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COMMONWEALTH AGRICULTURAL BUREAUX, CENTRAL SALES BRANCH, FARNHAM ROYAL, SLOUGH, BUCKS, ENGLAND.
RECENT DEVELOPMENTS AFFECTING
LIVESTOCK PRODUCTION
IN THE AMERICAS
RECENT DEVELOPMENTS AFFECTING LIVESTOCK PRODUCTION IN THE AMERICAS

Edited by
RALPH W. PHILLIPS
Deputy Director
Agriculture Division

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1956
CONVERSION TABLE

1 yard = 3 feet = 0.91 meters
1 mile = 1,609 kilometers
1 square mile = 2.59 square kilometers
1 hectare = 1,000 square meters
2.2 lb. = 1 kilogram
This publication, like others in the series, is designed to make available to member countries of the Food and Agriculture Organization of the United Nations information that should be useful to them in planning and implementing agricultural improvement programs. This Agricultural Development Paper is based on material presented to the Third FAO Meeting on Livestock Production in the Americas by delegations from 18 countries (Argentina, Bolivia, Brazil, Canada, Chile, Costa Rica, Dominican Republic, Ecuador, France, Guatemala, the Netherlands, Panama, Paraguay, Peru, United Kingdom, Uruguay, the United States of America and Venezuela), and by staff members of the Agriculture Division of FAO and the Inter-American Institute of Agricultural Sciences (IAIAS). Material submitted by the Government of El Salvador has also been used in preparing this publication. The names of those who participated in the meeting in the delegations from countries or as observers from organizations, and who contributed to the discussions, are listed in the "Introduction." Also, observers were present from the Caribbean Commission, the International Office of Epizootics, the International Association of Hydatid Disease, the Pan-American Sanitary Bureau and the World Federation of United Nations Associations. The following members of the staff of the Agriculture Division of FAO and of the Inter-American Institute of Agricultural Sciences participated in the Meeting as technical secretaries, and collaborated in the editing of the report from which much of the material in this Development Paper was drawn:

Mr. W. A. Beattie Adviser to the Government of Uruguay on range and pasture management, FAO.

Mr. Gerardo E. Bildesheim Program Analysis Specialist on Latin America, FAO.

Sir Thomas Dalling Veterinarian, FAO.

Dr. Hans J. Engler Poultry Specialist, FAO.

Dr. H. O. Hetzer Consultant on Analysis and Design of Experiments, IAIAS.

Dr. Douglas H. K. Lee Consultant on Animal Climatology, FAO.
Dr. José Marull

Mr. Roald A. Peterson

Dr. R. O. Whyte

Dr. S. H. Work

Acting Director, Southern Zone Center, IAIAS.

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Agronomist, FAO.

Agricultural Adviser, FAO North American Regional Office.

The full report of the Buenos Aires meeting was issued as a mimeographed document in English and Spanish in the FAO Agriculture Division's Meeting Report Series as No. 1955/11. Reports of the first and second meetings, held in Turrialba, Costa Rica and Baurú, Brazil, respectively, were issued as FAO Agricultural Development Papers Nos. 8 and 33, prior to the establishment of a numbered series of meeting reports by the Agriculture Division.
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Recognizing that the livestock industry is important to all of its member countries in North, Central and South America and in the Caribbean area, the Food and Agriculture Organization of the United Nations organized three meetings in which delegates from these countries had opportunities to discuss the problems of their respective countries, to exchange information on the research, extension and educational programs they are conducting aimed at the solution of those problems and to consider co-ordinated action on problems of common concern to two or more countries.

These meetings were:

1. The Inter-American Meeting on Livestock Production, held in Turrialba, Costa Rica, from 9 to 20 October 1950, and attended by delegations from Costa Rica, El Salvador, Honduras, Guatemala, Nicaragua, Panama, Peru, the Netherlands, the United Kingdom, the United States of America, and Venezuela;

2. The Second Inter-American Meeting on Livestock Production, held in Baurú, Brazil, from 8 to 15 December 1952, and attended by delegations from Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, France, Haiti, the Netherlands, Nicaragua, Panama, Paraguay, Peru, the United Kingdom, the United States of America, Uruguay and Venezuela; and

3. The Third FAO Meeting on Livestock Production in the Americas held in Buenos Aires, Argentina, from 18 to 30 April 1955, and attended by delegations from Argentina, Bolivia, Brazil, Canada, Chile, Costa Rica, Dominican Republic, Ecuador, France, Guatemala, the Netherlands, Panama, Paraguay, Peru, the United Kingdom, Uruguay, the United States of America and Venezuela.

The reports of the first and second meetings in this series were issued as FAO Agricultural Development Papers Nos. 8 and 33.
respectively, prior to the establishment of a regular series of reports of agricultural meetings convened by FAO. The report of the third meeting has been issued in this new mimeographed series as Meeting Report No. 1955/11. In order that the great amount of new information made available to the Buenos Aires meeting may be more generally available to government officials and other leaders concerned with the improvement of livestock production in the Americas, much of the material presented at that meeting has been extracted from the Report, edited, and published in this Development Paper. This includes not only new information of a technical nature, but also information on organizational arrangements which may facilitate co-operation among countries in the solution of their problems.

The information in this Development Paper concerning the work in the various countries was presented to the Buenos Aires meeting by the following workers, who, in many cases, were presenting the results of work by their colleagues who were unable to attend the meeting:

Delegates and Observers from Member Countries

**ARGENTINA**

- S.E.D. Carlos Alberto Hogan; Dr. Juan José Moreno; S.E.D. Conrado Carlos Beckmann; S.S. Dr. Carlos Alberto Pichot; D. Adolfo Pedro Lacu; Ing. Agr. D. Juan José Billard; Dr. Norberto A.R. Reichart; Dr. Roberto Escobal; Dr. Carlos Piazza; Dr. Gregorio A. Caro; Dr. Augusto D. Dellepiane Galli; Dr. José María Quevedo; Dr. Fernando A. Languasco; Dr. Valentín Conti; Dr. Osvaldo J. Gómez; Dr. Raúl Martín Mendy; Cont. Público Nacional Pedro J. Graziano; D. José F. Dubini; Ing. Agr. Oscar P.S. Ronco; Ing. Agr. René P. Delpeche; Ing. Agr. Isidro F.J. Carlevari; Dr. Raúl A. Antequeda; Dr. Enrique D.U. Pierángeli; Dr. Daniel F. Rupoli; Ing. José A. Cappelletti; Ing. Rafael H.F. Bellagamba; Ing. Silvio A. Tosello; Ing. Agr. José Carlos Vidal; Ing. Agr. Alfredo Spinelli; D. Antonio López Arias; D. Mariano O. Rodríguez Aguilar; D. Santos Plutarco Calvo; D. Carlos Alberto Stura; D. José María Grillo Torrado; D. Adolfo Tarelli; Ing. Agr. Pedro A.D. Sarasqueta; Ing. Agr. Osvaldo Boelcke; Ing. Agr. Norberto Hugo Comerio; D. Italo José Peretti; D. Astolfo Muñiz Saavedra; and D. Jorge Edgardo Ostolaza.

**BOLIVIA**

- D. Alfredo Franco Guachalla; D. Ciro Humboldt Barrero.

**BRAZIL**

- D. Paulo Cabral de Mello.
CANADA
  William Frederick Hillhouse.

CHILE
  Roberto Cabezas; Ing. Agr. Waldo Rojas.

COSTA RICA
  D. Doménico M. Bucci.

DOMINICAN REPUBLIC
  D. Salvador Monclus.

ECUADOR
  D. Gonzalo Sotomayor Navas.

FRANCE
  M. Charles Vincent.

GUATEMALA
  D. Luis E. Archila Peña.

THE NETHERLANDS
  Dr. Luis Bar; Mr. Jacobus Wagenaar; Mr. Henrich Verschuyl.

PANAMA
  D.A. Méndez; D. Bolivar Peñalba.

PARAGUAY
  Dr. Tomás Romero Ortiz; Dr. Ramón Codas; D. Rogelio Vargas
  Morel; Thomas S. Darrow.

PERÚ
  Dr. Teodoro Ramos Sacro.

UNITED KINGDOM
  Dr. Roger M. Arnold; Dr. Thomas P. Lecky.

URUGUAY
  Dr. Mario J. Lusiardo; Ing. Agr. Ernesto J. Cortabarria; Ing.
  Juan S. Hatchondo; Dr. Oscar Latourette.

UNITED STATES OF AMERICA
  Dr. Ollie E. Reed; Dr. Angus A. Hanson; Frederick G. Renner;
  William L. Rodman.

VENEZUELA
  Ing. Agr. J.J. Loreto Jiménez; Dr. Horacio Rosales Gil; Ing.
  Agr. Osvaldo Hernández León.
Observers

THE CARIBBEAN COMMISSION. Dr. Roger M. Arnold.

THE INTERNATIONAL OFFICE OF EPIZOOTICS. Dr. Carlos Ruiz Martínez.

THE INTERNATIONAL ASSOCIATION OF HYDATID DISEASES. Dr. Alfredo Ferro.

THE PAN-AMERICAN SANITARY BUREAU. Dr. Benjamin D. Blood and Dr. Erwin A. Eichhorn.

THE WORLD FEDERATION OF UNITED NATIONS ASSOCIATIONS. J. J. Aphalo and Susana Larguira.

The staff members of the Food and Agriculture Organization and of the Inter-American Institute of Agricultural Sciences (IAIAS) who contributed technical material to the meeting and who participated in the editing of the report are listed in the Foreword. In addition, Mr. Eduardo S. Bello, of IAIAS, participated in the discussions, and Dr. Jorge de Alba, also of IAIAS, prepared material for the use of the meeting.

In view of the many sources from which participants drew the information presented at the meeting, it is impossible to give credit to all those sources in this publication. References that were available with regard to published information or personal communications are noted at the ends of chapters, or sections of chapters, and the contributions of all others who cannot be so recognized or are not listed above are gratefully acknowledged.

In the Turrialba and Baurú meetings, attention was given to all phases of livestock production and, arising out of the discussions at these first two meetings, items that appeared to be of particular importance and current interest were selected for inclusion in the agenda of the third meeting in Buenos Aires. Therefore, the material contained in this Development Paper is related only to those subjects selected for consideration at the Buenos Aires meetings, and no attempt has been made to assemble and present material on other aspects of livestock production.

The material contained in the report of the Buenos Aires meeting, which has been made available only in limited numbers as a mimeographed document, has been recast in the form of a review of important developments. Thus, some material which was pertinent to the report but which does not have continuing reference value has been deleted, while material on some subjects has been expanded by incorporating additional details and in some cases illustrations which could not be included in the report of the Buenos Aires meeting.
In the first discussions of this subject at the Turrialba meeting, attention was given primarily to the basic scientific approach that is required if maximum progress is to be made in the improvement of livestock through breeding. Therefore, the discussion centered around two topics, namely, physiological and genetic studies as applied to livestock improvement. These subjects were pursued further at the Baurú meeting, where, on the genetic side, special attention was given to improving local types of livestock, to pure breeds and their use in cross-breeding and grading up, to developing new types of livestock, and to measuring performance. Regarding animal climatology, particular attention was given to the methods that could be used in laboratory and field studies of the reactions of livestock to climatic stress (Phillips, 1950 and 1953).

It became apparent from the discussions at the Baurú meeting that delegates were particularly interested in the development of animal climatology, including its application both to the tropical and the high Andean areas. Much interest was also expressed in the methods of keeping herdbooks and organizing performance tests in cattle. These items were, therefore, included in the agenda of the Buenos Aires meeting, together with artificial insemination, for which a special request had been made by the Baurú meeting owing to the growing interest in the possibilities of storing semen by deep freezing. Thus, this chapter is divided into three sections covering these three topics.

Animal Climatology

Climatic conditions under which livestock are produced in the Americas vary over an extremely wide range. They include the lush pasture and forage producing areas in intensive farming areas in the temperate zones where advantage is taken either of natural rainfall or irrigation. They also include the semi-arid grazing areas, such as those in southern Argentina and in the southwestern portion of the United States of America. There are also the low wet tropics and the high Andean areas, to mention only a few of the variable types of environmental conditions under which livestock are produced.
Man has also developed highly variable types of livestock in his efforts to wrest a satisfactory living from the land under these varying environmental conditions. These variations are well known, but may be emphasized by comparing the highly specialized dairy cow grazing on lush pastures with the vicuña searching for food in a semi-wild state under the sparse grazing conditions at 14,000 ft. in the Andean highlands.

Under these highly variable conditions, each country has its own particular problem or set of problems relating to the determination of the best adapted type or types of livestock to use, or in some cases to the development of a type or types adapted to particular conditions. To meet these problems, the sciences of genetics and physiology must both be utilized. Both are relatively young sciences, especially in their application to the improvement of livestock, and physiologists have only very recently taken up active work on a substantial scale in this field. Therefore, the following section is devoted to research facilities and personnel before turning to the effects of hot climates and high altitudes and the adaptability of breeds to unfavorable environments in the three succeeding sections.

Research Facilities and Personnel

A first attempt was made during the Turrialba meeting to prepare a list of the facilities available in the Americas for the study of animal climatology. This list was later expanded by the staff of FAO, and is summarized below, partly as a means of indicating the places where research is being undertaken, but primarily to point out places where advanced students or professional workers may be able to secure special training in the application of physiology and other sciences to the study of animal climatology.

<table>
<thead>
<tr>
<th>Institution</th>
<th>Facilities</th>
</tr>
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<tbody>
<tr>
<td>INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES (Turrialba, Costa Rica)</td>
<td>A large climatic chamber is available which includes provision for solar radiation studies. Various breeds and crossbreeds of dairy and beef cattle, including zebu types, are available for study, as are also swine and poultry. Arrangements may be made for credit towards a master's degree and facilities may be provided for research workers independent of studies leading to a degree.</td>
</tr>
</tbody>
</table>
The Departments of Animal Husbandry, Dairy Husbandry and Genetics, respectively, are all concerned with the study of animal climatology. Breeding work is in progress with both beef and dairy cattle. Advanced students may work for higher degrees, but there are only limited opportunities for independent investigators.

Various projects related to animal climatology are under way within the university, and in co-operation with the United States Department of Agriculture at Beltsville, Maryland. Graduate studies in bio-climatology may be pursued within the biological sciences group of the university, and, after completion of the necessary basic courses, advanced students may concentrate upon the specialized aspects of animal climatology or physiological climatology. Work may be taken leading to the master's degree or the degree of Doctor of Philosophy, and opportunities for special work for advanced non-degree students may be arranged.

The Departments of Dairy Husbandry and Agricultural Engineering, respectively, give particular attention to animal climatology studies. Special equipment includes two 6-cow chambers, and small chambers for laboratory animals, with facilities for controlling temperature, humidity, air movement and radiation, and for measuring metabolic processes, especially heat production. Advanced students may be accepted for the master's and doctor's degrees. Visiting workers seeking special experience may arrange for this without taking work leading to a degree.
The Department of Animal Science is particularly concerned with projects in animal climatology and facilities include a large, controlled environment room with air conditioned scales and entrance locker room attached, a respiratory chamber for indirect calorimetry, and two pneumatic chambers for respiration work on calves, sheep or swine. Advanced students may be accepted as candidates for the master’s or doctor’s degree, and post-doctorate students may work on problems of their own selection provided they fit in with the general type of research that the Department is best able to conduct.

The Department of Dairying is the one primarily concerned with studies of animal climatology and, in addition to work at the university, studies are also carried out at the New Iberia Livestock Station, Jeanerette, and the North Louisiana Hill Farm Experiment Station, Homer, Louisiana. Heat tolerance studies are being conducted with various types of dairy cattle of the European breeds and with crosses of these breeds with the Sindhi. Students may be accepted for graduate training leading to the Master of Science or the Doctor of Philosophy degrees and arrangements may be made for special work by persons not wishing to take a degree.

The Department of Animal Industry is the one primarily concerned with studies of animal climatology and the effects of various environmental factors on livestock are being studied. Advance studies may be taken leading to the master and doctor degrees. The available equipment includes two 2-cow chambers with equipment for maintaining and measuring temperature, humidity and light.
University of California  
(Davis, California)

The Departments of Animal Husbandry, Poultry Husbandry and Agricultural Engineering, respectively, are concerned with research on animal climatology. Facilities for large animals include an animal psychometric chamber and there is also a small chamber for laboratory animals. In addition to facilities at Davis, field facilities are available at the Imperial Valley Station near El Centro and at the San Joaquin Experimental Range, East of Madera, California. For poultry there is one climatic chamber for controlling temperatures and several projects are under way dealing with reactions of poultry to climatic and other environmental circumstances. Arrangements may be made for graduate work leading to the Master of Science and Doctor of Philosophy degrees.

FAO has given attention to this problem of animal climatology not only through the organization of discussions in meetings such as those held in Turrialba, Baurú and Buenos Aires, but also through the issuing of publications for the use of leaders in this field. These publications have included one dealing with the over-all problems of breeding livestock adapted to unfavorable environments (Phillips, 1948), and one describing the zebu cattle of India and Pakistan, these breeds being particularly adapted to hot climates (Joshi and Phillips, 1953). Also, a manual of field methods for the study of heat tolerance of domestic animals has been issued (Lee, 1953), which is intended primarily to show how the available techniques may be applied under field conditions where, often, good laboratory facilities are not available in the vicinity. Such publications are of restricted usefulness to a country, however, unless there is at least one person in that country who is well trained in the scientific principles involved in animal climatology and who can give guidance in the planning and interpretation of studies carried out under local conditions. Governments wishing to undertake work in this field, and who do not already have available trained workers to lead such work, should give consideration either to the selection of promising young men for training or to the selection of professionally trained workers who may be given special training. At the same time, facilities already available in countries should be fully utilized, for it is often possible to carry out important work in this field even with limited facilities and personnel.
Current research tends to attach greater importance to evaporation of water from the skin in the heat regulation of mammals than was formerly given, but at the same time to suggest that the difference in heat tolerance between one animal and another is due rather to differences in heat formation than to differences in ability to lose heat. If this is true, the efficiency of an animal in converting food energy into useful products becomes doubly important in hot countries: first, it means that the more efficient animal forms less heat, and is, therefore, less bothered in hot climates by a given amount of product; and second, that the more efficient animal consumes less food for the given amount of product. This would mean that the search for the efficient animal would be doubly rewarding, in that it would give an animal which is not only more heat tolerant, but also more economic under all conditions. The proof of this point will require much more elaborate research than has hitherto been conducted, and the problem of readily recognizing the efficient animal will still remain. In this respect, however, nutritional and climatic research would have a common goal.

The view expressed in the preceding paragraph gains some support from the work under way at Beltsville, Maryland, U. S. A., where workers had been unable to satisfy themselves that the animal with better heat tolerance owes that tolerance to better facilities for losing heat to environment. First generation Sindhi-Jersey crossbred cows are distinctly more tolerant to heat than their Jersey dams, but they do not have any greater proportion of surface area to mass (McDowell, Lee and Fohrman, 1953), or more rapid evaporation of water from the skin (McDowell, Lee and Fohrman, 1954), or greater evaporation through respiratory activity (McDowell, Lee, Fohrman and Andersen, 1953). The investigators were being driven to the belief that the more tolerant animals owe their superiority to a lower rate of heat production. If this is true, that is, if two groups of animals kept under identical circumstances and producing the same amount of milk show consistent differences in heat production, it can only mean that one group is using its food energy more efficiently than the other. This suggests that, in the present state of our knowledge, it would be unwise to attempt to select animals for hot conditions on the basis of morphological characters, but rather that more emphasis should be placed upon selecting those animals which show smaller rises of temperature when exposed as heifers or dry cows to hot conditions, show less urge to seek shade or stop eating on hot days, or show a greater conversion ratio of fodder to milk when studied in the test barn.
The work at Beltsville, to which reference is made on p. 10, is part of a program being carried out by the Dairy Husbandry Research Branch of the U. S. Department of Agriculture at Beltsville, Maryland, in collaboration with agricultural experimental stations of several southern states. It is a seven-point program of studies on the adaptability of dairy cattle to hot conditions:

(a) determination of "normal" values for rectal temperature, pulse rate, respiration rate, etc.;
(b) measurement of climatic conditions to which animals are exposed in different areas;
(c) systematic study of the reactions of various breeds and crosses, at different ages and stages of lactation, to a fixed hot atmosphere;
(d) investigation of the characteristics which make one animal more tolerant than another;
(e) elaboration of methods for study of animals in the field;
(f) conduct of field studies; and
(g) systematic study of the relative influence of various climatic factors, such as humidity, temperature, radiation, air movement, etc., upon animal reaction.

In addition to the facilities at Beltsville and several state experimental stations, those at the U. S. Department of Agriculture Iberia Livestock Farm at Jeanerette, Louisiana, are also being used.

Work is also under way at several places in the United States of America on other aspects of animal climatology, including studies in which dairy cattle, beef cattle, sheep and swine are utilized. Some of the results are summarized briefly below.

Most of the work on hogs at the California Agricultural Experiment Station has been concentrated in the optimum to high temperature range (Heitman, Kelly and Bond, 1954). Hogs below 140 lb. liveweight were found to use feed more efficiently at temperatures around 75°F. (24°C.) while those above 140 lb. grew more efficiently near 60°F. (16°C.). The rate of growth fell off rapidly as temperatures increased above the optimum.

Work in California with artificial shades for beef cattle and hogs (Ittener, Bond and Kelly, 1954) indicates that the summer sun may raise the effective temperature around the animal very considerably, with retardation of growth and inefficient use of feed. Shades, free air movement, and cooling of drinking water are valuable in protecting animals from solar heat and high air temperatures.

Tests in the Missouri Agricultural Experiment Station’s laboratory indicate significant reductions in the milk production of dairy cows at temperatures above 85°F. (29°C.), with wide varia-
tions in the heat tolerance between animals of the same breed as well as between breeds (Worstell and Brody, 1953). Work now in progress there concerns the influence of climatic factors on the growth of calves. When the temperature was cycled each day between 70°F and 100°F. (22°C and 27°C.) the milk production declined 8 percent in Jerseys and 20 percent in Holsteins. It is believed that the stressful effects of high diurnal temperatures depend not only upon the range of temperature but also on the number of hours spent under the hotter and colder conditions respectively.

The Missouri Station also has some evidence that the development of lighter hair color observed in animals kept in high environmental temperatures is due to depressed thyroid activity; but more significant than change in color with changing temperatures is change in the texture of the coat (Brody et al., 1954). As the temperature rises the coarse, shaggy hair is replaced by fine glossy hair that may be more reflective to solar radiation.

Investigators in Louisiana have concluded that, on the average, there is a 2.14 lb. decrease in the daily yield of fat-corrected milk for each 1°F. (1°C.) rise in body temperature above normal (Branton, Johnston and Miller, 1953). They recommend selecting cows whose body temperature rises least on hot days.

At the North Carolina Agricultural Experiment Station (Casady, Myers and Legates, 1953) impaired spermatogenesis was found when bulls were exposed to temperatures of approximately 100°F. (37°C.) for two weeks, or 86°F. (30°C.) for five weeks. The semen of some bulls did not return to normal for several weeks after the temperature had been reduced. Temperature also affected the fertility of rams. Rams kept in a room at 45°F to 48°F. (7°C to 9°C.) from May until the breeding time in August settled 64 percent of the ewes, while only 26 percent were settled by a corresponding group of rams exposed to higher summer temperatures (Dutt and Simpson, 1954).

Other studies relating to the effect of temperatures on fertility in rams have been carried out at the agricultural experiment stations in Kentucky and Wisconsin. The Kentucky workers (Dutt and Simpson, 1954) kept rams in an air-conditioned room at 45°F to 48°F. during the summer months and compared them with control rams kept at ordinary temperatures. Fertilization rates were 64.2 and 26 percent respectively for the cooled and control rams, and lambing percentages were 50 and 14.3 percent respectively. The Wisconsin workers (Hulet, El Sheikh, Pope and Casida, 1954) compared rams which had been sheared in April with rams that were re-sheared at monthly intervals until breeding was completed. Fertilization rate was significantly higher in the rams which had been re-sheared at monthly intervals. These studies, aimed at increasing the fertility of rams during the early portion of the
breeding season in areas where temperatures are still high at that time, follow the initial work carried out at the Missouri Station on the thermo-regulatory function and mechanism of the scrotum (Phillips and McKenzie, 1934). Similar beneficial effects of cooling on dairy bulls have been found by Patrick, et al. (1954).

**Effects of High Altitudes**

It is only in the lower latitudes that animals can be maintained at really high altitudes, since the heavy snow cover at higher latitudes restricts pasturage to quite low levels in winter, and permits grazing at only intermediate levels in summer. The problem of year-round maintenance of livestock at really high altitudes in the Americas is, therefore, a peculiarly South American problem, the solution of which must be sought at the instigation of countries whose borders include high Andean regions. The Andean scene presents a number of stresses to newly introduced domestic animals, the effects of which are hard to disentangle. Low oxygen tension, cold, rugged terrain and poor pasturage occur together, although in varying proportions. Lack of oxygen tends to reduce the efficiency of all bodily processes in animals not especially adapted to it and so tends to restrict growth and productivity as well as to interfere with reproduction. The burden put upon the circulation by the high concentration of red blood cells may result in specific disturbances, such as edema of dependent parts ("brisket disease"). Sterility is frequently attributed to the same cause. Cold increases the food requirements of the animal, while restricting the growth of forage, thereby putting the animal in a difficult position. In order to acquire sufficient protection against the cold the animal must either grow a thick coat, lay down subcutaneous fat, or keep up a high rate of heat formation. All these processes make heavy demands upon nutrition. It is probable also that only certain types have the genetic potential for adequate response.

Delegates to the Baurú meeting, recognizing the importance of giving attention to this complex problem, recommended that, in view of the special problems encountered in the production of livestock in high altitudes such as are found in Andean countries, also because of the special types of livestock such as llamas, alpacas and vicuñas, which are important in certain areas of high altitude, governments in the Andean region should consider the setting up of a center for high altitude livestock and/or the development of co-operative programs aimed at utilizing all the facilities available in the several countries, and the Food and Agriculture Organization of the United Nations should be requested by the governments concerned to assist in planning and implementing this proposal.

Further attention was given at the Buenos Aires meeting to
the possibility of a co-ordinated approach to this problem, based on information the FAO staff had been able to assemble through personal communications from workers in the Andean region and from publications (Cook and Pace, 1952; Instituto Nacional de Biología Andina, 1949; Keys, 1936; Koff, 1954; Monge and Hurtado 1947; and Moore and Price, 1948). The need for more extensive and better organized studies of the problems of animal production at high altitudes in the Andes was recognized, and it was recommended that governments in that region should form small national committees to review the present state of the problem, advise their governments on measures necessary for the improvement of production, and indicate the types of assistance that might be needed from outside each country in dealing with the problem. A working group for inter-country consultation was also suggested. These suggestions were aimed at improving the present position in which only limited research projects have been undertaken (and these mostly on a personal basis); there is little intercommunication among workers, and no over-all systematic plan of approach has been made. Insufficient use is being made of the information obtained and techniques developed in studies of the effects of altitude upon man. It is not possible at this stage to say what may be the relative importance of low oxygen tension, cold, and poor nutrition in producing the observed effects. The position appears to warrant systematic study by modern research methods, with utilization and probable extension of all the facilities that now exist.

The problem is recognized in Colombia, where attention has been given to the description of high altitude disturbances in livestock, together with a critical consideration of the pathology and experimental treatment. The clinical picture is often confused by inter-current events. An animal may show no symptoms of altitude sickness as long as it is healthy and not subjected to a heavy work load or pregnancy, but fail quite rapidly when disease, malnutrition, pregnancy, or heavy work intervenes. In such cases treatment of the precipitating factor may result in relief of the condition, but the animal is still close to its maximum tolerance of altitude, and will be likely to fail at any time when an additional stress is imposed. Subcutaneous administration of oxygen was found in many instances to bring about relief of both cardiac and local disturbances where there was no serious complicating factor such as infection. Administration of iron, cobalt and copper together had some effect, especially in newly introduced animals. It has been recommended that newly introduced animals be spared any additional stress, such as pregnancy, during the first 12 months.

