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NINTH ANNUAL CONFERENCE ON

# Livestock and Poultry in Latin America

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

UNIVERSITY OF FLORIDA

INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

GAINESVILLE, FLORIDA 32611

OFFICE OF THE VICE PRESIDENT
FOR AGRICULTURAL AFFAIRS
1008 McCARTY HALL
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May 5, 1975

TO: Our friends from Latin America

On behalf of the faculty and staff of the Institute of Food and Agricultural Sciences (IFAS), I cordially welcome you to the University of Florida and Gainesville.

We in IFAS are pleased that you could participate in this ninth Annual Latin American Conference on Livestock and Poultry. This conference and the information made available through it is a small measure of the continuing interest we of IFAS and the University of Florida have in exchanging information and ideas with our friends from the Latin American nations. We sincerely hope this conference will be productive for you and will help you in the further development of your country's livestock industry.

May your stay here in Gainesville be a beneficial and enjoyable experience. Our sincere best wishes for the future.

Sincerely yours,

K. R. Tefertiller
Vice President for
Agricultural Affairs

UNIVERSITY OF FLORIDA
INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

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

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Dear Latin American Friends and Colleagues:

It is a distinct pleasure for me once again, as Director of the Center for Tropical Agriculture, to welcome you to the Annual Latin American Livestock and Poultry Conference. We are happy to see our old friends and hope that for you who are attending this Conference for the first time, it will be a rewarding experience both personally and professionally.

One of our major hopes for this Conference each year is that you will derive practical information that you can take back to your country to help your friends, neighbors and countrymen in their quest to improve the quantity and quality of food available in your countries. Anything we can contribute along these lines makes the time and effort of the Conference worthwhile.

The fourth livestock short course, in conjunction with the Central American Livestock Fair, was held in San Jose, Costa Rica this year and attendance exceeded 500.

The Center continues to have technical assistance contracts in El Salvador, Ecuador and Vietnam, with smaller contracts for work in Nicaragua, Venezuela and Honduras. We are also continuing research under our 211(d) grant from the Agency for International Development to improve our expertise in tropical pasture and livestock production. We have received a new two year contract for mineral research in the tropics which is just now getting underway. The contract is with the Agency for International Development and most of the work will be done in Brazil, Colombia and Ecuador.

We have begun developing a multidisciplinary research program on nitrogen fixation of tropical grasses which holds great promise for the tropical livestock producer. We have also secured four water buffalo which we hope will be of benefit in controlling the aquatic weed problem in Florida and offer alternatives to the use of herbicides and other chemicals which pose environmental problems.

We hope that your visit to Gainesville and the University will be pleasurable and that we will see all of you here again next year.

Sincerely yours,

Hugh Popenoe

Hugh Popenoe
Director

UNIVERSITY OF FLORIDA

INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES

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May 5, 1975

Dear Friends:

The Departments of Agronomy, Animal Science, Dairy Science, Editorial, Poultry Science, and Veterinary Science offer you a most cordial welcome to the Ninth Annual Conference on Livestock and Poultry in Latin America. We wish to take this opportunity to express to you the University of Florida's interest in the problems of livestock and poultry production in Latin America. The University of Florida has a long history of working with its neighboring countries, and each year we attempt to improve this exchange among the Americas.

This conference is a most important function, in the sense that there is a valuable interchange between our personnel and you. The conference is only one part of the continuous collaboration which we have with the livestock and poultry producers of Latin America. Your interest in our work here and in the cooperative work being conducted in most of your countries is appreciated.

We hope that your visit to the University of Florida will be of value and that you will give us your ideas as to how we might improve this conference. All of the professors and the nineteen participating Latin American students are at your service in helping to make your stay here most beneficial.

Sincerely yours,

T.J. Cunha
Assistant Chairman of
Conference Committee
Chairman, Department of
Animal Science

Joe H. Conrad
Chairman of Conference Committee
Coordinator of Tropical Animal
Science Programs

UNIVERSITY OF FLORIDA
Gainesville, Florida

Ninth Annual Conference
on
Livestock and Poultry
in Latin America

May 5-9, 1975

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INDEX

Page

SECTION A - AGRONOMY

Biological nitrogen fixation . . . . . 1-A
D.H. Hubbell

Use of nitrogen fertilizer in tropical forage-livestock feeding systems . . . . . 5-A
D.H. Timm

Nitrogen Fertilizer: The future . . . . . 11-A
E.C. Doll and D.L. McCune

Factors affecting persistance of legumes in tropical legume-grass associations . . . . . 24-A
L.E. Tergas

Intensive pasture utilization for milk production in the humid tropics . . . . . 30-A
G. Cubillos

Legumes and legume-grass association in the American tropics . . . 38-A
N.S. Raun

SECTION B -- BEEF CATTLE

Problems of artificial insemination . . . . . 1-B
Julio R. Brouwer

Synchronization of estrus: Its present use in artificial insemination programs . . . . . 30-B
A.C. Warnick

Present status on the cause of weak calves at birth . . . . . 37-B
D.E. Franke

Comparison of crossbred animals from exotic and regular beef breeds . . . . . 41-B
M. Koger

Suggestions on improving the calf crop in beef cattle . . . . . 50-B
M.J. Fields

The Florida beef industry: Dimensions and directions . . . . . 63-B
Kary Mathis

Page

SECTION C - DAIRY CATTLE

Performance of daughters of sires used on different farms . . . . . 1-C
C.J. Wilcox

Feeding systems for maximizing milk production from dairy herds . . . . . 6-C
J.K. Loosli

Hormonal induction of lactation . . . . . 12-C
H.H. Head

Genetic change in milk production . . . . . 17-C
C.J. Wilcox

Management factors that pay based on a five-year study of El Salvadorian dairy herd records . . . . . 23-C
C.W. Reaves

Utilization of Prostaglandin $F_{2\alpha}$ for ovulation control: Fertility results . . . . . 32-C

SECTION D - HORSES

Equine disease control . . . . . 1-D
W.S. Cripe

Internal parasite control . . . . . 4-D
R.E. Bradley, Sr.

Balancing horse rations . . . . . 10-D
E.A. Ott

Techniques for better breeding efficiency . . . . . 18-D
D.C. Sharp, III

Optimizing production by proper management . . . . . 20-D
S. Lieb

SECTION E - POULTRY

Utilization of by-products as feed ingredients . . . . . 1-E
R.H. Harms

Prevention and control of Aflatoxicosis in poultry . . . . . 6-E
G.T. Edds

The importance of salt for poultry . . . . . 9-E
C.R. Douglas

Page

SECTION E - POULTRY (continued)

Tips for turkey producers . . . . . 12-E
R.A. Voitle

Further processing of poultry products . . . . . 18-E
D.M. Janky

A video tape presentation of commercial poultry operations . . . . 21-E
D.M. Janky

SECTION F - SWINE

Medical management of sows and litters . . . . . 1-F
H.N. Becker

Preservation of high moisture grains .. . . . . 5-F
D.L. Hammell

Recent happenings in swine nutrition . . . . . 7-F
G.E. Combs

# BIOLOGICAL NITROGEN FIXATION

by

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## Introduction

Nitrogen is the mineral element most frequently found limiting to plant growth. It is continually removed from the soil by cropping practices, leaching and denitrification. The two significant mechanisms by which this critical element may be maintained at adequate levels in the soil are (1) application of nitrogen fertilizers and (2) biological nitrogen fixation.

The high cost and limited availability of nitrogen fertilizers are now a well-documented reality. Informed sources now predict that availability of these fertilizers will gradually improve beginning this year, as new fertilizer plants begin production and old plants step up production to help meet increased demands. However, it is also predicted that there will be little or no reduction in the current price of these fertilizers. This means that for many potential users, the application of nitrogen fertilizers will continue to be minimized or even eliminated for lack of sufficient capital.

For this reason, the increased use of biological nitrogen-fixing systems as an alternative to nitrogen fertilizers is becoming increasingly advantageous, if not imperative, from an economic standpoint. It is the purpose of this paper to review briefly the various nitrogen-fixing systems, and their real or potential contribution to forage-livestock production systems. Additional papers presented at this and previous conferences discuss other aspects of this general problem in detail.

## Biological Nitrogen-Fixing Systems

Nitrogen fixation has been demonstrated in a number of free-living microorganisms which are commonly found in the soil. These include bacteria such as Azotobacter, Klebsiella, Bacillus, Mycobacterium and Clostridium, and blue-green algae such as Nostoc and Anabaena. Laboratory studies using sensitive methods of detection continue to extend the list of true nitrogen-fixers. Free-living fungi and actinomycetes apparently uniformly lack this important trait. The practical significance of N-fixation by free-living bacteria is not clearly known and may be negligible. The reason for this is the large amounts of carbohydrate

required for appreciable N-fixation. Simple carbohydrates utilized by the N-fixers generally occur in limited amounts in the soil and are readily consumed by competing microorganisms which do not fix nitrogen. There apparently has been no attempt to measure the cumulative contribution of these organisms to soil nitrogen under field conditions. In the case of the blue-green algae, the carbohydrate limitation does not apply under conditions permitting photosynthesis. We, therefore, find that these algae fix significant amounts of nitrogen in aquatic environments (rice paddies) and terrestrial environments (soil crusts).

A number of plant-microorganism associations are known to fix nitrogen symbiotically. Certain actinomycetes are capable of infecting and fixing nitrogen in the roots of a limited number of higher plants. In these cases, the plants themselves are not of agronomic importance and levels of nitrogen fixed are relatively low. There are also reports of nitrogen fixation by associations of ectomycorrhizal fungi with the roots of higher plants, but the true basis for this observation remains unknown.

Several tropical grasses, such as Paspalum notatum, Digitaria decumbens (Pangola grass), Pennisetum purpureum (Elephant grass), Brachiaria spp. (Para grass) and Panicum maximum (Guinea grass), in association with certain bacteria, have been shown capable of fixing as much as half of their required nitrogen. The association may be at the root surface, as in the Paspalum notatum - Azotobacter paspali combination, or it may occur within the roots, as has been found in the association of the bacterium Spirillum lipoferum with several tropical grasses, notably Digitaria decumbens cv. Transvala. This latter association has only been recently discovered and is, therefore, comparatively unknown. However, preliminary results indicate that the association is highly variety-specific with regard to both formation and level of N-fixing activity of the association. Plant genetic studies, therefore, hold great promise as a means of developing grass varieties which will form the best association. These studies should be carried out in conjunction with microbiological studies designed to find the best bacterial strains, methods and conditions of inoculation, etc.

Without question, the best known biological nitrogen-fixing system is the classical symbiotic association of Rhizobium bacteria with plants of the legume family. This association has proven invaluable as a direct source of food for man and forage for animals. Its importance in maintaining or improving soil nitrogen levels for non-legumes in crop rotations is perhaps of equal importance. There is not sufficient time to elaborate on the details of this association. Instead, it may be more valuable to emphasize some broad concepts. The legumes constitute an amazingly diverse group of plants, including trees, shrubs, vines and herbaceous plants. Representatives are found adapted to virtually any combination of climate and soil conditions which will support life. The tropical regions of the Earth are particularly well-endowed in this respect. The rhizobia appear to have adapted along with their plant hosts and generally can be found where the host plant is indigenous. Where the plant is introduced, the bacteria can be simultaneously introduced into the soil at planting by relatively simple and inexpensive procedures.

Some knowledge of climate, soil and plant characteristics is necessary in order to insure a desirable and successful introduction. Soil pH, temperature, moisture, nutrient status and possible aluminum and/or manganese toxicity are all factors which may determine establishment of legumes.

## Benefits of Legume-Grass Combinations

In a successful grass-legume pasture, the legume component has the dual function of providing forage which is high in protein and of maintaining or increasing soil nitrogen levels. The legume should fix sufficient nitrogen to satisfy its own requirements and enough additional nitrogen to support strong grass growth.

As an example of the capability of legumes, nitrogen fixation rates for clover pastures in New Zealand have been shown to range from 100 - 500 lbs N/acre with values commonly in the range of 150 - 250 lbs N/acre. Comparable nitrogen fixation rates have been shown for legume-tropical grass combinations such as Stylosanthes - Heteropogon, Pueraria (Kudzu) - Melinis, and Pueraria - Panicum in widely scattered parts of the world.

The presence of a legume in the forage results in a higher percent crude protein in the forage, increased dry matter per acre, higher average daily weight gain, higher cow conception rate, increased digestibility of forage and lower pasture costs per pound of beef.

## Practical Aspects of Legume Establishment

The proper choice of legume to incorporate in a forage - livestock system is critical. This choice can be more easily made after answering some basic questions. Is the pasture to be used for hay, forage, or both? What total acreage is involved? The grower must first clearly define his needs in terms of a specific purpose and capability.

Other important considerations may help to restrict the possible choices. Are the soil and climatic conditions more conducive to temperate or tropical legumes? Valuable information on this may be obtained from observing the types of legumes, either native or introduced, which are already growing successfully in the area. One or more of these may be suitable for the intended purpose and would be worth testing. Such plants are obviously adapted to local conditions and there is the possibility that information will already be available related to their cultivation and management. By using native legumes, it is sometimes possible to establish the plants without inoculating the corresponding rhizobia, although inoculation is generally beneficial in increasing nitrogen fixation and is always recommended.

In attempting to test a legume for possible use in a particular forage - livestock system, it is advisable to limit initial trials to small field trials. Any problems leading to failure of the legume to establish or perform as desired will, thereby, be a learning experience, but will not result in a large economic loss, as might be expected from failure of a large acreage of the crop.

It is advisable to obtain an analysis of the soil in order to detect possible deficiencies of any of the major and minor minerals generally required for good crop growth. Legumes will form a successful nitrogen-fixing association with rhizobia only when all nutrient elements (other than nitrogen) are adequate for normal physiological activity. A possible combination of test plots for a legume might include:

(1) legume plus complete fertilizer;
(2) legume plus fertilizer, minus nitrogen;
(3) as in (2), plus inoculation;
(4) legume only, no fertilizer or inoculation.

If possible, the grower should discuss the problem with an agronomist or pasture specialist before beginning field tests. Such consultation may save much time and effort by revealing available information.

## Summary

The most important point is to emphasize the great value of grass-legume combinations as a source of high-quality forage needing no fertilizer nitrogen. Additionally, it should be emphasized that knowledge and technology required for introduction and use of legumes for any purpose is available. Some investigation is generally required, depending on problems inherent in a local situation. These problems can be solved and past experience indicates that it is well worth the effort.

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# USE OF NITROGEN FERTILIZER IN TROPICAL FORAGE-LIVESTOCK FEEDING SYSTEMS

by

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One of the most serious problems facing farmers and ranchers in the wet-dry tropics, where cattle feeding is based almost entirely on forages, is the fluctuating feed supply throughout the year. There is commonly a surplus of feed during the wet season, with a corresponding shortage during the dry season. This problem is complex and must be viewed with the forage-livestock feeding system in mind. The optimum solution, in most cases, does not involve a simple choice of one alternative as opposed to another but rather the selection of a combination of alternatives. The use of fertilizer on pastures generally increases the production of forage during the wet season and helps to shorten the adverse effect of the dry season. However, the use of fertilizer alone usually does not give an adequate solution to the problem. Forage supplies are often more fully utilized when combined with a forage conservation program, such as hay and silage making, or deferred grazing. Irrigation, green chopping and grass legume associations are other alternatives that might be used to increase forage production and develop a more uniform supply throughout the year. Once the yearly feed supply has been increased and more evenly distributed, more animals are usually needed in the system to convert this added feed supply into additional production.

To receive the maximum benefit from any improved forage-livestock feeding system, it is imperative that the cattle and pastures receive the highest level of management possible. The cattle must have ready access to fresh water, salt, and minerals. They should be vaccinated against the common diseases in the region and be treated periodically to control internal and external parasites. A grazing system should be utilized that will make maximum use of the pasture produced. Weeds should be controlled by mechanical and/or chemical means. The pastures should be checked periodically for insect damage, and, when deemed necessary, insecticide applied.

## General Considerations Concerning the Grass-Nitrogen System

The grass-nitrogen system has resulted in yields of more than 1000 kg of live weight gain per ha on several different occasions using high nitrogen rates (3,5,9). Live weight gains of more than 1000 kg/ha have been obtained in Jamaica using *Brachiaria decumbens* and *Digitaria*

decumbens (Pangolagrass) applying nitrogen at the rate of only 212 kg/ha/year (3). Seven years results in Brazil indicated that the 200 kg N/ha/year pastures averaged nearly 2-1/2 times more beef per ha than the minus-nitrogen pastures. The live weight gains were 241 and 578 kg/ha/year applying 0 and 200 kg N/ha/year, respectively. The response that is obtained depends quite heavily on the fertility level of the soil when the N fertilizer is applied and the climatic conditions that prevail. The highest live weight gain recorded has been 1880 kg/ha/year as reported by the Department of Primary Industries in North Queensland (1) with heavily fertilized Pangolagrass under irrigation. Dry matter yields of 38.3 tons/ha/year have been reported in Puerto Rico (10) applying 2000 kg of N/ha/year to Elephantgrass. Table 1 shows the influence that the optimum level of N (using urea, 46% N) had on the daily gain per animal, the carrying capacity, and the live weight gain per hectare in a grazing trial conducted west of Lake Maracaibo, Venezuela. These results were obtained with Guineagrass using a grazing system of 7 days grazing and 30 days rest and a phosphorous application of 56 kg $P_2O_5$/ha/year.

Table 1. Influence of Nitrogen Fertilizer on Animal Performance, Carrying Capacity and Live Weight Gain per Hectare.

| N (kg/ha/year) | Gain/Animal (kg/steer/day) | Carrying Capacity (steers/ha/year) | Live Weight Gain/ha (kg/ha/year) |
|---|---|---|---|
| 0 | 0.494 | 4.34 | 782 |
| 371 | 0.556 | 5.49 | 1115 |

The carrying capacities obtained with 0 and 371 kg N/ha/year are the averages for the entire year. The number of animals per ha varied at any one time during the year depending on the quantity of forage available. In order to maintain the carrying capacity constant in this wet-dry region it is necessary to combine a forage conservation program with the fertilization program. It should be noted that the fertilizer nitrogen had a greater effect on the number of animals/ha than it did on the daily gain/animal. This is to be expected when the pastures are grazed at an optimum grazing pressure.

The productivity of nitrogen fertilized tropical grasses would be truly spectacular if the problem of their nutritive value could be overcome. Even with good management on pasture that is apparently of high quality, cattle often gain only 1/2 kg per day. Milford and Minson (6,7) have shown that this low feeding value is not due primarily to a low level of protein in the grasses, but rather to a shortage of digestible energy in the diet, caused by a low intake of material with a relatively low digestibility and high fiber content.

A definite disadvantage for the grass-nitrogen system is the high cost involved. Nitrogen is being produced in some Latin American countries as a by-product of the oil refining industry thus making it relatively cheap and profitable to use with grass. In many countries, however, even with rapidly increasing secondary industry, fertilizer is still very expensive. Including transportation costs, nitrogen often costs between $0.45 and $0.65 per kg by the time that it has finally arrived at the site where it is to be used. One must also consider the high capital expenditure required to maintain the pastures at the higher stocking rates and, in the case of the wet-dry tropics, the extra expenses that must be incurred in conserving and feeding the excess forage produced in the rainy season.

The economics of fertilizer use are influenced considerably by the efficiency with which the fertilized grass can be converted into beef. This efficiency will depend a great deal on applying the proper amount of nitrogen at the proper time and on keeping the pasture at the optimum grazing pressure. It has been proven that under these circumstances it is possible to obtain 3 kg of live weight gain per kg of N applied (5). As has already been mentioned, it may well be necessary to combine a forage conservation program with the fertilization program to more fully utilize the forage produced.

It is quite likely that once a high level of nitrogen has been established in the grass-nitrogen grazing system that the same quantity of beef could be produced with lower rates of nitrogen being applied in subsequent years. Davidson (4) makes the assumption that 80% of the herbage nitrogen is returned to the soil as excreta of which 25% is recovered by the grass in the first season and another 25% in the second season. This assumption is further confirmed by recent studies conducted in Brazil by Mott et al.(8). It is assumed that this effect of recycling would be even more pronounced at the higher fertilizer rates due to the greater quantities of forage being produced and higher stocking rates being used, resulting in a larger amount of excreta, and consequently nutrients, being returned to any given area of pasture over any given period of time. It is suggested that greater efficiency of nitrogen may be obtained by applying an initial heavy dressing of nitrogen followed by smaller annual dressings to replace the losses of nitrogen in the system as opposed to applying moderate dressings of nitrogen every year.

Burton (2) points out another factor that ought to be considered when discussing the grass-nitrogen system. He found that when high levels of nitrogen are used with corresponding high stocking rates (12 animals per ha during the rainy season) that the urine and droppings from this many animals per area will contaminate so much of the grass that inefficient patch grazing results. He felt that the problem might be solved by rotation or strip grazing or by feeding green chopped herbage.

## Example of Forage-Livestock Feeding Systems Using Nitrogen Fertilizer

### Description of the Study Area

A dairying region west of Lake Maracaibo, Venezuela (10°N Latitude) was chosen for this study. The area includes approximately 200,000 ha and is one of the principal dairying regions in the country. The majority of the pastures in the area is sown to Guineagrass (*Panicum maximum*, Jacq.) with this grass forming the base of the ration for the cattle in the area.

The climate is sub-humid with the daily mean temperature varying between 27-34°C and the annual precipitation between 800 and 1,400 mm. The rainy season is from April through November with the highest intensity during May and October. There are four seasons recognized in the zone. The long dry season usually begins in December and ends sometime in April. The first rains come in April and May. There is a short dry season during June and July followed by the longer rainy season which usually begins in August and extends through November. The soils are of the "Ultisol" and "Alfisol" orders. The texture varies from loamy-sand to loamy-clay. The effective depth goes as far as one meter with an accumulation of clay in the B horizon.

### Procedures Used and Results

The methodology that is used is very important in developing systems of production that are meaningful for a region. An economic study was made of the use of nitrogen on pastures using the conventional method of marginal cost equal to marginal return. The cost of conserving the excess forage produced in the rainy season for future dry season use was included. A large scale grazing trial and forage conservation studies in the area provided the information necessary for making this analysis. The prices which were used are shown in Table 2.

Table 2. Prices Used in the Economic Study of Fertilization of Guineagrass (*Panicum maximum*, Jacq.)

| Item | Cost ($) |
|---|---|
| Cost/kg N Applied | 0.26 |
| Cost/Ton of Dry Matter Conserved | 29.07 |
| Other Variable Costs/Steer (Purchase of Steer, Labor, Salt and Minerals, Veterinary Fees) | 141.42 |
| Live Weight Price of Beef/kg | 0.67 |

The results of the study are presented in Table 3.

Table 3. Results of the Economic Study of Fertilization with Nitrogen.

| N (kg/ha/ year) | Carrying Capacity (steers/ha/year | Quantity of Pasture to Conserve (kg/ha/year) | Gross Income ($ /ha/ year) | Variable Expenses ($/ha/ year) | Gross Income minus Variable Expenses ($/ha/year) |
|---|---|---|---|---|---|
| 0 | 4.34 | 1435 | 1113.16 | 667.19 | 445.97 |
| 371 | 5.49 | 2095 | 1491.91 | 943.92 | 547.99 |

It can be seen that the optimum level of N (371 kg/ha/year) requires more animals/ha,more conserved forage, and more available capital to pay the additional variable expenses of the system. The gross income/ha/year is larger using N, however, resulting in a net income which is more than $ 100 greater than the minus N system. These systems were developed assuming that there were no restrictions on the systems, particularly capital, and that the prices were not subject to change.

Resource restrictions and price changes should be included, however, to make the results more realistic and applicable to a particular farm situation. Through the use of linear programming and the aid of an electronic computer it was possible to include limitations on the resources of particular farm sizes and vary the price of N. Complete farming systems were developed for 150-300- and 450- hectare dairy farms with their respective capital restrictions of $ 39,535, $ 70,698 and $ 107,209. The gross income minus variable expenses varied from $32,530 to $96,690 depending on the size of the farm, the amount of capital available, and the price of N. When the price of N increased from $0.13 to $0.26 kg applied, in a 300 ha farm situation, the dairy cow herd remained constant with 130 cows, but the number of fattening steers decreased from 529 to 375. The hectares of pasture being fertilized decreased from 300 to 20 and the tons of hay being conserved decreased from 508 to 374. In the previous study, where restrictions were not considered, it was recommended to apply 371 kg N/ha/year on the entire farm when the price of N was $0.26 kg applied. The gross income minus variable expenses decreased from $ 64,395 to $ 57,074 as a result of the increase in the price of N. As the price of N increased the level of N used under grazing conditions and in the area set aside for hay making decreased.

## Conclusion

Nitrogen fertilization is only one component of the forage-livestock feeding system. The tropical grasses respond quite favorably to N fertilizer, but the response is usually more fully utilized when combined with other improved forage-livestock practices. The use of nitrogen fertilizer in tropical forage-livestock feeding systems depends

quite heavily on the resource restrictions that are placed on the system and on the prices of the inputs (N fertilizer in particular) and the value of the products (beef, milk and wool).

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# NITROGEN FERTILIZER - THE FUTURE

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The title of this discussion, "Nitrogen Fertilizer - The Future," is quite general; however, this presentation will be confined to two specific subjects. First, what we can expect with respect to the availability and cost of nitrogen fertilizers in the immediate future; and second, what new types of nitrogen fertilizers are being developed which may have potential for pasture fertilization. Regarding the availability of nitrogen fertilizers, the basic feedstock for their production is either natural gas or naptha. Consequently, production of nitrogen fertilizer is directly affected by the present worldwide fossil fuel situation. Thus, the uncertainties of the energy situation combined with the critical world economic situation make projections as to possible nitrogen production extremely difficult; however, we will describe the developments in this area as we see them now. Insofar as new nitrogen fertilizers are concerned, we will describe materials now being tested and discuss some of the properties which these fertilizers should have to increase both yields and the efficiency with which the applied nitrogen is utilized.

## Nitrogen Fertilizer Situation

This portion of the discussion will deal largely with the world fertilizer situation rather than just the situation in Central and South America. This is because the nitrogen supply and prices are more dependent upon the world supplies than those in any particular country or region. This is especially true in those areas which do not have a significant amount of domestic nitrogen production and, therefore, must import nitrogen fertilizers purchased in the world market. Also, in order to view the nitrogen fertilizer situation in the proper perspective, we will include some information as to the fertilizer situation with respect not only to nitrogen, but also to phosphate and potash.

The popular dramatization of the current fertilizer situation illustrates the fact that fertilizer is no longer considered a luxury item, but an absolutely essential "input." It is important to note that the fertilizer shortage comes at a time of great need to increase world food production, when developing nations have the incentives to act, when farmers are willing to change, and when developmental assistance agencies are giving priorities to agriculture and especially to the low income subsistance farmer.

One objective of this paper is to give perspective to the present status of the world fertilizer situation and to extend this perspective, to

the extent possible, to the 1980 s. In view of all of the global uncertainties and limitations placed on market intelligence, the use of sophisticated analytical techniques quite often does not explain nor predict with an acceptable degree of accuracy the expected developments in future fertilizer supply-demand relationships. Consequently, we must, on occasion, resort to crystal ball gazing and judgements. These data in this paper represent some of each.

Total world fertilizer consumption in 1973 was estimated at 77.5 million mt of plant nutrients (table 1). Nitrogen, phosphate, and potash use levels were 36.0 million mt, 22.8 million mt, and 18.7 million mt, respectively. Although fertilizer use in the world has been growing steadily since 1946, the trend has been cyclic in that the growth rates have varied considerably around the trend line reflecting the impact of supply-demand differentials. However, with the exception of the great depression years of the 1930 s and World War II, fertilizer consumption has maintained a steady upward course.

We have estimated that total fertilizer consumption in 1980 will fall in the range of 105 to 123 million metric tons (mt) of nutrients with a mid-point of about 114 million mt. Nitrogen will account for about 50%, phosphates about 27% and potash 23% of the 1980 demand. This implies an annual growth rate of between 5-7%, which is somewhat less than previous rates for comparable periods.

However, one should bear in mind that projected growth rates are calculated from a much larger base than in previous years, a much higher analysis fertilizer is being consumed in today's market, and there is reason to believe that farmers are using fertilizer more wisely and efficiently.

Importantly, the developing regions of the world are projected to increase consumption between 8-11% compared to 4-6% for the developed countries. In the developing regions it appears that Latin America (10-12%) will experience greater market gains than either Asia or Africa. However, developing Asia will continue to use more fertilizer than Latin America and Africa combined.

## Nitrogen Production Capacity

A recent review of the world nitrogen situation indicates that the balance between supply and demand for fertilizer nitrogen could remain precarious over the next several years.

How precarious--small shortages or overproduction--depends on how much more production capacity is started in coming months.

The industry is expanding production substantially. Worldwide, more than 18 million metric tons of new nitrogen capacity have been announced since January 1, 1974.

With this level of expansion, potential nitrogen fertilizer supplies would continue to fall short of expected demand by a million or more

tons annually through 1976. The gap would then close and supply could exceed demand slightly in 1978 and 1979 (table 2).

The key, however, centers on decisions yet to be made. More than 20 million additional tons of capacity are under consideration. If several of these "indefinite" plants should become "firm" in the near future, the world would again face an excess capacity situation by 1980.

World nitrogen capacity is estimated at 62.3 million metric tons at the end of 1973 and the expected 1974 level at 67.1 million. This should increase to 72.1 the following year and to 77.2 in 1976. Announced expansions would take nitrogen capacity to 93.1 million tons in 1978 and to 96.7 in 1980 (table 2).

However, if all of the "maybe" plants being considered should be built, the 1980 capacity would zoom to 117.2 million tons. This would create as much as 8 million tons of excess capacity for fertilizer nitrogen.

The largest "firm" expansion is slated for the developing regions. Capacity of these areas, on three continents, is expected to go from 9.3 million tons in 1974 to 22 million in 1980, a gain of 136 percent.

Developing Asia has scheduled the biggest increase--6.3 million tons. Gains set for Latin America are 4.8 million tons and for Africa, 1.6 million.

Second largest regional increase is expected in North America, where announced 1974-80 expansions total 6.1 million tons of nitrogen. Other expected regional increases are: Eastern Europe and Russia--4.4 million tons; Western Europe--3.0; and other Asia--3.3 million.

Developing Asia also has the largest total of "indefinite" capacity--7.4 million metric tons in addition to the already announced 6.3 million ton expansion by 1980. Next largest amount of capacity under consideration is about 4 million tons in North America.

## Phosphorus Production Capacity

Phosphoric acid continues to gain in importance as the major contributor to the world phosphate fertilizer supply. At the end of 1973, total world phosphoric acid capacity was estimated to be just over 19 million metric tons $P_2O_5$. The increase expected by 1978 would bring the total to over 27 million tons. As indicated in table 3, there has continued to be some expansions in capacity planned; however, the rate of increase has slowed. Latest estimates for 1978 show an expected capacity level of 29.6 million tons with little further gain through 1980 indicated.

The tight phosphate supply situation of the last 2 years brought about a capacity expansion that was well underway prior to November, 1973. Plans announced as of the end of last year totaled more than 8 million tons of $P_2O_5$ to be in operation by the end of the decade. In the last 9 months, another 2.5 million tons of capacity has been added.

With the exception of Latin America and Asia there is only a small amount of capacity indicated as "indefinite." Including all indefinite units in the total for 1980 would raise the total world phosphoric acid capacity to over 35 million tons--more than 80% above the 1973 level.

As indicated in table 3, all regions will be expanding capacity; however, the major expansion will be in North America. By 1980 this region is scheduled to have in operation one-third of the total world capacity for phosphoric acid. The developed regions will continue to dominate the supply picture for phosphates; however, Africa will become much more prominent in the phosphate market in the years ahead.

To determine the potential phosphate supply level, phosphoric acid capacity must be adjusted for processing losses, industrial use, and operating rates--and then combined with estimated supplies of other phosphate materials, some of which are based in part or entirely on the reduction of phosphate rock by other acids. The resulting potential supply level is compared with total world demand to determine the supply surplus or deficit expected in the next few years.

As indicated in table 3, the deficit market situation of the last few years will change to a surplus, reaching its maximum in 1977. A return to a possible market balance during 1979-80 has been indicated as supply contributions from sources other than phosphoric acid continue to decline in importance. This substitution of low-analysis products for high-analysis materials derived from phosphoric acid will temper the overall market surplus or deficit as these plants come in or go out of production in response to market conditions.

Capacity to produce phosphate fertilizers should be adequate for demand. However, tightness in phosphate rock supplies could be a bottleneck in the future supply of phosphates. Rock production capacity has not been expanded as fast as have fertilizer production facilities. As a result, shortages of rock could restrict operation of some phosphoric acid plants scheduled to come on-stream in the next few years. The longer term prospect is that current high prices of phosphate rock will speed development of rock-mining capacity around the world and that phosphate rock supplies will not be a limitation to fertilizer supply by the end of the decade.

No discussion of the phosphate fertilizer supply-demand situation can be complete without knowledge of the prime raw materials from which phosphate products are derived--namely, rock phosphate and sulfur.

World rock phosphate production reached approximately 100 million mt in 1973 and is projected to climb to 150 million mt by 1978. World deliveries and production of rock were nearly in balance in 1969. Since that time the world industry has been trading more than has been mined. Therefore, world inventories have decreased from nearly 18 million mt in 1970 to about 9 million mt in 1973, a five-week supply of marketable rock.

In the long run, phosphate rock-mining capacity is not expected to limit phosphate fertilizer supply. In the short run, rock supplies will be tight until new mining capacity becomes available which at the present time

is limited due to delivery delays in equipment and environmental restrictions in the United States.

Higher rock prices of late have stimulated new investment in rock exploration around the world. The United States, Africa, and USSR will probably continue as the major suppliers of rock for world trade in the immediate future, but Spain and possibly Australia could become important rock exporters by 1978.

Sulfur has joined rock phosphate as a limited raw material. The causes of the rather rapid reversal in supply-demand balance is partially explained by the logistical restraints on sulfur movements from the brimstone fields of Canada plus a host of political and technological constraints associated with marketing sulfur.

In the long run, however, worldwide recovery of sulfur should be sufficient to meet the requirements of the phosphate fertilizer industry. However, in the short run, sulfur prices are expected to remain firm while supplies remain tight.

## Potash Production Capacity

Estimates of the potash supply-demand situation indicate a favorable balance during 1975-76, although there are some indications of serious equipment and mining problems in the Canadian potash fields. Now that the Saskatchewan government has relaxed production controls, capacity utilization is expected to rise from the present rate of 70% to about 85% by 1976. How much of the existing unused capacity can be tapped without substantial investment is not yet clear. However, it is expected that supplies will remain tight even at the new allocation levels.

The only region planning any major expansion in potash capacity is Eastern Europe and Russia. With the expansion the region will strengthen its position as the world's largest producer of potash.

## Kinds of Fertilizer Materials

Although there are many sources of nitrogen, the world market is becoming dominated by urea. Its high nitrogen analysis and technological complementarity with ammonia production has insured urea as a leader in world nitrogen supply. By 1980 it is expected that world urea capacity will exceed 30 million mt with over one-half of this capacity in the developing world. It is estimated that over 40% of the total nitrogen traded in the world market in 1973 was urea. In Asia, especially developing Asia, urea accounts for nearly all of the new-planned nitrogen capacity for dry material production.

The high analysis trend is also true for phosphates. Ammoniated phosphates such as diammonium phosphate (18-46-0), monoammonium phosphate (11-55-0), and high analysis complex fertilizers account for nearly two-thirds of the world's $P_2O_5$ production. With this trend expected to continue, polyammonium phosphate, monoammonium phosphate, concentrated superphosphate, and complex fertilizers will supply most of the $P_2O_5$ and a considerable amount of

the nitrogen and $K_2O$ in world trade.

## High Prices are Bringing about a New Economics

From the present market has emerged the highest fertilizer prices ever. Only a year and one-half ago, $200 would have delivered a metric ton of nitrogen (N) from the United States or Europe to any point in Asia. Today, that same ton of nitrogen will cost somewhere in the range of $850-900.

It is obvious that such prices if passed on to the farmer, will alter the fertilizer-crop price ratio of the past few years, assuming no change in crop prices. This impact is already being experienced in the United States. Prior to 1973 the ratios had been declining, but in 1974 the ratios have increased reflecting the higher fertilizer prices.

The impact of the higher prices is much more significant for those countries which are heavily dependent on imports to supply their fertilizer needs. These are some of the same countries which have limited foreign exchange. Consequently, many developing nations are now considering or have already instituted fertilizer subsidy programs which put even more pressure on national budgets.

As supply and demand come into balance, as expected in the latter 1970's, fertilizer prices will begin to decline but not to the low levels of the late 1960 s nor even to the more moderate prices of the early 1960 s.

## What are the Clues to the Future

In this paper we have alluded to the following suppositions:

1. The world fertilizer shortage will ease when new production capacity comes on-stream but not before a hard year in 1975.

2. For nitrogen, this shortage will continue for the next three years before relief comes.

3. For phosphates, rapid improvement in supply levels is expected with potential significant surplus by 1976-77.

4. For potash, supplies will remain tight and prices firm for the next several years.

5. Fertilizer prices will remain high for the next several years and then decline, but not to the low levels of the late 1960 s.

6. The import bill for developing countries has increased four-fold, giving rise to a serious shortfall for several countries with large food requirements.

For the projected developments as outlined in this paper to come to fruition requires certain actions and/or conditions in the world market.

The availability of feedstocks and at what price for both nitrogen and phosphates is a serious question. Consequently, those who control access to raw materials and energy will, in part, dictate their availability and price.

The ability of the world fertilizer industry to achieve a high level of capacity utilization is essential for successful industrial ventures. Problems with plant downtime because of lack of spare parts, lack of feedstocks, power outages, untrained engineers, etc., have prevented most of the developing nations from achieving high levels of operation.

The high capital cost of building new nitrogen and $P_2O_5$ capacity is causing potential investors to be extremely cautious before rendering investment decisions. Approximately one year ago an ammonia-urea complex (1,000 tpd ammonia and 1,667 tpd urea) cost about $120 million. Today that same complex is quoted at about $220 million assuming normal infrastructure.

The world freight market has added to the woes of those who import. Tramp freight rates per ton today cost as much or more than a ton of nitrogen did several years ago.

Demand for food will continue to dictate the demand for fertilizer. If anything, the correlation between food and fertilizer demands will become even more significant in the future.

The world fertilizer industry appears to be taking, or willing to take, the action necessary to produce sufficient fertilizer to meet demand by 1980. It remains to be seen whether conditions will permit this action to be successful.

## Nitrogen for Pastures

The use of fertilizer nitrogen on tropical and subtropical pastures can generally be economically justified only on improved pastures composed of grasses with a high yield potential, and which are utilized intensively. This is particularly true when fertilizer prices are at the current high level; while prices can be expected to soften somewhat as supply comes into balance with demand, relatively high fertilizer prices are expected to continue. On pastures utilized less intensively, moderate rates of application of phosphate and potash fertilizers to encourage the establishment and persistence of adapted tropical legumes may be the most profitable fertilizer choice.

The efficiency of utilization of fertilizer nitrogen by pasture plants is quite low--only 30-50% of the applied nitrogen is actually absorbed by the immediate crop--the remainder is usually lost by either leaching or volatilization. In the preceding discussion of the nitrogen fertilizer situation, it was noted that urea is rapidly becoming the dominant form of nitrogen fertilizer. However, urea is one of the least efficient sources of nitrogen for topdressed applications, because of volatilization, which is especially high on neutral or alkaline soils. For the most efficient utilization of applied nitrogen, frequent applications at low rates are much more

effective than heavier annual or semi-annual applications. Thus, as nitrogen topdressing of tropical pastures becomes more prevalent, more efficient nitrogen fertilizers will be needed.

The Tennessee Valley Authority has developed a slow-release nitrogen fertilizer at the National Fertilizer Development Center at Muscle Shoals, Alabama. This material is sulfur-coated urea, commonly known as SCU. SCU is granular or prilled urea coated with molten sulfur to form a uniform sulfur base coat on each particle. Depending upon the urea particle size, the sulfur content is about 16% of the product. Following the sulfur application, a thin film of microcrystalline wax or other sealant, such as a mixture of petroleum oil and low molecular weight polyethylene, is applied by spraying the molten sealant onto the sulfur-coated substrate in a second rotary drum, the product contains about 2% sealant. The product is then cooled in a rotary or fluid-bed cooler. In the last unit, a rotary drum, about 3% powdered conditioner is added to offset the tacky nature of the sealant.

Recent improvements in the engineering phase of producing this product (mainly the falling curtain technique) have resulted in a vast improvement in the sulfur coating process. This has led to a more uniform coating of either the urea prill or granule, increased production rates, and thereby shows promise to reduce production costs. Recent engineering estimates incorporating these new improvements indicate SCU should cost no more than 15-20% more per unit of N than regular urea.

Although SCU has been extensively tested with a number of tropical crops, only a limited amount of research has been conducted with tropical pastures. This has been because it was felt that the higher cost of SCU as compared to regular urea could be justified only on high value, intensive crops. A number of experiments have been conducted with warm-season grasses in the sourthern United States. In general, the results of these experiments indicate that yields obtained with one application of SCU in the spring are about equal to those obtained with several split applications of urea or ammonium nitrate when equal amounts of nitrogen are applied. Thus, no yield advantage was noted, and the only advantage was the savings in time and labor due to a single application of SCU as compared to multiple applications of the soluble nitrogen fertilizers. Some preliminary results have been obtained under high-rainfall tropical conditions at Yurimaguas, Peru, by Dr. Pedro Sanchez of North Carolina State University. These results indicate that yields obtained when SCU is applied may be two or three times as high as those when regular urea is applied. But it should be remembered that these are only preliminary results. Furthermore, an extensive series of experiments have been initiated by Dr. Gustavo Cubillos, of CATIE in Costa Rica. When the results are obtained from the experiments in Costa Rica and Peru, then the potential for using SCU on tropical pastures can be evaluated.

In conclusion, nitrogen fertilizers will be in short supply and will be expensive in the immediate future. The potential returns from the use of nitrogen fertilizers in pastures must be sufficient to justify their use. The principal source of fertilizer nitrogen in the world market is and will continue to be urea. More efficient urea-based nitrogen fertilizers such as SCU must be developed and evaluated to increase the efficiency of nitrogen fertilizers applied to tropical pastures.

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Table 1

World Plant Nutrient Consumption

| Fiscal Year | | Nitrogen (N) | Phosphate ($P_2O_5$) | Potash ($K_2O$) | Total |
|---|---|---|---|---|---|
| | | metric tons | | | |
| 1950 | | 3,639,000 | 5,864,000 | 3,994,000 | 13,497,000 |
| 1955 | | 6,521,309 | 7,552,948 | 6,438,865 | 20,513,122 |
| 1960 | | 9,626,357 | 9,531,905 | 8,109,038 | 27,267,300 |
| 1961 | | 10,800,870 | 10,047,939 | 8,435,626 | 29,284,435 |
| 1962 | | 11,868,776 | 10,517,746 | 8,783,042 | 31,169,564 |
| 1963 | | 13,430,491 | 11,310,505 | 9,347,466 | 34,088,462 |
| 1964 | | 14,822,959 | 12,334,088 | 10,083,784 | 37,240,831 |
| 1965 | | 16,404,014 | 13,634,393 | 11,031,100 | 41,069,507 |
| 1966 | | 18,841,520 | 14,772,286 | 12,179,519 | 45,793,325 |
| 1967 | | 21,778,393 | 16,129,403 | 12,978,005 | 50,885,412 |
| 1968 | | 23,936,254 | 16,986,561 | 13,950,337 | 54,873,989 |
| 1969 | | 26,618,116 | 18,197,663 | 14,631,618 | 59,446,322 |
| 1970 | | 28,652,789 | 18,809,668 | 15,441,913 | 62,903,469 |
| 1971 | | 31,720,898 | 19,868,084 | 16,504,912 | 68,092,851 |
| 1972 | | 33,700,259 | 21,090,163 | 17,480,094 | 72,270,516 |
| 1973[a] | | 36,023,000 | 22,766,000 | 18,704,000 | 77,493,000 |
| | | Forecast | | | |
| 1975 | Low | 39,600,000 | 22,900,000 | 19,000,000 | 81,500,000 |
| | High | 44,300,000 | 26,800,000 | 21,800,000 | 92,900,000 |
| 1980 | Low | 53,100,000 | 28,300,000 | 23,500,000 | 104,900,000 |
| | High | 60,800,000 | 34,100,000 | 27,800,000 | 122,700,000 |

[a]Preliminary

Table 2

World nitrogen production capacity forecast, August 1974

| Region | 1965[a] | 1970[a] | 1973[a] | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | Indefinite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *million mt of nitrogen* | | | | | | |
| *Developed* | | | | | | | | | | | |
| North America | 7.3 | 13.6 | 14.0 | 14.3 | 15.0 | 16.7 | 18.2 | 20.4 | 20.4 | 20.4 | 24.5 |
| Western Europe | 9.4 | 13.7 | 15.8 | 15.4 | 15.6 | 16.2 | 17.6 | 18.4 | 18.4 | 18.4 | 19.8 |
| Other[c] | 2.0 | 4.2 | 5.5 | 5.6 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 5.8 | 6.0 |
| Total | (18.8) | (31.5) | (35.3) | (35.3) | (36.4) | (38.7) | (41.6) | (44.6) | (44.6) | (44.6) | (50.3) |
| *Developing* | | | | | | | | | | | |
| Latin America | 1.1 | 1.5 | 2.0 | 2.5 | 2.7 | 4.3 | 5.0 | 6.0 | 6.4 | 7.3 | 8.5 |
| Africa | 0.2 | 0.5 | 0.6 | 0.7 | 0.8 | 0.8 | 1.5 | 2.3 | 2.3 | 2.3 | 4.1 |
| Asia | 0.9 | 3.2 | 5.8 | 6.1 | 7.8 | 8.6 | 9.9 | 11.6 | 11.6 | 12.4 | 19.8 |
| Total | (2.1) | (5.2) | (8.4) | (9.3) | (11.3) | (13.8) | (16.4) | (19.9) | (20.3) | (22.0) | (32.4) |
| Eastern Europe-USSR | 5.5 | 11.3 | 14.6 | 18.5 | 20.3 | 20.4 | 21.2 | 21.4 | 22.9 | 22.9 | 26.3 |
| Other Asia | 1.4 | 3.1 | 4.0 | 4.0 | 4.1 | 4.3 | 7.2 | 7.2 | 7.2 | 7.2 | 8.2 |
| World total N capacity | 27.8 | 51.1 | 62.3 | 67.1 | 72.1 | 77.2 | 86.4 | 93.1 | 95.0 | 96.7 | 117.2 |
| Potential fertilizer supply[d] | 16.4 | 28.7 | 35.6 | 38.2 | 40.9 | 43.6 | 47.3 | 51.2 | 54.5 | 56.3 | – |
| World demand | 16.4 | 28.7 | 36.0 | 39.2 | 42.0 | 44.8 | 47.8 | 50.7 | 53.8 | 56.9 | – |
| Net surplus or deficit | – | – | (-0.4) | (-1.0) | (-1.1) | (-1.2) | (-0.5) | 0.5 | 0.7 | (-0.6) | – |

[a]Actual
[b]Total including plants of unknown status or date of scheduled operation.
[c]Includes Japan, Israel, Republic of South Africa, and Oceania.
[d]Potential supply less distribution losses, 1973-80. Based on a 90% operating level in developed regions and 70% in developing regions after 3rd year of operation.

Table 3

World phosphoric acid production capacity forecast, July 1974

| Region | 1965[a] | 1970[a] | 1973[a] | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | Indefinite[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *million mt of $P_2O_5$* | | | | | | | |
| *Developed* | | | | | | | | | | | |
| North America | 3.3 | 6.2 | 6.7 | 7.0 | 9.1 | 9.3 | 9.9 | 9.9 | 9.9 | 9.9 | 9.9 |
| Western Europe | 1.7 | 3.8 | 4.4 | 4.8 | 5.4 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 | 6.0 |
| Other[c] | 0.4 | 1.3 | 1.5 | 1.4 | 1.6 | 1.6 | 2.1 | 2.1 | 2.1 | 2.1 | 2.3 |
| Total | (5.4) | (11.3) | (12.6) | (13.2) | (16.1) | (16.5) | (17.6) | (17.6) | (17.6) | (17.6) | (18.2) |
| *Developing* | | | | | | | | | | | |
| Latin America | 0.1 | 0.7 | 0.7 | 0.8 | 0.9 | 1.6 | 1.7 | 1.7 | 1.7 | 1.7 | 2.9 |
| Africa | 0.2 | 0.3 | 0.6 | 0.7 | 1.0 | 1.8 | 2.3 | 2.3 | 2.3 | 2.3 | 2.6 |
| Asia | 0.1 | 0.6 | 0.9 | 1.1 | 1.7 | 1.7 | 2.0 | 2.0 | 2.0 | 2.0 | 3.6 |
| Total | (0.4) | (1.6) | (2.2) | (2.6) | (3.6) | (5.1) | (6.0) | (6.0) | (6.0) | (6.0) | (9.1) |
| Eastern Europe-USSR | 1.1 | 2.6 | 4.3 | 5.2 | 5.5 | 5.8 | 5.8 | 5.9 | 6.0 | 6.1 | 7.7 |
| Other Asia | — | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| World total | 6.9 | 15.6 | 19.2 | 21.1 | 25.3 | 27.5 | 29.5 | 29.6 | 29.7 | 29.8 | 35.1 |
| Potential fertilizer supply[d] | 13.9 | 18.3 | 22.4 | 23.7 | 25.6 | 27.4 | 29.2 | 30.1 | 30.4 | 30.3 | |
| World demand | 13.5 | 18.8 | 22.6 | 23.6 | 24.8 | 26.1 | 27.3 | 28.6 | 29.9 | 31.2 | |
| Net surplus or deficit | 0.4 | (-0.5) | (-0.2) | 0.1 | 0.8 | 1.3 | 1.9 | 1.5 | 0.5 | (-0.9) | |

[a] Actual.
[b] Total including plants of unknown status or date of scheduled operation.
[c] Includes Japan, Israel, Republic of South Africa, and Oceania.
[d] Includes normal superphosphate, basic slag, and the phosphate rock contribution to supply from concentrated superphosphate and nitric phosphates, plus estimated potential supply for fertilizer from phosphoric acid. Potential supply, less distribution losses, is based on a 90% operating level in developed regions and 70% in developing regions after 3rd year of operation.

# FACTORS AFFECTING PERSISTANCE OF LEGUMES IN TROPICAL LEGUME-GRASS ASSOCIATIONS

by

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## Introduction

The use of legumes in forage production has been recommended by agronomists in tropical pasture management. These recommendations have been based on results from research conducted in several different places in the tropics, on experiment stations as well as on commercial ranches.

Even though we know the advantages of establishing legumes in association with forage grasses; among them, an increase in forage production especially during the dry season, an increase in crude protein concentration and yield per hectare due to the atmospheric nitrogen fixation in association with soil *Rhizobium*, the improvement of forage quality in terms of digestibility, voluntary intake and animal productivity, as well as improving soil fertility, etc; it can be pointed out that the establishment and maintenance of these associations requires management practices which are not well known among cattlemen in Latin America. The persistance of these systems is fundamental to obtain the benefits in weight gains and animal productivity reported in short and long term field experiments.

## Species Adaptation and Compatibility

The persistance of legume-grass associations is determined by the degree of adaptation of forage species and competition between grasses and legumes. Generally, grasses have a better range of adaptation than legumes and a more vigorous growth habit which allow them to compete better in the association. When forage species show a growth habit and adaptation to the environment which allows the growth of the grass as well as the legume in association we find that the compatibility between species is excellent. For example, the legumes perennial soybean (Glycine weightii) and Centrosema (*Centrosema pubescens* Benth) grow well in association with Paragrass (*Brachiaria mutica*) and Guineagrass (*Panicum maximum* Jacq) respectively, because of the adaptation to similar environment and a growth habit which allows competition for light, water, and nutrients. Table 1 shows the botanical composition of several legume-grass associations evaluated under grazing conditions. In some mixtures more than 20%

legume was maintained in the association, except perhaps during the rainy season. The good compatibility between forage species resulted in a reduction in the weed component.

## Soil Fertility

The natural soil fertility is a very important factor to consider in the selection of forate legumes to establish legume-grass associations. The persistance of the association will depend to a great extent on good legume establishment and its capability of nitrogen fixation in symbiosis with soil Rhizobium. Generally the genus Stylosanthes is better adapted to acid low fertile soils than Centrosema. Phaseolus, Desmodium, Glycine, etc. Phosphorus and sulfur are very important nutrients which are usually limited in a great majority of soils in Latin America; the minor elements zinc and molybdenum are usually deficient and sometimes a manganese deficiency or toxicity may also be limiting soil fertility factors. With regard to calcium and magnesium it depends on the adaptation of legume species to acid soils where these elements may be deficient and potassium could be very important in sandy soils. A correction of soil mineral deficiencies will also improve seed production which will enhance persistance.

Sometimes when soil fertility is high in terms of nitrogen, grass growth is excessive, seriously affecting legume persistance. Therefore, the best results are obtained under nitrogen deficient conditions.

## Insects and Diseases

Tropical forages legumes are usually insect resistant once they are well established. In some cases caterpillars and mites can cause severe defolations when mature vegetative growth is allowed to accumulate as in case of seed production.

Diseases probably are the most serious factors limiting persistance of legumes in association with grasses, especially under wet conditions in the tropics. While grasses are usually more disease resistant or are capable of a faster recovery than legumes, they are very susceptible to fungus diseases which cause severe defolation. The most important legume diseases in the tropics are: antracnose (Collectotrichum sp) which affects the genus Stylosanthes causing lesions on the leaflets and on the stem, Cercospora sp. which causes severe defolation mainly in Centrosema sp, and web-blight Rhizoctonia solani on Siratro and other forage legumes. We also have "Little Leaf Virus" inhibiting leaf growth on Desmodiums. Other diseases like Cylindrocladium sp and rust (Uromyces phaseoli) may be very important on Centrosema and Siratro under wet conditions.

It had been found that under certain conditions, native legumes sometimes show some degree of disease resistance. Therefore, it is important to collect and evaluate native species to select those showing resistance to the most important diseases in each genera.

According to our observations the genus Glycine seems to be fairly resistant to the diseases mentioned before and perhaps this should be taken into consideration to increase its use as a forage plant. Tropical kudzu also seems to be quite resistant to fungus diseases specially in wet environments.

## Grazing Systems

After the legume-grass association has been established with forage species adapted to the environment and having good compatibility and after the soil mineral deficiencies have been corrected, it is important to manage the system to help the persistance of the legume. According to R.R. Evans*, agricultural scientist with many years of experience in evaluating legume-grass associations under grazing conditions in subtropical Australia, we should try to maintain a minimum of around 20% legume in the association to obtain maximum benefits.

