter of feeder cattle in the world, Mexico is evolving a set of policies that will in the future reduce export quotas in favor of local consumption. Unlike Argentina, which has vacillated on the subject, the President of Mexico stated on March 17, 1973, at Uruanpan, Mexico that during his term, local consumption would have priority over exports. However, this policy, like many Mexican policies, is not being changed immediately but only as quickly as irrigated pastures for fattening can be developed in the dry northern parts of Mexico.

Using local and international credit, the Bank of Mexico is rapidly expanding its credit facilities for this purpose. At the same time, it is not discounting any paper for grain-fattened beef. The grass-fattened beef would be channeled into local markets and would not be exported. Such a measure could greatly burden U. S. supplies, for a complete cutoff of Mexican feeders would diminish U. S. supplies 3 per cent or would require the United States to expand its beef breeding herd (cows, bulls and replacements) by well over 2 million; that is, a 4 per cent increase. It would also keep Mexican consumer prices some 20 to 30 per cent below U. S. prices, as all of Mexico's beef would be grass fattened, leaving Mexico's feed grain industry to concentrate on supplying its growing pork and poultry industries.

On the fiscal side, Mexico does not levy heavy taxes on beef producers. Mexico's principal policy objective, as stated above, is to ensure adequate supplies of grass-fed beef at a reasonable price for its growing middle-class population. To achieve this, it carefully controls live cattle and beef exports, these being allowed only from the low rainfall areas north of Mexico City, where it is virtually impossible to fatten cattle without irrigation. Exports from the higher rainfall areas south of Mexico City have been prohibited for many years. Cattle from these areas are designated for Mexico City meat supplies. This policy is unlikely to be changed.

A second objective is to prevent the reestablishment of large tracts of privately owned lands that are underutilized for cattle grazing. Toward this end, government policies prohibit individual ranchers from owning land acreages that are more than sufficient to maintain the equivalent of 500 head of cattle. Despite this law, ranchers meeting this target are often reluctant to invest in ranch improvements, as they feel that once they do, neighboring small farmers will insist that those ranch lands over and above the amount required to maintain 500 head be expropiated and distributed to the local small farmers and rural landless. Given the enormous population growth (3.6 per cent annually in the rural areas), there is likely to be an increasingly severe problem for the beef cattle sector of Mexico.

## RANCH BUDGET SIMULATION AS A POLICY TOOL

For the Latin American beef producer, the policy tool of ranch budget simulation can serve both financial and economic analytical needs. Financially, the projection of herd and development and resultant cash flows enables the rancher to determine sensitive management areas in his operation. Economically, ranch budget simulation can assist both the producer and finance/agriculture ministry officials. The methodology and a case application is briefly described below.

What is "simulation analysis"? Simulation is a simple projection of the effects of the interaction of a series of specified events. In the case of a beef ranch, a producer "simulates' into the future by projecting his herd development and resultant cash flow. The effects of changes in endogenous variables (inputs under the control of the producer) and exogenous factors (variables such as price, weather, general policy not under the individual producer's direct control) can then be tested by recalculating the "simulation" with the "new" specified event or events.

What is the importance of "representative ranch budgets"? To use simulation for policy evaluation, derivation of "representative ranch budgets" is necessary; that is, budgets representative of the ecological, tenure and financial conditions prevailing in a country. This requires basic data about prices, costs, taxes, ranch-size distribution, herd composition and technical coefficients. (See Annex 1 for a sample representative ranch budget.)

The purpose of this particular budget is to measure the financial rate of return to the rancher on a package of new cattle, pasture and fixed, on-ranch investments. The financial rate of return can then be used as a sensitivity measure for changes in one or more of the numerous variables (see Annex 3) that affect the profitability of the additional investment.*

In simulation analysis, computer assistance is a useful but not a necessary tool. In this budget in Annex 2, recalculation of the technical variables (weaning, culling and mortality rates, etc.) takes about four hours; changes in financial variables (prices and costs) takes about half an hour to do. A computer-assisted run takes about 18 seconds, but in and out time often takes a day. For use as a policy tool, the use of a simple calculator usually suffices. But for those wishing to use this simulation extensively as a ranch management tool, computer assistance on the herd development aspects of the model is probably advisable.

The Latin American government that used this budget methodology was mainly interested in testing the effect that various levels of monetary devaluation would have on rancher incentives to make new, productive on-ranch investments. To the surprise of some of its policy makers, it discovered that other policy variables were more important to rancher incentives. Variables include:

* In this methodology, emphasis is placed on sensitivity measurements on additional or incremental investments, not on gains from total capital employed. This paper does not discuss the merits of either methodology (return on total capital employed including land versus measuring return on incremental capital). As a policy tool, however, the latter methodology does give a better measure of sensitivity.

a) Processor margins

b) Export taxes

c) Sales taxes

d) Fertilizer subsidies

e) Availability of official credit

As a result, the government was able to tailor adjustments in a number of policy variables which, taken as a package, substantially improved rancher investment incentives. None of the variables involved adjustment of the exchange rate which had been used traditionally to increase rancher incentives. While the rate was eventually adjusted, the government has continued to use this simulation methodology to assess the effects of its policies on the ranchers' investment incentives.

## THE CENTRAL BANK AS A MAJOR FORCE IN LATIN AMERICAN BEEF PRODUCTION

Since 1965, the central banks of a considerable number of Latin American countries have formed special funds designed especially to encourage livestock production. Many of these funds began rediscounting operations in order to stimulate beef cattle sectors in their countries, gradually broadening their credit activities to the agricultural sector as a whole. Since 1965, central banks have stimulated development investments amounting to nearly US$650 million in Latin American beef production. Table 1 provides a breakdown by country and source of finance (1965 to 1973).

These special agriculture and livestock funds in the central banks are thus emerging as an important tool of government policy in Latin America, an area where ministries of agriculture and agricultural development banks have frequently not been as effective in stimulating the beef sector as their counterparts in other parts of the world. These central bank funds operate with four objectives:

a) To encourage commercial and government banks to lend to the beef cattle sector by providing them with a substantial portion of the long-term funds required on a rediscount basis.

b) To provide a technical basis for cattle loans as a condition for receiving long-term liquidity (7- to 12-year money). In practice, this has meant that the central bank itself has also built up a special technical force of agricultural technicians (from 7 in the Dominican Republic to more than 285 in Mexico) who live in the livestock

Table 1. **Selected central bank/World Bank financing of beef cattle development (in millions of US$).**

| | Total funds* | World Bank | Central bank/ participating banks | Government | Number of technicians |
|---|---|---|---|---|---|
| **Mexico** | | | | | |
| Loan 1 | 50 | 25 | 25 | — | 40 |
| " 2 | 115 | 42 | 51 | — | |
| " 3 | 83 | 42 | 41 | — | |
| " 4 | 165 | 75 | 90 | — | |
| Subtotal | 413 | 184 | 207 | — | 40 |
| **Brazil** | | | | | |
| Loan 1 | 65 | 40 | 25 | — | |
| " 2 | 42 | 26 | 16 | — | |
| Subtotal | 107 | 66 | 41 | — | 40 |
| **Argentina** | 32 | 15.3 | 13.5 | 3.2 | 30 |
| **Ecuador** | | | | | |
| Loan 1 | 5.5 | 4.0 | 1.5 | — | |
| " 2 | 4.0 | 3.0 | 1.0 | — | |
| " 3 | 15.8 | 10.0 | 5.8 | — | |
| Subtotal | 25.3 | 17.0 | 8.3 | — | 20 |
| **Panama** | 9.5 | 4.1 | 5.3 | 0.1 | 5 |
| **Dominican Republic** | 7.5 | 5.0 | 2.5 | — | 4 |
| **Costa Rica** | 6.1 | 4.1 | 2.0 | — | 10 |
| **Uruguay** | 34.2 | 20.6 | 9.5 | 4.1 | 85 |
| **Honduras** | 4.4 | 2.5 | 1.8 | 0.1 | 6 |
| **Guyana** | 3.6 | 2.2 | 0.8 | 0.6 | 4 |
| **Guatemala** | 6.2 | 4.0 | 0.6 | 1.6 | 5 |
| Total | 648.8 | 324.8 | 292.3 | 9.7 | 289 |

* Exclusive of rancher investment

regions. Approval of the on-ranch development plan is required by these technicians before the central bank will rediscount a beef cattle development loan. Approval involves the preparation of an overall ranch development plan, giving the technical parameters of a herd and ranch development plan during the life of the proposed loan and providing a detailed case cash flow indicating how the development loan made by a participating bank and rediscounted with the central bank is to be serviced.

c) To develop a technical basis, especially on the feed supply side, for increased beef cattle production. As a result, a number of the central bank special funds have organized their own pasture research programs, most of them practical, on-ranch trials of improved temperature and tropical legumes and grasses. The central bank staffs in Mexico, Brazil, Ecuador, Guyana and the Dominican Republic have developed well-known capabilities in this area of pasture research, complementing development bank technicians and research and extension personnel in the ministries of agriculture.

d) To mobilize noninflationary internal and external funds for relending and rediscounting operations for beef cattle. Table 1 cites the success of these funds in this effort. A number of central banks (Mexico, Brazil) have had some success in generating internal banking resources, both directly and indirectly, for lending to their cattle sectors.

These development credit loans thus become the umbrella under which commercial banks can develop expanded shorter term lending for:

a) Working capital (start-up feed costs, chick purchases, processor inventory, etc.)

b) Seasonal financing for growers, feed millers, etc.

c) Financing for imports and exports of feed grains, highbred chicks, meat and crop processing and milling equipment.

## BIMODAL LIVESTOCK DEVELOPMENT AS A MEANS OF STIMULATING THE BEEF INDUSTRIES

As beef continues to rise in price, a balance has to be found between its value as a source of foreign exchange to Latin American economies not blessed with oil or mineral export surpluses and its value as the source of animal protein. The importance of beef as a source of animal protein in Latin America was noted earlier. Thus, in Central America particularly, and to a lesser extent in countries such as Colombia, internal beef consumption has stabilized or even begun to decline as exports increase faster than beef production.

The difference, of course, is due to the marked growth in nonbeef meat consumption in Australia, chiefly pork and poultry. Rising beef prices, chiefly brought about by export demands, caused Australian consumers to shift to other sources of meat. Although policy makers and research groups have attempted to pursue a balanced program of encouraging other meat as well as beef production, technical and pricing constraints have limited the commercial impact. Traditionally, Latin American countries have not been able to utilize fully these alternatives to beef, as consumer prices of pork and poultry have been frequently higher than beef. In tropical regions in Latin America, for example, this problem has been made worse by the lack of suitable feed grains. Research has been done to promote beef cattle production, yet the estrus cycle of the cow is insufficient to keep up with beef demands. This biological limitation of the cow* has been compounded by government policy in a number of countries. This has kept the beef price below export price levels to control inflation besides the fact that there is no developed nonbeef meat industry to service primarily urban protein requirements.

To overcome some of these problems, Mexico has followed this bimodal strategy, as Figures 7a and 7b indicate. Both pork and poultry production, geared primarily to serve urban markets, have grown during the past decade, with poultry prices to the consumer showing relatively little nominal change, a decline in real terms when inflation is taken into account.

Guyana was another country which found itself in a difficult meat situation about ten years ago, faced by a decline in meat consumption whereas that of beef was 77 per cent. The government encouraged the development of a commercial broiler industry located on the outskirts of the capital. A poultry adviser brought in from abroad and a local feed grain supplier combined forces to provide technical and financial support to 11 local store clerks and small businessmen who were encouraged to enter full time into the broiler feeding and processing business. Since 1963 "chicken in the basket" has become a well-known advertising slogan in Guyana's principal cities. Whereas beef consumption continued to decline and then stabilize, chicken consumption has enabled Guyana to increase its overall per capita meat consumption, reducing that of beef to 51 per cent of total meat consumption in ten years (Figure 8).

This bimodal approach to meat production in Guyana has given that country sufficient time to take a detailed look at the structure of its beef industry and its production problems in order to develop a strategy that will eventually encourage beef production and that will not upset existing income distribution patterns in that country. Some of the implications of a bimodal policy approach to meat production in Latin America are listed below.

a) The greatest demand for meat occurs in urban areas, areas where political pressures are often most readily articulated. In the absence of alternative sources of animal or

* Of course, much still has to be done to ensure that a cow does actually have an effective estrus cycle.