In Peru the problem has also been recognized by some workers as one of great importance to the agricultural economy of that
country. In the course of the well known studies carried out by Monge and Hurtado (1947) on human effects, numerous small animals have been subjected to investigation and attempts are now being made to extend this work to larger animals. There is a government farm for alpacas at La Raya, and it is hoped to utilize facilities made available by the Institute of Andean Biology at Huancayo for studies on sheep.

In Argentina, some attention is being given to the improvement of sheep in the northwestern portion of the country by crossing the local ewes with Merino rams. The native animals yield only small amounts of wool (1.74 lb.) with short fibers of uneven quality. A plan of improvement by the use of Merino rams has been put into operation, since these animals have shown themselves more adaptable to the conditions than any other pure breed. The results to date indicate that:

(a) in the northwestern regions, which are hilly or mountainous and subject to dry periods, introduction of Merino strains is desirable for the improvement of wool and meat characteristics, especially as that breed resembles most closely the local stock;
(b) the Merino adapts itself very well at 5,000 ft., and recovers its fertility after five months;
(c) the crossbred progeny are strong and healthy;
(d) this method cannot be used at very high altitudes or on very poor pastures, since the reproductive ability of the purebred animals is greatly reduced;
(e) certain basic difficulties in management, largely attributable to long established customs, need to be rectified.

There is a danger of disturbing the biological adaptation of animals maintained for a long time under difficult conditions, when attempts are made to improve them by crossing with breeds not adapted to those conditions, especially since increased production invariably calls for increased feeding. The genetic potentialities, food supply, and management must be improved simultaneously in a balanced fashion.

In Peru, two methods of combatting lamb loss have been used. The first is to mark those ewes whose offspring die and to discard any one which loses two lambs in succession. The other is to rotate the lambing corrals, so that organisms responsible for infection of the newborn do not become endemically established.

Adaptability of Breeds to Unfavorable Environments

This subject received consideration in both the Turrialba and Baurú meetings, where information was presented on a number
of types of livestock which had been developed in various countries or introduced in pure form for use in a country (Phillips, 1950 and 1953). Some additional information was made available at the Buenos Aires meeting.

In Colombia, the Blanco Orejinegro breed of cattle appears to have a wide range of adaptability, varying from the tropical lowlands to the cold mountain regions at altitudes of as much as 7,877 ft. It is also reported to have a high resistance to parasites such as Dermatobia ("nuche" or "torsola"). It has been suggested that this breed should be developed for use in the "coffee zone" of Colombia, where other types cannot be maintained successfully because of heavy parasite infestation and where there is a shortage of milk and a high infant mortality.

In Panama, estimates have been made of the relative acceptability of different breeds under the conditions prevailing in that country. Of milking cattle, Jerseys imported from Jamaica proved most acceptable, and Brown Swiss next. Holsteins, by contrast, did not maintain production unless one quarter of criollo type was introduced by crossing. Aberdeen Angus and Hereford cattle, introduced from the United States of America, failed to maintain their condition. Among swine, Duroc and Hampshire breeds have proved acceptable, but of the two the Hampshire is the more acceptable because the ears are less apt to catch on wire and other obstructions, and it yields a greater percentage of meat. Improved strains require greater care than native types, however, and this is sometimes a limiting factor in the amount of improvement that can be effected. In fact, the subject which probably calls for greatest consideration in the immediate future is the determination of the suitability of pure strains and their crosses for the various levels of management which prevail.

The situation in Panama may be considered typical of that generally prevailing. Attempts made by the FAO staff to collect information from all available sources have made it quite evident that our present knowledge is very incomplete, and that a systematic study of the heat tolerance of the various breeds of livestock in various parts of the tropics and sub-tropics is badly needed. It is quite important that such studies be conducted upon a reasonably uniform basis, so that fair comparisons can be made of the reactions of different breeds under similar circumstances, and of the same breeds under different circumstances. It is also important that the information be made generally available as rapidly as possible. Only as the results of such a systematic survey become available will breeders be able to select foundation stock with confidence that the ecological demands will be met.
Zoological and Ecological Maps

The Baurú meeting heard a report on the preparation of a zootechnical map in Argentina, which at that time was only partially completed. There was much interest among the delegates and they recommended the making, as expeditiously as possible, of zootechnical and ecological maps showing the current distribution of types and breeds of cattle, and of environmental conditions.

Draft maps have now been prepared in Argentina, one showing subdivisions into ecological zones (Parodi, 1947), and another based on the prevailing climatic conditions and vegetation and related to the carrying capacity for various classes of livestock. Attention is being given by the National Meteorological Institute to classifying the climatic conditions in such a way that correlations may be established between the various climatic factors and the responses, such as growth, wool weight, milk production, etc., of animals maintained in different parts of the country. It is hoped by these means to help producers in deciding what types of animals should be maintained, and the most suitable times at which to carry out certain phases of their management programs.

A small scale reproduction of one of these maps is shown in Figure 1. It illustrates the zones currently used for various types of cattle production.

A series of maps has been produced in Paraguay indicating the distribution of important climatic and geographic factors, for comparison with other maps showing the present distribution of agricultural production. Paraguay is divided into two areas which are completely different in soils, climate and vegetation. The region to the east of the Paraguay river has rich pastures, while that to the west carries many inedible species. Each region is divisible into three types of country: lowlands, dry highlands and plateaux. The vegetation and other conditions affect animal welfare. Now that the distribution of these conditions has been mapped, it remains to determine the extent to which they affect the carrying capacity of the land and the most profitable form of land use. Cattle now contribute only 13.4 percent of the national income, but this could probably be increased by 50 percent, especially if some way were found of utilizing the northwestern portion of the country to greater advantage. One of the great difficulties in the southern regions is the great amount of surface water, which makes for coarse grass and dense vegetation, as well as promoting swarms of insects. The maps referred to in this paragraph have been prepared in connection with a reconnaissance soil and land classification of Paraguay (Tirado-Sulsóna, Hammon and Ramírez, 1952). A further map, outlining the major types of production areas in Paraguay is shown in Figure 2.
Figure 1. Map showing the major types of areas for cattle production in Argentina:
A. Breeding zone; B. Fattening zone; C. Marginal fattening zone; D. Dairy area; E. Marginal livestock area; F. Northern breeding zone; G. Marginal breeding zone; H. Marginal dairy area; I. Sub-tropical livestock - principal zone of crossing with zebu, criollo and hybrids; J. Breeding zone (north sub-Andean); K. Breeding zone (south sub-Andean); L. Agricultural zone - eventual sub-tropical livestock area; M. Breeding zone of the “Litoral” area; N. Zone of breeding and slow fattening (Courtesy of the Government of Argentina).
These maps are cited as examples of the products of studies which have been initiated in two countries. Their makers would not claim that they provide a fully adequate basis for determining the best type of livestock and livestock management practices to recommend in each portion of the areas covered. However, they represent important contributions, and should provide a useful example for work in other countries.

Figure 2. Map showing the major types of animal production areas in Paraguay (Courtesy Government of Paraguay).

Attention is still needed to the question of the criteria to be used in preparing maps for use in planning for the improvement of animal production. Information that would be most desirable for heat tolerance studies would be the distribution of temperature, vapor pressure and radiative conditions, preferably with indications of the range of variations to be expected. Mapping one factor which may affect livestock production is a relatively simple matter
once the data are available for an adequate number of points in the area to be mapped. However, the preparation of a single map or a group of maps small enough in number to be useful in judging the combined effects of the several important factors which affect livestock production is far from a simple task. It is worthy of considerable attention, and it is the type of project in which the meteorologist, the physiologist and the animal husbandman should join forces.

**Literature Cited Regarding Animal Climatology**


**Instituto Nacional de Biología Andina, El estudio de la biología de las grandes alturas en las regiones andinas del Perú, Facultad de Medicina de Lima, 1949.**


PHILLIPS, RALPH W. Breeding Livestock Adapted to Unfavorable Environments. FAO Agricultural Study No. 1, 1948, Food and Agriculture Organization of the United Nations, Rome, Italy.


Herdbooks and Performance Tests

General Problems

The organization of herdbooks and the safeguarding of interests of breeders has been discussed at various international congresses and meetings. As a result of such discussions an international
convention for the standardization of methods of keeping and operating herdbooks was signed in Rome under the auspices of the former International Institute of Agriculture in 1936. This convention was signed by 20 governments among which were those of Brazil, Guatemala, Nicaragua, Paraguay and the United States of America in the Western Hemisphere. It was ratified by ten governments, including the Government of Brazil, and the Government of Colombia also notified its adherence to the convention, which entered into force. One stipulation of this convention provides for consultation among experts of the governments adhering to it after five years of its entering into force. Since the war prevented the timely convening of such a meeting, this took place only in 1947 and was convened by FAO in Rome, FAO having become the custodian of this and other conventions prepared under the auspices of the former Institute. At this meeting, in which only European countries were represented, it was stated that the aims envisaged in this convention were of primary interest to all countries in which frequent exchange of breeding stock occurred, but that it had been found that the original convention was out-of-date in certain respects and should be amended in order to make it more effective. In this connection, the experts present at this meeting stressed the importance of standardizing the methods of milk-butterfat recording, since, without this, a comparison of the data indicated in the different herdbooks relative to the yields of cows was impossible. They felt, furthermore, that if uniformity in measuring productivity in dairy and dual-purpose cattle could be brought about, within the limitations of the management practices of the various countries, improvement programs might be carried out more effectively. They stated that this would facilitate considerably the selection, distribution and maximum use of efficient breeding stock, including the exchange of breeding stock among the countries. The meeting recommended, therefore, that FAO should endeavor to bring about an agreement on the standardization of milk-butterfat recording methods. After careful preparations, a standardized scheme was worked out, suitable for European conditions, and representatives of European national organizations responsible for milk-butterfat recording were invited to consider and eventually adopt the proposed scheme. This meeting took place in Rome in March 1951 and after minor modifications, the proposed scheme was unanimously adopted by the representatives of such national milk-butterfat recording organizations as were interested then in it. Since then, more organizations have adhered to the agreement and, at present, this scheme is in operation in 12 countries. Further steps are now being taken which may eventually make it feasible to revise the convention on methods of keeping and operating herdbooks, signed in 1936,
including the collection by FAO, in co-operation with the European Association for Animal Production (EAAP), of material on the methods used in the keeping and operating herdbooks for cattle in the various European countries. The outcome of this work will be of much interest to countries in the Americas, particularly those which are parties to the convention.

At the Turrialba meeting it was recognized that national or area-wide improvement in the productive capacity of any type of livestock will, in most cases, be based on males produced from a very small percentage of the livestock population and in relatively few flocks or herds, maintained either by private breeders or government-owned studs. Granting this, it must be recognized that any improvement which may be possible in the producing capacity of commercial stock is in the long run dependent upon continued genetic improvement in the stud stock. At the Baurú meeting much interest was shown in the use of imported breeding stock in many countries and the need for safeguarding the interests of breeders in the importing countries was noted. Having regard for the importance of higher genetic quality in the imported animals and the adaptability to living conditions of the types being imported, it was pointed out that governments should take steps to ensure that documents setting forth the origin and qualities of animals to be imported should be examined and approved by appropriate and well qualified authorities in the importing country before shipment is made, and that breeders interested in importing desirable stock should be assisted by the provision of advice on sources, selection and utilization of animals. These statements show clearly a recognition of the need for careful organization of herdbook keeping, which should provide for accurate and reliable information for the use of breeders.

When considering the manner in which herdbook keeping might be improved it must be recalled that herdbooks developed in association with the so-called pure breeds and that the concept of pure breeds is relatively new in the history of the animal industry. Great progress in the formation of purebred cattle had already been achieved before breeders’ associations had been organized. Some of the modern breeds of livestock owe their origin to the work of a few outstanding breeders who were particularly successful in improving their stock over and above that raised by their neighbors. The influence of the work of these breeders upon the existing local type of animals gave such renown to these particular breeds that it was considered advisable to avoid crossing them with cattle of other regions. When the associations which were entrusted with maintaining the purity of breeds were formed, rules were laid down as to which cattle were to be accepted for registration in the herdbooks as being “pure.” The purity did
not refer to the genetic constitution of the animals but simply to their appearance. In this way, for example, all red animals were at once discarded from the first herdbooks in the regions where the original Aberdeen Angus was bred. The new breed began to be pure as far as its black color was concerned, but the gene for red, being recessive in relation to the black, remained unperceived in many of the selected animals. It was intended to produce pure breeds because it was found that in the hands of good breeders they produced better quality stock. The Aberdeen Angus became famous not because of its uniform black color but because, in the hands of some breeders, it produced more meat and was more economical. One way to recognize this useful animal was to give it a distinguishing mark. The color provided such a mark, easy to understand and relatively simple genetically.

The development of the science of genetics based upon Mendel's Law gave great force to the concept of pure breeds. Certainly the particular marks of some of the breeds could be explained by Mendelian genetics. It was shown that the red color was controlled by a gene allelic to the one for black, the latter being dominant to the former in exactly the same way as had been shown to be the case for certain colors in flowers. Although Mendelian genetics helped to explain the particular marks of the breeds, this concept was inadequate to explain hereditability insofar as it concerned quantitative characteristics. The magnitude of this difference in behavior of quantitative characteristics has only recently been fully appreciated. Research has led to the conclusion that the hereditary factors controlling productivity in animals are very numerous (Shrode and Lush, 1947).

The concept of a pure breed assumed that once the basic animals had been found, they should be used exclusively as sires for future generations and so the breed would maintain its purity forever. For some characteristics this concept held good; as regards those features which are of importance economically, it has been shown in practice that it is impossible to maintain a herd pure as far as productive qualities are concerned.

Some degree of homozygosity may be acquired due to animals being kept in restricted groups and by the process of intensification in the use of the offspring of outstanding bulls instead of using bulls chosen at random. Lush (1945) calculates that the mere fact of not introducing new blood into a breed for a hundred years would only entail the loss of barely 10 percent of its heterozygosity. Failure to maintain the standard of purity in the herdbook, registration errors and mutations would almost destroy this progress in genetic purity. The increase in homozygosity depends upon the extent to which breeders utilize certain preferential blood. In this respect, no observed breed has ever acquired greater purity
than the Shorthorn at the time of the Collins brothers who intensi-
fied the use of a single bull and his offspring (Favourite). Yet
in spite of this, from the formation of the breed up to 1920 the
Shorthorn had barely lost 30 percent of its heterzygosity.

Upon the formation of breeders’ associations for “pure” breeds,
a new term was employed, i.e. “registered” cattle. The term
simply refers to cattle which, having met certain requirements,
are entered in the herdbooks of the association. Were the animal
admitted solely upon visual inspection, the concept of “registered”
as a synonym for “pure” partakes of the error of believing that
the inspection of an animal and its admittance to the herdbook
in some way guarantees the manner in which it is going to reproduce.
The error grows when the associations close their books to outside
blood and only register the offspring of animals whose progenitors
appear in the herdbook. The variability or the impurity of the
animals which were registered in the first place being recognized,
accepting the registration of all their offspring is tantamount to
allowing haphazard reproduction of those animals which may
constitute the lowest grade within that breed; that is to say that
animals, which barely deserve to be admitted upon the basis of
inspection, have the same chance to be sires of registered stock
as the most outstanding specimens of the breed. The future
improvement of the breed is left to the breeders’ discretion. This
slight guarantee given by the term “registered” as far as it con-
cerns productivity, has given rise to attempts to establish “merit
books” within the general herdbooks, thus taking account of the
need to recognize qualities superior to those implied within the
concept of registration.

As regards breeds or associations where the inspection of any
animal previous to its registration in the books is maintained, it
is assumed that an official organization exists in order to eliminate
constantly from the nucleus of the race the “tails” or lower speci-
mens of the breed. This is true of nearly all European register
associations and in South America, the most notable example of
inspection previous to registration may be found in Brazil with
the zebu breeds.

The danger of registering through inspection lies in the use of
an excessively uniform selective standard. Uniformity may be
desirable in a breed but it may be carried too far. Even assum-
ing that the inspectors are highly efficient or that they judge by
breed standards accepted by a majority, it does not follow that
they are accurate in their judgment of what is most desirable.
Some breeders working towards different goals may in time prove
that their ideas are the best. For example, in nearly all the
dairy cattle associations, a wide, short head is preferred. However,
statistical evidence indicates the existence of a correlation between
a long head and high production. An independent breeder working against the majority may eventually render some service to the breed.

The worst mistake in registering through inspection lies perhaps in stressing small points while overlooking completely the productive or reproductive qualities of the animal. This appraisal remains, naturally, in the hands of the breeder. A conflict between inspection and the breeders' appraisal will be inevitable in the case of animals that, having won prizes in cattle shows and being admired by the breeders' associations in accord with their standards of excellence, have proved to be mediocre sires. The breeder, therefore, continues to be the keystone of breeding programs for improvement in any system of registration which may be adopted.

Another disadvantage of the system of registration through inspection is its cost, which may be so high that it can only be maintained with government subsidies. Although most of the long established herdbooks are now closed, many herdbook associations admitted grade animals in their books at the outset, and some of the new breeds (such as Santa Gertrudis) admit in their herdbooks high grade animals. There is much to be said in favor of such a system if production and excellency standards are adopted for the acceptance of grade animals. This method may be useful to introduce desirable genes into a breed. This is especially important when adapting a breed to surroundings different from the original ones.

The method of including in a herdbook all the offspring of animals already registered, but establishing special herdbooks for superior animals, has great advantages. It does not impose any restrictions upon the breeder in his selection methods. It does not discriminate directly against inferior animals, but it implicitly recognizes that they do not qualify for the merit herdbook. It does not imply a reduction in the profits of the breeders' association by reducing the number of qualified animals. This is an important point. The financial solvency of herdbook societies is usually based on the fees for entering animals.

Those responsible for these merit herdbooks in the Western Hemisphere generally have not made great efforts to determine if an animal is a good transmitter of its qualities. Some countries in Europe have made progress (Lush and Gilliard, 1955), especially Denmark (Helger, 1954). Central testing stations are established there to investigate the progeny of different bulls, under uniform management and feeding conditions.

There are certain other problems in connection with the establishment of herdbooks since, with the exception of countries such as Argentina, Canada, Uruguay, the United States of America and a few others in the Western Hemisphere, the numbers of ani-
mals to be registered in any one country are so small that it is difficult to support breed associations on registration fees alone. This problem might be overcome in small countries by the establishment of a central registry system which would provide facilities for the registration of animals of several different breeds. Another problem arises from the fact that many areas in Latin America have climatic conditions which impose limitations on livestock production. Thus, the importation of pure breeds from temperate zones, where good conditions of climate and feeding exist, may lead to the establishment of herdbooks for these breeds and emphasis on types not well adapted to local conditions. Therefore, consideration needs to be given to the kind of registration systems which are best suited to the promotion of breeds adapted to difficult environmental conditions, such as those encountered in the tropics and sub-tropics. This would involve the recognition of some measures of merit through which both production characters and those reflecting adaptability to environmental conditions might be recorded. Thus, the mistake of simply adopting herdbook systems used in other areas without considering how they should be best adapted to serve conditions in such areas should be avoided.

In relation to the last point in the preceding paragraph, and recognizing that types which have been developed in particular environments may make important contributions to livestock improvement in those or similar areas even though they are not generally recognized as important breeds, the FAO staff are preparing a catalog of cattle stocks originating in the Americas. This should provide the basis for a publication similar to the one already issued on the zebu cattle of India and Pakistan (Joshi and Phillips, 1953), and one which is in preparation describing the important types of cattle originating in Africa. It is intended to make available to governments information on the conditions under which these American breeds or types originated, and the physical characteristics and performance of those types in their native areas and in other areas if they have been exported.

Recent Developments in Various Countries

In preparation for the Buenos Aires meeting, governments were requested to submit information on the nature and extent of the herdbook and performance testing activities in their countries, particularly with regard to cattle. Much current information was brought together as a result, including some on livestock species other than cattle. It was prepared in somewhat different forms by various countries; it is not comparable in all respects from country to country, and no data are available for many countries. However, it is sufficient to give a good indication of
the present position in those countries which have established reg-
istration systems, and the information from Argentina, Canada,
Chile, El Salvador, the United Kingdom (for Jamaica) and the
United States of America is summarized below.

In Argentina, herdbooks are managed by a leading breeders' asso-
ciation – the Argentine Rural Society – which handles the
herdbooks for nearly all breeds and types. Only studbooks for
purebred racehorses and horses of the Arab breed are managed
by a specialized official department, while the registration of poultry
and rabbits is handled by a department of the Ministry of Agri-
culture and Livestock.

In 1954, the Government passed a law setting up government
control of herdbooks, which is to be applied as soon as rules have
been formulated. A feature of the Argentine herdbooks is that
the majority have no provision for admitting new blood, only the
offspring of purebred stock being eligible for registration. There
are a few new open herdbooks in three parts, i.e., basic regis-
trations; first, second and third preliminary registrations; and final
registrations for certain breeds already established and whose en-
largement on the basis of pedigree is about to be terminated. This
is the case, for example, with the "criollo" breed of horses. Also,
some experimental approaches are being made with several herd-
books, some of which have been definitely established. Among
the latter are to be found herdbooks for the Anglo-Argentine horse,
the Argentine Santa Gertrudis cattle and the breed of goats which
is to be designated as "Argentine" or "National." However,
the tendency is to utilize the so-called closed herdbook.

The Association of "Holando" Argentina Breeders, under
official supervision, has established a herdbook for "half-pedigree"
cattle (referred to as "purebred by cross") which will permit,
after selection, preliminary registration after inspection and appro-
val of the type, and upon the basis of a fixed minimum milk pro-
duction. The offspring of those animals registered in the prepara-
tory herdbooks, upon approval of type and meeting the minimum
milk production, will be registered in the final herdbook. These
herdbooks are being established with the object of improving and
standardizing type and increasing milk output. The existence
of this herdbook does not mean that those animals registered would
be considered as purebred. They remain as "purebred by cross," but
after five generations, the offspring may be recorded automa-
tically as "purebred by cross."

As regards beef cattle yield trials, work in Argentina has been
limited to that carried out with purebred herds. With a precise
knowledge of the different forages fed to the cattle over a fixed
period and the relative weight increase, the results obtained have
allowed for an assessment of the importance of selection of sires
which transmit their digestive capacity or efficiency of feed utilization to their offspring.

The numbers of animals registered in various herdbooks for cattle in Argentina since those herdbooks were established until 31 December 1954 are shown in Table 1. It will be noted that the breeds for which the largest numbers of animals have been registered are the Shorthorn, Aberdeen Angus and Hereford. For these three breeds, the numbers registered from 30 June 1953 to 30 June 1954 were 19,000, 24,000 and 12,000, respectively.

### Table 1: Numbers of Cattle Registered in Various Herdbooks in Argentina Since Those Herdbooks Were Established to 31 December 1954

<table>
<thead>
<tr>
<th>Breed</th>
<th>Year Herdbook Founded</th>
<th>Total Numbers Registered since Founding of Herdbook</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Males</td>
</tr>
<tr>
<td>Shorthorn</td>
<td>1888</td>
<td>385,609</td>
</tr>
<tr>
<td>Polled Shorthorn</td>
<td>1909</td>
<td>360</td>
</tr>
<tr>
<td>Aberdeen Angus</td>
<td>1901</td>
<td>162,967</td>
</tr>
<tr>
<td>Hereford</td>
<td>1889</td>
<td>121,554</td>
</tr>
<tr>
<td>Polled Hereford</td>
<td>1944</td>
<td>3,634</td>
</tr>
<tr>
<td>Holstein-Friesian</td>
<td>1920</td>
<td>28,719</td>
</tr>
<tr>
<td>Brahman</td>
<td>1920</td>
<td>149</td>
</tr>
<tr>
<td>Dexter</td>
<td>1920</td>
<td>114</td>
</tr>
<tr>
<td>Flemish</td>
<td>1920</td>
<td>1,640</td>
</tr>
<tr>
<td>Galloway</td>
<td>1920</td>
<td>127</td>
</tr>
<tr>
<td>Jersey</td>
<td>1920</td>
<td>736</td>
</tr>
<tr>
<td>Normandy</td>
<td>1920</td>
<td>1,199</td>
</tr>
<tr>
<td>Red Polled</td>
<td>1920</td>
<td>2,505</td>
</tr>
<tr>
<td>Brown Swiss</td>
<td>1920</td>
<td>873</td>
</tr>
<tr>
<td>West Highland</td>
<td>1920</td>
<td>147</td>
</tr>
</tbody>
</table>

In Canada, livestock is registered and herdbooks subsequently published under the authority of an Act of the Government of Canada respecting the incorporation of purebred livestock record associations. The Act is commonly cited as the Livestock Pedigree Act 1949. The Act provides the authority for a purebred association or recording association to become incorporated and protects such bodies from competing associations of the same breed or species. Each association incorporated under the Act has complete freedom with respect to the constitution and bylaws but the initial constitution must be approved by the Department of Agriculture and all amendments to the constitution must be likewise approved. Approval of constitutions and amendments thereto are not withheld unless they are in conflict with the Act under which the associations enjoy their privilege.

The Livestock Pedigree Act also provides for the affiliation of recording associations under the Canadian National Livestock
Records. The affiliation is composed of thirty active associations which combine for the purpose of the processing of certificates of registration and publishing herdbooks. The general policy of the Canadian National Livestock Records is determined by a board composed of representation from each of the affiliated associations from which is elected a records committee operations of the Canadian National Livestock Records. The organization is a non-profit one, and charges for services to affiliated associations are based on actual cost. All associations incorporated under the Act are so affiliated, with the exception of the Canadian Holstein-Friesian Association.

The Canadian National Livestock Records maintains what is termed a General Stud and Herdbook for the registration of animals of those breeds too small in numbers to maintain an active association.

The federal government provides office accommodation and a cash grant of $25,000 annually to the Canadian National Livestock Records as a means of supporting the efforts of the affiliated associations in the cost of registration. Apart from this assistance, no subsidies are provided for the keeping and operation of herdbooks.

The data recorded in the herdbooks include a listing in numerical order of allotted registration numbers, the name of the breeder, the name of the animal, the sex, the names of the sire and dam and the identification (if tattooed or ear-tagged) and in certain instances the color is noted. Animals are registered upon application by the breeder who certifies the parentage, except in the case of Hunter horses where final registration is delayed for three years.

All herdbooks operated under the authority of the Livestock Pedigree Act are closed with the exception of books recording Clydesdale horses and Standard Bred horses. With these breeds registration is possible after four crosses with purebred stallions.

The certificate of registration issued by the Canadian National Livestock Records is a simple birth certificate including two generations of parentage. In the case of the Holstein-Friesian breed, only the sire and dam are recorded in the certificate of registration. Facilities are provided by the Canadian National Livestock Records and the Canadian Holstein-Friesian Association for a more elaborate pedigree for a fee based on cost. The Canadian Holstein-Friesian Association and the Canadian Ayrshire Breeders' Association require that bulls to be registered must be from dams with the required minimum for inspection as to breed type and milk and butterfat production. All certificates of registration processed by the Canadian National Livestock Records are approved by the
Chief Registration Officer of the Canada Department of Agriculture before they are issued.

The numbers of animals registered in 1953 and the total registration under the Livestock Pedigree Act of 1949 are shown in Table 2.