Under continuous grazing conditions it is dificult to maintain legume persistance because their recovery from grazing is slower than grasses. Usually the botanical composition in terms of legumes decreases with time regardless of an adjustment in the carrying capacity of the pasture.

Under rotational grazing the opportunity to maintain a good botanical composition is much better because this grazing system not only allows the adjustment in the carrying capacity of the pasture but also a rest period which permits the recovery of the legume after each grazing period. Table 2 shows the results of an evaluation of a Centrosema Guineagrass association under grazing conditions with different rest periods during the dry season in Pichilingue, Ecuador. With short rest periods (14 days) the incidence of weed is greater and with long rest periods (42 days) the percentage legume begins to decline as a component of the pasture. On the other hand, a rest period around 28 days would give us the best results not only in terms of legume persistance but also forage quantity and quality. This grazing system could be established with four paddocks in each pasture and a grazing period of nine days in each one while the others are resting. Another alternative is alternate grazing with two paddocks with four weeks grazing and rest periods.

## Observations and Recomendations

The persistance of the legume should be the most important objective of pasture management in legume-grass associations. To accomplish this objective we can make the following observations and recomendations:

1. The native legumes are very valuable in the botanical composition of the pastures. We should learn to recognize them and to stimulate their growth rather than to consider them weeds. The indiscrimate use of herbicides in weed control in pastures could be very harmful to these plants.

2. The use of a mixture of several legumes in a legume-grass association could be the best way to obtain good compatibility between forage

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*Personal communication

species to give us good legume persistence. We should choose varieties which are disease resistant and adapted to the environment.

3. The correction of soil mineral deficiencies is essential, especially with regard to phosphorus, sulphur, and molybdenum. Continuous fertilization with these elements may be necessary for a while to assure persistance of the legume.

4. The best grazing system which will insure legume persistance is probably rotational grazing with two to four paddocks in which a rest period is allowed after each grazing period. The rest period in most cases should be approximately 28 days, depending upon the rainfall distribution.

Table 1. Botanical Composition of Legume-Grass Associations under Grazing Conditions* in Pichilingue, Ecuador

| Legume-Grass Association | Grass | Legumes | Weeds |
|---|---|---|---|
| | % | % | % |
| Perennial Soybean-Paragrass | 53 | 42 | 5 |
| Centrosema-Guineagrass | 73 | 23 | 4 |
| Tropical Kudzu-Jaraguagrass | 0 | 97 | 3 |
| Stylosanthes-Pangolagrass | 15 | 0 | 85 |

*Seven grazings during 1 year.

Table 2. Evaluation of Centrosema-Guineagrass Association under Grazing Conditions with Different Rest Periods During The Dry Season* in Pichilingue, Ecuador.

| Criteria for Evaluation | Rest Periods (days) | | | | |
|---|---|---|---|---|---|
| | 14 | 21 | 28 | 35 | 42 |
| Yield of dry matter (kg/ha) | 14,864 | 12,865 | 19,265 | 16,390 | 19,802 |
| Crude protein concentration (%) | 18.4 | 16.9 | 14.0 | 13.3 | 12.7 |
| Yield of crude protein (kg/ha) | 2,734 | 2,178 | 2,710 | 2,183 | 2,507 |
| Botanical composition | | | | | |
| Grass (%) | 48 | 53 | 65 | 71 | 71 |
| Legume (%) | 38 | 34 | 28 | 23 | 26 |
| Weeds (%) | 14 | 13 | 7 | 6 | 3 |

*June-December, 1973. Total rainfall 24.2 mm.

# INTENSIVE PASTURE UTILIZATION FOR MILK PRODUCTION IN THE HUMID TROPICS

by

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Milk production in tropical areas has been mainly concentrated in the high altitude areas. These areas greatly resemble the temperate regions of the world due to their mild climate and the forage species utilized for animal production.

Several efforts have been made to transfer dairy production to the low, hot, and humid areas of the tropics with varying degrees of success. One of the limiting factors for efficient production in the lowland tropics has been the usage of breeds and production systems not always adapted to those conditions.

The experience gained at CATIE can be useful for efficient milk production in the lowlands and to help the Latin American countries to make the change over from net importers of dairy products to self sufficiency.

## Dairy Production in the Tropics

At Turrialba, Costa Rica, we have been engaged in determining the productive capacity of improved pastures under intensive utilization systems. This work was undertaken mainly because the success of the dairy industry is dependent upon the efficient utilization of available resources. Among these resources, herbage is usually not well utilized in feeding the ruminant animal, resulting in wastage of the cheapest source of feed and in low economic returns to the animal enterprise.

In order to achieve the greatest possible efficiency in dairy production, one should have a regular and abundant, good quality forage available throughout the year. However, it is necessary to have an estimate of the forage production potential. That is to say, how much milk can a cow produce when its sole source of feed is grass? Evidence coming from different places indicates that, when the animals feed on only one of the following grasses - Guinea grass (*Panicum maximum* Jacq.), Pangola grass (*Digitaria decumbens* Stent), or Napier (*Pennisetum purpureum* Schum.) - they allow for a production of no less than 8 liters per cow per day with 3.8 percent fat. Information from Puerto Rico shows that, under intensive management, African Star grass (*Cynodon niemfuensis*) allows for a production of over 8 liters per cow per day during a reasonable length of lactation.

Under commercial management, milk production per animal is not the only factor to be considered. The economic return of a farm depends upon the individual productivity of the animals and the number of animals on the farm. It follows that the stocking rate has a marked effect in terms of total animal product to be obtained per unit area of land.

## Intensive Management Systems

We have stated that grass is the cheapest source of feed for cattle; therefore, intensive pasture management systems pursue maximum utilization of grass. Methods are designed to facilitate the grazing animal's maximum consumption of herbage grown. One must consider that even a single leaf produced in a sward demands some expenditure of energy. If the grazing management system allows for sizeable losses of the forage grown, then a sizeable amount of energy is being wasted.

Under tropical conditions, the more common opinion is that the rotational grazing systems are superior to continuous grazing. Among the advantages of the rotational systems, the following are often mentioned: a better utilization of the herbage grown, better parasite control, better distribution of manure, and a more uniform grazing. There are quite a few alternatives in rotational grazing systems, ranging from moving the animals to a new area twice daily to changes every 15 or 30 days.

However, it is not only the grazing management system which determines the productivity of a pasture. It also depends upon the stocking rate being used, the grass species of the sward, and the level of fertility of the soil. The producer can exert some influence upon these factors and improve the overall efficiency of production, but there are other factors which are difficult to control. Among these, the effect of climate upon forage growth is of great importance. In the tropics, there are areas where pasture production is almost nil during several months as a result of a lack of enough moisture in the soil. Under these conditions, the use of irrigation is often too expensive to stimulate forage production. Even in the humid tropics, there are marked differences in forage growth rates throughout the year. This means that, when pasture production is low, the producer must utilize other feeding sources if he wants to maintain productivity.

In order to be able to develop an intensive grazing management system, it is necessary to know the production potential of the pasture and to adjust its production to the nutritive requirements of the animals. This implies the utilization of forage species of greater productivity. As an example of variation in sward productivity, the data of Table 1 illustrate some results obtained at Turrialba. These are averages for a commercial herd of 70 to 100 cows and show that, even under a very similar grazing management system, production per unit area depends mainly upon the total amount of forage produced and its utilization by the animal. Under these conditions, Guinea grass has been the least productive due to its low carrying capacity, when 7 days of grazing and 35 days of rest are used. Pangola grass has a carrying capacity more than double that of Guinea grass and, since milk production per cow is the same, the production per unit area is also doubled. With African Star grass, a highly agressive grass, and under a management system similar to the one mentioned above, a stocking

rate of 5.39 cows per hectare can be maintained. Here, even with a lower production per cow, the high stocking rate results in double the milk production per hectare when compared with Pangola grass pastures.

## Milk Production From African Stargrass Pastures at Turrialba

Under the conditions found at Turrialba, some intensive grazing management systems for milk production have been developed and compared. Some details of these systems and their potential for usage under tropical conditions are hereby presented. Two intensive grazing management systems were compared. The first was based on the utilization of well established African Stargrass pastures under a daily rotational system, followed by a variable number of days of rest, according to the season of the year (Method 1). In the second system, the pastures were grazed 7 days and the period of rest varied from 21 to 28 days (Method 2). In Table 2, the results for the whole year's production are given. It can be seen that Method 1 had a production of 14,073 liters of milk as compared to 11,862 liters in Method 2. It is interesting to note that the higher production per unit area was due mainly to the higher carrying capacity of the daily rotation system during the period of flush growth of pastures. This indicated that, in order to obtain maximum utilization of the herbage, special attention should be given to grazing management during the period of more active plant growth.

Since an intensive grazing management system should lead to better utilization of the herbage grown, it is necessary to know how the length of the grazing period may affect animal performance. Table 3 shows the effect of length of grazing period upon milk production per cow. When animals stay on the same pasture, it can be seen that milk production per cow increases initially and then later decreases. This is a response to changes in the protein content and digestibility of the herbage consumed (see Table 4). These changes in forage quality caused a decrease of 10.4 percent at day six, and 18.1 percent at day seven, in daily milk production per cow. The longer the animals stay on a pasture, the lower the forage availability and the lower the possibilities for selection, in addition to the changes in chemical composition and nutritive value.

Table 5 provides some data on forage production from pastures under both management systems. The data refer to the May to November period, the season of greater forage growth. During this time period, Method 1 produced 349.6 kg more dry matter than Method 2, but the utilization percentage was similar. The forage growth rate varied throughout the period and represents the effect of environment upon pasture production.

The high levels of dry matter production reflect the frequent utilization of the herbage grown and adequate fertilization. The latter was based on 250 kg N, 50 kg $P_2O_5$, 40 kg $K_2O$, and 30 kg MgO per hectare per year.

Although the forage growth rates measured were lower than the potential for similar areas, they are adequate for the size of the enterprise used.

Forage utilization in both methods was quite satisfactory since almost all the forage produced was consumed by the animals. A small amount of residual vegetative material was left which was fairly constant in each paddock.

Tables 6 and 7 show the consumption of concentrate, molasses, and grass during the period of more active forage growth. Forage consumption was 12.6 and 17.7 kg per animal per day for methods 1 and 2, respectively; and the conversion efficiencies of 17.7 and 23.5 express kilograms of dry matter consumed for kilogram of milk produced.

In both grazing management systems, 90 to 92 percent of the milk production was attributed to the grass consumed. This demonstrates the capacity of African Stargrass to produce large amounts of milk per hectare with very low levels of concentrate and sugar cane molasses supplementation per cow.

The advantage of one grazing management system over another is based maily on the economic return of the enterprise using them. In this case, the annual economic return expressed in terms of return over capital invested was 11.02 percent for Method 1 and 10.22 percent for Method 2. These results show that both methods allow for milk production with similar response in economic terms. The main difference is due to the lower efficiency of herbage usage in Method 2 which in turn requires a more extensive area of land to produce the same amount of milk. It is interesting to note that, in percentage distribution of the variable costs, the concentrates account for 17 percent and contribute only 10 percent to milk production. It follows that, in order to have an efficient milk production enterprise, one should look for ways to maximize forage usage which is the cheapest source of feed.

Table 1. Average annual production of three different pastures under similar systems of use.

| Type of Pasture | Cows/ha | Milk/Cow/Day | Milk/ha/Day |
|---|---|---|---|
| Guinea grass | 1.06 | 6.9 | 7.31 |
| Pangola grass | 2.57 | 6.9 | 16.48 |
| Star grass | 5.39 | 6.0 | 32.51 |

Table 2. Milk production on African Stargrass pastures under two grazing management systems.

| Month of the Year | Grazing Management System | | | | | |
|---|---|---|---|---|---|---|
| | Daily Rotation | | | Weekly Rotation | | |
| | Cows/ha | Milk/Cow/Day | Milk/ha/Day | Cows/ha | Milk/Cow/Day | Milk/ha/Day |
| December | 4.7 | 6.48 | 33.46 | 4.7 | 6.00 | 28.20 |
| January | 4.5 | 5.70 | 25.65 | 4.5 | 5.90 | 26.55 |
| February | 5.0 | 6.44 | 32.20 | 5.0 | 6.10 | 30.50 |
| March | 5.0 | 7.33 | 36.65 | 5.0 | 6.70 | 33.50 |
| April | 5.0 | 7.56 | 37.80 | 5.0 | 7.10 | 35.50 |
| May | 5.0 | 6.58 | 32.90 | 5.0 | 6.32 | 35.50 |
| June | 6.3 | 5.61 | 35.34 | 6.4 | 5.56 | 31.60 |
| July | 7.0 | 5.22 | 36.54 | 6.5 | 5.11 | 35.58 |
| August | 7.3 | 5.55 | 40.52 | 5.6 | 5.49 | 33.22 |
| September | 8.9 | 6.17 | 54.91 | 5.8 | 6.28 | 30.74 |
| October | 7.9 | 5.96 | 47.08 | 5.7 | 6.07 | 36.42 |
| November | 6.7 | 5.55 | 37.19 | 5.5 | 5.74 | 31.57 |
| Average | 6.11 | 6.18 | 37.75 | 5.39 | 6.03 | 32.51 |
| Total Milk/ha Year | | | 14,073.60 | | | 11,862.12 |

Table 3. The effect of length of grazing period upon daily milk production per cow (kg).

| Cycle No. | Days of Grazing 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1 | 5.24 | 5.58 | 5.89 | 5.74 | 5.69 | 5.44 | 5.29 |
| 2 | 4.92 | 5.30 | 5.23 | 5.35 | 5.18 | 4.60 | 4.71 |
| 3 | 5.08 | 5.19 | 5.36 | 5.32 | 5.26 | 4.93 | 4.63 |
| 4 | 5.50 | 5.81 | 5.87 | 5.93 | 5.70 | 5.07 | -- |
| 5 | 6.14 | 6.42 | 6.29 | 6.38 | 6.21 | -- | -- |
| 6 | 5.64 | 6.06 | 6.45 | 6.25 | 6.12 | 6.08 | -- |
| 7 | 5.57 | 6.22 | 6.43 | 6.38 | 6.14 | 5.81 | -- |
| 8 | 5.33 | 5.65 | 6.15 | 6.20 | 5.81 | 5.45 | -- |
| Average | 5.43 | 5.78 | 5.96 | 5.94 | 5.76 | 5.34 | 4.88 |

Table 4. The effect of length of grazing period upon the quality of forage consumed.

| Days in Pasture | Crude Protein % | Digestible Dry Matter % |
|---|---|---|
| 1 | 14.9 | 68.0 |
| 2 | 12.7 | 63.2 |
| 3 | 12.4 | 61.4 |
| 4 | 11.1 | 56.8 |
| 5 | 11.0 | 58.4 |
| 6 | 10.4 | 56.9 |

Table 5. Dry matter production, rate of growth and percent of utilization of forage by method of grazing.

| Cycle | Method 1 | | | Method 2 | | |
|---|---|---|---|---|---|---|
| | DM Prod. kg/ha/Cycle | Rate of Growth kg DM/ha/Day | % Utilization | DM Prod. kg/ha/Cycle | Rate of Growth kg DM/ha/Day | % Utilization |
| 1 | 2114.00 | 75.50 | 50.59 | 4404.12 | 157.29 | 56.66 |
| 2 | 2009.38 | 61.43 | 113.32 | 912.96 | 57.06 | 142.21 |
| 3 | 1493.62 | 83.77 | 89.80 | 1004.26 | 57.07 | 105.87 |
| 4 | 1762.26 | 87.47 | 111.83 | 1495.53 | 68.76 | 112.02 |
| 5 | 1899.80 | 94.99 | 83.69 | 2048.81 | 124.17 | 99.53 |
| 6 | 1596.16 | 114.01 | 128.78 | 2081.63 | 136.50 | 97.68 |
| 7 | 1946.92 | 97.65 | 84.14 | 2380.99 | 134.14 | 90.11 |
| 8 | 1631.60 | 97.25 | 104.22 | 1681.92 | 93.44 | 111.30 |
| 9 | 1906.10 | 86.83 | 96.65 | --- | -- | -- |
| Average | | 88.66 | 95.89 | | 103.55 | 101.92 |
| Total* | 16,359.84 | | | 16,010.22 | | |

*For a period of 180 days.

Table 6. Forage, concentrate, and molasses consumption and conversion efficiency in grazing Method 1 (kg/animal/day).

| Period | No. of Days | Forage | Concentrate | Molasses | Total | C. E.* | % Due to Forage |
|---|---|---|---|---|---|---|---|
| I | 30 | 10.28 | 0.795 | 0.975 | 12.050 | 15.39 | 85.31 |
| II | 12 | 10.19 | 0.565 | 0.975 | 11.730 | 16.02 | 86.87 |
| III | 27 | 11.06 | 0.474 | 0.975 | 12.509 | 16.72 | 88.42 |
| IV | 100 | 14.05 | 0.291 | 0.975 | 15.319 | 18.86 | 91.73 |
| Average | | 12.63 | 0.429 | 0.975 | 14.033 | 17.70 | 90.00 |

* Conversion efficiency (kg DM consumed/kg of DM produced in milk).

Table 7. Forage, concentrate, and molasses consumption and conversion efficiency in grazing Method 2 (kg/animal/day).

| Period | No. of Days | Forage | Concentrate | Molasses | Total | C. E.* | % Due to Forage |
|---|---|---|---|---|---|---|---|
| I | 30 | 18.79 | 0.795 | 0.975 | 20.560 | 26.95 | 91.39 |
| II | 12 | 14.15 | 0.565 | 0.975 | 15.690 | 22.29 | 90.18 |
| III | 27 | 12.48 | 0.474 | 0.975 | 13.929 | 17.68 | 89.60 |
| IV | 100 | 19.12 | 0.291 | 0.975 | 20.386 | 24.24 | 93.79 |
| Average | | 17.65 | 0.429 | 0.975 | 19.052 | 23.53 | 92.64 |

* Conversion efficiency (kg DM consumption/kg DM produced in milk).

# LEGUMES AND LEGUME-GRASS ASSOCIATION IN THE AMERICAN TROPICS

by

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There are 12,000 species of Leguminosae in the world; of these, 7,000 are tropical and 4,000 are native to the Americas. Stylosanthes, Desmodium, Centrosema, Macroptilium (syn. Phaseolus) are among principal genera in the Americas. Although these legumes are widely distributed throughout tropical America, only limited exploitation has been made of this germ plasm base in the establishment of legume based pastures. In contrast, Australian workers have tapped this germ plasm, selecting and developing varieties adapted to the Australian environment.

This paper will first discuss productivity of legumes and legume-grass associations and will be followed by commentary on considerations in developing improved pastures based on tropical legumes. Principal sources of information are from the Centro Internacional de Agricultura Tropical (CIAT) and the Instituto Colombiano Agropecuario (ICA) in Colombia, and the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA) in Peru.

## Production of Legume and Legume-Grass Based Pastures

### Legumes

Legumes alone would generally be used under two situations, i.e., as fresh cut forage and as a standing forage for deferred grazing.

Examples of fresh cut forage are Desmodium distortum and Stizolobium beerangianum. These forages are generally used as a supplement to low-protein diets during the dry season and for dairy cattle. These legumes are not suitable components of perennial pasture mixtures, being biennial and annual plants, respectively.

Standing legume forage is sometimes used during the dry season as a feed reserve for deferred grazing to provide a high protein forage to supplement low quality, low protein grass pastures. Leucaena leucocephala is and example. It is a browse plant, deeply rooted, withstands drouth, and is suitable for medium to higher fertility soils. It is generally not used under continuous grazing. On occasion, Stylosanthes guyanensis might be similarly used.

Legume-Grass Pastures

Although optimal ratios of grasses and legumes will vary widely depending upon species and environment, available information would indicate that at least 50%, or even more, of legume is desirable in the tropics and sub-tropics. On the other hand, it is generally felt that, if pastures are used all the year round, then some grass mixed with the legume would be preferable to a pure legume pasture. This is in consideration of the generally higher dry matter production of the grasses during the rainy season, their faster growth following early rains, and their tendency to provide more ground cover which controls weeds and minimizes erosion and water runoff.

Legumes contribute in three principal ways to increasing productivity when incorporated in a grass pasture. The legume forage is more nutritious, being especially higher in protein. Secondly, the level of protein is generally sufficiently high that the legume acts as a protein supplement to low protein grass pastures which prevail during the dry season, and also in grass pastures which are marginally deficient in protein in the rainy season. In this instance, the supplemental legume increases digestibility and intake of grass forage. In a series of CIAT investigations, addition of Stylosanthes guyanensis to dry season Melinis minutiflora (3% crude protein) increased total intake, digestibility of consumed dry matter, and increased intake of digestible dry matter from 60 to 100% of maintenance requirements (CIAT, 1973). Thirdly, legumes and soil Rhizobia symbiotically fix nitrogen in the soil, improving nitrogen status and providing nitrogen for enhanced growth of both grass and legume.

In CIAT's beef program, principal emphasis is placed on developing life-cycle beef cattle production systems on pasture, including legume-grass mixtures, pure improved grass pastures, and also native grass pastures. However, particular attention is given to legume-grass improved pastures. Much of the field work in this program is carried out in collaboration with the Instituto Colobiano Agropecuario (ICA) at their Carimagua Station in the heart of the Colombian Llanos. Climates and soil type are similar to those found in other savanna grassland areas, i.e., Venezuelan Llanos and Campo Cerrado of Brazil. The average rainfall is 2,000 mm, the dry season lasts 4 to 5 months, the mean temperature is 27°C, soils are acid (pH 4.5), phosphorus is low (2 ppm), other bases are low (Ca, Mg, K), and exchangeable aluminum is high (3.5 m.e/100 gr) (Spain, 1974).

Predominating native grass genera are Trachypogon, Andropogon, Paspalum, and Leptocoryphium. All species present are regarded to be of low nutritive value and slow growth. Principal naturalized grass species include Melinis minutiflora, Hyparrhenia rufa, and Brachiaria decumbens. During the rainy season, total weight gains are considerably higher on the naturalized grass pastures as compared to the native grass pastures. However, during the dry season, severe weight losses are encountered on all grasses. The only exception would be the bajos, low areas which remain moist during the dry season, and where growth of pasture plants continues.

Adapted improved "naturalized" grasses are available, and establishment methods and management systems are reasonably well defined. However, this is not true with legumes. In many instances, adapted varieties which will persist and are insect and disease resistant are either not available or are just being identified. Further definition is needed on phosphorus fertilizer requirements, establishment methods, required pasture management, and seed production systems. Serious errors have been made in assuming that "overseas" selected varieties and technology would be directly useable in the Latin American tropics.

Annual liveweight gains of animals grazing native grass pastures in the Colombian Llanos have been low, i.e., 8 to 21 kg/ha/yr with stocking rates ranging from 0.2 to 0.5 animal units/ha (Table 1). Whereas nominal weight gains were made in the rainy season, severe weight losses resulted in the dry season (CIAT, 1974).

Table 1. Productivity of native savanna Melinis minutiflora pastures at the ICA Carimagua Station, Colombia.

| Pasture | Stocking rate steers/ha | Weight change/animal (kg) Dry season | Rainy season | Year | Weight gain kg/ha/yr |
|---|---|---|---|---|---|
| Native | 0.20 | 6 | 57 | 63 | 13 |
| | 0.35 | -14 | 75 | 61 | 21 |
| | 0.50 | -27 | 43 | 16 | 8 |
| Melinis minutiflora all year[1] | 0.44 | -54 | 170 | 116 | 51 |
| | 0.88 | -56 | 68 | 12 | 11 |
| Melinis minutiflora rainy season[2] | 0.44 | - | 143 | 143 | 63 |
| | 0.88 | - | 102 | 102 | 90 |
| | 1.30 | - | 67 | 67 | 87 |

[1] 335 days.
[2] Rainy season only (241 days); dry season (124 days, not included.

In comparison, weight gains on Melinis minutiflora pastures have been considerably higher during the rainy season, i.e., 63 to 90 kg/ha/yr with stocking rates ranging from 0.44 to 1.30 animal units/ha (Table 1). However, as with the native grass pastures, severe weight losses were incurred during the dry season, actually more severe than on the native pastures. Although quite acceptable gains were achieved during the rainy season, a large portion of these gains were wiped out by dry season losses (CIAT, 1974).

Although preliminary, results to date indicate that annual weight gains can be sharply increased through use of tropical forage legumes (Paladines et al., 1974). Good weight gains were obtained during the dry season on Stylo-grass pastures (Table 2), whereas cattle on native and improved grass pastures suffered severe weight losses. Performance on the legume-grass pastures has been superior to that of animals on improved grass pastures in the rainy season, both in stocking rate and live weight gain. Stocking rates ranged from 0.90 to 1.70 animals/ha with weight gains of 611 to 800 gm/head/day.

These results are highly encouraging, but it must be emphasized that all currently available commercial Stylo varieties, i.e., IRI 1022, Endeavour, Schofield and Cook, are very susceptible to anthracnose, a fungus disease caused by Colletotrichum sp. (Grof, personal communication). This disease results in reduced plant vigor, defoliation, often death of susceptible ecotypes, and subsequent reduction in stand. Also, some cultivars are susceptible to attack by an unidentified stem borer insect which killed a large number of plants. This emphasizes the importance of identifying adapted varieties of Stylosanthes guyanensis which are resistant to disease and insect attack.

Table 2. Weight gain of steers grazing mixed pastures containing Stylosanthes guyanensis at the ICA Carimagua Station, Colombia.

| Pasture | Stocking rate steers/ha | Weight gain (gm/head/day) Dry season Dec. 73 - Apr. 74 | Rainy season Apr. - Oct. 74 |
|---|---|---|---|
| Stylosanthes guyanensis | 0.50 | 532 | - |
| + Melinis minutiflora | 0.90 | - | 714 |
| | 1.30 | - | 713 |
| | 1.70 | - | 611 |
| Stylosanthes guyanensis | 0.50 | 446 | |
| + spontaneous Gramineae | 0.90 | - | 773 |
| | 1.30 | - | 800 |
| | 1.70 | - | 703 |

These results indicate that incorporation of the tropical forage legume Stylosanthes guyanensis in the swards improved forage quality, especially protein content, which in turn increased consumption of total forage, resulting in increased TDN production/ha/yr, as indicated by increased carrying capacities of the legume-grass swards.

Similar results have been obtained by researchers in the Instituto Veterinario de Investigaciones Tropicales y de Altura (IVITA) at their tropical station in Pucallpa, Peru. This station is located in the Amazon basin. Terrain is undulating, vegetation is of the high rain forest type. Annual rainfall is 1,600 mm and is fairly well distributed, with June, July and August being relatively dry. The mean temperature is 30.8°C. Soils are lateritic clay loams, acidic (pH 3.8 to 5.3), low in phosphorus (1.5 to 4.5 ppm), low in Ca, Mg, and K, and high in exchangeable Al (0.20 to 7.60 m.e/100 gm). Several legume species (Macroptilium atropurpeum, Glycine wightii, Lotononis bainsii, Desmodium intortum, Stylosanthes humilis, Stylosanthes guyanensis, Pueraria phaseoloides, Centrosema pubescens) were observed with associated grass species at Pucallpa. Of these, Stylosanthes guyanensis, Pueraria phaseoloides and Centrosema pubescens appeared to be suitable legumes to develop grass-legume mixtures in that region (Santhirasegaram et al., 1972). Productivity of the legume-grass association was markedly higher than that of the pure grass pastures. Santirasegaram (1974) obtained live weight gains of 352.4 kg/ha/yr with two yearling

Nellore heifers on Pueraria phaseoloides-grass pastures. They observed that, at this stocking rate, only about two-thirds of the available forage was utilized and that potential production was estimated to be 581.7 kg/ha/yr.

Santhirasegaram (1974) also observed that direct phosphorus supplementation is necessary for animals grazing legume-grass associations. Although the legumes have a higher phosphorus content than the grasses, they are still deficient in phosphorus. Spain (1974) observes that, although the phosphorus fertilization level will influence the phosphorus content of tropical forage legumes, it generally will not be economical to fertilize to the level necessary to make the legume forage nutritionally adequate in phosphorus. The fertilization level should be adjusted to achieve optimum dry matter productivity which, for Stylosanthes guyanensis in Carimagua, Colombia, would generally be no more than 40 to 50 kg P/ha at time of establishment and with maintenance levels of no more than 10 to 20 kg P/ha/yr, thereafter. Deficiency of phosphorus in the forage can be corrected by ad lib feeding of a mineral supplement.

Thus far, only live weight gain comparisons have been made between pure grass and legume-grass pastures, with no reference to effect on reproductive performance. Calving percentages are low in most lateritic soil areas, averaging probably no more than 45 to 50% with cows calving every two years (Stonaker, 1974). Inadequate nutrient intake is the principal cause of low reproductive performance and often is accentuated during the dry season when forage protein content declines sharply, often to as low as 2 to 3%. In these situations, the legume could be invaluable in correcting the marked protein deficiency of dry season pasture grasses, acting as a supplement in increasing forage digestibility and intake, and raising the nutritional plane sufficiently to enable the lactating cow to rebreed.

In Pucallpa, preliminary results indicate sharply higher pregnancy rates for cows grazing legume-grass pastures as compared to grass pastures (Santhirasegaram, 1974). Although no data are yet available in CIAT, growth data indicate that the Stylosanthes guyanensis-grass pastures would provide a plane of nutrition adequate for lactating cows to rebreed. Nutrient requirements established by the National Research Council indicate that a ration which would support live weight gains of 500 gm/day in yearling steers would also provide nutrient intake adequate to enable the lactating cow to rebreed. Current live weight gains in Carimagua on the Stylo-grass pastures are well above this amount of a year round basis.

## Developing Pasture Improvement Programs Based on Tropical Legumes

These results and others obtained in the Latin American tropics, when reinforced by the Australian experience, are highly encouraging and illustrate the tremendous potential to increase beef cattle production through use of tropical forage legumes. But there are still some gaps in workable, legume-based pasture systems at the field level. Some of the gaps are technological, some are socio-economic, some relate to availability of inputs. These problems are not only critical, but must be resolved before the legume package will be saleable and workable. Principal constraints are 1) adapted varieties, 2) availability of phosphorus fertilizers, and 3) availability of seed.

## Adapted Varieties

Native tropical forage legumes abound in the Americas. Of these, the Australians have collected ecotypes and developed varieties that will perform under their conditions, which are generally more acid and less tropical than in much of the Latin American tropics. With the success obtained in Australia with these varieties, many organizations were prompted to directly use these varieties in the Americas. Results have been disappointing. The Australian commercial varieties have often not been adapted to the tropical conditions in the Americas.

Susceptibility to disease, insect attack and inability to compete with other species have been common problems. This perhaps seems strange since these varieties were developed from ecotypes collected in the Americas. However, the American ecotypes were selected for Australia, and not Latin America.

But little has been done in the Americas to understand and exploit this germ plasm. There is a job to be done in adequately sampling and evaluating native species. Whereas variability within grass species would appear to be fairly low, natural variability within legume species appears to be quite high. Consequently, the probability of identification of adapted - and superior - ecotypes from the native germ plasm pool must be fairly high.

Identification of adapted varieties which will persist in association with grasses using simple management practices is an absolute requirement. CIAT, in collaboration with national agencies, is now systematically collecting and evaluating selected genera (*Stylosanthes*, *Centrosema*, *Desmodium*, and *Macroptilium*) of tropical forage legumes with the goal of identifying ecotypes that will be adapted to the major tropical ecosystems in the Americas.

## Phosphorus Fertilizer

Establishment of legume based pastures in most humid tropical areas will require the application of some phosphorus fertilizer. Although amounts required for establishment and maintenance are nominal, sizeable quantities of phosphorus fertilizer will be required in a pasture improvement program of any significant dimension.

It is encouraging that in many legume species, maximum response to phosphorus fertilization is obtained at fairly low fertilization levels (no more than 40 to 50 kg/P/ha, and maintenance requirements are low).

## Seed Production

Once adapted varieties are identified, seed production will first be limited by the initiallquantity of seed, which is generally only a few grams; secondly, by time to produce a seed crop which often is as much as a year; thirdly, by multiplication rate which is about 50 to 100 kg harvested for every kilo of seed planted in the case of *S. guyanensis*; and, fourthly, by economic feasibility of commercial seed production. Although

recommended seeding rates are only 2 to 3 kg/ha, total area required annually in seed production would be 2 to 6% of the area to be seeded. These combined considerations all emphasize the importance of developing comprehensive seed production packages that are efficient, economically feasible, and attractive to commercial seed producers. Any large scale pasture improvement program based on tropical legumes will require sizeable quantities of commercially produced seed.

Apart from commercial seed production, sizeable quantities can and should be produced in "on farm" seed production plots. For instance, one kilogram of Stylosanthes guyanensis will seed one hectare, which in 12 months will produce 50 to 100 kg of seed, which if seeded in 50 cm rows would seed as much as 50 to 100 ha. If every livestock farm could seed such an area annually, with an adapted variety that would persist, the beef cattle industry would be revolutionized, and beef production increases would be phenomenal.

## Conclusion

Tropical forage legumes are not new. But, even so, we have not yet exploited this resource, nor do we yet have the comprehensive legume package, i.e., the varieties, fertilizer, and seed production systems to enable us to put tropical legumes to work at the field level. A concentrated and systematic effort will be required to close these gaps.

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# BEEF CATTLE

# PROBLEMS OF ARTIFICIAL INSEMINATION WITH CATTLE IN LATIN AMERICA

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The problems encountered in the Artificial Insemination with cattle in Latin America are essentially the same as those in many other parts of the world, but here the bulk of the cattle suffers from the effect of tropical stress. Pastures of low nutritional value, extended periods of feed shortage, tick-transmitted diseases, widespread parasitism and intense heat combine to play havoc with the fertility of the herds, especially in beef cattle.

The herds of dairy cows are found mostly in the areas which are most suited to its gainful operation, that is where the climate is mild or at the higher elevations in the tropics, which are free of ticks and pastures are high in nutritive value.

For this reason, in this presentation of Artificial Insemination we shall deal only with beef cattle.

## The Equation of Reproduction

In order to properly study the problems of artificial insemination in beef cattle, it is necessary to have a perfect understanding of the equation of reproduction which consists of four variable factors, essentially independent of each other, which determine the percentage of the calf crop to be expected in beef herds using A.I. These are:

A = percentage of the herd inseminated
B = fertility of the herd expressed in %
C = fertility of the semen expressed in %
D = efficiency of the inseminator expressed in %

The equation of reproduction is written as: A x B x C x D, which equals the number of calves born from A.I. and expressed in %. Since we are dealing with percentage figures, the product of the multiplication will always be smaller than the smallest factor involved, and also that the weak factors unduly affect the result obtained. Let us now see what we can obtain through the use of A.I. in a beef herd during a breeding season of a single estrus cycle which covers approximately three weeks. (See Figure #1)

A. Percentage of the Herd Inseminated

Depends on two factors: the percentage of cows in heat and the percentage of cows detected in heat.

The percentage of cows in heat depends primarily on the level of nutrition and whether the cow is dry or nursing a calf. It is also affected by the cow's age and the length of time since calving. The percentage of estrus among the cows may be used as a close estimate of the herd's fertility, since the above mentioned causes affect in a similar way, the percentage of pregnancies. (See Figure #2)

The percentage of heat detection depends on the efficiency of those doing the work and the aids or auxiliary methods used. In Latin America, cowhands are generally very skillful in detecting cows in heat. Of the many helpful aids we consider most appropriate the use of bulls which cannot complete sexual contact and are, besides, affixed with a Chin-Ball marker.

B. Fertility of the Herd

Depends on numerous causes which act collectively or individually on the cows of the herd and we shall point out those which are of greatest importance.

Nutrition. Among the environmental factors, feeding occupies the first place. Sterility due to malnutrition is the most common cause of low fertility in the herds of the Latin American tropics. Pastures provide feed of rather low nutritional value and during the dry season even the dry, scarcily nourishing grass is almost wanting.

Energy. The research work done by Wiltbank has amply shown that an adequate level of total digestible nutrients (TDN) before calving is necessary for the cows to resume rapidly their normal estrus cycle, and that a sufficient level of TDN after calving is also essential in order to maintain a normal fertility. (See Figure #3)

It takes a few weeks to correct the effects of a deficient TDN intake, therefore, we cannot expect that after a long dry season cows will come in heat at the very beginning of the rainy season. (See Figure #4)

Protein. Protein deficiency lessens the cow's appetite with the concurrent loss of weight and the discontinuance of the estrus cycle. Tropical grasses have a low protein content especially after an extended dry season. It is therefore well advised to feed the herd a protein supplement. The benefit from growing grass-legume mixtures has also been shown. (See Figure #5)

Minerals. Phosphorus is the mineral that is most likely to be deficient in the Latin American tropics. Cows with a phosphorus deficiency do not show signs of estrus. The effect of a phosphorous supplement is shown in Figure #6.

Vitamins. Vitamin A is the most important of the vitamins whose deficiency has an influence on the reproduction of the cow. Extended periods of low intake may deplete the reserve of vitamin A. Retention of the placenta is quite common in the tropics after a long dry season. Studies performed in Oklahoma have shown that cows given a vitamin A supplement had 88.5% pregnancies compared to 79.3% for those not receiving the supplement. Similar results were obtained in Argentina. (See Figure #7)

Feeding requirement. The feeding requirement of a beef cow varies according to the different stages of its reproductive year. In looking over this requirement we recognize the importance of inserting the breeding season when pasture grases offer the highest nutritive value. It is important to select this period when the herd is gaining weight in order to obtain a high percentage of cows in heat and, most importantly, a high percentage of pregnancies. (See Figure #8)

Nursing the calf. On calving, the cow is subjected to the competing tensions of nursing and procreating. Unless she is on full feed, a cow nursing a calf will not resume sexual activity and her first estrus after calving will be delayed. An early weaning will cause the reproductive cycle to resume and the cow will be in heat a few days later, which seems to indicate that a hormonal mechanism must have been involved. The effect of weaning on the fertility of nursing cows is still more noticeable in first-calf heifers. (See Figures Nos. 9, 10 and 11)

If a cow has her calf weaned early she will go through the period of feed shortage without the additional burden of nursing a calf, a condition which will benefit her fertility during the following breeding season. If the calves are weaned when they are 4 to 5 months old, their mothers will show a higher fertility rate than those with calves weaned between the ages of 7 to 8 months. This is undoubtedly an advantage in favor of a short lactation.

The fertility curves. The influence of feeding on reproduction when we compare dry cows with those that are nursing a calf is well illustrated in a comparison of the "fertility curves" of two herds in different climatical regions of Argentina: on the one hand a subtropical zone (grass pasture), on the other a humid pampa (alfalfa). (See Figures 12 and 13)

We notice that heifers and dry cows conceive readily in both regions, but that cows nursing a calf have a lower fertility which is much more noticeable in the subtropical zone, especially among first-calf heifers. Furthermore, the proportion of dry cows being serviced is considerably higher in the subtropical zone. Whenever there is a great difference in fertility between dry and nursing cows we can be fairly certain that the pasture grasses are not very nourishing.

Transmissible diseases. Transmissible diseases (infecto-contagious and parasitic) have a great importance. It is simply impossible to attain an adequate level of fertility in a herd if we don't control genital diseases.

Brucellosis and venereal diseases--vibriosis and trichomoniasis--are widespread in certain countries of Latin America. Heifer calves are seldom vaccinated against brucellosis, and venereal diseases are ignored or at the most, receive very little attention. It is also regrettable that in some countries it is spreading the use of vasectomized bulls for the detection of heat, thus contributing to the propagation of venereal diseases.

Parasitism is widespread throughout the tropics. Gastrointestinal parasitism and heavy tick infestation are very detrimental to the proper nutrition of the cow, which naturally affects the fertility of the whole herd.

The heat. The intense heat of the tropics affects the fertility of the cows, especially those of breeds not adapted to this environment and death of the embryo is quite common during extremely hot periods.

Adaptation to the environment. The genetic make-up of the herd is probably the most important factor in its fertility. The adaptability to the environment and the fertility of the herd are closely related. Scientific research and the experience of cattlemen have both shown that the European breeds, no matter how fertile they may be in a temperate climate, do not behave in the same manner in the tropics. The geographic distribution of European breeds on the one hand and the Zebu breeds on the other is quite meaningful. (See Map)

All available information indicates that in the tropics the highest fertility and productivity in a herd is obtained by crossing Zebu breeds with European beef breeds. To the genetic adaptability to the tropical environment of the Zebu is added the beneficial effect of hybrid vigor (heterosis). The half-breed female ($F_1$) is the most fertile. Crossbred cows with a predominance of Brahman blood are more fertile than those with a higher percentage of European blood. (See Figures 14,15,16, 17 and 18)

Artificial insemination is the only practical way to obtain these objectives since it allows all types of crosses to be tried without having to separate the different herds or incurring in the risk of exposing valuable sires of European breeds to a hostile environment.

## C. Semen Fertility

Is a most important factor in the equation of reproduction and very easy to control by the cattleman since he has at his disposal frozen semen of high fertility, obtained from sires free of transmissible diseases, and coming from an organization with a well established reputation. A problem in some countries is the commercialization of frozen semen pellets processed at the ranch and obtained from bulls without the proper sanitary safeguards.

## D. Efficiency of the Inseminator

Is another equally important factor in the equation of reproduction and also easy to control by the cattleman. It depends on the training received by the inseminator and the supervision to which he is subjected.

The inseminator must thoroughly learn how to handle the frozen semen, how to recognize the signs of estrus and how to properly inseminate a cow. Furthermore, he should keep accurate reproduction records of the herd and maintain them up-to-date.

Some Management Recommendations for Artificial Insemination

If the cattleman keeps in mind what each of the factors A, B, C, and D represents and strives to manage the herd in such a way that each factor attains its highest level, the reproductive efficiency of the herd will reach its highest possible peak.

Record keeping is essential for a good herd management. Through reproduction records breeding problems are discovered and in many occasions the causes of such problems can be determined. Records constitute a guide for the cattleman and are the best aid for the veterinarian in charge of the A.I. program. Unfortunately, there is a tendency in Latin America to neglect record keeping.

As much time as possible should be dedicated to heat detection. In some countries it is quite economical to keep the cowboys watching the herd during the entire day. Cows in heat should be marked, for which a paint ball system is recommended. This consists of a compressed gas gun or sling shot to fire the paint ball. As an aid to visual observation, it is highly recommended, particularly in Brahman herds, the use of surgically treated bulls provided with a Chin-Ball to mark the cows in heat. Some ranches combine visual observation during the daytime with the use of detector bulls provided with a marker, during the night hours, with excellent results.

Conditioning and patterning the cows to a daily routine is essential, and it is best to conduct the cows slowly, at the same time every day, to the fenced area where the A.I. installations are located, starting one or two weeks before the breeding season. The installations do not have to be expensive, but they must be well constructed, conveniently located and workable.

When pastures do not offer sufficient amounts of nutrients for the nursing cow, it is necessary to furnish high energy supplements or to wean the calves early, if we want to obtain a good conception rate. On occasions it is difficult to obtain feed supplements or these are too costly. Then, the only alternative would be to supress the tension of nursing. This practice is particularly important to allow first calf heifers to resume sexual activity. Starting the breeding season for heifers one month or more ahead of the regular breeding season is beneficial and would allow a longer period of rest after calving the following year. Also, their calves could be weaned with more than 2-1/2 months of age before the breeding season for the entire herd starts.

To furnish mineral salts with sufficient phosphorus throughout the year more than repays its reduced cost. Synthetic vitamin A injections during periods of feed shortage and before the breeding season, should be part of the herd's nutritional program.

To increase the herd's resistance to the environment through cross-breeding programs directed to maintain a sufficient genetic participation of Zebu breeds, and to obtain the highest possible rate of heterosis should be subject to a careful planning.

Management practices in general, should be directed to minimize the effects of tropical stress over the fertility of the herd and to increase its adaptability to the environment.

## Management Systems for Artificial Insemination

In Latin America, different systems of management have been devised for A.I. programs, which are both simple and logical.

In farms obtaining only 40% conception rate on cows under natural service, it is recommended a management systems that combine A.I. with natural breeding. At the beginning of the breeding season the herd is made up of approximately 25% heifers, 25% open dry cows, and 50% cows either nursing a calf or about to calve. Half the herd which is made up of heifers and open dry cows is artificially inseminated and a 90% rate of pregnancies is expected. The other half of the herd which includes cows with very young calves and those expected to calve during the current breeding season, is sent to pasture with the bulls, and a 30% pregnancy rate is expected. Out of the total number of females at the start of the breeding season, the expected conception rate is 65%. We thus see that two-thirds of the calf crop will result from A.I. and one-third from the bulls of the ranch. (See Programs 1 and 2)

We are aware that these A.I. programs are not ideal, but they bring about a number of profitable achievements such as: an increase in calf crop of which two-third is the progenie of bulls with superior genetics; great advantage from heterosis obtained through the use of bulls not adapted to the environment; and finally, an important saving is realized on the maintainance of bulls since they are used only on cows showing very low heat occurrence. All these improvements will bring in greater profit which will allow the cattleman to introduce other management practices to help him reach still higher goals of productivity.

When the nourishing value of the pastures is increased and the shortage of feed during the dry season is made up through different management practices, the proportion of dry cows entering the breeding season is greatly reduced and the fertility of the nursing cows is considerably increased. Under these conditions, other management systems are advisable as for instance, one in which the entire cow herd is placed on A.I. Some management systems include two breeding seasons, the first one taking place while the grass is lush, and the second one later on when the pastures are less nourishing. The cows failing to conceive during the period of abundant feed get another chance in the second breeding season, after their calves are weaned. Following this system, nearly 85% pregnancies have been obtained in some farms. (See Program #3)

In summary, a beef A.I. program should be logically implemented through the use of simple management systems designed to control the variables of breeding and to facilitate heat detection and cow control.

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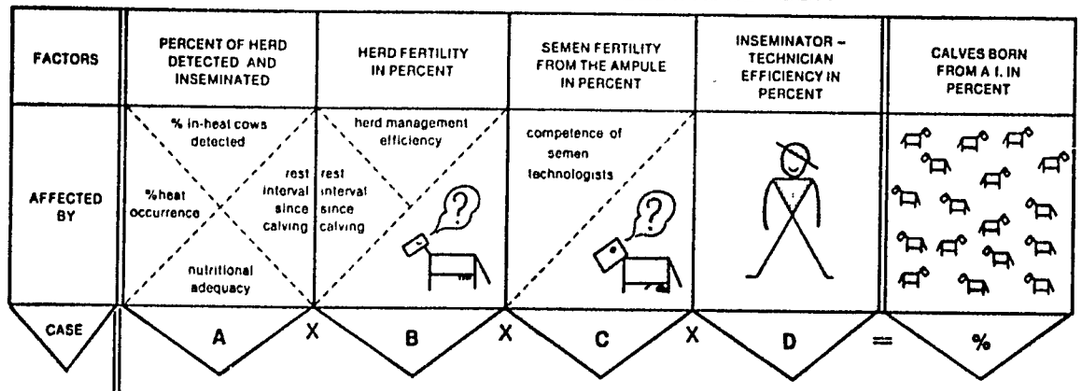
# FIGURE No. 1

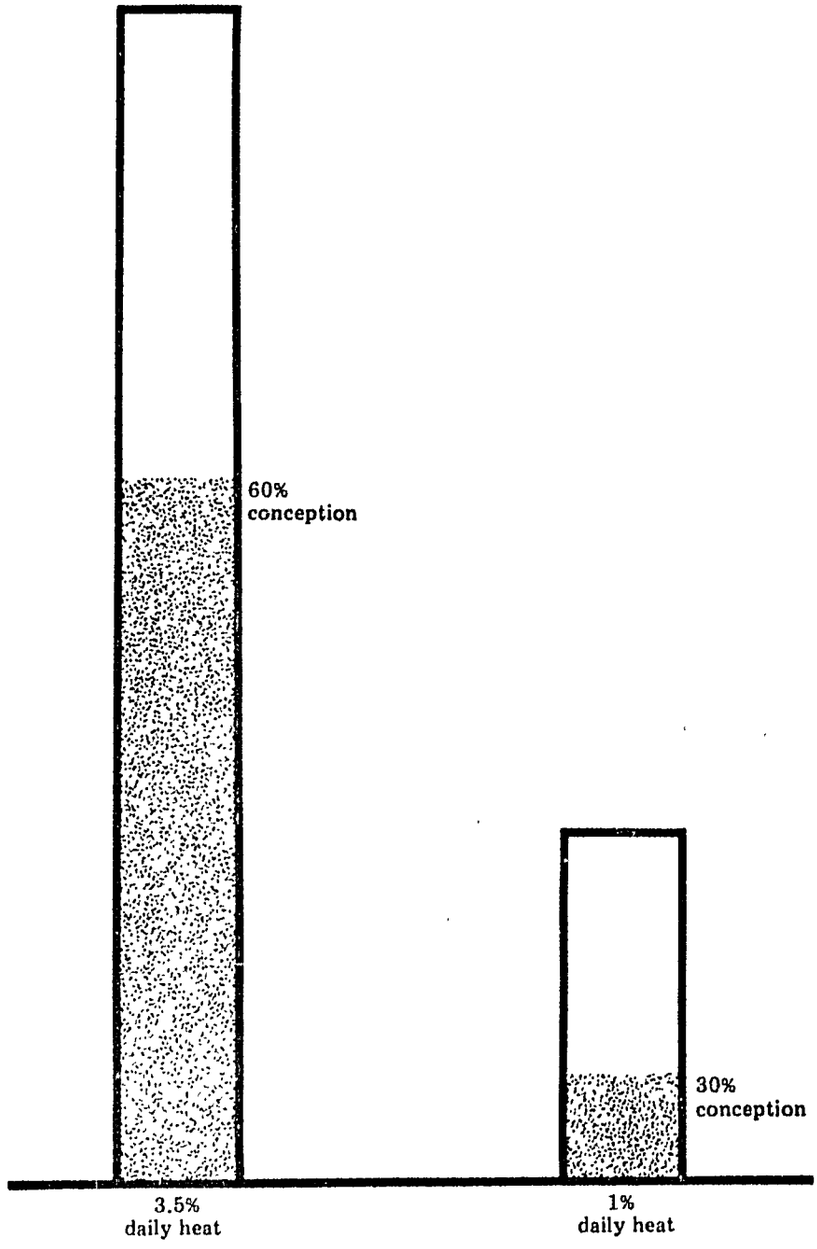
## POSSIBLE RESULTS IN A BEEF HERD FROM A. I. DURING A "ONE CYCLE" BREEDING SEASON




| CASE | | A | X | B | X | C | X | D | = | % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ideal situation. | 95 | x | 90 | x | 95 | x | 100 | = | 81.2 |
| 2 | Good percent of herd inseminated (85%); other factors ideal. | 85 | x | 90 | x | 95 | x | 100 | = | 72.7 |
| 3 | Poor percent of herd inseminated (60%); herd fertility lowered 10%); other factors ideal. | 60 | x | 80 | x | 95 | x | 100 | = | 45.6 |
| 4 | All factors lowered 10%. | 85 | x | 80 | x | 85 | x | 90 | = | 52.0 |
| 5 | Percent of herd inseminated and technician efficiency lowered 10%; other factors ideal. | 85 | x | 90 | x | 95 | x | 90 | = | 65.4 |
| 6 | Fair percent of herd inseminated (70%); semen fertility lowered 10%; other factors ideal. | 70 | x | 90 | x | 85 | x | 100 | = | 53.5 |
| 7 | Poor semen fertility (50%); other factors ideal. | 95 | x | 90 | x | 50 | x | 100 | = | 42.8 |
| 8 | Poor technician efficiency (60%); other factors ideal. | 95 | x | 90 | x | 95 | x | 60 | = | 48.7 |
| 9 | Poor semen fertility (50%); poor technician efficiency (60%); other factors ideal. | 95 | x | 90 | x | 50 | x | 60 | = | 25.6 |

From Bartlett

FIGURE No. 2




RELATIONSHIP BETWEEN CONCEPTION PERCENTAGE ON FIRST SERVICE AND DAILY HEAT PERCENTAGE OF THE HERD.

From Llorens

FIGURE N° 3

Pregnancy rate in cows on different levels of energy

| Feeding regime | | Percent cows pregnant | Percent cows not coming in heat | Percent cows in heat but not conceiving |
|---|---|---|---|---|
| Before calving | After calving | | | |
| High | High | 95 | 0 | 5 |
| High | Low | 77 | 14 | 9 |
| Low | High | 95 | 5 | 0 |
| Low | Low | 20 | 70 | 10 |

From Wiltbank, taken from Beverly.

FIGURE N° 4

Performance of Cows Which had not Shown Estrus on 8.0 Pounds of TDN per Head Daily after Calving Raised to 16.0 Pounds of TDN per Head Daily at 90 Days Post-Calving or Later

| 10 Cows | Showing Estrus | Settling 1st.Service | Ration Change to 1st.Estrus |
|---|---|---|---|
| Changed to 16.0 lb. TDN per head daily | 8 | 5 | 49 days |
| Continued at 8.0 lb. TDN per head daily | 0 | | |

From Wiltbank, taken from Bartlett

FIGURE N° 5

Effect of Protein Supplementation on Reproduction of Commercial Cows* in Improved Pastures

| Group | No. of Cows | % Calvings 1955** | Avg. No. of days Dec. to Calving | % Pregnancy for 1956 |
|---|---|---|---|---|
| Grass - Supplement*** | 14 | 100 | 38 | 40 |
| Grass - No Supplement | 16 | 75 | 80 | 0 |
| Grass/Clover - Supplement | 6 | 100 | 29 | 83 |
| Grass/Clover - No Supplement | 5 | 100 | 33 | 80 |

* 3 yr. old non pregnant cows with calf weaned in October
** 96 day breeding season
*** Cows in grass/clover pastures received 0.68 Kg. cottonseed cake at 36% from Nov. 29/53 to March 2/54; cows on grass pastures received 0.68 Kg. cottonseed cake at 36% from Nov. 29/53 to April 2/54.

From Warnick.