**Figure 7a.** Latin America

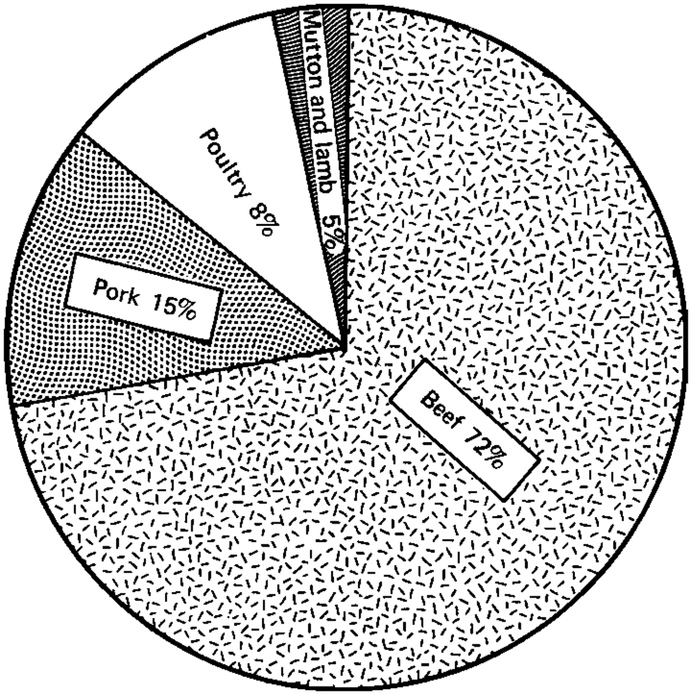
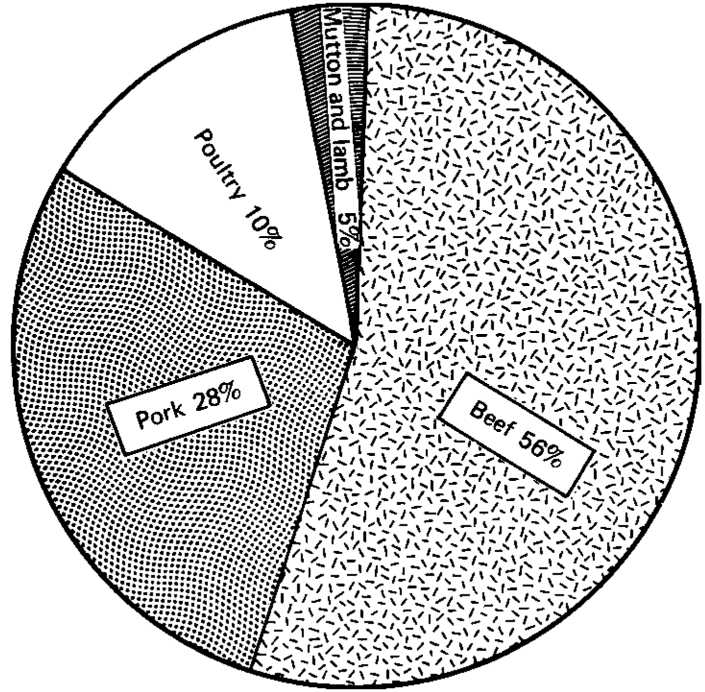
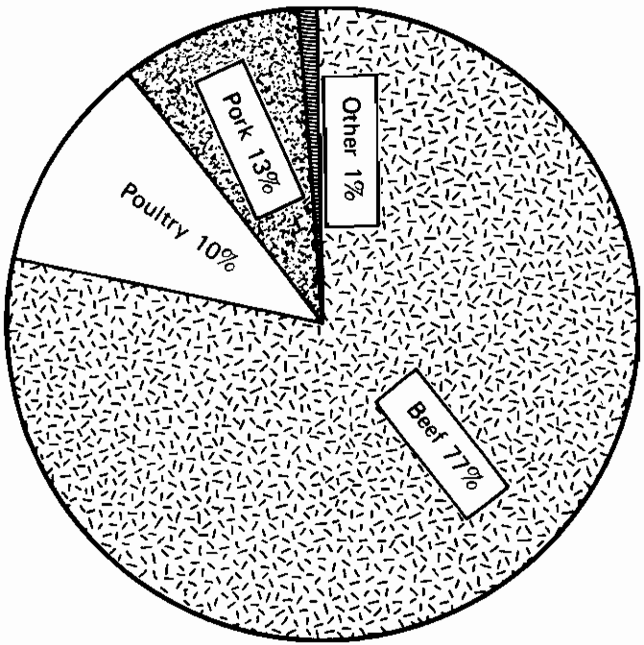



**Figure 7b.** Mexico



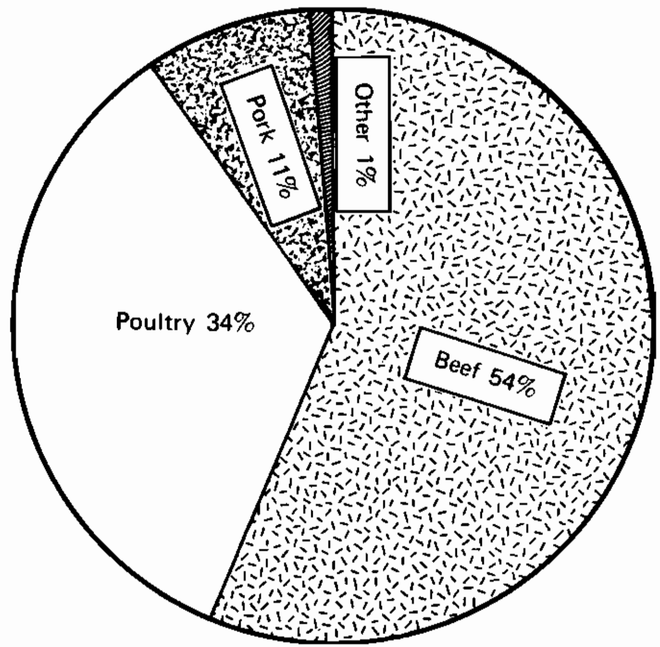

**Figures 7a. and b.** Categories of meat consumption in Latin America as compared with Mexico.

Figure 8a. 1960




| Per capita consumption (kg) | |
|---|---|
| Beef | 7.6 |
| Poultry | 0.9 |
| Pork | 1.4 |
| Other | neg. |
| Total meat | 10.0 |

Figure 8b. 1970




| Per capita consumption (kg) | |
|---|---|
| Beef | 7.5 |
| Poultry | 4.7 |
| Pork | 1.7 |
| Other | neg. |
| Total meat | 14.0 |

**Figures 8a and b.** Changes in meat consumption in Guyana (1960 and 1970).

fish protein, this political pressure is brought to bear on the urban price and availability of beef. Since the central bank and the ministry of finance are greatly concerned about foreign exhange, which causes beef prices to skyrocket, they are sensitive to protests received from "pot and pan" brigades.

b) In a considerable number of the countries represented at this conference, central banks have special funds (staffed with competent technicians) geared to provide substantial lines of development credit designed to increase cattle production. These banks have not put the same technical and financial effort into alternative forms of meat with a quicker production payoff.* International development agencies, with the exception of a few lending operations, have also suffered from this bimodal lacuna.

c) Regional and national research agencies have also historically neglected the pork and poultry segments of Latin America's meat industry. Existing commercial pork and poultry enterprises relied extensively on imported feed grains with little research being done to develop alternative local feed grains particularly suitable for tropical conditions. Recent evidence indicates that this neglect is being rapidly reversed at this center with regard to pork production and other industries, as the forthcoming major London conference on tropical animal feedstuffs indicates.

d) Commercial bank participation in a bimodal strategy requires coordination with central bank and development bank operations. The World Bank, Interamerican Development Bank, Adela and Ladd, with access to long-term bond and credit markets, are able to give 15- to 30-year loans supporting livestock infrastructure, such as port improvements, grain elevators, farm-to-market roads and research programs on pasture management and seed production. In addition to these infrastructure loans, these international development banks frequently provide an umbrella of long-term loan liquidity to central bank special funds discussed above. These funds provide the capability (hitherto little used) of eight- to twelve-year liquidity, against which commercial banks can discount development loans made for farrowing pens, feed mills, growing houses, feed storage bins, processing equipment and hatcheries.

Beef producers may rightly ask why this section of the paper on beef policy has dwelled so extensively on poultry and pork production. There are two reasons: First, with increasing urbanization, consumers in these areas continually worry about rising meat prices, which in Latin America is almost synonymous to rising beef prices. Governments respond by holding down meat (beef) prices with a variety of controls. As we know rather well, rising input costs and low output prices do not particularly encourage investment in expanding beef production. Secondly, with beef in increasingly short supply in a number of developed countries, beef exports can contribute significantly

* Poultry and pork production, as compared with beef, have, of course, a substantially quicker production payoff.

to foreign exchange earnings. However, without alternative sources of meat for domestic consumption, few governments are likely to let foreign exchange needs override domestic animal protein requirements. Thus, this paper argues that the Latin American beef producer should have a close and continuing interest in encouraging (directly or indirectly) the domestic production and consumption of alternative meats to beef, while at the same time, he should strive to improve his own technical efficiency.

## RESPONSES TO GOVERNMENT POLICY TO STIMULATE INCREASED BEEF PRODUCTION

So far, this paper has been somewhat negative concerning the influences government policy has had in encouraging additional beef production in Latin America. In concluding, I would like to cite a number of instances where changing government policies have, in fact, contributed to a marked increase in producer demand for investment credit used for on-farm development.*

In Uruguay, for example, ranchers have responded very well to a package of new beef policies promulgated in 1970. Demand for development credit (11 per cent interest indexed to the annual rise in beef and wool prices) almost tripled on an annual basis as compared with the previous five years. In Argentina, in 1972, ranchers in the Balcarce area began to undertake longer term investments to develop their ranchers. Similarly, in Brazil in 1972 and early 1973, ranchers undertook significant investments, even though much of the development credit was indexed. Rancher investment response to the policy measures undertaken in mid-1973 (mentioned earlier) is unclear to date. During the past seven years, Mexican ranchers located in the more tropical areas of that country have responded noticeably to the government policy of making development credit more readily available on repayment schedules tailored to the capacity to repay from earnings generated from the additional investments.

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* Since four to seven years frequently pass between the time ranchers respond to investment incentives and incremental production is apparent, the utilization of investment credit (on seven- to twelve-year terms) can be used as a measure of rancher responses to stimulative government policy.

## ANNEX 1

Table 1. **Livestock numbers and beef production in Latin America (1970).**

| | No. | % | (1,000 tons) | % | Per head | Per capita Production | Per capita Consumption | Pigs No. | % | Pork (1,000 tons) | Chickens (Millions) | % | (1,000 tons) | Sheep (1,000) | % | (1,000 tons) | Beef exports* (1,000 tons) | Percentage of beef production | Percentage of total meat | Total meat production (1,000 tons) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mexico | 25.0 | 10.0 | 550 | | 22 | 11 | 10 | 10,305 | | 270 | 143.0 | | 110 0 | 5,400 | | 56 | 172 | 31 | 17 | 986 |
| Guatemala | 1.5 | 0.5 | 57 | | 38 | 11 | 8 | 800 | | 10 | 9.7 | | 8.2 | 630 | | 1 | 17 | 30 | 40 | 76 |
| Salvador | 1 1 | 0.5 | 20 | | 18 | 6 | 6 | 419 | | 11 | 7 9 | | 5 6 | 3 | | — | — | — | — | 37 |
| Costa Rica | 1 5 | 0.5 | 44 | | 29 | 24 | 10 | 200 | | 7 | 4 0 | | 4 7 | 2 | | — | 26 | 59 | 46 | 56 |
| Nicaragua | 2.1 | 1.0 | 60 | | 28 | 29 | 14 | 561 | | 15 | 3.0 | | 2 8 | 2 | | — | 34 | 57 | 41 | 78 |
| Panama | 1.2 | 0.5 | 35 | | 29 | 24 | 23 | 195 | | 4 | 3 7 | | 3 2 | 2 | | — | 3 | 9 | 7 | 42 |
| Honduras | 1 6 | 0.5 | 30 | | 19 | 11 | 5 | 800 | | 9 | — | | 4 2 | 9 | | — | 17 | 57 | 40 | 43 |
| Dominican Republic | 1 3 | 0.5 | 24 | | 18 | 6 | 6 | 500 | | 11 | 7.3 | | — | 25 | | — | 4 | 17 | 11 | 35 |
| Colombia | 21 0 | 9.0 | 426 | | 20 | 20 | 24 | 2,530 | | 87 | 38.0 | | 30 0 | 1,700 | | 4 | 8 | 2 | 1 | 547 |
| Venezuela | 8.5 | 3.0 | 201 | | 24 | 19 | 20 | 1,609 | | 42 | 20.4 | | 87.0 | 96 | | 3 | — | — | — | 333 |
| Guyana | 0.3 | 0 1 | 5 1 | | 18 | 6.6 | 6.6 | 7 | | 1 | 7.0 | | 3 3 | 1 | | — | — | — | — | 903 |
| Brazil | 98.0 | 40.0 | 1,850 | | 19 | 19 | 19 | 67,000 | | 641 | 278.0 | | 192.0 | 24,500 | | 57 | 124 | 7 | 4 | 2,740 |
| Uruguay | 8.5 | 3.0 | 313 | | 37 | 72 | 59 | 390 | | 21 | 4.9 | | 9.4 | 19,700 | | 83 | 142 | 45 | 33 | 426 |
| Argentina | 50.0 | 20.0 | 2,600 | | 52 | 107 | 82 | 4,400 | | 210 | 55 0 | | 212 0 | 44,000 | | 177 | 670 | 26 | 21 | 3,200 |
| Chile | 3.0 | 1.0 | 176 | | 60 | 18 | 22 | 1,150 | | 38 | 17.0 | | 20.0 | 6,800 | | 22 | — | — | — | 256 |
| Peru | 3.6 | 2.0 | 85 | | 24 | 6 | 7 | 1,710 | | 41 | 22.0 | | 58.0 | 14,500 | | 39 | — | — | — | 187 |
| Ecuador | 1.9 | 1 0 | 40 | | 21 | 7 | — | 2,201 | | 27 | 5 4 | | 7 8 | 2,300 | | 7 | — | — | — | 82 |
| Bolivia | 2.4 | 1.0 | 35 | | 15 | 8 | 8 | 950 | | 2 | 3 2 | | 1 5 | 6,800 | | 2 | — | — | — | 42 |
| Cuba | 7 0 | 3.0 | 181 | | 26 | 22 | — | 1,460 | | 39 | 10.5 | | 23 0 | n a | | n a | — | — | — | 243 |
| Paraguay | 5.8 | 2 0 | 126 | | 22 | 52 | 41 | 560 | | n a | 6.3 | | n a | 320 | | 1 | 28 | 22 | 22 | 127 |
| Haiti | 0.9 | 0.4 | 8.5 | | 9 | 2 | — | 1,800 | | n.a | 3.6 | | n a | 81 | | — | — | — | — | 9 |
| Jamaica | 0.3 | 0 1 | 5.1 | | 17 | 3 | — | 190 | | n a. | 2 3 | | 7 0 | 13 | | — | — | — | — | 12 |
| Total | 246.5 | 100.0 | 6,871.9 | | 28 | | | 100,132 | | 1,960 | 651.0 | | 789.0 | 125,182 | | 452 | 1,245 | 189. | 139 | 9,566 |