### Table 2 – Livestock Recording Associations Operating under the Livestock Pedigree Act 1949 in Canada, and Numbers Recorded

<table>
<thead>
<tr>
<th>Association</th>
<th>Registrations 1953</th>
<th>Total Registrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Aberdeen-Angus Association</td>
<td>7 329</td>
<td>128 568</td>
</tr>
<tr>
<td>Canadian American-Saddle Horse Breeder's Association</td>
<td>35</td>
<td>619</td>
</tr>
<tr>
<td>Canadian Ayrshire Breeder's Association</td>
<td>12 778</td>
<td>408 849</td>
</tr>
<tr>
<td>Canadian Belgian Horse Association</td>
<td>136</td>
<td>10 941</td>
</tr>
<tr>
<td>Canadian Cattle Breeder's Association</td>
<td>806</td>
<td>36 333</td>
</tr>
<tr>
<td>Canadian Horse Breeders' Association</td>
<td>21</td>
<td>3 568</td>
</tr>
<tr>
<td>National Chincillas Breeders of Canada</td>
<td>8 074</td>
<td>28 848</td>
</tr>
<tr>
<td>Clydesdale Horse Association of Canada</td>
<td>86</td>
<td>94 710</td>
</tr>
<tr>
<td>Canadian French Coach Horse Breeders' Association</td>
<td></td>
<td>158</td>
</tr>
<tr>
<td>Canadian Galloway Association</td>
<td>80</td>
<td>3 618</td>
</tr>
<tr>
<td>Canadian Goat Society</td>
<td>237</td>
<td>5 443</td>
</tr>
<tr>
<td>Canadian Guernsey Breeders' Association</td>
<td>4 169</td>
<td>68 864</td>
</tr>
<tr>
<td>Canadian Hackney Horse Society</td>
<td>54</td>
<td>3 975</td>
</tr>
<tr>
<td>Canadian Hereford Association</td>
<td>33 537</td>
<td>398 647</td>
</tr>
<tr>
<td>Canadian Holstein-Friesian Association</td>
<td>67 650</td>
<td>1 351 200</td>
</tr>
<tr>
<td>Canadian Hunter Society</td>
<td>59</td>
<td>405</td>
</tr>
<tr>
<td>Canadian Jersey Cattle Club</td>
<td>12 715</td>
<td>387 207</td>
</tr>
<tr>
<td>The Canadian Kennel Club</td>
<td>13 905</td>
<td>332 464</td>
</tr>
<tr>
<td>Canadian National Silver Fox Breeders' Association</td>
<td>377</td>
<td>472 806</td>
</tr>
<tr>
<td>Canadian Palomino Horse Association</td>
<td>391</td>
<td>391</td>
</tr>
<tr>
<td>Canadian Percheron Association</td>
<td>144</td>
<td>43 213</td>
</tr>
<tr>
<td>Canadian Pony Society</td>
<td>66</td>
<td>2 320</td>
</tr>
<tr>
<td>Canadian Red Poll Association</td>
<td>315</td>
<td>21 038</td>
</tr>
<tr>
<td>Canadian Sheep Breeders' Association</td>
<td>13 550</td>
<td>537 763</td>
</tr>
<tr>
<td>Canadian Shire Horse Association</td>
<td></td>
<td>3 424</td>
</tr>
<tr>
<td>Canadian Shorthorn Association</td>
<td>20 301</td>
<td>783 053</td>
</tr>
<tr>
<td>Canadian Standard Bred Horse Society</td>
<td>757</td>
<td>12 822</td>
</tr>
<tr>
<td>Canadian Suffolk Horse Society</td>
<td>3</td>
<td>766</td>
</tr>
<tr>
<td>Canadian Swine Breeders' Association</td>
<td>15 019</td>
<td>651 213</td>
</tr>
<tr>
<td>Canadian Thoroughbred Horse Society</td>
<td>488</td>
<td>14 526</td>
</tr>
</tbody>
</table>

**General Stud Herdbook**

<table>
<thead>
<tr>
<th>Horse</th>
<th>Registrations 1953</th>
<th>Total Registrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabian Horse</td>
<td>27</td>
<td>132</td>
</tr>
<tr>
<td>Brown Swiss Cattle</td>
<td>64</td>
<td>3 722</td>
</tr>
<tr>
<td>Devon Cattle</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>German Coach Horse</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>Highland Cattle</td>
<td>48</td>
<td>247</td>
</tr>
<tr>
<td>Jacks and Jennets</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Lincoln Red Shorthorn</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Morgan Horse</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Tennessee Walking Horse</td>
<td></td>
<td>13</td>
</tr>
</tbody>
</table>
In Canada also, there is no federal program for evaluating or appraising the sires of beef-producing breeds. The Province of Ontario conducts a testing program which provides for the feeding out after weaning of the steer and bull progeny of bulls. Four progeny are tested and results are available on feed consumption, rate of gain and carcass quality. Apart from this, the appraisal of bulls of the beef breeds is still in the exploratory stage.

With respect to dairy cattle, the situation is somewhat different. The federal Department of Agriculture for a great many years has provided a service whereby the breeders of purebred dairy cattle may have their herds tested for milk and butterfat production. The objective of this service, which includes a staff of 150 field inspectors, is to provide 12 inspectional visits per year, each visit covering 24 hours when the production and butterfat content of each individual cow in the herd is checked and reported. There are two plans in operation. Plan A is based on the individual weights taken by the herd owners and checked up to 12 times per year by the inspectors, and Plan B under which the herd owner does not record daily production of milk but the individual cow's performance is based on the inspector's weights and butterfat test taken at monthly or near-monthly intervals. The federal Department of Agriculture issues a certificate of production at the end of each lactation and these certificates are accumulative in that to the end of a cow's producing lifetime, her certificate will carry the official record of each of her lactations. A report is published annually, which includes the lactation records of each cow finishing a lactation within the year of publication. The cows' names and registration numbers are listed under their sires.

Most of the provinces of Canada where dairy cattle production is of importance have official services for the recording of dairy cattle production. Their operations are designed primarily for servicing the owners of non-registered herds, but none of the provincial services are at present recognized for the selective registration of cattle. The dairy cattle breed associations, which do not require production performance for registration, use the Record of Performance certification in a variety of ways in the classification of bulls.

There is at the present time no national program for the evaluation of dairy cattle sires although the rapid development of artificial insemination is increasing the advisability of a national service. The province of British Columbia has for many years provided annually information on the performance of bulls based on the Record of Performance service results and the provincial cow testing program results. At present, results are published on all bulls with five or more daughter/dam comparisons. A service is in the process of development within the fabric of
the breed associations to provide information on the performance of bulls used at artificial insemination units. There is increasing evidence to indicate that this service is being used effectively by the units in discarding bulls if not as yet in the procuring of bulls.

In Chile, there are three agricultural societies (National Agricultural Society, Agricultural Society of Temuco, Agricultural Society of Osorno) and one breed association (Association of Magallanes) which have official sanction to maintain herdbooks. Animals are registered according to class and breed, the classification by breeds being subdivided into purebreds, high grades and low grades. The agricultural societies register animals of all classes, while the Breed Association of Magallanes only registers sheep. The number of animals registered by the four organizations in 1954 is shown in Tables 3 to 6.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Purebred</td>
<td>Grade</td>
<td>Purebred</td>
<td>Grade</td>
</tr>
<tr>
<td>Dutch Lowland</td>
<td>1 143</td>
<td>121</td>
<td>1 300</td>
<td>347</td>
</tr>
<tr>
<td>German Lowland</td>
<td>23</td>
<td>473</td>
<td>603</td>
<td>694</td>
</tr>
<tr>
<td>Holstein-Friesian</td>
<td>—</td>
<td>17</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Brown Swiss</td>
<td>—</td>
<td>7</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Norman</td>
<td>68</td>
<td>21</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Simmental</td>
<td>—</td>
<td>—</td>
<td>22</td>
<td>—</td>
</tr>
<tr>
<td>Durham Shorthorn</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Aberdeen Angus</td>
<td>30</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Hereford</td>
<td>10</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1 276</td>
<td>632</td>
<td>1 295</td>
<td>1 041</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Purebred</td>
<td>Grade</td>
<td>Purebred</td>
<td>Grade</td>
</tr>
<tr>
<td>Chilean</td>
<td>1 589</td>
<td>—</td>
<td>154</td>
<td>—</td>
</tr>
<tr>
<td>Thoroughbred</td>
<td>7</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Belgian</td>
<td>16</td>
<td>2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Percheron</td>
<td>30</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Hackney</td>
<td>3</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1 645</td>
<td>2</td>
<td>154</td>
<td>—</td>
</tr>
</tbody>
</table>


The council charged by the Chilean Ministry of Agriculture with the responsibility of administering the registry of livestock consists of the National Director of Agriculture, the Director of the Department of Livestock Production, one representative of each of the three agricultural societies, the Breed Association of Magallanes, the Dutch Lowland Cattle Association and one representative of any new association which might be formed. None of the organizations maintaining herdbooks is subsidized by the Government. The information the breeder must furnish with his application for registry of his animals is essentially the same as that required by most breed associations. The three agricultural societies mentioned on page 33 have immediate control over the cow testing program now in operation in Chile.

---

**TABLE 5 - NUMBERS OF SHEEP AND GOATS OF VARIOUS BREEDS REGISTERED BY CHILEAN AGRICULTURAL AND BREED ASSOCIATIONS IN 1954**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Purebred Grade</td>
<td>Purebred Grade</td>
<td>Purebred Grade</td>
<td></td>
</tr>
<tr>
<td>Hampshire Down</td>
<td>730</td>
<td>46</td>
<td>8</td>
<td>789</td>
</tr>
<tr>
<td>Oxford Down</td>
<td>10</td>
<td>36</td>
<td>7</td>
<td>46</td>
</tr>
<tr>
<td>German Merino</td>
<td>669</td>
<td>69</td>
<td>669</td>
<td>69</td>
</tr>
<tr>
<td>French Merino</td>
<td>619</td>
<td>233</td>
<td>619</td>
<td>233</td>
</tr>
<tr>
<td>Australian Merino</td>
<td>328</td>
<td></td>
<td>18</td>
<td>348</td>
</tr>
<tr>
<td>Corriedale</td>
<td>82</td>
<td></td>
<td>1 446</td>
<td></td>
</tr>
<tr>
<td>Suffolk Down</td>
<td>88</td>
<td>69</td>
<td>48</td>
<td>69</td>
</tr>
<tr>
<td>Ideal</td>
<td>18</td>
<td></td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Isle of France</td>
<td>10</td>
<td></td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Romney Marsh</td>
<td>16</td>
<td></td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>2 544</td>
<td>381</td>
<td>46</td>
<td>4 632</td>
</tr>
</tbody>
</table>

**TABLE 6 - NUMBERS OF PUREBRED HOGS OF VARIOUS BREEDS REGISTERED BY CHILEAN AGRICULTURAL SOCIETIES IN 1954**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Berkshire</td>
<td>304</td>
<td>27</td>
<td>171</td>
<td>582</td>
</tr>
<tr>
<td>Duroc</td>
<td>42</td>
<td></td>
<td>4</td>
<td>42</td>
</tr>
<tr>
<td>German Landrace</td>
<td>70</td>
<td>292</td>
<td>4</td>
<td>366</td>
</tr>
<tr>
<td>German Saddleback</td>
<td>52</td>
<td></td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>496</td>
<td>319</td>
<td>227</td>
<td>1 042</td>
</tr>
</tbody>
</table>
The Government of El Salvador has established a register for the individual production of dairy cows in the Ministry of Agriculture. Data in Table 7 show the progress of this work since February 1953.

**TABLE 7 – INCREASE IN RECORDING OF MILK PRODUCTION IN EL SALVADOR**

<table>
<thead>
<tr>
<th>Time</th>
<th>Number of Herds</th>
<th>Number of Animals</th>
<th>Total (Cows)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pure</td>
<td>Mixed</td>
</tr>
<tr>
<td>February 1953</td>
<td>3</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>January 1955</td>
<td>34</td>
<td>154</td>
<td>286</td>
</tr>
</tbody>
</table>

This recording of the performance of the animals is a part of the Ministry of Agriculture’s program for selecting the better producing females and the males that sire progeny of higher productive capabilities than their dams, and for improving the care of the herds and the quality of the milk. There are three agents, one of whom visits each herd every month to record the weights of milk produced by each cow and to take samples for determining the butterfat content in the laboratory of the dairy section. For every pound of milk produced, 5 cc. are taken for analysis for each cow producing less than 10 lb.; 3 cc. for each pound for those producing 10 to 20 lb.; 2 cc. for those producing 20 to 30 lb. and 1 cc. for those producing 30 lb. or more. Samples of milk are also sent to the laboratory of animal pathology to be tested for brucellosis. Each herd is tested at intervals of three months. These records of milk and butterfat production and brucellosis are assembled in the central dairy office and sent to each dairyman with recommendations for the quantities of concentrated feed each cow should have to maintain and improve her production.

In summarizing the records of practically 1,000 cows from 1 November 1953 to 31 October 1954, 140 purebred cows averaged 25 lb. of milk daily; 241 cows of mixed breeding averaged 14 lb. while 379 criollo cows, fed concentrates, averaged 10½ lb. and 229 criollo cows, without concentrates, averaged 7.8 lb. of milk daily. A study of the average production of all the cows by months shows remarkable uniformity, varying from a minimum of 11.2 lb. in November to a maximum of 13.6 lb. in March, and 13.4 lb. in May and August, with an average of 12.9 lb. for the twelve-month period. The fact that most of the cows received concentrates to supplement pasturage accounts largely for this uniform production. However, it should be noted that the purebreds failed to maintain their production at a uniform level. It dropped from 29 lb. in November 1953 to 21 lb. in September 1954 on account of a 40 percent slump in the production of one herd. The
study of these records emphasizes the vital importance of the best feeding and management in order to obtain high production from purebred cattle. The records show that while cows of mixed breeding produced 2.1 lb. of milk for each pound of concentrate fed, and the criollos 2.5 lb., the purebred cows produced only 1.8 lb. of milk for each pound of concentrates fed. However, as noted above, the average daily production of the purebreds was more than twice that of the criollos. Accordingly, it is considered quite probable in El Salvador that the purebreds were more profitable producers on account of the larger volume of total production even though they produced less in return for the supplemental concentrates fed.

In Jamaica, four herdbooks are maintained; the names of the societies are listed below, together with the numbers of animals registered to date:

<table>
<thead>
<tr>
<th>Name</th>
<th>Animals Registered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamaica Brahman Breeders' Society</td>
<td>Males: 300, Females: 1,630</td>
</tr>
<tr>
<td>Jamaica Black Cattle Breeders' Society</td>
<td>Males: 30, Females: 400</td>
</tr>
<tr>
<td>Jamaica Hope Cattle Breeders' Society</td>
<td>Males: 210, Females: 1,550</td>
</tr>
<tr>
<td>Jamaica Red Cattle Breeders' Society</td>
<td>Males: 220, Females: 1,610</td>
</tr>
</tbody>
</table>

The Department of Agriculture is the responsible authority for each of these herdbooks, and while the records are kept by the secretary of the society concerned, pedigrees and other forms are signed by the secretary and a government officer. There is no direct subsidy of these herdbooks, but government officials carry out appraisals of cattle in connection with provisional registration and milk recording, and do clerical work in connection with herdbook registrations. Data recorded are: date of birth, markings, tattoo and brand number of the animal and the name and herdbook number of the sire and dam. Calves must be registered within 120 days of birth. Declaration of service prior to birth is not required. Operation of the first closed herdbook began in January 1955 for the Jamaica Brahman breed. Other herdbooks are open, and animals are entered in a provisional register pending appraisal by a team of government officials and breeders for three successive years. First appraisals are made at two years of age. If declared eligible, they are included in the final herdbook when it is closed. In the beef breeds, when the visual examination is made, consideration is also given to breeding history, quality of progeny and/or sibs. In the dairy breeds, production is assessed in terms of
milk produced, and while most farmers keep records there is also an official government milk recording scheme in connection with the Jamaica Hope Cattle Breeding Society. Government sponsored bulls, which are issued on loan to dairy farmers and placed at stud centers for use by peasants and for artificial insemination, exercise considerable influence. In 1954, approximately 12,000 calves were born to such services out of an estimated dairy cow population of 55,000.

All purebred animals in the Jamaica Hope breed were produced at the outset on the government farm. All other animals which are registered arise from the use of bulls from this farm, and only animals resulting from four top crosses or more by these bulls can be registered. Five breeding sections are maintained in the government herd to prevent any substantial amount of inbreeding. Since registered animals may be produced from outside stock only by top crossing from bulls produced at the government farm, the latter has become the sire-producing center for the improvement of cattle in the island.

In the United States of America the registration of cattle is in the hands of breed associations which keep a record of the pedigrees of all registered animals. There are 84 breed registry organizations for the various kinds of livestock, summarized by types as follows: horses – 20; cattle – 23; sheep – 23; goats – 3; swine – 14; and asses – 1.

Tables 8 to 12 contain available and approximate figures on the numbers of purebred livestock registered in the United States of America during each of the five years beginning with 1949, grouped according to their utility type or purpose. In addition, 1,950 asses had been registered.

The terms applied to books of record of various classes of livestock are as follows: studbook for horses and asses; herdbook for cattle, goats and swine; and flockbook for sheep; while the term studbook is used as a collective term to describe all types.

The books originally were printed for distribution and sale to interested breeders, but many of the breed organizations have discontinued publication of their records due to the increased costs of printing. These discontinued books include Jerseys, in the dairy cattle breeds, and Shorthorns, in the beef cattle breeds. Only one flockbook — the American Hampshire Down Flock Book — is published for sheep, and no book is published for swine. Some of the light breeds of horses, such as Thoroughbred, American Saddle Horse, American Standardbred, and the Morgan Horse are listed in published books but none is published for draft breeds.

The Federal Government in the United States of America has no authority over purebred registration. However, the organiza-
### TABLE 8 - CATTLE REGISTERED IN THE UNITED STATES OF AMERICA

<table>
<thead>
<tr>
<th>Purpose</th>
<th>1953</th>
<th>1952</th>
<th>1951</th>
<th>1950</th>
<th>1949</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>828 952</td>
<td>872 701</td>
<td>736 277</td>
<td>657 309</td>
<td>565 300</td>
</tr>
<tr>
<td>Dairy</td>
<td>396 448</td>
<td>423 450</td>
<td>403 108</td>
<td>394 746</td>
<td>381 130</td>
</tr>
<tr>
<td>Dual purpose</td>
<td>30 181</td>
<td>35 963</td>
<td>40 139</td>
<td>35 799</td>
<td>34 000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1 255 581</td>
<td>1 330 114</td>
<td>1 179 524</td>
<td>1 087 854</td>
<td>980 430</td>
</tr>
</tbody>
</table>

### TABLE 9 - HORSES REGISTERED IN THE UNITED STATES OF AMERICA

<table>
<thead>
<tr>
<th>Purpose</th>
<th>1953</th>
<th>1952</th>
<th>1951</th>
<th>1950</th>
<th>1949</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft</td>
<td>357</td>
<td>311</td>
<td>364</td>
<td>403</td>
<td>606</td>
</tr>
<tr>
<td>Light</td>
<td>33 994</td>
<td>29 795</td>
<td>19 576</td>
<td>15 627</td>
<td>14 831</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>34 351</td>
<td>30 106</td>
<td>19 940</td>
<td>16 030</td>
<td>15 437</td>
</tr>
</tbody>
</table>

### TABLE 10 - SHEEP REGISTERED IN THE UNITED STATES OF AMERICA

<table>
<thead>
<tr>
<th>Purpose</th>
<th>1953</th>
<th>1952</th>
<th>1951</th>
<th>1950</th>
<th>1949</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium wool</td>
<td>77 242</td>
<td>97 051</td>
<td>89 721</td>
<td>87 207</td>
<td>80 595</td>
</tr>
<tr>
<td>Fine wool</td>
<td>10 182</td>
<td>13 810</td>
<td>14 664</td>
<td>14 383</td>
<td>8 594</td>
</tr>
<tr>
<td>Coarse wool (long)</td>
<td>19 931</td>
<td>19 622</td>
<td>18 384</td>
<td>16 543</td>
<td>14 530</td>
</tr>
<tr>
<td>Fur (Karakul)</td>
<td>323</td>
<td>301</td>
<td>320</td>
<td>661</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>107 678</td>
<td>130 794</td>
<td>123 089</td>
<td>118 133</td>
<td>104 380</td>
</tr>
</tbody>
</table>

### TABLE 11 - GOATS REGISTERED IN THE UNITED STATES OF AMERICA

<table>
<thead>
<tr>
<th>Purpose</th>
<th>1953</th>
<th>1952</th>
<th>1951</th>
<th>1950</th>
<th>1949</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mohair</td>
<td>5 463</td>
<td>4 708</td>
<td>5 269</td>
<td>4 265</td>
<td>3 454</td>
</tr>
<tr>
<td>Milk</td>
<td>7 153</td>
<td>6 847</td>
<td>2 725</td>
<td>2 760</td>
<td>6 976</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12 616</td>
<td>11 555</td>
<td>7 994</td>
<td>7 025</td>
<td>10 430</td>
</tr>
</tbody>
</table>

### TABLE 12 - SWINE REGISTERED IN THE UNITED STATES OF AMERICA

<table>
<thead>
<tr>
<th>Purpose</th>
<th>1953</th>
<th>1952</th>
<th>1951</th>
<th>1950</th>
<th>1949</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacon</td>
<td>16 077</td>
<td>14 574</td>
<td>4 715</td>
<td>18 859</td>
<td>13 376</td>
</tr>
<tr>
<td>Lard</td>
<td>531 694</td>
<td>225 515</td>
<td>313 400</td>
<td>325 404</td>
<td>343 417</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>547 771</td>
<td>240 089</td>
<td>718 115</td>
<td>344 263</td>
<td>356 793</td>
</tr>
</tbody>
</table>
tions sponsoring the different record books are practically all chartered by the various states in which the societies originate and operate. The Federal Government has exerted an influence in developing and perpetuating certain useful breeds employed in agriculture, such as the Morgan horse, long popular in the northeastern section of the country, the Santa Gertrudis cattle, and Columbia and Targhee sheep. The U.S. Department of Agriculture has likewise exercised a significant influence, through research, in the development of new breeds of swine from hybrid foundations of Danish Landrace and other breeds developed in, or imported into, the United States of America. This development led to the organization of the Inbred Livestock Registry Association, which records animals in new breeds as they are formed. They include the Minnesota No. 1 and No. 2, formed from crosses of the Danish Landrace x Tamworth, and Yorkshire x Poland China, respectively, the Beltsville No. 1 and No. 2, formed from crosses of the Landrace x Poland China, and Yorkshire x Duroc x Landrace x Hampshire crosses, respectively, and the Montana No. 1 and Maryland No. 1, formed from crosses of the Landrace with Hampshire and Berkshire, respectively. Registration of these lines is in the hands of the Inbred Livestock Registry Association, St., Paul, Minnesota.

Regarding the formation of new breeds of cattle through crossing, the Sindhi Breed is being crossed with the Jersey, Holstein and Brown Swiss breeds in an attempt to develop strains possessing high resistance to heat. Detailed records are being kept on all animals so as to provide a sound basis for selection of the most desirable individuals. It is expected that these strains will eventually have their own herdbooks.

Most of the prominent and active breeds used in the agriculture of the United States of America originated in Europe, particularly England, and the registrations of these animals trace to the studbooks abroad. There have been a number of breeds developed in the United States, e.g., the American Saddle Horse, the Morgan Horse, and the Standardbred Horse. The Columbia, Montdale, Romeldale and Targhee sheep breeds are of United States origin. In addition to the swine breeds registered by the Inbred Livestock Registry Association, the following are of American origin: Poland China, Spotted Poland China, Chester White, Duroc and Hereford. In all of these instances, private breeders and fanciers have undertaken a careful and organized breeding plan with a definite ideal in mind, directed towards the fixation of type in the animals involved and a consequent perpetuation of this type so that the individuals will breed reasonably true to the standard desired.

In the United States of America the most common system for recording animals is by numerical registration. In some books
the numerical registration is without regard to sex, while in others a separate section is devoted to each sex. This plan is followed entirely by all the cattle, sheep and goat breeds. In the case of the Thoroughbred horse, animals are registered under their dams and a record given therein of the produce of an individual dam for a period of years. This is patterned after the General Stud Book in England and other prominent thoroughbred studbooks throughout the world. The usual record for an animal in a studbook includes the animal’s name, registry number, sex, color, marks of identification, date of birth, a record of the breeder and his address, and subsequent owners. In instances involving cattle and sheep, swine and goats, the record of markings includes those of tattoo marks and possibly ear tags.

Of equal importance, and as an accompaniment to the maintenance of a studbook, is the registry association’s issuance of a registration certificate. This is the breeder’s or livestockman’s credential substantiating that the animal is a purebred of the particular breed involved. The registration certificate contains not only the pedigree of an animal, but certifies that it is registered in the book of record of the association issuing the document. It is prepared on a prescribed form of the association and comprises, in brief, essentials as follows: name, registry number, color, markings, date of birth, name and address of breeder. Provision is usually made in the certificate for subsequent owners which, in most instances, are officially recorded by the registry association. With few exceptions, cattle, sheep, goats and swine are identified by tattoo markings and such markings should be entered on the certificate. Marked cattle, such as Holstein-Friesians and Ayrshires, are generally identified by charts or photographs, which are usually given on the reverse side of the certificate. The certificate must include at least the name and registry numbers of the recorded animal’s sire and dam and some of the certificates show two or more generations of ancestry.

Each association in the United States of America has its own rules, although the rules of the various associations are very similar. To be eligible for registry an animal must be from registered parents, the only exception being the Milking Shorthorn, Santa Gertrudis and Red Dane breeds. In the Milking Shorthorn and the Red Dane breed three and four top crosses are necessary for eligibility of females and males, respectively. In the Red Dane breed, representatives of which were first imported into the United States of America in 1935, cows are eligible only if they have a milk and butterfat record. This record, regardless of its size, is stamped on the cows’ registration papers. The various dairy cattle associations also keep milk and butterfat records on all cows tested in cow testing associations.
Regarding the methods used in record of performance testing of beef cattle, the work is done co-operatively among 38 states and the U.S. Department of Agriculture. The testing involves the selection of young bulls from herds of commercial breeds. The bulls are put on test at weaning time and are fed for 150 days under environmental conditions similar to those found in commercial herds. Weight and feed consumption records are kept on each bull. Average daily gain has been found to vary from approximately 1 1/2 to 3 lb. indicating that there are large differences in economy of production even when dealing with animals as closely related as full brothers. Many of these bulls are later sold to interested breeders. The record made by the bulls in the feed lot has been found to influence the price which breeders have been willing to pay. The records are made available to any interested party, including the extension service and local press agents. Regarding the effect of selection for rate of growth on other economically important characteristics in cattle, it was pointed out that this would depend on whether the characters in question were genetically correlated. The best way to guard against any undesirable changes which might occur in one character when selecting for another character would be to construct a selection index giving proper consideration to the economic importance of characteristics for which improvement is sought.

Literature Cited Regarding Herdbooks and Performance Tests


Artificial Insemination and Storage of Semen

The Baurú meeting gave some attention to the subject of artificial insemination, and a few delegations submitted reports on the progress made in their own countries. The possibilities of wider application owing to the development of the deep freezing technique were considered, and the FAO staff were requested to make available to countries information on new developments in this field. This was done at the Buenos Aires meeting and a summary of the information is presented here.

The use of deep frozen semen was introduced following studies in the United Kingdom on the value of glycerol in protecting spermatozoa from the damaging effects of freezing and thawing. The latest available results from the United Kingdom show that semen still caused conception after storage for at least two years at -79°C. The development of this technique may be summarized as follows: early indications of a method followed the observation of Polge, Smith and Parkes (1949) who showed that spermatozoa in fowl semen containing 15 percent glycerol and frozen at -79°C. were still capable of fertilizing eggs from which normal chicks were hatched. Polge and Rowson (1952 a, 1952 b) showed that bull spermatozoa could be protected against the damaging effects of freezing and thawing by the addition of glycerol: and Polge and Rowson (1952 c) reported that glycerol-tested bull semen retained normal fertilizing capacity when kept at -79°C. up to 31 weeks. Further results reported by Rowson and Polge (1953) showed that bull semen, diluted 1 in 4, in the presence of 10 percent glycerol maintained normal fertilizing capacity during one year’s storage at -79°C. and that 7 out of 12 cows became pregnant following insemination with semen diluted 1 in 100 and kept frozen at -79°C. for 2 to 24 days. These authors also stated that they gained the impression that live spermatozoa in bulls’ semen stored for 16 months at -79°C. became slightly reduced in number as compared with semen stored for shorter periods. Similar results were obtained by workers at Cornell University (Bratten, Cruthers, Wearden, Foote, and Dunn, 1954) in Wisconsin (Dunn, Hafs, Buckner, Young and Conrad, 1954), and by workers at the University of Illinois (Van Demark and Kinney, 1954). The effects of thawing temperatures and composition of the extender have been studied by Hafs and Elliot (1954).