FIGURE N° 6

The effects of three methods of supplying supplemental phosphorus to range cattle in South Texas *

| Item | Group 1 (no phosphorous supplement) | Group 2 (bone meal in self feeders) | Group 3 (disodium phosphate in drinking water) | Group 4 (range fertilized with triple superphosphate) |
|---|---|---|---|---|
| Average weaning weight of calves | 489 | 535 | 542 | 551 |
| Average number of days between calvings | 459 | 365 | 367 | 364 |
| Average annual supplement or fertilizer per cow | - | 56 | 73 | 376 |
| Average percent calf crop weaned | 64 | 88 | 92 | 96 |

*Data is reported for a 4-year study

From Riggs, taken from Beverly

FIGURE N° 7

Conception Rate According to Breed or Cross

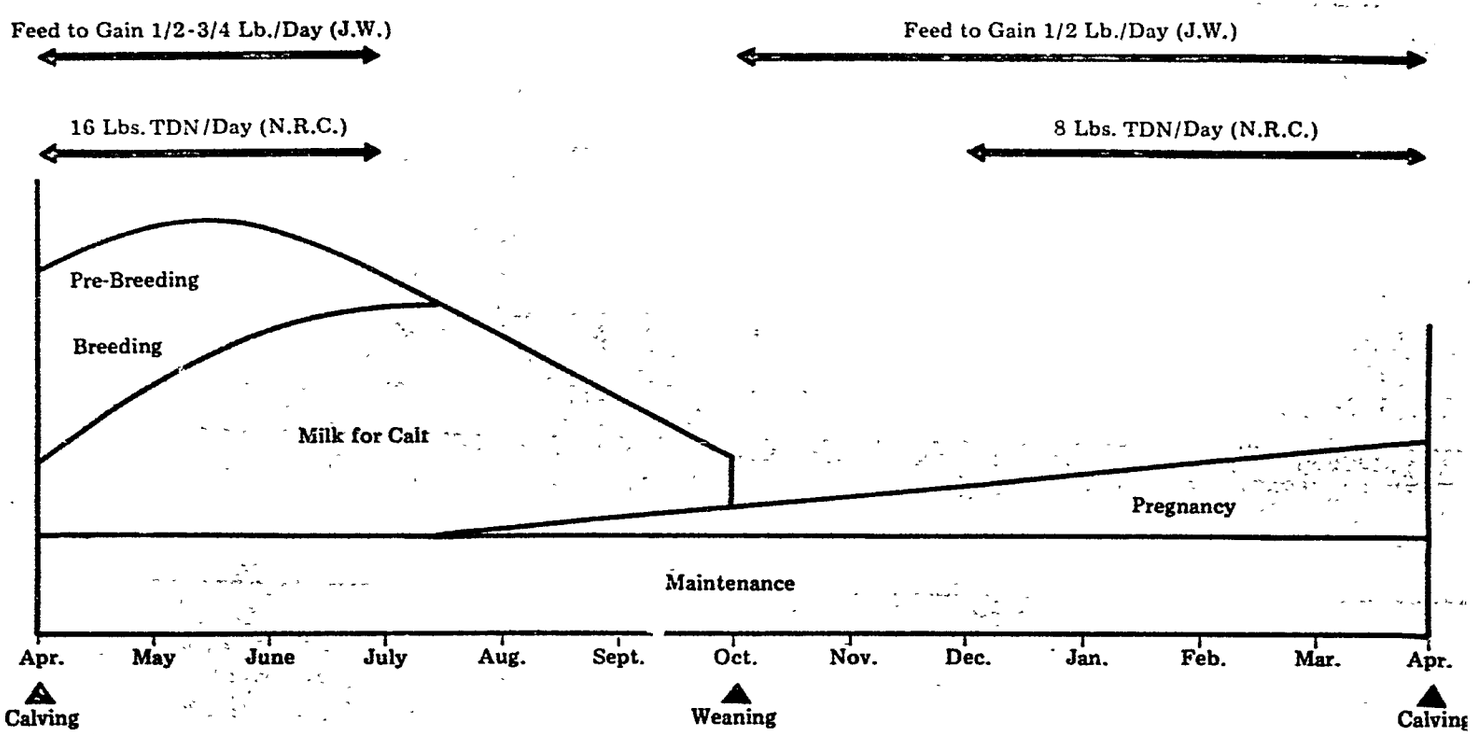
| Breeds or Crosses | With Vitamins A, $D_3$, E * | | | Without Vitamins A, $D_3$, E | | | Difference in favor of those Treated % |
|---|---|---|---|---|---|---|---|
| | No. of Cows | Pregnant | % Conception | No. of Cows | Pregnant | % Conception | |
| Pampas | 360 | 273 | 75.8 | 409 | 258 | 63.1 | 12.7 |
| Hereford | 20 | 19 | 95.0 | 20 | 16 | 80.0 | 15.0 |
| Braford | 86 | 79 | 91.9 | 204 | 180 | 88.2 | 3.7 |
| Aberdeen Angus Cebu | 118 | 31 | 26.3 | 119 | 23 | 19.3 | 7.0 |
| Brangus | 221 | 191 | 86.4 | 208 | 177 | 85.1 | 1.3 |
| TOTAL | 805 | 593 | 73.7 | 960 | 654 | 68.1 | 5.6 |

* Injections of Vit. A = 1,500,000 U.I.; Vit. $D_3$ = 225,000 U.I.; Vit. E = 150 U.I.

From Carrazzoni

FIGURE No. 8

ANNUAL BALANCED RATION REQUIREMENTS - BEEF COW




From Bartlett

FIGURE N° 9

Effect of Early Weaning and Creep Feeding on Breeding Efficiency in Young Heifers *

| | Control heifers | Heifers calves creeped | Heifers calves weaned ** |
|---|---|---|---|
| No. Animals | 7 | 7 | 7 |
| Calf wt. at 60 days | 114 lb. | 99 lb. | 134 lb. |
| Calf wt. at 7 mo. | 352 lb. | 378 lb. | 376 lb. |
| Gain to weaning | 1.54 lb. | 1.80 lb. | 1.55 lb. |
| Percent heifers pregnant | 29 | 57 | 100 |

* 90-day breeding season
** Calves weaned at 60 days of age

From McCartor, taken from Beverly

FIGURE N° 10

Conception Rate in First-Calf Heifers Weaned and Unweaned
(Breeding season from September 1 to December 31)

| Status | Cows Bred | % Conception |
|---|---|---|
| Weaned Oct. 21/72* | 70 | 94.4 |
| Weaned Nov. 18/72* | 70 | 94.3 |
| Nonweaned | 681 | 67.4 |
| Entire Herd | 11,800 | 82.4 |

* Calves approximately 4 months old at weaning.

From Carrazzoni

FIGURE N° 11

Conception for the first 21 days and for the total breeding period

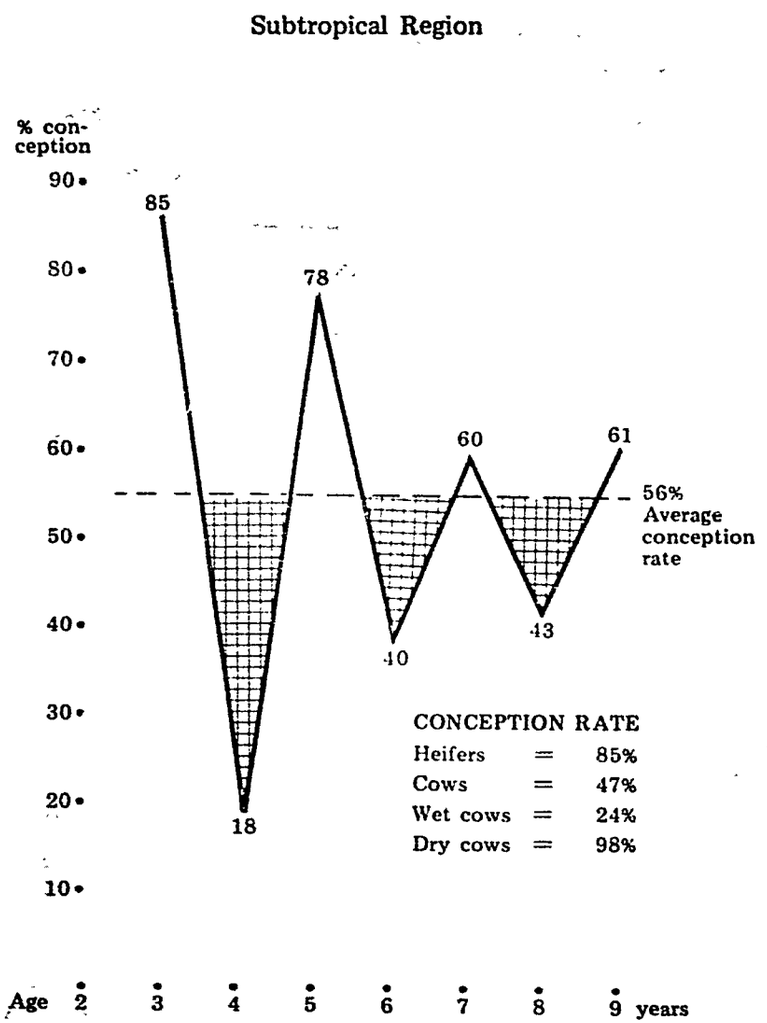
| Cow breed | Weaning status | Conception during 1st. 21 days of breeding: % of total in group | | | Conception during 1st. 21 days of breeding: % of cows inseminated | | | Conception during the 42-day breeding period, % | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2yr-olds | 3 yr-olds | ±4 yr-olds | 2 yr-olds | 3 yr-olds | ±4 yr-olds | 2 yr-olds | 3 yr-olds | ±4 yr-olds |
| Hereford | Weaned | 37.5 | 80.0 | 43.8 | 50.0 | 80.0 | 50.0 | 75.0 | 80.0 | 68.8 |
| | Nonweaned | 50.0 | 46.7 | 35.3 | 100.0 | 77.8 | 60.0 | 57.1 | 46.7 | 47.1 |
| Angus | Weaned | 83.3 | 36.4 | 61.1 | 83.3 | 50.0 | 68.8 | 100.0 | 72.7 | 72.2 |
| | Nonweaned | 41.7 | 42.1 | 39.4 | 71.4 | 72.7 | 65.0 | 41.7 | 63.2 | 78.8 |
| Charolais (1/2) | Weaned | 42.9 | 33.3 | -- | 50.0 | 60.0 | -- | 42.9 | 77.8 | -- |
| | Nonweaned | 27.8 | 47.4 | -- | 50.0 | 81.8 | -- | 38.9 | 68.4 | -- |
| All | Weaned | 52.4 | 44.0 | 52.9 | 61.1 | 61.1 | 60.0 | 71.4 | 76.0 | 70.6 |
| | Nonweaned | 38.6 | 45.3 | 37.3 | 70.8 | 77.4 | 62.5 | 45.5 | 60.4 | 62.7 |
| | Difference | 13.8 | -1.3 | 15.6 | -9.7 | -16.3 | -2.5 | 25.9* | 15.6* | 7.9 |

* P <.05

From Laster

FIGURE No. 12

FERTILITY GRAPHIC




From Llorens

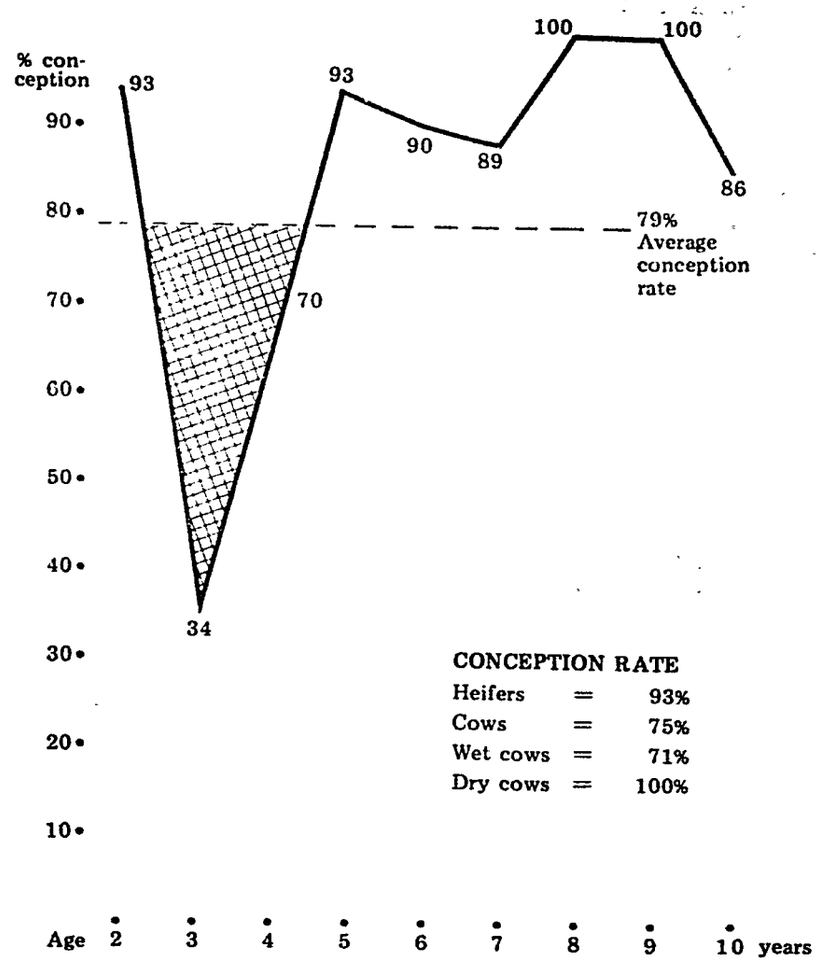


FIGURE N° 13

Interpretation of Fertility Graph

Subtropical Region

| Age Yrs. | No. of females bred during season | | | Pregnancy Test Results Pregnant | | |
|---|---|---|---|---|---|---|
| | Total | Wet cows | Dry cows | Wet cows | Dry cows | Total |
| 3* | 250 | - | - | - | - | 212 (85%) |
| 4 | 200 | 200 | - | 35 (18%) | - | 35 (18%) |
| 5 | 165 | 35 | 130 | - | 127 (97%) | 127 (78%) |
| 6 | 132 | 127 | 5 | 47 (37%) | 5 (100%) | 52 (40%) |
| 7 | 105 | 52 | 53 | 11 (20%) | 52 (99%) | 63 (60%) |
| 8 | 85 | 63 | 22 | 15 (24%) | 22 (100%) | 37 (43%) |
| 9 | 63 | 37 | 26 | 13 (35%) | 26 (100%) | 39 (61%) |
| Total | 1000 | 514 | 236 | 121 (24%) | 232 (98%) | 565 (56.5%) |

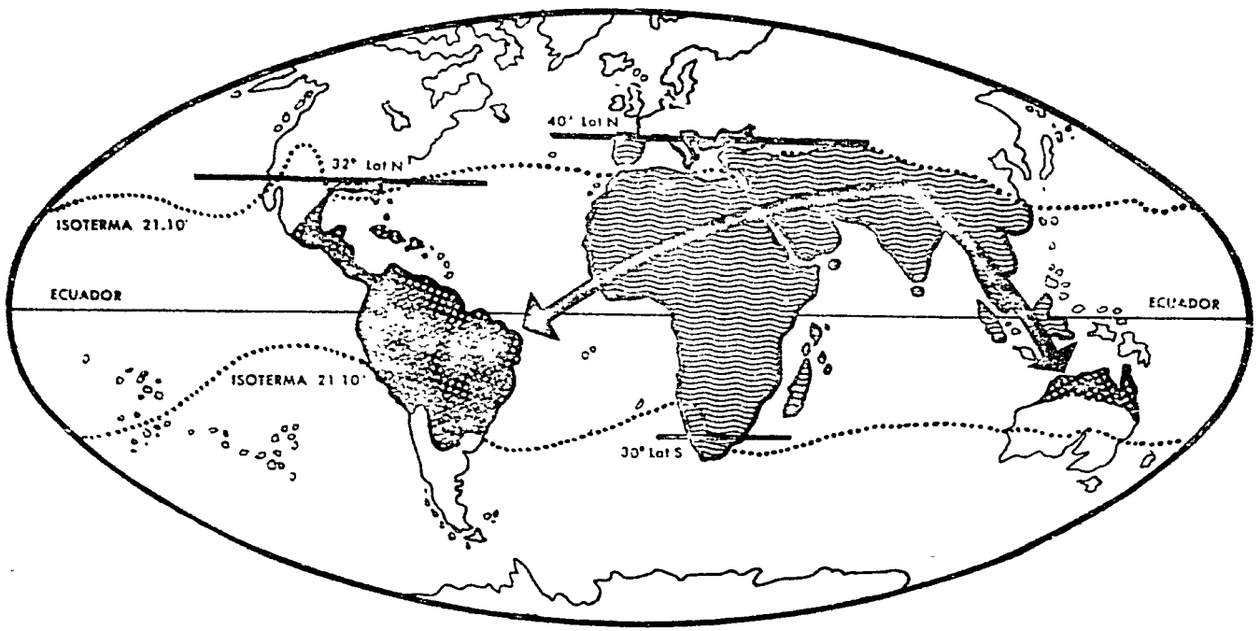
Humid Pampa Region

| Age Yrs. | No. of females bred during season | | | Pregnancy Test Results Pregnant | | |
|---|---|---|---|---|---|---|
| | Total | Wet cows | Dry cows | Wet cows | Dry cows | Total |
| 2* | 200 | - | - | - | - | 186 (93%) |
| 3 | 174 | 174 | - | 60 (34%) | - | 60 (34%) |
| 4 | 134 | 52 | 82 | 12 (23%) | 82 (100%) | 94 (70%) |
| 5 | 118 | 94 | 24 | 86 (91%) | 24 (100%) | 110 (93%) |
| 6 | 100 | 100 | - | 90 (90%) | - | 90 (90%) |
| 7 | 86 | 86 | - | 76 (89%) | - | 76 (89%) |
| 8 | 74 | 74 | - | 74 (100%) | - | 74 (100%) |
| 9 | 62 | 62 | - | 62 (100%) | - | 62 (100%) |
| 10 | 52 | 46 | 6 | 34 (74%) | 6 (100%) | 40 (86%) |
| Total | 1000 | 688 | 112 | 494 (71%) | 112 (100%) | 792 (79%) |

* Heifers

From Llorens

MAP




WORLD DISTRIBUTION OF ZEBU CATTLE

From Helman *et al.*

FIGURE N° 14

Conception Percentage for 2 year old Heifers *

| Group | No. of Cows | % Conception |
|---|---|---|
| Criollas | 34 | 88.2 |
| Brahman | 27 | 77.8 |
| Purebred 1) | 61 | 83.6 |
| Crossbred 2) | 119 | 91.6 |
| TOTAL | 180 | 88.9 |

* Data reported on a 2 yr. study

1) Average Criollas and Brahman

2) Average Criollas/Brahman, Criollas/Sta. Gertrudis, Brahman/Charolais, Brahman/Brown Swiss

From Plasse

FIGURE N° 15

Calving Percentages for Matings of Hereford, Brahman and $F_1$'s

| Dam / Sire | H | B | HB | Mean |
|---|---|---|---|---|
| H | 84.9 | 76.7 | 80.1 | 80.6 |
| B | 63.0 | 74.2 | 81.3 | 72.8 |
| HB | 86.6 | 87.8 | 83.0 | 85.8 |
| Mean | 78.2 | 79.6 | 81.5 | |

From Cartwright

FIGURE N° 16

Weaning Percentages for Matings of Hereford, Brahman and $F_1$'s

| Dam / Sire | H | B | HB | Mean |
|---|---|---|---|---|
| H | 75.4 | 69.9 | 72.2 | 72.5 |
| B | 62.3 | 56.3 | 75.2 | 64.6 |
| HB | 80.1 | 78.5 | 74.0 | 77.5 |
| Mean | 72.6 | 68.2 | 73.8 | |

From Cartwright

FIGURE N° 17

Longevity and Lifetime Fertility of Hereford, 3/4 Hereford-1/4 Brahman and $F_1$ H-B Cows at Lufkin, Texas

| | H | 3/4H 1/4B | HB |
|---|---|---|---|
| No. of Cows | 54 | 16 | 14 |
| Av. age at last calf, yr. | 7.9 | 10.2 | 10.9 |
| Av. no. calves weaned | 4.6 | 6.9 | 7.6 |
| Lifetime calving % * | 58.2 | 67.6 | 69.7 |

* Average no. of calves per year of life in herd.

From Cartwright

FIGURE N° 18

Cumulative Advantage in Production due to Hybrid Vigor*

| Increase of calves weaned | Increase of weaning weight | Increase of Production per cow |
|---|---|---|
| 5.7% | 16% | 25% |

*Based on weaning weight of 400 lb. and 70% calf crop for the purebred.

From Cartwright

## PROGRAM #1

### A. I. Program - Tropical Region

Personal communication from Ing. Guillermo Sánchez, General Manager, Compañías Pecuarias Sucesores de Anastasio Somoza, Managua, Nicaragua.

This program has been established for 12 years and it presently includes over 4,000 cows, distributed in three farms.

Classification of the herd - from July 20 to July 30

| Group | Status | Comments |
|---|---|---|
| 1 | Pregnant cows | To calve from date to October |
| 2 | Open cows with calf | Calved from May to date |
| 3 | Dry open cows | Not pregnant previous year or lost calf |
| 4 | Heifers | Good size and good condition |
| 5 | Heifers and dry cows | Poor condition |

| | |
|---|---|
| Breeding season | August 1 to December 31 |
| Natural service | August 1 to December 31 - groups 1, 2 & 5 |
| A.I. | August 1 to November 15 - groups 3 & 4 |

Heat detection by visual observation along with detector bulls provided with Chin-Ball marker.
Cows bred are marked with a different color each month.
Periodical pregnancy tests to move the pregnant cows, relieving the heat observation pastures.
Follow-up bulls from November 16 to December 31.

Feeding Program

Mineral salts mixed with bone meal on a year-round basis.
Vitamins A, D and E, three injections a year at critical periods.

Health program

Treatment for gastrointestinal parasitism once a year
Treatment for cattle grubs twice a year
Dip treatment for ticks
Vaccinations against existing diseases
Removal of reactors to brucellosis test

Genetic program

Crossbreedings of Brahman/Brown Swiss, and Brahman/Chianina.

Results:

Pregnancy: 65% - Calf crop: 55 to 60%.

- - -

## PROGRAM #2

### A. I. Program - Subtropical Region

Personal communication from Dr. José Manuel Llorens, Technical Director, Instituto de Inseminación Artificial S.R.L., Buenos Aires, Argentina.

Classification of the Herd - two months after breeding season

| Dry cows | | Wet cows with calf | |
|---|---|---|---|
| Pregnant | Open | Pregnant | Open |
| 1 large fetus | 4 normal | 6 large fetus | 9 normal |
| 2 medium fetus | 5 abnormal | 7 medium fetus | 10 abnormal |
| 3 small fetus | | 8 small fetus | |

Distribution of the groups

| | | |
|---|---|---|
| Pasture unit A | Groups 1 and 6 | - large fetus |
| " " B | Groups 2 and 7 | - medium fetus |
| " " C | Groups 3 and 8 | - small fetus |
| " " D | Group 9 | - open cows |
| For sale | Groups 4, 5 and 10 | |

Breeding season

Five months - period of abundant pastures

Natural service

Pasture units A, B and C - Cows calved or will calve within a short period of time.

A.I.

Heifers and cows in Group 9 which are all weaned.

Periodical pregnancy tests to remove pregnant cows, relieving the heat observation pastures.

Results:

65% pregnancy

- - - -

## PROGRAM #3

### A. I. Program - Tropical Region

Personal communication from Dr. Aurelino Menarim Junior, Technical Director, CIPARI, Londrina, Paraná State, Brazil

**Breeding season**

Long season - October 1st. to January 31

Period of good pastures
All cows and heifers except those pregnant during previous short season
Pregnancy test 60 days after end of season.
Open cows will be rebred during the next short season

Short season - June 1 to July 31

Reserve pastures are used
All open cows from long season--all weaned
Pregnancy test 60 days after end of season
Cows not pregnant for sale

During the breeding season the herd is assembled twice a day in a convenient location or small fenced area for heat observation.

Some ranches use detector bulls provided with Chin-Ball marker along with visual observation.

**Health program**

A strict animal health program is followed, including control of infectious and parasitic diseases. Minerals and vitamin supplementation are also provided.

**Results**

85% pregnancy rate

- - - -

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# SYNCHRONIZATION OF ESTRUS: ITS PRESENT USE IN ARTIFICIAL INSEMINATION PROGRAMS

by

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Gainesville, Florida

The two primary advantages of estrous or heat synchronization are (1) to use artificial insemination with outstanding bulls under extensive conditions and (2) to save labor and time in checking cows for heat so they can be bred by artificial insemination. The successful use of estrous control is dependent upon a high percentage of cows in heat during a 2 to 5 day period along with satisfactory fertility comparable to non-treated females.

The cow has a 21 day estrous cycle with approximately 5% of the herd expected in heat each day if all cows are showing regular heat cycles. Most treatments are based on inhibition of heat during a specified period (9 to 20 days) in which the ovaries of all females at the end of treatment do not contain a corpus luteum but have follicles which will mature and ovulate within 2 to 5 days after the end of treatment. A new compound called Prostaglandin acts to cause immediate regression of the corpus luteum and heat then occurs within 2 to 3 days.

In the following discussion the different methods of estrous synchronization will be presented with results of heat and fertility obtained.

## Progesterone Injections

One of the first methods used to control heat was done at Wisconsin by Ulberg *et al*. in 1951 using daily injections of progesterone beginning on the 15th day of the heat cycle and continuing for 14 days. Dairy heifers were injected with progesterone dosages of 50 mg, 25 mg, 12.5 mg, 6.25 mg and 3.125 mg per day to determine effects on heat, ovulation, follicle development and interval to heat from last injection. They found that with 50 mg progesterone injected daily completely inhibited heat and ovulation during the 14-day treatment period and the controlled heat occurred 5.2 days after last injection with a range of 4 to 6 days. The 25 mg dosage inhibited heat but one of 7 heifers ovulated during treatment and was not synchronized. The 12.5 mg dosage allowed follicle growth although heat was inhibited but there was mucous discharge from the vagina. The two lower dosages did not control the estrous cycles.

A larger field study with beef cattle using progesterone injections was done by Ulberg and Lindley in 1960 at Mississippi. A comparison was made of 50 and 25 mg progesterone dosages using estradiol benzoate 72 hours

after last progesterone injection on occurrence of heat and subsequent fertility. Beef heifers and lactating and nonlactating cows were injected daily with the appropriate dosage for 14 days beginning on a given date. Eighty-one % of all females injected with progesterone showed heat within a 9 1/2 day period vs. 97% of all females given progesterone followed by an estrogen injection. The average interval from end of treatment to beginning of heat was 5.7 days for the 50 mg dosage vs. 4.8 days for the 25 mg dosage of progesterone. Table 1 shows the pregnancy results at first heat and service following treatment at the different dosages and treatments in heifers.

Table 1. Effect of Progesterone and Estrogen on Pregnancy Rate in Beef Heifers

| Treat (mg.) | 1st Service | | 2nd Service | |
|---|---|---|---|---|
| Progest./estrogen | No. ♀ | % Pregnant | No. ♀ | % Pregnant |
| Control | 106 | 51 | 36 | 25 |
| 25/0 | 64 | 31 | 41 | 56 |
| 50/0 | 40 | 17 | 39 | 51 |
| 50/8 | 26 | 15 | 19 | 53 |
| 25/0.5 | 9 | 11 | - | - |
| 25/1.0 | 10 | 20 | - | - |
| 25/2.0 | 42 | 38 | 17 | 41 |

There was a reduction in fertility in all hormone treatment groups compared to the control females with the 25 mg progesterone and 2 mg estrogen being best. Thus, a comparison was made in cows using 25 mg progesterone and 2 mg estrogen, table 2.

Table 2. Effect of 25 mg Progesterone and Estrogen on Pregnancy in Cows

| Treatment Progest./Estrogen | 1st Service No. ♀ | 1st Service % preg. | % Pregnancy during 41 days breeding |
|---|---|---|---|
| Control | 32 | 45 | 58 |
| 25 mg/0 | 32 | 46 | 88 |
| 25 mg/2 | 32 | 38 | 63 |

The daily injections of 25 mg progesterone with or without the estrogen gave a pregnancy rate at first service similar to the controls and higher during a 41-day breeding season than the controls.

## Progestogen Feeding

A progestogen which could be fed and inhibit heat was developed by the Upjohn Company in Kalamazoo, Michigan by Dr. Robert Zimbleman in 1963. This material was 6α-methyl-17α acetoprogesterone called M.A.P. and was fed at the rate of 120 to 180 mg daily for 18 days. Heat was inhibited during the 18 day feeding period in 94% of the beef heifers. Of the dairy and beef heifers showing heat following MAP feeding 93% of the females were in heat on the 2nd, 3rd or 4th day after last feeding. The interval range from last feeding to heat was 1.5 to 5.5 days with most beef heifers having an interval of 2 days and dairy heifers a 2.5 day interval. The conception rate at first service following treatment bred

within 7 days after last feeding was 51% vs. 74% for the control females. However, 76% of all treated females conceived within 26 days after last MAP feeding. Thus, although fertility was lowered at the first heat post treatment feeding with MAP the fertility during a 26 day period after the end of feeding was similar to that in control cows.

A group of workers at Montana, Dhinda et al. (1967) fed 180 mg MAP daily to heifers and postpartum cows 45 days post-calving during 18 days under ranch conditions. There was no advantage in feeding the MAP twice daily vs. once daily in estrous control or fertility. MAP feeding suppressed heat during the 18 day period. Eighty-seven % of heifers showed heat within 90 hours after last MAP feeding while only 55% of the postpartum cows showed heat. Only 11% of the control females showed heat during the 90 hour interval. Calving rate to breeding at first estrus after treatment was 33% in 119 treated females vs. 37% among 60 control females, no significant difference. However, calving % to breeding during 3 estrous cycles was 97% in treated and 83% in control females, a significant difference in favor of the treatment group.

Another oral progestogen, Dihydroxyprogesterone acetophenide (DHPA) produced by E. R. Squibb & Sons for estrous control was tested by Dr. J. N. Wiltbank et al. in 1967 at Colorado. They found that 500 mg daily of DHPA fed for 9 days was effective in inducing heat during a 48-hour period in 96% of the beef heifers. In some cases the duration of heat was slightly shorter in hormone fed heifers vs. control heifers. However, the fertilization rate at 3 days and number of embryos at 34-days post breeding were not significantly different between the synchronized and the control females.

In another experiment, Wiltbank and Kasson (1968), fed 400 mg DHPA daily for 9 days and injected 5 mg Estradiol valerate on second day of feeding to beef heifers and cows. They obtained 95% of the heifers synchronized within a 96 hour period with 54% conception on first service. This fertility was similar to that in control heifers. They also found that if DHPA was dissolved in sesame oil prior to mixing with feed 75 mg daily was as effective as 150 or 300 mg dosage not mixed with oil.

Subcutaneous Implants and Injections of Norethandrolone

The use of subcutaneous implants or injections containing Norethandrolone (G. D. Searle & Co., Chicago, Ill.) have been used by Wiltbank et al. 1971 at Colorado and Smith and Vincent 1973 at Louisiana.

Wiltbank showed that an implantation period of 9 days was as effective as a 16 day period in regard to heat synchronization and pregnancy rate after service. He also showed a favorable effect of injecting 5 mg Estradiol valerate on day of implantation and 2 mg Estradiol 17β 24 hours after implant removal.

A comparison of the effectiveness of the above treatment vs. control females on heat control and fertility was made with heifers, 2 year old and 4 year old cows, table 3.

Table 3. Comparison of Norethandrolone Implant Plus Estrogen on Heat and Pregnancy

| Age group & treat. | No. ♀ | % heat 60 hrs. after implant removal | % heat by 22 days | % pregnant after 22 days | % pregnant 45 days | % pregnant at 1st service |
|---|---|---|---|---|---|---|
| Yearling treat. | 27 | 100 | 100 | 43 | 86 | 10[a] |
| Control | 19 | - | 84 | 42 | 68 | 44[a] |
| 2 yr old cows-treat. | 17 | 71 | 94 | 65 | 100 | 54 |
| Control | 14 | - | 72 | 53 | 68 | 57 |
| 4 yr old cows-treat. | 16 | 94 | 94 | 69 | 100 | 67 |
| Control | 14 | - | 86 | 71 | 68 | 75 |

[a] Significant difference (P <.05).

Fertility was reduced at first service in yearlings whereas there was no difference between fertility in treated and control cows. Overall, there were more pregnancies during a 45 day breeding period in the three treated age groups compared to the control females.

Workers at Louisiana used multiple injections of Norethandrolone with heifers and cows to control heat and determined conception. They found better heat control in terms of interval and percent responding when either 2 or 4 multiple injections were given compared to a single injection. The multiple injections were given on day 0, day 10, day 16 and day 18 or 19. The dosage of norethandrolone given on the respective days was 75 mg, 25 mg, 15 mg and 5 mg. A comparison of heat control and conception in postpartum cows is shown in table 4.

Table 4. Heat Control and Conception in Cows Injected with Norethandrolone

| Group | No. cows | % Conception 1st A.I. | % Conception during 60 days | Avg. interval (day) calving to conception |
|---|---|---|---|---|
| 4 Injections | 19 | 16[a] | 79 | 98 |
| 3 Injections | 20 | 15 | 90 | 87 |
| Control | 17 | 47 | 82 | 87 |

[a] Injection groups were significantly (P <.05) lower than control cows.

The conception at first A.I. service was significantly lower for the cows injected with Norethandrolone but the conception during the 60-day breeding season was comparable with the control cows.

## Prostaglandin Injections to Control Heat

Prostaglandins are unsaturated 20-carbon fatty acids and they can be synthesized from Arachidonic acid. The Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) is the form that has been used for heat control.

Workers at Michigan State (Louis *et al.* 1974) have shown that the corpus luteum regresses soon after injection of prostaglandin along with a decline in progesterone hormone levels, table 5.

Table 5. Effect of Prostaglandin on the Corpus Luteum and Hormone Levels

| Item | Hours after treatment 0 | 12 | 24 | 48 | 72 |
|---|---|---|---|---|---|
| Size of C.L. (cm) | 2.5 | - | 1.6 | 0.9 | regressed |
| Progesterone (ng/ml) | 3.6 | 1.7 | 1.2 | 1.0 | 0.8 |
| Estradiol (pg/ml) | 5.0 | 6.1 | 11.3 | 12.7 | 15.5 |

Also, the average interval to heat after prostaglandin treatment was 72 hours with the subsequent estrous cycle averaging a normal 21 day period. The increase in estrogen levels during the 3 days after treatment corresponds to the normal estrogen increase 3 days before a natural heat.

It has been shown that cows injected with prostaglandin during the first 4 days following heat do not respond and will not be synchronized. Also, cows must be coming into heat so they have an active corpus luteum when prostaglandin is injected to have successful heat control.

A large scale cooperative experiment with dairy cows injected with 30 mg prostaglandin was done at Michigan, Louisiana and Florida. Cows were randomly assigned (table 6) to one of the following three groups: (1) control cows not injected and inseminated 12 hours after beginning of heat during an 18 to 21 day interval, group 2 cows injected with 30 mg $PGF_{2\alpha}$ and inseminated 12 hours after heat began during 7 days following prostaglandin injection, group 3 cows inseminated 72 and 90 hours following injection of 30 mg $PGF_{2\alpha}$.

Table 6. Effect of Prostaglandin ($PGF_{2\alpha}$) and Location on Pregnancy Rate (%) in Dairy Cows

| Location | Group: Control | $PGF_{2\alpha}$-AI at estrus | $PGF_{2\alpha}$- AI at 72 & 90 hrs. |
|---|---|---|---|
| Kalamazoo, Mich. | 56 | 38 | 59 |
| Michigan State Univ. | 62 | 90 | 79 |
| Louisiana State Univ. | 48 | 39 | 65 |
| Univ. of Florida | 55 | 32 | 33 |
| Pooled % | 53 | 52 | 56 |
| Number of cows | 122 | 69 | 86 |

There was no significant interaction between location and treatment so the data could be combined for analysis. The authors concluded that fertility in the Prostaglandin treated groups was similar to the control cows and that a timed insemination may be possible.

A cooperative experiment in Florida with beef heifers and cows using Prostaglandin ($PGF_{2\alpha}$) and a Gonadotrophin Releasing Hormone (GnRH) was conducted by Dr. M. J. Fields and coworkers in 1974 at the Brooksville Station and 2 locations in Gainesville. Females that had been in heat and were at least 7 days since heat were randomly allotted to one of the

3 following groups, table 7. Group 1 were control females inseminated at the beginning of heat during a 25 day period, group 2 were females injected subcutaneously with 30 mg $PGF_{2\alpha}$ + 100 µg GnRH 48 hours post $PGF_{2\alpha}$ and AI 63 hours post $PGF_{2\alpha}$; group 3 were females injected with 30 mg $PGF_{2\alpha}$ with AI at beginning of heat period.

Table 7. Effect of $PGF_{2\alpha}$ and GnRH on Heat Control and Pregnancy

| Group No. | No. ♀ assigned | Heat within 7 days post $PGF_{2\alpha}$ | | Interval treat to heat (hrs.) | % Pregnant |
|---|---|---|---|---|---|
| | | No. | % | | |
| 1 | 76 | - | - | - | 36 |
| 2 | 65 | 27 | 42 | 59 | 22 |
| 3 | 72 | 53 | 74 | 77 | 24 |

The percent of cows synchronized was significantly higher in group 3 ($PGF_{2\alpha}$) compared to group 2 ($PGF_{2\alpha}$ + GnRH). Also, the pregnancy percent was significantly higher in the group 1 (Control) cows vs. the treated cows in groups 2 and 3.

When using Prostaglandin to control heat it will be necessary to check heat for a 5-day period previous to injections so those cows in heat during this period are not treated. You could inject that group one week later and have effective heat control.

## Summary

Synchronization of heat in cows has been done successfully under experimental conditions using injections, subcutaneous implants and oral feeding of various hormones. Some of the materials that have been used are progesterone, 6α methyl-17α acetoprogesterone called MAP, Dihydroxy-progesterone acetophenide called DHPA, Noretandrolone and Prostaglandin.

In several experiments 80 to 90% of the treated females have been synchronized within a 2 to 5 day period but the fertility at the controlled heat following treatment is usually reduced from 20 to 30% below the non-treated females. However, this is a temporary situation and fertility at the second heat following treatment is as high or slightly higher than control females.

One of the recent materials, Prostaglandin appears to have a possibility of controlling heat without the usual reduction in fertility at the first heat after treatment. However, it can only be used in cows 5 days and later in the estrous cycle. Also, approval from the Food & Drug Administration has not been obtained so it is still not available for commercial use. I would conclude by saying that heat control is still in the experimental stage and cannot be recommended for commercial producers. Also, there is some hope that in the future timed inseminations can be made in cows following a prostaglandin injection and a Gonadotrophin Releasing Hormone.

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# PRESENT STATUS ON THE CAUSE OF WEAK CALVES AT BIRTH

by

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A condition in cattle where neonatal (newborn) calves are so weak they cannot stand at birth to nurse has been referred to as Weak Calf Syndrome (WCS). This problem has been observed in most straightbred Brahman herds throughout the Gulf Coastal area of the United States, in Central and South America and in Africa. WCS also has been observed in cattle herds (beef and dairy) in the Northwestern United States. There is some evidence, however, that WCS observed in the Northwestern United States is different from WCS observed in Brahman calves.

Several factors can cause weak calves. Among these are high levels of inbreeding, nutritional deficiency of the dam during late stages of pregnancy, reproductive diseases, dystocia (difficult birth), hormonal and placental deficiencies and heavy infections of pathogenic organisms of young at birth. Up to the present time, it has not been possible to suggest which of these factors are directly associated with WCS in Brahman cattle, however, several factors are considered suspect.

Research is in progress at the University of Florida to study WCS in Brahman cattle. The University of Idaho also is studying WCS in the Northwestern United States in cooperation with the National Animal Disease Center at Ames, Iowa. Calf losses up to 30 percent have been observed in many Northwestern herds. Losses in Brahman herds have been smaller, up to 20 percent in some years but generally ranging between 5 and 15 percent.

Research at the University of Florida currently is directed toward understanding physiological differences between normal and weak neonatal Brahman calves. Major emphasis has been placed on blood characteristics. The data collected to date are summarized in table 1. Similar information obtained on normal (no weak calves observed) crossbred calves (7/8 Brahman-1/8 British) also is presented. Birth weight, rectal temperature, pulse rate, a blood sample and rectal swab was taken on calves within 12 hours after birth, and within 6 hours after birth on most calves. Calving pastures were checked three times daily, in early morning, noon and late afternoon.

Weak Brahman calves tended to be smaller, have a lower pulse rate, slightly elevated temperature and exhibit no vigor at the time they were observed. Most weak calves would not respond to assistance to stand. Rectal swab samples did not indicate a presence of unusual bacteria or microorganisms. This more or less suggests that intrauterine subclinical infections

are not present in the cow. Blood parameter estimates gave no abnormal values, however there was evidence that weak calves may be more dehydrated as shown by higher packed cell volume values and possibly are more stressed as indicated by higher corticord hormone levels. All calves appeared to have normal blood sugar levels. Protein level in the blood of weak calves may indicate a slight deficiency in this area and could suggest inadequate protein consumption by the cow during the last trimester of pregnancy.

Inbreeding coefficients were computed on normal and weak neonatal Brahman calves. No association between inbreeding level and incidence of weak calf was found. However, inbreeding levels were not greater than 6.25 percent and could explain why no association was found. Even though no association was found in these data, sufficient experimental evidence in all species exist to suggest that birth weight and vigor or survivability of young decreases with increasing levels of inbreeding. Animal geneticists familiar with development of Brahman cattle in the U.S. speculate that inbreeding in the Breed in general is high, perhaps as much as 25 percent. This would suggest that part of the problem could be the decreased vigor in offspring as a result of high levels of inbreeding.

Work in the Northwestern U.S. has shown that protein intake of the cow during the last 90 days of pregnancy strongly influences the incidence of WCS (Bull, 1974). The importance of protein intake of the female on vigor and learning ability of laboratory animals is well documented (Levitsky and Barnes, 1973). It is also well known that most (two-thirds) of fetal growth occurs during the last 90 days of pregnancy (Brody, 1945). This growth is mostly tissues composed of protein and minerals. The stress of growth of young cows, coupled with the need for nutrients by the developing fetus, may result in a nutrient deficiency that would make the developing fetus susceptible to WCS. Normal growth of a fetus is shown in Figure 1.

A calf weak at birth generally does not nurse during the first 24 hours, unless given assistance. If a calf does not obtain colustrum before 14 hours of age, it does not absorb gamma globulins, or antibody proteins, and is not resistant to infections from numerous viruses, such as Bovine Virus Diarrhea (BVD), Infectious Bovine Rhinotracheitis (IBR), Parainfluenza-3-virus (PI3) as well as others (Kruse, 1970). It is possible that all colustrum does not contain these antibodies. This depends upon whether or not the cow is immune to the disease.

A survey of Brahman breeders in the U.S. has revealed that culling sires as well as cows which produced weak calves has tended to reduce and in some ranches eliminate the incidence of weak calves. This suggests that some genetic variation may be present which is associated with the incidence of WCS. Sufficient data are not available in our Experimental Station herds to assess this consideration. Other evidence in private herds has shown that certain sires tend to sire more weak calves than others, thus supporting the idea of genetic association.

Even though WCS observed in the Northwest may not be closely associated with WCS in Brahman cattle, results from their research could be helpful in understanding WCS in Brahman cattle. Bull (1974) reported that

protein intake of the cow herd during the last trimester of pregnancy was negatively associated (r = -.74) with incidence of WCS. Herds with at least 2 pounds of intake of crude protein per day (average = 2.5) per cow had an incidence of 0.6 percent, herds with 1.5 to 2.0 pounds intake of crude protein (average 1.8) per day per cow had an incidence of 3.4 percent, and herds with less than 1.5 pounds of crude protein intake (average = 1.2) per day per cow had an incidence of 9.8 percent. As the intake of protein dropped below 2 pounds per day, the problem steadily increased. Discussions of private ranch problems with WCS in Brahman cattle have led to the possibility that protein could be a factor here also. In nearly every case, the occurance of WCS could be associated with a low quality or lack of sufficient winter feed, prior to calving in the spring. Ranchers calving in the summer do not have as many instances of WCS as at other times.

Calves born early (prior to normal gestation length) also are weaker at birth and usually are smaller. In general, however, there is no evidence to suggest part of the problem is due to early parturation.

## Summary

The Weak Calf Syndrome (WCS) in Brahman cattle may be due to several factors. The more important of these may be nutritional intake (protein) of the cow prior to calving and increased inbreeding in the breed in general. Once a weak calf is born, other factors contribute to its continued stress. Some of these are cold, damp weather and lack of protection obtained from colostrum for various bacterial and virus organisms. Perhaps also important to prevention of the WCS is culling of sires and dams producing weak calves, assuming some genetic influence. Increased survival of weak calves is realized by giving colostrum to calves prior to 14 hours of age (from its mother or another cow) and keeping the calf warm (if cold). Use of antibodies is also recommended to help the calf fight invading organisms.

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TABLE 1. DATA ON NORMAL AND WEAK NEONATAL BRAHMAN CALVES.

| Trait | Brahman Normal | Brahman Weak | Crossbred (Normal) |
|---|---|---|---|
| Birth weight, lbs. | 66.3 | 62.0 | 66.0 |
| Pulse rate | 136.0 | 118.0 | 142.0 |
| Rectal temperature, °F | 101.5 | 102.5 | 102.0 |
| Packed cell volume | 51.3 | 57.0 | 49.6 |
| Blood urea nitrogen | 14.2 | 9.7 | 10.3 |
| Total protein | 6.5 | 5.2 | 7.5 |
| Albumin | 2.5 | 2.1 | 2.1 |
| Globimun | 4.0 | 3.1 | 5.4 |
| Phosphorus | 7.6 | 6.4 | 7.0 |
| Calcium | 9.8 | 12.1 | 9.7 |
| Glucose mg% | 75.0 | 87.0 | 87.0 |
| Corticords | 42.6 | 67.5 | 38.1 |

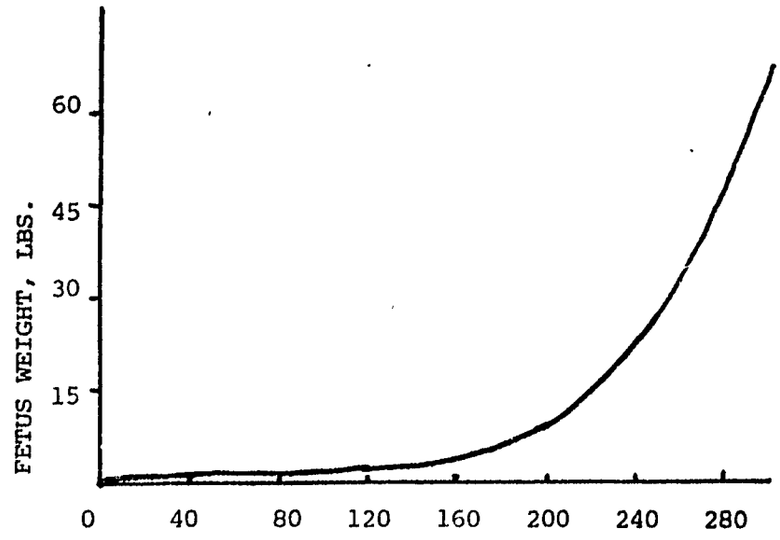


Figure 1. Prenatal growth of calves.

# COMPARISON OF CROSSBREDS FROM EXOTIC AND STANDARD BREEDS

by
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During recent years the term "Exotic" has been applied to newly introduced breeds of cattle that are being tested for their utility in areas other than that where they originated. In the United States the term is used mostly in reference to the large beef and dual purpose breeds which originated in continental Europe. The term is used rather loosely, however, and some of the dairy - beef crosses and more recently introduced British breeds are sometimes included as "Exotics".

In this discussion some of the recent information released on results from crossbreeding studies involving a number of breeds will be summarized. The breeds represented include large continental European breeds (Charolais, Chianina, Gelbvieh, Limousin, Maine-Anjou, and Simmental), British breeds (Angus, Hereford, Red Poll and South Devon), American breeds (Beefmaster and Brangus) and dairy breeds (Brown Swiss, Holstein and Jersey). It should be noted that beef strains of Brown Swiss and Holstein are being developed and that the division between beef, dairy and dual purpose breeds is becoming less discrete. Other breeds are being tested on which data will become available in the near future.

The data presented will be in the nature of a progress report. Firm conclusions will be avoided. An attempt will be made to point out what appear to be significant trends, however.

The utility of a breed for a given situation depends on its impact on the economically important production traits. The more important characteristics include fertility, ease of calving, survival, weaning rate, growth rate, the ability to reach marketable finish under the conditions prevailing and carcass characteristics acceptable to the market. To meet acceptable standards for the above characteristics obviously requires satisfactory adaptability of a breed or its crosses to the conditions where it is to be used. Thus, performance must be evaluated under various environments to be most meaningful. This is an important aspect of breed evaluation just as it is for variety testing in plants. A breed or cross should be tested under a variety of conditions prior to attempting broad generalizations.

## Results From U. S. Meat Animal Research Center

This center (MARC) is located at Clay Center, Nebraska, and has undertaken a comprehensive evaluation of cattle germ plasm from a wide range of

sources. Much of the work will be carried out at Nebraska, however, cooperative arrangements with various states including Florida, are being negociated to test the breeds under different environmental conditions.

Progress Report No. 1 was released in March of 1974. Some of the data of greatest interest to this group are summarized in tables 1 and 2.

The preweaning performance of the $F_1$ progeny from Angus and Hereford dams are shown in table 1. The crosses of these two breeds were combined into one group designated as "British" and are utilized as the reference group in these studies. The $F_1$ progeny of sires of six of the large continental European breeds (Limousin Simmental, Charolais, Gelbvieh, Maine-Anjou and Chianina) two British breeds in addition to Hereford and Angus (South Devon and Red Poll) and two dairy breeds (Jersey and Brown Swiss) were represented in the preweaning data. For this presentation calves from dams 3- to 7-years-old only were included since 2-year-old dams are not common in Latin America.

The preweaning performance of the $F_1$ calves may be summarized as follows: (1) The growth rate of surviving calves paralleled the size of the sire breed, as would be anticipated. (2) The progeny of the large breeds were generally heavier at birth, experienced more calving difficulty and had a lower survival rate than calves sired by smaller breeds. (3) Considering both growth rate and calf survival, total production per cow was remarkably similar for all of the sire breeds represented in this study. It should be pointed out, however, that results could be influenced by breed of dam. If, for example, bulls of the large breeds were mated to dams that had the ability to give birth to the $F_1$ calves without difficulty, breeding to large bulls might increase production appreciably. Also in Florida, birth weights generally are lower than those reported from Nebraska and calving difficulty is less of a problem.

The feedlot performance of a portion of the $F_1$ progenies is shown also in table 1. As with preweaning growth, feedlot gains were positively related to genetic size of the sire breed. Feed conversion, however, showed small differences only, except for the case of the Jersey crosses where feed efficiency was lower than for other breeds. The carcasses from the larger breeds were leaner and the percent of retail product higher than for the smaller breeds. In terms of economics in the U. S., however, the advantage in yield was offset by a reduced quality grade for the larger breeds.

Of greater significance than preweaning and feedlot performance is that of maternal performanc in the crossbred female. This is because of that fact that fertility and maternal performance in the cow herd largely determines the economy of the total production system. Preliminary performance of crossbred females sired by different breeds is shown in table 2. The heifers were mated to produce 3-breed cross calves.

Birth weights were large for all groups with South Devon cross heifers being lightest at 38.6 kg. Calving difficulty was frequent varying from a low of 21.8% in Jersey cross heifers to 47.8% for the South Devon crosses. The percent of heifers which became pregnant ranked by sire breed as follows: Jersey (93.1%), British (90.2%), Limousin (88.1%), Simmental (85.1%), Charolais (84.5%) and South Devon (82.5%). Weaning performance of calves was not reported

## Performance of $F_1$ Crosses in Florida by Sire Breeds of Different Types

In the Florida study summarized in table 3, bulls of eight breeds each were mated to approximately equal numbers of Angus, Hereford and Brangus females. The preweaning and feedlot performance of calves resulting from these crosses is summarized in table 3. Maternal performance of the crossbred heifers is presently being evaluated.

The birth weights of the Florida calves have been markedly lower than those from the Nebraska study. For the five sire breeds included at both locations the average birth weight was 31.8 kg in the Florida study compared with 40.1 kg for Nebraska. Calving difficulty score was low for the Florida cattle with no significant differences between sire breeds. Calf survival to weaning, however, has tended to parallel birth weight although differences were not statistically significant for the numbers involved.

Weaning weights were lowest for the British-sired calves, intermediate for the Limousin, Beefmaster and Brangus while being highest for the Simmental, Brahman and Main-Anjou. In terms of kilograms of calf weaned per calf born (survival % x 205-day weight) sire breeds ranked in the order of Brangus (204), Main-Anjou (200), Simmental (197), Brahman (192), Beefmaster (189), Limousin (185) and British (184). It should be noted that the British sires produced fewer crossbred type progeny than other breeds, resulting in some bias in the comparison. The Brahman crosses are the reference group in this study. For sires classified by breed type, calf weight weaned per calf born was highest for the American breeds (197 kg), second for the "Exotic" (194 kg), third for the Brahman (192 kg) and fourth for the British breeds (184 kg).

## Performance of Crossbreds by Different Sire Breeds in Honduras

The project from which these data came is located at the Escuela Agricola Pan-Americana near Tegucigalpa. It is conducted under the leadership of Dr. Candelario Rios with technical cooperation from the University of Florida Institute of Tropical Agriculture. The Zebu herd (mostly of American Brahman breeding) maintained at the school is used as a reference (control) group. The foundation cows for forming the crossbred progeny groups were predominantly grade Brahman and grade Santa Gertrudis females. Sires of three introduced breeds, (Angus, Charolais and Holstein) representing the British, large continental European and dairy breeds, respectively, were chosen to combine with the Brahman in three 2-breed rotational crossbreeding programs beginning with the foundation cows on hand. The data presented here came from the first generation progeny produced in this trial and include the preweaning growth of the first generation crossbred calves and the maternal performance of the $F_1$ heifers producing backcross calves. The Brahman-sired heifers (except for purebreds) were distributed equally to Angus, Charolais and Holstein sires while daughters of these breeds all were mated to Brahman sires. The data are summarized in table 4.

The most striking feature of the results to date is the superior performance of the crossbred progeny both as preweaning calves and as

young cows. This response is in agreement with numerous previous studies involving Zebu-European crosses.

With reference to progeny of the "introduced" breeds results have been in line with expectations from what is known of the size and general characteristics of the breeds. The growth rates of Charolais and Holstein progenies have been similar and both exceeded that of the Angus-sired calves. On the other hand, Angus calves have had a slightly better condition score and Angus-sired heifers have been the most fertile although numbers are still too small to be conclusive. In terms of calf weaned per unit of cow weight maintained, the Angus-sired females rank first with differences being nonsignificant.