* Includes carcass equivalent of live animal

Sources USDA + FAO

## ANNEX 2

Table 1. **Development of a 1,000-ha ranch: on-ranch investment cost projections.**

| Investment category | Average units per ranch (No.) | Unit cost (Ur $) | Average cost per ranch (Ur $ 1,000) | | Foreign exchange component (%) | Foreign exchange component (Ur $ 1,000) | | Foreign exchange component (US$) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Year 1 | Year 2 | | Year 1 | Year 2 | Year 1 | Year 2 |
| Pasture improvement* | | | | | | | | | |
| Fertilizer (ha) | 100 | 2,515 | 252.0 | — | 75 | 189.0 | — | 756.0 | — |
| Freight (M.T.) | 25 | 2,500 | 62.0 | — | 40 | 25.0 | — | 100.0 | — |
| Seed (cultivated pasture) | 30 | 3,550 | 107.0 | — | 70 | 75.0 | — | 300 0 | — |
| Seed (oversowing) | 42 | 1,454 | 61.0 | — | 70 | 43 0 | — | 172.0 | — |
| Inoculant | 72 | 64 | 5.0 | — | 10 | — | — | — | — |
| Steaker (cellofax) | 42 | 48 | 2.0 | — | 80 | 1.0 | — | 4.0 | — |
| Cost of cultivation | | | | | | | | | |
| Labor | 30 | 720 | 22.0 | — | — | — | — | — | — |
| Machinery | 30 | 4,980 | 149.0 | — | 60 | 89 4 | — | 358.0 | — |
| Cost of oversowing** | | | | | | | | | |
| Labor | 70 | 107 | 11.0 | — | — | — | — | — | — |
| Machinery | 70 | 747 | 48.0 | — | 60 | 29.0 | — | 116.0 | — |
| Refertilization (2nd Year) | | | | | | | | | |
| Fertilizer | 100 | 1,000 | — | 100 0 | 75 | — | 75.0 | — | 300.0 |
| Labor | 100 | 120 | — | 12.0 | — | — | — | — | — |
| Machinery | 100 | 530 | — | 53.0 | 60 | — | 32.0 | — | 128.0 |
| Freight | 100 | 250 | — | 25.0 | 40 | — | 10.0 | — | 40.0 |
| Fencing (km) | 3 | 145,000 | 435.0 | — | 45 | 196.0 | — | 784.0 | — |
| Water supply | 1 | 55,000 | 55.0 | — | 50 | 28 0 | — | 112.0 | — |
| Machinery | — | — | 125.0 | — | 70 | 88.0 | — | 352.0 | — |
| Bulls | 1 | 60,000 | 60 0 | — | — | — | — | — | — |
| Building and others | — | — | 50.0 | — | 30 | 15.0 | — | 60.0 | — |
| Subtotal | | | 1,444.0 | 190.0 | | 778 0 | 117.0 | 3,114.0 | 468.0 |
| Contingencies (15%) | | | 217.0 | 29.0 | — | 117.0 | 18.0 | 467.0 | 70 0 |
| Total | | | 1,661.0 | 219.0 | | 895.0 | 135.0 | 3,581.0 | 538.0 |

* Based on 20% of pasture area cultivated and drilled, 42% oversown or sodseeded; 38% fertilized natural pasture

** Oversowing and fertilizing: per ha oversowing Ur$800 for machinery, Ur$180 for labor, per ha fertilized Ur$530 for machinery, Ur$120 for labor

## ANNEX 2

Table 2. **Development of a 1,000 ha ranch: beef cattle herd development projections.**

| Category | Stable herd before development | Years 1 | 2 | 3 | 4 | 5 | 6-12 |
|---|---|---|---|---|---|---|---|
| Composition (No.) | | | | | | | |
| Bulls | 8 | 9 | 10 | 10 | 10 | 10 | 10 |
| Breeding cows | 205 | 236 | 255 | 255 | 255 | 255 | 255 |
| Weaned calves | (113) | (113) | (142) | (166) | (166) | (165) | (166) |
| Heifers (9-24 months) | 52 | 52 | 53 | 67 | 79 | 79 | 79 |
| Heifers (24-36 months) | 49 | 34 | 20 | 10 | 13 | 15 | 15 |
| Steers (9-24 months) | 52 | 52 | 53 | 67 | 79 | 79 | 79 |
| Steers (24-36 months) | 49 | 49 | 50 | 51 | 65 | 77 | 77 |
| Steers (36-48 months) | 47 | 47 | 40 | 34 | 10 | — | — |
| Cull cows | 20 | 20 | 34 | 44 | 49 | 49 | 49 |
| Total | 595 | 612 | 657 | 704 | 726 | 730 | 730 |
| Total beef cattle units | 472 | 489 | 499 | 516 | 535 | 539 | 539 |
| Total sheep, cattle equivalent units | 198 | 203 | 203 | 201 | 199 | 204 | 186 |
| Total animal units | 670 | 692 | 702 | 717 | 734 | 743 | 725 |
| Total available carrying capacity, AU | 675 | 690 | 710 | 730 | 730 | 730 | 730 |
| Deaths (No.) | | | | | | | |
| Bulls | — | — | — | 1 | — | — | 1 |
| Breeding cows | 10 | 10 | 9 | 10 | 8 | 8 | 8 |
| Heifers ( 9-24 months) | 5 | 5 | 4 | 4 | 4 | 4 | 4 |
| Heifers (24-36 months) | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| Steers ( 9-24 months) | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Steers (24-36 months) | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| Steers (36-48 months) | 2 | 2 | 2 | 1 | — | — | — |
| Cull cows | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Total | 28 | 28 | 24 | 25 | 21 | 21 | 22 |
| Purchases (No.) | | | | | | | |
| Bulls | 1 | 2 | 2 | 3 | 1 | 2 | 2 |
| Sales | | | | | | | |
| Cull bulls | 1 | 1 | 1 | 2 | 1 | 2 | 1 |
| Cull cows | 19 | 19 | 33 | 43 | 48 | 48 | 48 |
| Surplus heifers (24-36 months) | 19 | — | — | 4 | 5 | 18 | 20 |
| Cull heifers (24-36 months) | — | 3 | 2 | 3 | — | — | — |
| Steers (24-36 months) | — | 7 | 15 | 41 | 65 | 77 | 77 |
| Steers (36-48 months) | 47 | 47 | 40 | 34 | 10 | — | — |
| Total | 86 | 77 | 91 | 126 | 129 | 144 | 146 |
| Heifers retained (No.) | — | 31 | 19 | — | — | — | — |
| Technical coefficients | | | | | | | |
| Weaning date (%) | 55 | 55 | 60 | 65 | 65 | 65 | 65 |
| Mortality, 9-24 months (%) | 8 | 8 | 7 | 6 | 5 | 5 | 5 |
| Mortality, over 24 months (%) | 5 | 5 | 4 | 4 | 3 | 3 | 3 |
| Bull/cow ratio (%) | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Cow culling rate (%) | 10 | 10 | 15 | 18 | 20 | 20 | 20 |
| Heifer (24-36 months) culling rate (%) | — | 5 | 10 | 25 | — | — | — |
| Heifers over 24 months transferred to breeding herd or sold, % + (No.) | — | 30(15) | 60(30) | 80(41) | 80(52) | 80(62) | 80(62) |
| Steers sold at 24-36 months, % + (No.) | — | 15( 7) | 30(15) | 80(41) | 100(65) | 100(77) | 100(77) |
| Bull culling rate, % | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Cull cows, AU per year | .5 | .5 | .5 | .5 | .5 | .5 | .5 |

## ANNEX 2

Table 3 **Development of a 1,000-ha ranch: sheep flock development projections.**

| Category | Before development | Years 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9-12 |
|---|---|---|---|---|---|---|---|---|---|---|
| Flock composition (No ) | | | | | | | | | | |
| Rams | 14 | 15 | 16 | 18 | 18 | 20 | 20 | 20 | 20 | 20 |
| Breeding ewes | 350 | 374 | 413 | 444 | 462 | 499 | 500 | 500 | 500 | 500 |
| Lambs | (228) | (228) | (244) | (289) | (333) | (347) | (374) | (375) | (375) | (375) |
| Ewes 12-24 months, unmated | 104 | 104 | 104 | 111 | 132 | 152 | 158 | 137 | 137 | 137 |
| Ewes 24-36 months, unmated | 100 | 100 | 80 | 60 | 43 | 25 | 29 | 30 | 26 | 26 |
| Wethers 12-24 months | 104 | 104 | 104 | 111 | 105 | 122 | 95 | 84 | 85 | 85 |
| Wethers over 24 months | 291 | 291 | 268 | 228 | 194 | 156 | 162 | 138 | 120 | 115 |
| Cull ewes | 57 | 57 | 61 | 68 | 85 | 88 | 96 | 96 | 96 | 96 |
| Total animals | 1,248 | 1,273 | 1,290 | 1,329 | 1,372 | 1 409 | 1 434 | 1 380 | 1 359 | 1,354 |
| Total sheep equiv | 991 | 1,016 | 1,016 | 1,006 | 996 | 1,018 | 1,012 | 957 | 936 | 931 |
| Total cattle equiv. | 198 | 203 | 203 | 201 | 199 | 204 | 202 | 191 | 187 | 186 |
| Deaths (No ) | | | | | | | | | | |
| Rams | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Breeding ewes | 14 | 14 | 15 | 17 | 18 | 18 | 20 | 20 | 20 | 20 |
| Lambs | 12 | 12 | 12 | 13 | 15 | 14 | 12 | 12 | 12 | 12 |
| Ewes 12-24 months | 4 | 4 | 4 | 5 | 6 | 6 | 6 | 6 | 6 | 6 |
| Ewes 24-36 months | 4 | 4 | 4 | 4 | 4 | 5 | 6 | 6 | 5 | 5 |
| Wethers 12-24 months | 4 | 4 | 4 | 5 | 4 | 5 | 4 | 4 | 4 | 4 |
| Wethers over 24 months | 12 | 12 | 11 | 10 | 8 | 7 | 7 | 6 | 5 | 5 |
| Cull ewes | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| Total | 52 | 52 | 52 | 56 | 58 | 58 | 58 | 57 | 55 | 55 |
| Purchases (No ) | | | | | | | | | | |
| Rams | 3 | 4 | | 6 | 4 | 6 | 5 | 5 | 5 | 5 |
| Sales (No.) | | | | | | | | | | |
| Cull rams | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 |
| Cull ewes | 56 | 56 | 60 | 67 | 83 | 86 | 94 | 94 | 94 | 94 |
| Lambs | — | — | — | 29 | 33 | 69 | 131 | 131 | 131 | 131 |
| Cull ewes, 24-36 months | 5 | 5 | 5 | 4 | 3 | 2 | 1 | 1 | 2 | 1 |
| Surplus ewes | 24 | — | — | — | — | — | 24 | 34 | 18 | 15 |
| Wethers over 24 months | 92 | 116 | 134 | 137 | 136 | 109 | 113 | 97 | 85 | 80 |
| Total | 179 | 179 | 201 | 240 | 258 | 269 | 367 | 361 | 334 | 325 |
| Ewes retained | — | 24 | 39 | 31 | 18 | 37 | 1 | — | — | — |
| Technical coefficients, % | | | | | | | | | | |
| Lamb weaning | 65 | 65 | 65 | 70 | 75 | 75 | 75 | 75 | 75 | 75 |
| Mortality to 1 year | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Mortality over 1 year | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Culling rate, ewes | 17 | 17 | 17 | 17 | 20 | 20 | 20 | 20 | 20 | 20 |
| Culling rate, rams | 15 | 15 | 15 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Culling rate, ewes 24 36 months | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Culling rate, wethers over 24 mos | 33 | 40 | 50 | 60 | 70 | 70 | 70 | 70 | 70 | 70 |
| Ram-ewe ratio | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Ewes over 24 months transferred to breeding flock or sold, % + (No ) | — | — | 20(20) | 40(40) | 60(64) | 80(102) | 80(117) | 80(122) | 80(106) | 80(106) |
| Lambs sold* | — | — | — | 10(20) | 10(33) | 20(69 ) | 35(131) | 35(131) | 35(131) | 35(131) |

* Only male lambs sold in years 3 and 4 From year 5 on, 20% of female lambs and 50% of male lambs are sold

## ANNEX 2

Table 4. **Development of a 1,000-ha ranch: wool sales projections (kg).**

| | Production wool/sheep | Before development | Years 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rams | 5.0 | 70 | 75 | 80 | 90 | 90 | 100 | 100 | 100 | 100 | 100 |
| Breeding ewes | 3.5 | 1,225 | 1,309 | 1,446 | 1,554 | 1,617 | 1,747 | 1,750 | 1,750 | 1,750 | 1,750 |
| Ewes 12-24 months | 2.5 | 260 | 260 | 260 | 278 | 330 | 380 | 395 | 343 | 343 | 343 |
| Ewes 24-36 months | 3.5 | 350 | 350 | 280 | 210 | 151 | 88 | 102 | 105 | 91 | 91 |
| Wethers 12-24 months | 3.0 | 312 | 312 | 312 | 333 | 315 | 366 | 285 | 252 | 255 | 255 |
| Wethers over 24 months | 4.0 | 1,164 | 1,164 | 1,072 | 912 | 776 | 624 | 648 | 552 | 480 | 460 |
| Cull ewes | 3.0 | 171 | 171 | 183 | 204 | 255 | 264 | 288 | 288 | 288 | 288 |
| Subtotal | | 3,552 | 3,641 | 3,633 | 3,581 | 3,534 | 3,569 | 3,568 | 3,390 | 3,307 | 3,287 |
| Lambs | .8 | 182 | 182 | 195 | 231 * | 266 | 278 | 299 | 300 | 300 | 300 |
| Belly wool & pieces | .4* | 396 | 406 | 406 | 402 | 398 | 407 | 405 | 383 | 374 | 372 |
| Total | | 4,130 | 4,229 | 4,234 | 4,214 | 4,198 | 4,254 | 4,272 | 4,073 | 3,981 | 3,959 |