The technique now recommended in the deep freezing of bull semen is to collect the sample in the usual way and dilute it at once to the required extent with a buffer made from equal quantities of egg yolk and 3.92 percent sodium citrate, the operation being carried out at a temperature of 82.4°F. (28°C.). The diluted semen is then placed in the refrigerator at a temperature
of 23°F. (-5°C.) and when the semen has reached this temperature, an equal part of a mixture composed of 3 parts 3.92 percent sodium citrate solution and one part glycerol (this gives a concentration of 10 percent glycerol by volume) is added to the sample. The mixture is kept overnight in the refrigerator at 23°F. and next day freezing is carried out by the use of solid carbon dioxide and alcohol. The freezing operation consists of two parts, (a) reduction of temperature from 23°F. to 14°F. (-10°C.) over a period of 30 minutes, and (b) reduction of temperature from 14°F. to -79°C. over a period of 20 minutes. These times of reduction of temperature are considered to be of much importance. The frozen semen is then stored at -79°C. in the deep freeze apparatus. When required for use, the frozen semen can be thawed in a water bottle at 104°F. (40°C.) and used within a few hours, but the common practice is to remove the sample from the deep freeze apparatus and take it to the farm in a vacuum flask, thawing being carried out at the farm.

Although satisfactory conception rates are reported from the use of semen so treated and stored up to two years, there are still problems to be solved before practicability of its wide use will have been proved. They include the cause and methods of prevention of the death of some 20 percent of the spermatozoa during freezing and thawing operations, the reasons for better results with semen with a low spermatozoa count but, where they are highly active, variation in the response of semen of different bulls to the treatment and satisfactory methods of transport of deep frozen semen over long distances.

Following upon development of deep frozen semen and the likelihood of increased export and import of semen, consideration has been given to conditions and regulations. A recent European meeting, convened by FAO in Cambridge, England, studied the subject and agreed that it is still too early to suggest international regulations. Recommendations, however, were formulated, and they may form a basis for, firstly, national requirements and later international use. The subjects dealt with included tests to ensure freedom from transmission of disease in the use of semen; standard methods of calculating fertility of semen; international identification of semen; packing and transport of semen; and methods of progeny-testing of bulls, including considerations of lethal and semi-lethal factors.

In connection with the problem of disease-transmission, attention should be drawn particularly to trichomoniasis and genital vibriosis as causes of infertility. A meeting of experts convened by FAO and held in Copenhagen, Denmark, in December 1954, considered these diseases and a report has been issued by FAO containing information on the recent findings on the diagnosis
and control, especially of bovine genital vibriosis. It is expected that an account will be published soon, based on a study in which *Vibrio fetus* was found in Costa Rica.

Information concerning recent developments in the use of artificial insemination in several countries is summarized below, including reference to the use of deep frozen semen where attempts have been made to use it.

In *Argentina*, there has been an increase in the practice of artificial insemination and new centers have been opened. Both dairy and beef cattle are included in the schemes and highly valuable pedigree bulls of the required type, either already in the country or specially imported, are used. In the shipment of semen all means of transport are used, depending on the geographical position of the center and the farms. Semen has been sent successfully to other countries, including Paraguay. Full arrangements concerning technique and transport for artificial insemination in distant parts of the country have not yet been made, but conceptions following first service of 30 to 40 percent and parturitions up to 70 percent have been obtained from the methods now in use. Except for artificial insemination within a herd, the Ministry of Agriculture controls all the operations. The control of infertility is also being studied in Argentina and it has been found that brucellosis is mainly concerned. Deep frozen semen produced in the country has not yet been used, but some has been received from Canada.

In *Canada*, artificial insemination is sponsored chiefly by the provincial departments of agriculture and in some instances by the federal Department of Agriculture. The operation is conducted mostly on a non-profit basis as a program of cattle improvement and is confined almost entirely to dairy cattle. Bull studs are maintained in several provinces, by the provincial departments of agriculture; in other provinces, the artificial breeding units are organized by the dairy breeders. The organization of artificial insemination is governed by provincial government legislation, either in the form of an Artificial Insemination Act or special regulations. In 1953, some 433,000 cattle were bred by this method. Artificial insemination of sheep is not practised in Canada. Research work in the handling, storage and deep freezing of semen is in progress and deep frozen semen is now in daily use in some areas. Semen may be imported into Canada only with permission of the Veterinary Director-General. Export of semen takes place, for example, to the United States of America and some shipments have been made to Great Britain.

In *Chile*, in 1952, the Ministry of Agriculture decided to support artificial insemination in the country. It was planned to build well equipped centers and to have official control over them and the whole of artificial insemination work for some years. Dairy
co-operatives will take over the centers at the end of this period and will repay financial investments. Up to the present, two centers have been established for cattle work and a further six for cattle and one for sheep, are contemplated. It has been shown that brucellosis, tuberculosis, trichomoniasis and genital vibriosis exist in Chile; all may be transmitted through breeding. Attention is being given to the details of the working of centers in all respects and to the use of high quality bulls.

In Columbia, there has been considerable development in the use of artificial insemination in the different parts of that country, and further plans have been made. In the past, difficulties have been experienced consisting largely of a lack of appreciation of farmers of the benefits to be derived from this method of breeding, failure always to give or maintain a satisfactory service to the farmers, indifference of livestock owners to development of modern technical methods, lack of satisfactory transport and the transference of veterinarians engaged in artificial insemination to other more urgent work, such as the control of foot-and-mouth disease. In 1955, better all-round co-operation was planned, together with a withdrawal of artificial insemination services from areas in which many difficulties had been encountered, provision of better roads where a demand existed, especially in dairy districts, the provision of better service from centers and the development of more and better propaganda among farmers.

In 1952, the Government of El Salvador began a program for the artificial insemination of dairy cows. The Ministry of Agriculture and Livestock designated the sum of 125,082.65 colones to carry it out. Eleven routes, each of which was covered by an inseminator, were established in the regions of the greatest dairy cattle population. The difficulties encountered over two years gave rise to a reorganized plan towards the end of 1954. Under this new system the country is divided into seven zones, each of which is supervised by a technician of the Ministry, and served by a small group of inseminators, trained at the National Livestock School of Santa Ana. These inseminators are employed by the farmers. Records are kept of each insemination so that the percentage of conception and live calves can be determined. Records are also being kept of the fertility levels of the bulls. In cooperation with the Animal Health Department, a study is being made of the diseases in the herds affecting reproduction. At present, four Brown Swiss, five Holstein, five Ayrshire and four Jersey bulls are being used. Young bulls of good pedigree and conformation have been imported from the United States of America. According to plans, the Jerseys will be replaced by the other breeds as there is not much demand for their semen. There is a tendency among the dairymen to use the semen from bulls of different
breeds rather than from one breed, indicating no marked preference for any one of the other three breeds. Inseminations have increased from less than 1,000 in 1952 to over 9,000 in 1954, which indicates the growing popularity of the program.

In Panama, schemes have been developed for the artificial insemination of cattle and horses. It is proposed to carry out experimental work on the American Brown Swiss cattle and American Holstein-Friesians. Beef cattle are also to be included in the scheme, using Aberdeen-Angus bulls. Plans for the development of artificial insemination in horses are also being made.

In Paraguay, attention is being given to the development and practice of artificial insemination and there has been an increase in the use of this method of breeding.

In Peru, artificial insemination has been practised only in dairy cattle and the operations were carried out under the supervision of the National School of Agriculture working in conjunction with the Ministry of Agriculture. In some dairy districts, up to 50 percent of the cows were being bred by this method. Although artificial insemination is a satisfactory method for improving livestock, the Peruvian officials recognize that the dangers associated with its use should not be overlooked. These dangers include the transmission of diseases of a venereal character such as trichomoniasis and brucellosis. The need for satisfactory regulations to prevent such occurrences is recognized.

In Jamaica, technical difficulties have been encountered mainly in transport and the failure of owners to recognize estrus: subestrus is prevalent throughout the county. There is one main center and three sub-centers and the scheme is operated by the Government. Artificial insemination has no marked effect on disease control: such diseases as brucellosis and genial vibriosis are of minor importance as causes of infertility. Deep frozen semen has been used only to a limited extent.

In the United States of America, artificial insemination is increasing rapidly particularly among dairy cattle; more than 20 percent of dairy cows are now being bred by this method. There are three general types of organizations concerned, namely, cooperative farmer-owned and farmer-operated associations, in which semen is produced and used on members' cattle; private corporations which produce and sell semen and give an insemination service to individual farmers and breeders; and individual enterprises in which farmers and breeders use artificial insemination within their own herds. The co-operative is much the most popular type of organization. An organization, known as the National Association of Artificial Breeders, made up of a large number of the individual co-operatives and corporations, has been formed to advance the artificial insemination business, to establish
uniform policies and procedures, and to promote research and education in the subject. Artificial insemination organizations are required to abide by the applicable organizational laws in the state to which they belong.

Artificial insemination in beef cattle in the United States of America, however, is practised only to a limited extent. In 1954, a total of 177 beef bulls were used mainly for the production of hybrid calves, while some 2,400 bulls, of which only 800 were progeny-tested, were used for semen production for dairy cows in the same year. One of the important problems is to obtain bulls of the right type. This difficulty will be partly overcome by the use of deep frozen semen because the whole of each ejaculate can be used, and thus, more semen will be available from a small number of bulls. Artificial insemination is also carried out in sheep mainly on a research basis and in private flocks. This method of breeding is also being applied to poultry and bees.

Deep frozen semen, as now used in the United States of America, is giving even better conception rates than those obtained with non-frozen semen. One of the important advantages of deep frozen semen is that livestock breeders are able to obtain a "nominated" service from any desired sire. Research work is in progress on the causes and control of infertility in its many aspects. Very little semen is imported into the country. Quarantine arrangements prohibit importation from most countries.

When the practice of artificial insemination was first introduced, fears were expressed by many lest the resulting offspring would not be normal in all respects. Similar fears now attend the introduction of the frozen semen technique. Two points in favor of the latter as compared with non-frozen semen are generally recognized, i.e., the possible utilization of the whole of each ejaculation with consequent prevention of wastage, with an ultimate reduction in the necessary number of semen-producing bulls, leading to their better selection; and the greater availability of "nominated" services, which many livestock breeders desire. On the other hand, it may be necessary to carry out some further investigations into deep frozen semen from the point of view of the effect of low temperatures on spermatozoa with regard to their possible subsequent influence on the genetic constitution of offspring derived from them, in order to clarify the doubts which now exist in some quarters on this point.

Selected References Regarding Storage of Semen

DUNN, H.O., HAFS, H.D., BUCKNER, P.J., YOUNG, G.F. and CONRAD, E.O. 
A Comparison of Fertility of Bovine Spermatozoa Stored at 5°C. 

HAFS, H.D. and ELLIOTT, F.I. Effect of Thawing Temperature and 
Extender Composition on the Fertility of Frozen Bull Semen. 

1949.


and Artificial Insemination, Copenhagen), 3, 90, 1952 b.

---. Results with Bull Semen Stored at -79°C. Vet. Rec. 64, 851, 
1952. (c).

ROWSON, L.E.A., and POLGE, C. Storage of Bull Semen at -79°C. and 

VAN DEMARK, N.L. and KINNEY, W.C., Jnr., The Freezability of Bull 
Sperm as Affected by Inter-actions of Glycerol Levels, Rates of 
Freezing and Sub-zero Storage Temperatures. J. Anim. Sci. 13: 
1034, 1954.
Attention was given in the Turrialba and Baurú meetings to many phases of livestock management, nutrition and feeding practices (Phillips, 1950 and 1953). It became apparent from the discussions at those meetings that four problems, which were of importance to many countries and of substantial current interest, should be selected for further consideration at the Buenos Aires meeting. Two of these relate particularly to the livestock grazing industry, one to the conservation of fodder, and one to nutritional deficiencies. The material in this chapter is, therefore, arranged under four sub-headings, according to the topics upon which governments have supplied information.

National Planning and Management Aspects of the Grazing Industry

Grazing, either on open or fenced permanent ranges and pastures, and on pastures grown in rotation with other crops, is an important aspect of agriculture in most countries in the Americas. This point is emphasized by the figures in Table 13 showing the numbers of various types of livestock in the Americas. It will be seen that the numbers of the cattle and sheep are not only large, but that cattle numbers had increased substantially from the prewar level during the last two decades, while sheep numbers had increased in South America and decreased in North America.

Methods which can be adopted to improve the efficiency of the livestock industry include the improvement of livestock by breeding and selection, the increasing of productivity of grassland and fodder crops, and the addition of measures for animal health. To livestock owners, all these methods call for an increased outlay of funds for investment in their enterprises, but the incentive for such investment will not be found unless the return is at least equal to that which may be obtained in alternative projects. In Argentina, for example, it is said that the return from a farming enterprise is of the nature of 2 percent whereas it is possible to obtain 12 percent for mortgages.

In many American countries, as in other parts of the world, insecurity of land tenure, and in some cases uneconomic sizes of holdings, are important factors limiting investment and develop-
ment. Under this general heading, consideration should also be given to duration of leases, private ownership as related to government ownership, grazing permits on public or other lands, and the question of forest grazing on land which has timber resources and value as a catchment area.

**TABLE 13 - NUMBERS (IN MILLIONS) OF MAJOR LIVESTOCK SPECIES IN NORTH AND SOUTH AMERICA**

<table>
<thead>
<tr>
<th>Years and Area</th>
<th>Horses</th>
<th>Mules</th>
<th>Asses</th>
<th>Cattle</th>
<th>Pigs</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North and Central America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prewar</td>
<td>18.0</td>
<td>5.5</td>
<td>3.2</td>
<td>100</td>
<td>64</td>
<td>60</td>
</tr>
<tr>
<td>1948/49</td>
<td>12.4</td>
<td>4.0</td>
<td>3.5</td>
<td>110</td>
<td>72</td>
<td>39</td>
</tr>
<tr>
<td>1950/51</td>
<td>11.0</td>
<td>3.8</td>
<td>3.6</td>
<td>118</td>
<td>79</td>
<td>38</td>
</tr>
<tr>
<td><strong>South America</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prewar</td>
<td>18.2</td>
<td>3.9</td>
<td>2.7</td>
<td>106</td>
<td>30</td>
<td>95</td>
</tr>
<tr>
<td>1948/49</td>
<td>18.3</td>
<td>4.4</td>
<td>3.5</td>
<td>132</td>
<td>34</td>
<td>120</td>
</tr>
<tr>
<td>1950/51</td>
<td>18.4</td>
<td>4.4</td>
<td>3.7</td>
<td>136</td>
<td>37</td>
<td>123</td>
</tr>
</tbody>
</table>

1 For the prewar period, the latest estimates up to 31 December, 1939, except for a few 1940 figures, have been used.
2 From 1952 FAO Yearbook of Food and Agricultural Statistics (Vol. VI, Part 1, p. 109)

In view of the importance of the grazing industry, a major question to be considered is the extent to which national planners are at present taking account of the special interests and requirements of the livestock industry.

Under the modern system of land use based on the conservation of natural resources and their improvement, costs are necessarily higher than under the exploitative system. The cheap food era, which was possible only with uncontrolled exploitation of the natural resources of the producing countries, is being replaced by a period in which there is increasing realization of this fact, and of the urgent necessity to restore the damage which has been done. The next stage will have to be the building-up of the productive capacity of the land to meet the needs of a growing population. The main items of cost in such a program are:

1. **Interest on the capital invested.** If this is inadequate, money will be invested elsewhere.

2. **Wages.** These are governed largely by the size of the individual holding, the purpose for which it is used, and the necessity of attracting to this work people of sufficient knowledge to learn and apply modern methods; the wage must be at a level which will compete substantially with that paid in industry.
(3) **Depreciation and obsolescence.** In addition to normal depreciation, as new methods of farming are introduced, equipment will become out-of-date and much will have to be written off, otherwise the work will be done uneconomically, old houses will have to be dismantled and modern housing built to attract skilled labor.

(4) **Rent, taxes, insurance and general contributions.** By virtue of their comparative isolation, rural farmers are called upon to meet expenses in connection with education, holidays and local social activities which are greater than those to be met by people in industrial centers; these should be a charge on the industry.

National planning has one basic purpose, that of creating an atmosphere for efficiency of operation on the individual level. There are several factors which governments need to consider if national planning is to be effective, namely:

(a) analysis of future trends, i.e., the relation between population and needs for livestock products, information which must be placed in the hands of producers by 5 or 10-year periods, so that they can make long range plans;

(b) examination of the needs for research in relation to critical animal problems, and orientation of the program to meet the needs;

(c) provision of technical services to carry new information to the producer; and

(d) provision for the orderly marketing of products.

A primary need in national planning is an inventory and classification of natural resources, namely, soil, water and vegetation. It would also be important to obtain information on the potential demand and availability of both major and minor plant nutrients which are essential for improvement of grassland and fodder resources to the level required by an efficient livestock industry.

Water is an especially important item in national planning. A major problem is the depletion of underground water stores — an occurrence which is at present a critical problem in the plains of Argentina and elsewhere in the hemisphere. A new technique has been developed in Australia to reduce evaporation of water in open storage through the use of powdered cetyl-alcohol, which, when scattered on the surface forms a thin film, one molecule thick. Water supplies and resources, their use and depletion if not wisely managed, are multiple, and it becomes necessary to
consider and co-ordinate conflicting interests. Some type of hydrological service might well be established in each country to protect existing water sources, reconcile interested users, and formulate plans for use on a national basis, in cases where such bodies do not exist.

Programs of national planning should take into account the balance between the natural, economic and social factors in a given country. For example, in the River Plate region, there has been much improvement in the animals themselves, but no comparable improvement in other aspects of animal production such as the maintenance of soil fertility, pasture management, etc. A need exists for an inventory of human, natural and economic resources, which is lacking in many countries. Only through this will it be possible to determine what resources are available, how they can be used, and which problems require solution. Throughout a considerable part of the Americas there is little relation between research and extension activities, nor is the researcher in many cases thoroughly familiar with the problems of the producer. A great need exists, therefore, for a closer relation between extension, research and the producer.

One fundamental step is the adequate training of capable personnel. Such technicians, who have practical knowledge of the problems, can arrive at their solutions after careful study and analysis and with the help of the people. Only after the producers have adopted the new practices and procedures will the desired progress result.

Information on current developments in a number of the countries in the Americas is summarized in the following paragraphs.

The Government of Argentina has taken steps towards making public lands in Patagonia available for sale to those who are actually working on these areas. Some 490,625 square miles are involved in the whole region south of the Rio Negro. The previous history of these lands has been maximum exploitation by lessees under the short-term leases prevailing. Since 1950, new laws have provided not only for private ownership by resident operators, but also for economic operational units, calculated to provide an adequate standard of living based on the number of sheep which can be grazed on a given holding. The Government of Argentina has also had a national program of seed multiplication and distribution since 1948. In the last year, there were some 60 to 70 cooperators in this work.

Chile has in operation a national program to improve, among other things, the livestock industry. The operation is being carried out in three areas under a scheme which can be described as the "Plan Chillán"; this covers the provinces of Maule, Nuble and Concepción. In addition, there is a plan for the southern
part of the Central Zone of Chile, specially for the Province of Cautín, and another for Magallanes. The “Plan Chillán” lays considerable emphasis on pasture management and improvement, soil conservation and the production of seed of introduced species of pasture and fodder plants. New techniques are introduced into farming practice through extension work. In the province of Cautín, while the work is primarily concerned with the conservation and restoration of soils, the establishment of permanent pastures is of great importance under the special conditions of the zone. The region covered by the “Plan Magallanes” is almost entirely devoted to livestock production (sheep); the objective here is to increase this production by the improvement of existing pastures and the establishment of new improved pastures. A reconnaissance soil survey of the country has been practically completed. There is some concern in Chile over the instability created under existing systems of land tenure for those who rent from the State. The Government of Chile has sent a message to the Chamber of Deputies, aimed at modifying existing land tenancy legislation and foresees the possibility of the sale of government lands in the extreme south.

In Costa Rica, there is full recognition that agricultural prosperity depends largely on livestock production based on the development and more effective utilization of the grassland and fodder resources of the country. This development will not react unfavorably on the coffee crop which has been the main source of export revenue up to the present; in fact, the indications are that coffee production will be higher if this is integrated with dairy farming. A program is being planned on a national scale and envisages the progressive development of milk, meat, pork and egg production for which there are three inseparable, interdependent and fundamental requirements:

(i) inherently productive livestock adapted to the environment;
(ii) adequate feed supplies throughout the year equal to the nutritional standards required; and
(iii) a standard of management which ensures effective utilization of feed and the maintenance of livestock in a healthy condition.

Since none of these fundamental aspects are of permanent value without the others, the ecological approach has been adopted in full recognition of the relationships between plant, animal and man, and the complete interdependence of the one upon the other. It is realized that, as the program develops, many new problems will emerge which can be solved only by research and some may require facilities not yet available in Costa Rica. How-
ever, the country is developing these as rapidly as possible and is seeking outside assistance, where necessary.

In El Salvador, about 685,000 ha., or 32 percent of the land in that country, has been classified as pasture. Of this 17,528 ha. are cultivated, and the remainder is natural range. The variations in carrying capacity have not been determined. According to the 1953 census there were 132,932 draft oxen; 694,498 head of other cattle, 261,252 hogs; 32,858 mules, 3,187 asses, 15,098 goats, 5,453 sheep and 2,243,851 poultry. It is calculated that the people consume on an average only about 27 1/2 lb. of meat, fish and poultry per person, per year. Milk consumption is low. Cheese is made by rudimentary methods in places very distant from fluid milk markets. For many years there has been a considerable migration of cattle and hogs from Honduras and Nicaragua to El Salvador. Some of them continue to Guatemala on foot or by train, and some of the cattle remain for a time, fattening on pastures before entering Guatemala or being shipped to Peru.

In 1952, more than 4,000 steers and 30,000 hogs entering the country in this manner remained for slaughter and local consumption.

In Paraguay, studies under way as part of a national plan to give guidance to the stockmen include the following: the rational use of pasture; introduction of new legume species; establishment of improved pastures; the value of lime and fertilizers for pasture production; elimination of undesirable plants; practices to improve soil structure and moisture; best combination of grasses and legumes in relation to carrying capacity; improvement in the quality of cattle; animal disease control; breeding and management practices; provision of mineral supplements to animals on pastures; and improved handling and transport facilities.

Panama has a national project under way to map and classify all the soils of the country; most work at present is in the region of Chiriqui. While land tenancy studies have been concluded by the Statistic and Census Section of the Ministry of Finance, the results have not yet been analyzed or made available as a help to the livestock industry. Soil conservation is a problem due to various factors. However, in Chiriqui, land contour demonstrations have been established, as also have demonstrations to point out the harm of burning pasture lands.

The United States of America has under way a number of activities which relate to the national planning and management aspects of the grazing industry in that country, where grazing may be considered of two major types: A, grazing as a part of the farming enterprise in the more humid or irrigated parts of the country; and B, grazing as a major enterprise in arid and semi-arid portions of the country. Grazing, in these two types of
enterprise, involves the use of more than half of the total land area of the United States. It is practised on 168 million ha. of open permanent pasture or rangelands, 55 million ha. of forest on farms, 28 million ha. of cropland in farms, and approximately 162 million ha. of forested and non-forested rangeland outside of farm boundaries. Of the total land area used for grazing, about 121 million ha. are in federal ownership and about 26 million ha. are owned by state and local governments.

National planning and management, as it affects the grazing industry based on these lands, has concentrated largely on attempts by the federal government to create an atmosphere in which livestock producers can operate efficiently. Such planning involves the national study and analysis of situations or problems within, or affecting, the industry. Needed action may be translated in the form of development orientation, and operation of:

1. research programs;
2. educational facilities involving federal and state extension services and other channels;
3. aids in the form of technical services and financial assistance, where needed to promote wider use of technological improvements in the industry, and to promote conservation of soil and other resources, and
4. rules for the protection of public health, and for the orderly operation of transportation and marketing facilities.

National planning aids the federal, state and local governments in taking those actions which will help the grazing industry to overcome its problems or lessen their effects.

As a phase of such national planning, recent studies of the future needs for agricultural production have been made, based on probable increase in population, trends in consumers' tastes, trends in the use of agricultural products in industry, and changes in total consumption which might be possible with a high level of employment and continued active economy. By 1975, an anticipated increase of between 6 to 8 percent per capita in consumption of agricultural products, and population increase of 32 percent will require an over-all increase in farm production of 30 percent over present levels.

Of major importance to the grazing industry, these studies show that as part of the over-all increase in farm production, there will need to be an increase of an estimated 38 percent in virtually all livestock and livestock products. This is in contrast to a needed increase in all crop production of 24 percent over the 1951-53 level. This lower increase is the result of present production of several major crops in excess of consumer require-
Notable among these is the production of wheat as a food grain. Shifts in production are required to meet the 1975 requirements, most pressing of which is shift from production of wheat as a food grain towards more livestock and livestock products. Such a shift is of significance to the grazing industry and presents several major problems. Associated with the shifts and the need for higher livestock production is another problem — that of obtaining more adequate supplies of high protein concentrate feeds.

To meet the increased needs for agricultural commodities by 1975 will require increased yields per acre of virtually all agricultural commodities except wheat. Nearly all land suitable for agriculture in the United States of America is now in use; a net increase of only 6 percent in the acreage of cropland is probable by 1975. Some land can be used more intensively; other land, in the interests of conservation, doubtless should be used less intensively. As it applies to the grazing industry and use of grazing lands, to obtain these increased needs for livestock production efficiently will require continued efforts to encourage use of present known improved production techniques, and continued research along many lines to increase the output of grazing lands and grazing animals.

The need for attaining greater forage production on pasture and rangelands is another major problem facing the grazing industry. The increased production of forage on pastures and ranges, especially that of the ranges, has not kept pace with the increases in yields per acre of agricultural lands devoted to other crops. An increase of approximately 30 to 35 percent in the yields per acre of pasture and grazing lands would be needed to meet the requirements for livestock production by 1975.

Statistics on labor used in grazing phases of the livestock industry are not available separate from the labor requirements of major enterprises of agriculture. The agricultural industry of the United States of America is estimated to have required 15 thousand million man-hours of labor in 1953 as compared to an annual average requirement of more than 23 thousand million man-hours in the 1910-1914 period. A steady and significant decline has occurred during the past 40 years. Sheep and cattle production, as compared with other agricultural commodities, have always been relatively low consumers of labor. In 1953, they used only slightly more than 1 thousand million hours of labor. Labor efficiency in the sheep and cattle industry has increased, but relatively less than with other major aspects of agriculture. Further increases are still possible.

Soil and water conservation is taken into account a great deal in national planning and operations in the United States of America.
This affects the grazing industry, just as it does other phases of agriculture. As a result of such planning, several significant legislative actions have been taken by the federal government. Legislation establishing the Soil Conservation Service to provide leadership and assistance in a national program of soil and water conservation, and to provide means for the federal government to share with farmers and ranchers the cost of establishing approved conservation practices to be administered by the Agricultural Conservation Program Service has been taken. Recent legislation has provided for both direct and insured loans for conservation work through the Farmers Home Administration of the Department of Agriculture; permission to landowners who establish conservation practices to deduct, as expenses, the cost of such practices, from their income in calculating income taxes; and a national program of soil and water conservation and flood retardation in small watersheds which provides a means for the federal government to share with local units of governments the cost of planning and applying complete watershed treatment programs.