## Summary, Trends and Conclusions

Many of the characteristics of crossbreds by different sire breeds can be predicted in advance from what is known about the breeds involved and type of females to which they are mated. For example, it is axiomatic that large sires mated to indiginous or adapted females will sire faster-growing, leaner progeny than sires of smaller breeds. Associated with this greater genetic size and growth rate, however, will be heavier birth weights and more calving problems. Survival rate is likely to be lowered. These responses may be influenced to some extent by specific combining ability shape and comparative local adaptability of the crossbred groups being compared. There is need, thus, for breed comparisons to sort out the better combinations for given situations. Much time and cost could be avoided, however, by testing representatives of different classes of breeds rather than attempting to test individual breeds from all over the world.

The data from Nebraska has demonstrated the problems arising from mating large bulls to cows of genetically smaller size. Calving difficulty (requiring assistance of some type) averaged 10% compared with 5% in other matings. Death loss at or near birth for the two groups averaged 5.4% and 1.7%, respectively. Gain in the feedlot in $F_1$ cross calves paralleled size of sire breed. Feed conversion was similar for all groups except Jersey crosses where feed requirement was slightly higher. Limited data from the Florida study likewise showed only small differences in feed conversion. In both trials the progeny of the large sire breeds produced leaner carcasses. This attribute could be an asset or detriment depending on market demands and quality of feed available for growing and finishing cattle. It should be recognized that a genetic tendency toward excessive leanness may be a disadvantage in finishing cattle on roughage because of the longer period required to finish leaner cattle to a marketable condition and the impact of condition on % bone in the carcass. The world market will almost certainly discriminate against too much leanness as well as against too much fat.

The most important charcteristic in evaluating breeds and their crosses is that of maternal performance, especially in the 2-4 year old cows. Data of this kind are still too limited to establish definite trends. The Nebraska study shows a high rate of calving difficulty in $F_1$ females mated to produce 3-breed cross calves. In the Honduras study, crossbred heifers entered into rotational backcrossing programs have experienced negligible calving problems. Numbers are too small, however,

to be conclusive at this time. Also, it is recalled that the Honduras heifers all had an undercurrent of Zebu breeding which appears to reduce calving problems as compared with the European and British breeds. Furthermore, birth weights in the southeastern United States and Latin America appear to be lower than for central United States and Canada.

For total production to weaning, data were available only from the Honduras Project. Considering both weaning rate and weaning weights, total annual production per cow has been almost identical for young crossbred females sired by Brahman, Angus, Charolais and Holstein sires.

Table 1. Summary of Preweaning and Feedlot Performance of Eleven Different $F_1$ Crosses in the Nebraska Study. Data shown include progeny from 3- to 7-year-old dams only.

| Sire-breed of progeny | Calving difficulty | Died at or near birth | Birth weight | Adj. 205-day weight | Daily gain on feed | Adj. final weight | Feed efficiency | Carcass quality | Retail product |
|---|---|---|---|---|---|---|---|---|---|
| | % | % | kg | kg | kg | kg | TDN/gain | grade | % |
| Cycle 1 | | | | | | | | | |
| British | 6.8 | 0.5 | 37.0 | 216 | 1.06 | 473 | 6.75 | 11.9 | 65.1 |
| Jersey | 1.2 | 2.5 | 33.1 | 205 | 0.99 | 447 | 7.07 | 11.7 | 65.1 |
| South Devon | 17.3 | 4.1 | 38.9 | 217 | 1.12 | 484 | 6.73 | 11.8 | 66.2 |
| Limousin | 12.6 | 4.1 | 39.2 | 219 | 1.05 | 480 | 6.56 | 10.7 | 69.8 |
| Simmental | 17.3 | 5.9 | 41.3 | 227 | 1.16 | 509 | 6.61 | 11.1 | 68.4 |
| Charolais | 24.1 | 8.7 | 41.7 | 229 | 1.17 | 512 | 6.62 | 11.4 | 69.3 |
| Cycle 2 | | | | | | | | | |
| British | 8.1 | 2.9 | 37.0 | 194 | - | - | - | - | - |
| Red Poll | 3.1 | 1.0 | 37.2 | 195 | - | - | - | - | - |
| Brown Swiss | 9.2 | 1.0 | 40.1 | 205 | - | - | - | - | - |
| Gelbvieh | 11.8 | 4.9 | 39.9 | 209 | - | - | - | - | - |
| Maine-Anjou | 21.7 | 8.0 | 42.7 | 206 | - | - | - | - | - |
| Chianina | 14.3 | 6.7 | 42.3 | 214 | - | - | - | - | - |

Table 2. Performance of 2- and 3-year-old $F_1$ females in the Nebraska study[a].

| Breed of Sire[b] | Number of matings | Average weight | Calf birth weight | Calving difficulty[c] | Postpartum interval[d] | Pregnancy rate[e] |
|---|---|---|---|---|---|---|
| | | kg | kg | % | Days | % |
| A or H | 126 | 422 | 41.9 | 40.1 | 75 | 90.2 |
| Jersey | 118 | 364 | 41.9 | 21.8 | 75 | 93.1 |
| South Devon | 94 | 440 | 38.6 | 47.8 | 70 | 82.5 |
| Limousin | 123 | 438 | 44.4 | 33.9 | 70 | 88.1 |
| Simmental | 128 | 448 | 41.9 | 42.5 | 71 | 85.1 |
| Charolais | 107 | 477 | 42.5 | 37.4 | 74 | 84.5 |

[a] Abstracted from Report No. 1 (ARS-NC-13) Germ Plasm Evaluation Program. March, 1974.

[b] Each group of $F_1$ heifers contained approximately equal numbers from Angus and Hereford dams.

[c] Required assistance.

[d] Interval to first estrus.

[e] In parous heifers.

Table 3. Preliminary summary of performance of $F_1$ crosses in Florida by sire breeds of different types.[a]

| Sire Breed of $F_1$[b] | Preweaning Performance | | | | Feedlot Performance | | | |
|---|---|---|---|---|---|---|---|---|
| | Birth wt., kg | Calf surv. % | Adj. 205-day wt., kg | Condition score[c] | Daily gain, kg | Feed efficiency[c] | Carcass grade[d] | Estimated yield, %[e] |
| Angus and Hereford combined | 27.7 | 94.6 | 195 | 9.2 | 1.27 | 671 | 11.9 | 47.2 |
| Brangus | 28.1 | 95.3 | 214 | 9.9 | 1.09 | 710 | 10.8 | 48.5 |
| Beefmaster | 31.3 | 89.5 | 211 | 9.4 | 1.34 | 658 | 10.9 | 49.0 |
| Brahman | 33.6 | 84.8 | 226 | 10.0 | 1.25 | 701 | 11.1 | 48.4 |
| Limousin | 32.7 | 89.2 | 207 | 8.7 | 1.21 | 660 | 10.1 | 50.7 |
| Maine-Anjou | 34.0 | 88.3 | 227 | 9.2 | 1.38 | 677 | 11.6 | 49.8 |
| Simmental | 32.7 | 87.1 | 226 | 9.6 | 1.40 | 680 | 11.2 | 50.3 |
| Average by breed type: | | | | | | | | |
| British | 27.7 | 94.6 | 195 | 9.2 | 1.27 | 671 | 11.9 | 47.2 |
| American | 29.7 | 92.4 | 213 | 9.6 | 1.22 | 684 | 10.8 | 47.8 |
| Zebu | 33.6 | 84.8 | 226 | 10.0 | 1.25 | 701 | 11.1 | 48.4 |
| Exotic | 33.1 | 88.2 | 220 | 9.1 | 1.33 | 672 | 11.0 | 50.3 |

[a]Preweaning data were from a total of matings over a three-year period at the Belle Glade station. Feedlot data represent one year only.

[b]Each sire was mated to approximately equal numbers of Angus, Brangus and Hereford dams.

[c]Feed required per 100 units of gain.

[d]Scores of 8, 9, 10, 11 and 12 = high standard, low good, high good and low choice, respectively.

[e]Closely trimmed boneless cuts.

Table 4. Preweaning and Maternal Performance of Crossbreds by Different Sire Breeds in Honduras[a].

| Breed group | No. of matings | Percent pregnant | Percent survival | Percent weaned | Weaning age, days | Weaning wt. kg | Adj. 205 wt. kg | Condition score |
|---|---|---|---|---|---|---|---|---|
| | | | Preweaning Performance (1972-1974) | | | | | |
| Purebred Brahman | 109 | 86 | 90 | 78 | 240 | 198 | 176 | 9.7 |
| Brahman crosses | 229 | 89 | 94 | 84 | 247 | 221 | 198 | 9.7 |
| Angus cross | 93 | 92 | 97 | 89 | 255 | 217 | 188 | 10.3 |
| Charolais cross | 89 | 90 | 97 | 87 | 250 | 221 | 196 | 10.0 |
| Holstein cross | 90 | 85 | 97 | 82 | 257 | 233 | 203 | 9.0 |
| | | | Maternal Performance of Young Cows (1973-1974) | | | | | |
| Purebred Brahman | 70 | 81 | 89 | 72 | 232 | 196 | 179 | 10.0 |
| Brahman crosses | 210 | 82 | 95 | 78 | 249 | 230 | 205 | 11.0 |
| Angus cross | 43 | 100 | 92 | 92 | 261 | 218 | 194 | 10.0 |
| Charolais cross | 53 | 92 | 92 | 85 | 248 | 241 | 210 | 11.0 |
| Holstein cross | 44 | 82 | 94 | 77 | 243 | 239 | 225 | 10.0 |

[a]Data through courtesy of Dr. Candelario Rios, Escuela Agricola Panamericana, Tegucigalpa.

# SUGGESTIONS FOR IMPROVING REPRODUCTION IN BEEF CATTLE

by

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## Introduction

Reproduction in cattle is the single most important factor affecting "Percent Calf Crop" and, thereby, determining the profitability of a cow-calf program. Many cattlemen today normally have high calf crop percentages, but there is still room for improvement, even in those herds with greater than 90%. This is particularly true with the advent of multiple births, sexed semen, frozen embryos and non surgical embryo transfers. In 1974, there were 1,232,000 beef cows in Florida, a 13% increase over 1973. However, for all of the state there was only a 72% calf crop. Approximately 1/4 of our cows are not contributing to the income of the cattlemen. A 10% increase in the percent calf crop to 82% would mean for the state, an increase in gross income of 128,200 calves, averaging $160 per head or $20,512,000 per year.

The impact of the percent calf crop harvested on the net return to a cow-calf operation can be seen in Table 1. As the percent calf crop declines, cost per calf increases and return per calf decreases.

Table 1. Influence of Percent Calf Crop on Cost and Return Per Calf

| Percent Calf Crop | Cost per Calf* | Return per Calf 500 lb | Return per Calf 400 lb |
|---|---|---|---|
| 100 | $110 | 590 | 550 |
| 90 | 122 | 78 | 38 |
| 80 | 138 | 62 | 22 |
| 70 | 157 | 43 | 3 |
| 60 | 183 | 17 | -23 |

*These figures based on a market price of 40¢ per pound and a cow operating cost of $110.00 per year.

These figures will fluctuate between individual operations, nonetheless, they are indicative of how a reduction in calf crop will lower net returns. The 10% drop from 100 to 90% in calf crop weaned increases the cost of each calf weaned by $12 and reduces at the same time the profit from each calf

by $12. Note the influence of weaning weights on return per calf. An increase of 100 lbs. per calf weaned has a dramatic effect on net returns, i.e., $90 versus $50. However, management practices designed to increase weaning weights and, thereby, net returns have a minimal effect when working with a low percent calf crop. Under these conditions, return per calf declines precipitously along with the number of calves marketed. Extrapolating these figures to a 200 cow herd a decline from a 100 to an 80% calf crop weaned results in a loss of $8,000 profit on 500 lb. calves:

| | |
|---|---|
| $ 110 | Cost to maintain each open cow |
| +$ 90 | Cost in profit from each open cow |
| $ 200 | |
| X 40 | No. of calves lost due to 20% reduction in calves weaned for 200 head |
| $8,000 | Profit loss |

Expressed in a different context, an open cow consumes the profit of one weaned calf, i.e., each calf earning $90 profit goes to recover the $110 cost to maintain each cow not calving.

Weaning 400 lb. instead of 500 lb. calves at these prices with a 60% calf crop will cost $23 per calf just to stay in the cow business. Theoretically, if you weaned a 100% calf crop at 400 lb. rather than at 500 lb. weaning weights, the 100 lb. reduction in weaning weight would have cost you $8,000 for a 200 cow herd.

| | |
|---|---|
| $ 90 | Profit from 500 lb. calves at 100% weaning |
| - | |
| $ 50 | Profit from 400 lb. calves at 100% weaning |
| $ 40 | Loss in profit |
| X 200 | 200 cow herd |
| $8,000 | |

Weaning 400 lb. calves rather than 500 lb. calves coupled with a 20% reduction in calf crop on a 200 cow herd would result in a loss of potential profit of $14,400

| | |
|---|---|
| $ 8,000 | Loss due to 80% calf crop |
| + 6,400 | Wean 160 calves at 400 lb. |
| $14,400 | Potential profit loss on 200 hd. herd |

These figures may not apply to your operation particularly if you are operating above an 80% calf crop and weaning heavier than 400 lb. calves. Fluctuating prices will also influence these figures of loss and profit, however, the concept of this profit loss applies to every operation.

It is the purpose of this report to: (1) Identify the calf losses contributing to less than a 100% calf crop and the reasons for less than a 500 lb. weaning weight from a reproductive vantage point and (2) To offer alternatives in management, whereby, adjustments for individual operations should yield an improvement in reproduction and relief from these losses.

## Identification of Calf Losses

Various factors influencing the percent calf crop harvested compiled from the Beef Cattle Experiment Station at Brooksville and the Beef Research Unit at Gainesville from 1951 to 1973 are shown in Table 2. It is clearly demonstrated that the most significant factor contributing to a reduction in calves weaned was the 21% of the cows that failed to become pregnant. Other factors negatively influencing % calf crop harvested accounted for only 5.8% of the failures.

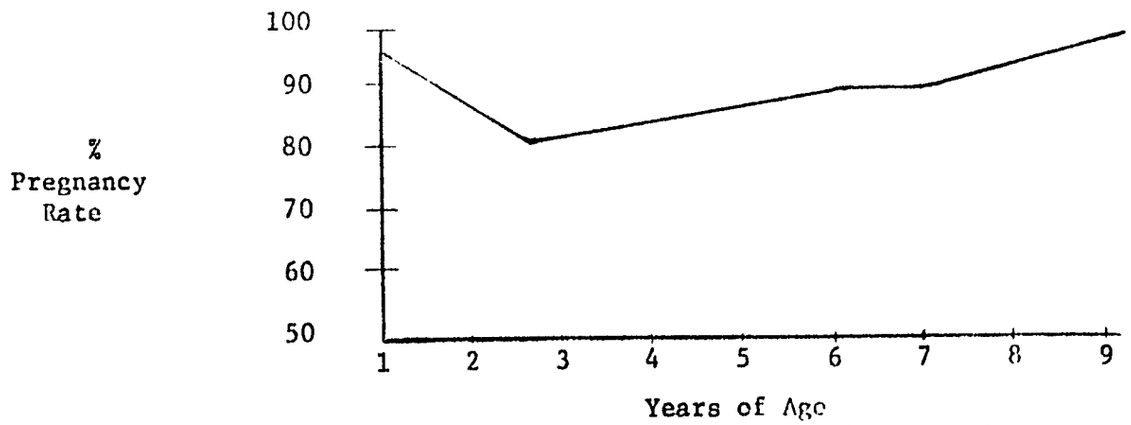
Table 2. Factors Influencing the % Calf Crop Harvested*

| Factors | | |
|---|---|---|
| Cows open at palpation (pregnancy failure) | 1,961 | 21.2% |
| Calves lost during gestation (Palpation to calving) | 79 | .8% |
| Calves lost at birth | 191 | 2.1% |
| Calves lost during first 4 days postpartum | 80 | .9% |
| Calves lost 4 days following birth to weaning | 190 | 2.0% |
| Calves weaned | 6,756 | |
| Total Possible Calves: | 9,257 | |
| % Calf Crop Harvested: | 73.0% | |

*Data compiled from the Beef Research Unit at Gainesville and the Beef Cattle Experiment Station (USDA) at Brooksville from 1951 to 1973.

The largest proportion of these losses have been shown to occur in the first calf heifer irregardless of whether she was two or three years of age. This was clearly shown here in Florida where it was reported the greatest loss due to lack of pregnancy was in the first calf heifer. Figure 1 shows initially that heifers have a comparable pregnancy rate to the more mature cows, however, following their first calf the percent pregnancy declined from the mid nineties to the low eighties. This is shown to carry over into the 3rd breeding season, most likely resulting from the heifer in many cases having been bred the very last of the second breeding season, calving late and thus completely missing the third breeding season. After the heifers recover from there first two calving experiences as a group, they continue to increase in reproductive efficiency, particularly if a strick culling program is observed.

Figure 1. Effect of Age on Pregnancy Rate* - (Crockett, 1973)




*Breeding heifers to calve at 2 years of age

The primary reason for this low reproduction in young heifers is inadequate nutrition following weaning, especially during the winter period so adequate growth and puberty are not attained. If growth is not attained at this time, the heifer will attempt to gain it during the course of nursing her first calf. This is compounded by the need for the nutritional level to be maintained for the postpartum nursing cow to recycle and breed during the subsequent short breeding season. These additional nutritional requirements are necessary for this first calf heifer to perform all of the body functions of a mature cow such as nursing, while at the same time maintaining growth. This problem is further compounded by the fact that the heifer may be shedding incisor teeth and has a limited capacity for grazing.

Wiltbank (1969) reported that these demands on the first calf heifer two to three years of age resulted in their coming into heat 20 to 30 days later than the more mature cows. This is seen in Table 3 where 90% of the older cows were in heat by day 70 postpartum versus only 65% of the animals 2 to 3 years of age. It was 100 days following calving before 90% of the 2 and 3 year olds were in heat.

Table 3. Percent Cows in Heat at Varying Intervals Following Calving (Wiltbank, 1969)

| Age of Cow | Days After Calving | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |
| | % | % | % | % | % | % | % | % |
| 4 years or older | 55 | 70 | 80 | 90 | 90 | 95 | 100 | 100 |
| 2-3 years old | 15 | 30 | 40 | 65 | 80 | 80 | 90 | 90 |

This data has shown the major portion of our losses (21%) occurred in the cow that was open at palpation following the breeding season. The greatest percentage of this happened in the first calf heifer in her failing to rebreed the second and third breeding season irregardless of whether she was 2 or 3 years of age.

## Suggestions for Changes in Management Providing Possible Relief From These Open Cow Losses

### Factors Determining Puberty in Heifers

In the future, more heifers are going to be bred at 1 year of age to calve at 2 years of age to take advantage of the 1 to 1.3 calf increase in lifetime production. This is, of course, provided the heifer rebreeds her second and third breeding season. This calls for having the heifer reach puberty and conceiving at an early age and preventing the decline in pregnancy rate following the first calving. In most all cases, the following suggestions will apply whether heifers are to be bred to calve at 2 or 3 years of age. Table 4 shows the effect of nutrition on first expression of estrus in heifers.

Table 4. Age of Puberty in Heifers on Two Levels of Nutrition (Bellows, 1967)

| Feeding Regime Months: | Percent in heat by 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|
| Low Level | | | | | | | |
| Angus | 0 | 0 | 0 | 33 | 82 | 90 | 100 |
| Hereford | 0 | 11 | 22 | 33 | 38 | 50 | 100 |
| Crossbred | 0 | 0 | 12 | 68 | 85 | 100 | 100 |
| High Level | | | | | | | |
| Angus | 0 | 33 | 58 | 100 | 100 | 100 | 100 |
| Hereford | 0 | 12 | 50 | 100 | 100 | 100 | 100 |
| Crossbred | 0 | 18 | 76 | 94 | 94 | 100 | 100 |

These heifers, following weaning, were wintered on a low level feeding regime to gain .8 lb./day and a high level of 1.6 lb. daily gain. In this particular group of heifers breeding at 14 months of age would have resulted in a disastrous pregnancy rate for the low level feeding regime subgroup since only 33% of these heifers had cycled at that time. Whereas, in the high level, feeding regime 100% of the heifers were in heat by 14 months of age. This vividly points out the need for adequate nutrition for young heifers to cycle at an early age. It is interesting to note the crossbreds cycled earlier and responded more favorably on the low level of nutrition than the purebreds. This was partially due to the effect of heterosis on weight gains resulting in heavier weights for the crossbreds. The probable reason for the delayed estrus or puberty in the group on the low level of nutrition was these heifers hadn't attained the weight of the heifers on the high level. Available information indicates that heifers don't reach puberty until they have sufficient weight as seen in Table 5.

Table 5. Weight at Which Heifers Reached Puberty (Wilthank, 1972)

| Breed | Percent in Heat Before 500 lb | 550 lb | 600 lb | 650 lb | 700 lb | 750 lb |
|---|---|---|---|---|---|---|
| Angus | 8 | 44 | 72 | 84 | 88 | 100 |
| Hereford | 0 | 0 | 27 | 50 | 62 | 88 |
| Crossbred | 0 | 18 | 43 | 68 | 78 | 93 |

Few heifers reached puberty prior to attaining 600 lb. weights and a 650 lb. weight was necessary for at least 50% of the heifers to have reached puberty in these breeds. Thus, age alone may not be as adequate an indicator for breeding heifers as a combination of weight and age. It would be prudent not to breed animals at a light weight since any advantage is often costly in terms of calves and possibly heifers lost.

Information of this type is incomplete for the more recent imports although from preliminary data it appears breeding to an "exotic" bull does not drastically change the time at which puberty is reached.

Breeding heifers to calve at two years of age offers the added advantage of initiating a selection program for early maturity and more efficient producers coupled with a rapid growth rate. The late maturing slow growing animal will be eliminated due to their inability to breed in a short calving season. However, initially in this type of earlier breeding program, a larger number of heifers will be needed due to the difficulty of selecting at weaning, heifers which will cycle early. Cull only the tail end heifers at weaning. There will be a good market for the open yearling heifers.

## Breeding Heifers 20 Days Earlier Than the Cow Herd and a Shortened Breeding Season

It is imperative that cattlemen operate with a short breeding season if advantage is to be taken of the technological ideas being offered now and in the future. Producers should be operating with at least a 90 to 120 day breeding season. However, if a producer is operating on a year round basis and prefers having marketable animals year round, this should be altered to two controlled breeding seasons a year. However, it must be remembered that in every operation, there is a single date at which calves born at that time will make their best gains. Calves born earlier will not necessarily have heavier weights even though they are older and certainly younger calves will not weigh as much as those born at the optimal time of calving. A short breeding season will allow an operation to take advantage of their optimal calving time for weaning heavier calves. Remember, we are not selling 205-day weights.

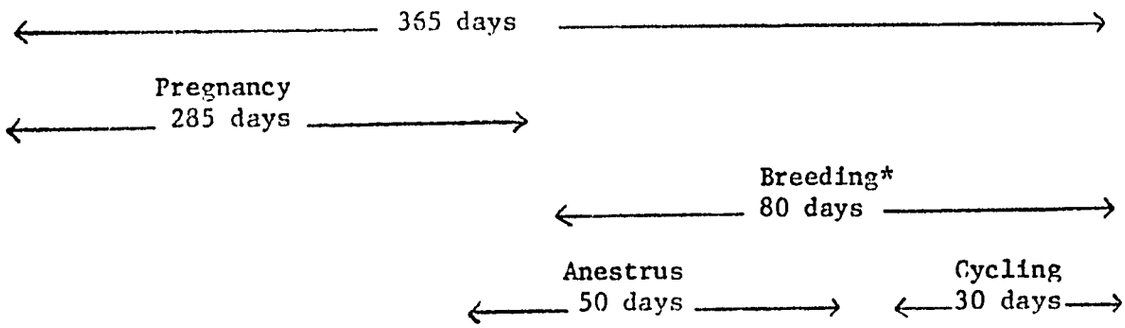
Actually, there is data that indicates the need for operating on a 42-day breeding season (2 estrous cycles). A breeding season longer than 90 days in many cases is futile both in that cows conceiving after this time are few and have a tendency toward failure to settle the next year. In addition, these cows wean light calves. Thus, it would be better to replace this animal with a more productive one.

There are two ways to counteract the serious losses occurring in first calf heifers. First, start the heifers early enough their first breeding season so as to give them time to "mend" and rebreed following their first calf and second, provide an adequate nutritional program, particularly for the postpartum animal. Younger animals take longer to return to estrus following calving than the more mature cows, in fact, on an average 20 to 30 days longer (Table 3). If we are going to breed in a short breeding season of 42 days, the cows must have a 45 day postpartum period prior to the start of the breeding season for 90% of the cows to be in heat during the breeding season. The same treatment for the younger animals would leave only 80% in heat by the end of a 42 day breeding season. However, breeding the heifers 20 days earlier than the cow herd should achieve 90% cycling by the end of the breeding season (Table 3). This is not always the case and if difficulties are still encountered in getting these heifers to cycle their second breeding season, consideration may be given to early weaning of the calves at 30 days of age.

Early weaning of calves removes the stress of lactation enabling nutrients to be used for growth and reproduction. This may be particularly advantageous during times of extreme environmental stress, i.e., drought, hard winters and hurricanes.

One of the best ways to assure a reproductively sound herd of cattle is by starting the heifers calving 20 days earlier than the cows. In Florida cattle tend to have a longer than a 12-month calving interval. If the cow is pregnant 285 days, this leaves only 80 days to rebreed and at least 50 days of this will be used to involute the reproductive tract. This leaves just 30 days for the animal to rebreed and calve every 12 months.

Schedule for Calving Annually




*Cow must rebreed in an 80 day period to keep from calving later each year she is in the herd.

Most cows, however, take longer than 80 days to rebreed. If the cow was bred late the first breeding season, subsequent breeding will eventually lead to the first postpartum estrus occurring after the short breeding season. Breeding heifers early the first breeding will help maintain the animal in the herd for a longer period of time rather than losing her at an early age due to a longer than 12-month calving interval.

In Table 6, it can be seen that heifers bred early did in fact continue to breed earlier and maintain higher reproduction rates during subsequent short breeding seasons.

Table 6. Influence of Early Breeding of Heifers on Subsequent Reproduction (Wiltbank, 1972)

| In Heat After 45 Days of Breeding | Heifers Bred Earlier Than Cows | Heifers Bred Same Time as Cows | Differences |
|---|---|---|---|
| 2nd year | 100% | 95% | 5% |
| 3rd year | 100% | 93% | 7% |
| 4th year | 100% | 94% | 6% |
| Pregnant after 45 days of Breeding | | | |
| 2nd year | 74% | 51% | 23% |
| 3rd year | 90% | 80% | 10% |
| 4th year | 94% | 79% | 15% |

Heifers bred 20 days earlier than heifers bred the same time as the cow herd resulted in only a small percentage increase in these animals showing estrus during the 45 day breeding season for the three years following the first breeding. The pregnancy rate, however, of the early bred heifers the 2nd year of 74% versus 51% for heifers bred later. This 23% increase in pregnancy rate the 2nd breeding season followed by 10 and 15% the third and fourth year clearly demonstrates the advantage of breeding heifers early.

An explanation for such large differences in pregnancy rate in view of the fact there was little difference in percent animals showing heat could possibly be the heifers, bred at the same time as the cows, actually came in heat toward the latter part of the breeding season. Table 7 indicates cows bred on first estrus or soon thereafter are not as fertile as cows that have a longer time to "mend" following calving. The heifers bred 20 days early had 20 days longer for involution of the uterus, and this is reflected in the increased pregnancy rate.

Table 7. Time of Calving and Conception Rate (Wiltbank, 1972)

| | Ave. No. Days Calving to Start of Breeding | Cows Conceiving on First Service |
|---|---|---|
| February 10 - March 1 | 70 days | 62% |
| March 2 - March 21 | 50 days | 58% |
| March 22 - April 10 | 30 days | 33% |
| April 11 - May 1 | 10 days | 33% |

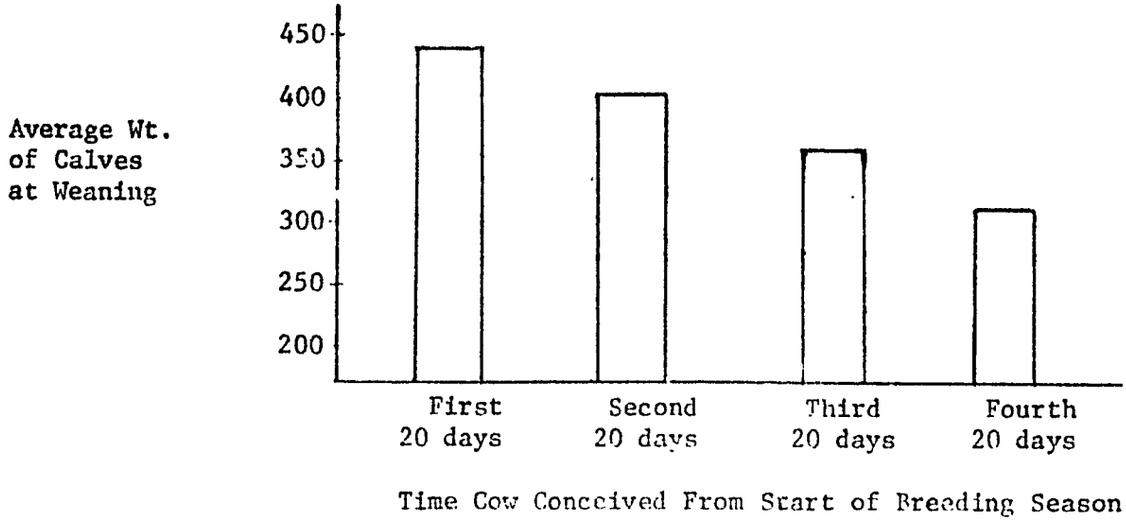
Table 7 demonstrates that animals having a shorter interval from calving to start of breeding have a lower pregnancy rate on first service versus those having a longer interval from calving to start of breeding, 33 versus 62%, respectively. This reflects that the first estrus following calving is less fertile than subsequent heats. This may be particularly true in the case of first calf heifers where a demand is made by the processes of growth and lactation.

It is clearly shown breeding heifers early improves reproduction but there is also another economical advantage. That is cows bred early in the breeding season wean heavier weighing calves when there is a single date for weaning.

Figure 2 shows the further into the breeding season the cow progresses unbred the lighter the calf she weans. Cows bred the first 20 days of an 80 day breeding season produced nearly 100 pounds more calf than those calves produced from breedings the last 20 days. Each 21 days a cow is in the breeding herd is not bred, she is cutting into the profit. Weaning calves later and later to make up for the mismanagement of late calvings is not the answer. It is a poor substitute to trade the quality spring growth for the low quality mature fall grass. It will certainly be reflected in the performance of the calves. This is just the obvious part of the picture, for the loss is magnified next year when the late calving cows do not rebreed. This is the result of the short interval from the time the calf is born until the next breeding season. An operation weaning 400 lb. calves rather than 500 lb. calves could have been the result of a large number of

cows breeding late in the breeding season.

Figure 2. Effect of Time of Breeding Upon Subsequent Average Weaning Weight of Calves (Burns, 1973)




The best approach to having the cow herd calve early is to start the heifers early as reported above. In addition, an adequate nutrition program is necessary particularly for the young postpartum cow.

Increased Conception in the Postpartum Cow With Adequate Nutrition

Nutrition has a two fold effect on achieving pregnancy in the postpartum cow. First, sufficient levels are necessary for animals to cycle and second, there is the additional requirement for maintaining pregnancy in the early stages. Both effects as shown by the influence of feeding prior to and following calving are seen in Table 8.

Table 8. Influence of Energy on Reproduction in Mature Hereford Cows (Wiltbank, 1972)

| Level of TDN (Energy) (lbs) Before Calving | After Calving | No. Cows | % Pregnancy in 90 days | % cows Showed No Heat | % Conception on First Service |
|---|---|---|---|---|---|
| Mod. 9 | Mod.16 | 21 | 95 | 0 | 67 |
| Mod. 9 | Low 8 | 22 | 72 | 14 | 42 |
| Low 4.5 | Mod. 16 | 20 | 95 | 5 | 65 |
| Low 4.5 | Low 8 | 20 | 20 | 70 | 33 |

Moderate versus low levels of TDN before and after calving and combinations thereof showed the level of TDN following calving had the greatest influence on pregnancy rate during a 90 day breeding season. In this case,

95% were pregnant when fed 16 lbs. TDN following calving irregardless of the level of feeding prior to calving. Thus, cows should be in the gaining state (0.5 lb./day) during the breeding season. Even though cows showed heat in the group receiving moderate levels of nutrition before and low levels after calving the percent conception on first service was much lower, 42% versus 67% for those on moderate levels of TDN. In addition, those animals in estrus and having a lowered conception rate on first service during the 90 day breeding season no doubt started cycling later resulting in a less fertile estrus than those cycling at an earlier postpartum stage. This chart, however, can be misleading just as some cattlemen mislead themselves for in the group achieving a 95% pregnancy in 90 days following a low-moderate level of nutrition, these calves were born later in the calving season resulting in less pounds of harvestable beef than in the moderate-moderate group which also had a 95% conception rate in 90 days. Thus, adequate nutritional levels prior to calving were necessary for early breeding and heavier calves. When low levels of energy were fed throughout the experiment only 20% of the cows became pregnant due to 70% of the animals never showing a postpartum estrus. Feeding postpartum cows levels of energy necessary for conception early in the breeding season is going to have the added advantage of providing more nutrients for the nursing calf and thus, again more harvestable beef.

The price-cost squeeze makes it imperative to look for alternatives in feeding cattle during the winter following weaning or calving. In Florida, one possibility is the grazing of white dutch clover and grass combinations where the soil and moisture conditions permit. The primary advantage of the clover-grass combination was the 82 versus 48% pregnancy rate in the lactating cows and was further reflected in the interval from calving to first heat of 72 versus 90 days. Due to the moisture requirements for clover, it may be that winter grazing of annuals, i.e., rye or oats would provide the same favorable results. Adequate research data on this is unavailable.

Table 9. A Comparison of Reproduction in Commercial Cows on Clover-Grass Versus Grass Pastures (Warnick, 1969)

| Criteria | Clover-Grass | Grass |
|---|---|---|
| Acres per cow | 1.33 | 2.00 |
| % pregnant, lactating | 82 | 48 |
| % pregnant, non-lactating | 100 | 93 |
| % weaning, all cows | 84 | 64 |
| Interval calving to first heat, days | 72 | 90 |

Dr. Warnick further reported winter grazing of heifers on a clover-grass combination resulted in just as favorable an increase in reproduction as supplementation with cotton seed meal. This is particularly significant with the exorbitant cost of feed.

There was little difference in pregnancy rate for the non-lactating cow whether she was on clover-grass or pangolagrass alone. This suggests that under adverse conditions (i.e., drought) or an environment that prevents a high pregnancy rate, early weaning of calves will possibly improve reproduction. It must be emphasized that early weaning is suggested only as a temporary measure. The cause of a low pregnancy rate should be dealt with directly to enable the producers to take advantage of the favorable environment in the Southeast for weaning heavier calves.

## Improved Reproduction by Culling Open Cows

Cows should be eliminated from the herd if they fail to conceive during a short breeding season. Warnick and Koger in their classical work with native cattle purchased in South Florida demonstrated the effectiveness of removing open cows from the cow herd on subsequent reproductive performance (Table 10).

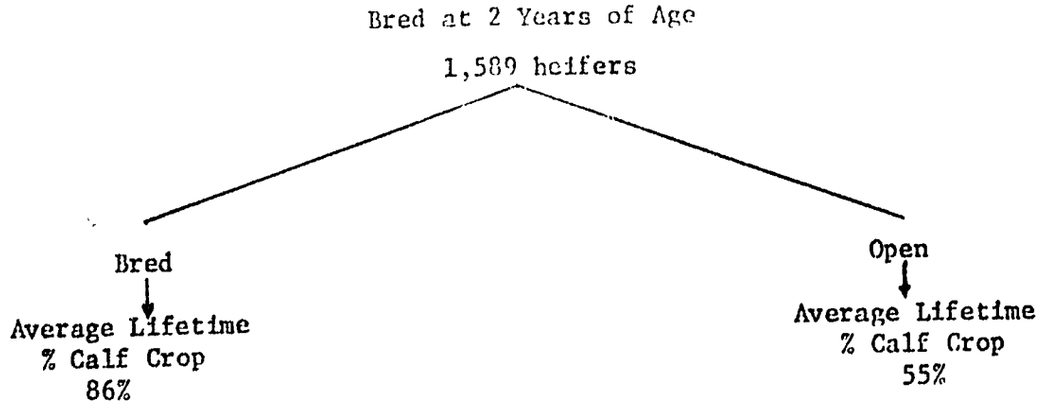
Table 10. Effect of Culling Open Cows on Subsequent Reproduction of the Cow Herd (Koger, 1973)

| Year | % Pregnant | Weaning Weight (lbs) |
|---|---|---|
| 1953 | 44 | 350 |
| 1954 | 55 | 415 |
| 1955 | 82 | 432 |
| 1956 | 86 | 428 |
| 1957 | 88 | 431 |
| 1958 | 88 | 422 |
| 1959 | 92 | 406 |
| 1960 to 1964 | 94 | 508 |

This has been consistently repeated in commercial herds with the same beneficial results No doubt a great deal of the advantage in culling open cows is the increased nutrition available to the pregnant cows. It must be emphasized that if management is lax, the cow will not have an opportunity to express her genetic ability to reproduce. Selection in this case against open cows will not be effective. I refer you back to Table 1 for the economic importance of removing open cows. An open cow consumes at least the profit of one weaned calf. Identifying the open cow through palpation 45 days following removal of the bulls will at least recover some of the cost incurred that year and would provide selection pressure for future generations against infertile animals.

Breeding heifers early and maintaining adequate nutrition should minimize the "open cow" problem as reported earlier. In addition, it also appears that the ability of the heifer to conceive at an early age is an indication of an animal with a more efficient lifetime production record compared to those animals not pregnant from the first breeding season. This was verified as seen in Figure 3.

Figure 3. Effect of Failure to Breed First Year in the Breeding Herd on Subsequent Reproduction (Bellows, 1968)



All heifers were exposed to be bred at 2 years of age. Heifers that failed to breed at 2 years of age were then assigned to a group to be bred at 3 years of age. The subsequent lifetime performance of those breeding at 2 years was an 86% calf crop compared with a 55% calf crop for those that were open following the first breeding season. There is comparable data available for animals bred as yearlings to calve at two years of age.

The tendency in these heifers that do not breed their first breeding season is to retain them for the next years breeding. The above argument tends to invalidate this as a sound management policy. The same thing applies to keeping open cows. In many instances, these animals have become sterile; it is not a case of just not cycling during a short breeding season. This is believed to be particularly true in cattle selected for production over a period of time. Reynolds, et. al. (1966) reported failure of cows to breed in a 75 day spring breeding season was an indication of future poor reproductive performance for when open cows from the spring breeding were subsequently rebred for 30 days in the fall only 33% conceived.

Although little is known about the basic physiology of reproduction of the cow, we do have at hand a vast array of management tools that should make poor reproductive performance in most herds obsolete.

## Summary and Recommendations

In closing, nearly 80% of losses are identified as the animal that failed to become pregnant. These losses can be minimized by selecting for those animals pregnant following removal of the bulls by culling open heifers and cows. Furthermore, adequate nutrition in the form of white dutch clover-grass combinations will result in higher conception rates and heifers that reach puberty at an earlier age.

Heifers should be wintered to gain approximately 1.0 to 1 1/2 lbs. daily if they are to reach puberty at 14 months and be bred as yearlings to calve at 2 years of age. They should weigh at least 650 pounds at breeding to minimize dystocia and loss of heifers. Select heifers to go into the breeding herd based on their ability to become pregnant. These heifers should be bred 20 to 30 days prior to breeding the cow herd to give the heifer a longer period of time to "mend" following calving and thereby increase her chances to rebreed the second breeding season. To take further advantage of this type of management shorten the existing breeding season so there will be a harvest of older calves of heavier weights at weaning.

In adapting any or all of these management programs, none are meant to preclude the use of common cow sense.

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# The Florida Beef Industry: Dimensions and Directions

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The drastic reversal in cattle prices and beef industry profitability in 1974 prompted many questions. Some of these are: Have we entered a "new era" for the grain-livestock complex in an international economy? Will we be forced to suffer through several years of "boom and bust" price instability, and the resulting risks? Can the beef industry, especially the cow-calf sector, survive the current cost-price squeeze without permanent damage?

These are complex questions, without simple answers, maybe with no answers at all. But looking at the recent past can give us some indications about the future. When we step back for better perspective, we can see great changes in the beef industry in Florida and the U.S. as a whole during the past 15 years.

Beginning in 1958, cow-calf producers started increasing herds by keeping more heifer calves and retaining cows in the breeding herd longer. Many other changes began to be evident then, also. Large commercial feedlots grew up, in California and Arizona, especially. Packing plants began to change, both in location and method of operation.

By 1967, beef, especially the ranch and feedlot, was the "glamor industry" of agriculture. Having recovered from the 1963-64 low price "wreck," cattlemen were riding a bull market in all respects. What, precisely, did happen during the past 15 years, and particularly during the last 8 or 10?

Trends in the major sectors and important dimensions of the national beef inudstry can show very clearly how the industry developed, and what kind of beef production - distribution system we have today. These national trends have affected and shaped Florida beef production, so that what we say about the U.S. applies in general to Florida, also. The following discussion of what might be called the dimensions of the beef industry will be the first portion of my discussion, and will prepare the ground for the final section on directions for the future.

## Dimensions of the U.S. Beef Industry

U.S. farmers and ranchers have been building their beef herds and producing more cattle each year since 1958 (Figure 1). Florida cattlemen began expanding about 1962, but made up for lost time by increasing cattle numbers very rapidly (Figure 2). Notice that in both Florida and the U.S. as a whole, a period of rapid expansion started in 1967.

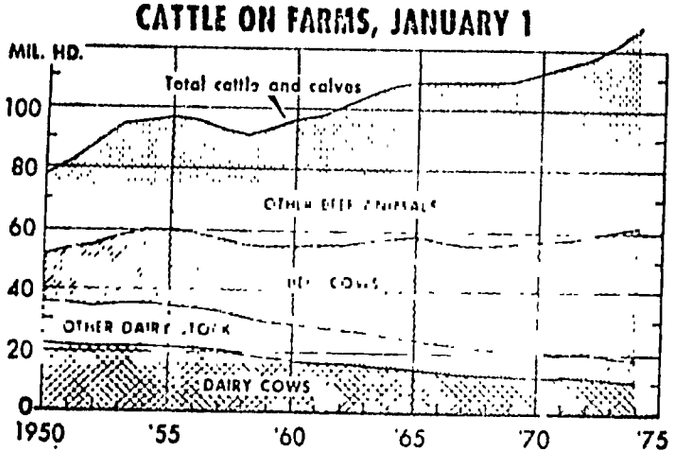



Figure 1

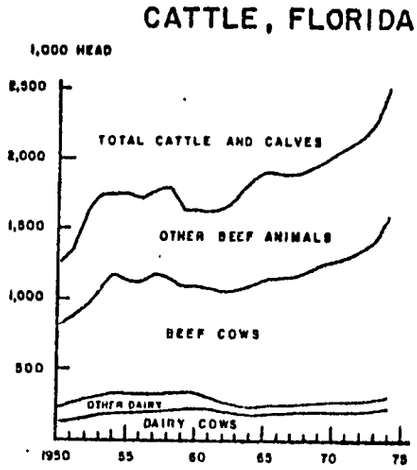



Figure 2

## The Boom Days

Cattlemen were raising more cattle in large part because American consumers had more money to spend (Figure 3). With greater affluence, we all ate more beef - 87 pounds of beef and veal for each of 173 million Americans in 1958, soaring to 119 pounds per capita in 1974, with 211 million consumers (Figure 4).

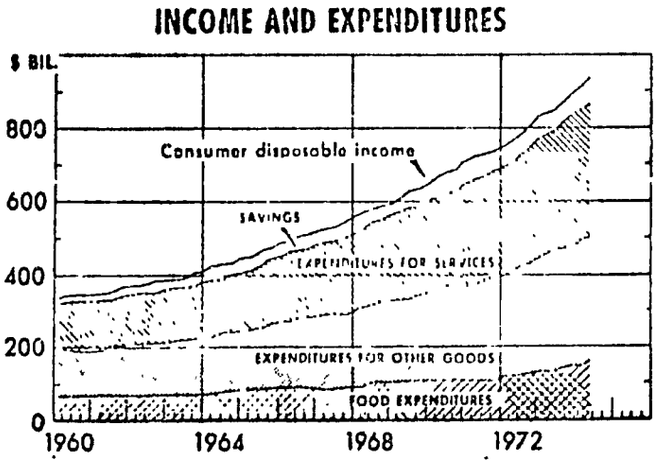



Figure 3

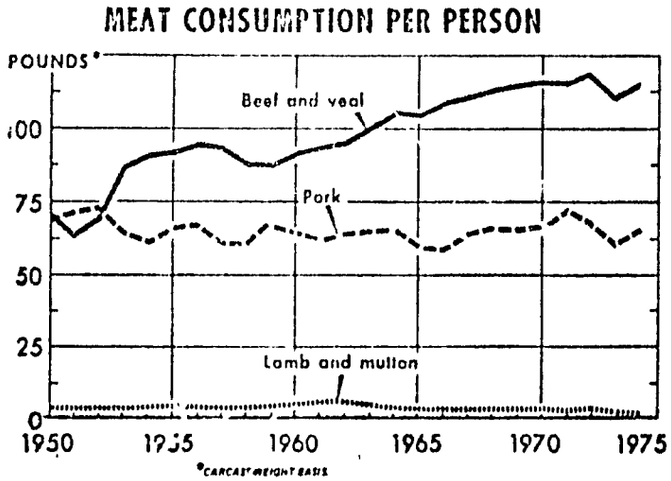



Figure 4

Consumers, through their dollars cast in the marketplace, demanded not only more beef, but higher grading beef. Their demands were met (Figure 5) in several ways. First, we killed fewer calves (Figure 6), putting them into feedlots instead and marketing heavy fed cattle (Figure 7).

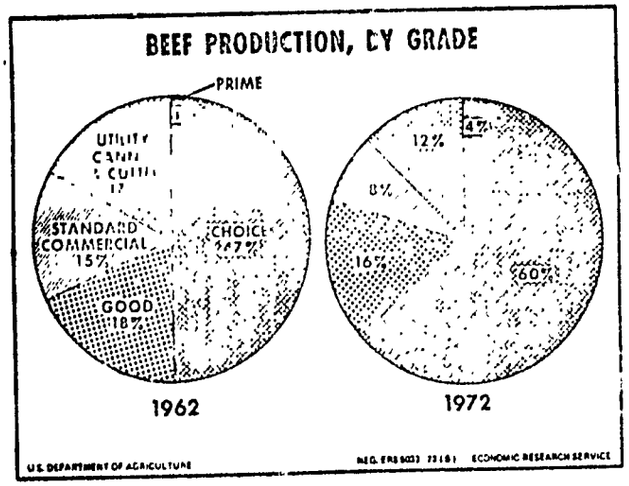



Figure 5

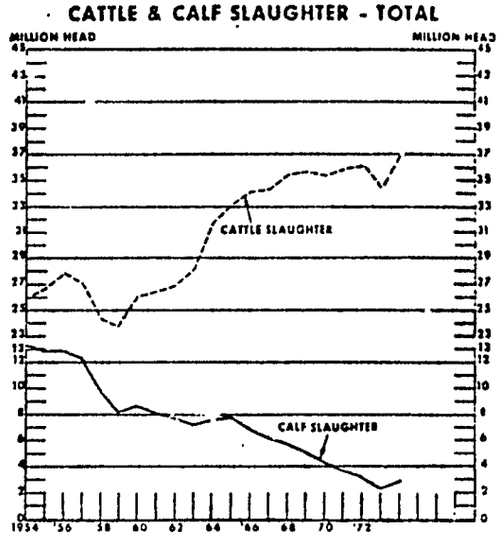



Figure 6

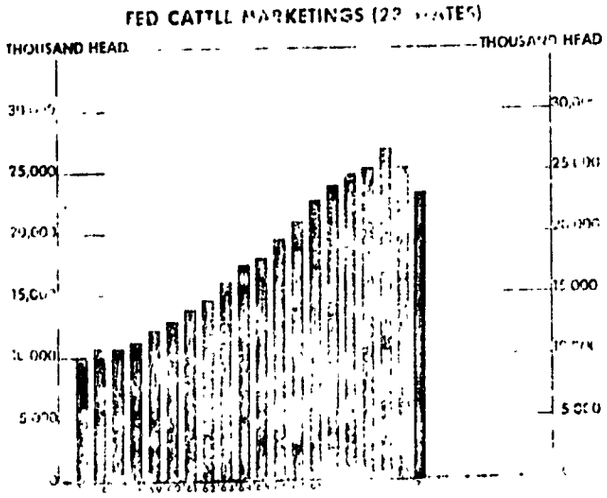



Figure 7

Commercial feedlots (1,000 head and over one-time capacity) produced an ever-growing share of these fed cattle (Figure 8). The large lots in the 16,000 head and over category experienced marked increase, especially since 1967 (Figure 9). The 23 major feeding states showed dramatic growth in their fed cattle output (Figures 10 and 11).

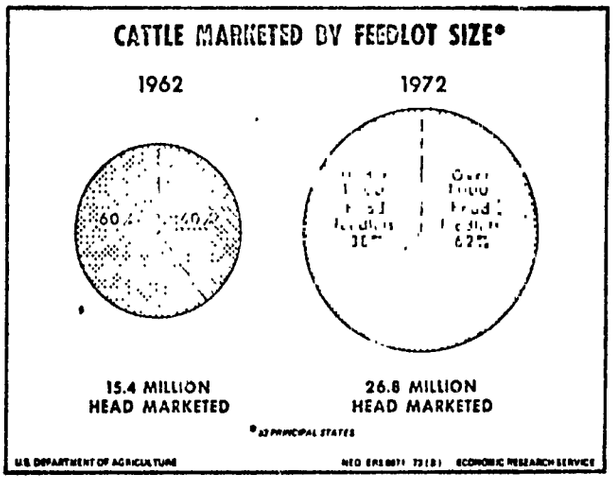



Figure 8

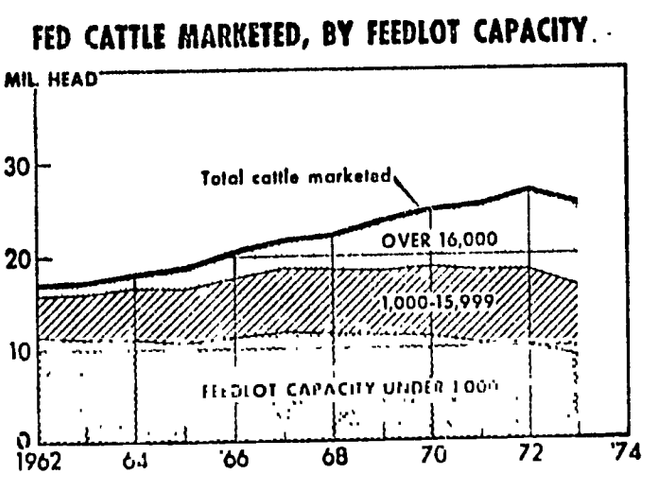



Figure 9

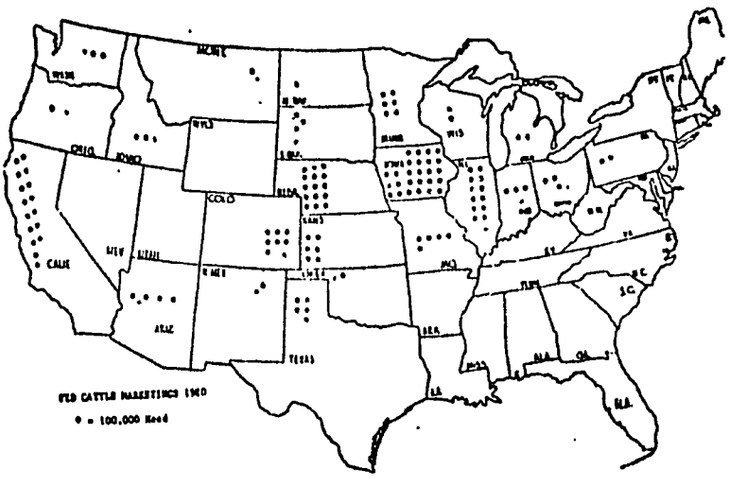


Figure 10

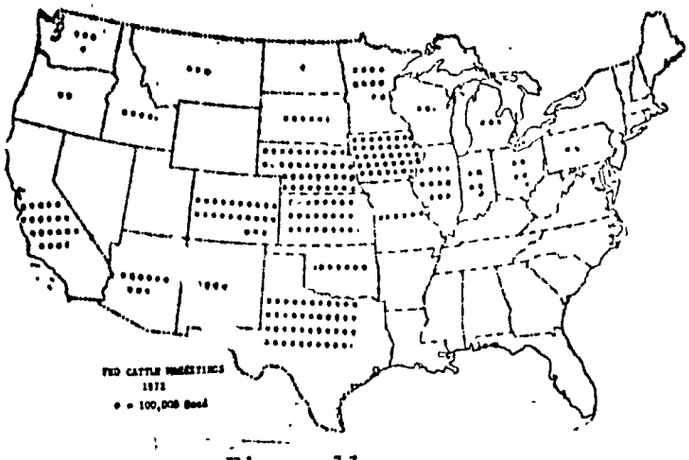


Figure 11

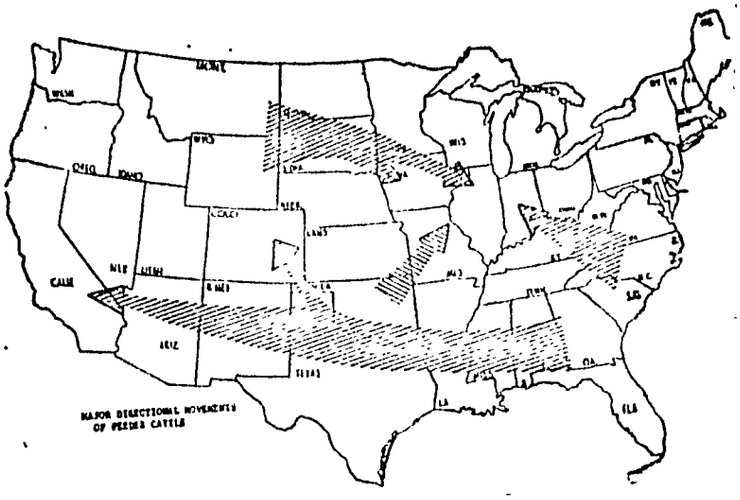
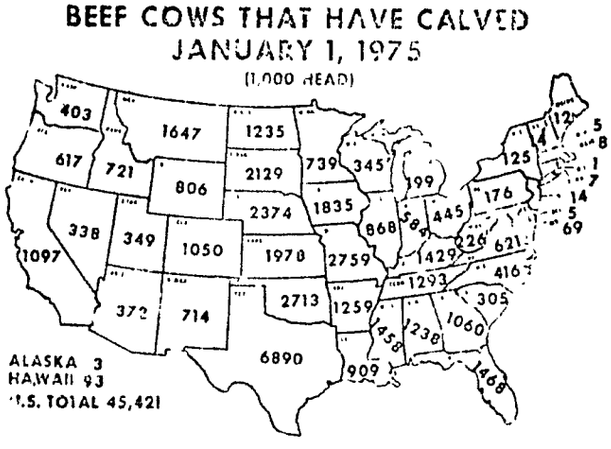


Figure 12

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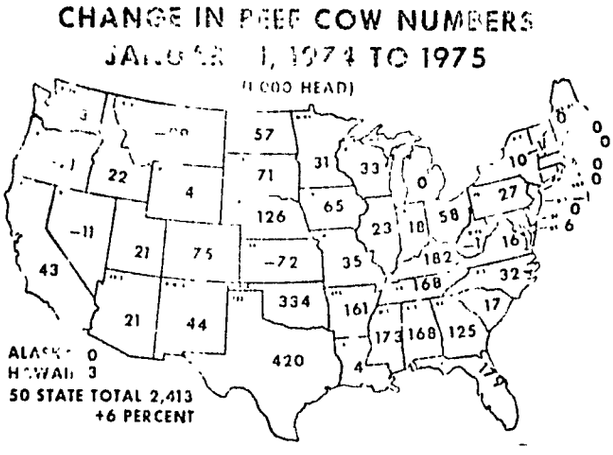


Figure 14

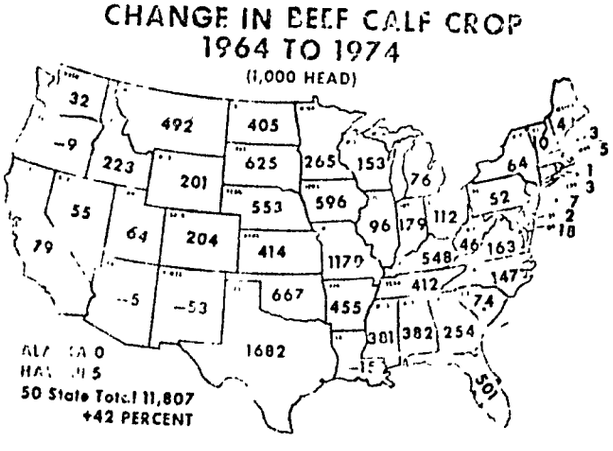


Figure 15

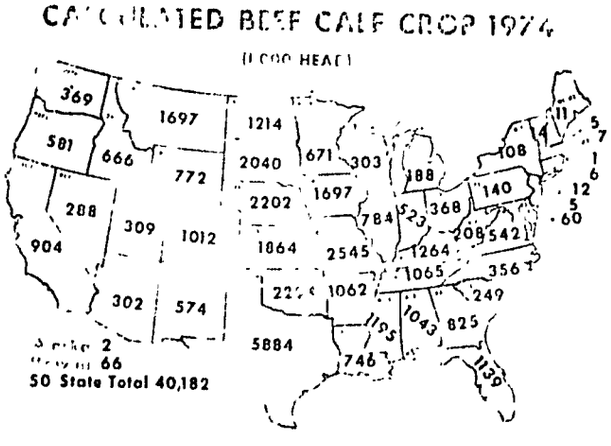


Figure 16

Cow-calf producers sent feeder calves to those states (Figure 12) from their ever-expanding herds (Figures 13 and 14). The beef calf crop grew at a faster rate even than cow numbers as ranchers increased herd productivity (Figure 15). The 1973 beef calf crop, of 1,003,000 head, was the largest on record till then, and marked the first year Florida produced over a

million beef calves. In 1974, the U. S. beef calf crop was over 40 million, with Florida producing 1,139,000 beef calves (Figure 16).