* Per adult sheep

# ANNEX 2

Table 5. **Development of a 1,000-ha ranch: operating costs projections (Ur$ 1,000).**

| Category | Before development | Years | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9-12 |
| Salaries and social contributions (1) | 718 | 737 | 760 | 796 | 834 | 834 | 834 | 834 | 875 | 875 |
| Maintenance | | | | | | | | | | |
| Machinery (2) | 95 | 95 | 108 | 108 | 108 | 108 | 108 | 108 | 108 | 108 |
| Buildings (3) | 61 | 61 | 62 | 62 | 62 | 62 | 62 | 62 | 62 | 62 |
| Fencing and water (4) | 83 | 83 | 107 | 104 | 104 | 104 | 104 | 104 | 104 | 104 |
| Fuel and lubricants | 80 | 80 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| Fertilizer for pasture maintenance (5) | — | — | — | 190 | 190 | 190 | 190 | 190 | 190 | 190 |
| Shearing expenses (6) | 52 | 53 | 54 | 56 | 58 | 59 | 60 | 58 | 57 | 57 |
| Veterinary expenses (7) | | | | | | | | | | |
| Cattle | 39 | 40 | 41 | 42 | 44 | 44 | 44 | 44 | 44 | 44 |
| Sheep | 58 | 60 | 60 | 59 | 59 | 60 | 60 | 56 | 55 | 55 |
| Replacements | | | | | | | | | | |
| Bulls and rams (8) | 78 | 83 | 123 | 155 | 83 | 155 | 149 | 149 | 149 | 149 |
| Machinery (15%) | 110 | 110 | 129 | 129 | 129 | 129 | 129 | 129 | 129 | 129 |
| Fences, water supply and buildings (3%) | 149 | 149 | 165 | 165 | 165 | 165 | 165 | 165 | 165 | 165 |
| Taxes | | | | | | | | | | |
| Land and capital (9) | 209 | 209 | 209 | 209 | 209 | 209 | 209 | 209 | 209 | 209 |
| Cattle and sheep sales (10%) | 239 | 225 | 258 | 350 | 350 | 406 | 412 | 411 | 410 | 409 |
| Wool and skin sales (6.5%) | 29 | 30 | 30 | 29 | 29 | 30 | 30 | 28 | 28 | 28 |
| Selling expenses (10) | 96 | 90 | 103 | 140 | 140 | 162 | 165 | 164 | 164 | 164 |
| Freight (11) | | | | | | | | | | |
| Cattle | 47 | 42 | 50 | 69 | 71 | 79 | 80 | 80 | 80 | 80 |
| Sheep | 12 | 12 | 13 | 16 | 17 | 18 | 24 | 24 | 22 | 21 |
| Subtotal | 2,155 | 2,159 | 2,357 | 2,764 | 2,737 | 2,899 | 2,910 | 2,900 | 2,936 | 2,934 |
| Contingencies (10%) | 216 | 216 | 288 | 276 | 274 | 290 | 291 | 290 | 294 | 293 |
| Total | 2,371 | 2,375 | 2,645 | 3,040 | 3,011 | 3,189 | 3,201 | 3,190 | 3,230 | 3,227 |

**Source:** PLAN and Mission estimates

(1) Per year: rancher Ur$ 322,000; 2 stockmen Ur$ 181,000 each; plus casual help as required. Stockmen and casual helps' wages are estimated to rise 8% in year 4 and another 8% in year 8.
(2) 16% on vehicle, 10% on machinery
(3) 2% on Ur$ 3,060,000
(4) Fencing 20 km; Ur$ 2,750 per year; water supply Ur$ 27,500 per year
(5) 100 kg/ha per year of phosphate fertilizer (including freight and labor)
(6) Ur$ 42 per sheep, including wool packs and twine
(7) Cattle, Ur$ 82 per head; sheep Ur$ 59 per head
(8) Bulls Ur$ 60,000 per head; rams Ur$ 5,800 per head
(9) Ur$ 209 per ha
(10) Cattle and sheep, 4% of sales
(11) Cattle Ur$ 350 per head; sheep Ur$ 66 per head

## ANNEX 2

**Table 6. Development of a 1,000-ha ranch: sales projections (Ur$ 1,000).**

| | Weight Years 0-4 (Years 5-12) | Unit value Ur$ | Before development | Years | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9-11 | 12 |
| Cattle | | | | | | | | | | | | | |
| Cull bulls | 500 | 62/kg | 31 | 31 | 31 | 62 | 31 | 62 | 31 | 31 | 31 | 31 | 31 |
| Cull cows | 410(430) | 53/kg | 413 | 413 | 717 | 934 | 1,043 | 1,094 | 1,094 | 1,094 | 1,094 | 1,094 | 1,094 |
| Heifers (24-36 months) | 350 | 60/kg | 399 | 63 | 42 | 147 | 105 | 378 | 420 | 420 | 420 | 420 | 420 |
| Steers (24-36 months) | 420(450) | 65/kg | — | 191 | 410 | 1,119 | 1,775 | 2,252 | 2,252 | 2,252 | 2,252 | 2,252 | 2,252 |
| Steers (36-48 months) | 450 | 65/kg | 1,375 | 1,375 | 1,170 | 995 | 293 | — | — | — | — | — | — |
| Subtotal cattle | | | 2,218 | 2,073 | 2,370 | 3,257 | 3,247 | 3,786 | 3,797 | 3,797 | 3,797 | 3,797 | 3,797 |
| Sheep | | | | | | | | | | | | | |
| Cull rams | | 1000 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 |
| Cull ewes | | 650 | 36 | 36 | 39 | 44 | 54 | 56 | 61 | 61 | 61 | 61 | 61 |
| Lambs | | 900 | — | — | — | 26 | 30 | 62 | 118 | 118 | 118 | 118 | 118 |
| Maiden ewes | | 800 | 23 | 4 | 4 | 3 | 2 | 20 | 28 | 16 | 13 | 13 | 13 |
| Wethers | | 1200 | 110 | 139 | 161 | 164 | 163 | 131 | 136 | 116 | 102 | 96 | 96 |
| Subtotal | | | 171 | 181 | 206 | 240 | 252 | 272 | 347 | 315 | 298 | 292 | 292 |
| Wool | | 104.2/kg | 430 | 441 | 441 | 439 | 437 | 443 | 445 | 424 | 415 | 413 | 413 |
| Skins | | 250 | 13 | 13 | 13 | 14 | 15 | 15 | 15 | 14 | 14 | 14 | 14 |
| Subtotal sheep | | | 614 | 635 | 660 | 693 | 704 | 730 | 807 | 753 | 727 | 719 | 719 |
| Total sales | | | 2,832 | 2,708 | 3,030 | 3,950 | 3,951 | 4,516 | 4,604 | 4,550 | 4,524 | 4,516 | 4,516 |

# ANNEX 2

Table 7. **Development of a 1,000-ha ranch: financial rate of return calculation (Ur$ 1,000).**

| Years | Total sales | Operating costs | Net operating income | Incremental net op. income | On-ranch investment | Net cash flow |
|---|---|---|---|---|---|---|
| 0 | 2,832 | 2,371 | 461 | — | — | — |
| 1 | 2,708 | 2,375 | 333 | (128) | (1,661) | (1,789) |
| 2 | 3,030 | 2,645 | 385 | (76) | (219) | (295) |
| 3 | 3,950 | 3,040 | 910 | 449 | — | 449 |
| 4 | 3,951 | 3,011 | 940 | 479 | — | 479 |
| 5 | 4,516 | 3,189 | 1,327 | 866 | — | 866 |
| 6 | 4,604 | 3,201 | 1,403 | 942 | — | 942 |
| 7 | 4,550 | 3,190 | 1,360 | 899 | — | 899 |
| 8 | 4,524 | 3,230 | 1,294 | 833 | — | 833 |
| 9–11 | 4,516 | 3,227 | 1,289 | 828 | — | 828 |
| 12 | 4,516 | 3,227 | 1,289 | 828 | — | 1,475* |

Financial rate of return = 26%.

* Includes incremental herd and flock value of Ur$ 647,000

# ANNEX 2

Table 8. **Development of a 1,000-ha ranch: cash flow projections (Ur$ 1,000).**

| | Before development | Years 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. **Cash inflow** | | | | | | | | | | | | | |
| Sales | 2,832 | 2,708 | 3,030 | 3,950 | 3,951 | 4,516 | 4,604 | 4,550 | 4,524 | 4,516 | 4,516 | 4,516 | 4,516 |
| Loans – development | — | 1,329 | 175 | — | — | — | — | — | — | — | — | — | — |
| – incremental working capital | — | 345 | 345 | — | — | — | — | — | — | — | — | — | — |
| Total | 2,832 | 4,382 | 3,550 | 3,950 | 3,951 | 4,516 | 4,604 | 4,550 | 4,524 | 4,516 | 4,516 | 4,516 | 4,516 |
| 2. **Cash outflow** | | | | | | | | | | | | | |
| Operating costs | 2,371 | 2,375 | 2,645 | 3,040 | 3,011 | 3,189 | 3,201 | 3,190 | 3,230 | 3,227 | 3,227 | 3,227 | 3,227 |
| Investment of development loan | — | 1,329 | 175 | — | — | — | — | — | — | — | — | — | — |
| Rancher contribution (20%) | — | 332 | 44 | — | — | — | — | — | — | — | — | — | — |
| Total | 2,371 | 4,036 | 2,864 | 3,040 | 3,011 | 3,189 | 3,201 | 3,190 | 3,230 | 3,227 | 3,227 | 3,227 | 3,227 |
| 3. **Balance before debt service** | 461 | 346 | 686 | 910 | 940 | 1,327 | 1,403 | 1,360 | 1,294 | 1,289 | 1,289 | 1,289 | 1,289 |
| 4. **Debt service*** | | | | | | | | | | | | | |
| Year 1 loan – interest 11% | — | 92 | 184 | 184 | 184 | — | — | — | — | — | — | — | — |
| amortization 7 years | — | — | — | — | — | 355 | 355 | 355 | 355 | 355 | 355 | 355 | — |
| Year 2 loan – interest 11% | — | — | 29 | 57 | 57 | 57 | — | — | — | — | — | — | — |
| amortization 7 years | — | — | — | — | — | — | 110 | 110 | 110 | 100 | 110 | 110 | 110 |
| 5. **Cash balance after debt service** | 461 | 254 | 473 | 669 | 699 | 915 | 938 | 895 | 829 | 824 | 824 | 824 | 1,179 |

* Loans at 11%, repayable over 11 years, including 4 years grace

## ANNEX 3

Table 1. **Sensitivity analysis of key variables on a cow-calf operation.***

| Run | Description | Change | Rate of return | Percentage in rate of return |
|---|---|---|---|---|
| 1 (Base) | Breeding/weaning ranch | — | 14 | — |
| 2 | Breeding/fattening ranch | Weaners carried to slaughter weight at 4 years of age | 21 | + 50 |
| 3 | Breeding/weaning ranch | Cattle market prices decreased 20% | 9 | — 35 |
| 4 | Breeding/weaning ranch | Cattle market prices increased 20% | 18 | + 29 |
| 5 | Breeding/weaning ranch | Effective calving rates increased 20% | 17 | + 21 |
| 6 | Breeding/weaning ranch | Effective calving rates decreased 20% | 12 | — 14 |
| 7 | Breeding/weaning ranch | Ranch investment costs increased 20% | 13 | — 7 |
| 8 | Breeding/weaning ranch | Operating costs increased 20% | 13 | — 7 |
| 9 | Breeding/weaning ranch | Mortality rate at 5th year increased 20% | 13 | — 7 |
| 10 | Breeding/weaning ranch | Mortality rate at 5th year decreased 20% | 15 | + 7 |
| 11 | Breeding/weaning ranch | Carrying capacity increased 20% at full development | 14 | — |
| 12 | Breeding/weaning ranch | Carrying capacity decreased 20% at full development | 14 | — |

* A breeding/weaning herd development projection was used as a base with coefficients, prices and costs selected as the "most likely" to prevail during the 15-year ranch life. Ranch policy, technical coefficients, prices and costs were varied as indicated in the notes in Column 3. The resulting percentage change on the internal rate of return is shown in Column 5 and the most sensitive parameters ranked in descending order of importance.

## ANNEX 4

Table 1. **The broiler industry of Guyana (population and per capita income of Guyana).**

| Year | Population | Rate of growth* | Per capita income | Rate of growth |
|---|---|---|---|---|
| 1970 | 714,200 | 137 | G$ 565 | 140 |
| 1969 | 705,800 | 136 | 533 | 132 |
| 1968 | 695,700 | 134 | 506 | 125 |
| 1967 | 688,900 | 133 | 474 | 117 |
| 1966 | 671,700 | 129 | 442 | 109 |
| 1965 | 651,700 | 125 | 438 | 108 |
| 1964 | 634,800 | 122 | 407 | 100 |
| 1963 | 619,600 | 119 | 377 | 93 |
| 1962 | 602,100 | 116 | 421 | 104 |
| 1961 | 587,300 | 113 | 430 | 106 |
| 1960 | 575,900 | 111 | 399 | 99 |
| 1959 | 559,800 | 108 | 379 | 94 |

* 1956 — 1958 = 100

**Source:** Ministry of Finance

## ANNEX 4

Table 2. **The broiler industry of Guyana (retail prices of dressed beef and poultry in Georgetown).**

| Year | Retail prices per pound | | | |
|---|---|---|---|---|
| | Beef | Index* | Poultry | Index |
| 1970 | G$ 0.74 | 154 | G$ 1.02 | 105 |
| 1969 | 0.65 | 135 | 1.00 | 103 |
| 1968 | 0.63 | 131 | 0.97 | 100 |
| 1967 | 0.60 | 125 | 0.91 | 94 |
| 1966 | 0.61 | 127 | 0.86 | 89 |
| 1965 | 0.55 | 115 | 0.98 | 101 |
| 1964 | 0.57 | 119 | 1.00 | 103 |
| 1963 | 0.57 | 119 | 0.98 | 101 |

* 1960 — 1962 = 100

**Source:** Ministry of Agriculture

## ANNEX 4

Table 3. **The broiler industry of Guyana** (meat consumption in Guyana).