Federal departments administering federally-owned land also give major emphasis in planning and action programs to soil and water conservation, and to the management and improvement of ranges. Since about 121 of the 184 million ha. of public land administered by the federal government is used for grazing, this planning and action influence the grazing industry in a major way.

A shift from government to private ownership of some public lands, such as reported by the Argentine delegation, is being considered in the United States of America. For these areas remaining under public domain, the present policy is, firstly, towards a longer tenure, which is now 10 years and is renewable, and secondly, towards a growing tendency to give the user of the land some responsibility for its care and management, thus, in effect, enabling consideration of the leased land as though it were his own.

Problems such as land tenure, transportation facilities, livestock prices, and others facing the grazing industry are also considered in national planning. Situations are analyzed, and necessary steps of research, education, technical or financial assistance and legislation are taken as needed by federal, state and local units of government. Additional steps may also be taken by associations of livestock producers, or through national meetings attended by representatives of agriculture, industry and government.

The National Foundation Seed Project was established in the United States of America to provide a rapid and improved supply of seeds of hay and pasture crop varieties. This assures that the amounts of certified seed required by farmers are readily available. It was initiated in 1948.
It is considered in the United States of America that continuing attention needs to be given to all of these many phases which concern the grazing industry. One of the major phases essential to national planning on which new work is needed is a national inventory of pasture and rangelands, with specific attention to their condition, improvement, needs and grazing capacity.

Technical Problems in the Use of Grasslands

Much interest was shown in the various technical problems involved in the improvement of range and pasture lands at the Turrialba and Baurú meetings, and the information made available on the work in various countries has already been published (Phillips, 1950 and 1953). A growing awareness of the importance of work in this field was reflected by the large amount of information made available to the Buenos Aires meeting, and which is summarized in this section. The information for each country is presented in sequence to give an indication of the amount and type of work reported for each country.

In Argentina, nine major ecological zones are recognized with particular reference to their value for grazing. A publication is in preparation which gives details on the extent of each zone, its climate, soil, vegetation, natural and cultivated forage plants, pasture and feeding problems. In most of the regions, overgrazing has caused deterioration of the soil and vegetation and thus has affected the livestock population. The regions are as follows:

1. Patagonian steppe;
2. western low scrub;
3. Pampean open woodlands;
4. northwestern mountain steppe;
5. central mountain grasslands;
6. Chaco woodland;
7. Chaco parkland;
8. northeastern open woodlands and savannas; and

Two-thirds of the surface of Argentina is arid or semi-arid; the livestock of these regions (sheep, cattle and goats) subsist entirely on the natural vegetation. The prolonged dry period and uncontrolled use of the land have resulted in serious deterioration in the vegetation cover and soil, markedly reducing the carrying capacity; this whole process has led to serious erosion. In order
to cope with this situation, the Ministry of Agriculture and Livestock has initiated a series of studies to regenerate these lands to a condition in which they will maintain an optimal number of livestock, while at the same time ensuring conservation in all its aspects. The studies noted below have been initiated in Patagonia, and will be extended to the north of the country as soon as facilities permit:

(1) Preparation of a manual of the flora of the Patagonian semi-desert.

(2) Study of the vegetation. A map of the vegetation of the Chubut region has been published (Soriano, 1950) which shows the floristic districts, the areas characterized by species or populations that are lacking or rare in adjacent areas. A map has just been completed of all the floristic districts south of the 42nd parallel, which were surveyed by the line transect method.

(3) The effect on the vegetation of elimination of grazing. A network of hare-proof enclosures 1 ha. in size has been set up in vegetation types representative of extensive areas; this system will be extended to the Central Pampa. The changes are being observed using Parker’s method (Parker, 1950). Marked increases in density and height of grass and other species have been noted as a result of protection for less than one year.

(4) Ecology of dominant, useful and undesirable species. An attempt is being made to ascertain the characters or mechanisms which give advantage to one species over another. Studies are being made on germination, establishment, root systems and amount and longevity of buried seeds, as well as on environmental factors.

(5) Seeding trials. About 20 indigenous and introduced perennial grass and browse species are being tested in five representative sites. On one site a very palatable indigenous plant, Bromus macranthus, was the only species which germinated and grew well in a year when the precipitation was 54 mm. of rain and 16 cm. of snow. In another locality with 500 mm. of rain Agropyron desertorum and A. intermedium appeared promising.

Action has been taken by Argentina during recent years to make adequate quantities of seed of adapted and improved species and strains available to farmers. This includes the planning and co-ordination of work in progress at the various experimental stations of the Ministry of Agriculture and Livestock; in 1954, there
were 27 forage crop improvement projects under way, apart from
the work concerned with the multiplication of seed of new forage
varieties and introductions. A special experimental station at
Anguil was created to work primarily with the improvement and
management of forage species. Improved strains of forage plants
available to date in Argentina include:

<table>
<thead>
<tr>
<th>Plant</th>
<th>Strain</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>General San Martin FAV</td>
<td>Resistant to stem nematode</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>Nemasint FAV, synthetic</td>
<td>Resistant to stem nematode</td>
</tr>
<tr>
<td></td>
<td>variety</td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>Selección Pergamino MAG</td>
<td>Resistant to root rot</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>Magníf, M₁ and M₃</td>
<td>Resistant to stem nematode</td>
</tr>
<tr>
<td>Barley</td>
<td>Negra de Manfredi MAG</td>
<td>Resistant to aphids (Schizaphis graminum)</td>
</tr>
<tr>
<td>Barley</td>
<td>Gautrache Araucana MAG</td>
<td></td>
</tr>
<tr>
<td>Bromus carthaticus</td>
<td>Selección Angel Gallardo</td>
<td></td>
</tr>
<tr>
<td>Bromus carthaticus</td>
<td>Selección Pergamino MAG</td>
<td></td>
</tr>
<tr>
<td>Oats</td>
<td>Santa Fé, No. 3</td>
<td></td>
</tr>
<tr>
<td>Phalaris tuberosa</td>
<td>Selección Pergamino MAG</td>
<td></td>
</tr>
<tr>
<td>Ph. tuberosa</td>
<td>Selección Pergamino MAG</td>
<td></td>
</tr>
<tr>
<td>Ph. tuberosa x</td>
<td>Selección Castelar MAG</td>
<td></td>
</tr>
<tr>
<td>Ph. arundinacea</td>
<td>Hibrido Castelar (synthetic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>allopolyploid)</td>
<td></td>
</tr>
<tr>
<td>Ph. minor</td>
<td>Selección Pergamino MAG</td>
<td></td>
</tr>
<tr>
<td>Ph. minor</td>
<td>Selección Castelar MAG</td>
<td></td>
</tr>
<tr>
<td>Perennial rye grass</td>
<td>Selección Pergamino MAG</td>
<td></td>
</tr>
<tr>
<td>(Lolium perenne)</td>
<td>(Schizaphis graminum)</td>
<td></td>
</tr>
<tr>
<td>Black sorghum</td>
<td>Magníf 504 MAG</td>
<td></td>
</tr>
<tr>
<td>(Sorghum alburnum)</td>
<td>Oliveras Paraná MAG</td>
<td></td>
</tr>
<tr>
<td>Sudan Grass</td>
<td>Oliveras Carcaraña MAG</td>
<td></td>
</tr>
<tr>
<td>(Sorghum sudanense)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet Sorghum</td>
<td>Selección Pergamino MAG</td>
<td></td>
</tr>
<tr>
<td>(Sorghum saccharatum)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vicia sativa</td>
<td>Selección Pergamino MAG</td>
<td></td>
</tr>
</tbody>
</table>

The superiority of the new selections has been verified in regional trials.
These varieties are now being multiplied for introduction into culti-
vation on a large scale; several are already available to farmers in lim-
ited quantities. In addition to the above-mentioned types work is
in progress on other species including Phalaris arundinacea, Dactylis
glomerata, Vicia and sweet clover.
In view of the interest expressed in hardy types of oats for winter fodder, it should be noted that such types have been developed in Argentina; it is considered that these may be of use in countries with a warm climate, since they are resistant to yellow rust (*Puccinia coronarium*). A need is recognized in Argentina to organize seed exchange between the various countries in Latin America, particularly for those plants which grow well and are valuable forage species in a certain region, but which do not mature seed under the environment of the country.

In Chile, work is under way in the cold climate of Magallanes, where the Ministry of Agriculture and Livestock is planning to establish eight demonstration centers. The type of grassland dominated by "coiron" (species of *Festuca* and *Stipa*) has deteriorated greatly owing to excessive grazing by sheep. The palatable soft grasses are often eradicated by continuous summer grazing on the higher lands. On the other hand, the coarser bunch grasses are grazed in the winter and with too heavy grazing may be eliminated. This occurs on the lowlands which are used in winter. The heavy winds cause "blow-outs" as a result of the depletion of the soil cover by this method of management. These pastures are being improved by protecting them from grazing for one year. Seeding of suitable areas with grasses and legumes is also practised, using *Agropyron elongatum*, *A. intermedium*, *Festuca elatior*, alfalfa (Ranger and Rhizoma), and in some parts *Dactylis glomerata*. Seed of indigenous species of *Elymus*, which promises to be of value for re-seeding, is being multiplied.

Overgrazing and rabbit infestations have led, in some cases, to the formation of large sand dunes which may move at a rate of up to 5 km. per annum. *Elymus arenarius* and *Ammophila arenaria* are used for their control, together with complete protection from grazing by all animals for at least 5 years. Similar results have been obtained with these species in the part of Tierra del Fuego belonging to Argentina.

Following the report of the Baurú meeting, the Government of Chile has taken action on the biological control of the rabbit through the use of the myxomatosis virus. In Australia and other countries, the virus has been transmitted by an insect vector such as the mosquito; in Tierra del Fuego, it is spread by direct contact of one rabbit with another. This action is having a marked effect in reducing their numbers. A similar problem exists in the Argentine part of Tierra del Fuego, north of the Rio Chico, where rabbits have been increasing rapidly in numbers. The hard winter of 1954 greatly reduced the rabbit population. The spread of myxomatosis from the Chilean part of Tierra del Fuego is also having its effect.
An experiment is being conducted in the Magallanes region of Chile to improve the carrying capacity of the range land covered by Mata negra (*Verbena tridens*) and Mata verde (*Chiliotrichum diffusum*). As a result of the mechanical elimination of these unpalatable species, and reseeding, the carrying capacity of the experimental area has, in two years, increased 80 times (from one animal per 20 ha. to 4 animals per ha.). Rainfall in this area approximates 250 mm. per annum.

The following tabulation shows the present status of land development in Chile:

<table>
<thead>
<tr>
<th>Description</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area of country</td>
<td>74,177,000</td>
</tr>
<tr>
<td>Area usable for agriculture</td>
<td>29,000,000</td>
</tr>
<tr>
<td>Area under agricultural rotation</td>
<td>5,903,200</td>
</tr>
<tr>
<td>Irrigated area</td>
<td>1,342,000</td>
</tr>
<tr>
<td>Area under cultivation</td>
<td>2,536,898</td>
</tr>
</tbody>
</table>

Of the area under cultivation, 1,285,700 ha. are in annual crops, 141,198 ha. in fruit trees and 555,000 ha. in fallow land. There are pasture lands, as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On land not subject to rotation</td>
<td>6,800,000</td>
</tr>
<tr>
<td>On unwatered land under cultivation</td>
<td>3,107,000</td>
</tr>
<tr>
<td>On irrigated land under cultivation</td>
<td>733,000</td>
</tr>
</tbody>
</table>

Experiments in progress indicate that the carrying capacity of the irrigated artificial pastures may be greatly increased by the use of superior species, proper fertilizers and control of grazing by the electric fence. It is also believed that the 430,000 ha. of irrigated natural pastures could, with advantage, be plowed up and sown to superior mixtures which would greatly raise livestock production.

Some years ago, Chile began to prepare a soil map and now only a few areas remain to be surveyed. This map shows not only the soil types but also gives climatological data, and furnishes a sound basis for planning the pasture work in the different zones of the country. The chief problems are prolonged dry periods in spring, summer and autumn and low temperatures in winter; these, added to bad management and a gradual deterioration in soil fertility, are resulting in the disappearance of the most valuable species and their replacement by unpalatable species and weeds.

Artificial pastures which have, until recently, been based almost exclusively on alfalfa, red clover (*Trifolium pratense*) and perennial rye grass (*Lolium perenne*) have shown a lack of resis-
tance to adverse conditions of soil and climate. Prolonged investigations have now shown that the following pasture species are of value to the dry zone: Sanguisorba minor, Trifolium incarnatum, Phalaris tuberosa, Festuca pratensis, Arrhenatherum elatius, Eragrostis curvula, E. lehmanniana, Dactylis glomerata. These species are planted in pure stands or mixtures, according to the possibilities shown by the soil map of Chile.

Ladino clover (Trifolium repens var. giganteum) has given excellent results on soil with medium to heavy texture on which alfalfa and red clover did not do well. Tall oat grass (Arrhenatherum elatius) is adapted to the Andean Precordillera and the coastal terrace lands, on light soils which are largely covered with poor annual species.

The species of pastures and fodder crops which are grown on the dry and irrigated artificial pastures are indicated in Table 14.

TABLE 14 - AMOUNTS OF PASTURES OF VARIOUS TYPES IN CHILE

<table>
<thead>
<tr>
<th>Type of Pasture</th>
<th>Irrigated Land</th>
<th>Dry Land</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>100 000</td>
<td>3 000</td>
<td>103 000</td>
</tr>
<tr>
<td>Arrhenatherum elatius</td>
<td>—</td>
<td>6 000</td>
<td>6 000</td>
</tr>
<tr>
<td>Dactylis glomerata</td>
<td>2 000</td>
<td>246 000</td>
<td>248 000</td>
</tr>
<tr>
<td>Red Clover</td>
<td>190 000</td>
<td>135 000</td>
<td>325 000</td>
</tr>
<tr>
<td>Holcus lanatus</td>
<td>—</td>
<td>121 000</td>
<td>121 000</td>
</tr>
<tr>
<td>Lolium perenne</td>
<td>6 000</td>
<td>10 000</td>
<td>16 000</td>
</tr>
<tr>
<td>Trifolium incarnatum</td>
<td>—</td>
<td>5 000</td>
<td>5 000</td>
</tr>
<tr>
<td>Mixtures</td>
<td>5 000</td>
<td>300 000</td>
<td>305 000</td>
</tr>
<tr>
<td>Others</td>
<td>—</td>
<td>16 000</td>
<td>16 000</td>
</tr>
<tr>
<td>Total</td>
<td>303 000</td>
<td>842 000</td>
<td>1 145 000</td>
</tr>
</tbody>
</table>

Parallel to the pasture program in Chile for some years there has been in operation a plan for forage seed production under the Ministry of Agriculture and with the co-operation of the farmers. There are at present about 3,000 ha. in seed production, yielding enough seed of the different species to meet the country’s needs.

In Colombia, with the exception of a few ranges, the usual practice is to maintain the livestock under extensive pasture conditions without any particular management. The cattle graze throughout the year on swards formed by Para, Guinea, India and Yaragua grasses. To sustain an animal, 1.6 ha. are required. It is felt that improvements in pasture management, including seeding and the use of the pastures in the young stage, might
improve the nutritive condition of the animals. The use of the mowing machine is advised to favor the growth of legumes, to eliminate weeds, and to maintain the pasture in a short and more palatable condition; these steps should help to increase the carrying capacity per unit area.

In Costa Rica, several productive species are now well established including, the following:

<table>
<thead>
<tr>
<th>Grass</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahia</td>
<td>Paspalum notatum</td>
</tr>
<tr>
<td>Carpet</td>
<td>Axonopus compressus</td>
</tr>
<tr>
<td>Elephant</td>
<td>Pennisetum purpureum</td>
</tr>
<tr>
<td>Gamalote</td>
<td>Paspalum conjugatum</td>
</tr>
<tr>
<td>Guinea</td>
<td>Panicum maximum</td>
</tr>
<tr>
<td>Imperial</td>
<td>Axonopus scoparium</td>
</tr>
<tr>
<td>Honduras</td>
<td>Ixophorus unisetus</td>
</tr>
<tr>
<td>Kikuyu</td>
<td>Pennisetum clandestinum</td>
</tr>
<tr>
<td>Molasses</td>
<td>Melinis minutiflora</td>
</tr>
<tr>
<td>Para</td>
<td>Brachyaria purpurascens</td>
</tr>
<tr>
<td>Yaragua</td>
<td>Hyparrhenia rufa</td>
</tr>
</tbody>
</table>

As the pastures are at present deficient in legumes, a concentrated effort is being made to discover types which can be established and to maintain a grass/legume mixture for the production of balanced herbage with a higher protein and mineral content. Some of the promising indigenous legumes are being collected and tested as pure species and in mixtures with grasses.

Work in progress indicates that, in the highlands (temperate zone), Kikuyu grass with white or subterranean clover (Trifolium subterraneum) makes excellent pastures, and that in the intermediate zone (8,752 to 17,304 ft.), Molasses grass (Melinis minutiflora) blends well with white clover (Trifolium repens). In the lower lands of Guanacaste, mixtures of Yaragua (the dominant grass in this area) can be made with tropical Kudzu (Pueraria javanica), velvet bean (Stizolobium deeringianum) and Alsike clover (Trifolium hybridum).

Strains of common grasses are being tested for higher production of better quality herbage, and the effects of fertilizers and animal manure on the yield and composition of herbage are being observed. Laboratory facilities have been provided at "El Alto" for the analysis of samples of herbage cut at different stages of growth and under different systems of treatment and management.

It is considered that one of the fundamentals for successful livestock production, namely "a standard of management which ensures effective utilization of feed and the maintenance of stock
in constant good health" is the most difficult part of the program to achieve because it embraces simultaneously the management of both grass and animals. This depends very much on those who carry out the daily routine tasks and many have not yet acquired the necessary skill in modern methods of pasture and livestock management. In helping to overcome this difficulty the extension service, established in 1948, and now having over 60 officers at 32 centers, has been most useful.

At the "El Alto" animal research center and at "El Capulin" research covers different methods of grazing, varying intensities of defoliation, use and effects of fire for grass control, and the conservation of surplus grass as hay and silage. Suitable farms are being used for the demonstration of practices and the need for concentrates and mineral mixtures is being studied. A soil survey of the country is now well advanced and this is being followed by research into mineral deficiencies which may be reflected in deficiencies in the forage and in animal health and production.

In El Salvador, technicians of the Ministry of Agriculture and FOA (recently re-named International Co-operation Administration) are conducting experiments to compare Para, coastal Bermuda Pangola and other grasses for fattening steers. Also, on account of the very high price of corn, root crops are being tested for the feeding of swine.

In Panama, laboratory and field facilities have been established for investigations and demonstrations of pasture problems, but sufficient personnel is still lacking. Plants used for pasture improvement include: Pueraria javanica, Panicum barbinode, and Hyperrhenia rufa.

In Paraguay, in the work of STICA, a number of species have been found of special value. An indigenous species, Paspalum guenoarum, (P. rojasii — pasto rojas), has given excellent results, being superior to Hyperrhenia rufa (Yaragua) or Chloris gayana (Rhodes grass) in the maintenance of a uniform level of production throughout the year; seed production is also good. Avena strigosa var. glabrescens is proving valuable for winter grazing. Among the legumes, two indigenous species of Vicia (V. selloii and V. graminea) are promising, and introductions of Vicia obscura, Trifolium repens, T. Hirtum and T. pratense have shown good behavior. At present, improved pastures are based on the use of Paspalum guenoarum, Chloris gayana, Hyperrhenia rufa, Pennisetum purpureum, Panicum maximum and cereal rye.

In Uruguay, trials are being conducted at "La Estanzuela" on the effect of mineral fertilizers and inoculation on the yield of legumes. A pasture fertilized with 1,760 lb. of superphosphate per ha. produced 17.5 tons more green weight per hectare than
the control; more than half the vegetation was composed of native clovers and fine grasses, while the control plots contained species of *Stipa* and weeds. Similar results were obtained on a mixture of alfalfa and rye grass L.E. 284 (*Lolium multiflorum*); the degree of response to the fertilizer was related to the proportion of alfalfa in the mixture.

In all soils a favorable reaction to phosphatic fertilizer was found which was not the case for lime. In these cases the hyperphosphate was more economic than the use of lime and superphosphate. In alkaline or neutral areas superphosphates or similar fertilizers should be used.

The experiments with fertilization and rotation have shown that it is more convenient to use phosphatic fertilizers on legumes which precede cereals rather than directly on cereals not preceded by crops which increase organic matter content and improve soil texture.

Experiments on pastures have shown that both quality and production increase after the application of phosphorus.

In trials initiated in 1948 on a crop rotation of fertilized alfalfa (2 to 4 years) with wheat, maize, oats and flax, the yield of wheat was doubled as compared with the control plots. The integration of crop and livestock husbandry constitutes a decisive factor in preventing any further decrease in cereal yields, even on lands which have been in continuous crop production for 50 years. Experimentally it has been shown that this procedure has resulted in the recovery of the productive capacity of the soil.

In the Forage Crop Department at “La Estanzuela,” trials are in progress on the pasture value and seed production of the following grasses and legumes:

- *Agropyron elongatum*
- *A. intermedium*
- *Arrhenatherum elatius* var. *tualatin*
- *Bromus carthaticus*
- *Dactylis glomerata*
- *Dactylis maritima*
- *Phalaris arundinacea*
- *Festuca elatior*
- *Trifolium pratense*
- *Lolium multiflorum* T. *procumbens*
- *L. perenne* T. *repens*
- *Lotus corniculatus* T. *subterraneum*
- *Medicago sativa*

A special service has been set up in Uruguay for the multiplication and distribution of various grasses and legume seeds. In the year 1954/55, the production by the station at “La Estanzuela” of seed of forage plants for intensive multiplication in subsequent years was as follows:

- Italian rye grass (*Lolium multiflorum*) .......... 22 050 lb.
- *Vicia* ........................................ 11 025 lb.
In Jamaica, pasture research is closely related to work on livestock breeding, husbandry and nutrition. The officers dealing with the different sections work together as a team and so ensure that the work has a practical application and that the economics of the industry will be considered. There are three stages:

A. A search for new species or varieties to give greater carrying capacity and for a grass which will supplement the other grasses during periods of dormancy or reduced yield. Drought-resistant strains are required. A wide range of species and varieties has been introduced but so far only very few have shown promise. Most of the legumes have given very disappointing results.

B. Establishment of observation plots for promising types, to make recordings of chemical tests, weights, leaf/stem ratio, growth behavior and fertilizer requirements. The results obtained are used in selecting varieties for further tests, not to determine their potential value as pasture species.

C. Planting several acres of the best grasses for pasture trials. These are fertilized and yields are recorded. The steers used in the experiments are weighed through the trials to determine their yield of beef per acre. Trials on management and comparisons with other grasses are also made. The first year is used to develop the technique of pasturing the species to the best advantage and the actual trial begins after this.

The following are some of the results obtained in the pasture trials:

(a) The native flat grasses predominantly *stenotaphrum secundatum* have been tested for six years to determine feeding value and management. Yields could be increased appreciably by subdivision, mowing, rotational grazing and the application of fertilizers, but they are still too low for economic production and the response to treatment too small to cover the costs. The carrying capacity is 3 to 5 acres per steer. Live-weight increases of up to 1 lb. per head per day were obtained, but these were still uneconomical. This species is the chief grass in the undeveloped upland pastures. Because of its limitations, attention is now being directed towards Pangola grass (*Digitaria decumbens*) and Coastal Bermuda grass (*Cynodon dactylon*).
(b) Feeding trials have been conducted for six years on Napier grass (*Pennisetum purpureum*) with promising results. Twelve steers were maintained on 9 acres and gave an average increase of about 2 lb. per head per day for 9 months during the growing season. During the past two years, enough fodder was cut to make silage for the time of shortage. An undesirable character of this grass is its long resting period in the autumn and winter months. Experience has shown the need of grazing for no more than 4 days at each time of pasturing. Eighteen pastures are necessary for the best rotation. Napier grass requires heavy application of fertilizers. When the grass is cut, it lasts for only 2 to 3 years, whereas it can be maintained for 6 years when pastured. A trial is in progress at present to work out the ratio of acreage of Pangola and Napier grasses necessary to provide fodder throughout the year; both grasses have different resting periods and complement each other.

(c) In 1950, Pangola grass was introduced and has so far been the most promising species. Liveweight increases of 2 to 2½ lb. per head per day have been obtained during periods of good growth. Extensive feeding trials have been made to compare Pangola with Guinea grass (*Panicum maximum*) and Coastal Bermuda, as well as studies of methods of management and response to fertilizer. Pangola has about 24 percent dry matter compared with 16 percent in Napier grass, and it is much more leafy.

(d) Research on Guinea grass is in progress at the dairy cattle breeding center. This is the best grass for the coastal plains. It is difficult to pasture in such a way as to maintain maximum production. When properly managed, a higher milk production has been obtained. Eighteen pastures are necessary for proper feeding and to maintain the pastures themselves in good condition. One hundred and fifty cows, dry stock and heifers are maintained on 230 acres (about 0.8 acre per cow). The land is irrigated and the average daily temperature is between 85° to 90°F. (29.4° to 32.2°C.). The yield per acre is approximately 7,000 lb. of milk (5 percent butterfat) in 305 days with twice daily milking. Pangola grass is now being grazed at this station, and has not so far increased the yield of milk as compared with Guinea.

In the *United States of America*, the mapping of the soils and determination of the conditions of pasture and range land, based on the botanical composition, are an integral part of the technical assistance extended to co-operators in the grazing industry in soil conservation districts. Soil maps and land capability information
are used for conservation planning of the crop land and tame pasture areas. Plans for correct management of range land are based on site and condition inventories supplied to the land operators. Agencies administering federal grazing land also map these and determine grazing capacities in order to be able to advise on the improvement of these lands for the grazing industry. Substantial progress is being made in the mapping and determination of the productive capacity of privately and publicly owned land in soil conservation districts. A national inventory of all pasture and range lands is urgently required, with particular reference to their potential composition, ecological status, present condition, productive capacity and possibility for improvement.

Research and demonstration programs for grassland management in the United States of America are conducted primarily by the Agricultural Research Service, the Forest Service and the Soil Conservation Service of the Department of Agriculture, the Bureau of Land Management of the Department of the Interior, and the state agricultural experiment stations.

In the work of the Agricultural Research Service, most of which is co-operative with the states, the state experiment stations generally furnish office, laboratory, greenhouse and field facilities. Centers provided primarily by federal funds include Plant Industry Station, Beltsville, Maryland; Regional Pasture Laboratory, State College, Pennsylvania; Northern Great Plains Field Station, Mandan, North Dakota; U.S. Range Livestock Experiment Station, Miles City, Montana; Central Plains Experimental Range, Nunn, Colorado; Southern Great Plains Field Station, Woodward, Oklahoma; and the Jornada Experimental Range, Las Cruces, New Mexico. At the Pasture Laboratory, excellent laboratory, climatic control chamber, and greenhouse facilities are provided for fundamental work in physiology, nutrition, genetics, pathology, and soils phases of grasslands. Extensive land facilities are required for range management studies in the Great Plains. For example, at the Southern Great Plains Experimental Range there are approximately 4,000 acres involving 60 different pastures varying in size from 60 to 200 acres. On the Jornada Experimental Range there are 105,000 acres, including 18 different pastures. The Central Plains Experimental Range includes 30 pastures totaling 9,500 acres. At Mandan, North Dakota, and Miles City, Montana, the acreage involved is 1,200 and 1,800, respectively. In the humid regions land required for pasture experiments is much less, with individual pastures usually varying in size from one-half to 4 acres. Small plot studies involving plots about 6 x 20 ft. in size are conducted at a number of locations.

In the Forest Service program a network of 15 major experimental ranges or field laboratories forms the backbone of research
on management and improvement of range lands for maximum production of forage, livestock and livestock products. One or more of these field laboratories is located in each of seven major native vegetation types of the western and southeastern United States of America used for grazing by livestock. Each of these, in addition to providing centralized locations for field research, provides demonstration in grassland management and improvement.