From 1964, and particularly since 1967, everything was "fat city" for the beef industry. Long-time cattlemen expanded herds and acreage and improved pasture with every dollar they could find, whether theirs or someone else's. Everybody jumped on the beef bonanza - the city investor who didn't know a Charolais from a Chevrolet, and the bona fide cowman. They were all "high rollers." The "Wall Street Wranglers" and "condominium cowboys" bid higher and higher for the chance to own cattle, whether in tax-sheltered Florida cow herds, Texas cattle feeding clubs or some other way - and many, many genuine cattlemen were right in the thick of the bidding.

The buildup in cattle numbers, the restructured industry and the good times from 1967-74 were made possible by a booming economy during most of the period. Consumer incomes rose at an even greater rate than rising prices (Figure 17). On the supply side of the picture, the cattle industry and indeed, all of agriculture, enjoyed cheap grain, energy and money during most of those years.

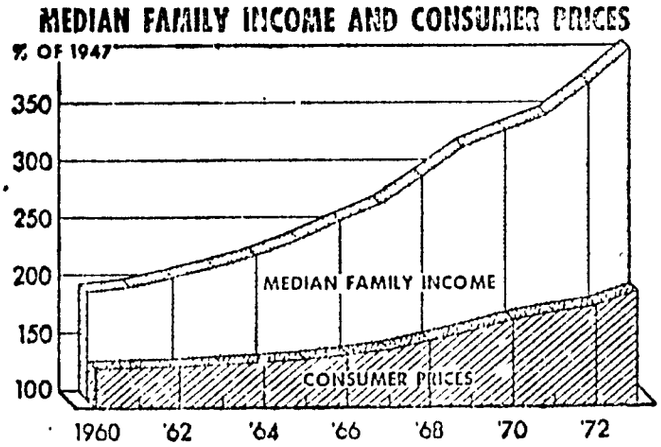


Figure 17

## Boom Turned to Gloom

All this changed in 1973. The economy fizzled, sagged, stagnated and slid into recession by 1974 (Figure 18). Along with a ruinous inflation rate, the sick economy took a terrific toll from consumer purchasing power (Figure 19). A succession of bad crop years here and around the world cut grain supplies and used up our stocks (Figure 20).

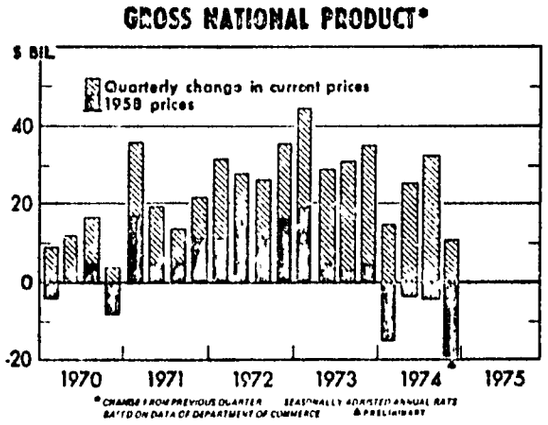


Figure 18

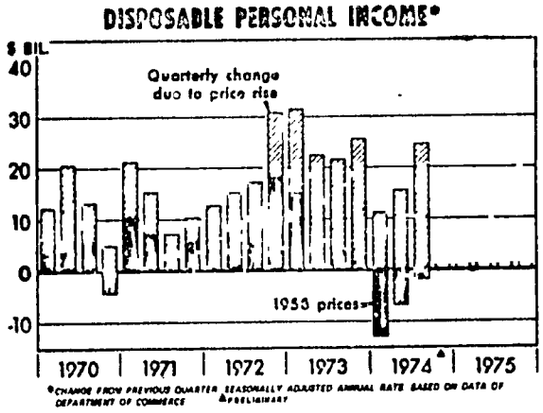


Figure 19

Prices for corn and other grains and feeds skyrocketed (Figure 21). Energy prices did likewise (Figure 22), and so did interest rates (Figure 23).

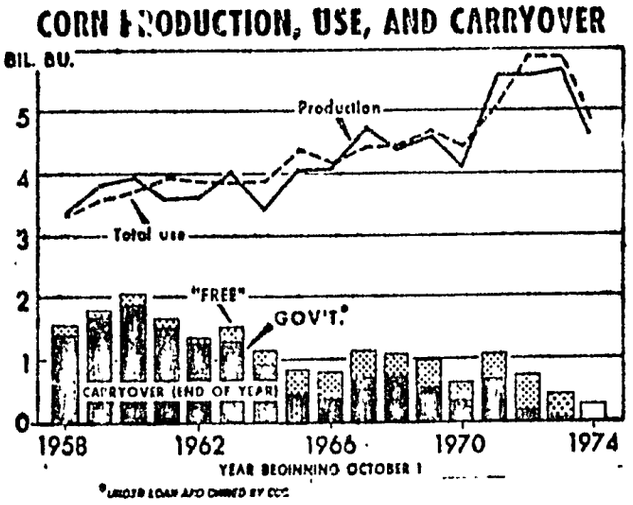


Figure 20

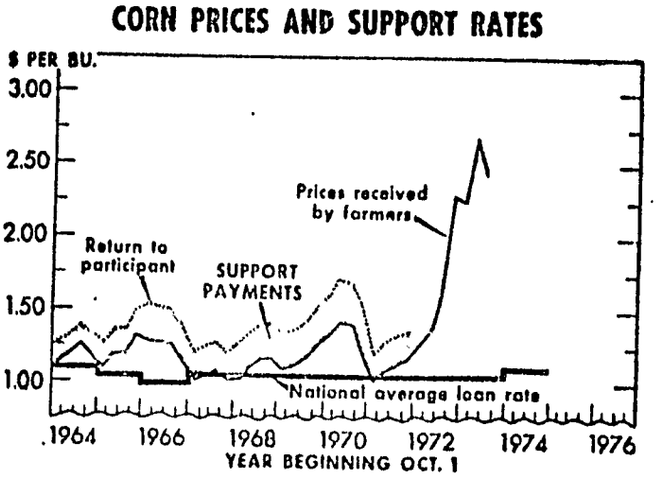


Figure 21

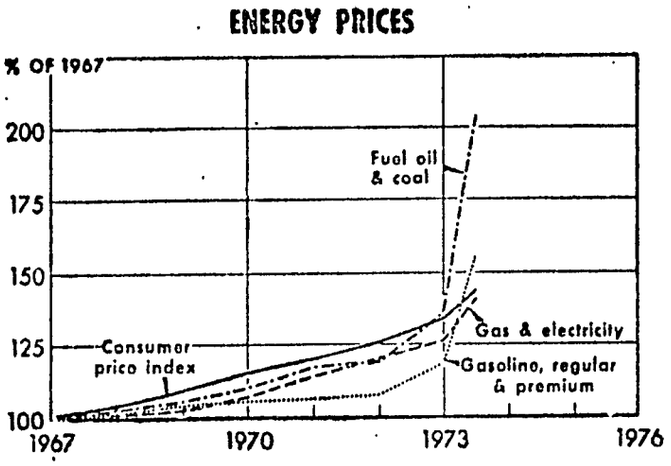


Figure 22

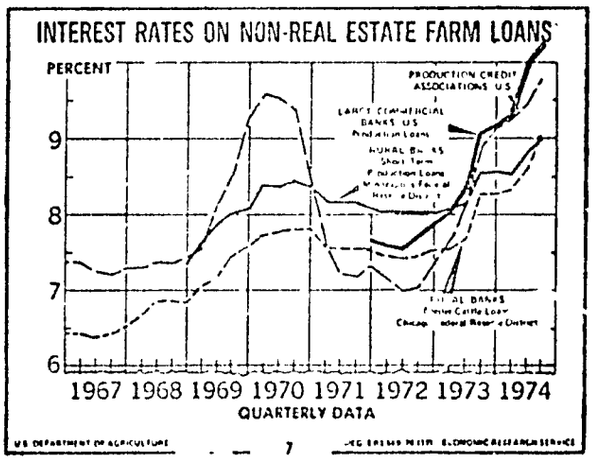


Figure 23

Suddenly last summer, the cattle business became more like Russian roulette- with five chambers loaded and only one chance for survival, it seemed to many cattlemen. Feeding costs were up for feedlots and production costs rose sharply for ranchers. These jumps made themselves felt about the time the big buildup in cattle numbers hit the market. When beef production increases, prices go down, and vice versa. A 10 percent change in beef production per capita results in a 15 percent change in prices in the opposite direction (Figure 24).

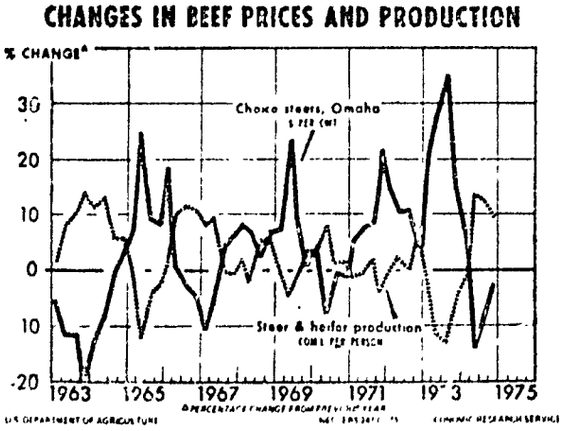


Figure 24

This cost-price squeeze hit the feeder, then the cow-calf man, causing them serious losses. One cowman said he was broke worse than a dispossessed snake - he didn't have a pit to hiss in.

## Beef Industry Directions

What is likely to happen to the cattle business in the next two to three years?

Three major factors will shape the answer to that question:
(1) Economic conditions
(2) Grain supplies, prices and feedlot profitability
(3) Cattlemens' decisions on herd liquidation

## The Economy - A Rough and Rocky Road

Economic conditions are important, since they determine consumers' incomes and purchasing power, and thus their beef buying ability and inclination. The rate of inflation and unemployment, the availability of money and credit, business confidence and the general health of the economy all affect consumers' food spending.

Cattlemen are likewise affected both as consumers and more particularly as buyers of production items. Costs for major non-farm production goods - fertilizer, feed, machinery - have risen sharply and seem destined to remain high. The producer's borrowing ability will be affected by costs and supplies of funds, and his own profits, if any.

Will the economy show any signs of recovering by mid year? Can we bring the rate of inflation down from last year's 10 to 12 percent to 6 to 8 percent? Even that range is ruinously high, but any relief would be a help. Can we stop the rise in unemployment and restore investors' and consumers' confidence?

We can hope so - but I am not optimistic about much recovery before 1976. The current recession, along with continuing inflation, puts us all in a severe wringer. I fear consumer demand will be depressed, which, in combination with large beef supplies, will not be much help in improving cattle prices. Retail prices for beef, while down some in recent months, are substantially higher than 1970-72 levels and further dampen consumer enthusiasm (Figure 25).

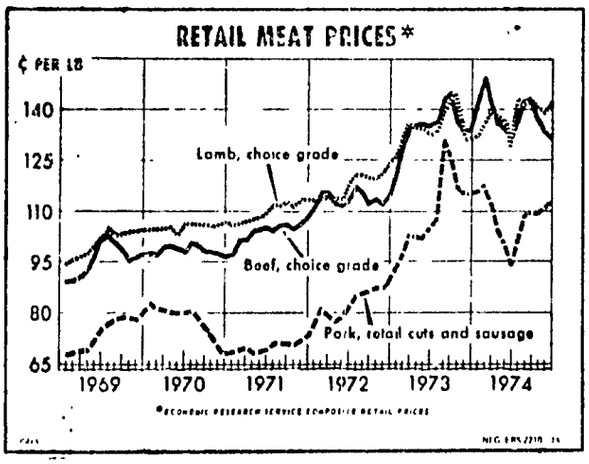


Figure 25

## The Grain Drain

Recent publicity, not all of it well-reasoned or factual, has covered the U.S. and international grain supply-price situation. We need large crops in 1975 and 1976 to restore the grain-livestock economy to something like its former relations. But even two successive large crops are not likely to return dollar a bushel corn to U.S. feeders.

International demands to stave off starvation the need to rebuild stocks and larger livestock numbers worldwide will keep upward pressure on grain prices.

Further, the terrific cost increases the past two years could keep farmers from producing as much feed grain acreage as they might otherwise, with current price levels.

We need and expect substantially greater feed grain production this year and next. The consequences of one or more short crops following the previous three years are grim, indeed. Assuming, however, that the 1975 crop is much larger, there should be some improvement in feeder cattle prices late this year.

## Feedlot Financial Health

Expected improvement in fed cattle markets the first half of 1975 should also help strengthen the feeder cattle picture. Cattle feeders lost large amounts of money during 1974 and are in difficult financial straits. Estimates by USDA for all cattle fed during 1973 and 1974 showed losses of $300 million to $400 million each quarter from the last three months of 1973 to the third quarter 1974 (Figure 26).

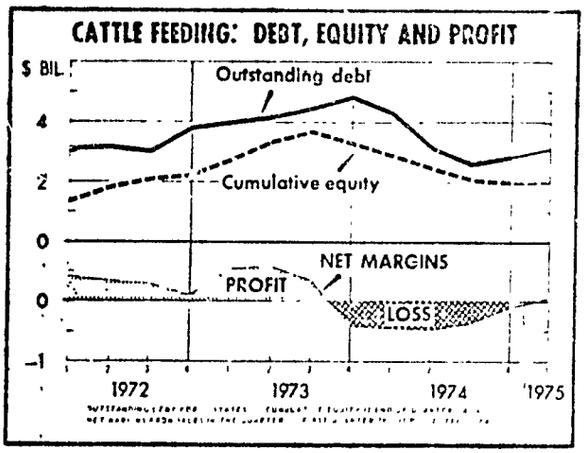


Figure 26

The USDA study concluded: "Although there still appears to be sufficient equity capital in total to sustain the industry at the reduced level of feeding at which it is now operating, under-utilization of capacity is likely to result in higher overhead per head fed for plant and equipment. Further expansion of feeding facilities has been checked, and a consolidation period has been underway, which is likely to continue until normal net margins are restored The prospects of attracting additional outside investor capital are not favorable, in view of the operating history of most of the firms that are seeking additional capital of this type to restock their lots."[1]

## Cattle Numbers, a.k.a. We're Up to Our Assets in Cows

Earlier, I discussed the rapid buildup in cattle herds, especially in Florida and other Southern states, during the past few years. U.S. cattle numbers increased steadily from 1958, with sharp jumps since 1967, as more females were retained rather than going to slaughter (Figure 27).

Will cattlemen decide to reduce brood cow numbers? Almost certainly - but when? The number of cows going to slaughter increased sharply late last year. From a low of 16.7 percent of total cattle slaughter in 1972,

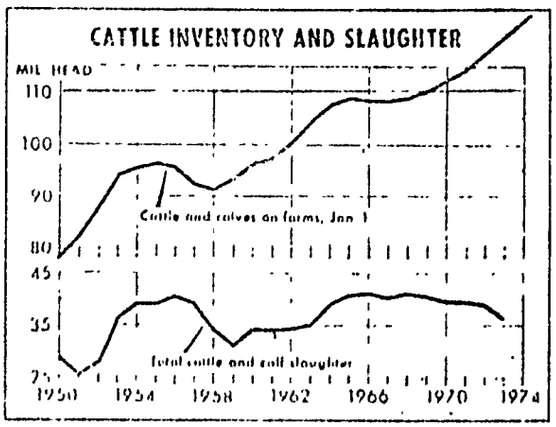


Figure 27

1. William H. Scofield, "Operating Capital Requirements of the Cattle Feeding Industry," Livestock and Meat Situation, ERS, USDA, November, 1974.

cow slaughter went over 23 percent by last fall (Figure 28). Continued heavy

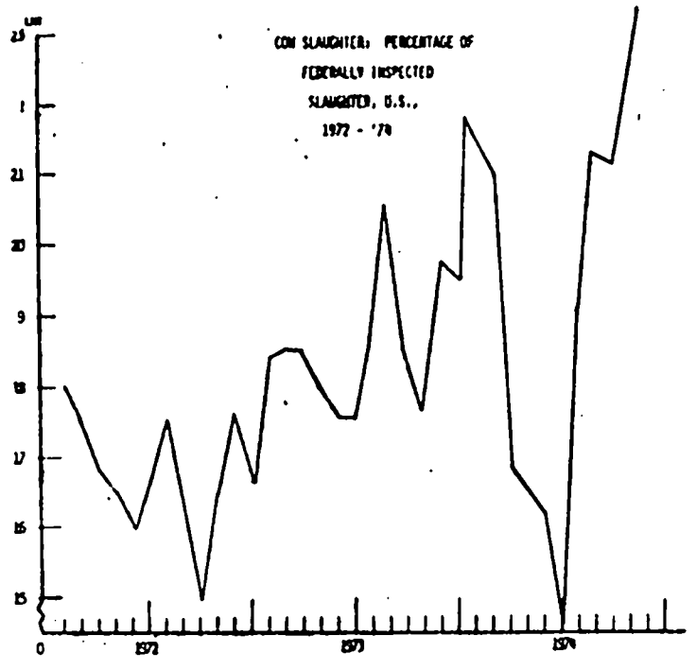


Figure 28

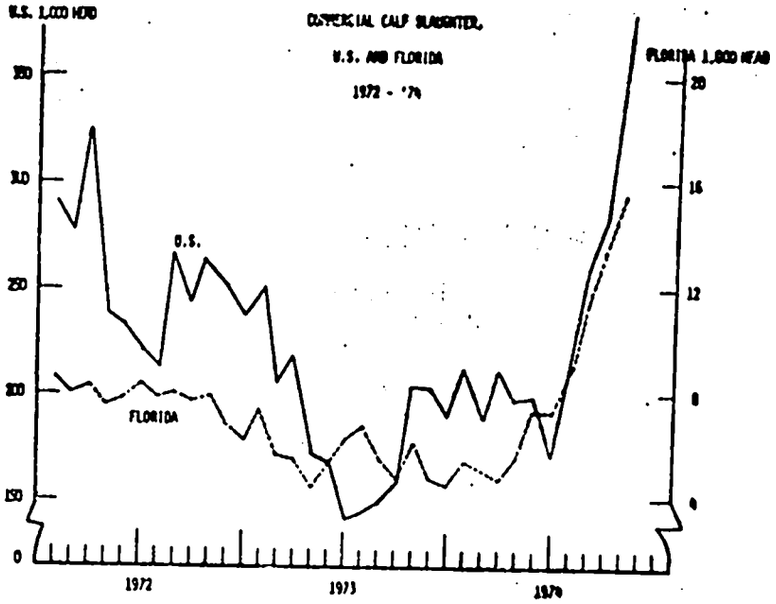


Figure 29

culling and cow slaughter is expected in 1975. The timing of cow marketings, and larger volume will keep pressure on cattle prices while the liquidation is in progress.

A reversal of the calf slaughter trend mentioned earlier (Figure 6) saw more light, grass-fed animals killed during 1974 (Figure 29). This development, a return to the "baby beef" of 15 years ago, will mean lower volume of meat even though numbers slaughtered will be higher. Also, the beef supply during 1976 and 1977 will be less burdensome than if those calves were fed to heavy slaughter weights.

## Little Optimism for 1975-76

The combination of depressed demand, high costs and large cattle numbers will make the next two years lean ones for most cattlemen. There will, of course, be bright spots and higher price periods. But the pattern is fairly well established, since cattle and beef production is a long-term business, requiring several years for major changes to work themselves out. Are there encouraging words and clear skies, either now or after 1976?

## Opportunities for the Future

Cattlemen have always been able to identify and take advantage of favorable chances and to survive and even find humor in adversity. A cattle

feeder expressed this attitude when he said, "I've been feeding cattle over 20 years and never lost money - of course, some years I had some mighty high-priced manure."

Some things I see as opportunities and important developments are improved efficiency with forage-beef systems, and innovations in feeder cattle marketing and distribution.

## Beef From Forage[2]

Earlier paragraphs discussed briefly the rising prices and expected strong demand for feed grains and concentrates.

Increased relative prices of concentrates could result in a reversal of the trend toward more concentrates being fed in livestock rations. In the early 1940's (Table 1) concentrates amounted to only about 14 percent of the feed unit intake of beef cattle. By 1970, this percentage had increased to 24. The proportions of concentrates and forages in livestock rations tend to follow their relative prices. Notice that the price of corn relative to the price of hay has been falling throughout most of the past 25 years, when the increased feeding of concentrates has occurred.

—Concentrates and forages fed in beef cattle rations, fed beef share of total beef, and corn-hay price ratio

| Years | Feeding of— Concentrates | Feeding of— Forages | fed beef | $Corn / $Hay |
|---|---|---|---|---|
| | *Percent* | *Percent* | *Percent* | *Ratio* |
| 1940-44 ..... | 14.3 | 85.7 | n.a. | 2.12 |
| 1950-54 ..... | 16.9 | 83.1 | 45.4 | 2.31 |
| 1960-64 ..... | 20.0 | 80.0 | 63.5 | 1.74 |
| 1970 ..... | 23.9 | 76.1 | 77.7 | 1.60 |

Table 1

Greater reliance on concentrates reflects the increased prevalence of fed beef and feeding "high energy" rations to beef cattle at lighter weights. Fed beef accounted for 84 percent of all beef in 1972, 78 percent in 1973, and 75 percent last year, while it was only 45 percent during the early 1950's. Formerly, cattle were 800 - 900 pound 2-year old steers when placed on feed. Increasingly, cattlemen have been placing younger and lighter animals on feed and the amount of concentrates fed per pound of beef produced has increased. We see in Table 2 the pounds of forage per pound of live beef produced goes from 3.3 pounds for the 425-pound feeder to 6.2 pounds for the 650-pound feeder, and up to 7.6 pounds for an 800-pound feeder.

Other factors also indicate that the feed concentrate-forage price ratio will run higher in the years ahead than has been the case for these products over the past two decades. Exporting feed concentrates to rapidly growing foreign

—Total forages and concentrates required to produce fed beef with varied feedlot starting weights

| Type of feed and steers | Cattle feeding system: 425 to 1,075 lbs. | 650 to 1,150 lbs. | 800 to 1,200 lbs. |
|---|---|---|---|
| | *Pounds* | *Pounds* | *Pounds* |
| Forage ..... | 3,600 | 7,095 | 9,175 |
| Concentrates ..... | 3,274 | 2,896 | 2,822 |
| Pounds of meat produced[1] ... | 452 | 483 | 504 |
| Pounds of forage/pounds of liveweight ..... | 3.3 | 6.2 | 7.6 |

[1] Retail weight.

Table 2

2. Most of this section taken from Melvin D. Skold, "Forage Requirements to Meet Meat Production Demands," Livestock and Meat Situation, ERS, USDA, July, 1974.

markets will strengthen prices, and at the same time, the fertilizer and energy shortage could limit production. Feed concentrates require far more fuel and fertilizer in their production than do forages, which makes them more dependent on higher priced inputs. We can expect grain production costs to rise relatively and in the event nitrogen fertilizer supplies are short, prices could be pressured up further because of tight supplies. With either or both of these cases, we would have to rely increasingly on forages to meet our growing domestic demand for increased beef production.

## Feeder Cattle Marketing

The pace of change in beef industry structure already documented will focus pressure on the feeder cattle marketing and distribution system -- pressure to modernize, to meet the requirements of the other sectors.

Modern feedlots and packers require relatively large lots of uniform cattle in dependable and consistent volume to achieve designed efficiency. Packers in major feeding areas can generally acquire cattle to these specifications. Large commercial feedlots have more difficulty. National and regional order buying firms have expanded enormously and can meet part of these demands. But the stress of supplying total U.S. requirements for modern mass distribution enterprises like feedlots and packers from the current haphazard, conglomerate, antiquated feeder cattle distribution system will become too great for even the largest order buyers.

Basic changes in feeder marketing methods and arrangements must come from cow-calf producers. Examples and indications of these changes have been discussed at this and previous conferences, and will not be reiterated here. It should be sufficient to say that pressure to modernize will be focused on feeder cattle marketing in the future, even without the large increase in cattle numbers that has taken place in the last few years. Increased numbers, particularly of feeder and stocker cattle, will accentuate the need to revise marketing methods.

## Summary

This paper began with several questions that cattlemen and others concerned with the beef industry are asking. Some hints may have been provided, but no definite answers. If a serious, forward-looking cattleman were asked those questions: Have we entered a "new era" for the grain - livestock complex; will we experience several years of "boom and bust" price instability; and can the beef industry survive the current cost - price squeeze without permanent damage; and if that cattleman was required to respond with one word in 30 seconds, he would probably say 'Yes' to all three. I believe he would be most positive about the last one - because I believe the cow-calf business will weather this storm as it has so many others.

AIRY CATTLE

# PERFORMANCE OF DAUGHTERS OF SIRES USED ON DIFFERENT FARMS

by

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With the advent of artificial insemination (AI), it is common to have dairy sires on many different farms. These farms may be located in a relatively small area, where climatological factors are about the same for each farm, and economic factors such as feed and labor costs do not vary much either. Management practices may vary in this situation, but because of climate and economics, most dairies would be following fairly similar management programs.

Today, semen can be shipped and used in other parts of the country, and even outside of the country, however, where conditions are very much different. Semen from the U.S. is available for use in almost all Latin American countries, for example, and is being used quite extensively.

An important question then is "do sires whose daughters perform well on some farms also perform well on other farms?" This can be extended to the question of whether or not sires which rank well (according to production of the daughters) in another part of the country or even in another country would also be expected to rank well in your part of the country and on your farm. Would the sires proven to be genetically superior for milk yield in the U.S. also be expected to be superior in Venezuela and Ecuador also, where conditions are very different?

We do not have very many answers to these questions, but we have some, and this is the subject of this presentation. The consistency of performance of good or bad sires from farm to farm is measured by the magnitude of "sire by farm interaction." If the interaction is small, poor sires will tend to be poor on all farms, and vice versa.

This is not a new question. In the mid- to late-1800's, long before AI in dairy cattle was practiced, bulls were moved from farm to farm on the small farms of Denmark. Dairymen wished to avoid inbreeding. According to Dr. R. B. Becker [Dairy Cattle Breeds, Origin and Development, University of Florida Press, 1973], the Tauras Cattle Breeding Society was organized in Jutland in 1874. Other societies followed; sires were picked by committees who investigated performance of prospective dams of sires. AI came into organized use with dairy cattle in Denmark with the formation of the Elite Breeding Society in 1936. The first U.S. AI breeding cooperatives were formed in 1938.

Consistency of performance of sires from farm to farm has been questioned throughout these times.

Milk yield is not a highly heritable trait, with heritability estimated at about 20 to 25%, which means that considerable variation exists among yields of cows for non-genetic reasons. Considerable variability exists among daughters of the same sire producing on the same farm, therefore. This is environmental variability and its magnitude must be taken into consideration, in studies of sire by farm, sire by area and sire by region etc. interaction.

The study of interactions can be demonstrated in the following hypothetical examples (Table 1).

Table 1. Demonstration of sire by farm interactions of various types and magnitude

| SIRE | FARM A | FARM B | DIFFERENCE[a] |
|---|---|---|---|
| | | NO INTERACTION | |
| 1 | 8,000[b] | 7,000 | 1,000 |
| 2 | 6,000 | 5,000 | 1,000 |
| | | INTERACTION I | |
| 1 | 9,000 | 6,000 | 3,000 |
| 2 | 7,000 | 8,000 | -1,000 |
| | | INTERACTION II | |
| 1 | 10,000 | 10,000 | 0 |
| 2 | 9,000 | 5,000 | 4,000 |

[a]Farm A yield minus Farm B yield
[b]Average milk yield of daughters of that sire on that farm

Let us assume that conditions for dairy cattle are better on Farm A than on Farm B. At least in nearly every case the animals are producing more milk on Farm A. In the first example, NO INTERACTION, daughters of Sire 1 on the average each gave 1000 pounds of milk per lactation more on Farm A than the Sire 1 daughters on Farm B. Likewise although Sire 2 daughters on Farm B did not do as well as Sire 2 daughters on Farm A, the difference again was 1000 pounds in favor of Farm A. As a dairyman, regardless of whether your farm was A or B, you obviously would pick Sire 1 to use on your farm.

In the next example, INTERACTION I, a change in rank occurred between the sires. Sire 1 was superior to Sire 2 on Farm A (9000 versus 7000 pounds per daughter) but inferior on Farm B (6000 versus 8000). This is an extreme interaction, an actual change in rank of the sires. The good sire on Farm A was poor on Farm B, and vice versa. If you only had production records on Sire 1 from Farm A, and you were on Farm B, you

wouldn't know whether to use him or not. If this type of interaction existed, it would mean that you could not select bulls for use on your farm based on performance of their daughters on other farms.

INTERACTION II is a different type of interaction. Daughters of Sire 1 produced at the same level on both farms (10,000 pounds). Sire 2 daughters were almost as good on Farm A but nowhere as good on Farm B. This type of interaction is not nearly as serious as the first type, since you would pick Sire 1 over Sire 2 on either farm, there being no change in rank.

The usual situation, of course, is that a large number of sires are used on a large number of farms. The questions which need answering are (1) do interactions exist? (2) if they exist, how large are they? and (3) if they exist, do they involve changes in ranks of sires?

Dr. Omar Verde of Venezuela studied the problem during his doctoral studies here. The data he used were from Florida DHI herds for 1958 to 1967 (see Table 4 in "Genetic Change in Milk Production" from this conference). Climatic conditions do not vary widely within Florida, but some variation occurs, and considerable variation in management practices occurs also from farm to farm.

Milk yield was adjusted for several systematic environmental effects known to be important, such as age of cow and season and year of calving. These data then were analyzed, and the variability divided into the four portions shown in Table 2. With two breeds, our estimates of the interaction actually were negative; in Jerseys they accounted for 8% of the total variability. We felt justified in pooling the estimates across the three breeds since results were approximately the same for each. In the overall column, note that 35% of the variability in milk yield resulted from the fact that the cows were living on different farms, 17% of the variability was due to the cows having different sires, and 48% was unexplained variability among cows by the same sire living on the same farm. This is the environmental variation mentioned earlier. Overall, our estimate of the interaction turned out to be slightly negative, but close to zero. Zero would be the best estimate of its magnitude in any event.

Table 2. Percentage of total variability in milk yield due to several factors

| | HOLSTEINS | JERSEYS | GUERNSEYS | OVERALL[a] |
|---|---|---|---|---|
| Herd (H) | 34 | 27 | 40 | 35 |
| Sire (S) | 14 | 8 | 25 | 17 |
| HxS interaction | ** | 8 | ** | 0 |
| Remainder | 52 | 57 | 35 | 48 |

**Negative estimates
[a]Pooled across the three breeds

At about the same time that Dr. Verde obtained his estimates for Florida herds, Dr. Jorge Roman, also studying here in a doctoral research

program, analyzed data from the Ecuadorian DHI program. He grouped cows into three groups of several farms each; the farms assigned to each group were located in the same region and either had the same owner or had similar management programs. Represented were 21 sires with a total of 660 daughters. Dr. Roman detected a sire by group interaction which was statistically significant but which was not very large. It accounted for 5% of the total variability.

As our capabilities with the giant University of Florida electronic computer increased, we were able to examine these data further. Graduate student Wayne Adkinson analyzed 5481 records of Ecuadorian Holsteins by 879 sires; 104 farms were represented. He did not group the farms. His estimate was that the farm by sire interaction accounted for only 1% of the variability in milk yield.

Another set of data from Latin America was analyzed by Dr. Juan Salazar of Colombia as a part of his research program here. These data were quite limited since they included only 456 records completed in three herds, and representing 20 sires. They were interesting for several reasons, however.

The farms were quite varied and could be characterized as farm 1, 2500 meters, good management; farm 2, 2500 meters, average management, and farm 3, 1000 meters, average management. Average annual rainfalls were 606, 1227 and 879 mm; annual temperatures were 13.1, 13.9 and 23.7° C and annual maximum daily temperatures were 19.5, 17.4 and 29.8° C. Average relative humidities were high, ranging from 72 to 75%. Management practices varied considerably among these herds also. The sires used were genetically diverse, being from Colombia, Holland and the U.S.

The estimates of magnitude of the sire by farm interaction was high enough to be of practical importance, 8 to 9% of the total.

How do these results compare with results from other scientists? Unfortunately most other research has been completed on data from the temperate zones, particularly the U.S. Not much research has been published, as yet, from other regions. Nearly all research has indicated that sire by farm interactions accounted for very little of the variation in milk yield, with estimates ranging from 4% down to 0. It would be extremely interesting to obtain and analyze a large volume of data (that is, at least 5000 records and preferably 10,000 or more) from herds and sires as diverse as those represented in the Colombia study by Dr. Salazar.

Some outstanding research was completed by Drs. Lytton and Legates of North Carolina State University in 1966. They analyzed records of 10,548 AI daughters of 46 sires. These sires had daughters with production records in North Central and Southeastern U.S. Although both of these regions are well developed dairy production areas, major differences in climate, economics and management exist. Thus, they studied a broader type of interaction, that of sire by region interaction. Their estimate was that essentially none of the variability in milk yield was due to the

interaction. Ranking of the sires from good to bad would be just about identical, regardless of whether their daughters produced in the North or the South. The practical importance of this to our Florida dairymen was that they could rely on semen from bulls with desirable proofs completed in the North, since the bulls would rank the same in the South as they did in the North.

The next, even broader question is, "Are there sire by country interactions for milk yield?" This is important to you if you are thinking of purchasing semen from the U.S. or some other foreign country. There is a disappointing amount of research on this subject. Not enough sires have been used both in the U.S. and Latin America and which have production records on the daughters in both places. Preliminary results from sires with tested daughters in the U.S. and Ecuador, and sires with tested daughters on mainland U.S. and Puerto Rico, suggest that interactions of this broadness likewise are not large.

Recent research (Hinks and Zarnecki, 1974) compared U.S. and Canadian Holstein sires, each sire being used in each country. The correlation in ranks of the sires was not very high, 0.64, but the authors pointed out that only a small number of records were available for analysis. A high correlation, of course, would mean that interactions were unimportant, whereas a low correlation would mean that they were. The magnitude of this correlation, and the fact that only a few records were involved, did not permit a conclusive answer.

In summary, the magnitude of sire by farm interactions for milk yield seems to be quite small under U.S. conditions, and those of other specialized dairy production areas. Under conditions where environmental differences among farms are large, and/or sires are of wide genetic background, sire by farm interactions may be of practical importance. If this is true (and evidence is not conclusive that it is), then sires would need to be proven under conditions more nearly like those under which they will be used. Not enough evidence is yet available to make an intelligent judgement on whether or not sire by country interactions are important. Needed to answer this important question are large numbers of records from cows by sires used in several countries.

# FEEDING SYSTEMS FOR MAXIMIZING MILK PRODUCTION FROM DAIRY HERDS

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A successful feeding system for a dairy herd should consider the feeding and management of the calves, heifers, and dry cows, as well as the milking cows. The objective should be to produce the maximum amount of salable milk with minimum cost for feed and labor. Facilities for housing, segregating, and managing the animals, and for feed storage and distribution must be properly arranged to make a feeding system function, but time and space do not allow consideration of these. Primary emphasis will be given to feeding the milking cows, with only brief suggestions for calves and heifers.

## Feeding Calves and Heifers

Newborn calves should receive colostrum from their mothers the first two to three days. This first milk is rich in antibodies needed for resistance to infections, and in vitamins A, D, and E, as well as protein, energy, and other essential nutrients. Milk or milk replacers must be fed to calves until they have learned to eat at least 0.5 kg of dry feed daily, usually by four to six weeks of age. After that, calves can be weaned from liquid feeding and given only a high quality concentrate mixture and forage. The milk or milk replacers can be fed either warm or cold, and once a day feeding has given results about equal to twice daily, if drinking water is also provided. Many dairy farms waste some colostrum because good cows produce more than one calf needs. Milk from cows treated for mastitis cannot be sold and, thus, it should be fed to calves. The extra colostrum and waste milk can be stored to feed to older calves, and letting it sour does not reduce its value appreciably. Calves should be fed milk individually, and the amount adjusted according to size for maximum economy. They can be housed individually or in groups, but death losses are often higher among calves penned in large groups, especially if older calves are included. The use of movable individual pens on pasture has given good results in warm climates. In New Zealand, rotational grazing of calves on pasture ahead of the milking cows resulted in satisfactory growth. Wing (1974) has reviewed systems for feeding calves.

The protein and energy requirements of dairy calves and heifers of the larger dairy breeds are shown in Table 1. Jerseys and smaller breeds need slightly less nutrients than shown for any body weight because they gain less rapidly. The protein required in the ration declines from 22% initially for calves to about 10% for older heifers (Table 2). The energy content needed also decreases so that high quality forage having 60 to 65% TDN is adequate for normal growth after 200 kg body weight. However, some

concentrates should be fed until heifers reach sexual maturity and are bred whenever excellent quality forage cannot be provided liberally. Early calving (24 to 30 months) is important in any efficient dairy operation.

Table 1. Daily nutrient requirements of calves and heifers

| Body weight (kg) | Dry feed (kg) | Total protein (g) | Total protein (%) | Digestible energy (Mcal) | TDN (kg) | TDN (%) |
|---|---|---|---|---|---|---|
| 40 | 0.5 | 110 | 22 | 2.2 | 0.5 | 95 |
| 100 | 2.9 | 370 | 13 | 8.8 | 2.0 | 69 |
| 200 | 5.3 | 500 | 9.4 | 15.0 | 3.4 | 64 |
| 400 | 9.3 | 800 | 8.6 | 22.9 | 5.2 | 56 |

Source: N.R.C. (1971).

Table 2. Composition of rations for dairy cattle

| Feeds | Protein (%) | DE (Mcal/kg) | TDN (%) | Calcium (%) |
|---|---|---|---|---|
| Milk replacer | 22 | 4.2 | 95 | 0.5 |
| Calf starter | 16 | 3.2 | 72 | 0.4 |
| Heifers and dry cows | 10 | 2.3-2.9 | 53-66 | 0.3 |
| Milking cows | 14-18 | 2.7 | 60-70 | 0.45 |

Source: N.R.C. (1971).

## Feeding Systems for Dairy Cows

To devise an optimum feeding system for a dairy herd demands consideration of 1) herd size; 2) physical facilities for holding, feeding, and milking; 3) availability and cost of feeds; and 4) price of milk and value of surplus animals. The facilities and equipment available largely determine the labor requirements. Health of the animals is an important consideration regardless of the system used.

### Feeding Bred Heifers and Dry Cows

It is generally most economical to feed bred heifers and dry cows on forage alone in a separate group from the milking cows. When the amount or quality of forage is not adequate, other supplements should be fed. Unless cows have some extra body fat reserves at calving, they will

not produce milk at their potential levels. The maintenance requirements are shown in Table 3. Grazing animals need more energy than listed, depending on the distance they must walk to gather their feed.

Feeding Milking Cows

The type and level of feeding should be decided on the basis of the availability and cost of feeds and the dairy merit of the cows, or their ability to secrete extra milk from extra feed, rather than to store body fat. After reviewing the published data, Pearson (1970) concluded that "the genetic capabilities of many breeds of cattle in hot climates is so low that they are incapable of responding to improved environmental conditions." Concentrate feeding should be limited to the ability of cows to respond. Good pasture, hay or silage alone is adequate for maintenance plus 10 kg of milk per day or up to 2,000 kg per lactation. This represents an energy intake of about twice maintenance (Table 3). In contrast, high producing cows will consume feed and produce milk equivalent to four to five times maintenance, when concentrates are included in the ration.

Table 3. Daily nutrient requirements of milking cows

| Body weight (kg) | Total feed (kg) | Protein (g) | Energy DE (Mcal) | Energy NE (Mcal) | Energy TDN (kg) | Ca (g) | P (g) |
|---|---|---|---|---|---|---|---|
| | | Maintenance Requirements | | | | | |
| 450 | 6.0 | 585 | 10.5 | 8.3 | 3.4 | 18 | 14 |
| 550 | 7.0 | 691 | 17.6 | 9.6 | 4.0 | 21 | 16 |
| 650 | 8.0 | 776 | 19.8 | 10.9 | 4.5 | 23 | 18 |
| | | Requirements for Milk Production | | | | | |
| Milk/day (kg) | | | | | | | |
| 10 | | 780 | 14.6 | 7.4 | 3.3 | 27 | 20 |
| 20 | | 1,560 | 29.2 | 14.8 | 6.6 | 54 | 40 |
| 30 | | 2,340 | 43.8 | 22.2 | 9.9 | 81 | 60 |
| 40 | | 3,120 | 58.4 | 29.6 | 13.2 | 108 | 80 |

Source: N.R.C. (1971).

Low milk production is typical of native cattle in tropical countries. In Kenya (Mahadevan et al., 1962), upgrading East African Zebu cattle with Sahiwals increased average milk yields from 832 kg to 1,368 kg in a lactation. Selected Zebu cows in Nigeria (Adeneye et al., 1970) produced an average of 1,148 kg of milk per year. In one study with this herd, feeding of concentrates did not increase milk yield during the rainy season when pastures were good. However, liberal supplemental feeding is practiced during the dry season because of the absence of pasture or stored forages. Hariana cows in India (Ngere et al., 1973) produced 791 kg of

milk on green chop and 840 kg per lactation on dry fodder. Milk production of Criollo cattle in Latin America is similar to those cited above or even lower.

Most of the milk now produced in tropical countries is obtained from native cattle, goats, and sheep. It is consumed as fresh milk, fermented alone or mixed with cereal grains, or made into cheese. In all forms, it supplies important quantities of critically short animal protein. These animals are also slaughtered for meat. The production of both milk and meat could be appreciably increased by improving feeding and management. In extensive cattle production systems, only limited improvement will be economically possible. This might include feeding mineral supplements and, possibly, extra feed to lactating cows and young heifers when grass is scarce or very poor in quality. If surplus forage can be stored for dry season use as silage or dry hay, this would be the cheapest supplemental feed. Improving the pastures in limited areas and reserving these for selected animals would be desirable. The sale of all surplus male animals at an early age and culling for beef the old and less productive cows will conserve feed for the productive females and their calves and greatly increase herd performance.

Even the small amounts of milk produced by the better native cows could be a very important source of protein. In Kenya, it was found that many Zebu or crossbred beef cows would yield 5 to 10 kg of milk in the morning when their calves were separated from them during the night. The calves and cows were allowed to graze together during the day. This system produced as heavy calves at weaning on pasture alone for milked cows as for those not milked. A similar system has apparently been used in Cuba with good results.

## Intensive Milk Production Systems

It had been generally thought that improved breeds of dairy cattle could not survive in the hot, humid tropics. However, there is ample evidence that pure dairy breeds and their crosses with native cattle will produce much more milk in warm areas than the best selected native cattle. The pure bred animals require more protection from disease and they suffer more from heat stress unless they are properly fed and managed, but, for commercial milk production to supply the cities, the inputs may be justified.

Many reports show that improved breeds of dairy cattle can produce large amounts of milk in hot areas if they are properly fed and managed to control diseases and to minimize heat stress. In Israel in 1970, the average of all cows in the country having records was 6,431 kg of milk. Several of the better herds of 140 to 180 cows each averaged 7,500 to 8,500 kg, and individual cows produced up to 13,000 kg in a lactation. High levels of concentrate feeds were fed, and one can question the economics of such practices. The cows are bred for efficiency of both milk and beef production, and this seems like a desirable method for tropical and developing countries to increase animal protein production.

Emphasis should be placed on improved forage production for better dairy herds. High yielding grasses should be rotationally grazed and fertilized regularly to maintain productivity. Storage of silage or hay for periods of pasture shortage should be planned. Concentrate feeds must be supplied for highest milk production of better cows. The Latin American Tables of Feed Composition can serve as a guide in formulating the best mixtures. Recent studies in Puerto Rico illustrate the potential from improved feeding.

McDowell et al. (1975) reported the effects of three different levels and types of supplemental feeding of Holstein and Brown Swiss cows grazing mixed pastures of Pangolagrass, Stargrass, Guineagrass, and Paragrass during two successive lactations in Puerto Rico. The pastures were rotationally grazed for 2 to 4 consecutive days, then allowed to rest for at least 21 days. The following supplements were fed at the morning and evening milkings: 1) None, 2) 1.0 kg molasses per 2.0 kg of milk above 10 kg/day, 3) 1.0 kg ground corn per 2.0 kg of milk above 10 kg/day, and 4) 1.0 kg of a commercial concentrate mixture per 2.0 kg of milk, regardless of milk yield (20% protein, 72.5% TDN). Dry cows received no supplement. By using fertilizers and irrigation when needed, the pastures were actively growing throughout the year. The results are summarized in Table 4.

Table 4. Effect of supplements on performance of dairy cattle

| Supplement | None | Molasses | Corn | Concentrate |
|---|---|---|---|---|
| TDN/Conc. fed/lactation, kg | 0 | 333 | 502 | 1530 |
| Milk (ME) kg | 3144 | 3558 | 3755 | 4534 |
| Milk/day lactation, kg | 11.8 | 12.8 | 13.3 | 15.5 |
| Lactation length, days | 264 | 279 | 282 | 291 |
| Calving interval, days | 420 | 382 | 388 | 428 |
| Return, $ | - | 54 | 70 | 4 |
| FCM/kg Conc. TDN, kg | - | 11.0 | 7.9 | 2.8 |
| Forage intakes, %/w | 12.2 | 9.9 | 9.0 | 5.5 |

Source: McDowell et al. (1975).

The Holstein cows used in the study produced two to three times more milk on pasture alone than native cattle probably would have produced. Milk yields increased 414 kg (12%) on molasses, 611 kg (19%) on corn, and 1,390 kg (45%) on the commercial concentrate. The corn supplement gave the highest return over feed cost. The pasture grass was usually high in protein content, varying from 9.4 to 14.3% on a dry basis for the samples before grazing. The samples taken after grazing were appreciably lower in protein, showing that the cows had selected the more leafy, higher protein parts of the plants. Since cows need less than 10% (8.5 to 9.0%) of crude protein in the dry matter of their rations for maintenance and about 12.5% when they are milking, it appears that digestible energy (or NE) in-

take rather than protein was the limiting nutrient for the control group on pasture alone. However, when corn and especially molasses were the supplements, it is likely that protein was limiting, especially in early lactation when milk yields were highest. Minerals were adequately supplied at all times, so that milk yield was not impaired by a mineral deficiency. The higher milk yield on the commercial concentrate which supplied protein and energy supports this view, but it was fed at too high a level to be economical. In another comparison, cows fed the commercial concentrate at the same rate as the corn produced 4,062 kg of milk (14.4 kg/day) in a 282 day lactation, which was 8.0 kg of FCM per kg of concentrate and returned $164 above feed cost.

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# HORMONAL INDUCTION OF LACTATION

by

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Many dairy cows with the genetic capability for high milk production are culled by dairymen because they are problem breeders. When dealing with these cows a dairyman only has two options. He can continue to breed them in the hope they will "settle", but with little guarantee of success, or he can cull them from the herd. A practical means for the dairyman to induce lactation in cows with inherent genetic capability for high milk production would be of obvious economic value and could offer a third alternative to handle problem breeders.

For example, in Florida dairy herds perhaps as many as 10,000 to 15,000 cull cows yearly could qualify for artificial induction of lactation if a practical approved procedure existed. The exact number may be higher or lower depending upon the severity of breeding problems in individual herds and the relative economics of culling and obtaining herd replacements by purchasing or by the owner raising the heifers.

## General Considerations of Mammary Gland Growth

Under normal circumstances extensive mammary gland growth and initiation of lactation occur as a consequence of pregnancy and parturition. However, mammary gland growth is not confined to this time period. Rather it occurs during all phases of the animals' growth cycle.

Prepubertal mammary gland growth proceeds at a rate generally comparable to body growth. Thereafter, accelerated mammary gland growth is associated with postpubertal hormonal changes. Complete mammary gland growth and initiation of lactation occur as a consequence of an ensuing pregnancy and parturition. An interplay of ovarian steroids, adrenal corticoids, pituitary hormones and steroid and protein hormones from the placenta provoke the extensive growth observed during pregnancy. Changes in hormone secretion and plasma concentration, their cellular actions, and the subsequent expulsion of the fetus and placenta all contribute to the as yet incompletely understood process of initiation of lactation occurring at or near parturition.

## Summary of Early Results

Previous attempts to artifically induce lactation in the absence of pregnancy have required long hormone treatment periods. Also they

focused on the use of the ovarian steroids or synthetic hormones such as stilbesterol. Heifers or cows implanted or injected with stilbesterol responded poorly and milk production was too low to justify use in commercial operations. Many subsequent efforts to induce lactation used injections of various forms of estrogens and/or estrogens plus progesterone. Using these hormones mammary gland growth and lactation often resulted, but again milk yields were low. The long injection schedules used (60 to 180 days), which were intended to mimic pregnancy, were not convenient. Also a great number of these animals failed to lactate at all. Yields from successful lactations were generally only 50 to 80% of contemporaries undergoing a normal lactation and the peak production, length of lactation, and persistency were less than normal and complete failure often was observed. Generally mammary gland tissue growth was not extensive nor was it entirely normal in appearance when viewed histologically. The record production for a lactation from cows treated using such procedures was about 5000 kg of milk and 210 kg of fat.

## Current Efforts

Interest in a practical yet effective means to induce lactation has been stimulated by the recent report of D. K. L. Smith and co-workers at Ohio State University. They were investigating the effects of estrogen and progesterone on colostrum formation and also obtained an indication that the same hormone treatment they used might be effective in initiating lactation. They were successful using 7 day injections. Milk production was initiated within 14 days after injections were stopped. The procedure required short-term (7 days), high injection doses of estrogen (17β-estradiol) and progesterone (0.10 and 0.25 mg/kg/day, respectively) to induce lactation. Utilizing this 7-day injection schedule, field trials, blood hormone concentration and mammary gland histology studies have been conducted during the past several years.

The quantities of estrogen and progesterone injected were chosen to provide blood steroid hormone concentrations comparable to those found during the latter stages of pregnancy. Therefore, they may be mimicing the concentrations found in late pregnancy and at parturition.

In a large field trial using this procedure 38 of 48 injected cows lactated (79%) and produced an average of 13.6 kg of milk per day or more. Lactation began an average of 19.6 days after the steroid injections were started. Based upon preinjection ovarian palpation records, the 48 cows were subdivided into four groups in an effort to determine whether ovarian status influenced response to the steroid injections. Cows were injected between 0 and 7 days postestrus (I), 7 to 18 days postestrus (II), when a follicle was present (III), or with a cystic ovary (IV). Percentages of cows lactating within these groups were 100, 75, 85 and 78%, respectively. It was not established whether ovarian status at the time injections were initiated was important in the response obtained. In an additional study, 7 to 10 injected cows lactated. These seven lactations were characterized by a rapid increase in milk yield during the first 10 days of milking with a production peak at 30 to 50 days. Lactation persistency seemed normal and the mean 305 day FCM yield was just over 5000 kg.