| | Consumption (metric tons) | | | | | | | | | | Per capita consumption | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Beef | Index of rate of growth* | Poultry | Index of rate of growth | Pork | Index of rate of growth | Other | Index of rate of growth | Total | Index of rate of growth | Volume | Index of rate of growth |
| 1970 | 5,335 | 137 | 3,344 | 1,276 | 1,195 | 143 | 85 | 188 | 9,959 | 196 | 30.6 | 145 |
| 1969 | 5,132 | 131 | 2,676 | 1,021 | 1,089 | 130 | 94 | 208 | 8,991 | 177 | 28.0 | 133 |
| 1968 | 5,028 | 129 | 2,659 | 1,014 | 1,175 | 140 | 88 | 195 | 8,950 | 176 | 28.3 | 134 |
| 1967 | 5,255 | 135 | 2,465 | 940 | 1,235 | 148 | 105 | 233 | 9,060 | 179 | 28.9 | 137 |
| 1966 | 5,416 | 139 | 1,879 | 717 | 1,201 | 143 | 81 | 180 | 8,577 | 169 | 28.1 | 133 |
| 1965 | 4,808 | 123 | 958 | 364 | 923 | 110 | 80 | 177 | 6,769 | 134 | 22.8 | 108 |
| 1964 | 4,814 | 125 | 892 | 340 | 956 | 114 | 76 | 168 | 6,738 | 133 | 23.4 | 111 |
| 1963 | 4,778 | 122 | 489 | 262 | 874 | 104 | 62 | 137 | 6,203 | 122 | 22.0 | 104 |
| 1962 | 4,671 | 119 | 604 | 230 | 831 | 99 | 56 | 124 | 6,162 | 121 | 22.5 | 107 |
| 1961 | 4,526 | 116 | 669 | 255 | 772 | 92 | 50 | 111 | 6,039 | 119 | 22.6 | 107 |
| 1960 | 4,380 | 112 | 533 | 203 | 766 | 91 | 48 | 106 | 5,733 | 113 | 21.9 | 104 |
| 1959 | 3,735 | 95 | 395 | 150 | 794 | 95 | 44 | 97 | 4,968 | 98 | 19.5 | 93 |

* 1959 – 1958 = 100

**Source:** Ministry of Agriculture

## ANNEX 5

Table 1. **Ranch operating costs in selected Latin American countries (categories of annual expenditure by percent before development).**

| | Guatemala | Colombia | Venezuela | Uruguay | Dominican Republic | Ecuador | Honduras | Bolivia | Argentina | Rio Grande Brazil | Mato Grosso Brazil | Goias Brazil | Parana Brazil | Paraguay Chaco | Paraguay Oriental | Mexico Temperate | Mexico Dry tropics | Mexico Wet tropics | Panama | Average weight before development |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Labor and management | | 32 | 55 | 30 | | 37 | | 38 | 38 | 13 | 20 | 23 | 24 | 60 | 64 | 19 | 30 | 26 | 39 | 36 |
| Pasture (maintenance) | | — | 14 | — | | 15 | | — | 6 | — | 2 | 8 | — | — | — | — | 14 | 26 | 10 | 4 |
| Machinery (maint. replacement and operation) | | 14 | 14 | 12 | | 9 | | 1 | 14 | 3 | 9 | 15 | 14 | — | — | 18 | 9 | 10 | — | 11 |
| Animal health (incl. salt and minerals) | | 12 | 5 | 4 | | 6 | | 20 | 5 | 4 | 30 | 21 | 19 | 8 | 11 | 18 | 9 | 6 | 38 | 15 |
| Breeding replacements | | 28 | 2 | 3 | | — | | 22 | 7 | 3 | 18 | 5 | 11 | 6 | 6 | 12 | 15 | — | — | 9 |
| Buildings fences and water (repl. and maint.) | | 10 | 6 | 12 | | 7 | | 5 | 6 | 2 | 5 | 13 | 7 | — | — | 17 | 8 | 6 | 3 | 5 |
| Selling expenses | | — | 2 | 6 | | 2 | | — | — | 8 | 7 | — | 9 | 7 | 3 | — | — | — | — | 6 |
| Sales taxes | | 5 | — | 20 | | — | | 2 | 19 | — | — | — | — | 14 | 15 | 4 | 6 | 15 | — | 9 |
| Other | | — | — | 10 | | 7 | | 7 | 5 | 7 | 9 | 20 | 9 | 5 | 5 | 5 | 16 | 10 | 6 | 6 |
| US$/AU before full development | | 8 | 24 | 14 | | 12 | | 5 | 24 | 16 | 7 | 13 | 8 | 3 | 4 | 20 | 24 | 17 | 19 | 15 |

Source: IBRD appraisal report

## ANNEX 5

Table 2. **Ranch operating costs in selected Latin American countries (categories of annual expenditure by percent after development).**

| | Guatemala | Colombia | Venezuela | Uruguay | Dominican Republic | Ecuador | Honduras | Bolivia | Argentina | Rio Grande Brazil | Parana Brazil | Mato Grosso Brazil | Goias Brazil | Panama | Paraguay Chaco | Paraguay Oriental | Mexico Temperate | Mexico Dry tropics | Mexico Wet tropics | Average weight after development |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Labor and management | 9 | 27 | 41 | 26 | 17 | 30 | 24 | 26 | 32 | 15 | 20 | 19 | 16 | 16 | 40 | 43 | 21 | 25 | 31 | 26 |
| Pasture (maintenance) | 15 | 10 | 23 | 6 | 8 | 12 | 23 | — | 16 | 33 | 18 | 5 | 14 | 29 | — | — | — | 11 | 13 | 14 |
| Machinery (maint. replacement and operation) | 4 | 10 | 14 | 10 | 3 | 13 | 7 | 1 | 11 | 9 | 16 | 15 | 12 | 5 | 5 | 5 | 19 | 6 | 6 | 9 |
| Animal health (incl. salt and minerals) | 24 | 17 | 7 | 3 | 10 | 16 | 26 | 45 | 5 | 18 | 29 | 37 | 34 | 25 | 8 | 11 | 19 | 18 | 14 | 15 |
| Breeding replacements (mainly bulls) | 16 | 24 | 4 | 5 | 6 | 7 | 12 | 9 | 6 | 5 | 7 | 15 | 11 | 15 | 13 | 12 | 11 | 15 | 12 | 11 |
| Buildings, fences and water (repl. and maint.) | 2 | 7 | 9 | 5 | 4 | 7 | 8 | 7 | 5 | 6 | 5 | 4 | 3 | 5 | 5 | 5 | 5 | 4 | 4 | 5 |
| Selling expenses | — | — | — | 8 | — | — | — | — | — | — | — | — | — | — | 10 | 6 | — | — | — | 10 |
| Sales taxes | 9 | 5 | — | 20 | — | — | — | 3 | 22 | — | — | — | — | — | 17 | 15 | 3 | 6 | 12 | 9 |
| Other | 9 | — | 2 | — | 14 | 8 | 4 | 9 | 3 | 10 | 5 | 5 | 5 | 5 | 2 | 3 | 5 | 17 | 9 | 3 |
| US$/AU at full development | 16 | 9 | 43 | 17 | 34 | 10 | 12 | 7 | 25 | 15 | 11 | 9 | 9 | 19 | 4 | 4 | 20 | 24 | 24 | 16 |

## NOTES ON ANNEX 5, TABLES 1 AND 2

**The data in these two tables were derived from IBRD appraisal report estimates for breeding operations, many of which also include fattening of ranch bred stock. Argentine data were based on actual data from 88 ranches in the Balcarce area of Buenos Aires Province. The data refer to the following:**

| Country | Year | Size of ranch model (in ha) Location |
|---|---|---|
| Argentina | 1970 | 1,100 (Balcarce) |
| Brazil | 1972 | 2,000 (Parana)<br>1,500 (Rio Grande do Sul)<br>8,500 (Mato Grosso)<br>4,500 (North Goies) |
| Bolivia | 1970 | 4,000 (Beni) |
| Colombia | 1969 | 750 (North Coast) |
| Dominican Republic | 1971 | 400 (Eastern region) |
| Ecuador | 1970 | 300 |
| Honduras | 1973 | 400 |
| Guatemala | 1970 | 350 |
| Guyana | 1970 | 1,000 (Coastal) |
| Mexico | 1971 | 150 (Wet tropics) |
| Nicaragua | 1970 | 300 |
| Panama | 1972 | 400 |
| Paraguay | 1969<br>1969 | (Chaco)<br>(Oriental) |
| Uruguay | 1971 | 1,000 |
| Venezuela | 1971 | 1,500 |

## ANNEX 6

Table 1. **Unit costs for investment inputs used on Latin American beef breeding ranches (1970 or dates specified) in selected countries (US$)**

| | Dominican Republic 1971 400ha | Honduras 1973 400ha | Venezuela 1971 1500ha | Panama 1972 400ha | Uruguay 1971 1000ha | Guatemala 1970 350ha | Mexico Wet tropical 1971 150ha | Argentina Balcarce 1970 | Brazil Parana 1972 | Ecuador 1969 | Bolivia Beni 1969 | Guyana Coastal ranch 1970 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pasture establishment | 60 | 60 | 116 | 30 | 40 | 70 | 108 | 60 | 48 | 33 | 50 | 55 |
| Fencing | 400 | 225 | 400 | 350 | 580 | 150 | 240 | 675 | 322 | 165 | 300 | 230 |
| Water | 3,100 | 1,000 | 2,222 | 500 | 220 | 400 | 1,100 | 1,150 | 806 | 2,000 | 2,000 | 750 |
| Corrals | 3,150 | 2,000 | 2,222 | 800 | — | 1,000 | 880 | 1,375 | 3,200 | 1,000 | 2,000 | 2,250 |
| Dips/spray | 1,200 | — | 1,111 | 1,500 | — | 750 | 1,440 | — | — | 825 | 700 | — |
| Cows | 180 | 150 | 111 | 250 | 85 | 100 | 160 | 70 | 100 | 110 | 75 | 50 |
| Bulls | 575 | 500 | 600 | 650 | 240 | 500 | 800 | 175 | 485 | 400 | 252 | 185 |
| Tractor (plow and harrow) and equipment | 8,000 | — | 5,500 | — | — | 5,400 | — | — | — | — | — | — |

**Source:** IBRD appraisal report estimates

## ANNEX 6

Table 2. **Categories of investment on Latin American beef breeding ranches in selected countries (percentage).**

| | Mexico Wet tropics | Argentina (Balcarce) 1970 | Brazil (Parana) | Ecuador 1969 | Bolivia (Beni) 1970 4000ha | | Guyana (Coastal ranch) 1970 | Nicaragua 300ha | Dominican Republic 1971 400ha | Honduras 1973 400ha | Vene - zuela 1971 1500ha | Guate- mala 1970 350ha | Panama 1972 4000ha | Uruguay 1971 1000ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pasture establishment | 27 | 14 | 44 | 31 | 4 | 34 | 22 | 41 | 33 | 20 | 37 | 29 | 29 | 49 |
| Fencing | 5 | 8 | 6 | 7 | 25 | 7 | 15 | 14 | 16 | 10 | 11 | 7 | 7 | 30 |
| Watering points | 5 | 4 | 2 | 5 | 7 | 4 | 4 | 8 | 5 | 19 | 4 | 10 | 2 | — |
| Machinery | 5 | 4 | 3 | 9 | 3 | 5 | 13 | — | 11 | 4 | — | 17 | — | 9 |
| Corrals, etc. | 4 | 2 | 7 | 9 | 10 | 6 | 6 | 28 | 4 | 4 | 3 | 9 | 9 | — |
| Breeding stock | 51 | 47 | 36 | 38 | 44 | 44 | 20 | 9 | 30 | 40 | 39 | 28 | 43 | — |

**Source:** IBRD appraisal report estimates

# DOMESTIC RESPONSE TO INTERNATIONAL TRADE

*Curt Wolffelt*

In discussing the domestic response to international trade as it relates to beef production development projects, it can be said that the producing countries have responded actively and amply to the demands of the trade in the fields of sanitation, technological improvement and product development.

As other colleagues have focused on the aspect of animal production and the policies that affect or regulate the volumes of meat that countries allow for export, I would like to refer to the meat processing industry itself and its evolution during the last ten years or so, the lessons that were learned, and how they can best be utilized in formulating new projects for increasing meat production.

## BACKGROUND

The decade of the 60's witnessed the most significant transformation the meat industry has ever had in the producing countries. This was a direct result of the pressure brought to bear by importing markets, particularly the United States, the United Kingdom, the member nations of the European Economic Community and others. The transformation was essentially one of increased sanitation in operating practices and facilities.

Of the two main Latin American beef exporting blocks—namely, tropical America and Argentina, Brazil, Paraguay and Uruguay— the latter group (South American block) was most severely affected, mainly because of the endemic foot-and-mouth disease of its livestock and the significant role these exports play in their total volume of exports.

There were also important technological advancements and new products developed by the industry; however, they were directly or indirectly a result of the importing countries' demand for better sanitation to obtain a more wholesome product.

There were several concurrent reasons for this emphasis on sanitation. Some of the more important include

1. The export of fresh salted meat (cured meats) to the United States in unwholesome conditions from Argentina, which led to the definite curtailment of the importation of fresh meats from South America

2. The outbreak of typhoid in the United Kingdom, traced to a can of cooked corned beef sold in Aberdeen

3. The outbreak of foot-and-mouth disease, also in the United Kingdom, which compelled the destruction of one million head of cattle. The outbreak was believed to have been caused by the importation of fresh bone-in meats from South America.

These and other concurring factors, such as gross inconsistencies in the sanitary practices at the plants, compelled importing countries to formulate codes of strict sanitary standards to which the industry was initially slow in conforming.

At the time, products received by the importing countries were either passed or rejected on the basis of sampling inspection at the port of entry and, in some cases, at the port of loading. However, there was a growing awareness that inspection of the finished product was in itself not enough. Inspection should start much earlier in the processing. In fact, it should start with the livestock intended for slaughter and follow through all stages of production. Only plants with adequate sanitary work methods, buildings, equipment and quality control should be allowed to produce for export.

This philosophy eventually developed into the concept of the "approved plant," which armed the importing nations with considerable strength and authority to demand progressively more and more sanitary improvements and controls at all stages of processing.