The Soil Conservation Service assists farmers and ranchers in approximately 2,650 soil conservation districts in the United States. These districts cover four-fifths of the farm and range lands in the country, including more than 90 percent of individual farms and ranches. The basic purpose of the program is to assist bringing about adjustments in land uses and treatments and in the use of water and forage resources, establishing a permanent and balanced agriculture, and reducing the hazards of floods and sedimentation. This purpose is served by the development of a well rounded, co-ordinated program of soil, water and plant conservation and land use. The program involves making conservation plans for individual farms and ranches, assisting groups of landowners in improving facilities for the use and disposal of water, work with soil conservation districts and on watersheds and other use areas; and the application and maintenance of all known adapted conservation practices and treatments on the different kinds of land in accordance with their needs and capabilities as shown by detailed land capability surveys. Approximately 2,500 technicians are specifically employed to help farmers under the Soil Conservation Service program.

Emphasis on research in grasslands is placed on development of superior varieties, improved cultural, production and management practices, and better methods of seed production. Basic studies of plant diseases, physiology, breeding behavior, and other factors of forage plants related to their improvement and culture are stressed. Research is under way on species and species combinations to meet the wide variety of climate, soil, and use conditions throughout the country; methods of establishment, culture and management to provide the most economical and stable returns with various species and under different conditions; methods of weed and brush control in pasture and ranges; measures for the control of hazards to stands and production such as diseases, insects, unfavorable weather, and misuse by man or the grazing animal, and methods of harvesting and preserving forage for subsequent use in adverse or stress periods. Closely coupled with the demand for improved varieties has been the need for rapid increase of seed of new varieties in sufficient volume for general use on the farm.

It is not feasible to list all significant accomplishments in the
grassland improvement program and the following are merely indicative of the progress from recent studies in the United States.

Spectacular increases in yield are being obtained in improved pastures and ranges through the use of more productive species combinations, improved varieties, renovation, adequate fertilization, better grazing management, and other techniques developed by research. Increases in production of 4 to 6—fold are not common. From this research program have come deep-rooted, tall growing, productive grasses and legumes such as brome grass (*Bromus inermis*), Ladino clover (*Trifolium repens* var. *giganteum*), and alfalfa for the northern part of the East; orchard grass (*Dactylis glomerata*) and Ladino clover for the middle latitudes; tall fescue (*Festuca arundinacea*), Ladino and crimson clovers (*Trifolium incarnatum*), Bermudagrass (*Cynodon dactylon*), Dallis grass (*Paspalum dilatatum*) and Bahia grass (*Paspalum notatum*) for the South, and crested wheat grass (*Agropyron cristatum*) and other wheat grasses for the West. Notable among improved strains of these species are: Lincoln brome grass; Pilgrim white clover (large type similar to Ladino); Dixie crimson clover; Ranger, Buffalo, Atlantic, Williamsburg, Narragansett and Vernal Alfalfa; Coastal and Suwanee Bermudagrass; Nordan crested wheat grass.

Birdsfoot trefoil (*Lotus corniculatus*) is becoming increasingly important as a legume in hay and pasture. In many areas, it has given better stand survival than Ladino clover and the bloat problem is less acute. At the Dixon Springs, Illinois, station, after two successive dry years, birdsfoot was one of the few pasture legumes which survived and it produced over 3 tons of dry matter per acre. Lambs fattened on this pasture for early market sold in June for $29.50 per cwt. Lambs on pasture grass alone did not fatten and were sold the following autumn, after feeding, for only $20.00 per cwt.

Dallis grass (*Paspalum dilatatum*) is one of the most important perennial pasture grasses in the South, but its usefulness is limited by its total susceptibility to the ergot fungus. Because of this susceptibility, seed supplies of Dallis grass are limited and there is danger of ergot poisoning of livestock. The Mississippi station is making good progress in the development of seed producing and ergot-resistant strains. Progeny from a Dallis grass x *Paspalum malachophyllum* hybrid have proved to be highly resistant to ergot.

Fundamental taxonomic, physiological and ecological studies are contributing to the understanding of factors responsible for range deterioration or improvement, of relationships between climatic variation and plant growth, and to the development of improved grazing practices.

Research on range measurement techniques seeks to develop methods for the appraisal of grazing capacity, the relative condition
and trend, and other features of range lands essential to evaluation, management and improvement of such lands. An objective method for determining range condition has recently been developed by technicians of the Soil Conservation Service.

Pasture renovation by thorough working of the sod, fertilizing and seeding to produce tall growing species mixtures, such as orchard grass-Ladino clover, brome grass-alfalfa, or Bermuda grass-clover, greatly increases total production and distribution of production. Research has shown that renovation can more than double production from unimproved pastures. The quality of forage is improved by the introduction of nutritious grasses and legumes and by fertilization.

Dryland seeded pastures decrease in productivity, even though maintaining stands, as they become older. The Wyoming Station (co-operative USDA) learned that crested wheat grass (*Agropyron cristatum*), Russian wild rye (*Elymus junceus*), and western wheat grass (*Agropyron smithii*) respond to severe renovation as well as to applications of nitrogen. The degree of response, however, is directly related to the amount of spring moisture. The combination of renovation and fertilization gives higher production than either fertilization or renovation alone. In years of low amounts of spring moisture the increased production does not pay for the cost of applying fertilizer, but with ample rainfall a new gain of more than $15.00 per acre above the cost of the fertilizer and its application is obtained.

An awakening to the fact that species with high yielding potential will respond to relatively large applications of fertilizer and that plant feeds applied to pastures will give as economical returns as such applications on cultivated crops has been a big step forward in pasture improvement. Coastal Bermuda grass (*Cynodon dactylon*), fertilized with 200 lb. per acre of nitrogen, has produced over 700 lb. of beef per acre. Species such as Ladino clover and alfalfa are potash-loving plants, and recent studies have shown greater response to potash than to phosphate on many soils. In some of the range areas of the West, sulphur and nitrogen have given outstanding results.

Research on mountain meadows by the Colorado station now suggests the possibility of producing “super hay” which may take the place of costly protein supplements in winter feeding. Controlled irrigation and the application of 480 lb. of nitrogen per acre produced hay containing 2,400 lb. of crude protein per acre. If further feeding tests prove to be satisfactory, it may be possible for ranchers to set aside areas of their meadows to raise the high protein hay and thus avoid the necessity of buying protein supplements.

The importance of knowing the reaction of all types of forage plants to fertilization is shown by studies at the Oklahoma Station
where it was found that the influence of fertilization on the quality of protein varies in different plants. With Sudan grass (*Sorghum sudanense*), although the yields were greatly increased by fertilizers, the relative amounts of the principal amino acids remained essentially the same. On the other hand, fertilization of alfalfa brought about a substantial variation in the leaf/stem ratio and, since the composition of the leaf and stem protein differs, the composition of the whole plant is affected by fertilizer treatments.

The irrigation of pastures in humid areas is a comparatively recent development but recent research has shown that supplemental irrigation plays as important a part on pastures as it does for cereal or row crops. The Indiana station found no difference in animal daily gains on irrigated and non-irrigated pastures, but a heavily grazed irrigated Ladino clover-brome grass pasture produced about 500 more sheep-days per acre for the grazing season than did a similar non-irrigated pasture.

During an exceptionally dry pasture season the North Carolina station found that supplemental irrigation increased milk production 35 percent, total digestible nutrient yield 109 percent, days grazed 70 percent, and carrying capacity 100 percent. It is pointed out, however, that only high yielding, well fertilized pastures can be irrigated profitably.

The Massachusetts station has reported that, by applying adequate potash, increases of 30 to 80 percent in hay production were obtained for the first 3 harvest years. Although liberal amounts of potash fertilizer were applied 3 times each year, the grasses studied removed 79 to 94 percent of the application during the 3 years.

Perennial and annual weeds result in approximately 9% reduction of potential forage yield on the 1,200 million acres of pasture and range lands in the United States of America. Research has shown that a 20 to 60 percent increase in forage production will result from the chemical control of weeds on infested pasture and range lands.

Recent results on salt-desert-shrub winter ranges in Utah and ponderosa pine ranges in Colorado continue to confirm that moderate grazing (50 percent or less of current production of desirable native range plants) plus other good grazing practices improve the forage cover, nearly double the income, and control undesirable range plants.

Development of methods for managing and improving range grazed by herbivorous big game animals and correlation of this use with grazing by livestock is being studied. General principles applying to intensity of range use by livestock also apply to range used by big game animals. Big game and livestock use, in common, many of the same plants and range areas, but the degree
of competition varies with animal and plant species, and season and intensity of use. All of these factors must be considered in determining optimum stocking for either game or livestock, and in manipulating the forage supply through management.

Research on grazing influences shows that grazing of lands useful also as timber producing lands or watersheds (catchment areas) may require additional consideration of the grazing practices or timber harvesting practices for optimum production of timber, water and forage. Research on the relation of grazing to rodent population has shown that grazing practices may influence these populations and, in turn, the impact they may have on range grazing capacity.

An intensive series of studies in Colorado and New Mexico showed that as ranges improved in condition as a result of conservation management the green feed season is lengthened, calf crops are higher, calf ages are more uniform, individual cow and calf weights are heavier, and the gross yield of beef is invariably increased. The average of all ranches studied showed that those in poor condition produced 405 lb. of forage and 8 lb. of beef per acre. Potentially similar ranches with their range in good condition produced 1,026 lb. of forage and 14 lb. of beef per acre, an increase of 253 percent in the forage yield and 175 percent in beef production.

After 20 years of federal range management under the guiding principles of the Taylor Grazing Act, the major destructive uses of the public grazing lands have been eliminated. An outstanding example of the results of effective range management has occurred on the Nipple Rim area of Colorado Grazing District No. 6. A detailed study indicated that over a 13-year period from 1937 to 1950, with range use in accordance with grazing capacities and proper seasonal use, the downward trend of forage values and ecological plant succession occurring prior to managed grazing had been stopped. An upward trend was being maintained in quality and quantity in forage. An outstanding increase in abundance, vigor and distribution of grass species in all range types was the earliest significant response to proper management. In some places grass increased at least tenfold. The protective cover developed by increased vegetation has had a marked effect on reducing surface run-off of water and increasing percolation. Litter and humus are building up, raw draining channels are becoming sloped and covered with perennial vegetation, and head cutting of gullies has been slowed or stopped.

The Nebraska station compared lactating cows on an irrigated Ladino (Trifolium repens var. giganteum) — brome grass (Bromus inermis) pasture with a comparable group in dry lot. The pasture saved 5 lb. of hay, 35.9 lb. of silage, and 4.1 lb. of grain per
cow day and these savings amounted to $114.00 per acre for
the grazing season.

A federal forage crop improvement program in the United States
of America is divided into research projects devoted to breeding,
and cultural work in each of the following fields: (i) soybean;
(ii) alfalfa; (iii) clovers (Trifolium and Melilotus sp.), (iv) grasses,
(v) lespedeza (Lespedeza sp.), (vi) pasture and range production in humid areas, (vii) pasture
and range investigations in arid and sub-humid areas, and
(viii) foundation seed production. Federal workers are en-
couraged to conduct fundamental studies on methods of breeding,
cytogenetics and other pathological and physiological investiga-
tions, directed toward assisting or stimulating applied breeding
breeding work at state experiment stations. Many federal per-
sonnel are located at state agricultural experiment stations and
their programs are supported to varying degrees by state funds.
Although the type of federal program conducted at a given location
varies with needs and conditions these programs are initiated on
the premise that federal personnel have regional responsibilities
and consequently any breeding work should be directed towards
the region in which they are located. Regions will generally
involve several states or more restricted areas depending on cli-
mate, soils and the species involved in the program. Active
co-operation among state-supported grass and/or legume breeding
programs and the co-operative state-federal programs mentioned
above is encouraged. Co-operation is realized through conferences
and the exchange of reports and experimental material, and by
virtue of the fact that federal workers are located at state ex-
perimental stations.

At the present time breeding work is in progress in the United
States of America with the following legumes:

Alfalfa (Medicago sativa) Soybeans (Glycine max.)
Lespedeza cuneata Sweet clover (Melilotus sp.)
L. stipulacea Trifolium incarnatum
Lotus corniculatus T. pratense
Lupinus sp. T. repens

T. subterraneum

The main grasses that are receiving attention include:

Andropogon gerardii Bouteloua curtipendula
Agropyron cristatum B. gracilis
A. intermedium Bromus inermis
A. trichophorum Bromus carthaticus
Plant introduction is basic to, and forms the initial step in, grass and legume breeding. There are at least two principal reasons for this emphasis on plant introduction. Firstly, a considerable portion of the livestock industry in the United States of America is based on legumes and grasses introduced from other countries. All of the 40 to 45 major legume species and approximately two-thirds of the 80 or so major forage grasses used on improved pastures were introduced into the United States from foreign lands. The range land of the great plains and western intermountain states consists primarily of native species, but thus far introduced grasses have been used more extensively in re-seeding abandoned farmland and deteriorated range than have the native species. Naturally, there is a good expectation that new introductions can result in bringing other valuable species to the farmers and ranchers of the United States.

Secondly, the large number of forage species together with limited personnel and financial support, means that concentrated breeding work cannot be devoted to each and every species. At the present time breeding work with some important grasses and legumes is very limited and many species are not receiving any attention whatsoever. Introductions provide an avenue for isolating superior strains in the absence of organized breeding programs.

Interspecific hybrids have been obtained between *Paspalum dilatatum* and *Paspalum malachophyllum* which have given rise to Dallis grass segregates that are immune or highly resistant to ergot (*Claviceps paspali*). Johnson grass (*Sorghum halepense*) — sorghum (*Sorghum vulgare*) hybrids have led to the production of perennial sorghum types and sweet Johnson grass lines. Selection work is continuing with the ergot-resistant Dallis grass lines while seed of the experimental Johnson grass-sorghum hybrids was to be distributed for testing in 1955. Hybrids have also been obtained by crossing *Lolium multiflorum* and *Festuca elatior* and *Lolium perenne*. These hybrids are sterile, but results suggest that it should be possible to restore fertility by utilizing colchicine. The objective of these programs is the production of fescue strains.
which are vigorous and palatable. Many other examples could be listed here, including a wide variety of crosses among species of Poa and Dactylis. In addition, some work has been done with Agropyron-Triticum hybridization but in common with similar programs in other countries, most of this work has been directed towards wheat grass improvement. Continuation of this work will emphasize the development of forage types. Other Agropyron hybrids, especially Agropyron-Hordeum and Agropyron-Elymus, are in the process of being examined for possible economic utilization. A natural hybrid between Oryzopsis hymenoides and Stipa viridula has been increased and is being evaluated in regional tests.

Interspecific hybridization in the leguminosae has been discouraging. Hybrids have been difficult to obtain and where crosses have succeeded, the resulting hybrids either fail to develop or are highly sterile. Nevertheless, interspecific hybridization in the legumes present some fascinating possibilities and should be expanded. Thus, it has been possible to transfer the low coumarin genes of Melilotus dentata to Melilotus alba. The cross between Melilotus alba and Melilotus dentata is successful, but the resulting hybrid seedlings are deficient in chlorophyll and do not develop beyond the cotyledon stage. Hybrids have been grown to maturity, however, by grafting them on to stalks of normal plants. The culture of these hybrids has provided a source of low coumarin that has been incorporated successfully into sweet clover breeding programs.

After a new variety has been developed serious problems may arise in producing satisfactory supplies of breeder and foundation seed to initiate a substantial increase of certified seed for farm use. Until recently some rather promising varieties were developed which eventually passed out of existence because of the lack of sufficient seed stock.

In 1948, the National Foundation Seed Project was established in the Forage and Range Section of the U.S. Department of Agriculture with the express purpose of facilitating the multiplication of seed of improved forage crop varieties. In this program breeder seed of accepted varieties is allocated to seed producing states where foundation seed is grown under government contract. Production goals for a given variety are determined by estimates of possible seed usage in the regions where the variety is adapted for forage. Varieties must be recommended to the planning committee of the National Foundation Seed Project by a regional forage crop technical committee and this recommendation must be supported by evidence of superiority. The planning committee includes two representatives designated by each of the four regional forage crops technical committees, two from the International Crop Improvement Association, two from the American
Seed Trade and four from the U.S. Department of Agriculture. This project provides a means whereby promising varieties can be increased rapidly and the seed made available to farmers interested in using them. At present there are five alfalfa varieties, three red clover (Trifolium pratense) varieties and one sudan grass (Sorghum sudanense) in the project and there was a good possibility that an orchard grass (Dactylis glomerata) variety would be added in 1955.

Through the allocation of breeder seed to regions that are well equipped and suited for seed production, it has been possible to bring about a rapid increase in the available supply of certified seed. The progress in building seed supplies of Vernal alfalfa under the auspices of the Foundation Seed Project will serve as an example of what planning can do to shorten the time between the release of a new variety by an agricultural experiment station and the time when seed is available to the consuming farmers. Vernal was approved by the planning conference of the Foundation Seed Project in February 1953. Foundation seed fields were established in Utah and Washington in April of that year. At the same time, 10 lb. of stock seed were planted in California for certified seed production. In six months there were 7,888 lb. of foundation Vernal from a 31-acre field in Washington and 6,400 lb. of certified seed from California. The foundation seed was allocated by the planning conference of the Foundation Seed Project to states interested in producing seed of this variety. As a result of this co-operative effort, approximately two million lb. of certified Vernal alfalfa seed was made available in 1954 — 18 months after the initial plantings were made with breeder seed. In 1955, an estimated six million lb. of certified seed was produced. This rapid increase of certified seed contrasts sharply with the slow increase that was possible prior to the initiation of the Foundation Seed Project. Certified seed supplies of Ranger and Buffalo alfalfa can be cited as further evidence of the program’s value. In 1949, the production of certified Ranger seed was 1,101,250 lb. while in 1953, there were 27,160,000 lb. of certified seed. The increase in Buffalo alfalfa was from slightly over 300,000 lb. in 1949 to almost nine million lb. in 1953.

A grassland problem of particular concern to Argentina, Brazil, Paraguay and Uruguay is the lack of winter-growing species in the natural pastures of Northern Argentina, Southern Brazil, Paraguay and Uruguay. There is generally adequate grazing in these natural pastures in the spring, summer and autumn, but the winter period is critical. Cattle which gain up to 440 lb. from spring to autumn may lose half of this gain in weight in the subsequent winter, and it usually takes 4½ to 5½ years for steers to reach a market weight of 1,100 lb. Research on indigenous
and exotic species suitable for winter grazing would, in association with fodder conservation programs, contribute greatly to the solution of the problem.

Conservation of Fodder as Silage and Hay

In tropical regions where there is a marked variation in growth between the wet and dry seasons, conservation of forage constitutes one of the important means by which the shortage of grazing in the dry season may be offset. In other areas, such as the one mentioned at the end of the previous section of this chapter, livestock producers are more interested in the possibility of provision of winter grazing, but also have a definite interest in fodder conservation to supplement winter grazing and to meet emergencies.

In either type of area there are special problems related to silage crops adapted to growth and conservation in these areas, to legumes which may be used in silage to increase the protein content of the ration, to efficient methods of harvesting, to the use of preservatives in silage making, and to feeding practices when silage is used. The costs of harvesting and of feeding silage must also be taken into account in relation to the advantages gained through more adequate feeding. Much interest was expressed in this subject at the Baurú meeting and participants in the Buenos Aires meeting were, therefore, asked to present new information on the developments in their countries. That information is summarized in the following paragraphs.

In Argentina, silage production and preservation in farm practice includes the use of maize, alfalfa, sorghums and grass/legume mixtures. The types of silos used vary with the zones of the country and the character of the subsoil. Temporary silos of the stack type are commonly used where there is a relatively impermeable clay subsoil. Trench silos are used in dry or well drained soils and the material may be stored for many years as an emergency fodder reserve. Tower silos are rarely used apart from certain dairy farms. It is essential to mechanize the harvesting and transporting of the green material to reduce the cost of the operation. Crops to be ensiled should have a high yield per unit area and silage quality is higher if the crop is free of weeds. Efficient use of pastures in Argentina often involves making of feed reserves, such as silage, during the lush periods. For example, in the Province of Buenos Aires there are two production peaks in alfalfa during the year, the more important in the spring and the other in the autumn. Production reaches the lowest level during the winter. Thus, storage of surplus forage during the spring is essential if a constant number of animals are to be fed more or less
uniformly during the year from a given land area. Variations in protein content of several crops used for silage in Argentina are shown in Table 15.

**TABLE 15 - PROTEIN CONTENT OF VARIOUS SILAGES IN ARGENTINA***

<table>
<thead>
<tr>
<th>Crop</th>
<th>Stage of Growth</th>
<th>Crude Protein</th>
<th>Digestible Protein</th>
<th>Moisture</th>
<th>Digestible Protein in Dry Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixture of alfalfa, whiteclover, and rye grass</td>
<td>Grasses and legumes blooming</td>
<td>5.35</td>
<td>1.29</td>
<td>52.10</td>
<td>2.69</td>
</tr>
<tr>
<td>Bromus catharticus and Phalaris minor</td>
<td>Blooming</td>
<td>4.65</td>
<td>1.65</td>
<td>73.41</td>
<td>6.20</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>Blooming</td>
<td>7.35</td>
<td>2.73</td>
<td>67.40</td>
<td>8.37</td>
</tr>
<tr>
<td>Weedy cut of Alfalfa</td>
<td>Blooming</td>
<td>5.58</td>
<td>2.75</td>
<td>67.10</td>
<td>8.35</td>
</tr>
<tr>
<td>Sweet Sudan</td>
<td>Ripe grain</td>
<td>1.97</td>
<td>0.45</td>
<td>82.25</td>
<td>2.53</td>
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<tr>
<td>Sweet Sorghum</td>
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<td>2.92</td>
<td>0.85</td>
<td>75.50</td>
<td>3.46</td>
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<tr>
<td><em>Silybum marianum</em></td>
<td>Before blooming</td>
<td>2.59</td>
<td>0.71</td>
<td>83.00</td>
<td>4.17</td>
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<tr>
<td>Peas</td>
<td>Green grain</td>
<td>3.84</td>
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<td>69.00</td>
<td>7.58</td>
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<tr>
<td>(plants and pods)</td>
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<td>2.35</td>
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* Analysis made by Ing. Agr. M.A.L. Reichart

In Chile, there are great variations in climatic conditions, both from high to low altitudes and from the north to the south of the country. In the irrigated valleys many tower silos had been built with government credit, but there is now some question as to whether pastures with cool season species, properly fertilized, may not make silage unnecessary. Silos are of particular value in the cold climates with long winter seasons; it is, however, always desirable to attempt to produce pastures particularly suitable for winter grazing before undertaking the making of silage.

In *El Salvador*, the principal problem in the production of cattle is their maintenance during the severe part of the dry season extending from January through April. During this period the cattle suffer severely from lack of forage and water, often becoming very emaciated and sometimes dying. There are abundant rains from May to October and light rains from October to January. While it is a common practice to move cattle from the highlands to the fertile lowlands during the dry season, some progress has been made in the use of silos to store a part of the green forage during the rainy season to feed the animals during the dry season. As part of a campaign started by the Agricultural Extension Service in 1948, agents help in planning and filling the silos and
return for the opening of new silos to advise the farmers on the use of silage. Guinea grass (Panicum maximum), Yaragua (Hyperrhenia rufa), Para (Panicum purpuroscens), elephant grass (Pennisetum purpureum), corn, sorghum, pigeon peas (Cajanus cajan) and frijol criollo (Phaseolus sp.) are being used. The legumes are always used with grasses such as sugar cane tops, and sorghum. Trench silos are commonest because of their low cost. Beginning with one silo in 1948, the number built has increased each year until 1954 when 39 were built, making 111 in all. It is believed that there are an equal number which have not been supervised and counted by the Extension Service. There is no longer a prejudice against the use of silage and dairymen and consumers no longer suffer from a marked shortage of milk during the dry season.

No silage is made in French Guiana.

In Panama, the crops used for silage include: maize, sorghum, beans, kudzu (Pueraria javanica), Crotalaria, Guatemala grass (Tripsacum dactyloides), Para grass (Brachyaria purpurascens), Guinea grass (Panicum maximum), imperial grass (Axonopus scoparius) and Yaragua grass (Hyperrhenia rufa). The best months in which to make silage are October and November, towards the end of the rainy season.

The United States of America had, according to the 1950 census, 680,000 silos, 90 percent of which were tower silos and the remainder chiefly trench silos. The average capacity was 103 tons. Crops ensiled include maize (73 percent of all silage), grass crops (9 percent) and sorghum (of great importance in the dryland areas of the Great Plains and the South). Attempts made to self-feed silage from the base of tower silos have not been entirely successful; some degree of mechanization has been successful in top unloaders and bottom unloaders. Extraction of silage from trench silos is efficiently effected by means of hydraulic manure scoops to load the material into wagons or trucks for transport to the livestock. Many operators are self-feeding silage from the trench by means of a movable barrier at the face of the silage.

Results published by the U.S. Department of Agriculture (Shepherd et al., 1954) have shown the increased efficiency of making the alfalfa crop into silage rather than hay; about 12 percent more milk per acre can be produced. When the hay suffers damage by rain, about 28 percent more milk was produced due to greater retention of the leaves in the crop. The result has been a higher content of total dry matter, protein and carotene in the silage than in the hay, with equivalent demands on motor and manpower.

The use of chemical preservatives is now receiving considerable attention in the United States of America. Recently a commercial
product named "Kylage" has become available, produced under patent rights and similar to a German product "Kofa." It consists largely of a mixture of calcium formate and sodium nitrate.

In many parts of the United States, silage made from hay crops is being used to supplement pastures during periods of low rainfall in the summer, thus providing a more uniform level of feeding and leading to increased livestock production.

The making of hay is very difficult under tropical conditions. However, it is of such potential importance that efforts should be made to develop the special techniques which may be necessary. Such methods might be based on the utilization of the great heat of the sun's rays, while at the same time ensuring protection for the herbage against their direct influence, to prevent loss of carotene. The storage of baled hay through a rainy season frequently presents special difficulties in the tropics. In studies of hay making and the use of hay, three problems should be considered:

(1) the need to cut the grass while it still has considerable nutritive value;
(2) the prevention of deterioration in baled and stacked hay due to molds; and
(3) the undesirability of excessive cutting of grasses which may eradicate them and favor weeds.

Relatively little new information on these problems or on ways of solving them is available.

In Argentina, there is no research specifically on hays or haymaking. Hay produced in irrigated zones is green, leafy and of high quality; hay from dry zones is poor in quality, many leaves are lost in handling, and the color is poor. Eight cuts are obtained from some irrigated land and three or more cuts from dry land, with a yield 5,500 lb. to 7,700 lb. per ha. per cut. Both the old-fashioned and more modern methods of cutting, loading and transporting are used. Alfalfa is practically the only hay crop. The effect of unfavorable weather during the haymaking season may be reduced by the use of modern farm machinery. The use of round bales practically prevents damage by rain in the field.

Haymaking, particularly of alfalfa, is most important economically in Chile. The methods already noted for Argentina are practised. In the colder southern part of the country, alfalfa is replaced by red clover, but the crop is frequently damaged due to variable weather conditions. Oats are used for hay in the extreme south.

In French Guiana, conditions are most difficult for haymaking,
particularly in the lowland areas which are accessible only in the dry season. It is not yet known whether baled hay of these swamp grasses will keep free of mold during the wet season.

In Paraguay, haymaking is a problem due to heavy rains and overheating of the stored material, and the whole subject requires detailed study.

In Uruguay, good hay can be made consistently only in mid-summer. Dews are heavy at other seasons of the year. Alfalfa is the main hay crop.