We have utilized the same 17β-estradiol and progesterone injection scheme at Florida in our studies to evaluate blood hormone changes, effect of ovarian status, animal behavior, lactation yield and subsequent reproductive status. In addition one-half of the treated animals received a synthetic corticosteroid (20 mg of dexamethasone per 700 kg of body weight) on days 18, 19 and 20 after beginning the steroid injections. Frequent ovarian palpations throughout the experiment were used to assess ovarian activity. Daily blood samples were obtained beginning the week of steroid injection and continuing through the first 2 weeks of lactation. Plasma concentrations of 17β-estradiol, estrone, progesterone and total glucocorticoids, have been determined on six of these cows. During the period of steroid injections, 17β-estradiol, estrone and progesterone concentrations increased rapidly and remained elevated, whereas glucocorticoid levels were variable. During the subsequent 2 weeks, estrogen and progesterone concentrations declined. Plasma glucocorticoids decreased in animals receiving dexamethasone. Also, during this 2 week interval extensive udder development occurred in many of the cows. This was characterized by gradual swelling of the udder, somewhat like that usually observed during the last third of gestation. In several instances rapid accumulation of milk occurred and leakage from the teats was observed. Milking was begun on day 21. In 13 of 22 cows, production increased fairly rapidly during the first 30 days and was sufficient to justify continued milking. Twelve lactations continued for 305 days or longer, and lactation yields were between 2500 and 5000 kg. However, milk production during the induced lactations was generally lower than produced by normally calving contemporaries.

Overall hormonal patterns observed during and following steroid injections did not resemble those observed during the latter stages of pregnancy, but the peak 17β-estradiol and progesterone concentrations during injection were comparable to late pregnancy concentrations. However, the pattern of increase and decrease of the individual hormones was not similar to that observed near parturition. Failure to detect significant ovarian structures coupled with the continued decline in blood hormone concentrations during the first 2 weeks of lactation indicated that cyclic ovarian activity which had been suppressed had not been reestablished in this time.

Evaluating all the hormone concentration changes occurring within the 21 days from start of injection until milking started did not indicate why some cows milked better than others or why some cows completely failed to respond.

There did not appear to be a relationship between the preinjection ovarian status and the effectiveness of the treatment, although some workers believe it is best to begin estrogen and progesterone injections on cows between estrus and 7 days postestrus. We have induced lactation in 15 ovariectomized cows so we know that the ovary is not essential to success, but we do not know yet whether at some stages of cyclic activity it may be detrimental to success.

The poor preinjection reproductive performance of our cows did not permit adequate postinjection evaluation. However, other workers have

shown that the steroid injection schedule does not ruin normally reproducing cows. After lactation induction such cows show normal estrous cycles, conceive and apparently have a normal gestation and parturition. Of such cows 50 to 75% were rebred and pregnant but days open following steroid injections were increased anywhere from 15 to 100% compared to normally calving cows.

The induced lactation cows do not look nor act like normal cows do around parturition. Because of the large injections of these steroids they show a continuous estrous-like activity until about the third or fourth week of lactation and may be more difficult to handle. They have rough hair coats, raised tailheads, and it seems they are more susceptible to injury, perhaps due to their hyperactivity. Ovarian activity and ovarian structures decrease or disappear during treatment, and mucus discharge from the vulva increases. Ovarian activity starts up again about the time the intense estrous-like activity diminishes. The udder conformation isn't typical either. Udders are less symmetrical and smaller than seen during regular pregnancy. But udder development appears to continue to increase throughout the first 4 to 6 weeks of lactation in these cows. With this increase udders become larger and more symmetrical. This means that the peak of production may occur later in induced cows. So a decision on the success or failure of the steroid injection scheme cannot be made too early in the lactation. We have no reason to believe that milk composition is different in induced cows.

## Conclusions and Outlook

It is evident that although the procedure looks quite promising many questions about its application to commercial operations remain unanswered. The short-term 17β-estradiol and progesterone injection technique to induce lactation gives only a 60 to 80% success rate and the lactation yields may be only 45-105% of yields expected from cows following a normal calving. But on the positive side it is apparent that it is equally effective in non-lactating cows and in heifers that had not lactated. We have tried to optimize the injection schedule by injecting a glucocorticoid on days 18, 19 and 20, just preceding milking on day 21. Our results indicate it results in a better success rate and in higher yields, especially during the first month of lactation. But as of yet we do not know why. Success or failure occurs for unknown reasons, which just illustrates how little we understand what we really are doing when we administer large doses of these hormones to our cows. Subsequent breeding performance cannot be predicted nor can expected lactation yield and persistency. So far there is no evidence that the large doses of these steroids have positive effects in correcting breeding difficulties in cows. Our own results show this clearly. Out of 24 cows with a poor reproductive history only one conceived following this steroid injection schedule. So we should not anticipate that this will help us with our breeding problems. In fact using this technique to induce lactation creates additional problems along the way. The extensive estrous-like behavior in cows during and following steroid treatment may necessitate their isolation from other cows to avoid injury due to their agressive behavior. The cost of the steroids injected to

induce lactation will probably be quite small compared to the financial loss arising from culling cows from the herd. Nonetheless, its use should be evaluated carefully with full consideration given to all the problems involved.

Induction of lactation will not improve production of cows whose genetic merit is questionable. Furthermore, this procedure should only be attempted on non-lactating cattle free of mastitis. A comparable estrogen and progesterone injection during 7 days in a lactating cow may reduce milk yield by as much as 54%, rather than stimulate milk production. More detailed studies to determine the most beneficial hormone injection sequence and quantities need to be carried out. For instance, chemical forms of estrogens other than 17β-estradiol are much less effective. The obvious advantages inherent in the short-term treatment with readily accessible and economical chemicals need to be retained. Once more effective procedures have been developed more uniform success and higher milk yields should result. Until such time, however, the use of the 7 day estrogen and progesterone procedure coupled with a corticoid prior to milking may prove satisfactory. But this technique can only be utilized where there are no restrictions on its use for this purpose, such as is true in the U.S.A. The U.S. Food and Durg Administration restrict its use because we are unsure about the subsequent appearance of these injected steroids in the milk. Once the most effective practical procedures have been established, approval to permit their widespread use in commercial operations will be necessary, where current use is restricted.

# GENETIC CHANGE IN MILK PRODUCTION

by

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The dairy cow has provided milk and meat for man for centuries. In the early years she was used also as a beast of burden, and of course still is today in many parts of the world. Records indicate that cows were being milked as long ago as 6000 B.C. in India, Egypt and Mesopotamia. Christopher Columbus brought the first cattle across the Atlantic in 1493 on his second voyage when he established a colony on Santo Domingo.

Man must certainly have been interested in getting as much milk as possible from the dairy cow from the very beginning. In actual pounds, however, more progress has been made in the past 40 years, than in the previous 8000 years. This can be seen in Table 1.

Table 1. Average U.S. milk production (pounds per cow per year)

| YEAR | DHI COWS | UNTESTED COWS | ALL COWS |
|---|---|---|---|
| 1930 | 7642 | 4435 | 4508 |
| 1940 | 8133 | 4519 | 4622 |
| 1950 | 9172 | 5113 | 5314 |
| 1960 | 10561 | 6522 | 7026 |
| 1970 | 12750 | 8490 | 9353 |

In all years previous to 1930, progress in milk yield was such that the average U.S. cow was producing 4508 pounds per year. In the 40 years to 1970, average yield more than doubled, to 9353 pounds. The table also shows the advantage in milk yield for cows in DHI (tested) herds. Since 1950 it has been over 4000 pounds per cow. There certainly is no evidence that the difference in favor of DHI herds is getting any smaller.

This increase in milk yield has resulted from a combination of improvement in feeding and management practices over the years as well as improvement in the genetic ability of the cows to give milk. Since these two changes have occurred at the same time, it is very difficult to separate them, that is, to say how much was due to genetic change

and how much was due to nongenetic (environmental) change. With the availability in recent years of high speed electronic computers with large capacity, however, these studies are now possible on large groups of dairy cows.

The herd testing program of Ecuador has yielded over 60,000 Holstein lactation records for the years 1948 to 1968. These were made available to us by the kindness of the Asociacion Holstein Friesian del Ecuador and the Instituto Nacional de Investigaciones Agropecuarias (INIAP). Change in the registered and grade populations is shown in Table 2. These are total changes (genetic plus environmental).

Table 2. Average milk yield of Ecuadorian Holsteins on herd test (lactations of 305 days or less)[1]

| YEARS | REGISTERED | GRADE | COMBINED |
|---|---|---|---|
| 1948-50 | 9003 | 4396 | 6918 |
| 1951-55 | 8606 | 6018 | 6971 |
| 1956-60 | 8385 | 6470 | 6974 |
| 1961-64 | 8621 | 7192 | 7436 |
| 1965-68 | 8743 | 7459 | 7612 |

[1]From research by Roman et al., 1970; yields are in pounds.

There appeared to have been little overall change among the registered cows. There were only a few records in the period 1948-50, and these cows may have been in the higher producing herds. An appreciable increase is obvious in the grade population, from 4396 pounds to 7459 pounds.

We took the records of first calf heifers in this population to study genetic change. We could only use data where the sire of each animal was known, of course. So all records from grades without known sires had to be deleted. Our graduate student Wayne Adkinson completed this work in 1972. Average performance of 5481 first-calf heifers on 104 farms was 6825 pounds of milk, 3.46% fat and 235 pounds of fat. Records were 305 days or less in length, averaging 294 days. Average age at first freshening was 33 months.

The overall trend in first calf heifers was quite similar to the trend shown for all registered cows in Table 2. Milk yield per cow was above average in the early years and declined until about 1958 at which time it leveled off with perhaps a very slight increase towards the end of the study (1968).

This decrease in yield, according to our estimates, apparently was due to environmental factors. The genetic trend was positive, with a total gain of about 300 pounds per cow from 1948 to 1962. There was a leveling off from 1962 to 1968, however, with no appreciable change. We can not give specific reasons as to why these particular changes occured. Economic conditions from year to year influence herd management decisions of the dairymen in Ecuador just as they do everywhere else.

We completed a study of first-lactation records in our own University of Florida Jersey herd for the period 1931 to 1968. These data are shown in Table 3 and represent research by James Palmer.

Table 3. Production of first lactation Jerseys, Florida Agricultural Experiment Station, 1931 to 1968 (625 records)

| | |
|---|---|
| Age fresh (months) | 25.1 |
| Days open | 164 |
| Length of record (days) | 295 |
| Milk yield (pounds) | 6113 |
| Fat yield (pounds) | 317 |
| Fat percentage | 5.22 |

These data are interesting for several reasons. They represent a sub-tropical environment. Average annual temperature for north-central Florida is 71.7° F with 52.9 inches of rainfall. We have fairly distinct seasons, and the average maximum daily temperature for Gainesville for June through September is 89.9° F. Nearly 70% of the rain falls during May to October; the average annual humidity for Florida is 78.2%.

The annual genetic change in this herd was 83 pounds per cow per year. Expressed as a percentage of the overall milk yield (6113 pounds), this amounts 1.36% gain per year.

Another set of Florida data was analyzed by Omar Verde (now at the Central University, Maracay, Venezuela) in 1970. These data also were from first lactation records, and are summarized in Table 4.

In Table 5 are the estimates of genetic change for this population. Appreciable genetic increase is evident for milk yield in each breed. On a percentage basis, it amounts to 0.7% per year per cow for Jerseys and Holsteins. The value for Guernseys is considerably higher than expected, and there appears no obvious explanation for this.

We have presented estimates of genetic change in milk yield from three populations of cows, Ecuadorian Holsteins, the Florida Experiment Station Jerseys, and Florida DHI cows. Estimates from each group were

Table 4. Performance of first lactation heifers, Florida DHI herds, 1958 to 1967

| | HOLSTEINS | JERSEYS | GUERNSEYS |
|---|---|---|---|
| Number of records | 1250 | 2031 | 1498 |
| Number of sires | 40 | 61 | 54 |
| Number of herds | 58 | 54 | 69 |
| Age at parturition (months) | 27.4 | 26.4 | 29.5 |
| Length of lactation (days) | 298 | 293 | 287 |
| Milk yield (pounds) | 10388 | 6931 | 7114 |
| Fat yield (pounds) | 381 | 345 | 324 |
| Fat percentage | 3.70 | 4.99 | 4.57 |

Table 5. Average annual genetic change (data from Table 4

| | HOLSTEINS | JERSEYS | GUERNSEYS |
|---|---|---|---|
| Milk yield (pounds) | 73 | 49 | 203 |
| Fat yield (pounds) | -1.5 | 2.9 | 6.2 |
| Fat percentage | - .03 | .01 | - .05 |

positive though somewhat variable. How do these estimates compare with estimates from other researchers? See Table 6.

There is quite a bit of variability in these estimates. That is to be expected. There doubtless are real differences in the genetic change for milk yield. Different breeds and different years are represented, and different methods of making the estimates. Some of the populations resulted from artificial insemination, some used natural service, and some represented both. Some of the studies were very large and others were quite small. Each of the estimates has a certain amount of experimental error associated with it.

On the whole, however, it appears that there has been genetic improvement in milk yield of the dairy cow. On a percentage basis, the value of 0.7% of the overall average per cow per year seems to be the approximate average genetic change.

We need to make three additional points before summarizing:

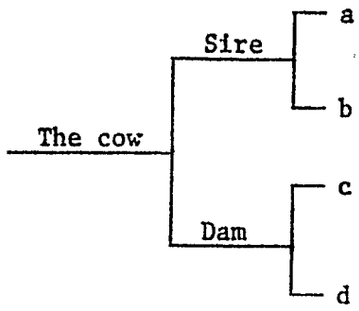
1. Where does genetic improvement come from? Most change comes from selection of males, and only a small portion from selection of females. We can think of the four grandparents of a cow in the following manner, (a) sire of the sire, (b) dam of the sire, (c) sire of the dam, and (d) dam of the dam.

Table 6. Estimates of genetic change in milk yield.

| SENIOR AUTHOR | LOCATION | YEARS | BREED | NUMBER OF LACTATIONS | TYPE[1] | CHANGE ACTUAL | CHANGE % | REMARKS |
|---|---|---|---|---|---|---|---|---|
| Arave | California | 30 | Jerseys | 11,993 | A | 74 | 0.7 | Institutional herds |
| Burnside | U.S. | 9 | Holsteins | 34,380 | F | 121 | 0.9 | Many herds |
| Walton | Iowa | 29 | Holsteins | 1,747 | A | -- | 0.6 | Single herd |
| Acharya | India | 20 | Hariana | 1,875 | A | 22 | 1.5 | Single herd |
| Powell | Midwest U.S. | 12 | Holsteins | 13,615 | F | 181 | 1.4 | One of 5 estimates |
| Harville | New York | 6 | Holsteins | 9,352 | F | 104 | 0.8 | One of 3 estimates |
| Branton | Louisiana | 36 | Holsteins | 772 | F | 112 | 1.1 | Single herd |
| VanVleck | New York | 9 | Holsteins | 57,826 | F | 57 | 0.5 | AI population |
| Mahadevan | Ceylon | 16 | Red Sindhi | <1,000 | A | 0 | 0 | Single herd |
| Dillon | Illinois | 54 | Holsteins | 1,656 | A | 0 | 0 | Single herd |
| Hargrove | Southeast U.S. | 4 | Holsteins | 251,322 | A | 117 | 0.8 | Many herds |
| Hargrove | Southeast U.S. | 4 | Jerseys | 59,274 | A | 55 | 0.6 | Many herds |

[1]A=all lactations; F=first lactations only

In the pedigree, these are:




Research shows that 90 to 94% of the genetic change in milk yield comes from a, b and c, with the remainder coming from d. This occurs because we cannot practice very severe selection for milk yield among females because we need to keep nearly all females born to maintain the herd at the same size (in one year only about 6% of the female dairy cow population in the U.S. is culled for low milk yield; the rest are kept to reproduce or are culled for other reasons), and we can not obtain very good estimates at a young age of the genetic merit of females.

2. What estimates of environmental change have been obtained? As one would expect, these estimates are quite variable. An important point here is that they are not always positive as one would hope. In fact, a number of negative estimates have been obtained. If true, these could result from greater mechanization of dairy herd operations, larger herds, and less individual attention being given to each cow.

3. What magnitude of genetic change for milk yield is possible? It should be possible to increase milk yield genetically at the rate of 1.5 to 2.0% per year. This would result from judicious selection of sires, selection nearly totally for milk yield with little attention to other traits, and an efficient sire proving program. If 0.7% is the actual rate of change being attained, we are only changing at a rate of 1/3 to 1/2 the maximum possible.

SUMMARY: Research from temperate, semi-tropical and tropical areas shows in general that appreciable genetic improvement has been made in milk yield of the dairy cow. Rate of change is at a rate of about 0.7% per cow per year, 1/3 to 1/2 of the maximum possible. Most progress comes from rigid selection of males. Environmental effects on yield are apparently not always positive, although estimates are quite variable.

# MANAGEMENT FACTORS THAT PAY BASED ON A FIVE-YEAR STUDY OF EL SALVADORIAN DAIRY HERD RECORDS

by

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To El Salvador, 1972-1973

This paper will deal with herd management factors with data on several factors developed from the Milk Recording records of El Salvador from 1967 to 1972. A total of 2919 records representing 19 farms in four areas of the country are involved, except that only 2224 had information for studies on effect of "days open."

## Effect of Month of Calving

The effect of the month of calving on milk production shows a difference of over 900 pounds between the 305 day lactation of those Holsteins calving in February and in August. For all breeds, this difference was 729 pounds.

Table 1 gives the average production in 305 days of cows calving in each month of the year for the different breeds and for all breeds together. January to April calving were generally good months for maximum yearly production while May to December were poor months. It is true that dairy farmers producing milk for milk bottling will need to breed some cows for calving during the latter period. The losses can be partially offset by a well planned feeding program.

## Age at First Parturition, by Breed Group

Table 2 gives the means of the age at first parturition for the various breeds and for breed groups of the two major breeds representing the percentage of pure breeding. All breeds show six months older than cows in the United States at first calving and about 10 months older than the recommended age for well grown heifers at first calving. The groups of Holstein and of Brown Swiss with a greater percent of pure breeding show a trend to a younger age at first calving.

## Age Effects: A Set of Age Conversion Factors for El Salvador

The effect of age at calving was studied using all the records. Computerized adjustments were made for farm, breed group, month of freshening and year, thus eliminating the influence of other factors. The calculated age conversion factors represent the relation between the adjusted records made by cows calving at the specific ages and the

Table 1. Effect of month of calving on milk production with adjustments for breed group, farm, year and age.

| Month of Calving | BROWN SWISS (749 records) Average Production 305 days (Milk, lbs.) | BROWN SWISS (749 records) Variation from Average (Milk, lbs.) | BRAHMA, CRIOLLA AND MESTIZA (537 records) Average Production 305 days (Milk, lbs.) | BRAHMA, CRIOLLA AND MESTIZA (537 records) Variation from Average (Milk, lbs.) |
|---|---|---|---|---|
| Jan. | 5921 | 8 | 5017 | 208 |
| Feb. | 6030 | 117 | 5237 | 428 |
| Mar. | 5827 | - 86 | 5015 | 206 |
| Apr. | 5960 | 47 | 5144 | 335 |
| *May | 5832 | - 81 | 4918 | 109 |
| June | 5835 | - 78 | 4625 | -184 |
| July | 6012 | 99 | 4797 | - 12 |
| Aug. | 5673 | -240 | 4733 | - 76 |
| Sept. | 6065 | 152 | 4632 | -117 |
| Oct. | 5890 | - 23 | 4420 | -389 |
| Nov. | 6153 | 240 | 4583 | -226 |
| Dec. | 5758 | -155 | 4587 | -222 |
| Average | 5913 | | 4809 | |
| | HOLSTEINS (1477 records) | | ALL BREEDS (2919 records) | |
| Jan. | 6017 | - 20 | 6048 | 95 |
| Feb. | 6691 | 654 | 6402 | 449 |
| Mar. | 6163 | 126 | 5996 | 43 |
| Apr. | 6082 | 45 | 6067 | 114 |
| *May | 6017 | - 20 | 5913 | - 40 |
| June | 6097 | 60 | 5938 | - 15 |
| July | 6009 | - 28 | 5983 | 30 |
| Aug. | 5760 | -277 | 5673 | -280 |
| Sept. | 5922 | -115 | 5922 | - 31 |
| Oct. | 5872 | -165 | 5822 | -131 |
| Nov. | 5767 | -270 | 5832 | -121 |
| Dec. | 6047 | 10 | 5840 | -113 |
| Average | 6037 | | 5953 | |

*The rainy season begins May 15.

Table 2. Age at first parturition by breed groups.

| BREED GROUP | NUMBER RECORDS | BREED MEAN (AGE IN MONTHS) |
|---|---|---|
| Holstein: | | |
| % not known | 81 | 36.4 |
| 50% | 116 | 35.0 |
| 75% | 80 | 34.1 |
| 87-1/2% | 54 | 34.1 |
| 96-3/4 to 100% | 46 | 32.2 |
| All Holsteins | 377 | 34.6 |
| Brown Swiss: | | |
| % not known | 106 | 35.5 |
| 50% | 29 | 33.5 |
| 75% | 11 | 33.1 |
| 87-1/2 to 100% | 25 | 31.4 |
| All Brown Swiss | 171 | 34.4 |
| Guernseys (all purebred) | 37 | 32.4 |
| Mestiza | 38 | 33.5 |
| Brahma | 62 | 34.0 |
| Criolla | 16 | 37.6 |
| All Breeds | 701 | 34.4 |

records made by cows at maturity (the age group with the largest record). The actual record made by a young cow or a cow past her prime is multiplied by the factor shown to convert it to its "Mature Equivalent." It enables comparison of records of cows of different ages. Mature equivalents are especially valuable in comparing the production of groups of daughters of different bulls.

Factors were calculated for Brown Swiss, Holsteins and Criolla. See Table 3. It will be noted that these El Salvador age conversion factors for Brown Swiss are very close to those in the United States. The Holstein factors calculated from the El Salvador records show a very smooth curve by years of age but the factors are considerably lower than those in the United States. This indicates that the Holsteins are exceptionally well developed and conditioned at first calving and/or they are not fed and handled to make the increase in production as they approach maturity.

The age factors in Table 3 calculated from the El Salvador production records should be useful to the farmer or research worker in evaluating production ability of Brown Swiss, Holstein and Criolla cows handled under conditions comparable to the more specialized dairy herds in El Salvador. These were milked twice daily in dairy barns without a calf at side. Pastures were reasonable well managed but most herds did not receive concentrates in the quantity to support production at the full potential of the better cows.

Table 3. Age effects with adjustments made for farm, breed groups, month of freshening and year effects.

The "factors" shown are the figures for multiplying the records made at the different ages to secure the "mature equivalent" (based on the averages of the records of cows of the specified breeds and ages in El Salvador, 1967-72.

| BROWN SWISS (749 records) | | | | CRIOLLA (91 records) | |
|---|---|---|---|---|---|
| Age at Freshening (Months) | Lbs. Milk | Calculated age factor (El Salvador) | U.S. Factor | Lbs. Milk | Calculated age factor (El Salvador) |
| 24 | 4350 | 1.37 | 1.45 | 4490 | 1.16 |
| 30 | 4717 | 1.27 | 1.35 | 4573 | 1.14 |
| 36 | 5030 | 1.19 | 1.23 | 4661 | 1.11 |
| 42 | 5292 | 1.13 | 1.16 | 4752 | 1.09 |
| 48 | 5506 | 1.09 | 1.10 | 4843 | 1.07 |
| 54 | 5676 | 1.05 | 1.07 | 4929 | 1.05 |
| 60 | 5804 | 1.03 | 1.04 | 5008 | 1.04 |
| 66 | 5895 | 1.01 | 1.02 | 5076 | 1.02 |
| 72 | 5951 | 1.00 | 1.00 | 5132 | 1.01 |
| 78 | 5977 | 1.00 | 1.00 | 5170 | 1.00 |
| 84 | 5974 | 1.00 | 1.00 | 5190 | 1.00 |
| 90 | 5948 | 1.00 | 1.00 | 5186 | 1.00 |
| 96 | 5900 | 1.01 | 1.00 | 5156 | 1.01 |
| 102 | 5835 | 1.02 | 1.01 | 5098 | 1.02 |
| 108 | 5755 | 1.04 | 1.01 | 5007 | 1.04 |
| 114 | 5664 | 1.05 | 1.02 | 4881 | 1.06 |
| 120 | 5566 | 1.07 | 1.02 | 4716 | 1.10 |

| HOLSTEIN (1476 records) | | | |
|---|---|---|---|
| Age at Freshening (Months) | Lbs. Milk | Calculated age factor (El Salvador) | U.S. Factor |
| 24 | 5445 | 1.14 | 1.31 |
| 30 | 5562 | 1.12 | 1.24 |
| 36 | 5668 | 1.10 | 1.18 |
| 42 | 5763 | 1.08 | 1.12 |
| 48 | 5849 | 1.06 | 1.08 |
| 54 | 5925 | 1.05 | 1.04 |
| 60 | 5991 | 1.04 | 1.02 |
| 66 | 6048 | 1.03 | 1.02 |
| 72 | 6096 | 1.02 | 1.00 |
| 78 | 6134 | 1.01 | 1.00 |
| 84 | 6165 | 1.01 | 1.00 |
| 90 | 6186 | 1.00 | 1.00 |
| 96 | 6199 | 1.00 | 1.00 |
| 102 | 6205 | 1.00 | 1.01 |
| 108 | 6202 | 1.00 | 1.02 |
| 114 | 6192 | 1.00 | 1.03 |
| 120 | 6175 | 1.00 | 1.04 |

## Effects of Days Open in Current Lactation and in a Three-Year Period

The question of how soon to breed cows after parturition for the most profitable production has been the subject of much discussion in Latin American countries. There is still some opinion that breeding should be delayed for seven or eight months from the belief that cows drop sharply in milk production following conception.

Table 4 shows the 305-day lactation records of cows grouped according to days open for the different breeds and all cows. While slightly higher production was made by cows in the delayed breeding groups, there was no evidence of the sharp drop in production following conception. The percentage effects of delayed breeding on increase in production in the current lactation was almost exactly the same as in the United States (Table 4, All Cows).

Table 4. Effects of days open with adjustments for breed group, farm, year, month of calving and age.

Additional milk in current lactation by delayed breeding beyond 90 days

| Days Open | 305 days Lactation (lbs.) | Additional Milk (lbs.) | 305 days Lactation (lbs.) | Additional Milk (lbs.) |
|---|---|---|---|---|
| | BROWN SWISS (604 records) | | HOLSTEINS (1036 records) | |
| 90 | 5882 | 0 | 5480 | 0 |
| 120 | 5944 | 62 | 5570 | 90 |
| 150 | 6005 | 123 | 5674 | 194 |
| 180 | 6066 | 184 | 5793 | 313 |
| 210 | 6127 | 245 | 5927 | 447 |
| 305 | 6320 | 438 | 6446 | 966 |
| | GUERNSEYS (142 records) | | BRAHMA, CRIOLLA, MESTIZA (442 records) | |
| 90 | 6195 | 0 | 4481 | 0 |
| 120 | 6254 | 59 | 4597 | 116 |
| 150 | 6311 | 116 | 4702 | 221 |
| 180 | 6366 | 171 | 4796 | 315 |
| 210 | 6419 | 224 | 4880 | 399 |
| 305 | 6579 | 377 | 5074 | 593 |

ALL COWS (2224 records)

| Days Open | Lactation (Lbs.) | Additional Milk (lbs.) | % of 90 day group | From Legates' study of U.S. Records |
|---|---|---|---|---|
| 90 | 5629 | 0 | 100 | 99% |
| 120 | 5741 | 112 | 102 | 102% |
| 150 | 5851 | 222 | 104 | 103% |
| 180 | 5960 | 331 | 106 | 105% |
| 210 | 6064 | 435 | 108 | 106% |
| 305 | 6380 | 751 | 113 | -- |

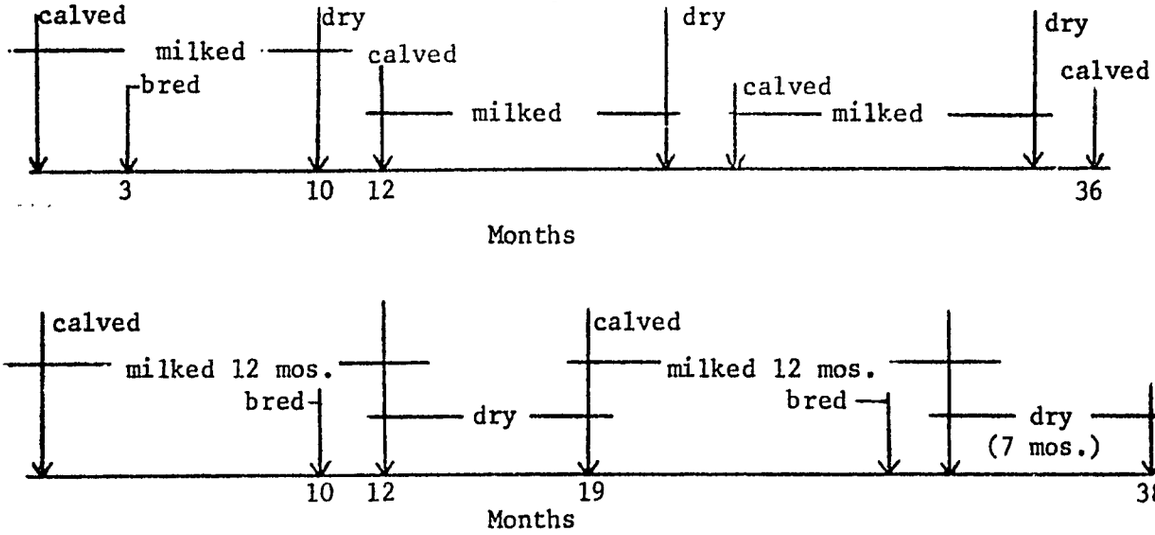
Table 4B extends the study to the production in a 3-year period using the average of those open three months (12-month calving interval) compared to those open 10 months (19-month calving interval). While the delayed breeding gives a little higher lactation records, the average annual production is over 1,000 pounds milk advantage to the 90 days open group.

Table 4B. Effects of days open on 3-year production.

Calculated production in a 3-year period based on 305-day production and days open data (only includes data on cows which "days open" were known).

| | Group Open 3 Months | Group Open 10 Months |
|---|---|---|
| Number lactations | 3 | 2 |
| Swiss, milk lbs. | 3 x 5882 = 17,646 | 2 x 6320 = 12,640 |
| Holsteins, milk lbs. | 3 x 5480 = 16,440 | 2 x 6446 = 12,892 |
| Guernseys, milk lbs. | 3 x 6195 = 18,585 | 2 x 6579 = 13,158 |
| Brahma, Mestizos, Criollas | 3 x 4481 = 13,443 | 2 x 5074 = 10,148 |
| All cows | 3 x 5629 = 16,887 | 2 x 6380 = 12,760 |

Illustration of Lactation and Dry Period of Cows Open 3 Months vs. 10 Months Open in a 3-Year Period




The cow in the upper graph represents 3 months open (10 months milking and 2 months dry each year; 3 lactations in 36 months). The cow in the lower graph is open 10 months (milks possibly 12 months and dry 7 months in her 19 month calving interval). She requires 38 months for just 2 lactations.

The milk production record of the foregoing table is for 305 days, hence an additional amount of possible 500 pounds should be added to the lactation of cows in the "10 months open" group as they may milk 2 months longer. Then, the comparison of the 3-year production of the average of "All Cows" in the table would be as follows:

| Cow | Number Lactations | Average 305-day Lactation | 3-year Production | Av. Production Per calendar year |
|---|---|---|---|---|
| 3 mos. open | 3 | 5629 | 16,887 | 5629 |
| 10 mos. open | 2 | 6380 + 500 = 6880 | 13,760 | 4587 |
| Additional milk from 3 mos. open cow | | | 3,127 | 1042 |

## Effect of Size of Cow

Table 5 shows the per cow production of different groups according to body weight from 700 to 1400 pounds. There was a wide variation in size with the Holsteins showing an average increase of 290 pounds milk per lactation with each 100 pounds increase in body weight. The Brown Swiss showed only 203 pounds milk increase per 100 pounds greater body weight.

Table 5. Effect of size of cow on production.

Relation of body weight to milk production with adjustments for breed group, farm, year and month of calving.

| Body Weight (lbs.) | Holstein (1476 records) 305 day lactation (Lbs.) | Brown Swiss (749 records) 305 day lactation (Lbs.) |
|---|---|---|
| 700 | 5192 | 4995 |
| 750 | 5329 | 4992 |
| 800 | 5470 | 5031 |
| 850 | 5613 | 5107 |
| 900 | 5758 | 5212 |
| 950 | 5905 | 5339 |
| 1000 | 6052 | 5483 |
| 1050 | 6200 | 5636 |
| 1100 | 6349 | 5792 |
| 1150 | 6497 | 5944 |
| 1200 | 6644 | 6086 |
| 1250 | 6791 | 6210 |
| 1300 | 6935 | 6311 |
| 1350 | 7078 | 6382 |
| 1400 | 7218 | 6415 |
| Average increase in milk per 100 lbs. of increase in body weight | 290 | 203 |

## Effect of Level of Concentrate Feeding on Production

Table 6 gives the production of Holstein and Brown Swiss cows on levels of concentrate feeding from 0 to 10 pounds daily as the average

amount fed per day throughout the 305-day lactation. The response varied from approximately 2 pounds increase in milk per pound concentrates fed at the lower levels of feeding to just over 1 pound at the higher levels. The average response per pound concentrate fed throughout the lactation was 1.54 pounds milk for the Holsteins and 1.49 for the Brown Swiss.

If the milk:feed price ratio is 1:1.33, the above response means $2.00 worth of milk for each $1.00 spent for feed. This value justifies feeding concentrates at a fairly liberal level to cows with the genetic ability for higher milk production.

Obviously, pasture and/or harvested forage should be provided in the best quality and quantity possible for economical milk production and conservation of feed supplies. However, by-products of the food industry and special feed crops can enable profitable concentrate feeding to cows of high production ability.

Table 6. Effect of level of concentrate feeding on production with adjustments for breed group, farm, year and month of calving.

| CONCENTRATES LBS. PER DAY | FED PER COW LBS. IN 305 DAYS | 305-DAY LACTATION LBS. MILK HOLSTEIN (1476 records) | BROWN SWISS (749 records) |
|---|---|---|---|
| 0 | 0 | 2665 | 2484 |
| 1 | 305 | 3288 | 3010 |
| 2 | 610 | 3878 | 3519 |
| 3 | 915 | 4433 | 4013 |
| 4 | 1220 | 4954 | 4491 |
| 5 | 1525 | 5441 | 4953 |
| 6 | 1830 | 5894 | 5399 |
| 7 | 2135 | 6313 | 5830 |
| 8 | 2440 | 6697 | 6244 |
| 9 | 2745 | 7048 | 6642 |
| 10 | 3050 | 7358 | 7024 |
| Average increase in milk per lb. increase in concentrates fed | | 1.54 | 1.49 |
| Returns per $1.00 for feed if milk:feed price ratio is 1:1.33 | | 1.33 x 1.54<br>$2.05 | 1.33 x 1.49<br>$1.98 |

## Averages by Breed Groups of Various Factors

Table 7 shows the variations between the different breeds and the variations between breed groups of varying percents of pure breeding within the Holstein and Swiss breeds.

Table 7. Milk production and other factors averaged by breed groups (without adjustments)

| BREED GROUP | NUMBER RECORDS | AGE (MONTHS) | LENGTH OF RECORD (DAYS) | DAYS OPEN | LACTATION (LBS.) |
|---|---|---|---|---|---|
| Holstein: | | | | | |
| % not known | 154 | 66 | 277 | 161 | 5696 |
| 50% | 385 | 67 | 281 | 137 | 5672 |
| 75% | 247 | 64 | 288 | 155 | 6081 |
| 87-1/2% | 107 | 54½ | 290 | 167 | 5848 |
| 93-3/4 to 100% | 143 | 67 | 288 | 195 | 6996 |
| All Holsteins | 1036 | 64.8 | 284 | 156 | 5974 |
| Brown Swiss: | | | | | |
| % not known | 270 | 67 | 284 | 147 | 5397 |
| 50% | 145 | 71½ | 288 | 138 | 6233 |
| 75% | 100 | 73 | 296 | 146 | 6816 |
| 87-1/2 to 100% | 89 | 57 | 294 | 190 | 7658 |
| All Brown Swiss | 604 | 67.6 | 288 | 151 | 6166 |
| Guernsey (all purebred) | 142 | 50 | 293 | 198 | 6034 |
| Mestiza | 204 | 80 | 277 | 156 | 5356 |
| Brahma | 147 | 54 | 253 | 123 | 4592 |
| Criolla | 91 | 83 | 259 | 135 | 4351 |
| All Breeds | 2224 | 66 | 282 | 154 | 5811 |

In summary, the 1967-72 dairy records of El Salvador show responses similar to that of the specialized dairy cattle breeds of the United States. The present annual average production of these herds at 5811 pounds (no adjustments) is about the same as the Florida DHIA average in 1947. The newer knowledge of feeding and management will result in rapid improvement on specialized dairy farms.

Feeding and milking practices can be changed in a short time. Better quality forage can be planned, produced and harvested in one to three years. Improvement of the quality of the cows takes longer but for the good dairyman who improves the other factors, the biggest long term advance will be made through improvement of the productive capacity of his cows. Better proved sires are now available than ever before to expedite the improvement.

# UTILIZATION OF PROSTAGLANDIN $F_{2\alpha}$ FOR OVULATION CONTROL: FERTILITY RESULTS

by

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Detection of estrus and the proper timing of insemination are major reproductive management problems facing dairymen. Large herd size and subtropical environmental conditions undoubtedly increase these problems for Florida dairymen. Any system which improve estrous detection will greatly improve reproductive management. This can be partially accomplished by estrus and ovulation control. However, we will never really be successful in regulating the estrous cycle to breed cows in groups when we want until a full understanding of the hormonal relationships controlling the estrous cycle are established. The first experiment to be presented was designed to characterize the transitory hormonal changes of progestins, estradiol and LH which culminate in spontaneous ovulation. Such knowledge is essential in developing an ovulatory control system.

Six animals were fitted with indwelling jugular catheters on day 14 (day 0 = day of last estrus) of the estrous cycle. Blood samples were collected daily on days -6 through -4 prior to heat, every 6 hr on days -3 and -2, and every 2 hr from day -1 to the time of ovulation. Animals were observed for estrus after every blood sample was collected and palpated per rectum to determine the time of ovulation. Plasma progestins, estradiol and LH were measured by radioimmunoassay, and the results are illustrated by the regression lines in figure 1. Associated with the regression of the corpus luteum (CL) was a decrease in plasma progestins (secreted by the CL) from a concentration of 5.7 ng/ml at day -6 to 0.068 ng/ml at the onset of estrus. Progestins remained at this low level until after ovulation. Plasma estradiol remained at approximately 2 pg/ml until day -4 at which time it began to rise. A substantial increase in $E_2$ did not occur until after the CL had begun regression. Estradiol remained elevated from 24 to 48 hr prior to the onset of estrus and declined preciptiously during the period of estrus. The low level of progesterone and elevated level of estradiol prior to the onset of estrus appear to cause a massive surge of plasma LH close to the onset of estrus. This peak of LH is responsible for ovulation that occurred 22 hr after the peak of LH (Table 1).

In the past few years a compound called prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) has been attracting much attention in the field of reproductive physiology. Research in sheep indicates that the uterus produces a luteolytic

Table 1. Intervals between certain physiological and behavioral events in the bovine at estrus.

| INTERVAL | MEAN HOUR | S.D.[a] | n[b] |
|---|---|---|---|
| Peak LH to Ovulation | 22.25 | 3.53 | 6 |
| Onset of Estrus to Peak LH | 2.83 | 1.27 | 6 |
| Duration of Estrus | 10.00 | 1.52 | 5 |

[a]S.D. = standard deviation
[b]n = number of animals measured

factor ($PGF_{2\alpha}$) and data from Cornell University indicate that a similar luteolytic compound might be produced by the cow uterus. $PGF_{2\alpha}$ causes CL regression in many species when injected. We designed the following experiment to determine if $PGF_{2\alpha}$ would induce CL regression (decreased progestins), follicle growth (increased estradiol), estrus (LH surge) and ovulation. If these events can be induced and appear to be normal, then $PGF_{2\alpha}$ may be a very useful tool for control of ovulation. Seven heifers were treated with $PGF_{2\alpha}$ (either 30 mg Intramuscular or 10 mg Intra uterine). Heifers were fitted with indwelling jugular catheters and blood samples were collected at 2 hr intervals for 6 hr prior to $PGF_{2\alpha}$ administration until ovulation. Plasma progestins, estradiol and LH were measured and this data is illustrated in figure 2.

Six of seven heifers expressed an induced estrus and ovulated after receiving $PGF_{2\alpha}$. By 7 hr after $PGF_{2\alpha}$ administration, plasma progestins declined 50% thus confirming that CL regression was induced. The induced hormonal changes in figure 2 synchronized to the peak of LH, reflects the same relative changes associated with spontaneous heats and ovulation of experiment I (Figure 1). Results from the second experiment indicate there are no major alterations of expected hormonal interrelationships between progestins, estradiol and LH approaching a $PGF_{2\alpha}$ induced estrous and ovulation. Other laboratories have reported similar findings. The intervals from $PGF_{2\alpha}$ administration to estrus, peak LH and ovulation were: 74.9, 78.8 and 99.5 hr, respectively (Table 2). The interval between the peak of LH to ovulation and duration of estrus was comparable to that observed with the spontaneous ovulations of experiment I (Table 1).

At this point it was felt that $PGF_{2\alpha}$ may provide a means of synchronizing ovulation with one treatment. However, the traditional progestational compounds used for estrous synchronization have resulted in lowered fertility at the synchronized estrus. Thus it was essential to determine if fertility at the $PGF_{2\alpha}$ induced ovulation was normal. A cooperative regional study was conducted between the University of Florida, Upjohn Co., Michigan State University and Louisiana State University involving 386 animals. The University of Florida component of the study was conducted in cooperation with Bassett's Dairy, Monticello, Florida. Cattle were assigned randomly to one of three treatment groups at each of the four locations. At the initiation of the experiment, ovaries of all animals

Table 2. Intervals (hr) between $PGF_{2\alpha}$ injection and certain physiological events in the bovine.

| INTERVAL | $\bar{X}$ (n=6)[a] | S.D.[b] |
|---|---|---|
| $PGF_{2\alpha}$ to Onset of Estrus | 74.9 | 21.1 |
| $PGF_{2\alpha}$ to Peak of LH | 78.8 | 20.8 |
| $PGF_{2\alpha}$ to Ovulation | 99.5 | 19.2 |
| Onset of Estrus to Ovulation | 24.6 | 4.8 |
| Peak LH to Ovulation | 20.7 | 5.4 |
| Length of Estrus | 11.2 | 1.5 |
| Onset of Estrus to Peak LH | 3.9 | 3.1 |

[a]n = number of animals measured
[b]S.D. = standard deviation

were palpated to determine the presence of a CL. Treatment I animals served as controls and were artifically inseminated approximately 12 hr after onset of estrus. Animals assigned to Treatments II and III were injected with 30 mg of $PGF_{2\alpha}$-Tham Salt if a CL was detected. Animals without a CL were injected one week later. Animals in Treatment II were inseminated as those in Treatment I, whereas Treatment III cattle were inseminated twice, at 72 and 90 hr after $PGF_{2\alpha}$ injection, without regard to time of estrus.

Cattle in Treatments II and III were considered to have responded to $PGF_{2\alpha}$ if they returned to estrus between days 1 to 7 following $PGF_{2\alpha}$ injection. Using this definition 58 and 72% of the animals responded to $PGF_{2\alpha}$ in Treatments II and III, respectively. However, if the rate of estrous detection for Treatment I (82.5%) can be considered a reliable measure of percent animals expressing estrus or capable of being detected, then 73 and 88% responded to $PGF_{2\alpha}$ for Treatments II and III, respectively. These data suggest that additional methods should be investigated for administering $PGF_{2\alpha}$ to cattle in order to obtain a greater rate of response. Of the heats induced within a 7 day period, 52% were observed on day 3 and 90% were detected between days 2, 3 and 4.

All animals were diagnosed for pregnancy by rectal palpation at 35 to 60 days after artificial insemination. The overall fertility and fertility for each region is expressed in Table 3.

There was no evidence of a treatment by area interaction so the data were pooled for the four regions: Fertility for Treatments I, II and III were 53.2, 52.2 and 55.8%, respectively. Thus, fertility was similar to controls when cattle were inseminated at the synchronized estrus following $PGF_{2\alpha}$; fertility was similar to controls when cattle were inseminated at predefined intervals following $PGF_{2\alpha}$. An additional way to express the fertility data is percent conceived of animals assigned

Table 3. Fertility following $PGF_{2\alpha}$[a].

| TREATMENT | LOCATION[b] | | | | |
|---|---|---|---|---|---|
| | Michigan | Florida | Louisiana | Upjohn | Total |
| I | 62.5 (24)[c] | 54.5 (33) | 48.2 (56) | 55.5 ( 9) | 53.3 (122) |
| II | 90.5 (21) | 31.8 (22) | 38.9 (18) | 37.5 ( 8) | 52.2 ( 69) |
| III | 78.9 (19) | 33.3 (30) | 65.0 (20) | 58.9 (17) | 55.8 ( 86) |

[a]Treatments I and II Fertility = (number of cattle pregnant 35 to 60 days after AI) divided by (number of cattle AI). Treatment III Fertility = (number of cattle pregnant 35 to 60 days after AI) divided by (number of cattle responding to $PGF_{2\alpha}$).

[b]Michigan State University, University of Florida, Louisiana State University, The Upjohn Company.

[c]Number of animals in parenthesis.

to each treatment groups. These were 42, 30 and 42% for Treatments I, II and III, respectively; such values reflect degree of estrous detection (Treatments I and II), response to $PGF_{2\alpha}$ (Treatments II and III) and conception rates (Treatments I, II and III).

These results indicate that the prostaglandin $F_{2\alpha}$ drug may provide dairymen with the first practical ovulatory control treatment that results in normal fertility. Such a compound could markedly improve reproductive management schemes in dairy heifer and cow operations. Animals between days 1 and 5 of the estrous cycle are non-responsive to $PGF_{2\alpha}$ and therefore such animals can not be synchronized. Additional research is needed to sensitize cattle to the drug at this time or devise appropriate management schemes to minimize the problem.

Use of $PGF_{2\alpha}$ on the farm will depend on its price and whether the drug receives clearance for use from the Food and Drug Administration. Drug residue studies are now under investigation. Fortunately $PGF_{2\alpha}$ is very rapidly metabolized and should not present a major problem. The amount of drug required will depend on route of administration and availability of more potent $PGF_{2\alpha}$ drug analogues.

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# EQUINE HEALTH CARE PROGRAMS

by

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The equine species requires the same careful consideration of production requirements as other animal production units. The three major areas of concern are nutrition, management, and health.

Equine health is very closely interrelated and interdependent upon management and nutrition. Therefore, to protect the owner's investment, the veterinarian's first concern is a program of preventive medicine. His responsibility is to maintain not only the general health, but the breeding health or soundness of all horses on the farm.

Each horse farm must be maintained as a "closed" animal unit. This means isolation of all incoming animals to the horse unit for a 30 to 60 day quarantine period. Though isolation facilities are not always available, every effort should be taken to provide such facilities as a standard safe-guard.

During the isolation period, a simple but rigid routine of examining new arrivals can prevent trouble later. A health record card should be established for each new arrival. On this card, a record of daily temperature, attitude, appetite, thirst, and character of the feces should be noted. Remember the new arrival's period of travel can be exhausting and the m stress factors can contribute to pleuritis, pneumonia, dehydration, constipation, and other serious complications.

During the quarantine period, standard diagnostic tests and required vaccination and treatment procedures should be instituted. These measures may include blood tests for equine infectious anemia, piroplasmosis, and leptospirosis; vaccination for control of equine encephalomyelitis, tetanus, rhinopneumonitis, influenza, etc.; treatments for external and internal parasites control; and evaluation of reproductive soundness by checking the stallion's semen and the culturing of the mare's cervix.

In general, the owner of the horses and the veterinarian should custom design these health, management, and nutrition programs for each ranch. Comfortable stables and safe corrals should be provided. The nutritional programs should be based on the type, age, sex, and use of the horses. The herd veterinarian should demonstrate to all horse handlers the proper hoof and leg care. A routine parasite examination and dental care program should be established. This latter procedure will help reduce colic and other gastrointestinal maladies.

The veterinarian is responsible for the type, number, and scheduling of inoculations. Different ranches and areas require somewhat different immunization programs. Thus, the custom design is required.

Breeding programs require constant surveillance and the maintaining of good records. Mares should be grouped as maiden mares, barren mares, and foaling mares. Only be rectal palpation of all the reproductive organs by an experienced person can the condition of the entire genital system be accuratley determined. Special attention must be given to the routine teasing of all mares if the breeding program is going to be successful. A complete and accurate teasing chart is extremely valuable for recording changes in the heat periods.

Conformation examination of the vulva for the possible "wind-sucking" condition in all breeding mares is very important. Correction of this anatomical problem with the "Caslick" surgical closure often prevents movement of air into the vagina and assures a full-term gestation period.

Paturition by the mare usually occurs between 315 and 350 days of gestation. As this is a sizable time variation, most breeders realize that a few days deviation in the average foaling time of 340 days is not unusual.

Certain physiological signs herald the approach of foaling time. First, the mare begins to "make bag". This can occur several weeks prior to due date, but the "waxing" phenomena occurs 24 to 48 hours before foaling. "Waxing" is the variable-sized honey-colored, waxy substance that forms at the end of each teat.

A quite, clean, and well bedded box stall is recommended when the birth process is imminent. If assistance is required for the foal delivery, remember that infection may be introduced by contaminated hands or instruments and bruised or torn tissue is more susceptible to infection than is healthy tissue. Thus, minor injuries to the gential tract at foaling time become easily infected unless strict care is taken to see that dirty hands, obstetrical ropes, chains, and other instruments are kept out of the birth canal. Asepsis is mandatory!

Allow the mare to rest in the recumbent position for 10 to 15 minutes after foaling. If the fetal membranes have not been discharged within 6 hours, the herd veterinarian should be notified. Also, an examination of the expelled membranes by the mare's attendant should be made to be certain that no pieces have torn away and remain in the uterus.

The mare and new foal should remain in the box stall for 12 to 24 hours so that the foal can nurse freely and derive all possible benefits from the colostrum.

The foal's umbilical stump should be treated immediately with strong iodine for its disinfectant and cautery action. The cord should be tied with umbilical tape only if excessive hemorrhaging is occuring or it becomes necessary to cover the umbilical cord from the fetal membranes. Antibiotic prophylactic therapy is often routinely administered to the foal as soon as the cord is severed. Weak foals may require oxygen, supportive fluid therapy, and/or whole blood transfusions (50-100 mls) from the dam.

These few comments about horse health programs can be summed up by stating that "Preventive Medicine" is the key to sound horse health management programs. Treating sick animals is costly and frequently a losing battle. Animals in good condition, well fed and watered, have greater resistance to disease. Therefore, horsemen in cooperation with their veterinarians need to develop a month by month annual calendar of nutrition, management, and health programs to meet their long-range production goals.

Keep 'um healthy!!

# INTERNAL PARASITE CONTROL

by

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Horses and ponies have the distinction of having more different kinds of internal parasites than any of the other domesticated animals. More than 50 different parasite species are capable of infecting horses and ponies and some of these species are capable of producing serious illness or death.

All horses and ponies have parasites; it is virtually impossible to completely eliminate them from individual animals. However, the strategic and judicious use of anthelmintic drugs will reduce the parasite population to a level that the animal can tolerate.

The internal parasites commonly seen in horses and ponies in Florida can be divided into the following groups for convenience: *Gastrophilus* sp. (bots), *Strongylus* sp. (large strongyles), *Oxyuris equi* (pinworms), *Parascaris equorum* (ascarids or large roundworms), small strongyles (many species), *Strongyloides westeri*, tapeworms (several species), and a few other species.

*Gastrophilus* sp. (bots): Bots are larval stages of flies that are attached to the horse's stomach lining. They occur in greatest numbers during the winter months in Florida (November to March) and treatment to remove bots is done once or twice during this period.

The most effective way to treat for bots is via a stomach tube. Carbon disulfide, in liquid form, may be used in adult horses, but it is highly toxic and should not be used in young animals. Due to their lesser toxicity piperazine-carbon disulfide trichlorfon-phenothiazine combinations are better choices since these are broad spectrum anthelmintics, useful against some worm parasites in addition to their activity against bots. Butonate is also an effective drug, against bots only. Dichlorvos may also be used, either mixed in feed or as a paste applied to the animal's tongue.

*Strongylus* sp. (large strongyles) and small strongyles (many species): These 2 groups of strongyles number at least 45 distinct species. Unfortunately, the eggs of all strongyle species look alike under the microscope. For this reason, fecal examinations that give only numbers of eggs present are of little value in diagnosis. However,

if the fecal sample is incubated allowing the worm eggs to hatch (usually within 24 hrs.), the resulting larvae can be readily identified and differentiated. By determining the species and relative numbers present an accurate diagnosis can be made.

Accurate diagnosis is essential with strongyle infections since 2 large strongyle species, *Strongylus vulgaris* and *Strongylus edentatus*, are the most pathogenic of all internal parasites of horses and ponies.

The true "blood worm" is *Strongylus vulgaris* and infection of any equine with this species can lead to serious illness or death. The larvae enter the horse via feed or water and migrate from the intestinal tract to the arteries that supply blood to the intestines. They migrate within the walls of these arteries causing inflammation and blood clots. If portions of these clots break off and are carried along in the bloodstream, they plug up smaller arteries thus cutting off the blood supply to a portion of the intestinal tract. This is "verminous colic" and is one of the most common types of colic in horses and ponies. If a larger blood vessel becomes partially plugged because of a clot, it can lead to a "ballooning" of the weakened artery (aneurysm formation) which makes it subject to rupture.