Therefore, the United States, the United Kingdom, Germany and other important markets would only accept products processed in plants previously inspected by their visiting veterinarians and listed as officially approved for export to their country, with formal notification through the respective governments.

Currently, approval of a plant for export to a specific country remains in force until a new inspection either upholds the status or disqualifies the establishment, in which case exports to that particular market are suspended until the reported deficiencies have been corrected and the plant has requested a new inspection via the respective governments. Intervals between visits by inspectors from the same country can vary from three months to one year.

The sanitary regulations of the importing countries are all basically similar. However, their interpretation and application depend to a great extent on the inspector's judgment. It can therefore happen that a plant approved by the United Kingdom inspector for export to his market may not necessarily be approved by the German inspector for export to his country. In fact, there is only one plant in the United States today approved for export to Germany, as other plants engaged in production for that same market have been deleted from the German list.

Stringent application of the standards can, of course, disqualify more than one plant in any country; and it is obvious that such a policy can serve well as a tool to restrict imports without the need of applying undesirable import quotas.

There are, or course, a number of considerations that influence the inspectors' judgment, such as prevailing plant hygiene, personnel discipline, attitude of plant management, age of the plant, and prevalence of certain endemic livestock diseases in the country. Above all, one consideration is the strength and effectiveness of the local government's veterinary inspection, and the confidence it inspires in the visiting veterinarians.

It was obvious that a high standard of hygiene and proper sanitary practices could only be achieved if they became a habit with supervisors and operators alike, as sporadic visits by foreign inspectors were not sufficient to achieve this objective. More than any other nation, it was the United States inspection that recognized that the answer lay in supporting and building up a competent and effective local inspection service working out of the producing countries' own ministries of agriculture.

In Argentina, particularly, this resulted in a healthy development of the Government Meat Inspection Service. Many perfunctory jobs became positions of challenge and responsibility with better pay. All stages of production came under the surveillance of a qualified government inspector. It took some time before the newly appointed veterinarians grasped the scope of their new duties. In fact, although they were not responsible for the operations as such, they were indeed answerable for the conditions under which they allowed the operations to go on. If the methods or the state of repair of the premises or equipment, etc. did not conform to the standards outlined in the book, the inspector had authority to stop operations until corrective action had been taken by plant management.

Another fruitful development was the publication of the most comprehensive meat inspection manual in the Spanish language by the Argentine Ministry of Agriculture and Livestock. This manual covers all food of animal origin and is an excellent reference for designing, as well as operating, animal-based food processing plants. On the subject of plant design, a recommended reference is Agriculture Handbook No. 191, entitled "U.S. Inspected Meat Packing Plants: A Guide to Construction, Equipment, Layout," issued by the United States Department of Agriculture.

## SUMMARY OF SANITARY MEASURES INTRODUCED IN THE MAJOR REPORTING COUNTRIES

Let us examine briefly what the sanitary measures were that transformed the meat processing industry so drastically and how this evolved in technological advancement and new product development. Taken at random, some of them include

1. The installation of potable water plants so only potable chlorinated water would be used, not only for processing but also for canning (retort cooling) and cleaning up

2. The refrigeration of all areas where fresh meat was handled and apt to be kept in temporary storage, such as the cutting rooms

3. The use of stainless steel, galvanized surfaces, or plastic for all equipment coming in contact with edible products

4. The general improvement in the standards of illumination throughout the plant, together with the installation of adequately equipped, in-process inspection stations

5. The provision of an isolated pen in the stockyards for cattle suspected of disease and adequate facilities for ante-mortem inspection

6. The provision of an autopsy room and digestor for disposing of carcasses that must be destroyed

7. The provision of separate facilities for slaughtering suspect and diseased animals in order not to risk contaminating the main killing floor

8. The cleaning and disinfection of cattle trucks before leaving plant premises

9. The introduction of wash basins and sterilizers to prevent the butcher's hand or his knife from being a vehicle of contamination

10. The elimination of all wood in the processing areas (This applies to the traditional meat cutting board, as well as to the modern handle of the butcher's knife; and even chillroom doors have to be lined with stainless steel or made of plastic material.)

11. The construction of smooth, pitched, impervious floors and washable walls with flat, unpainted ceilings to avoid having peeling paint fall on product

12. Screening of all openings to keep out birds and insects

13. The use of filtered, sterilized air to pressurize processing rooms that handle sterile products such as cooked meat

14. The provision of controlled access points to processing areas, where personnel have to cleanse themselves and don sterilized boots, apparel and caps so that no one can walk straight from the stockyards on to the killing floor with soiled shoes, for example

15. The simultaneous inspection of the viscera, carcass and head of each animal on the killing floor, with spacing between carcasses to avoid contamination from contact prior to inspection

16. The control of the health of all operators manipulating meat through regular checkups

17. The elimination of the dual standard of sanitation that had prevailed for some time, consisting in observing the sanitary requirements only when processing meat for export, reverting to the old, unhygienic facilities and methods in the handling of meat for local consumption (The strongest argument against the dual standard was that unsold meat for the local market could easily be rerouted for export.)

18. The change in processing equipment design so that surfaces had to be smooth, self-draining and often self-cleaning, with no sharp bends; and installation had to be made with ample spacing from walls and above floors to facilitate cleaning (This applied also to connecting piping and power wiring.)

## TECHNOLOGICAL ADVANCEMENT AND PRODUCT DEVELOPMENT

Nearly every sanitary regulation involved a physical improvement that constituted some form of technological advancement. To reduce manipulation of the product, mechanization was extensively introduced along with automatic controls for monitoring processes. Adequately equipped laboratories were provided for bacteriological and other tests to be made during processing and on the finished product.

However, the most significant advancement was the technology that evolved with the development of frozen cooked beef and, to a similar extent, the production of chilled, boneless cuts.

Frozen cooked beef was the response of the foot-and-mouth endemic countries to the United States ban on import of their fresh meat. It is a completely sterile product packed in 40-pound cartons either in the form of frozen chunks of cooked meat or cooked meat stuffed in 4-inch plastic tubes of about 10 pounds each and frozen. Its processing requires carefully controlled sanitary precautions.

The chilled boneless cuts developed as a consequence of the findings of the Lord Northhumbarton Commission. This body was appointed by the British Government in the latter half of the 60's to investigate means of reducing risk of foot-and-mouth virus infection transmitted by the chilled beef imported by the United Kingdom in the form of bone-in quarters.

This development was also a commercial boon. It permitted a more selective marketing of the various parts of the carcass, the export of a product with increased manufacturing, a more efficient utilization of refrigerated cargo space and the elimination of the need to freight bones across the ocean.

## RETROSPECTIVE VIEW, LESSON LEARNED AND RECOMMENDATIONS TO THE INDUSTRY EMBARKING ON NEW PROJECTS

There is no question that the sanitary improvements were necessary; and in general, most Latin American exporting plants found the will and the money to meet the demands. It cannot be said that exports dropped significantly because of massive disqualification of plants. Fluctuations in export volumes were always based on other factors. The industry was hurt financially as the improvements often had to be made during too short a time and usually could not be part of an organic plan to improve flow and layout simultaneously. To some extent, it was a learning period not only for the industry but for the inspectors themselves; and the price had to be paid.

In Argentina, particularly, the sanitary improvements carried out under pressure without allowance for such planning hurt the big industry to a considerable extent. Added to other important factors that developed later, it led to the bankruptcy of some of the large packers, resulting in recent government takeover to assure continuity of exports. Other packers closed down because of a combination of circumstances.

In retrospect, the following gains were made by the major exporters of the South American block

1. A strong and effective government meat inspection service was developed, creating more jobs with better pay.

2. Processing plants involved in the export of meat have attained high standards of sanitation.

3. New products were developed that involved a greater amount of processing and manufacturing, commanding a higher value on the export market.

4. These products increased the flexibility of the industry's product mix, allowing it to meet fluctuations in demand with less financial difficulties.

Based on the foregoing, there are recommendations which can be made to those involved in formulating new projects for increasing beef production.

1. Sanitary requirements

   a. A distinction must be made as to whether the projected plant will slaughter for the export market, the local market, or both.
   b. If the plant is intended for export or export and local production, all sanitary requirements that will affect flow, layout, building design and location must be incorporated right at the drawing board stage. At this time the extra cost is not so significant as it would be to make major construction modifications later.
   c. Individual pieces of equipment can always be added gradually, as demanded by visiting inspectors, if space has been provided when making the original design.
   d. A careful analysis should be made before deciding on making large-scale improvements on an old plant. Improvements should be planned so some degree of modernization and better product flow can be obtained at the same time. However, in general, the expenses will always exceed the most conservative estimates; and the demand for continual improvements will never cease. The alternative of building a new plant should always be analyzed.
   e. With reference to plants intended for slaughtering only for the local market, the degree of sanitation should be compatible with what the market can afford. In other words, it must bear a relation to how many cents per pound of meat the population can afford to pay for more wholesome meat.
   f. If the plant is fairly large and handles more than 50 to 100 head per day, processing of the by-products will help to pay for the added cost. However, in the case of small abbatoirs in most developing countries, the facilities must be confined to an enclosed slab, water for cleanup, and smooth concrete tables and basins to prevent manipulating the product on the floor.

2. Product mix

   There are four broad categories of beef products for export.

   a. Boneless beef for processing (frozen)
   b. Boneless or bone-in cuts (chilled or frozen)
   c. Frozen cooked beef
   d. Cooked corned beef in cans

The first two categories should constitute adequate and profitable outlets for the majority of processing plants built in connection with projects for increasing beef production. The investment required is about US$15,000 to $20,000 per head slaughtered daily. Marketing has few restrictions, except that of the United States for the foot-and-mouth endemic countries.

Frozen cooked beef and cooked corned beef are much more sophisticated products and require considerable investment. In addition to tighter controls, their processing is delicate and demands special skills on the part of supervisors, technicians and operators. The market is also more restricted. The United States is virtually the sole buyer of frozen cooked beef. Corned beef is a traditional product whose market is dominated by a number of well-established brands. The product is sold extensively in the United States, the United Kingdom and Western Europe.

# WORK GROUP REPORT ON PASTURES AND FORAGES/NUTRITION

*Ricardo Garza Treviño and Joe Conrad*

Because of the poor rainfall distribution in the tropics, there are extremely dry and rainy seasons that influence forage production, causing in most cases marked variations in the quality and quantity of available forage. Likewise, the tropical soils have different physical, chemical and fertility characteristics which have a direct effect on the growth, production, quality and degree of acceptance of grasses.

There are other factors involved in animal production, such as health, reproduction, genetics, transfer of technology to the cattle producer and socioeconomic and marketing problems, which will be handled by other work groups. Therefore, only those factors influencing the production of pastures and forages and those related to animal nutrition will be considered from a climatic, edaphic, agronomical and managerial standpoint.

The development of the cattle industry in the tropics is completely different from that in the temperate zones, therefore, it is not possible to extrapolate temperate climate technology to tropical regions. An in-depth study of the following factors is essential for tropical regions:

1. An intensification of studies of the existing forage species and of new introductions adaptable to the ecological conditions prevailing in the dry and humid areas of tropical America

2. A thorough study of the most appropriate methods for the establishment of the more adaptable species of grasses and legumes, as well as of grass-legume associations

3. A continuation of studies of the most adequate management practices with special emphasis on weed control and grazing systems

4. An intensification of studies on forage conservation, supplementation, seasonal fertilization, grass-legume mixtures, and irrigation practices in order to compensate, when possible, for low forage production during the dry season

5. Basic studies on tropical forage seeds (as there is a shortage of these) and an identification of ecological zones adequate for commercial seed production

6. An introduction of adequate zoning systems according to the most advisable type of cattle operation, taking into account the variation in forage production potential throughout the tropics

7. Grass and legume breeding studies of the most outstanding species (in special cases only)

8. A continuation of studies on the soil-plant-animal interrelationships, aimed at detecting critical factors that affect pasture production and quality, directly or indirectly, as well as animal production

It is evident that the items listed above in relation to pastures, forages and animal nutrition must be carried out in line with sound economic policies related to beef production in tropical America. Likewise, the different cattle programs must have the required technical assistance.

Regarding the exchange of technology and information among people and institutions dedicated to agricultural and livestock development programs, it should be mentioned that this seminar has shown that the efforts made to date have not produced the expected results because of the lack of contact among researchers from different countries.

It is urgent to compile a directory listing the field of specialization of professionals presently working in connection with the cattle industry. The Instituto Interamericano de Ciencias Agrícolas (IICA) of the OAS, through its library at Turrialba, Costa Rica, has made a significant effort to compile the pastures and forages bibliography of the countries that cooperate with them. It should also be mentioned that FAO has made an important effort in this respect.

The two work groups in charge of writing this document would like to make it clear that the staff dedicated to education, research and extension in the fields of pastures and forages anu animal nutrition is limited in quality and quantity; therefore, if a higher degree of development and a significant contribution to the world beef production are expected in tropical America, the support of national and international governments and institutions is urgently required to secure opportunities for the specialized training of the greatest possible number of professionals.

# WORK GROUP REPORT ON INTENSIVE FINISHING SYSTEMS

*Paul F. Randel*

A. The definition of finishing: rapid growth of beef cattle (in excess of 1 kilogram per head daily) with improvement in carcass quality

B. The definition of intensive finishing: production of a large output of beef cattle per unit of land employed

C. The function of pasture in intensive finishing systems

1. There can be no intensive finishing on pasture alone since high productivity per animal requires low grazing intensity.
2. Intensive utilization of pasture or other roughages will encourage the establishment of feedlots by providing cattle surpluses.

D. The definition of feedlot: an operation in which animals are fed in confinement with total ration under the operator's control

E. The factors required for viable feedlots, present status, and comments

1. Sufficient credit at reasonable interest rates

    a. The World Bank and other international financing agencies are now supplying an adequate volume of loan money in most countries.
    b. High interest rates are a problem, especially for new operations.
    c. Perhaps a graded schedule of interest rates could be used, with the schedule based on the recipient's ability to pay.