Nutritional Deficiencies in Livestock

An FAO Agricultural Study, No. 5, prepared by Allman and Hamilton (1948), brought together information from various parts of the world on the nature and incidence of various kinds of nutritional deficiencies which had been observed in various types of livestock and poultry. This Study provided the main basis for discussion at the Turrialba meeting, at which some new information on the occurrence of deficiencies in the Americas was presented, and further information was forthcoming at the Baurú meeting (Phillips, 1950 and 1953). Additional information was discussed at the Buenos Aires meeting, and an attempt has been made in the compilation of Table 16 to list the countries in which various types of deficiencies have been observed in the Americas. Obviously, this constitutes a very generalized approach, but it does indicate the scope of the problem. Some general observations, also some details concerning occurrences of deficiencies in various countries, which will be of interest to nutrition workers, are summarized below:

General Considerations

Energy shortages are not uncommon even in some sections of the most advanced countries where the level of economic development is low. They are often found in the semi-arid grazing areas, and in grazing areas characterized by dry and wet seasons, owing to inadequate feed reserves for the dry season.

Protein deficiencies, particularly qualitative deficiencies, are also responsible for slow growth rates, lowered milk yields and other troubles in many areas. Such deficiencies are apt to be found, for example, during the long dry season which characterizes much of the Pacific slope. Such deficiencies may be remedied by the use of protein-rich concentrates, or by the adoption of systems
### TABLE 16 - MINERAL EXCESSES OR DEFICIENCIES CAUSING NUTRITIONAL PROBLEMS IN THE AMERICAS*

<table>
<thead>
<tr>
<th>Country</th>
<th>Bone Diseases</th>
<th>Boron</th>
<th>Calcium</th>
<th>Cobalt</th>
<th>Copper</th>
<th>Fluorine</th>
<th>Excess</th>
<th>Iodine</th>
<th>Iron</th>
<th>Magnesium</th>
<th>Excess</th>
<th>Molybdenum</th>
<th>Nitrate</th>
<th>Phosphate</th>
<th>Pica</th>
<th>Protein</th>
<th>Selenium, Excess</th>
<th>Sulphur</th>
<th>Zinc</th>
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<td>Antigua (British Leewards)</td>
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*In addition to conditions involving specific minerals, reports of lack of vitamin A have been reported from Jamaica and Chile, urolithic conditions in Haiti and Argentina, lack of vitamin E in Jamaica and lack of vitamin D in Chile and acetonemia in Argentina.

...of forage production which ensure either adequate grazing or an adequate supply of stored feed during the dry season.

Improper balance between energy supplies and protein still remains a problem in many areas, since such rations are often wasteful owing to inefficient utilization of the total feed supply.

The use of antibiotics in animal nutrition is a relatively new phase. Study of them has been intensified owing to conditions created by highly specialized production systems and by the need...
for greater efficiency owing to increased costs of production. They have received particular attention in the United States of America. Other problems are perhaps worthy of higher priority in countries where intensive systems of livestock and poultry production are not yet in general use. The same may be said of hormones which are also receiving considerable attention in attempts to find treatments that will increase the efficiency of livestock and poultry production. At the same time, developments arising from research in these fields should be watched carefully to see where they may find effective practical application.

Much of the work on nutritional deficiencies has been related to mineral deficiencies. In this connection it is becoming more generally recognized among animal husbandmen that the mineral content and availability to plants of the minerals in the soils have an important relationship to the health of animals fed on plants grown on those soils. Also, studies of the signs of mineral deficiencies in plants are making available information of much importance to the livestock producer by enabling him to foresee from observations on the plants the deficiencies which may occur in his animals. However, such information cannot replace precise data on the mineral content of feeds and on the specific requirements of the animals.

The need for specific vitamins varies with the kind of animal. But for all, it can be said that good quality green roughage or pasture will take care of most needs. Thus, more attention should be paid to pasture improvement and management, and to better ways of conserving forage for use during non-growing periods. Ruminants, in particular, due to microorganisms in the rumen, have the ability to synthesize certain vitamins. But even non-ruminants do better if they have access to natural feeds in variety.

Care is necessary in considering the deficiency problem for several reasons. Bone chewing and other signs of apparently depraved appetite may be due to general upset, to deficiency of protein and to generally ill-defined hunger, which finds its outlet or expression in this way. The trouble may be temporary and connected with such things as the coming of new teeth in a young animal. It is, therefore, important to ascertain the true cause of depraved appetite with great attention to detail and then to remedy the trouble in the most direct and economical way.

The economics of combatting a deficiency should also be considered. Frequently, it is more economical to provide the minerals which are lacking through the drinking water or in the form of palatable licks, rather than by a direct application to the pasture.

The interconnection between minerals should also be considered. If, for example, an animal receives too little molybdenum, copper
might build up to toxic proportions. The complete copper-molybdenum story is not yet fully worked out, and it seems as though sulphur in some specific form may enter into the final picture.

The general status of the soil, including its acidity or alkalinity, may also affect not the amount but the availability to the animals of certain essential mineral elements. Similarly, minerals in the drinking water of the animals may have an effect, not only on the palatability of the water itself (thus seriously limiting normal water intake), but may affect the appetite and health of the animals and, in addition, have a bearing on mineral imbalance.

Further, it is not enough to ascertain all these things relative to improved nutrition, nor merely to publish the information in scientific, or even popular, journals. The message must be carried to the producers themselves, so that they can put the practices into common use. Search should be made for intelligent, willing co-operators to demonstrate in each community the value of the findings. Such work, and related activities in the extension of knowledge of improved methods of livestock production, opens up a whole new field for trained animal husbandmen in many countries, and one which is basic to increasing the supply of animal proteins. The problems will not be easy of solution in many areas since a chief stumbling block will be the price structure for saleable products, compared with the increased cost of obtaining the product. The stockmen should be shown, for instance, that even with no change of milk or meat prices, by adopting the improved nutritional practices, only half the number of cows will need to be milked; or that beef production per acre can be increased. It is essential, therefore, to show the producer how to increase his income, and, at the same time, keep prices within the reach of the consumer.

Observations in Countries

A type of avitaminosis in ruminants resulting from the continuous ingestion of Cynodon hirsutus and C. dactylon is rather common in Argentina. The HCN liberated from these species in the rumen of the animals seems to destroy the microorganisms which synthesize the B complex vitamins. The situation is aggravated following the first frosts. Affected animals have responded very favorably to injections containing a mixture of aneurin, nicotinic acid, riboflavin and adenine.

Urolithiasis is reported not to exist in some zones in Argentina, but there have been sporadic outbreaks, mainly in sheep, in certain parts of the Buenos Aires province, and in Patagonia, North of the Santa Cruz river. Grass tetany, principally in cattle, is re-
ported as occurring frequently throughout the livestock grazing area. Types of pasture giving rise to the illness are oat, wheat, barley, etc., especially when the environmental conditions favor consumption of forage with a high moisture content.

In addition, hypomagnesemia and acetonemia are reported to occur in dairy cows, as well as various non-specified vitamin deficiencies. In limited areas, a lack of iodine and cobalt affects cattle and goats; the former is deficient in certain valleys of the Province of Salta. The need for cobalt has been recognized in restricted areas of the Province of Buenos Aires, and perhaps in certain parts of Patagonia. The wool of sheep in these latter areas is characterized by brittleness which can be remedied by small doses of cobalt.

While species of *Astragalus* known to have a facility for concentrating selenium in their tissues are found in Argentina, no clinical symptoms of selenium toxicity in animals have been reported, nor was selenium found in the analyses of these plants. Also, no cases of iron deficiencies are known.

In Argentine, the appearance of "anteque seco" is reported to be related to deficiencies of phosphorus and manganese in the native pastures. Affected animals reacted favorably to mineral supplements at the rate of 5 g. of sodium acid phosphate (Na$_2$HPO$_4$) and 0.2 g. of manganese sulphate per head per day.

In Brazil, information has been recorded concerning the State of Piauí, where it has been most dry for three or more years, showing that many diseases described, as Broca, Oca, Mal da Ponta, Mal do Chifre, etc., all have the same syndrome. It has been suggested that all have a common cause in a nutritional deficiency; the area may be deficient in zinc, copper and probably cobalt. Post mortem examination and analysis of livers and spleens of cattle indicate a copper deficiency. Incidentally, heavy internal parasitism adds to the picture of malnutrition.

In a study of infertility of cows made in the State of Minas Gerais clinical observations included hypophosphorosis. Particularly near the Municipio de Pará in the eastern part of the state, groups of cows were encountered in which several years had passed since previous calving. Most of these cows were extremely emaciated, walked rigidly, had perverse appetites and low milk production. When bone meal was offered to these animals it was consumed avidly.

The ruminant (cattle) disease, commonly known as "Chorona, ," "Pela Rabo ," "Rabugem" or "Toca," occurs in the Zona da Mata of the State of Minas Gerais at altitudes above 1,370 ft. Striking emaciation is characteristic of all the conditions described by different names. Recovery is spontaneous upon removal to new pastures. Lack of copper or cobalt or both is attributed to be the
cause, or perhaps plant toxicity. Since copper sulphate medication produced fair results, it is believed this is a metabolic disease.

Congenital goiter is frequent in Minas Gerais State, especially in calves. Mineral supplementation or tincture of iodine treatment resolves the problem.

Deficiencies of Vitamin A and D have been reported in the North and Central Zones of Chile; lack of vitamin A in cattle, together with deficiencies in calcium and magnesium; and avitaminosis and mineral deficiencies in fowls in the southern zones. Specific local deficiencies have not yet been determined, although it is possible that they exist. Forage, both natural and introduced, in the various zones of the country, is being analyzed with a view to determining its mineral and vitamin content.

In Ecuador, numerous cases of osteoporosis and osteomalacia, indicating a Ca/P imbalance, have been reported; goiter in sheep has been reported at 8,230 ft. Sulphur may be lacking, as had been indicated by improvement observed following its administration in sulphurized salt blocks. The main experimental work being done is concerned with methods of overcoming the deficiencies, and so far the best results at lower elevations appear to come from injections of phosphorus calcium gluconate.

In El Salvador, the animal scientists are getting some of their answers from the plantsmen. Agronomic studies indicate that forage grasses are not only deficient in nitrogen, but also in trace minerals such as manganese, cobalt and zinc. The addition of these fertility elements to the soil materially improved plant growth. Iodine is lacking, as evidenced by goiter in humans and hairlessness in young pigs. However, data on which to base conclusions are meager, not only on stock feeds, but also on soils.

Reports from Guatemala indicate a number of areas deficient in one or more of the essential minerals, as determined from blood serum studies. Because the problem is complex and time consuming, no other actual research has been carried out. However, a practical solution has been successfully arrived at through the use of a mineral mixture that contains all the required elements. Continued observations show that goiter is a real problem in the Guatemala highlands. In humans, both potassium iodine and potassium iodate effected marked reduction of endemic goiter.

In Haiti, no direct relationship has been established between soil and plant composition and animal nutrition problems. Nevertheless, it is reported that, in a general way, Haitian soils are high in calcium and deficient in phosphorus and potassium. Animals suffering from a lack of potassium have been observed in a considerable area between Declay and Cap Haitien on the north coast, and in the drainage area behind Hinche (Papaye Breeding Station) in the north central region. Other areas reported as
calcium deficient are found around Kenscoff and behind Miragoane; on the other hand, at Anse a Pitre, a calcium excess is reported in the soil. Salt areas (and thus highly alkaline) have been observed around Port-au-Prince and on the shores of the Artibonite delta. Where soil composition is known in the Artibonite Valley, calcium is definitely in excess, and potassium and phosphorus deficient. In the Camp Parrin and Les Cayes region, where soil minerals have also been studied, phosphorus, potassium and calcium are deficient.

Reports from Honduras indicate that animal nutrition surveys are quite incomplete. In general, the soils of the country are low in phosphorus but sufficient in potash. Indications of mineral imbalance are reports of cases of grass tetany and non-pathological abortions in cattle. On the north coast, animals drink water high in calcium obtained from deep wells. Evidences of osteomalacia have been reported, indicating a Ca/P imbalance. There is also some reason to believe that certain other animal losses may be due to minor element deficiencies, or to maladies associated with lack of minerals. A new laboratory for the analysis of soils, plants and animals has recently been established, which should be invaluable to the work of animal improvement.

Mexico, like most large countries, has a wide variety of conditions. No general account of the soils seems available, although rather complete analyses are at hand for at least two areas — the Comarca Legunera in the western part of Jalisco State, and a region in the north comprising parts of Durango and Coahuila states. In an extensive area around Salinas, lambs have died with symptoms indicative of a cobalt deficiency. This malady only appeared as the local sheep type was being changed to the more robust Rambouillet, through a grading-up program. Here, a very significant point exists. A most important aspect of adaptability is concerned with local breeds and types which, through the centuries, have accustomed themselves to a certain dietary and management regime. Any sudden change, such as increased size due to grading up, will result in a higher maintenance requirement and, possibly, increased production. This gives rise to a need for more nutrients which, if not supplied, will cause a general upset in the organism as it attempts to meet these demands. If the environmental level (nutrition and proper management) changes concurrently, uninterrupted progress can be expected. Thus, there is a very real need for the animal breeder and the animal nutritionist to work together most closely.

Northern South America may well offer most excellent opportunities for livestock development because of year-round grazing. However, a real deterrent under present conditions is the lack of knowledge of the mineral needs of forages and animals. The
Guianas represent an area about which little is known from the standpoint of animal nutrition.

In Surinam, which is part of this area, it is suspected that mineral deficiencies exist. As an insurance, it is becoming a common practice to feed all cattle a rather complete mineral supplement. On the plant side, on heavy clay soils no deficiencies have appeared. However, sandy soils are reported generally lacking in zinc. Studies on citrus soils have revealed a shortage of manganese, copper and magnesium. A serious problem in cattle has not yet been resolved; it does not seem related to a lack of copper or Vitamin A. During long periods, cows fail to come into heat. While authorities are satisfied the problem is related to mineral or vitamin metabolism, no specific study, other than one involving unsuccessful gross therapy, has been reported.

Serious hypocalcemia is reported to occur in many parts of Paraguay, where soils are often very acid.

In Peru, feeding trials with sheep have been underway for a year in which animals fed ½ lb. of cottonseed cake per day have showed increases in body weight, have given birth to larger lambs and have produced more milk for their lambs than the ordinary range-fed control animals.

A recent report of the Government of British Guiana indicates that the vast areas inland from the coast of northern South America are probably lacking in certain mineral elements. Inland savannah pastures responded tremendously to basic slag (P plus many minor elements) and Potash (K) applications. However, costs remain a problem in improvement. Locuntu grass (*Ischaeumum timoreense*) growing on Wallaba sand is reported to support continuous grazing of hybrid Freisian cattle. In spite of the non-use of fertilizers, *Desmodium* sp. and *Alysicarpus vaginalis* are strongly established in the swards. The region reported upon is at the junction of the Essequibo and Mazaruni rivers.

In variety trials of forage crops at Ebini, sorghums millets, and *Coix lachryma-jobi* appear markedly chlorotic. However, Pangola grass makes tremendous growth in a leafy sward. Analyses made on different samples of native range, ungrazed and unburned, during the previous 18 months show $P_2O_5$ to range from 0.18 to 0.31 percent; CaO to range from 0.15 to 0.55 percent; and $K_2O$ with a range of 0.08 to 0.28 percent. Presumably this is on the basis of the total ash, which varied from 6.0 to 7.0 percent. Applications of 1.2 cwt. of 36 percent superphosphate per acre raised the yield of native range grass from 8.4 to 13.0 cwts. acre on the basis of 6 months growth.

Studies made at the Rothamsted Station in England on brown sand soils from the Ebini station gave the following analyses in parts per million: Cr 45; Ni 40; V 50; Mn 90; Mo 4; Yt 5; Sn 10;
CO 5; Pb 50; Cn 8. Workers in the country believe cattle exhibit a phosphorus and cobalt deficiency. Without doubt, these areas in British Guiana are indicative of much of the terrain of northern South America, and while soil types need to be studied, findings would have some value for adjacent regions of Brazil and Venezuela.

The Islands of the Caribbean represent an interesting geologic phenomenon. Their isolation and the ancient geologic origin, except for a few which have new volcanic soils, create, at the same time, problems and opportunities in animal husbandry.

From Jamaica, it is reported that some work on mineral deficiencies has been done. Phosphorus deficiency is widespread except in the so-called "Blue Mountain" area of granite rock. In the remainder of the island, excesses of calcium, aluminum and, probably, iron, set up a mineral imbalance involving phosphorus. Analyses of blood, and of soil and herbage, confirm this lack of phosphorus. Suggestions of cobalt, copper and manganese deficiency are not convincing, nor are they confirmed through feeding trials. However, there is a peculiar syndrome of cattle, characterized by wasting, stiffness of the joints, symptoms associated with impaired circulation and calcification of the elastic tissue of the body, particularly of the great blood vessels and lungs, which occurs in the limited area within the terra rossa group of calcareous soils of the central upland, that are high in alumina and which are mined to obtain aluminum ores. The local name for the trouble is "Manchester Wasting Disease." A definite aetiology is not yet possible, but it seems to be related to a mineral imbalance. Jamaican authorities believe it identical with "Enteque seco" of Argentina (Lignières, 1912) and the Matto Grosso area of Brazil (Pardi and dos Santos, 1947). A similar condition has been described in Hawaii (Hendershot, 1942) which has long been recognized as associated with grazing in certain parts of the island. Arnold and Fincham (1950) have given a description of the conditions under which the syndrome occurs and some of the gross pathological changes. Arnold and Bras (1955) have made available further information and have described in greater detail the histological changes associated with this disease. In view of the fact that this condition has been encountered in various places in the tropics, several illustrations from the paper by Arnold and Bras are reproduced in Figures 3 to 9 so that the details may be generally available to workers who encounter the disease.

Other diseases related to mineral metabolism appear in Jamaica. Among these are hypomagnesemia, milk fever and urolithiasis. None are common, however.

In the United States of America, total losses through nutritional
Figure 3. Heifer affected with Manchester Wasting Disease (After Arnold and Bras)

Figure 4. Gross aspects of the left ventricle and aorta in Manchester Wasting Disease, showing roughness of aorta due to calcific deposits. The semilunar valves are thickened and rigid (After Arnold and Bras, 1955)
Figure 5. Gross aspect of the lung, showing calcification in Manchester Wasting Disease (After Arnold and Bras, 1955)

Figure 6. Ulceration and degeneration of articular surface of a joint in Manchester Wasting Disease (After Arnold and Bras, 1955)
Figure 7. Cross-section of endocardium (x 43) showing sub-endocardial calcification in Manchester Wasting Disease (After Arnold and Bras, 1955)

Figure 8. Cross-section of a small artery (x 43) showing calcification of the sub-endothelium and media in Manchester Wasting Disease (After Arnold and Bras, 1955)
Figure 9. Cross-section of lung tissue (x 260) showing thickened alveolar septa with calcification and collagenization in Manchester Wasting Disease. (After Arnold and Bras, 1955)

deficiencies still represent large figures in financial terms, hence there is a constant attack on old and new problems of nutrition. Work in animal nutrition is carried out in all the states and territories, roughly in proportion to the size of the livestock industry in each. Numerous private organizations also contribute greatly. The results of all this research are conveyed to the people by means of federal and state agricultural extension activities, the farm press, and through private organizations, including radio and television.

Progress in the identification and mapping of nutritional deficiencies (and toxicities) has centered around the mineral nutrients. In the coastal plain of North and South Carolina, extensive surveys of soil and geological conditions, and study of the micro-nutrient element content of native forages, have revealed certain areas deficient in cobalt. Similar studies in New York and New Hampshire have also shown a lack of cobalt, and may reveal other trace element deficiencies.

The problem of toxicities resulting from excessive absorption of mineral elements from soils is assuming greater importance in certain portions of the United States of America. There are indications that the high manganese content of grasses in certain areas
in North Carolina may be responsible for certain ailments. Molybdenum and selenium are problems in California, Wyoming and South Dakota.

Studies in protein, energy, phosphorus and vitamins are not being neglected. The pastures and ranges in the western and southern states are often low in energy, protein, phosphorus and carotene during certain times of the year and during droughts. Farmers and ranchers are beginning to recognize these situations, and are taking action to overcome them.

The U.S. National Research Council has done much to establish and publish nutrient requirements for the several classes of farm animals, and is constantly attempting, by sponsored research, to increase the knowledge in this field. As a result, a common standard practice to correct certain mineral deficiencies, known or suspected, has been achieved by the use of mixed mineral supplements, including the trace elements. Improved reproduction and increased gains in weight have resulted. Studies on toxic minerals, such as selenium, fluorine and molybdenum, are revealing relationships which are clarifying problems. Occurrences of vitamin A deficiency have served to focus attention on the fact that green leafy roughage, or, in its lack, a vitamin A supplement, will solve this problem. Lack of vitamin D in the northern states is corrected by therapy, during the winter months, or in cases of Ca/P imbalance. A problem in lambs (stiff lamb disease), and in calves (white muscle disease) is related to vitamin E deficiency. Benefits have generally followed the use of concentrated sources of the vitamin or of vitamin E-rich feeds.

In the growing shortage (due to increased demand) of protein-rich by-product feed supplements in the United States of America the use of non-protein-nitrogen (urea) to increase or extend the supply of protein for feeding ruminants has been a subject of considerable interest.

Selected References Regarding Nutrition and Management


ARNOLD, R.M. and BRAS, G. Observations on the Morbid Anatomy and Histology of Manchester Wasting Disease of Cattle in Jamaica, B.W.I. A paper from the Department of Agriculture and the University College of the West Indies, Jamaica, B.W.I., presented to the Third FAO Meeting on Livestock Production in the Americas, Buenos Aires, Argentina, 18-30 April, 1955.


IMPROVING LIVESTOCK PRODUCTION
THROUGH BETTER DISEASE AND PARASITE CONTROL

The Turrialba meeting not only considered the broad problems of improving veterinary services, but also gave particular attention to the control of external parasites, internal parasites, foot-and-mouth disease, brucellosis, tuberculosis and rabies, and to the inspection of meats and other foods of animal origin. In addition to further consideration of the diseases just mentioned, the Baurú meeting also gave attention to hog cholera, and paratuberculosis or Johne's Disease, and to quarantine problems (Phillips, 1950 and 1953). In the light of the interest shown in various subjects in the discussions at Turrialba and Baurú, talks at the Buenos Aires meeting were limited to consideration of the control of foot-and-mouth disease and brucellosis, and to the control of parasitic infestation and of the diseases which parasites are known to transmit. Important information arising from the discussions in Buenos Aires is therefore summarized below under three headings.

Control of Foot-and-Mouth Disease

A number of recent events and technical developments having a bearing on the control of foot-and-mouth disease are summarized briefly in the following paragraphs.

Vaccines produced from "culture" virus are coming into more extensive use in some parts of the world. Some evidence has been produced to indicate that the degree of immunity set up by vaccines prepared from "culture" virus in use today may be slightly lower than that prepared from "natural" virus, but it is generally admitted that, for practical field purposes, "culture" virus-vaccine gives rise to a sufficient degree of resistance to natural infection. The duration of immunity produced by each type of vaccine has not yet been established under controlled conditions although field evidence in some countries indicates that animals injected with "natural" virus-vaccine, have withstood infection for at least 12 months following vaccination. The establishment, by controlled experiments, of the duration of immunity of a satisfactory level to withstand infection with foot-and-mouth disease virus is of much importance from the point of view of advising on the intervals between vaccinations in countries in which extensive use of
vaccine is a policy for control for the disease. In some countries in Europe extensive vaccination programs are being carried out; they vary from vaccination of all cattle in the country to vaccination in areas or zones surrounding outbreaks. In other countries, a "stamping-out" or slaughter policy is strictly adhered to or is practised together with vaccination. The occurrence of "variants" or "mutants" within the three different types of foot-and-mouth disease viruses has given rise to some difficulties in carrying out successful vaccination schemes; the results of research work are overcoming this limiting factor. Evidence from field observation is accumulating that a mixture of vaccines injected subcutaneously in one dose will successfully immunize cattle against all the types of virus from which the vaccines are prepared, but further work on the subject is necessary. Such research work is considered important in order definitely to ascertain whether this convenient method of administration of vaccine can be accepted as a satisfactory and efficient field procedure.

Although it is realized and appreciated that the eradication of foot-and-mouth disease must eventually consist of a "stamping-out" or slaughter policy, the use of vaccine will continue to have an important place in some countries for practical and economic reasons and, therefore, detailed attention should still be given to its satisfactory production and use.

The immunization of pigs still presents some difficulty, but there are hopeful signs from the result of work carried out in Denmark that virus recovered from infected cattle may be adapted to the pig and that from such an adapted strain a satisfactory immunizing product for pigs may be produced.

A major attempt at regional co-operation in the control of foot-and-mouth disease has been initiated in Europe through the formation of the European Commission for the Control of Foot-and-Mouth Disease within the framework of FAO. Eleven countries are now co-operating in this new venture, which should be watched with interest by other regions where co-operation among countries may be essential to the effective control of the disease. The objects of the Commission are to assist European countries by international effort to control the spread of the disease in Europe and to arrange and adopt measures for the prevention of its entry into Europe. Such regional measures are essential before world-wide control of the disease can be hoped for.

There is general recognition of the urgent need for international action for the control of foot-and-mouth disease in the Americas and the operation of an agreed policy on preventive measures to ensure continued freedom in the countries in which the disease is absent. The efficacy of methods of control now being applied in several countries to suppress outbreaks and to prevent spread of
the infection, the occurrence of vesicular disease which may simulate foot-and-mouth disease and the need to ensure accurate diagnosis, and the part played by native wild animals as reservoirs and vectors of the virus, are all problems of major interest.

New developments reported in a number of countries and observation on the current situation are summarized in the following paragraphs.

In Argentina, progress has been made in the control of foot-and-mouth disease and difficulties which arose from considerations such as the large number of livestock in the country and the extensive livestock movements throughout the country have been partially overcome. Until 1945, when a special decree was enacted, much of the control of the disease was vested in local authorities. The decree provides for over-all national powers of the Ministry of Agriculture, and since 1945, the general position has improved. Special precautions are taken to prevent the entrance of the infection into Patagonia which, because of its geographical position, lends itself to the exclusion of the disease. Cattle destined for Patagonia, for example, should be vaccinated and the supplying area should be free from foot-and-mouth disease for at least 15 days prior to the movement of the animals. The area of origin of cattle for export to foreign countries should be free for at least 30 days. Notification of outbreaks is compulsory and control consists in the application of restrictions on movement, sanitary police measures and extensive vaccination in the area surrounding an outbreak.

Vaccination against foot-and-mouth disease in Argentina is not compulsory but is usually practised. Many farmers adopt vaccination as a preventive plan. Compulsory vaccination is envisaged and pilot experiments are being carried out in different parts of the country. Experience has shown that when infection appears among vaccinated cattle, the symptoms of the disease are mild and the lesions slight. Vaccination carried out immediately in an area surrounding an outbreak is reported to be usually followed by a clearing-up of the epizootic in about 15 days. In calves, good results are reported following a combination of protein therapy and vaccination and this method of treatment is now receiving detailed study.

In Argentina, it is believed that vaccination should be carried out every four months in order to maintain a satisfactory level of immunity, since experiments had shown that after four months, the immunity drops sharply to a level below that accepted as efficient for protective purposes. By the adoption of a 4-monthly vaccination policy and the practice of sanitary control and movement restrictions, Argentine authorities report that foot-and-mouth disease is being effectively controlled.

In 1939, a National Foot-and-Mouth Disease Institute was
established. Its activities comprise research work on the many aspects of the disease and the control of the large quantities of vaccine produced by the 15 private or semi-private laboratories in Argentina. Different processes for the production of vaccine are being studied, e.g., the methods of Frenkel, Thomas, Belin, etc., and it was hoped that by the end of 1955 information regarding a new method for the production of vaccine might be available. Concentrated vaccine in doses of 2 c.c. injected intradermally was said to produce satisfactory results.

Canada has been free from foot-and-mouth disease since May 1952. The Animal Contagious Diseases Act provides the authority for all necessary measures to ensure freedom from the disease. Control of the disease is handled entirely by the federal government. Arrangements exist for diagnosis work, and courses of instruction for department veterinarians are regularly held. No vaccine is produced or used in Canada, complete eradication being the method of dealing with outbreaks.