An important point to remember about *Strongylus vulgaris* is that the life cycle (from egg to larval migration to egg-laying adult worms) requires about 6 months to complete. Therefore, foals under 6 months of age will not have large strongyle eggs on fecal examination and the use of anthelmintics against large strongyles is not necessary. However, foals can be infected with large strongyles from the day of birth if exposed to infective larvae. It is imperative to observe proper sanitation including daily removal of manure from the time a foal is born to reduce the chances of infection with large strongyles.

The other pathogenic large strongyle is *Strongylus edentatus*. It's life cycle is similar to that of *S. vulgaris* except that the cycle requires about 11 months to complete. Therefore, the use of drugs against this large strongyle worm in suckling or weanling foals is of no value.

In older horses and ponies, there are a number of effective anthelmintics that are effective in reducing the numbers of large strongyles, if administered on a regular basis. Combinations of these drugs are frequently used to get the maximum effect out of each one. The drugs of choice are most effective if administered via stomach tube since the exact dose can thus be given. Top dressing feed with anthelmintic formulations is second best, but often is a useful method, if employed as part of a regular program.

Phenothiazine was the first chemical that was widely used as an equine anthelmintic and is still in use today, either alone or in combination with other drugs. Thiabendazole, piperazine-carbon disulfide, mebendazole, and pyrantel tartrate are other examples of drugs that are effective against large strongyles (see Table 2).

*Parascaris equorum* (roundworms): These worms cause the most severe problems in young animals (suckling and weanling foals) and treatment every 4 weeks starting at about 8 weeks of age until the animal is about 6 months old is the recommended practice. There is not much point in starting treatment earlier than 8 weeks since about 10 weeks is required for large roundworms to complete their life cycle.

The drug of choice for treating young animals for *Parascaris* infections is piperazine. This drug is available in a variety of formulations and should be given by stomach tube or drench for best effect. However, a top dressing formulation can be used, if part of a routine program (Table 1).

*Oxyuris equi* (pinworms): These parasites are mainly a nuisance to horses since they live in the large intestine and rectum. The adult female worms inhibit the rectum and skin in the region of the anus. This leads to irritation of the area and the infected animal rubs the tail and anal region on fences, stalls, etc. The same drugs that are effective against strongyles are also effective in treating pinworm infections (Table 1).

*Small strongyles*: This group of internal parasites is mostly non-pathogenic. There is no larval migration as with large strongyles and disease production by these worms is debatable. However, since the eggs are indistinguishable from those of large strongyles, it is important that an effective treatment program be followed. Most of the anthelmintic drugs that are effective against large strongyles are also effective against the small varieties (Table 2).

*Strongyloides westeri*: These parasites may be more pathogenic to foals than once thought. It is now apparent that infection of suckling foals can occur through the colostrum. Diarrhea is a common clinical symptom of *Strongyloides* infection in foals. Thiabendazole is the only known effective drug treatment.

*Tapeworms*: These parasites are relatively common in horses and ponies in Florida, but usually are found in small numbers. It is usually difficult to associate tapeworms with disease. There is no effective known treatment although claims are made by some products such as lead arsenate. We do not usually recommend treatment for tapeworms in equines.

*Other parasitic diseases*: Horses and ponies may be infected with a stomach worm of cattle (*Trichostrongylus axei*) when grazing with infected cattle. Use of a regular treatment program for other internal parasites (Table 1) will control *T. axei* infections, if they occur.

Cutaneous (skin) infection with *Habronema* sp. occurs in Florida equines where the worm larvae invade an existing wound. This type of infection is associated with poor sanitation and can be very difficult

to treat. Thiabendazole paste applied to the wound is reported by some individuals as effective in helping to cure these "summer sores". There are also reports of using organo-phosphate insecticides directly on the wounds. However, surgical intervention is usually required to remove the granulation tissue that is produced around such wounds.

## Summary

Successful control of internal parasite infections of horses and ponies in Florida requires good management (manure disposal, use of feed bunks, clean water, rotation of paddocks and pastures, separation of different age animals) and the judicious, regular use of effective anthelmintics. An annual program involving the use of a variety of drugs is recommended. A suggested program is presented in Table 1.

We have purposely omitted giving specific drug dosages and listing trade names of drugs in this discussion. This is because of the large number of trade names that are currently marketed and also the number of formulations that have various recommended dosage rates. For this information, read the label on the package and follow those directions to the letter. All anthelmintic drugs are potentially toxic and should be handled and used with caution. Consult your veterinarian for advice on setting up a routine treatment program.

Table 1. Examples of Recommended Programs for Anthelmintic Treatment of Horses and Ponies in Florida.

A. Brood mares

1. *Gastrophilus* sp. (bots) - use butonate* or drug of choice - March and November.
2. *1 month prior to foaling* - use mebendazole* or thiabendazole-piperazine*
3. *10 days after foaling* - use mebendazole* or thiabendazole-piperazine* and move to new pasture

B. Foals

1. *8 weeks* - use piperazine*
2. *12 weeks* - use piperazine* (and thiabendazole* if *Strongyloides westeri* is problem)
3. *16 weeks* - use piperazine*
4. *20 weeks* - use piperazine-thiabendazole* or mebendazole*
5. *24 weeks* - use mebendazole* or thiabendazole* and start on regular treatment program afterward

C. Working horses

1. *Gastrophilus* sp. (bots) - use butonate* or drug of choice - March and November
2. February - use trichlorfon (feed)
3. May - use mebendazole or thiabendazole (feed)
4. July - use mebendazole* or thiabendazole*
5. September - use dichlorvos (feed); use mebendazole* or thiabendazole* instead, if necessary

D. Pasture horses (not working)

1. *Gastrophilus* sp. (bots) - use butonate* or drug of choice - March and November
2. March and November - use mebendazole* or thiabendazole*
3. July - use dichlorvos (feed)

* administration via stomach tube.

NOTE: Equally effective anthelmintics may be substituted, but alternation of the various types of drugs is desirable and recommended. The frequency of treatment may need to be increased, depending on intensity of infections.

Table 2. Activity of Currently-Approved Anthelmintics for Horses (1975)

| Generic Names | *Gastrophilus* sp. (bots) | Large Strongyles | *Oxyuris equi* (pinworms) | *Parascaris equorum* (roundworms) | Small Strongyles | *Strongyloides westeri* | Tapeworms |
|---|---|---|---|---|---|---|---|
| Butonate | + | 0 | 0 | + | 0 | 0 | 0 |
| Carbon disulfide | + | 0 | 0 | 0 | 0 | 0 | 0 |
| Dichlorvos | + | + | + | + | + | 0 | 0 |
| Dithiazanine iodide-piperazine | 0 | + | + | + | + | 0 | 0 |
| Mebendazole | 0 | + | + | + | + | 0 | 0 |
| Phenothiazine | 0 | + | 0 | 0 | + | 0 | 0 |
| Phenothiazine-piperazine | 0 | + | 0 | + | + | 0 | 0 |
| Piperazine | 0 | 0 | + | + | + | 0 | 0 |
| Piperazine-carbon disulfide | + | 0 | + | + | + | 0 | 0 |
| Piperazine-carbon disulfide-phenothiazine | + | + | + | + | + | 0 | 0 |
| Pyrantel tartrate | 0 | + | + | + | + | 0 | 0 |
| Pyrantel pamoate | 0 | + | + | + | + | 0 | 0 |
| Thiabendazole | 0 | + | + | 0 | + | + | 0 |
| Thiabendazole-piperazine | 0 | + | + | + | + | + | 0 |
| Trichlorfon | + | + | + | + | 0 | 0 | 0 |
| Trichlorfon-phenothiazine-piperazine | + | + | + | + | + | 0 | 0 |

+ = effective (> 75% removal)
0 = ineffective (<75% removal)

# BALANCING HORSE RATIONS

by

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The term "Balancing-a-Ration" refers to the technique of combining a series of ingredients to provide the nutrients an animal needs. The technique is applicable to all species and varies only with 1) the animal's requirements, 2) available ingredients and 3) desired physical characteristics of the ration.

The nutrient requirements of the horse are detailed in a publication entitled *Nutrient Requirements of the Horse*. Published by the National Research Council, it is available for $2.50 from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue N.W., Washington, D.C. 20418. A portion of the information contained in this booklet is shown in table 1. It can be seen from the information in this table that the horse's needs vary with age, size and activity.

Since most horse rations are built around an available forage, either in the form of pasture or hay, the initial step to balancing rations is to determine what forage will be available and what it will contribute toward the horse's requirements. Of primary concern is the level of forage consumption. Projected forage consumption is shown in table 2. When this information is applied to the composition data shown in table 3, the contribution of the forage to the animal's total requirement can be calculated. From these calculations it can be seen that a separate ration can be calculated for each animal on each forage. Since this would be rather impractical, a grouping of animals with similar requirements is recommended. Table 4 illustrates such a grouping.

Three ration standards were calculated to balance a good quality grass forage (table 5). These three rations are suitable for the three groups of animals shown in table 4 (Group 1, ration A; Group 2, ration B and Group 3, ration C). There are many different ways of providing these nutrients depending upon the availability of feed ingredients. There are no essential ingredients in a horse ration, only essential nutrients.

Example rations are shown in table 6. It should be noted that those ingredients which greatly influence the key nutrient levels have been altered. To change the protein level from 18% to 14%, soybean meal was decreased and the grains increased. A similar change occurred as the ration was reduced to 12%. The mineral content was reduced in a like

manner by reducing the dicalcium phosphate and limestone. Salt was increased in rations B and C since they make up a smaller portion of the animal's total intake than does the foal ration.

When economics are considered, it may be more economical to switch from one ingredient to another when altering the nutrient composition of a ration. The important thing is to keep all of the nutrients in balance with one another. Since the horse generally eats to meet his energy requirement, a constant relationship between nutrients and energy should be maintained.

## Summary

Balancing horse rations is somewhat more complex than adding another measure of oats to the feed bucket when the horse is worked. Since the horse has a requirement for at least 22 different nutrients, each must be considered when ration changes are made. For the most part, requirements for energy, protein, calcium and phosphorus are the most critical. Other nutrients can generally be kept within suitable range by the use of standard vitamin and trace mineral packages.

Table 1. Daily nutrient intake recommendations for horses.

| | Weight | Digestible Energy | Digestible Protein | Crude Protein | Calcium | Phosphorus | Sodium | Potassium | Magnesium | Manganese | Iron | Copper | Zinc | Iodine | Cobalt | Selenium | Vitamin A | Vitamin D | Vitamin E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | kg | Mcal | g | g | g | g | g | g | g | mg | mg | mg | mg | mg | mg | mg | IU (thou) | IU (thou) | IU |
| Maintenance (mature horse) | 400 | 13.86 | 268 | 505 | 18.0 | 12.0 | 25 | 50 | 5.6 | 320 | 320 | 64 | 400 | 0.8 | 0.8 | 4.0 | 10.0 | 2.6 | 100 |
| | 500 | 16.39 | 317 | 597 | 22.5 | 15.0 | 30 | 60 | 7.0 | 400 | 400 | 80 | 500 | 1.0 | 1.0 | 5.0 | 12.5 | 3.3 | 125 |
| Light Work, 2hr/day | 400 | 18.36 | 355 | 672 | 18.0 | 12.0 | 29 | 66 | 7.4 | 320 | 424 | 84 | 530 | 1.05 | 1.05 | 4.0 | 20.0 | 2.6 | 200 |
| | 500 | 21.89 | 424 | 803 | 22.5 | 15.0 | 35 | 80 | 9.3 | 400 | 534 | 107 | 668 | 1.33 | 1.33 | 5.0 | 25.0 | 3.3 | 250 |
| Medium Work, 2hr/day | 400 | 23.80 | 460 | 871 | 19.8 | 13.2 | 33 | 86 | 9.6 | 320 | 549 | 110 | 687 | 1.37 | 1.37 | 4.0 | 20.0 | 2.6 | 200 |
| | 500 | 28.69 | 553 | 1047 | 24.7 | 16.5 | 40 | 105 | 12.3 | 400 | 700 | 140 | 875 | 1.75 | 1.75 | 5.0 | 25.0 | 3.3 | 250 |
| Breeding | 400 | 15.3 | 319 | 599 | 20.5 | 13.5 | 30 | 50 | 5.6 | 320 | 800 | 80 | 400 | 1.6 | 1.6 | 4.0 | 20.0 | 2.6 | 200 |
| | 500 | 18.8 | 368 | 691 | 25.0 | 16.5 | 30 | 60 | 7.0 | 400 | 1000 | 100 | 500 | 2.0 | 2.0 | 5.0 | 25.0 | 3.3 | 250 |
| Mid-Gestation | 400 | 13.9 | 268 | 505 | 18.0 | 12.0 | 30 | 50 | 5.6 | 320 | 800 | 80 | 400 | 1.6 | 1.6 | 4.0 | 10.0 | 2.6 | 100 |
| | 500 | 16.4 | 317 | 597 | 22.5 | 15.0 | 30 | 60 | 7.0 | 400 | 1000 | 100 | 500 | 2.0 | 2.0 | 5.0 | 12.5 | 3.3 | 125 |
| Late Gestation | 400 | 15.3 | 375 | 613 | 21.5 | 15.0 | 30 | 50 | 5.6 | 320 | 800 | 80 | 400 | 1.6 | 1.6 | 4.0 | 20.0 | 2.6 | 200 |
| | 500 | 18.8 | 434 | 725 | 26.5 | 18.0 | 30 | 60 | 7.0 | 400 | 1000 | 100 | 500 | 2.0 | 2.0 | 5.0 | 25.0 | 3.3 | 250 |
| Peak Lactation | 400 | 24.4 | 748 | 1181 | 55.5 | 35.6 | 30 | 50 | 5.6 | 320 | 800 | 80 | 400 | 1.6 | 1.6 | 4.0 | 20.0 | 2.6 | 200 |
| | 500 | 27.6 | 829 | 1317 | 59.7 | 38.6 | 30 | 60 | 7.0 | 400 | 1000 | 100 | 500 | 2.0 | 2.0 | 5.0 | 25.0 | 3.3 | 250 |
| Late Lactation | 400 | 19.4 | 596 | 947 | 40.0 | 25.8 | 30 | 50 | 5.6 | 320 | 800 | 80 | 400 | 1.6 | 1.6 | 4.0 | 20.0 | 2.6 | 160 |
| | 500 | 22.0 | 660 | 1056 | 43.0 | 28.0 | 30 | 60 | 7.0 | 400 | 1000 | 100 | 500 | 2.0 | 2.0 | 5.0 | 25.0 | 3.3 | 200 |
| Growing Foal: | | | | | | | | | | | | | | | | | | | |
| Age mo. / Expected Mature Wt kg | | | | | | | | | | | | | | | | | | | |
| 3 / 400 | 85 | 10.44 | 553 | 741 | 26.1 | 16.4 | 7 | 14 | 1.6 | 80 | 200 | 24 | 100 | 0.4 | 0.4 | 2.0 | 3.4 | 0.56 | 42 |
| 500 | 110 | 12.07 | 618 | 834 | 30.3 | 19.1 | 9 | 18 | 2.0 | 100 | 250 | 30 | 125 | 0.5 | 0.5 | 2.5 | 4.4 | 0.73 | 55 |
| 6 / 400 | 170 | 12.41 | 430 | 640 | 30.0 | 17.6 | 14 | 29 | 3.2 | 160 | 400 | 48 | 200 | 0.8 | 0.8 | 4.0 | 6.8 | 1.12 | 85 |
| 500 | 225 | 15.40 | 536 | 800 | 35.3 | 22.5 | 18 | 36 | 4.0 | 200 | 500 | 60 | 250 | 1.0 | 1.0 | 5.0 | 9.0 | 1.48 | 112 |
| 12 / 400 | 260 | 13.63 | 370 | 600 | 22.0 | 14.8 | 22 | 39 | 4.8 | 240 | 600 | 72 | 300 | 1.2 | 1.2 | 6.0 | 10.4 | 1.72 | 130 |
| 500 | 325 | 16.81 | 472 | 750 | 26.0 | 17.4 | 27 | 49 | 6.0 | 300 | 750 | 90 | 375 | 1.5 | 1.5 | 7.5 | 11.0 | 2.14 | 162 |
| 18 / 400 | 330 | 14.10 | 339 | 575 | 19.0 | 13.8 | 29 | 52 | 6.4 | 320 | 800 | 96 | 400 | 1.6 | 1.6 | 8.0 | 14.2 | 2.18 | 165 |
| 500 | 400 | 17.16 | 418 | 700 | 23.0 | 16.1 | 36 | 65 | 8.0 | 400 | 1000 | 120 | 500 | 2.0 | 2.0 | 10.0 | 16.0 | 2.64 | 200 |

[1] Values are based upon the NRC recommendations (1973 revision in process) and the author's research and experience.

[2] Iodine toxicity has occurred at intakes of 40 mg/day.

[3] Selenium toxicity may occur at levels as low as 10 times the requirement.

[4] Vitamin D toxicity may occur at levels as low as 10 times the requirement, especially on high calcium intakes.

Table 2. Projected forage consumption by horses.

| | % Body Weight |
|---|---|
| Nursing Foals | 0 |
| Weanling Foals | 0.5 |
| Yearlings | 1.0 |
| Broodmares | 1.0 - 1.5 |
| Stallions | 1.0 |
| Performance horses | 0.75 - 1.25 |
| Idle horses | 1.5 - 2.5 |

Table 3. Nutrient composition of selected tropical forages[1,2]

| Name | DM % | DE Mcal/kg | CP % | DP % | CF % | Fat % | Ca % | P % | Mg % |
|---|---|---|---|---|---|---|---|---|---|
| Bermudagrass, Coastal, Hay | 91.0 | 1.57 | 9.0 | 5.4 | 29.6 | 1.5 | .31 | .14 | .15 |
| aerial part, fresh | 20.9 | 1.93 | 10.7 | 6.9 | 30.1 | 1.4 | .28 | .28 | - |
| Stargrass, hay | 90.1 | 1.44 | 5.5 | 2.4 | 37.2 | 1.6 | - | - | - |
| aerial part, fresh | 33.8 | 1.72 | 12.2 | 8.0 | 27.4 | 3.8 | .22 | .02 | - |
| Pangolagrass, hay | 88.0 | 1.59 | 6.0 | 2.9 | 29.3 | 2.1 | .22 | .09 | .33 |
| aerial part, fresh | 21.4 | 2.03 | 12.3 | 8.1 | 26.6 | 3.8 | .43 | .24 | .16 |
| Jaragua, hay | 90.0 | 1.51 | 4.1 | 1.2 | 32.5 | 1.8 | .50 | .13 | - |
| aerial part, fresh | 32.0 | 1.64 | 5.8 | 2.7 | 29.1 | 2.1 | .37 | .12 | .13 |
| Guineagrass, hay | 95.9 | 1.77 | 9.7 | 6.3 | 34.2 | 1.5 | - | - | - |
| aerial part, fresh | 27.4 | 1.94 | 10.4 | 6.7 | 26.4 | 3.2 | .43 | .25 | .24 |

[1] Analyses expressed on an air-dry basis. For pastures, 90% DM was used.

[2] Latin American Tables of Feed Composition, 1972, University of Florida.

Table 4. Animals with similar requirements

| | |
|---|---|
| Group 1 | Nursing foals, weanling foals |
| Group 2 | Yearlings, broodmares, 2-year olds in training |
| Group 3 | Performance horses, stallions |

Table 5. Ration standards for horses.

| Ration | A | | B | | C | |
|---|---|---|---|---|---|---|
| | min. | max. | min. | max. | min. | max. |
| Digestible Energy, Mcal/kg | | | | | | |
| Crude Protein, % | 18.0 | - | 14.0 | - | 12.0 | - |
| Calcium, % | .9 | 1.15 | .65 | .90 | .45 | .60 |
| Phosphorus, % | .75 | | .45 | | .35 | |
| Salt, % | .50 | .75 | .50 | .75 | .50 | .75 |
| Potassium, % | 1.0 | | 1.0 | | 1.0 | |
| Magnesium, % | .07 | | .07 | | .07 | |
| Manganese, ppm | 40 | | 30 | | 30 | |
| Iron, ppm | 100 | | 75 | | 75 | |
| Copper | 20 | | 15 | | 15 | |
| Zinc, ppm | 100 | | 75 | | 75 | |
| Iodine, ppm | 0.4 | | 0.3 | | 0.3 | |
| Cobalt, ppm | 0.4 | | 0.3 | | 0.3 | |
| Selenium, ppm | .10 | | 0.1 | | 0.1 | |
| Vitamin A, IU/kg | 7500 | | 10,000 | | 5,000 | |
| Vitamin D, IU/kg | 750 | | 500 | | 500 | |
| Vitamin E, IU/kg | 75 | | 50 | | 50 | |
| Lysine, % | .85 | | .60 | | .45 | |

Table 6. Example rations.

| Ration | A % | B % | C % |
|---|---|---|---|
| Corn | 20.0 | 26.0 | 31.0 |
| Oats | 35.0 | 40.0 | 40.0 |
| Rice bran | 10.0 | 10.0 | 10.0 |
| Soybean meal (44%) | 20.0 | 10.0 | 5.0 |
| Alfalfa meal, dehydrated | 5.0 | 5.0 | 5.0 |
| Molasses | 7.0 | 7.0 | 7.0 |
| Limestone, ground | 1.0 | 1.0 | 1.0 |
| Dicalcium phosphate | 1.25 | 0.25 | -- |
| Salt | 0.5 | 0.75 | 0.75 |
| Premix[1] | 0.25 | 0.25 | 0.25 |

[1] The premix should provide all of the vitamins and at least half of the trace mineral levels shown in Table 5.

# TECHNIQUES FOR BETTER BREEDING EFFICIENCY

by

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Although much remains to be learned about equine reproduction, it is clear that good management of broodmares is still the best way to get a high conception rate. If good management practices are maintained, and mares are teased frequently with a stallion, the patterns of each mare's estrous cycle will become evident, permitting the breeder to better predict appropriate breeding times. It is necessary to understand the estrous cycle before good management practices can be developed.

Perhaps the most confusing aspect of the estrous cycle of the mare is the re-initiation of sexual activity in the spring after the winter anestrus. During the winter anestrus, the ovaries are small and hard and bear only a few small follicles. Estrous behavior is seen only rarely. In fact, many mares appear to be indifferent to the stallion, neither rejecting nor accepting him. In the first months of spring, however, apparently in response to increasing daylength, sexual acceptance of the male by the mare is again observed. Ovarian activity is also renewed, and many (4 to 6) follicles begin to reappear. This transition from anestrus to cyclicity takes place over a period of time which varies from 30 to 60 days or longer. Mares are often bred during this transition since they are sexually receptive but breeding at this time rarely results in conception. The reason for this is that although follicles develop, ovulation generally does not occur until the end of the transition period. In fact, ovulation is probably the signal that ends the transition and starts regular estrous cycles. After the first ovulation has taken place, mares go out of heat for 14 to 17 days. The next heat period which occurs is probably the best breeding time because it is the first true estrous period of the year. Estrous cycles occur in a regular fashion (heat every 14 to 17 days) with ovulation also occurring regularly (every 21 to 23 days) after the first true estrous period in normal, unbred mares.

Since the technique of rectal palpation is not always available to the horse breeder, the major criterion for determining the stage of the estrous cycle is estrous behavior. Keeping an accurate record of a mare's estrus and diestrus length is probably the best breeding technique available. The behavior of a mare toward a teaser stallion is divided into two sections: 1. The period of time when a mare accepts the stallion is called estrus and 2. the period of time during which the mare rejects the teaser stallion is called diestrus. Estrus length is highly variable,

ranging from 4 to 10 days in length while diestrus length is quite consistent, ranging from 14 to 17 days. If teasing is done every day, as it should be, the onset of estrous behavior should be fairly predictable based on diestrus length.

If ovulation time is not known, breeding times can be planned in two ways: 1. Start breeding on the third day of estrus and breed every other day until the end of estrus, or 2. based on past estrous cycle records of each mare, breed on the day which is two days before the expected end of estrus i.e. in a 7 day estrus breed on day 5. All animals are variable, of course, and these times are not absolute, but a mare that varies greatly from these times (comes into heat every 8-10 days, or does not come into heat within 20 to 25 days) probably has some endocrine or pathological problem. In these cases, a veterinarian should be consulted. In cases where estrous behavior is not observed, rectal palpation of the ovaries should be done as ovulation occasionally occurs in the absence of behavioral estrus.

The technique of teasing mares to determine estrous behavior differs markedly in methodology from farm to farm, but several points should remain constant. 1. Teasing should be done on a regular basis (daily if possible) under similar conditions. 2. the stallion and mare should be brought together to observe their reactions. Standing along a fence with a stallion waiting for mares in heat to come up to him will miss almost 50% of the mares actually in heat. 3. the stallion should have access to the mare's head, flank and rump if maximum stimulation is to be achieved. 4. In indecisive cases, the stallion should be allowed to mount the mare. Many times mares will show no signs of heat until actually mounted by the stallion. Breeding can be prevented by deflecting the penis to one side. On the other hand, mares often appear to be in heat until the stallion attempts to mount. These mares will not allow the stallion to mount and move out from under him. Caution is urged here since the mare may also kick.

Finally, before breeding a mare, it is advisable to check for uterine contamination. This is best done prior to the breeding season, or perhaps during the transition period, at any rate, it should be done during estrus when the cervical opening of the uterus permits ready access to the uterus. A veterinarian should take the culture and test for antibiotic sensitivity. If there is no contamination, the mare may be bred readily. If the uterus is contaminated and the culture has been taken early enough in the season, there will be time to treat the organisms with antibiotics to which they are sensitive, and hopefully get a clean culture before the end of the breeding season.

There have been no miracle drugs or ready answers to horse breeding problems prescribed in these pages simply because there are none. Knowledge of each individual mare's estrous cycle gained from a diligent teasing program is the single most effective technique to improve the equine breeding record. The most important tool associated with this technique is pencil and paper to record with.

# OPTIMIZING PRODUCTION BY PROPER MANAGEMENT

by

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This presentation will emphasize proper management of breeding establishments; however, many of the ideas and suggestions will also apply to training, racing, boarding and pleasure horse operations. The primary goal of most horse operations is to, first, produce high quality horses and secondly, minimize cost. There are three main parts to any horse operation: 1) the horses, 2) the land and facilities and 3) the management. The quality of the last part, management, will determine whether the optimum production of the other two is attained.

I will discuss optimizing production through improved care of the horses and management of the farm facilities and records. However, one must remember that all the care in the world will not make a poor quality animal produce better and the cost of maintaining this animal is the same as the cost of maintaining a good quality one. Therefore, the wise breeder or trainer will obtain the best quality horses possible either by purchase or by breeding and culling to help guarantee the production of high quality offspring and performance.

## Individual Horse Care

Horses are bred as individuals and must have individual care to obtain maximum performance. Included in a horse's individual care are his nutritional or feeding requirements. He should receive a properly balanced ration which meets his daily nutrient requirements and is made up of good quality feed ingredients.

An economical way to formulate such a ration is to determine the nutrient content of your native forages (pasture and hay) and balance this, if necessary, by supplementing the forage with extra energy, protein, calcium, phosphorus, etc. Some likely supplements could be native grains, legume hay, protein supplements (soybean meal) and mineral supplements (dicalcium phosphate).

The rations must be adjusted to the type of horse fed also, such as, allowing for the higher requirements of growing foals and lactating mares. Insufficient or imbalanced rations will result in stunted foals and lower performance of the horses. On the other hand, excessive feeding will produce fat individuals and may lower performance and cause breeding and foaling difficulties. Both insufficient and excessive feeding will cause a

waste of money in the long run.

Aside from the feed, adequate amounts of good clean water and salt should be available at all times.

The second main factor in caring for horses is health care. This usually will require the services of a veterinarian but is well worth the investment as keeping the horse in good health will insure good performance and a healthy foal. Most important in health care are: 1) elimination of internal parasites by regular administration of worming compounds, 2) regular immunization for the infectious disease problems in your area (tetanus, encephalomyelitis, etc.) and 3) dental care to remove sharp tooth edges created by irregular wearing. Neglecting the horse's health care may result in poor doing or dead foals as a result of parasite infestation; sick or dying horses from diseases; and, poor digestion of the feed because of bad or irregularly worn teeth.

The regular care of a horse's feet is also important. Foals must get special attention to hoof care to encourage development of straight leg bones and good feet. It should be unnecessary to state that careful daily inspection and observation of each horse is necessary to catch disease problems early and to treat cuts and other injuries before they become advanced and possibly fatal to the horse.

## Land and Facilities

### Pastures

The major expense in maintaining a horse is the feed costs. This expense can be greatly minimized by growing as much forage as possible and even one's own grains if the quality of the land permits. Legume-grass mixes make the best pastures where they can be grown. Where this is not possible pick the grasses that: 1) will grow best in your area, 2) have high palatability and 3) high nutrient value, especially in protein and minerals. Regular fertilization of the pastures is important to increase forage production per acre and increase mineral content of the forage. Have soil samples taken on the farm analyzed to determine the fertilizer requirements.

Cattle or sheep can be rotated with the horses to graze down weeds and help in the control of parasite eggs on the pastures. Regular clipping and chain harrowing the pastures will serve the same purposes.

In most areas there is a period of dry or cold weather where the pasture drops off enough to require the feeding of hay. The hay supplied should be nutritious, palatable and free of mold. It should be fed off the ground in hay racks. This will help prevent wastage by trampling, reduce parasite reinfestation and reduce the intake of dirt, sand and other foreign materials which might cause digestive disturbances. Grains also should always be fed in feed tubs for the same reasons.

### Housing

The climate and the type of operation will determine the type and amount of housing needed. Barns containing box stalls are used extensively by show and racing establishments. A breeding farm may need stalls only if weather conditions are severe (cold or wet). Pastures with trees and hills where the horses can find shelter from the wind and rain are often all that

are needed. Construction of three-sided loafing sheds can also provide shelter in bad weather without great expense. These are good alternatives to keeping broodmares in stalls in bad weather as it eliminates the labor required to clean stalls. Keeping broodmares outside in mild climate regions has been shown to increase their fertility and produce healthier, happier animals than stall kept individuals.

Labor Saving Devices and Methods

Labor saving devices and planning of work crews to minimize work hours can make the farm operation more efficient without reducing the quality of the horse care. Examples of these are automatic waterers with heaters if winter freezing is a problem. Automatic hot walkers or horse exercisors to exercise horses at the walk or trot using no manual labor. These are especially useful in training-racing stables. Vacuum cleaners to replace brushing the horse's hair coat and even automatic feeders to feed the horse while you are gone are now being used.

Devices are not always necessary to save time and labor. Locating hay racks and feed troughs for convenient filling from outside the animal's stall or pasture will often save much time expecially if they are placed in sequence for rapid filling. Keeping as many horses outside on pasture saves on cleaning stalls. One must remember, however, with any device or fast feeding and care method that one must take special care to still check each horse closely everyday to detect unusual behavior and injuries. One must also watch for feed wastage and fighting over feed when horses are fed in groups. This can be prevented by grouping the horses in pastures according to temperaments and feed requirements.

The Foaling Mare and Breeding Stallion

The foaling mare needs to be carefully watched at foaling time. She needs a clean dry place which is well lighted so that the watchman may detect foaling problems. This usually means putting the mare in a roomy bedded box stall. However, an adequate, less expensive and often more natural and antiseptic situation is an outside lighted paddock.

A stallion can easily be kept in a spacious grassed paddock which may have a run-in stall. In a small breeding operation having the stallion's paddock next to the mares' is a labor saving way of teasing the mares. However, two things must be watched: 1) that the stallion does not lose excessive weight by walking the fence line and 2) that mares which will not show estrus by this method must be hand teased. Of course the most labor saving breeding method is pasture breeding if it will fit your situation.

Fences

Fences are a big initial investment but must be sturdy and safe in construction. Wood plank fences or small-mesh wire fences (diamond-mesh, 2 x 4-mesh, or chain-link types) are the best but can be rather expensive. The wire mesh fences will last longer and require less maintainence than the wooden fence. Many other types of fences can be used also but barbed-wire is definitely not recommended as eventually a horse will get hurt in it.

A new type of stretched rubber fence is being tried and appears to be both economical and safe.

An extra sturdy, solid and slightly higher fence in which feet and legs cannot get caught should be used around the stallion's paddock.

All fences should be kept in good repair to prevent injuries and escapes which could prove disastrous.

Farm Entrance

This may seem to be an out-of-place item; however, if you have a breeding operation or a stable which caters to the public in any way, the first thing they see when arriving at your farm is it's entrance. It should be neat and attractive and display the farm name with pride. Use your immagination in constructing it. A good first impression will help business and attract new patrons.

## Management

The manager is the most important person on the farm. He makes out the daily farm schedule and sees that it is carried out. He alone can greatly determine how adequately and efficiently the farm is operated and the horses are cared for. He should group horses and design feeding and housing methods suited to his farm that will save time and labor but give proper care to its charges. He is also responsible for the employees. Hiring experienced personnel and paying them well has been shown to be more economical than hiring cheaper less experienced labor.

An often neglected role of management is the keeping of records. Farm and horse records are necessary to assure a smooth working operation and to help determine what progress, if any, has been made. There are many types of records. All horse establishments, from the largest to the smallest, should keep health and farrier records on each horse. This provides a history on the animal and should indicate the date and type of work or medicine given to the horse. It also is a good check to assure that each animal is adequately protected by immunizations and regularly wormed and has had its feet trimmed.

All breeding farms should keep teasing and breeding records on each broodmare. These help to facilitate getting each mare in foal by knowing her particular breeding mannerisms and estrous cycle and also will conserve the stallion by reducing the number of covers per mare.

Growth records on foals taken by measuring their weight and height increases as they grow can be very useful. Slow growing foals can be detected and may trace to a poor milking mare, other nutritional problems, or parasite and disease problems. Growth records can also be used to indicate breeding progress where one is striving to produce larger animals and allows one to compare different stallions' offspring and make farm to farm comparisons.

Many more management hints could be offered in this presentation but many can also be created by yourself by observation, imagination and application.

# UTILIZATION OF BY-PRODUCTS AS FEED INGREDIENTS

by

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One of the greatest advantages of animals in meeting human food needs is that much of the feed used can come from by-products which are not suitable for human consumption. The purpose of this paper is to discuss the usage of these by-products in animal feeds. Some data will be presented to demonstrate their value in poultry feeds.

Those materials considered to be a good source of protein are shown in Table 1. Nine materials are included in this table, along with the percent protein and metabolizable energy per pound for each. The first material is hydrolyzed feather meal. This is chicken feathers which have been cooked under pressure and steam. It contains 85 percent protein and a relatively high level of energy. Actually, we will not discuss the energy levels of these materials since they are used primarily for protein. The second one is poultry by-product meal containing 63 percent protein and is made from the poultry offal remaining after dressing poultry. The third one is leather meal. This is a product which has recently been developed for use in the feed industry and is the waste from the leather industry. Blood meal, of course, is the dried blood meal resulting from poultry and meat processing plants. Meat meal is the residue from slaughtering plants as well as dead animals which are picked up and cooked and processed into a usable product. Fish meal may not necessarily be considered as a by-product since much of the fish used in this industry is caught specifically for processing into fish meal. Fish solubles, however, is the liquid waste from the fish canning plants which is condensed to 50 percent moisture and then used in poultry feeds. Crab meal is the waste from crab processing plants. The last is hydrolyzed hog hair, another ingredient which has recently been proven satisfactory as a protein source in poultry feeds.

A list of ingredients used primarily for energy is shown in Table 2. Again, we have listed energy per pound and percent protein. We will only be discussing energy since this is the primary purpose for these ingredients being used in feed. First is animal fat; this is the animal fat not suitable for human consumption. It is very high in energy as it contains 3480 metabolizable calories of energy per pound. Second is broken rice with 1580 calories. This material is not commonly used in the United States; however, a sizable amount is available in the Far East and Latin American countries. Rice polishings are a result of the processing of rice for human consumption and considerable amounts are available. Fourth

is dried bakery products, a product which has recently been developed for use in animal feed in the United States. This is nothing more than the stale cakes, bread, potato chips, and other bakery products returning from the store shelves along with uncooked dough. Next is distillers dried grains with solubles. This results from the distilling industry and is a very suitable product for poultry feeds, and also contains a very high level of protein. Wheat bran and wheat middlings are low in energy and high in fiber. They are not desirable in poultry feed, but can be used. The last on the list is citrus pulp, an excellent energy source for ruminants, but not a good ingredient for poultry. Two materials which are by-products and can be used to furnish minerals for poultry feeds are shown in Table 3. The first on the list is steamed bone meal which is high in both calcium and phosphorus. The second material is ground oyster shell, a very excellent source of calcium.

I would like for us to take a brief look at the performance of chickens utilizing some of these materials. The performance of laying hens fed diets containing feather meal or hog hair as a source of protein is shown in Table 4.

The basal diet used in this experiment contained 10 percent protein with the protein coming from corn and soybean meal. This diet was designed to be deficient in protein so they could show the value of the other protein sources. When five percent protein from soybean meal was added, the production was improved from 63.4 to 78.8 percent. Incidentally, 15 percent protein is approximately the amount required by the laying hen. The addition of five percent feather meal to the basal diet increased production from 63.4 to 70.7 percent. This was not maximum production since feather meal is deficient in the amino acid methionine. The addition of 0.10 percent methionine and the five percent protein from feather meal gave production equal to that obtained from soybean meal. When the five percent protein was obtained from hog hair, production was approximately equal to that obtained when feather meal was used. When additional methionine was added with the hog hair, maximum production was obtained.

Performance of chicks receiving hydrolyzed leather meal in the diet is shown in Table 5. Levels of 0, 2, 4, 6, and 8 percent leather meal were included in the diet. All diets were adjusted to be equal in protein and energy. Levels up to 8 percent leather meal in the diet of chicks for the first four weeks did not adversely affect body weight. The amount of feed required per gram of gain was also equal to that of the basal diet.

Performance of chickens fed different levels of dried bakery products in their diet is shown in Table 6. Levels of dried bakery products ranging from 0 to 10 percent were fed. Body weight gains from one day of age to 4 weeks were equal when these dried bakery products were included in the diet. Energy and protein levels were adjusted when the dried bakery products were used.

The performance of broilers fed diets containing 3 to 6 percent animal fat is shown in Table 7. The addition of 3 and 6 percent animal fat gave increased body weight at eight weeks of age. The amount of feed required to produce a pound of broiler was also reduced. Incidentally, the amount

of feed required to produce a pound of broiler was rather high in this experiment since this work was conducted in 1959. Animal fat is a very desirable ingredient since it improves the rate of growth and significantly reduces the amount of feed required to produce a pound of gain because of its exceptionally high energy content.

These data clearly indicate that materials that are inedible by humans can be used in poultry feeds. The composition of a laying hen feed which is composed almost entirely of waste by-products is shown in Table 8. It may be noted that this diet contains many by-products which are not suitable for human consumption. These include animal fat, distillers dried grains with solubles, dried bakery products, feather meal, poultry by-products, steamed bone meal, and oyster shell. This diet would be expected to give maximum performance of the laying hen. Since it does not contain a source of xanthophyll, it would be necessary to add some synthetic pigment if yolks are to be colored.

Table 1. By-products used as protein sources in animal feed

| | Protein (%) | Met. En. Cal./lb. |
|---|---|---|
| Feather meal | 85.0 | 1035 |
| Poultry by-prod.-meal | 63.0 | 1365 |
| Leather meal | 60.0 | 1350 |
| Blood meal | 84.0 | 1220 |
| Meat meal | 49.0 | 1000 |
| Fish meal | 64.5 | 1310 |
| Fish solubles | 32.0 | 920 |
| Crab meal | 32.0 | 850 |
| Hydrolyzed hog hair | 86.0 | ? |

Table 2. By-products used as energy sources in animal feed

| | Protein (%) | Met. En. Cal./lb. |
|---|---|---|
| Animal fat | --- | 3480 |
| Broken rice | 7.3 | 1580 |
| Rice polishings | 11.8 | 1300 |
| Dried bakery products | 9.8 | 1750 |
| DDGS | 27.6 | 1190 |
| Wheat bran | 15.4 | 575 |
| Wheat flour middlings | 18.0 | 1200 |
| Citrus pulp | Used for ruminants | |

Table 3. By-products used as mineral sources in animal feeds

| | Calcium (%) | Phosphorus (%) |
|---|---|---|
| Steamed bone meal | 26 | 13 |
| Ground oyster shells | 38 | -- |

Table 4. Egg production from hens fed various protein sources

| | Egg Production (%) |
|---|---|
| 10% Protein (corn-soybean meal) | 63.4 |
| + 5% Soybean meal protein | 78.8 |
| + 5% Feather meal protein | 70.7 |
| + 5% FM prot. + 0.1 meth. | 76.3 |
| + 5% Hog hair meal prot. | 70.5 |
| + 5% HH prot. + 0.1 meth. | 76.6 |

Table 5. Performance of chicks fed diets containing hydrolyzed leather meal

| % Leather Meal | 28-day Weight (gms) | Gms Feed/ gm Gain |
|---|---|---|
| 0 | 486 | 1.98 |
| 2 | 503 | 1.92 |
| 4 | 497 | 2.00 |
| 6 | 481 | 1.97 |
| 8 | 504 | 1.85 |

Table 6. Body weight of chicks fed various levels of dried bakery products

| % Dried Bakery Product | Body Weight (gms) |
|---|---|
| 0 | 468 |
| 2.5 | 462 |
| 5.0 | 467 |
| 7.5 | 468 |
| 10.0 | 466 |

Table 7. Body weight of broiler fed diets containing animal fat

| % Fat | Body wt. (lbs.) | lbs. feed/ lb. gain |
|---|---|---|
| 0 | 3.05 | 2.72 |
| 3 | 3.23 | 2.52 |
| 6 | 3.22 | 2.53 |

Table 8. A laying hen feed formulated using by-products

| Ingredients | % |
|---|---|
| Animal fat | 6.0 |
| DDCS | 10.0 |
| Broken rice | 44.7 |
| Rice polishing | 10.0 |
| Dried bakery product | 10.0 |
| Feather meal | 3.0 |
| Poultry by-product meal | 8.0 |
| Steamed bone meal | 2.5 |
| Ground oyster shells | 5.0 |
| Salt | 0.3 |
| Vitamins | 0.5 |

# PREVENTION AND CONTROL OF AFLATOXICOSIS IN POULTRY

by

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Molds associated with corn and other grains produce toxins when the moisture content exceeds 14 percent and temperature is 70°F or above. These are called mycotoxins. When ingested in toxic amounts by animals or birds, they cause mycotoxicosis. These toxins or their metabolites may be excreted in meat, milk or eggs and pose a public health hazard.

Molds commonly associated with mycotoxicosis in poultry:

1. a. Aspergillus flavus and A. parasiticus. The aflatoxins $B_1$, $B_2$, $G_1$, $G_2$ may cause lesions at 10-100 ppm or less. Levels as low as 0.2 ppm cause lesions in ducklings, trout, turkey poults. New Hampshire chicks, Rhode Island pheasants, and quail. Such levels are found in Florida feeds or may be present on grain left in fields and consumed by wild birds. Damage is characterized by loss of appetite, reduced growth rate, marked drop in egg production, increased susceptibility to other diseases, liver damage, jaundice, and ultimately liver, kidney or splenic cancer. There may be increased capillary fragility, hemorrhage, and shortened shelf-life or storage quality.

b. Short term or single dose exposure to aflatoxins may occur under practical conditions because of unequal distribution of the aflatoxins in the feed. These "hot spots" can develop in stored feeds. However, several instances of high levels of aflatoxin $B_1$ have been identified from field samples, or recently stored shelled corn, 1974. Animals or birds exposed for short periods, although sharing the acute toxic effects of aflatoxicosis, will likely recover from the physical or structural changes in 2 to 3 weeks. The continual susceptibility to infectious or nutritional diseases may persist for several weeks.

c. There has been an increased incidence of the fat soluble vitamin deficiency symptoms in poultry; this includes vitamins A, $D_3$, and E. There may be uneven flock size, stunted birds, bleached or pale birds, poor feathering, decreased hatchability, gizzard erosions and ulceration, with bloody diarrhea.

2. Detection of aflatoxin $B_1$.

a. Low levels are evidenced by fluorescing green-gold pigments in positive shelled corn-kernels. Extensive field tests have shown that 20-50 or more positive kernels per 10 pounds of corn indicates a relative high level of aflatoxin $B_1$.

b. Suspected moldy feed samples can be extracted with acetonitrile; the benzene extract is developed using the minicolumn technique with bright blue bands indicating a strong positive sample. The thin layer chromatographic technique, using known standards, can be utilized for quantitative assays as parts per billion.

c. A very recent technique, 1974, the fluorescence methods of detecting aflatoxin-producing strains of Aspergillus flavus in a modified Czapek's solution agar containing corn steep liquor, $HgCl_2$ and $(NH_4)H_2PO_4$ instead of $NaNO_3$ when the presence of aflatoxin is confirmed by thin-layer chromatography of $CHCl_3$ extracts of fluorescing agar.

3. Fusaria Toxin-$T_2$ is caused by the common corn cob rotting mold Gibberella zeae and Fusarium rosae. Although swine may refuse to eat such moldy corn, poultry or birds may consume it. The $T_2$ toxin causes impaired growth rates, marked decrease in spleen weights, liver cancer, and swollen vesicles in the birds' mouths with difficulty in closing the mouth. Death losses are high.

4. Ochratoxin from Aspergillus ochraceus and Penicillium viridicatum. This toxin has been demonstrated to cause growth depression, swollen liver, pancreas and gizzard. The liver enlargement is due to the deposition of glycogen, not fat as in aflatoxicosis.

Comparative Oral $LD_{50}$ Toxicities of Aflatoxin $B_1$

| | |
|---|---|
| Trout, 100 mg | 0.5-1.0 mg/kg in 10 days (280 ppb) |
| Ducks, day-old | 0.4-0.6 mg/kg in 5 days (30 ppb) |
| Turkeys | 0.5-1.0 mg/kg (250 ppb) |
| Rabbits | 0.3 mg/kg |
| Cattle | 0.5-1.0 mg/kg (300 ppb or 220-660 ppb) |
| Cats | 0.3-0.6 mg/kg |
| Pigs, 6-7 kg | 0.62 mg/kg (233 ppb) (2-3 kg - 230 ppb) |
| Puppies | 0.5-1.0 mg/kg |
| Rats, day-old<br>21 days-old | 1.0 mg/kg<br>5.5-7.2 mg/kg |
| Guinea pigs | 1.4 mg/kg |
| Sheep | 2.0 mg/kg |
| Chickens, Rhode Island | 6.3 mg/kg (200 ppb) |
| Monkeys, macaque | 7.8 mg/kg |
| Mice | 9.0 mg/kg |
| Hamsters | 10.2 mg/kg |
| Catfish, channel | 10.0-15.0 mg/kg does for 5 days |

Treatment: Take off toxin contaminated feeds; when damage is not too severe, tissues are restored to normal in 2-3 weeks. The increased susceptibility to other diseases may persist.

Placing birds on "clean" feed, high in protein with antibiotics to prevent secondary infections may reduce losses.

Prevention: Harvesting and storing of grain with a moisture content of less than 13% at temperatures less than 70°F.

Addition of acetic or proprionic acids to feed may prevent growth of molds and toxin production.

# THE IMPORTANCE OF SALT FOR POULTRY

BY

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For thousands of years, it has been known that man and animals, both domestic and wild, need salt. Even before scientific knowledge of feeds or nutrition became available, man recognized that livestock and poultry have this need.

## Functions of Salt

We tend to think of a requirement for "salt" in feed formulation, but since salt is the compound sodium chloride, we should realize that the animal has a separate need for sodium and chlorine.

The importance of sodium is evident when we consider that both plants and animals require sodium for normal metabolism. In the animal body sodium is the major basic component of the extracellular fluid. Thus it plays a major role in moving water from one part of the body to another, in regulation of acid-base balance and in preservation of normal irritability of muscles and permeability of the cells.

In contrast to sodium, chlorine is found in large concentrations both within and outside the cells of body tissue. The chlorides of the blood make up about two-thirds of its acid ions, thus this indicates the important role of chlorine in acid-base relations. Chloride ions also are needed in the production of hydrochloric acid for gastric juices.

## Salt Deficiency and Excess

With these functions in mind it should not be surprising that a deficiency or inbalance of one or both of these minerals produces deficiency symptoms such as muscle weakness, dehydration, loss of appetite, poor intestinal tone with intestinal distention, cardiac weakness and weakness of respiratory muscles.

The practical symptoms of a salt deficiency for poultry are retarded growth, loss in body weight, lower egg production and possibly reduced egg size.

Excessive levels of salt are toxic to poultry, but there is considerable variation in levels considered by various researchers to be

toxic. Early work indicated that growing chicks could tolerate diets containing 8% salt with no apparent detrimental effect. More recent work from Canada and from Cornell University showed that levels higher than 3% or 4% caused increased mortality among growing chicks. Studies with laying hens have shown that feeding 2% dietary salt caused excessive diarrhea. There seems to be a considerable margin between levels normally fed and toxic levels. It is unlikely that toxic levels will be fed unless an error is made in formulation or feed mixing.

## Practical Levels of Salt

Until recently, more attention was given to excessive levels of salt in layer diets than to minimum levels. It was not uncommon in the late 1950's for poultry diets to contain 1% salt. Then, with the shift from floor to cage egg production, a trend was begun to lower salt content of feeds in an attempt to reduce the moisture level of cage manure.

Another reason for interest in reducing dietary salt content was the increased usage of linear programming. Salt is not expensive, but if an excess can be eliminated, it allows room in the formula for more cereal grains or other ingredients which supply energy or protein, thus giving a better feed utilization.

According to the National Research Council (1971), the laying hen's requirement for sodium is 0.15% of the diet which would be provided by a dietary level of 0.37% salt. This level of sodium would be supplied by a corn-soy type layer diet containing defluorinated phosphate (which would provide 0.09% sodium) and 0.25% added salt.

## Experimental

Recent experiments at the University of Florida and by other researchers have raised concern that levels of salt used today may be marginal under certain circumstances. Over several years, the level of added salt in the University of Florida standard layer diet has been reduced from 0.40% to 0.25%. The lower level has also become the standard level for layer feeds of many commercial egg producers. With the phosphate shortage and the change in sources of phosphate from defluorinated phosphate to other forms, it seemed expedient to test the adequacy of 0.25% added salt in diets containing dicalcium phosphate (since dicalcium phosphate supplies no sodium).

Using a commercial type corn-soy layer diet containing 16% protein with either 0.25% or 0.40% added salt, it was found that feeding the diet containing the higher level of salt resulted in 3% to 4% higher egg production.

Two other experiments using salt as a variable have been conducted at the Florida Station and reported by Nesbeth and coworkers (1974 Poultry Science Association Meeting). The first experiment resulted when

a group of laying hens dropped from 70% production to approximately 0% production over a 21 day period. By a process of elimination and nutrient determination, it was discovered that the drop in production was a result of the accidental omission of salt from the feed. New laying feed was given, and production returned to normal within approximately 14 days.

To further study salt deficiency in laying hens, a second experiment was conducted using one diet in which no salt was added along with the control diet which contained 0.25% added salt. A progressive decline in egg production occurred and within 17 days, production had ceased. During this time, feed intake decreased to approximately 60% of that of the control birds and body weight decreased by 19%. Upon returns to the control diet, an increase in feed consumption occurred immediately and egg production returned to 79% which equaled production of the control birds.

Further studies are in progress using the diet containing no added salt to force birds out of production similar to a forced molting procedure. Preliminary results indicate that it will be a good method to use where starvation is not desired.

In conclusion, it would seem desirable to include 0.40% added salt in corn-soy type layer feeds especially when phosphate sources other than defluorinated phsophate are used. It also seems feasible to "force rest" birds by removing salt from the diet when other methods of forced molting are undesirable.

# TIPS FOR TURKEY PRODUCERS

by

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The first, and most important step in planning a turkey enterprise is to establish a market for your birds. Secondly, and of almost equal importance, is to ensure that there are adequate processing facilities. Thirdly, evaluate your production facilities, augment and update them as necessary, keeping in mind that sophisticated equipment is not always the answer to efficient production.

The turkey that is selected will depend on which strain (s) possess the type, size and color best suited for the market that will be supplied. In addition, the availability of the strain and the closeness of the hatchery should be considered.

If breeding stock is purchased, obtain only the very best. These breeders should come from a producer who has a pullorum and fowl typhoid clean, well bred, healthy flock of proven production. In the case of hatching eggs, there is the danger of a poor hatch, poor quality poults, or both. If it is planned to use birds presently on the farm as foundation stock, select them carefully and have them tested for pullorum and fowl typhoid.

If it is decided to purchase day-old poults, they should be ordered several weeks in advance of delivery date. These should be purchased from a reliable breeder hatcheryman who has a well established pullorum and fowl typhoid clean flock. The breeders in this flock should have been carefully selected for fast growth, conformation, uniformity, early maturity and lack of pin feathers at market age. Success or failure with turkeys can depend upon the quality of poults that are started. Secure poults as nearby as possible so they can be delivered and started on feed and water quickly in order to reduce the number of "starveouts"

## When to Start the Turkey Project

The large Bronze and White Broad Breasted turkeys mature (reach market weight) between 17 and 24 weeks of age. The hen of these varieties will mature in 17 to 20 weeks and the tom in 21 to 24 weeks. Beltsville Small Whites should be marketed between 12 and 16 weeks of age. Sexed poults can be purchased to take advantage of these differences. In addition, slightly better weight gains can be obtained by separating the sexes, either on range or in confinement. More efficient gains can also be obtained by formulating a feed especially for males and one for females after they are 12 weeks of age.

Since the majority of turkeys are produced for the Thanksgiving and Christmas market, they should be started at a time that will have them finished and in good condition for these markets. The months of April and May are the ideal months to start turkey poults.

In addition to the mature whole and deboned bird market, at least two other turkey markets exist; one is the turkey fryer that is marketed around 12 weeks of age, a second turkey parts, i.e., halves and quarters.

The Brooder House

Brooder houses can vary in size from one large enough to accomodate only 100 birds up to houses for several thousand poults. If brooder houses are to be constructed, they can be built along the same line as brooder houses for chickens. Some existing houses on the farm might be converted for use as brooder houses. Old tenant houses, barns, and even machine sheds may be used. The important thing is a house that can be heated, is rodent proof and bird proof, that will provide ventilation without drafts, can be kept dry and is easily cleaned.

Modern brooder houses are approximately 30 feet wide and long enough to accomodate the number of birds you wish to raise. Allow 1 1/4 to 1 1/2 square feet of floor space per bird. The building should be designed with ease of clean-out a prime consideration.

If it is planned to raise turkeys from brooding to market time in confinement, the building should be of the open pole-type construction. Plastic curtains or removable panels can be used during the brooding period to retain the heat and to eliminate drafts. If birds are to be grown to market weight in confinement, 3 to 6 square feet of floor space should be allowed per turkey, depending on the strain and sex.