2. Animal health control commensurate with low losses

   a. There are many problems with disease at present.
   b. Improved nutrition as required in feedlots would increase natural resistance.
   c. Feedlot management with daily observations of animals should be an aid to early detection of disorders.
   d. Feedlots constitute a quarantine period prior to slaughter.

3. Managerial ability

   a. Poor management accentuates the inefficiency of many ranches.
   b. Viable feedlot operations can afford to pay salaries that will attract competent managers.

4. Information needed concerning feeding programs

   a. Possible basic crops in each area (The definition of basic crop: source of one or more feedstuffs which can constitute the principal ration components, supplying a great deal more than 50 per cent of the utilizable energy)
   b. The availability of additional feed inputs in terms of quality, quantity and seasonality
   c. Market prospects for beef, including local factors that may permit premium prices

5. The availability of sufficient feeder animals

   a. Tropical America has a vast beef cattle population.
   b. Many good breeding females are presently being lost through slaughter; this practice should be prohibited by law and enforced.
   c. Fertility rates are far below optimum. Some mitigation of infertility due to poor nutrition could be achieved by moving part of the cattle population to feedlots, thereby reducing the grazing pressure for the breeding stock left on pasture.
   d. The sale of cattle at intermediate weights (i.e., feeders) is discouraged by the present pricing structure. Higher prices should be set for these cattle.
   e. Cow-calf and milking operations may also have a role in providing feeder cattle.

6. Meat grading systems and higher prices for finished animals

   a. The present lack of grades discourages finishing cattle for sale.
   b. Each country should implement at least an elementary system of meat classification although U. S. Department of Agriculture grades are unsuitable for Latin America.

F. Group recommendations

1. The compilation of this body of pertinent data should be undertaken by some international institute such as CIAT, perhaps as an extension and amplification of the Latin American Feed Composition Project begun by the University of Florida. Pertinent research information should be made available to all workers in this field as part of the services of an abstracting journal on agricultural sciences in tropical America—or at least as a bibliographical list of all published papers. Rapid informal communication among researchers could be facilitated by a worldwide directory of all personnel and their research interests.

2. The following should be considered the most likely basic crops for the lowland tropics of America:

   a. Those ready for immediate commercial testing, such as whole sugar cane, sugar pith (cane minus rind), cane molasses, maize silage and sorghum silage
   b. Those worthy of further research, such as treated sugar cane bagasse, bananas and citrus fruit by-products
   c. Those that are only research ideas at present, such as cassava and by-products of other fruits

3. All available agro-industrial by-products should be considered as possible additional feed inputs, with the following cited as examples: rice bran, hulls and straw; cane trash; cassava leaves; coconut meal; coffee pulp; animal carcass residues and manure; rum distiller's slops (condensed molasses solubles). NPN must figure prominently in this category.

4. International funding organizations should support (a) continued preliminary research where this is still required and (b) the establishment of pilot feedlots for purposes of demonstration (i.e., extension function) and evaluation of feeding programs and complete technological packages for feedlot operations under strictly commercial conditions. These pilot feedlots must be viable economic units as established, and their location should be chosen with this objective in mind. Ideally, a network of pilot feedlots should be set up at geographic regional and national levels and later at the international level, where complete commercial evaluation could take place.

   Complete commercial evaluation can be defined as a detailed study of not only feedlot input-output data but also economic factors in the broadest sense and social factors bearing upon the feasibility and desirability of the operation. It is especially important that gains in terms of edible tissue, carcass parameters and meat quality be considered.

G. A final note on the utility of feedlots: Some of these could be used, if desired, to facilitate performance testing as a tool for genetic improvement of the cattle population.

# WORK GROUP REPORT ON REPRODUCTION AND ANIMAL BREEDING

*Guillermo E. Joandet*

The most important single factor in beef production in the tropics is reproduction. Low birth rates, along with high mortality and seasonal interruptions in growth, make beef production in this area inefficient.

The achievement of greater efficiency will partially depend upon the study of single, isolated practices and other factors affecting production. It is, therefore, imperative to use integrated models involving all the aspects or disciplines that would improve the situation. Because of the interaction of single factors, their advantages are multiple as well as additive.

For this reason, the group used an integral model in studying the problem of the reproductive rate; however, only those aspects concerning reproduction and genetics are presented. This model is presented as an attempt to integrate the efforts of other groups and the technology related to beef production.

Although we have tried to keep to this model, there will surely be repetitions and overlappings, but they are preferable to omitting important aspects. The model used as the basis for general discussion is shown in Figure 1.

A herd's breeding efficiency depends on the behavior of its males and females. The behavior of each animal, whether male or female, is influenced by a series of variables shown in Figure 1. Some of them are associated with just one of the sexes while others are common to both. Also, some variables are permanent whereas others change with time and/or age of the animal. This general model attempts to give an idea of the complexity of the problem, as well as the need for interdisciplinary studies of the kind that will surely prevail in the future.

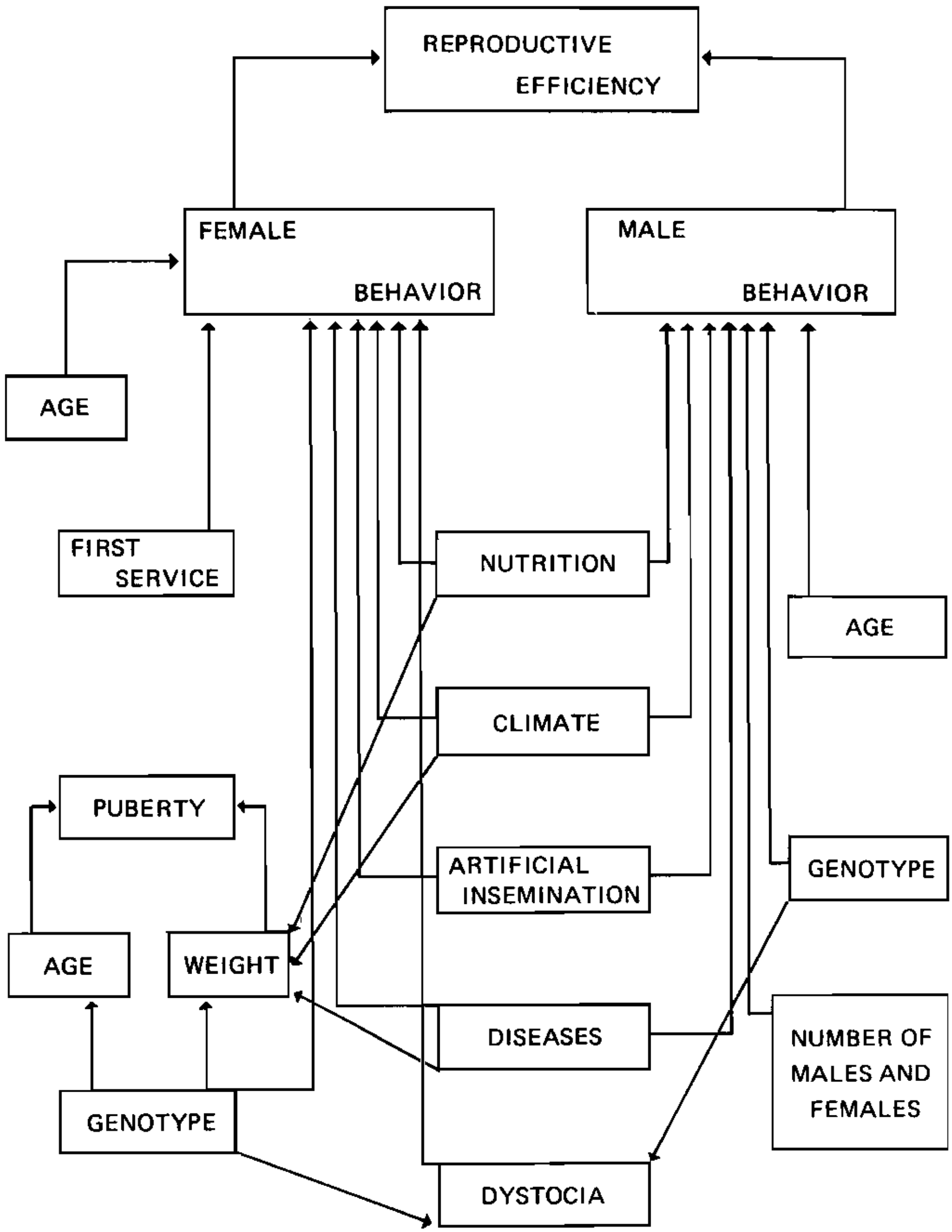


**Figure 1.** Some variables and their relationship to the reproductive efficiency of the herd.

In order to facilitate discussion, we have divided the factors related to the reproductive rate into environmental and genetic areas. The latter will be discussed when we consider improvement programs. A list of environmental factors can be found in Table 1.

Many research projects have shown the need for systematic mineral supplementation with mixtures containing minor elements, as well as calcium, phosphorus and salt. This is an uncommon practice in the tropics, yet it is within the reach of any operation because of its simplicity and low cost. This practice should not only be a recommendation at the individual farm level, but it should also become an official policy in tropical countries. The responses shown to this supplementation are often significant; therefore, this group wishes to emphasize the need for its systematic use. This is an important aspect to be discussed by the nutrition group, but we wish to emphasize its importance.

Deficiencies in proteins, energy or vitamins must be dealt with by another group; we only wish to mention the need to evaluate both their importance and the economic feasibility of supplying them.

Diseases also affect reproduction; again, this is not a subject for us to go into. We merely wish to point out that diseases should not only be described but their incidence should also be evaluated quantitatively. This would permit an economic appraisal of the importance of each disease under different conditions in tropical operations.

Studies describing the different stages or physiological changes related to the reproductive process are scarce in the tropics; therefore, it is difficult to determine where the problems lie and to propose solutions. It would be useful to have more information for females of different ages and/or weight conditions as regards the time of first heat, intervals between parturitions, the appearance of estrus after parturition, etc.

Table 1. **Environmental factors affecting reproductive behavior.**

| | |
|---|---|
| **Deficiencies** | |
| | Minerals, proteins, energy, vitamins |
| **Diseases** | |
| | Infectious, parasitic |
| **Management** | |
| | Milking, age of weaning, first service, vaccinations, parasite control, time of mounting for heifers and cows, use of artificial insemination |

Milking is another practice included in Table 1 as a factor affecting reproductive behavior. The data mentioned indicate the importance of this practice in some tropical regions. In Colombia, for example, approximately 55 per cent of the cows from beef production herds are milked, and 70 per cent of the milk sold commercially in this country is from that source. This provides a regular cash income, which is an economic reason for its being done in beef production herds, but it can also result in a higher mortality rate among calves and a general decrease in fertility. There is the possibility of better herd control and improvement as it is feasible to employ artificial insemination under this system, for example, which would probably not be advisable in an extensive herd management system. As can be seen, there are both positive and negative factors involved in this practice; nevertheless, it should be taken into account when formulating managements as well as nutrition, health and breeding programs.

Another discussion item was the practice of weaning. The need to wean at the earliest possible age was recognized, as long as adequate quality feed is available to minimize the adverse effects of this practice. The feasibility of early weaning (at two months or less) should be studied carefully since it is adequate only at a high technological level, which is not found in the tropics at present.

In deciding when heifers should be served for the first time, age should not be the only criterion. Weight, which varies for the different genotypes, should also be considered. Both factors should be taken into account in order to make recommendations in this respect.

The animal health group will surely recommend the promotion of vaccination and parasite control programs, but this group wishes to stress the potential importance of genetic resistance to certain parasites, as evidenced in studies published worldwide. In the future, research should deal with developing lines or varieties with this characteristic. The inheritability of tick resistance in beef cattle has been estimated at 0.4, which justifies the incorporation of this characteristic in selection programs.

The advantage of establishing mating seasons was recognized since it permits better breeding management. Several factors, such as the availability of forage, floods at certain times of the year, etc., make the establishment of seasonal service necessary. To set a season for parturition does not necessarily lead to a decrease in fertility. The transition to a seasonal system might seem to be a problem, but an adequate program--such as removing the heifers and nonmilking cows from the herd—might lead to establishing seasons for births at the most adequate time in just a few years. Seasonal parturition would not be advisable, however, for beef and dairy operations that must produce milk the year round.

Since it is generally recognized that the reproductive rate is reduced at the second birth, the time for servicing heifers should be a month or 20 days earlier than for cows. This makes it possible for heifers calving for the first time to have a longer interval between parturition and the next conception. It is not advisable to provide a second service for those heifers that did not conceive after the breeding season if at that time they were of sufficient age and weight for normal reproductive behavior.

In operations where penning of cattle is customary for milking or to prevent rustling, the use of artificial insemination is convenient and feasible. However, in those cases where estrus detection is difficult (as with certain genotypes), this practice is not advisable. Artificial insemination recognizedly represents an economic advantage since it facilitates sanitary management of the herd and it is a considerable aid in genetic improvement and crossbreeding.

Bulls are often changed before the mating season in order to ensure fertilization. According to the data, however, the importance of this practice is relatively minor in comparison with other factors. In general, the producer compensates for any deficiency by using a greater number of bulls.

The possibility of improving yield rates was studied in connection with breeding programs. These long-range plans allow the introduction of permanent modifications in a herd, passed on from one generation to the next. Some of the new characteristics will remain even after the plans have been abandoned. The group considered two forms of genetic expression: The first is related to additive genetic expressions and is the basis for selection plans within pure breeds; the second is of the nonadditive type, related to heterosis, which is useful in crossbreeding.

The group acknowledges the advantages of crossbreeding cows under tropical conditions. Selection and crossbreeding are not mutually exclusive but complement each other since the characteristics showing heterosis do not respond to selection, whereas those improved by selection are of low hybrid vigor. It is therefore possible to select the pure breeds to be used in crossbreeding.

Systematic crossbreeding requires at least two pure breeds adapted to tropical conditions. It is also important to have the greatest possible genetic divergence between them; therefore, one breed should be of East Indian origin and the other European. Some breeds of East Indian origin, already adapted to our environment  are available in sufficient numbers; but there might be a problem to find a breed of European origin in sufficient stock that is well adapted to our environment. The stock known under the genetic term "Criollo," which was once common, has disappeared in most of tropical America. Conservation programs of the surviving groups should be supported to prevent their total extinction. In the future, these herds could become an important source of germplasm for use in the production of crossbred females.

Sires used for producing beef cattle —whether for mating or artificial insemination-should be selected under tropical conditions. Although it is often necessary to import germplasm, there is sufficient evidence of the interaction of environmental and genetic conditions that make it advisable to select the animals from the same production area. Therefore, systematic importation of animals or semen is not recommended. The possibility of exploiting complementary effects between different breeds is another advantage of crossbreeding.

Another element to be considered in designing a crossbreeding plan is that the system should produce its own replacement females. For this reason, it would be advisable, especially in beef-dairy operations, to have more heifers served than the number necessary for replacement in order to make a postpartum selection to permit the evaluation of their milk production capacity.

A two-breed alternating crossbreeding system would seem to be the most feasible. Terminal breeding does not seem feasible at present production levels since it demands a high reproductive rate in both the pure breeds and the replacements. Definitive plans should take into account management capability and the availability of facilities.

Several characteristics to be considered in breeding plans (see Table 2) are related to reproduction, and most of them respond to heterosis. For this reason, it is necessary to use crossbred females, which have a longer useful life and are better dams.

In beef-dairy operations, selection must be made within the pure breeds in order to increase milk production. Growth characteristics and carcass composition ought to be considered also. There is at least one association of pure breeders that has placed great emphasis on the milk-producing characteristics of females when classifying live animals.

Improvement of growth rate and carcass characteristics should result in higher prices per unit weight. Unfortunately, most meat markets in tropical America do not have adequate systems for discriminating differences among carcasses. The group therefore recommends the establishment of official standards for cattle classification in order to obtain differential prices. These standards should consider age and carcass configuration and composition. This would stimulate producers to make a more effective selection and to favor other practices that result in higher quality products.

Table 2. **Elements to be considered in genetic programs.**

| | |
|---|---|
| Reproductive rate | Carcass characteristics |
| Calf mortality | Adult size (male and female) |
| Difficulties in parturition | Milk production |
| Rate of growth | Maternal ability |
| Beginning of puberty | |

Finally, the members of this group recognize the need to support long-range research projects in reproduction and genetics. We point out the lack of continuity in programs of this kind,either because of inadequate official support or because of changes in management that affect technicians dedicated to this type of research in tropical countries.

Utmost importance was given to the need for better channels for the exchange of information among different groups working on beef production in the tropics and that this interchange be made effective though this type of meeting.

# WORK GROUP REPORT ON ANIMAL HEALTH

*Manuel Moro*

The subject of animal health should be given primary consideration in order to maximize the level of production and to obtain animal products adequate for human consumption. The economic losses resulting from diseases may hinder the development of any cattle program undertaken in the tropics.

Because of the extreme temperature and humidity changes favorable for the reproduction of parasites, the tropical climate is limiting to the cattle industry; therefore, adequate technology should be developed for cattle production under the different climatic conditions.

There are many tropical regions where cattle operations have not yet been developed. Here, two kinds of problems may arise: First, introduced cattle may bring infections or parasitic agents with them. Second, diverse problems may be caused by the disturbance of the natural ecological balance.

In those areas where cattle operations have already been established, the existing systems are inadequate to control well-identified diseases because of the lack of suitable extension services. In other cases, problems of major economic importance have not yet been defined.

Factors influencing the development of the cattle industry in the lowland tropics include

1. The lack of adequate systems for extending veterinary services to cattle producers. This service should be incorporated into a multidisciplinary effort including production, nutrition, genetics, animal health, management, economics, sociology,

etc., because the importance of any disease may be influenced by some of these factors. This service would be provided by field veterinarians in conjunction with diagnostic and research centers.

2. Disease control at the production level. The following are examples of the health problems in this group:

   a. Low fertility of bulls and cows
   b. High mortality and morbidity rates of calves and adult animals
   c. Ecto- and endoparasitic diseases, etc.

3. The establishment of specific programs for the control of diseases such as

   a. Foot-and-mouth disease
   b. Ticks
   c. Brucellosis
   d. Bovine tuberculosis
   e. Bovine paralytic rabies
   f. New or emergent diseases (rhinotracheitis, viral diarrhea, etc.)

   It is important to have controlled production of standardized antigens and vaccines.

4. Adequate operational budgets

5. The improvement in status of the veterinarian working at the field level

The strategy to increase beef cattle production in the tropics should include

1. The implementation of already established services or the development of new ones, if necessary, to improve animal health services in the field and at the same time to ensure an adequate supply of efficient vaccines

2. The establishment of a training program at the undergraduate or graduate level on multidisciplinary or specific aspects, with emphasis on ecology and epidemiology

3. Research with emphasis on epidemiology and preventive medicine. Intensive research should be conducted on those diseases causing great losses to the beef cattle industry and on the development of economical control systems that can be easily applied by the cattleman. Priority should be given to studies on causes of low fertility and losses caused by ticks and other diseases. To support the system, programs based on field needs should be developed. Finally, in order to avoid the spread of hemoparasitic infections, systems should be established to detect the carrier animals.

4. The establishment of protective measures to avoid the spread of disease to nonaffected areas. Colonizations should be planned; and in such cases, the animal health aspect should be closely linked to nutrition, reproduction, management and economics.

In summary, a veterinarian should be part of a team working toward a common goal.

The recommendations to CIAT for the establishment of a basis for technological exchange would be as follows:

1. The development and expansion of CIAT's service of documentation and extracts of scientific papers

2. The provision of training on development techniques for the diagnosis, prevention and control of economically important diseases in the tropical areas not covered by the programs of the two centers operated by the Pan American Health Organization: the Center for Zoonses and the Center for Foot-and-Mouth Disease

3. The promotion of periodic meetings to deal with specific animal health problems in the tropics

# WORK GROUP REPORT ON APPLICATIONS OF TECHNOLOGY AT THE FARM/RANCH LEVEL

*C. Patrick Moore*

The objective is to increase and to improve the technology that is presented and that will be accepted and applied by the farmer/rancher for increasing production and productivity.

This seminar has presented evidence that there exists adequate technology capable of producing an increase in beef production and productivity in tropical America by eliminating the two major constraints: low reproductive rates and loss of weight during critical periods.

Data presented at the seminar indicate that production parameters are extremely low as compared with those from other regions of the world.

The working group then concludes that existing technology is not being applied at the farm level at a rate fast enough to have any impact. The group further recognizes that the failure of this transfer of technology to the producer is the main problem in increasing beef production. Because of the complexity of the problem, resolution will be dependent upon a coordinated effort on the part of all institutions and disciplines concerned with agricultural development.

Specifically, the group suggests the following actions by these institutions:

1. Educational institutions should

   a. Establish a special curriculum for training extension-type people with strong emphasis on pragmatic field work and on disciplines that will prepare the "change agent" adequately in the techniques of transferring technology to the beef producer
   b. Provide opportunities for additional formal and informal training

2. Research institutions should

   a. Form teams within research stations to carry out research using the systems approach
   b. Keep a research herd that would be used to evaluate technology as it is developed, as a part of a beef production system for the specific area in which it is located (The evaluation of this technology would include a complete economic analysis.)
   c. Provide demonstrations and training for extension agents and base further research action on field reports.

3. Extension institutions should

   a. Select and send their people to be trained on the production package at the research station
   b. Transfer the technology back to the community by using field demonstrations to show the new techniques
   c. Relate to local institutions (e.g., credit institutions) to assure that the package has all the necessary local inputs to be successful at the farm level
   d. Maintain a two-way communication between extension and research institutions so that researchers are kept informed of current problems at the farm level
   e. Develop short courses directed towards training ranch operators in new skills, using the learning-by-doing approach rather than classroom lectures

4. Agricultural planning institutions should define the beef production policy, put it into practice and give it sufficient time to see whether or not it works. Until a defined policy has been established, it is difficult—if not impossible—to identify the weaknesses of the system.

# WORK GROUP REPORT ON THE SOCIOECONOMIC AND DEVELOPMENT PROJECTS

*T. Granizo*

Taking into consideration the scope of the socioeconomic and development projects, the work group decided to choose only some of the aspects involved, in order to deal with them to a certain degree. For this reason, the recommendations made can in no way be interpreted as an exhaustive list but rather reflect the opinions of the members of this group as regards some subjects of significance in these areas.

A. The present status of the beef cattle industry within the economy of tropical America

Beef production in tropical America is based mainly on the exploitation of native pastures and introduced pastures in areas whose natural vegetation is the forest. With the exception of a few areas, the carrying capacity of the pastures is correlated to the present level of technology being applied. Therefore, beef cattle development will require an increase in the investments necessary for intensification.

In the forested areas of the humid tropics, the development of beef cattle production will demand significant investments to clear timber and to establish grass and forage crops.

In many areas of tropical America, beef cattle operations include both milk and beef production. In these cases, beef cattle development and related research should approach both lines of production jointly.

B. The role of specific beef cattle development projects

In recognition of the important contribution that well-planned and executed development projects can make in accelerating beef and milk production in tropical American beef cattle herds, it is recommended that national, regional and international research organizations become more deeply involved in this process. In doing so, these organizations would

1. Assist governments in their efforts to select and formulate development projects that are technically feasible, financially viable and economically sound
2. Assist governments in order to make fuller use of scarce resources by giving priority to projects featuring comprehensive, low-cost production packages
3. Provide project management with technological production packages geared to the production intensity most appropriate for the different ecological regions and that would result in productivity changes and sufficient profitability to attract producers
4. Involve project management staff in adapting technological packages to specific ecological regions as part of the research and demonstration process
5. Assist in efforts to develop projects that when considered jointly would provide a balanced program of assistance to the rural poor and would increase production
6. Encourage the establishment of effective project management units in credit organizations or under separate independent arrangements
7. Encourage the provision of technical services for ranch production and development planning, using production specialists employed directly by the agency administering the project for the time such services are required, as a complement of the general extension services
8. Assist in training programs for the preparation of production specialists to provide service for the technical project
9. Provide guidance and assistance to project management to ensure the establishment of effective monitoring systems to measure project impact and accomplishments
10. Establish effective national, regional and international outreach and linkage networks for beef cattle research and training

C. The institutional factors limiting livestock development

1. Economic policies in general

Occasionally, general economic policies influence the cattle sector more than specific sectorial policies. It is therefore deemed necessary to improve the coordination of both sectorial and overall policies, above all economic (such as foreign exchange rates for imports and exports, interest rates, etc.).

2. Sectorial economic policies

The lack of coherence in sectorial economic policies has frequently been a serious obstacle for beef cattle development because decisions based on short-term objectives prevail.

Although the aforementioned is obvious, the nature of the biological processes of cattle emphasizes the need for mid- and long-term plans, making it necessary to have coherent economic policies.

a. Product price policies move around restrictive limiting factors; i.e., the effect of prices on the cost of living on the one hand and the lack of incentives for production on the other. For this reason, price policies regarding beef cattle cannot play an important role in promoting livestock development, but they cannot be ignored.

b. In regard to prices for inputs, it is recommended to act upon those that are desirable from the physical-biological point of view and that would be profitable for the country's economy in the intermediate term.

c. Since beef cattle development requires large investments which are difficult to finance through credit alone, all possible resources (including the producers') must be put into action, using every available tool (extension, taxes, etc.). Credit should be granted together with technical assistance, preferably in the form of supervised loans, to ensure the success of the investments, gearing the credit to the integral development of the farm. Before granting credit, the different cattle farms' capacities for generating economic surplus should be taken into account, in accordance with their relative size and scale of operation. Three sources of financing investments for beef cattle development are the contribution of the product itself, preferential tax treatment, and bank credit. It is suggested that a system be structured whereby the per hectare investment of the small farmer would be almost exclusively financed through bank resources, whereas the larger producer would be financed through his own contribution, preferential tax treatment and a minimum of bank credit. In the short run, expansion of beef cattle production implies a decrease in supply destined to the consumer, together with a parallel, undesirable effect of an increase in beef prices. In this regard we already have broad experience in Latin America. Under such circumstances, noncyclic short- and intermediate-term loans are advisable, restricting this credit during the price increase periods in order to counteract these effects partially.

d. Land policies should be structured so as to decrease the degree of land concentration found today in important beef cattle areas of Latin America. This would facilitate access to land utilization by those producers who have shown entrepreneurial skills and efficiency.
A land tax that is in accordance with its productive capacity and that increases progressively in accordance with the size of the farm constitutes one of the measures conducive to the aforementioned objectives.

D. Transfer of technology

1. Prospects for livestock development in the lowland tropics in the intermediate term will be determined to a greater degree by factors influencing investment decisions to be made by the producers; that is, economic, socio-institutional and policy aspects and to a lesser degree, the availability of technology.
2. Research programs geared to livestock development should include the study of the aforementioned factors. Because of the fact that investment decisions are closely linked to prospects of increasing profits, it is also important to obtain all the data necessary to evaluate cost-benefit ratios of all the techniques under research.

3. Field technicians must have a thorough knowledge of modern project planning procedures, of the techniques available for expediting quantitative data assessment of available resources and the combination of these data with socioeconomic factors. This knowledge is needed to present feasible and logical alternatives for beef cattle development planning in general and specifically in development projects.
4. The training of a field technician must be oriented in a more practical manner toward the improvement of communication with the producers.
5. Technical assistance to the farmer must be provided at the individual level and also through mass media, otherwise the costs will be extremely high.
6. For individual technical assistance, it is necessary to be able to supply physical inputs and the necessary capital in cases where the proposed technological changes involve a greater use of inputs, implying more investments.
7. In many tropical countries in America, it has been found that one of the best ways to ensure an effective application of technology at the producer level is to combine technical assistance with credit, within specific development projects.
8. It is essential to coordinate applied research with technical assistance in order to ensure that the technician recommends the adequate solution for every situation and that research is based on the real needs of the producer.

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