The birds may be raised either on conventional litter floors or raised floors (wire, expanded metal, slats, plastic). Disease may be easier to control, the house can be kept more sanitary, feed efficiency will be better and weight gains may be better (especially to 12 weeks of age) on raised floors; however, odors, drafts, breast blisters and general management present more of a problem than is found on conventional litter floors.

No matter what type house or method of brooding is used for the raising of poults, sanitation and cleanliness are absolute necessities.

In preparing the brooder house, move out all equipment and thoroughly clean, sweep down the walls and ceiling, clean out all litter, remove dust and dirt that may be in the house and deposit it well away from the house. Wash the entire house with hot lye water (one pound to 10 gallons water) or a commercial cleaner disinfectant. Rinse the house with clean water, allow to dry and then spray or paint the house with any good disinfectant (lye water may be used). New houses should be washed down and disinfected, as it is dust (so prevalent in new houses) that harbors many disease causing agents.

All of these cleanout operations should be completed at least two weeks ahead of the poults' arrival. This helps break any disease cycle and allows time for the walls and floor to dry. If litter is used, spread it 4 inches deep over the entire floor. Round out all of the corners of the brooder room, or hang feed bags in the corners to discourage piling. See that there is adequate ventilation and that it can be controlled.

Provide one brooder per 300 poults (500-700 chick capacity). Do not brood more than 300 poults in one unit.

The following minimum feeder space should be allowed for each 100 poults: first two weeks - 16 linear feet + two filler flats or feeder lids; during third and fourth weeks - 24 linear feet; during fifth and sixth weeks - 32 linear feet; during seventh and eight weeks - 40 linear feet. (The feeder lip should be kept adjusted to the height of the turkey's back at all times.)

The following minimum drinking space should be allowed for each 100 poults: first two weeks - 3 linear feet or 2 one gallon founts; during third and fourth weeks - 6 linear feet or 4 one gallon founts; during fifth through eighth weeks - 8 linear feet or 2 five gallon founts.

Set up the brooder house 24 hours before the poults arrive. The brooder stove should be carefully checked and should have maintained a constant temperature of 95° for at least a 24 hour period. Check the thermometers to insure their accuracy. If litter is used it should be highly absorbent, nonpalatable, mold free, relatively dust free, low in cost and readily available. Cover the litter with cloth bags or some similar material. This will prevent the birds from eating the litter. Do not use smooth paper as "spraddle legs" are a problem in turkeys and the condition is greatly aggravated by placing the birds on a smooth surface. Place a 18" brooder guard (confinement ring) approximately 3 feet from the edge of the hover when the poults are started. The guard should be solid (cardboard or sheet metal is good) except in hot weather when a wire guard may be used. Arrange feeders and waterers in a spoke-like fashion within the circle to allow poults to move in and out from under the hover without going over the top of feeders. Place the water founts (water jars) on boards to help keep out litter and never place them near any light under the brooder. The poults tend to go toward the light and will sometimes upset the jars. Distribute the filler flats or feeder lids evenly in the open area and cover the center section of them with feed. This practice will reduce the number of "starveouts".

It is an excellent idea to dip the beak of the poults into the water and then into the feed as they are taken from the box and put under the brooder. The poults should be placed under the brooder as soon as possible after hatching. Some growers use colored feed or brightly colored marbles in feed and waterers to attract poults. Grass clippings or other similar material sprinkled on the feed have also proved very effective in reducing "starveouts". Some poults may have to be force fed.

You must guard against your turkey poults piling, especially around sundown. If piling is a problem, check the adjustment of the brooders and the ventilating system. Check brooder temperature two inches above

the floor at the edge of the brooder. Suggested brooding temperatures are 95° the first week and reduce the temperature 5° F per week until 70° F is reached (providing environmental temperatures will permit). Maintain 70° F until heat is no longer required (about 5 to 6 weeks in the summer and 8 to 10 weeks in the winter).

Check the poults 2 to 3 times during the night for the first few days. If they are comfortable they will be evenly distributed in the brooding area. If they are too hot they will move to the edge of the brooding area and if they are too cold they will huddle in the center. In this respect the actions of the poults are the better indicator of proper brooder temperature than a thermometer. Use dim all-night lights during the brooding period with a light under each hover. This also will reduce crowding and piling.

The first week of life is the most critical period for the poults. As much as 50% of the total mortality may occur during this period. Daily cleaning of the waterers is a recommended practice. Encourage the poults to use automatic waterers as soon as possible. A good practice is to gradually begin removing the founts on the second day and relocating the remaining founts closer to the automatic units.

The brooder guards can be removed on about the seventh day and the litter covering on the fourth or fifth day. In cold weather it is sometimes wise to enlarge the guards to include two to three stoves from the seventh to tenth day. If all birds have found feed and water at the time the guard is removed the filler flats and founts may also be removed. Keep feeders full for the first 7 to 10 days. The feed wastage during this period is a small price to pay for the reduction of "starveouts". Rid the house of rats, holes, sharp objects, bright spots, wet spots and open containers.

Debeaking is recommended only in flocks where cannibalism is a problem; however, once a problem does develop, the birds should be debeaked at once. Stop-pick salves and home remedies are a poor substitute for proper debeaking. Do not debeak at day of age as this will increase your problems with "starveouts".

Wing clipping or notching may be used to help confine birds on the range but is not considered necessary in confinement rearing. Notching of the wing is the recommended procedure.

Desnooding is an unnecessary expense unless you have experienced problems in this area before. If it is decided to desnood the birds, it should be done at hatching.

It is recommended that all birds be vaccinated for fowl pox at 6 to 8 weeks of age and gain 6 to 7 months later under normal conditions (immunity in turkeys is only about 6 months). In the advent of large mosquito populations, it may be necessary to vaccinate earlier than 6 to 8 weeks; consult your veterinarian. Vaccination programs against Newcastle and other diesases should be regarded as individual problems and the advice of a local veterinarian should be consulted as to the advisability of additional vaccination programs.

Confinement rearing. Turkeys of excellent quality can be raised in confinement. The same building can be used to brood and to grow out the turkeys. Under good management, mortality is usually lower than in range reared flocks. Predators are no problem in a well constructed house. The use of automatic feeders and waterers reduces the amount of labor required.

Range rearing. The range selected should be clean land on which no chickens or turkeys have been allowed to range in the past three years. Allow at least one acre of land for each 100 poults. To save feed and promote growth the range should be seeded to some crop that will afford feed and grazing i.e., corn, peas, soybeans, peanuts, millet and milo. The range, in addition to providing grazing and green feed, should afford shade and sunlight as well as maximum protection from predators. The range should be well drained and free from holes where water might stand and become stagnant. Portable shelters that will provide protection from rain and sun is all that is needed in the way of shelter. Some kind of shade on the range is essential. A range with a patch of woods is the most desirable. Waterers, feeders, and shelters should be placed out in the open. The sunshine will help destroy disease germs and parasites that might build up around the feeding and watering areas. During extremely hot weather feed and water should be moved to shade to encourage the birds to maintain an adequate intake of nutrients. When a large number of turkeys are to be placed on range, portable feeders that will hold at least 600 pounds of feed are to be recommended over small feeders. The feeders should be designed to give maximum protection from the elements. Provide 60 linear feet of feeder space per 1000 birds.

Waterers should be easily cleaned and leak proof. Provide at least 36 linear feet of watering space per 1000 birds. Turkeys will drink 2 to 2 1/2 pounds of water for every pound of feed. Placing the waterers on a wire platform reduces dampness and the possibility of disease outbreaks.

Protection of the turkeys while on range from predatory animals and thieves is very important. The use of lights at night is important. Steel traps on top of poles around the area are effective in controlling owls. Electric fences can be used to confine turkeys to the range as well as keeping predators out. If a large number of turkeys are kept on the range, it is desirable that someone stay near them during the day and provisions should be made for someone to sleep near the range at night to guard against predatory animals and thieves. Keeping a dog leashed near the range is another means of reducing losses.

Check the weeks's weather report before moving the poults to the range. Avoid moving the poults when the weather is threatening. Keep the poults inside until at least 2 to 3 days of fair weather is assured. Move about 1/3 of the poults; skip a day or two and move the remainder of the flock. Always move the birds early in the morning so they will have the maximum of daylight to become accustomed to the new surroundings! The rotation of the turkeys while on range is important. Gradually move them to new or clean areas. Don't let them stay in the same area until it becomes contaminated. Don't attempt to move turkeys if the weather is unusually hot. Watering down shaded areas will help prevent losses from heat prostration.

Feeding turkeys. Most turkey growers will want to use a complete feed. This may be a feed purchased from a feed company, or one mixed on the farm. Granulated or pellet form feeds are preferred over mash for range feeding. Turkey poults are usually fed for the first 6 to 8 weeks on a 26 to 28% protein feed. At the end of this period the poults should be changed to a growing diet containing about 22% protein. Such a diet can be fed from this time until market time.

If grain, such as oats and corn, are available locally or can be purchased from nearby states at an economical price, cheaper gains may be obtained through the feeding of these grains in addition to the complete feed. Usually the poults will begin to consume some grain at 7 to 8 weeks of age. As they get older they will gradually consume more grain and less mash. Feed should be kept before the turkeys at all times.

# FURTHER PROCESSING OF POULTRY PRODUCTS

by

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Further processing can be defined as any process applied to ready-to-cook poultry to yield a product that is marketable at a higher return than the original raw material. The further processing of poultry products can be divided into several categories. These processes have been developed because of either consumer preferences, convenience, increased shelf-life, utilization of low-value poultry and poultry parts, increased financial return from poultry processing, or combinations of these factors.

One of the first processes that comes to mind is simply to cut up the whole carcass into various parts. These parts may be custom cut to fit a particular customer's needs. This procedure is a first step in the preparation of chicken for restaurants and for the production of pre-cooked frozen chicken. These processes involve a breading step, where some type of coating is applied to the raw chicken parts, followed by a cooking process, usually deep fat frying. The cooked chicken may then be sold from a fast food outlet, or restaurant, or quick frozen for sale as a "heat and serve" convenience item. An advantage of further processing broilers in this way would be to open new markets and customers for the poultry processor.

The smoking of poultry meat offers various advantages to the poultry processor. Smoked poultry is very palatable, tender and juicy. The production of this very desirable product is highly profitable because of the price that the consumer is willing to pay for this delicacy. Shelf-life of the product may be increased due to the anti-microbiological effects of smoking. Presently, whole turkey is smoked in the United States for a rather limited market. Studies are under way at the University of Florida into the feasibility of smoking roaster type birds as well as cornish game hens. Other types of poultry such as pheasants, guineas and quail may also be marketable as smoked products. These products have great appeal at holiday times such as Christmas. Smoking is generally combined with a salt brining of the product and may also be used in conjunction with curing procedures. Turkey and chicken rolls and roasts, as well as whole birds and emulsion products such as frankfurters, all lend themselves to this type of further processing.

Turkey and chicken rolls and roasts are very popular with the consumer and institutional user because of the small amount of waste, ease or portion control and ease of cooking. These products are made from hand deboned meat, generally taken from the breast and thigh only. This makes for a relatively

expensive item because of the amount of labor involved and the amount of waste incurred. The consumer is willing to pay the resulting high price of these products, though, because of their inherent convenience. Other products which contain hand deboned poultry meat are frozen and precooked turkey and chicken pot pies, emulsion products such as "chicken-franks", and various canned products. In some of these operations the carcass may be cooked before deboning. This increases yields because the carcass is easier to debone. The major advantage that production of hand deboned meat gives to the processor is a new outlet for his poultry.

Shelf-life of fresh poultry is relatively short, usually a maximum of nine days when refrigerated. By deboning the carcass and then freeze-drying the meat, the shelf life is virtually unlimited even without refrigeration. Freeze-dried poultry meat may be used in dry soup mixes or as a flavoring agent. The dehydrated product rehydrates easily with a good recovery of texture and flavor. This procedure yields a rather expensive product, and is most widely used as a specialty item such as in a survival kit or camper's ration. However, this product may also be used in various commercial preparations which contain dried poultry meat. The main advantages of freeze-dried poultry meat are its increased shelf-life, use of unrefrigerated storage and light weight.

Another way to increase shelf-life of poultry meat is by canning it. Either deboned meat or whole carcasses may be canned. These products are widely used throughout the world, especially in soup preparations. Because of the extremely long shelf-life of canned poultry, it can be made available at a constant level on a year around basis regardless of seasonal processing fluctuations. The procedure for canning poultry is similar to that employed in the canning of other meats. The most important step is the final retort operation to insure complete removal of pathogenic anaerobic bacteria. This is a good market for older birds, since they tend to hold together better than younger birds under the rigors of the canning procedure. Canned poultry meat, though not a popular item, is a good high quality source of ever needed protein.

Turkey frames, chicken rib-backs, necks and wing tips are waste products of many further processing procedures. Recently, machines have been developed which will remove the meat economically from these bony pieces. The resulting product is called mechanically deboned poultry meat. Because the meat is actually extruded from the bone under a very high pressure, the product is of a paste-like consistency with no textural structure. In the United States, it is most often used in emulsion formulations such as bolognas and frankfurters. It can be used as a replacement for the more expensive red meats in these products with very little loss in total quality. Research is now under way to establish the possibility of and the procedure for the addition of mechanically deboned poultry meat to texturized vegetable protein. Such a combination could result in a meat analog such as a chicken patty or chicken loaf. The marketing of such products as these which are made from meat deboned from otherwise practically useless poultry parts, would be financially favorable to the processor.

Another source of raw material for mechanical deboners is fowl or spent hens. This type of poultry sells for a very low price as a ready-to-cook product. By mechanically deboning the entire carcass, a 60 to 70 percent meat yield can be obtained. This meat is worth nearly five times as much as it was while still on the carcass. New product development in the further processing area is presently aimed at uses for mechanically deboned poultry meat. Though problems concerning shelf-life are present with this product, it still offers a very good source of high quality protein to the consumer at an economical price. When new products are perfected for utilization of this raw material, mechanically deboned poultry meat may make up a tremendous part of the further processed poultry products industry.

# A VIDEO TAPE PRESENTATION OF COMMERCIAL POULTRY OPERATIONS

by

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The University of Florida Poultry Science Department recently acquired a Sony video tape recorder system with the aid of a grant from the Instructional Scientific Equipment Program of the National Science Foundation. This equipment was purchased for use as a classroom audio-visual aid, a research tool and to support extension activities. It is a portable unit which allows the Poultry Science Department to bring the poultry industry to the student. A demonstration of the video tape system will be given today.

In other areas of the poultry industry, this type of system may also have a use. Trouble areas on processing lines could be studied with this technique. As a research tool, it could be used for behavioral studies. The extension personnel could prepare training tapes for use in the field. This technique offers many possibilities to increase the effectiveness of the Poultry Science Department at the University of Florida.

# MEDICAL MANAGEMENT OF SOWS AND LITTERS

by

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No other phase of pork production is as important as the breeding herd. Proper management during breeding, gestation, and farrowing will maximize reproductive efficienty and this is the key to maximum production.

## Establishing Goals

Pork producers the world over need to establish goals. Such goals would include:

1. An 80 to 90 percent conception rate overall.
2. Ten pigs weaned per litter and two litters per sow per year or 1.5 litters per gilt per year.
3. Three pound birth weight.
4. Baby pig losses less than 15 percent prior to weaning.
5. Forty-eight pound pigs at eight weeks of age.
6. Weight gain of 1.65 pounds per day from weaning to market.
7. A 3.3:1 feed conversion ratio for the entire herd

## Reproductive Records

An attempt to achieve such goals can be monitored only if adequate and accurate records are maintained. If a system that utilizes the female month is employed, only four things need be recorded monthly:

1. Number of gilts, sows, and boars in the breeding herd.
2. Number of gilts and sows that farrow.
3. Total number of pigs and live pigs that are farrowed.
4. Number of pigs weaned.

By using such data, one can determine the number of pigs farrowed (live and dead), the number weaned, and the litters per year for both gilts and sows. Studies of such records indicate that it should be easier to increase the number of litters per female per year than to increase litter size. The ways by which this may be done include:

1. Sow indentification.
2. Close observation for estrus detection.

3. Pregnancy testing.
4. Breeding gilts at younger ages.
5. Early rebreeding of sows.

## Adopting a Herd Health Philosophy

Regardless of production size, pork producers must think "preventive medicine and total herd health" concepts. It is much too costly to treat disease after it occurs. The best way is to prevent disease. Properly invested veterinary service costs should return at least $5.00 for every $1.00 spent. Producers should be cautious not to be lead into believing that something cheaply obtained is always a "good buy". Cheap is not always best and good herd health programs are not cheap but they are economically feasible and financially sound business practices. As stated earlier, the breeding herd is the first place to apply herd health procedures. This is where 70 to 80 percent of preventive medicine dollars should be spent.

## Medical Management of the Breeding Herd

Because of the numerous aspects involved in breeding herd management the following is an abbreviated check list of highlights with additional comments added where felt important.

### Prior to Breeding

Gilt selection. Select for good udder capacity and freedom from inverted nipples. Check for soundness of feet and legs and lack of anatomical defects of external genitalia.

Sow culling. Remove sows that have become too large to care for pigs.

Boar acclimation. New boars should be purchased 30 to 60 days prior to intended use and should be isolated from the rest of the herd for 30 days. During the isolation period, details of deworming, spraying for external parasites, immunization, and blood testing can be performed.

Leptospirosis vaccination. In the United States, leptospirosis is an important disease that affects reproductive efficiency. At least five different strains can be involved and a polyvalent vaccine is available. The vaccine should be given prior to each breeding. It is often convenient to vaccinate sows at weaning time before they are released from the farrowing area (crates).

Cross exposure of boars, gilts, and sows. About one month prior to breeding gilts and sows should be "cross contaminated" by the boars intended for use. This is most easily done by mixing fresh boar manure in feed and giving it to the gilts and sows. This is usually repeated two or three consecutive days. The reason for this is to stimulate natural immunity to the group of viruses known to be responsible for causing the SMEDI syndrome.

Breeding Time

Boar rotation. Breed young boars no more than nine times weekly.

Detecting estrus.

Double mating. Increases litter size and conception rates.

Boar power. Have enough boars available.

Breeding area and floor surface. Most producers prefer outside lots with dirt or sand surfaces. Provide good footing and comfortable surroundings.

Feed additives. Use if needed. May help certain conception problems.

Gestation

Feed intake. Weight gain during gestation should be limited to 75 pounds for gilts and 40 pounds for sows. One-half pound of properly fortified protein daily and 3 to 5 pounds of grain daily, as needed, is adequate. Total feed intake is usually increased gradually beginning about one month prior to farrowing.

Immunization. Depending on the disease problems, several vaccines are given beginning about one month prior to farrowing. These might include erysipelas, commercial porcine mixed bacterins, E. coli vaccines, TGE-Vac and clostridial toxoids. These immunizing agents are given in order to increase the amount of antibodies in the colostrum, hopefully to better protect the piglet.

Deworming. We prefer Atgard (Shell Chemical Company) but special situations necessitate the additional use of other products. Usually done 1 to 3 weeks prior to farrowing.

Spraying. Control of external parasites on the sow eliminates most of the trouble for pigs.

Sow washing. This should be done just prior to entry into the farrowing area. Many good disinfectant-detergent combinations are available and may be applied through mechanical sprayers.

Farrowing

Nutrition. Many producers use a bulky ration beginning about one week prefarrowing and continued about two weeks. This is an attempt to prevent the constipation which is often seen in sows farrowed in total confinement. The bulky ration is gradually replaced about one week post-farrowing by a 16 percent protein lactation ration.

Feed additives. Antibiotics and/or chemotherapeutic agents are often added to prefarrowing rations in an attempt to reduce post-farrowing problems such as metritis-mastitis-agalactia (MMA), navel infection of piglets, and neonatal diarrhea. The compounds used should be selected on the basis of laboratory tests and past experience. Attention to vitamin-mineral content of the pre- and post-farrowing diet is also very important.

## Medical Management of the Piglet

Farrowing house environment. No amount of "medicine" will help the piglet that is chilled or has its leg caught between slats. Farrowing house temperature should be regulated to suit the pigs, not the people, and flooring should be constructed properly.

Iron injection. My experience has been favorable when an iron-antibiotic-vitamin mixture has been injected at 1 to 3 days of age. This mixture provides 150 mg iron dextran, long lasting antibiotic, and B-complex vitamins. The iron prevents anemia, the antibiotic prevents navel infections, and the B-complex vitamins stimulate appetite and blood formation. The mixture is delivered in a 2cc dose and is injected into the neck muscle with an 18 gauge, one half inch needle. When done properly little or no leakage occurs and the ham muscle is spared the trauma.

Iron supplementation. Commercially available, water soluble, iron-electrolyte-antibiotic preparations work well for additional supplementation. These are offered in small drinkers from day 1 to 21 on free-choice basis. Iron supplementation may also be accomplished by mixing 1 part $FeSO_4$ to 9 parts of 16 percent lactation ration and feeing a small amount to the pigs every third day.

Erysipelas vaccination. If needed, erysipelas vaccination may be given either by injection or orally through the drinking water. This is usually done after 8 to 10 weeks of age.

Deworming. This is usually done after weaning and again at about 125 pounds. The products used vary with specific parasite problems.

## Summary

Regardless of size but particularly as size of production grows, the need exists for a total herd health program. A competent herd health veterinarian will be able to deliver these services. The veterinarian's responsibilities as an advisor-diagnostician should include:

1. General ration analyses and recommendations.
2. Overall management suggestions on procedures, housing, ventilation and additives.
3. Diagnostic tests including fecal examination, bacterial culturing and postmortem examinations.
4. Slaughter inspections on a semi-annual basis.
5. Referral contacts with specialists in other fields.

# PRESERVATION OF HIGH MOISTURE GRAINS

by

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Considerable interest has developed in the last few years in the storage of high moisture corn and grain sorghum. The recent energy crisis has intensified interest of producers to store grain in a high moisture state in order to save on energy costs of drying. Harvesting of grains in a high moisture state (28-30%) results in reduced field losses with the possibility of utilizing the stalks as silage when they have a greater nutritive value. With storage facilities severely limited at many grain terminals and an energy crisis confronting the swine producer alternative methods of storage are currently being considered.

The use of organic acids for storing high moisture grains is currently receiving much interest, especially with the livestock producer, since the corn can be fed and thus eliminating the need for drying. High moisture grains may be stored in an airtight silo or treated with an organic acid. The acid reduces the pH of the grain to about 4.0 and prevents germination of the kernel, necessitating the feeding to animals. Treatment of grain with acid prevents mold growth as untreated high moisture grain will begin spoiling about 24 hours after it is removed from an airtight silo. Organic acid treated grain keeps much like dry corn providing it is stored in a non-airtight facility.

Organic acid preservatives consist of a mixture of propionic and acetic acids or propionic acid only. Feeding trials indicate the mixture should consist of a minimum of 80% propionic to prevent spoilage. Recommended rates of application are found in table 1.

The results of experiments conducted by Iowa State, Purdue, Texas, and Florida researchers indicate that preserving of high moisture grains with acid has no effect on average daily gain or feed efficiency when fed to growing-finishing swine. The advantage of treating grain with acid therefore, must be based on factors other than pig performance.

In summary, preservation of high moisture grain with acids offers the livestock producer an alternative method of storing grain. No appreciable differences have been observed in the nutritional value of acid preserved high moisture grains.

Table 1. Application rates

| Percent Moisture at Harvest, Oct. 1 | Pounds acid per 100 lbs. grain for indicated storage period | | | | | |
|---|---|---|---|---|---|---|
| | April 1, 6 mos. | | July 1, 9 mos. | | Sept. 1, 12 mos. | |
| | | Cost* | | Cost | | Cost |
| 21% or less | 1.0 | 35¢ | 1.2 | 42¢ | 1.4 | 49¢ |
| 22-25% | 1.2 | 42¢ | 1.4 | 49¢ | 1.6 | 56¢ |
| 26-30% | 1.4 | 49¢ | 1.6 | 56¢ | 1.8 | 63¢ |

*Estimated costs of preservative is 35¢ per pound.

# RECENT HAPPENINGS IN SWINE NUTRITION

by

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The general areas of swine nutrition and management are constantly undergoing change as new findings are presented by researchers. Selected topics within these areas to be discussed today include recent results in investigations concerned with the energy, protein, mineral, vitamin and antibiotic needs of swine of all ages.

## Energy

Research concerned with the energy components of swine diets have been generally directed toward complete or partial replacement of the corn or with using an ingredient for special attributes other than its energy content.

### Wheat Bran (Fla). Table 1.

A study, involving a total of 98 litters farrowed over an eight month period, was conducted to determine the influence of adding 15% wheat bran to the farrowing and lactation diet on sow performance.

Body temperatures of sows, incidence of MMA, number of pigs weaned per litter, weight of pigs at weaning and percent survival revealed no advantage for including this bulky ingredient in the diet.

### Alfalfa Meal (Fla). Table 2.

A study, involving a total of 72 litters farrowed over a six month period, was conducted to determine the influence of adding 15% alfalfa meal to the diet three days before farrowing and during a 2 week lactation period on sow performance.

Mild cases of MMA were observed in both control and alfalfa-fed sows. The incidence was significantly lower in sows fed alfalfa. However, this reduced incidence was not reflected in a significant improvement in sow performance. Number of pigs weaned per litter, weight of pigs at weaning and percent survival to weaning for control and treated sows respectively were: (9.57 vs. 9.77), (8.57 vs. 8.53) and (86.6 vs. 88.8).

### Grain Sorghum (Fla). Table 3.

Thirty growing-finishing pigs, fed individually, were used to

evaluate two varieties of sorghum grain as an energy feed. Corn was superior to both a bird resistant variety (Funk 79) and a non bird resistant variety (McNair 652). Pigs were able to gain reasonably well on both varieties of sorghum grain but feed conversion was poor, especially for the BR variety. Barrows gained faster than gilts but were slightly less efficient on all diets.

Florida Elodea (Hydrilla verticillata) (FLA). Table 4.

Forty early weaned pigs having an initial weight of approximately 14 pounds were given access to diets containing 0, 5, 10 and 15% elodea. Rate and efficiency of gain were not significantly influenced ($P < .05$) by dietary treatment. However, variation in performance with the highest dietary levels of elodea indicate a maximum of 5% of properly processed elodea be presently recommended for starter diets.

Feed Mixtures (FLA). Table 5.

A feeding trial, involving 42 finishing pigs, was conducted to compare a simplified corn-soybean meal mixture with a more complex mixture which included 5% of each ground whole oats, alfalfa meal and rice bran. Rate and efficiency of gain favored slightly the simplified mixture and formulation costs were $2.42 per ton less for this mixture.

Citrus Pulp (GA). Table 6.

A series of feeding trials were conducted with Yorkshire pigs to determine the effects of citrus pulp on growth rate, efficiency of gain and carcass characteristics.

Daily gains were significantly depressed with increasing levels of citrus pulp fed at 10, 20 and 40% of the diet although energy was held about constant by addition of prime tallow. Daily feed consumption also was depressed; however, this gave a limited feed effect and generally improved feed conversion. When estimated energy was held near constant, citrus pulp had corn replacement values of 97, 95 and 82% at the 10, 20 and 40% levels in the diet.

## Protein

Drastic changes in the price relationships between the protein and energy constituent of swine diets has resulted in re-evaluation of protein feeding programs and continued research in possible replacements for soybean meal and in the use of synthetic amino acids.

Roasted Soybeans (Louisiana)

Roasted soybeans improved feed efficiency 5% compared to soybean meal when fed in both corn and sorghum diets throughout the growing-finishing period. Source of protein had no significant effect on carcass cutability but carcasses from pigs fed roasted soybeans had softer fat.

Peanut Meal (Univ. of Alberta)

Substitution of peanut meal for 50% to 100% of the soybean meal in corn-soy diets reduced rate of gain and also efficiency of gain at the 100% level.

Hydrolyzed Hog Hair (VPI). Table 7.

Two to 3% hydrolyzed hog-hair can be substituted for soybean meal with depressing rate and efficiency of gain when the diets are formulated on a digestible energy basis.

Waste Products (Illinois and Michigan). Table 8.

The use of oxidation ditch liquor (ODL) has not produced consistent results. Finishing pigs fed ODL combined with 12% corn-soy diet and fed as a gruel gain more rapidly and efficiently than those which received water mixed with the feed (Ill.). The Michigan group found no improvement when ODL was mixed with a 12.4% corn-soy diet (1:1 weight basis) and fed twice daily.

## Minerals

Emphasis has been placed upon reducing the amount of several minerals in swine diets to alleviate current shortages and/or high prices.

Phosphorus (NRC)

A special report published by the NRC recommends that supplemental phosphorus be reduced to meet NRC recommended levels for total phosphorus in the diet. Also, unless forced to do otherwise use "emergency levels" only with older growing-finishing pigs, 77 lb. to market:

| Stage of life cycle | Body wt., lb. | NRC % | "Emergency level" % |
|---|---|---|---|
| Growth | | | |
| | 11-12 | 0.6 | 0.54 |
| | 22-44 | 0.5 | 0.46 |
| | 44-77 | 0.5 | 0.46 |
| | 77-132 | 0.4 | 0.38 |
| | 132-220 | 0.4 | 0.38 |
| Breeding Herd All Animals | | 0.5 | 0.46 |

Selenium (FDA)

The Food and Drug Administration now permits sodium selenite or sodium selenate to be added to the complete feed of swine at a level not to exceed 0.1 ppm of selenium.

Salt (Fla.). Table 9.

The supplemental salt level can be safely reduced in young and

growing-finishing swine diets from 0.5% to 0.2%, without adversely influencing rate and efficiency of gain.

## Vitamins

### Vitamin K (Fla.). Table 10.

A study, involving a total of 72 litters, was conducted to determine if vitamin K supplementation of the sow diet at 3 days prior to farrowing and during a 2 week lactation period would improve performance.

Body temperatures of sows, incidence of MMA, number of pigs weaned per litter, weight of pigs at weaning and percent survival revealed no advantage for the additional vitamin K.

### Vitamin E (NCR-42). Table 11.

The North Central Regional Committee on Swine Nutrition conducted a study to determine the effects of supplementary copper and vitamin E in growing-finishing swine diets. Performance data showed that 250 ppm of copper ($CuSO_4$) or 22 IU of vitamin E per kg. of diet did not significantly affect rate or efficiency of gain.

### Choline (NCR-42). Table 12.

This group reported that the addition of 770 ppm of choline to gestation and lactation diets resulted in improved reproductive performance. Choline supplemented sows farrowed significantly more pigs (10.54 vs. 9.89). No advantage for choline was reported with respect to pig weight at birth or weaning.

## Antibiotics

The use of antibiotics or chemotherapeutics as growth stimulants or in disease prevention and control continues to receive attention by many researchers.

### Farrowing and Lactation (Fla.). Table 13.

A study, involving a total of 149 litters farrowed over a 15 month period, was conducted to determine the influence on sow performance when the diet was supplemented with ASP-250 commencing 3 days prefarrow through 14 days of lactation.

Body temperatures of sows, incidence of MMA, number of pigs weaned per litter, weight of pigs at weaning and percent pig survival revealed no advantage for the treatment under the conditions of this experiment.

### Market Swine (Fla.). Table 14.

Two experiments were conducted to evaluate the influence of high dietary levels of Baciferm on rate and efficiency of gain. Young pigs fed 80 gm/ton of Baciferm gained 6% faster than those given either 0 or 20 gm/ton. Feed efficiency was improved by both the 20 and 80 gm/ton

additions with the biggest improvement (7%) occurring with the 80 gm level. Neither rate nor efficiency of gain was improved with growing-finishing pigs fed diets containing 10, 20, 40 and 80 gm/ton of Baciferm. These data indicate that to achieve the maximum response to Baciferm it may be necessary to provide higher levels than previously recommended.

Atrophic Rhinitis (Fla.). Table 15.

Four chemotherapeutic compounds (ASP-250, Tylan-Sulfa, Mecadox-Oleandomycin, Mecadox) were fed to determine which compound enabled pigs to maintain adequate performance in the presence of atrophic rhinitis. No significant difference was observed in rate or efficiency of gain due to chemotherapeutic feeding.

## Miscellaneous

Iodinated Casein (Fla.). Table 16.

Preweaning growth rate and within litter variation in pig weights may be influenced considerably by the milk production flow of the sow. In an attempt to increase milk production iodinated casein and other thyroidally active compounds have been fed to sows.

Twenty-seven sows and litters were used to study the effect of 220 mg iodinated casein per kg of sow diet on farrowing and lactation performance. Treated sows were extremely thin and had significantly ($P < .01$) increased respiration rate scores, rectal temperatures and weight loss at 14 days post partum. Litters from treated sows had significantly reduced 21 day gains compared to litters from untreated sows. Iodinated casein at a dietary level of 220 mg/kg diet is not recommended for sows under conditions comparable to this experiment.

Floor Designs (Fla.). Table 17.

Ten different floor designs for swine enterprises were evaluated. Four were commercially manufactured and six were fabricated at the University of Florida. As a result of this experiment, several things are evident. Clean pigs have an esthetic value but no real advantage in feed efficiency and rate of gain. Dryness does have an important role in swine production, especially with young pigs. When designing a floor, use either total slats or none at all. Partially slatted arrangements, like those used in this experiment, have the disadvantage of collecting manure and urine on the solid concrete section, thereby defeating the cleaning advantage gained with slatted or expanded metal floors. Wood is an unsatisfactory material for use in modern finishing units. The initial cost is low but its short lifespan and increased labor costs make it less desirable than other materials. Expanded metal works well for young pigs but feet problems are associated with its use for pigs over 130 pounds.

Commercially manufactured swine floors are more expensive initially, require less time and labor to assemble, have a longer, useful lifetime with less maintenance, resulting in a lower annual fixed cost.

Table 1. Summary of Sow Reproductive Performance as Influenced by the Inclusion of Wheat Bran in the Farrowing and Lactation Diet

| | Control | Wheat Bran |
|---|---|---|
| Number of litters | 48 | 50 |
| Av. litter number (sow maturity) | 2.67 | 3.02 |
| Av. number of live pigs per litter at birth | 11.48* | 10.84 |
| Av. wt. per pig at birth, lb. | 3.06 | 2.99 |
| Av. number of resorbing fetuses at birth per litter | 0.73 | 0.80 |
| Av. number of term pigs born dead per litter | 0.65 | 0.74 |
| Av. body temp. ($F^o$) of sows at farrowing 1/ | 102.8 | 102.5 |
| Av. body temp. ($F^o$) of sows 24 hr. post farrowing 1/ | 104.1 | 103.9 |
| Incidence of MMA (total number sows affected) 1/ | 6.0 | 6.0 |
| Av. number pigs weaned per litter at 2 wks. | 9.98 | 9.16 |
| Av. wt. per pig at 2 wks., lb. | 8.37 | 8.31 |
| % survival of pigs to 2 wks. of age | 86.9** | 84.5 |
| Av. sow wt. change (3 days prefarrow to 2 wks. postfarrow) | -59.8 | -68.3 |

1/ Measurements obtained on a total of 36 litters only for each group which consisted of the three most recent farrowings.

* $P < .05$.

** $P < .01$.

Table 2. Summary of Sow Reproductive Performance as Influenced by the Inclusion of Alfalfa Meal in the Farrowing and Lactation Diet

| | Control | Alfalfa Meal |
|---|---|---|
| Number of litters | 37 | 35 |
| Av. litter number (sow maturity) | 2.73 | 2.83 |
| Av. number of live pigs per litter at birth | 11.05 | 11.00 |
| Av. wt. per pig at birth, lb. | 3.02 | 3.06 |
| Av. number of resorbing fetuses at birth per litter | 0.27 | 0.32 |
| Av. number of term pigs born dead per litter | 0.57 | 0.60 |
| Av. body temp. ($F^o$) of sows at farrowing | 102.6 | 102.4 |
| Av. body temp. ($F^o$) of sows 24 hr. post farrowing | 103.8 | 103.3 |
| Incidence of MMA (total number of sows affected) | 21 | 13 |
| Av. number pigs weaned per litter at 2 wks. | 9.57 | 9.77 |
| Av. wt. per pig at 2 wks., lb. | 8.57 | 8.53 |
| % survival of pigs to 2 wks. of age | 86.6 | 88.8 |
| Av. sow wt. change (3 days prefarrow to 2 wks. post farrow) | -58.2 | -68.5 |

Table 3. Performance of Growing-Finishing Pigs Fed Diets Based on Yellow Corn, Bird Resistant Sorghum Grain and Non Bird Resistant Sorghum Grain

| Item | Corn | BR Sorghum | NBR Sorghum |
|---|---|---|---|
| Number of pigs | 10 | 10 | 10 |
| Av. initial wt., lb. | 58.2 | 58.2 | 58.2 |
| Av. final wt., lb. | 242.8 | 228.9 | 240.6 |
| Av. daily gain, lb. | 1.89 | 1.74 | 1.86 |
| Barrows | 1.93 | 1.81 | 1.92 |
| Gilts | 1.84 | 1.67 | 1.81 |
| Av. daily feed intake, lb. | 5.76 | 6.43 | 6.24 |
| Feed per lb. gain, lb. | 3.06 | 3.71 | 3.36 |
| Barrows | 3.13 | 3.74 | 3.42 |
| Gilts | 2.98 | 3.67 | 3.31 |
| Number days on test | 98 | 98 | 98 |

Statistical Evaluation

| | |
|---|---|
| Daily gain | |
| Corn vs. BR Sorghum | - NS |
| Corn vs. NBR Sorghum | - NS |
| BR Sorghum vs. NBR Sorghum | - NS |
| Barrows vs. gilts | - $P < .05$ |
| Feed efficiency (feed per lb. gain) | |
| Corn vs. BR Sorghum | - $P < .01$ |
| Corn vs. NBR Sorghum | - $P < .01$ |
| BR Sorghum vs. NBR Sorghum | - $P < .01$ |
| Barrows vs. gilts | - NS |

Table 4. Performance of Pigs Fed Starter Diets Containing Dehydrated Elodea

| % Dietary Elodea | 0 | 5 | 10 | 15 |
|---|---|---|---|---|
| Av. initial wt., lb. | 13.84 | 13.90 | 13.82 | 13.88 |
| Av. final wt., lb. | 72.90 | 70.80 | 65.77 | 70.12 |
| Av. daily gain, lb. | 1.20[a] | 1.16[a] | 1.06[a] | 1.14[a] |
| Av. daily feed cons., lb. | 2.28[a] | 2.29[a] | 2.14[a] | 2.23[a] |
| Av. feed/unit gain, lb. | 1.90[a] | 1.97[a] | 2.02[a] | 1.95[a] |
| No. of pigs | 10 | 10 | 10 | 10 |
| Days on test | 50 | 50 | 50 | 50 |

a/ Values in the same line having the same superscript are not significantly different ($P<.05$).

Table 5. Performance of Growing-Finishing Pigs Fed a Simplified Feed Mixture Compared to a More Complex Mixture

| | Simple Mixture | Complex Mixture |
|---|---|---|
| Combined Replications | | |
| Initial weight, lb. | 72.1 | 72.2 |
| Final weight, lb. | 190.7 | 188.6 |
| Daily gain, lb. | 1.69 | 1.66 |
| Daily feed, lb. | 5.36 | 5.31 |
| Feed/gain, lb. | 3.17 | 3.20 |

Table 6. Influence of Citrus Pulp Level on Rate and Efficiency of Gain and Carcass Traits. (Experiments 1 and 2).

| Item | Percent citrus pulp | | | |
|---|---|---|---|---|
| | 0 | 10 | 20 | 40 |
| Number animals | 16 | 16 | 16 | 16 |
| Av. weight on test, kg. | 15.1 | 15.1 | 15.1 | 15.1 |
| Av. weight off test, kg. | 94.3 | 93.9 | 95.1 | 93.7 |
| Av. daily gain, kg. | 0.80[a] | 0.74[b] | 0.72[bc] | 0.63[c]** |
| Av. daily feed intake, kg. | 2.56 | 2.30 | 2.19 | 1.99 |
| Feed/gain ratio | 3.24 | 3.10 | 3.06 | 3.13 |
| Corn replacement value, % | 100 | 97.4 | 95.5 | 82.2 |

[a,b,c]Each set not having common letters differ significantly
* P < .05
** P < .01

Table 7. Average Daily Gain, Feed Intake and Gain/Feed of Growing Pigs Fed Diets Containing Hydrolyzed Hog Hair Meal.

| Ration no. | Criteria | | | | |
|---|---|---|---|---|---|
| | HHH meal | Dig. protein sequence | Ave. daily gain | Ave. feed intake | Gain/Feed |
| | % | % | kg | kg | |
| | | Trial 1[a] | | | |
| 1 | 0 | 15.7 | 0.49[b] | 0.92 | 0.53[b] |
| 2 | 2 | 15.3 | 0.43 | 0.90 | 0.48 |
| 3 | 4 | 14.9 | 0.42 | 0.93 | 0.45 |
| 4 | 6 | 14.5 | 0.38 | 0.90 | 0.42 |
| 5 | 8 | 14.0 | 0.30 | 0.80 | 0.38 |
| | | Trial 2[a] | | | |
| 1 | 0 | 16-14 | 0.49[c] | 1.09 | 0.45[f] |
| 2 | 2 | 16-14 | 0.50[c] | 1.13 | 0.44 |
| 3 | 4 | 16-14 | 0.45[d] | 1.07 | 0.42 |
| | | Trial 3[a] | | | |
| 1 | 0 | 16-14 | 0.54[g] | 1.27 | 0.43 |
| 2 | 2 | 16-14 | 0.48 | 1.13 | 0.43 |
| 3 | 3 | 16-14 | 0.51 | 1.19 | 0.43 |
| | | Trial 4[a] | | | |
| 1 | 0 | 14-12-11 | 0.73[c] | 2.42[c] | 0.30[c] |
| 2 | 0 | 11.3-9.4-8.3 | 0.46[e] | 2.00[d] | 0.23[e] |
| 3 | 2 | 12.6-10.7-9.7 | 0.60[d] | 2.30[cd] | 0.26[d] |
| 4 | 4 | 14-12-11 | 0.69[c] | 2.43[c] | 0.28[c] |
| 5 | 6 | 15.3-13.3-12.3 | 0.69[c] | 2.48[c] | 0.28[c] |

[a]Pigs per mean were 12, 24, 11 and 24; length of trial was 28, 35, 42 and 126.5 (avg.) days; and the average initial weight (kg) were 9.1, 11.4, 8.6 and 20.0, respectively, for trials 1 through 4.
[b]Significant (P <.01) linear effect of diets.
[c,d,e]Means with different superscript letters are significantly different (P <.01).
[f]Significant (P <.05) linear effect of diets.
[g]Significant (P <.05) quadratic effect of diets.

Table 8. Performance With Finishing Swine[a] Fed 12% Protein Diet Mixed With Water or Oxidation Ditch Mixed Liquor (ODML)

| Item | Water[b] | ODML[b] |
|---|---|---|
| Avg. daily gain, kg | | |
| Rep. 1 | 0.49 | 0.51 |
| Rep. 2 | 0.46 | 0.55 |
| Rep. 3 | 0.49 | 0.57 |
| Rep. 4 | 0.64 | 0.65 |
| Rep. 5 | 0.50 | 0.53 |
| X | 0.52 | 0.56* |
| Gain/feed | | |
| Rep. 1 | 0.218 | 0.232 |
| Rep. 2 | 0.213 | 0.249 |
| Rep. 3 | 0.275 | 0.276 |
| Rep. 4 | 0.283 | 0.302 |
| Rep. 5 | 0.256 | 0.270 |
| X | 0.249 | 0.266* |

[a]Initial wt, 50 kg, 76 finishing swine.
[b]Liquid added to feed 2:1 ratio.
*($P < 0.05$).

Table 9. Dietary Salt Levels For Growing Swine 1/

| Salt% | 0 | 0.05 | 0.10 | 0.20 | 0.50 |
|---|---|---|---|---|---|
| Av. init. wt., lb. | 12.60 | 12.57 | 12.57 | 12.63 | 12.60 |
| Av. final wt., lb. | 32.40 | 55.43 | 70.80 | 93.67 | 87.17 |
| Av. daily gain, lb. | 0.28 | 0.60 | 0.81 | 1.13[a] | 0.99[a] |
| Av. daily feed, lb. | 1.26 | 2.44 | 2.56 | 2.06 | 1.97 |
| Av. feed/gain, lb. | 4.5 | 4.07 | 3.16 | 1.82[a] | 1.99[a] |

1/ 15 pigs per treatment.
a/ Significantly ($P < .05$) different from other treatments.

Table 10. Summary of Sow Reproductive Performance as Influenced by Supplementing Diet with Vitamin K During Farrowing and Lactation.

| | Control | Vitamin K Supplemented |
|---|---|---|
| Number of litters | 37 | 35 |
| Av. number of live pigs per litter at birth | 11.11 | 10.89 |
| Av. wt. per pig at birth, lb. | 3.02 | 3.07 |
| Av. number of resorbing fetuses at birth per litter | 0.65 | 0.51 |
| Av. number of term pigs born dead per litter | 0.35 | 0.23 |
| Av. body temp. ($F^{o}$) of sows at farrowing | 102.6 | 102.4 |
| Av. body temp. ($F^{o}$) of sows 24 hr. post farrowing | 103.3 | 103.7 |
| Incidence of MMA (total number sows affected) | 18 | 16 |
| Av. number pigs weaned per litter at 2 wks. | 9.89 | 9.43 |
| Av. wt. per pig at 2 wks. | 8.63 | 8.45 |
| % survival of pigs to 2 wks. of age | 89.1* | 86.6 |
| Av. sow wt. change (3 days prefarrow to 2 wks. post farrow) | -62.1 | -64.3 |

* $P < .05$.

Table 11. Effect of Vitamin E and Supplemental Copper on Rate of Gain and Feed/Gain

| | Daily gain (g) by replicate | | | | Feed/gain by replicate | | | |
|---|---|---|---|---|---|---|---|---|
| | Basal | 22 IU/kg vitamin E | 250 ppm Cu | 250 ppm Cu + 22 IU/kg vitamin E | Basal | 22 IU/kg vitamin E | 250 ppm Cu | 250 ppm Cu + 22 IU/kg vitamin E |
| Treatment means (x)[a] | 698 | 708 | 721 | 710 | 3.36 | 3.30 | 3.31 | 3.34 |

[a]Station sig. (P <.01), station X Cu sig. (P< .05) for rate of gain and feed/gain; rep/station sig. (P <.01) for rate of gain.

Table 12. Summary of Effect of Choline on Litter Size

| | Controls | | | | + Choline | | | |
|---|---|---|---|---|---|---|---|---|
| | No. Litters | Total Farrowed | No. Alive | No. Weaned | No. Litters | Total Farrowed | No. Alive | No. Weaned |
| Total | 281 | | | | 270 | | | |
| Avg. | | 9.89 | 8.64 | 7.29 | | 10.54 | 9.33 | 7.72 |
| Weighed Avg. | | 9.87 | 8.68 | 7.26 | | 10.33 | 9.18 | 7.66 |

Table 13. Summary of Sow Reproductive Performance As Influenced by the Addition of a Combination of Aureomycin, Sulfamethazine and Penicillin to the Farrowing and Lactation Diet

| | CONTROL | TREATED |
|---|---|---|
| Number of litters | 79 | 70 |
| Av. litter number (sow maturity) | 2.49 | 2.54 |
| Av. number live pigs per litter at birth | 10.62 | 10.97 |
| Av. wt. per pig at birth, lb. | 2.95 | 2.95 |
| Av. number of resorbing fetuses at birth per litter | 0.85 | 1.07 |
| Av. number of term pigs born dead per litter | 0.70 | 0.74 |
| Av. body temp. ($F^{o}$) of sows at farrowing 1/ | 102.6 | 102.4 |
| Av. body temp. ($F^{o}$) of sows 24 hr. post farrowing 2/ | 104.0 | 104.1 |
| Incidence of MMA (total number sows affected) 3/ | 7 | 8 |
| Av. number pigs weaned per litter at 2 wks. | 9.34 | 9.36 |
| Av. wt. per pig at 2 wks. | 8.36 | 8.26 |
| % Survival of pigs to 2 wks. of age | 88.0 | 85.3 |
| Av. sow wt. change (3 days prefarrow to 2 wks. post-farrow) | -63.2 | -65.0 |

1/ Data recorded for last 49 sows farrowed in each group only.
2/ Data recorded for last 36 sows farrowed in each group only.
3/ Data recorded for last 49 sows farrowed in each group only. All other measurements involved the total number of litters as shown.

Table 14. Baciferm For Young Swine

| Baciferm, gm/ton | 0 | 20 | 80 |
|---|---|---|---|
| Av. Replications 1 and 2 | | | |
| Initial weight, lb. | 14.80 | 14.60 | 14.55 |
| Final weight, lb. | 47.55 | 46.15 | 52.70 |
| Daily gain, lb. | 0.78 | 0.75 | 0.91 |
| Daily feed, lb. | 1.60 | 1.46 | 1.72 |
| Feed/gain, lb. | 2.05 | 1.96 | 1.90 |

Baciferm For Growing-Finishing Swine

| Baciferm, gm/ton | 0 | 10 | 20 | 40 | 80 |
|---|---|---|---|---|---|
| Initial weight, lb. | 65.00 | 64.40 | 64.90 | 64.20 | 64.80 |
| Final weight, lb. | 223.90 | 218.10 | 227.20 | 215.00 | 218.80 |
| Daily gain, lb. | 1.89 | 1.83 | 1.92 | 1.79 | 1.83 |
| Daily feed, lb. | 5.43 | 5.37 | 5.52 | 5.53 | 5.61 |
| Feed/gain, lb. | 2.87 | 2.93 | 2.87 | 3.09 | 3.07 |

Table 15. Performance of Pigs Fed Diets Containing Different Antibiotics

| Treatment | ASP-250 & Aureomycin | Tylan/Sulfa & Tylan | Mecadox & Oleandomycin | Mecadox & No Medication |
|---|---|---|---|---|
| Average daily gain, lbs. | 1.28 | 1.31 | 1.22 | 1.20 |
| Feed/gain | 3.15 | 3.07 | 3.11 | 3.25 |

Table 16. The Effect of Iodinated Casein and Bulkiness of Diet on Sow Performance

| Dependent Variables | Without Iodinated Casein | | | With Iodinated Casein | | |
|---|---|---|---|---|---|---|
| | Basal | Low Bulk | Avg. | Basal | Low Bulk | Avg. |
| Rectal temperature °C | | | | | | |
| 109th day of gestation | 38.94[c] | 39.40[d] | 39.06 | 38.93[c] | 39.42[d] | 39.15 |
| at parturition | 38.95 | 39.80 | 39.58 | 39.67 | 40.22 | 39.92 |
| 14th day postpartum | 40.62 | 39.67 | 40.38[a] | 41.37 | 40.72 | 41.07[b] |
| Respiration rate[1] | 3.56[b] | 4.00[b] | 3.67[b] | 2.17[a] | 2.80[a] | 2.45[a] |
| Sow condition[2] | 3.00[b] | 3.67[b] | 3.17[b] | 1.67[a] | 1.40[a] | 1.55[a] |
| Feed consumption[3] | 2.44[b] | 3.00[b] | 2.58[b] | 1.50[a] | 1.80[a] | 1.64[a] |
| Sow wt. loss (kg) | | | | | | |
| 109th day of gestation to 14 day post partum | 28.80 | 28.60 | 28.75[a] | 50.77 | 42.02 | 46.79[b] |
| 14-21 day post partum | 5.71 | 2.60 | 4.93 | 1.43 | 8.72 | 4.75 |

1 Score codes were: very high = 1; high = 2; fairly high = 3, normal = 4.

2 Score codes were: off feed = 1; slightly reduced = 2; normal = 3; above normal = 4.

3 Score codes were: thin = 1; fairly thin = 2; good or average = 3; fairly fat = 4; fat = 5.

ab Values in the same line with different superscripts are significantly different (P <.01).

cd Values in the same line with different superscripts are significantly different (P <.05).

The Effect of Iodinated Casein on Performance of the Litter

| Dependent Variables | Without Iodinated Casein | | | With Iodinated Casein | | |
|---|---|---|---|---|---|---|
| | Basal | Low Bulk | Avg. | Basal | Low Bulk | Avg. |
| Pigs born/litter | 12.33 | 9.67 | 11.66 | 10.50 | 11.40 | 10.91 |
| Pigs weaned/litter | 10.56 | 9.00 | 10.17 | 9.83 | 10.20 | 10.00 |
| Mortality rate % | 13.67 | 5.81 | 11.70 | 5.75 | 10.48 | 7.90 |
| Averaged daily gain/pig (kg) | | | | | | |
| Birth - 14 days | 0.17[a] | 0.16[a] | 0.17 | 0.17[a] | 0.13[b] | 0.15 |
| 14 -21 days | 0.19[a] | 0.19[a] | 0.19[a] | 0.10[b] | 0.13[b] | 0.14[b] |

ab Values in the same line with different superscripts are significantly different (P <.01).

Table 17. Floor Design and Pig Performance

| DESIGN | INITIAL COST | PROJECTED LIFE SPAN | ANNUAL FIXED COST | RATE OF GAIN LBS. PER DAY | FEED CONVERSION LBS. FEED PER LB. GAIN |
|---|---|---|---|---|---|
| 6" Aluminum slats | $88.97 | 10 yrs. | $ 8.90 | 1.6 | 3.2 |
| 3" Plastic slats | $71.40 | 10 yrs. | $ 7.14 | 1.4 | 3.2 |
| 4" Aluminum slats | $98.03 | 10 yrs. | $ 9.80 | 1.7 | 3.3 |
| 4" Double T Aluminum slats | $78.74 | 10 yrs. | $ 7.87 | 1.5 | 3.0 |
| Total Expanded metal with 2 x 4 oak supports | $41.57 | 5 yrs. | $ 8.31 | 1.5 | 3.0 |
| Total Expanded metal with 2 x 4 treated supports | $41.57 | 5 yrs. | $ 8.31 | 1.5 | 3.0 |
| 2' Solid oak center 1' Expanded metal on each side | $34.04 | 1 yr. | $ 7.98 1/ | 1.5 | 3.1 |
| 2' Solid cypress center 1' Expanded metal on each side | $34.04 | 1 yr. | $ 7.98 1/ | 1.4 | 3.2 |
| 12" Cypress slats with 2" openings | $13.15 | 6 mos. | $26.30 | 1.5 | 3.7 |
| 12" Oak slats with 2" openings | $13.15 | 6 mos. | $26.30 | 1.6 | 3.1 |

1/ This is based upon a five year lifespan for the expanded metal and 2 x 4 supports and one year lifespan for the 2' solid wood center. (This figure does not include labor costs for repairs).