In Chile, foot-and-mouth disease is enzootic and all three types of virus exist, although type C is seldom found to be the cause of outbreaks. Control plans have final eradication of the disease as the objective. The plans are on the following lines: in each of the provinces a trivalent vaccine will be used in the first instance, and then mono- or bi-valent vaccine, every six months for two or three years, depending upon the incidence of the disease. The scheme includes the movement of the operators from one zone to another at stated intervals, and provides for the vaccination of calves. In addition, there will be in operation, sanitary policy measures, market control, quarantines and livestock traffic control. The aim is that by the end of a few years foot-and-mouth disease will be under good control in the country.

In El Salvador, there is no foot-and-mouth disease. No facilities are available to deal with a possible outbreak. However, officials are working, with the help of FAO technicians, to draft a law which will provide a basis for meeting the problem of keeping the country free from the disease.

In Panama, educational campaigns are in operation whereby livestock owners are acquainted with the symptomology of foot-and-mouth disease and vesicular diseases in general, and the urgent need to report any suspiciously affected animals. At present, Panama is free from the disease, but there is in existence a decree in which regulations are laid down for the control of the entrance of the infection into the country. The Pan-American Sanitary Bureau (PASB) co-operates in diagnosis work; up to the present all outbreaks of vesicular disease have been diagnosed as vesicular stomatitis, type “New Jersey.”

In Peru, foot-and-mouth disease is usually confined to a re-
stricted area in the valley of Lima and rarely extends from this locality. Imported cattle are usually the sources of outbreaks. Cattle from abroad must now be vaccinated and the disease is no longer a serious problem. Because of geographical conditions in the country, e.g., rivers forming natural barriers, the spread of the infection is not difficult to control. Outbreaks are controlled by the use of vaccine, injected subcutaneously. Vesicular stomatitis in dairy cows, in which the lesions occur on the udder and which gives rise to mastitis, do occur. The disease may be confused with cow pox.

Jamaica is free from foot-and-mouth disease, and there is recent legislation on methods of control of the disease, should it appear in the country. Provision has been made for the operation of a "slaughter" policy, without the use of vaccines.

In the United States of America, the last outbreak of foot-and-mouth disease was in 1929. Measures for the control and immediate eradication of outbreaks of the disease exist and include provisions that the federal authority may take action independently or in co-operation with the affected states; the imposition of restricted livestock movement; the immediate slaughter of all infected and exposed animals and the payment of compensation; the inspection of premises within and outside the affected area; restriction of movement of people; and the application of disinfecting procedures. Also in the United States, a corps of veterinary diagnosticians, specially trained in differential diagnoses of vesicular diseases is strategically located throughout the country. Facilities are available for typing strains of virus; the use of vaccine is not contemplated. Total eradication by slaughtering all infected and exposed animals is considered the surest and most practical means of eradicating the disease should it appear in the United States. Research work is being carried out in recently opened laboratories located on an island.

In Venezuela, since 1950, different agencies have been used in dealing with foot-and-mouth disease. There is now a Foot-and-Mouth Disease Department in the Ministry of Agriculture. A special laboratory has been set up for purposes of diagnosis and vaccine production. Throughout the recent outbreaks, type O virus was prevalent, type A being much less commonly found and was confined to limited, small areas. The actual number of outbreaks recorded and types of infecting virus are as follows: 1950 - 44 (O); 1951 - 58 (O), 6(A); 1952 - 21 (O); 1953 - 5(O), 1(A); 1954 - 4(O), 3(A); making a total of 142 outbreaks in 132 of which the virus was O and in 10, A.

The general control methods in Venezuela are extensive vaccination, some slaughtering, the enforcement of sanitary police measures and the restriction of movement of livestock. In the
early stages of the recent outbreaks, slaughter was not practised; later, the slaughter of infected animals was introduced together with extensive vaccination. No indemnity is paid for slaughtered animals. The successful results obtained by this procedure made it possible to divide the country into zones that were clean; those freed from the disease; those under observation, and those in which vaccination was carried out. It has been reported that no outbreaks have been confirmed since July, 1954.

Vaccines in use are always mono-valent and if it is found necessary to protect against two types of virus, two mono-valent vaccines are used. In the north of the country, vaccination is carried out every four months, but in the south, because of difficult geographical and other conditions, the interval is six months. There have been no confirmed outbreaks in the south since 1953. Vaccine, in doses of 2 ml., is injected intradermally. The Frenkel type of vaccine has not yet been used. Only a limited study has yet been made on strains of virus; vaccines are prepared from strains recovered from infected animals. The laboratory has produced 24,145,334 doses of Type O vaccine and 217,750 of Type A, and keeps a large reserve stock of epithelium for preparing both types of vaccine.

Regulations in Venezuela provide for the notification of the occurrence of any vesicular type of lesion in an animal to the appropriate authority and samples of tissue are sent to the laboratory. Quarantine measures are applied at once; if foot-and-mouth disease is not diagnosed, the restrictions are removed, but if the disease is confirmed, the above-mentioned procedure is put into operation.

The Pan-American Sanitary Bureau maintains a Foot-and-Mouth Disease Center in Rio de Janeiro for the benefit of members of the Organization of American States. Its usefulness to the various countries is generally recognized. In addition to direct assistance to countries, information concerning foot-and-mouth disease and other vesicular types of disease in Central and South America is compiled.

Control of Brucellosis

A second meeting of the Joint FAO/WHO Expert Committee on Brucellosis, the report of which was published in 1953, reached conclusions which are of importance to countries in the Americas and elsewhere. Some of the conclusions are summarized in this paragraph. The most important basis of control of brucella infection concerns detection and elimination, or effective isolation, of the infected animals. Sero-agglutination tests should remain of
primary diagnostic importance for individual animals. Screening
tests to locate infected herds are, however, of considerable value,
examples of the tests being the milk ring or ABR test, the milk
plate test and the milk-capillary-tube test. Results of the milk
whey agglutination test indicate its value in differentiating between
cattle showing sero-agglutination reactions caused by Br. abortus,
strain 19, and those showing similar reactions caused by natural
infection. It has been shown that a high percentage of whey
samples from uninfected, strain 19-vaccinated animals show no
agglutinations below the minimum diagnostic level while a high
percentage from infected animals show agglutinin titres above the
diagnostic level. It has to be pointed out, however, that the
test loses accuracy when it is applied during the early and late
stages of lactation. No reports have been published of a more
satisfactory vaccine than that produced from Br. abortus strain 19.
It is still recommended that pregnant cattle should not be vacci-
nated, for although permanent infection in them does not result
from vaccination, the injected strain may be excreted from the
uterus or udder for a period up to one week following parturition.
It is now considered that, in herds in which the results of agglu-
tination tests are not taken into account in controlling brucellosis
but in which vaccination is being practised, young bulls of 6 to
8 months of age may be vaccinated as well as heifers. The avail-
able evidence indicates that animals vaccinated once as calves are
still resistant to infection up to five pregnancies. Some observers
believe that the continuing resistance may be related to age and
that, therefore, revaccination after the first or subsequent calving
is not likely to be necessary.

Recent Developments in Various Countries

In Argentina, considerable importance is attached to the milk
ring test. Studies have been made in dairies and milk pasteurizing
plants on the incidence of brucellosis in animals, as shown by
this test. It has been suggested that some scheme might be ope-
rated whereby premiums might be paid for milk from non-infected
herds and so farmers might be induced to clear their herds of
infection. Similarly, agglutination tests, using whole blood from
cattle at abattoirs, packing stations, etc., had been carried out
and have given rapid results of a satisfactory nature. Many
thousands of animals had been tested by this method, and infected
herds had been located.

Following the satisfactory results of the use of vaccine prepared
from Br. abortus, strain 19, as an immunizing agent of high value
and its safety in 1949, the Government of Argentina adopted this
as the only vaccine to be used in the country. This dispensed with
the use, among other vaccines, of live cultures which had actually
spread the disease. A policy of slaughter of infected animals
and vaccination of healthy animals as an ideal procedure presents
difficulties in a country like Argentina with a cattle population of
some 43 million and a scarcity of trained teams of workers to carry
out diagnosis work, hence such a policy could not be carried out.
Calfhood vaccination was, therefore, adopted in 1947 as a govern-
ment-sponsored, though voluntary, control measure. Following
the formulation and adoption of a plan to control the vaccine,
the official vaccination scheme was begun. Some farmers objected
to the scheme, largely because of the agglutination reactions fol-
lowing vaccination. The Government then limited vaccination
to calves and advised against repeat vaccinations so that reactions
in adult animals, vaccinated as calves, would be reduced to a
minimum. It was also felt that, if the immunity set up by calf-
hood vaccination persisted at a satisfactory level for say 5 or 6
lactations, the economic life of the dairy cattle would be covered.
Bulls were not included in the vaccination scheme because of the
permanence of sero-agglutination reactions, following the use of the
vaccine. It is now considered that the time will soon arrive when,
in small areas, a "stamping out" plan with slaughter of infected
cattle and the payment of compensation may be considered.

The program of prophylaxis in Argentina includes educational
work, given both orally and by the use of written material. Field
demonstrations of the carrying out of control practices are proving
of value not only from an educational point of view but also be-
cause, from them, information is obtained on the spread of bru-
cellosis and appropriate measures for its control can be taken.
The practical value of the sero-agglutination test for individual
animals and the screening tests for herds in the dairy zones has
been demonstrated.

In Canada, brucellosis is controlled through either the brucel-
losis-free listed herd plan, based on the results of the sero-agglutin-
ation tests, or the federal-provincial brucellosis calf herd vaccination
program. Brucellosis is not a notifiable disease in Canada. Sero-
agglutination tests are compulsory only for imported animals,
animals for export, herds under the brucellosis-free listed herd plan
and for cattle attending certain national livestock shows. Research
work is confined to specific problems arising from the control mea-
sures. Quarantines are not imposed on outbreaks of the disease.
The educational campaign in Canada is limited to the distribution
of pamphlets by provincial governments.

In Chile, the control program includes sero-agglutination tests of
cattle, progressive elimination of reactors throughout the country,
vaccination of calves between 4 and 6 months of age, and ex-
tension work. The production and use of vaccine is controlled by the Government. There is also a strict control of imported animals. Official declarations of freedom from brucellosis are required for imported breeding cattle, for cattle sent to shows, for the purchase and sale of high quality breeding animals and for all cattle in some parts of the country. A control campaign carried out jointly by the National Health Service and the Ministry of Agriculture, similar to that for cattle, is in operation for goats in the Province of Santiago; animals in which infection is diagnosed by sero-agglutination test are eliminated. Educational campaigns in Chile include the dissemination of information on the disease through the press, radio and publications.

In El Salvador, the highest incidence of brucellosis in cattle is in the central and coastal zones of the country. Of 3,104 sero-agglutination tests carried out in these regions, 12.6 percent were positive and the reaction in a further 18.6 percent was considered as indefinite. The tests are carried out with antigen, standardized according to the recommended international method. The ring test has been used for samples of milk taken from the market. In 1954, of 6,816 samples examined, 32.4 percent were positive; in 1955, of 2,287 samples, 10.5 percent were positive. Most of the milk examined came from the area around the capital and from the western zone. Similar tests carried out on 391 samples from the eastern zone proved negative, while in 109 samples from the Santa Ana area, 11 percent were positive. There is no legislation for the control of brucellosis, but some livestock owners are, voluntarily, following the advice given by government veterinarians. The introduction into the country of a vaccine against brucellosis is prohibited. It is only for purebred cattle that tests are carried out to ensure freedom from brucellosis on importation.

In Jamaica, although brucellosis is a notifiable disease no regulations are in force concerning its control, nor is the disease considered of sufficient economic importance to justify the application of permanent control measures. Vaccine prepared from \textit{Br. abortus}, strain 19, is used to a limited extent, and the features of the disease and methods of control are publicized throughout the country. In diagnosis work, the international standard \textit{Br. abortus} anti-serum is the basis of sero-agglutination tests, although there is no regulation for the compulsory carrying out of such tests. No quarantine regulations are in operation; government veterinary officers give advice as required.

In Panama, the control of brucellosis is still in a preliminary stage and regulations have not yet been passed on the subject. In Peru, the control scheme for brucellosis is practically identical with that carried out in Argentina. The central campaign is being carried out on a voluntary basis under official control,
and it is expected that it will be possible to reduce the incidence of the disease to such a low level that more drastic measures can be taken. Although no statistics exist to show the effects of vaccination in the incidence of the disease, it is significant that there are many fewer abortions and cases of retention of the placenta in the vaccinated herds; and further, that it is now possible to re-populate dairy cattle areas with animals produced in Peru, whereas, formerly, replacements had to be imported.

In the United States of America, there has been a constant increase in the funds made available for work on brucellosis, by county and state governments’ control and eradication procedures being developed jointly by the federal government and the states. An extensive educational program is in operation; many agencies are co-operating in this work. The eradication program now in operation aims at the eventual elimination of the disease. Primary attention is given to systematic sero-agglutination tests, the elimination of reactors, the disinfection of premises and replacements with healthy cattle. Calfhood vaccination with Br. abortus, strain 19, is an important part in the program. Research work is still progressing, especially on the titre interpretation of the results of sero-agglutination tests in cattle vaccinated in calfhood, non-specific reactions to the sero-agglutination and milk ring tests, brucella types infecting cattle, swine and goats, and improvement of immunizing agents.

In Venezuela, a campaign for control of brucellosis is being undertaken. For sero-agglutination tests the Br. abortus antiseraum used for standardization of antigens throughout the country is controlled by the State Veterinary Laboratory.

*Import Regulations Concerning Reactions to the Agglutination Test in Vaccinated Animals*

There is general agreement on the need for further research to establish the possible variations in the results of the sero-agglutination test in naturally infected and in vaccinated livestock in relation to gestation and post partum periods.

In Argentina, with regard to the importation of cattle, vaccinated with Br. abortus, strain 19, vaccine, there are in existence special regulations with which the countries of origin have to comply. Modifications of the regulations are now being studied because of the finding that sero-agglutination reactions in vaccinated animals may persist for longer periods than was at one time thought.

The subject of the duration of sero-agglutination reactions at different titres is a highly technical matter, however, which requires
further study and careful consideration by a group of experts such as the Joint FAO/WHO Expert Committee on Brucellosis. Among the points requiring further attention is the question of variation in the titres of sero-agglutination reactions during and immediately following pregnancy for which some experiments show that there is a considerable depression during this period and that, therefore, results might be misleading. Also, in Argentina, an increase has been noted in the titre of the sero-agglutination reaction of strain 19 vaccinated animals for a period subsequent to vaccination with foot-and-mouth disease vaccine.

**International Standards**

This subject was discussed at the Baurú meeting, where attention was drawn to the adoption by the Committee on the Standardization of Biological Products of the World Health Organization of the anti-serum evolved under the auspices of the International Office of Epizootics (OIE), as the international standard by which *Br. abortus* antigens, used in sero-agglutination tests could be standardized. Such standardization is essential if the results of agglutination tests carried out in various countries are to be readily comparable.

In Argentina, the antigens produced are reported to correspond with the international standards. The Ministry of Agriculture has decided that all antigens used in the country should be so standardized and standard anti-serum is being distributed for this purpose.

In Chile, the Institute of Veterinary Research is responsible for diagnostic and antigen production techniques, and international standardization methods are used.

In Canada, the international standard *Br. abortus* anti-serum has not been adopted. However, there is much exchange of information on sero-agglutination tests with the United Kingdom and the United States of America.

The Pan-American Sanitary Bureau, (PASB), which is also a regional office of the World Health Organization, takes an active part in standardization. A study carried out in 1951/52 showed marked differences in antigens from both medical and veterinary laboratories throughout Latin American countries. Seminars were held in 1951 and 1952, one for countries in South America and the other for those in Central and North America. Each country was represented, often by personnel concerned with both public health and livestock interests. Emphasis had been laid on the need and advisability to designate one or two laboratories in each country to be responsible for standardization of antigens. Few
countries have as yet seen fit, however, to implement this recommendation.

Although some differences of opinion exist, there appears to be rather good agreement that governments should take the necessary action to affect the standardization of procedures for the diagnosis of brucellosis and especially of antigens for use in the sero-agglutination test, through the designation of a central national authority to accomplish this purpose by following the standards agreed and recommended by the OIE, FAO, WHO and PASB.

Control of Parasitic Infestation and of the Diseases Parasites are Known to Transmit

The economic effect of parasitic infestations is not confined to losses by deaths of infested animals, but is largely concerned with lowering of normal production of animal products, including milk and meat, low yields of wool, damage to skins and hides and impaired labor activity of draft cattle. It is impossible, even in general terms, to evaluate the total loss from the various conditions arising from parasitic infestations, but it is agreed that they are extremely high in all countries.

Although some of the more recently introduced medicaments used for anthelmintic purposes are of marked value, there are still some parasites for which adequate control treatment does not exist; further research is needed. Again, it has to be pointed out that the use of anthelmintics alone, although playing an important part in its control of parasitic infestations, cannot produce entirely satisfactory results. The practice of improved methods of husbandry, together with the provision of suitable nutrition, with special attention to minor or trace elements, must also occupy an important place. Research is still needed on the influence of nutrition on parasitic infestations.

While total eradication of certain parasites may be possible, with others, especially those infesting the gastro-intestinal tract, the aim should be to reduce the numbers that the level of infestation does not markedly influence the economic position of the livestock in question.

Improvements in pastures mean that an increased number of livestock may be maintained in a given area. The effect on parasitic infestation may be great, unless attention is given to husbandry and the use of suitable anthelmintics.

Attention should also be directed towards the danger of introducing types of parasites into a country which is free from them, through importation of livestock.

In planning control measures to be used in a country for the
control of parasites, due regard should be given to climatic conditions which may influence the life cycle of the parasites; climatic conditions may, for example, determine the interval between the applications of insecticides for the control of some ecto-parasites.

In the field of zoonoses, some parasites assume an important role in both human health and livestock economy, and campaigns for control are, therefore, of special importance. Recent activities in various countries, aimed at the control of parasites, are summarized in the following paragraphs.

In Argentina, some 6 million ha. have been cleaned of ticks during the past ten years. The method consists of the regular treatment of cattle with satisfactory insecticides over a period, taking into consideration the duration of the stages of the life cycle of the tick under different climatic conditions when arranging the intervals between treatments. Stress has been laid on the need for rotation of insecticides used in treatment because of the tendency of ticks to become resistant to some of the products in use; and to the value, in land clearing schemes, of harrowing the land in the area. In woodland districts, such treatment of the land cannot be carried out and eradication may, therefore, be a more difficult problem in such areas. It is essential that all the cattle in the area be subjected to treatment with insecticides in any eradication scheme. There are now in progress some further pilot experiments in different parts of the country, representative of the various climatic and general husbandry conditions found in Argentina. In some, it has been found that ticks can be eradicated in about two years.

There is also a parasite, *Thysanosoma actinoides*, found in Patagonia and in the vicinity of Buenos Aires, which causes death of infested cattle. The life cycle of this parasite is unknown; however, there is evidence that a vector is necessary for its completion. Distomatosis is commonly found in cattle, sheep and pigs; good control results follow the usual methods of preventive treatment, and, when attention is given to the calcium content of the food of the animals, the commonly used drugs, such as carbon tetrachloride, can be safely administered.

The treatment of cattle imported into tick-infested areas from tick-free countries or areas to pre-immunize them is also practised; for this purpose the blood of infected animals is used. Treatment of those which become infected with anaplasmosis or piroplasmosis is also carried out. Such drugs as trypan blue, acaprin and acriflavin are used.

In Canada, diseases transmitted by ticks are not a problem. There are no regulatory provisions under the Animal Contagious Diseases Act with respect to tick or tick-transmitted diseases. Blood-sucking flies, Tabanidae, exist but have not been known to
transmit disease to livestock. The only outbreak of trypanosomiasis in Canada occurred in 1952; the infected cattle herd was destroyed and buried. Mange (scabies) in cattle, sheep and horses is a notifiable disease. Affected herds or flocks are quarantined and treated under official supervision. The control of endo-parasites is carried out by private veterinary practitioners, and educational pamphlets from official sources are distributed. Anthelmintic drugs and pasture control are used. Human tapeworm infestations, livestock cysticercosis, fascioliasis and hydatidosis exist, but are not under official control, except that there is compulsory cooking of all garbage fed to pigs and poultry.

In Chile, the tick family Ixodidae is prevalent and although the Boophilus type is found on cattle imported for slaughter purposes, it appears that this tick may not be adaptable to the conditions of the country. Trypanosomiasis does not exist in cattle in the country, nor are Dermatobia or Hypoderma found. In connection with Hypoderma, it has been noted that, although imported cattle sometimes carry the larvae, the adult fly does not develop.

*Thysanosoma actinoides* is commonly found in sheep, and hydatidosis, trichinosis and cysticercosis are also present. Campaigns are in operation for the control of hydatidosis. Distomatosis in its acute phase is responsible for deaths in sheep; the disease is now being controlled in both cattle and sheep. Parasitological investigations are carried out at the Institute of Veterinary Research.

In Ecuador, anaplasmosis has been found in zebu cattle, especially bulls imported from countries which for a long time have been tick-free. Thus, there is need for pre-immunization either before the animals leave the country or immediately on their arrival in Ecuador.

There are two different types of country: the mountainous region, and the low tropical region. Parasites infesting the gastrointestinal and respiratory tracts are commonly found in both types of country. On the other hand, distomatosis is found only in the high altitudes, for although eggs of the liver fluke find their way into streams, and are conveyed to the lower parts of the country, the mature flukes do not develop there. Research is in progress to determine the reason. The parasite, *Oestrus ovis*, gives rise to a considerable amount of loss in sheep, and is being only partly controlled by the methods in practice. Trichinosis does not exist in the country, and the incidences of hydatidosis and cysticercosis are insignificant.

In El Salvador, external parasites are among the principal causes of livestock losses. In the case of ticks, *Boophilus* spp. and *Amblyomma* spp. appear to be the most common but there
has been no study of their distribution. They transmit piroplasmosis and anaplasmosis. No rickettsiasis nor trypanosomiasis has been reported. Excepting the distribution of propaganda, there is no provision, such as a law or national program, for the control or eradication of ticks and other parasites. However, more and more individual farms and ranches are using pesticides to combat them.

Torsalo (Dermatobia hominis) is not severe. The majority of the infested cattle come from the frontiers bordering Honduras and Nicaragua. The central zone is practically free. In addition, there are a few isolated cases of infestation with Sarcoptes and Psoroptes.

Internal parasites are a very serious source of loss to the livestock industry as they infest about 99 percent of the animals. The principal ones are: in cattle — Haemonchus contortus; in horses: Strongylus spp; in swine: Ascaris lumbricoides, Cysticercus cellulosae (affecting approximately 15 percent of the hogs), but no Trichinella spiralis; in poultry: Coccidia and Haeterakis gallina. Individual farmers are using anthelmintics such as phenothiazine, kamala and carbon tetrachloride.

Information obtained concerning the occurrence of platelminths in humans and of cysticercosis and Fasciola hepatica in domestic animals is being used as propaganda in the drive to obtain adequate laws to serve as a foundation for fighting these pests on a nation-wide basis. FAO technicians are advising on the framing of a law to meet these problems in El Salvador.

In Jamaica, the ticks commonly found are Boophilus annulatus (var. microplus) and Amblyomma cayennense in cattle, Dermacentor nitens in horses, and Rhipicephalus sanguineus in dogs. Anaplasmosis and piroplasmosis are enzootic in native livestock, and imported animals suffer severely. There are no rickettsial diseases.

Ticks are controlled by dipping and spraying, using appropriate insecticides. There is no law for compulsory treatment. Biting flies and horn flies are present, but are not serious pests; trypanosomiasis is not present. Screw worms are found but torsalo is absent. Advice is given on the control of internal parasites by visits of veterinary officers to an area, following observations made in the abattoirs.

In Peru, no marked official effort has been made to control parasites and parasitic infestations. However, some work is under way. For example, one private corporation is now employing eight veterinarians on parasite control in the sheep. Mortality has been reduced from 26 to 2.5 percent; average wool yield had been raised from 3.5 to 6.5 lb., and average carcass weight had risen 24 to 42 lb. The number of sheep now owned by this corporation has increased from 160,000 to 200,000.
The faculty of Veterinary Medicine has undertaken a survey from which there will be available a complete picture of the types and locations of livestock parasites in the country.

As in some other countries, much care is taken with diseases of virus and bacterial origin; but little or no attention is given to parasites, with the result that parasites, not present in a country, may be introduced by imported livestock. An example is the introduction of the parasite *Thysanosoma actinoides*, which is responsible for some cattle losses and impaired production.

The prevalence of hydatidosis has been noted and there is urgent need for its prevention from both the public health and livestock economy points of view. In collaboration with the Inter-American Health Service, the Faculty of Veterinary Medicine is to carry out a survey of the condition, for which veterinary students will be used.

The United States of America enjoys a virtual freedom from piroplasmosis, theileriasis and trypanosomiasis, but heavy losses occur from cattle grubs, screw worms, horn flies, lice, ticks and mites. There are already some indications that the oral administration of phenothiazine, the medicament commonly used in the control of some gastro-intestinal parasites, may also have some value in reducing the intensity and incidence of grub (warble) infestation. Observations are being made on the value of other medicaments. In controlling mange (scabies) in the different species of livestock, and screw worms, lice and certain flies, a major problem with newer insecticidal dips is the disproportionate removal of the suspended particles of active ingredients by the passage of animals through the fluid; and a practical difficulty is the lack of a suitable biological or chemical test of dip strength.

In connection with the endo-parasites, considerable progress has been made in the United States of America in the control of coccidiosis, trichomoniasis and anaplasmosis in cattle. Improved husbandry, newer chemo-therapeutical agents, artificial insemination and better methods of diagnosis have all contributed to better control results. In cattle, there have been recognized some 40 species of helminths of more or less economic importance. Although available medicaments are of value in controlling some of these worms, there is, as yet, no appropriate treatment for more than half of them.

In pigs, helminths are the most important parasites causing economic losses. Some 18 species are recognized. Problems of control are complicated by the presence of certain other parasites, of which the commonest are kidney worms, lung worms, larval tapeworms, thorn-headed worms, trichinae, threadworms and whipworms. The annual loss in swine is estimated at more than U.S.$ 200 million.
Parasites of sheep and goats are of special importance throughout the country, the proportionate loss from helminth infestations being higher in these than in any other classes of livestock. The use of available anthelmintics is causing an encouraging reduction. It is recognized, however, that the use of antiparasitic drugs cannot alone solve practical problems of parasite control.

In Uruguay, so far as ectoparasites are concerned, mange (scabies) and lice infestation are no longer problems, but tick control is still of considerable importance. A new law is about to be enacted in this connection. With the improvement of pastures it will be possible to concentrate more sheep in a given area. This means there will be more opportunity for the development of gastro-intestinal and lung worm infestations, and attention will have to be given to rotation of the sheep stock and the necessary anthelmintic treatment, both arranged according to the duration of the stages of the life history and the parasites under the different climatic conditions.

In Venezuela, the livestock, as in the majority of the American countries, suffer the pernicious effects of ectoparasites, the most important among which are Amblyomma cayennense, Boophilus microplus, Dermatobia hominis, Lyperosia irritans and Stomoxys calcitrans. The Venezuelan Ministry of Agriculture, through its Ectoparasite Department, has been conducting intensive control of these parasites since 1936. As the first step in the campaign, arsenical dips were employed and it was possible to clear ticks from one part of the country (Aragua State) which specializes in milk production. After ten years of control, a problem cropped up in that the new tick generations had become resistant to arsenic. Fortunately, by that time there had been discovered chlorinated hydrocarbon insecticides which are harmless for warm-blooded animals, but lethal to ectoparasites, and are very persistent in their action.

After these insecticides had been the subjects of experimentation by the Department, plans were made for control with these products which are applied by means of spray pumps. In the case of toxaphene, it was found that the toxic dose for animals is 40 mg. per 2.2 lb. of live-weight. With the sprayers used, no animal received more than 10 g. of the active principle, in fine suspension, which is equivalent, for an animal weighing say 880 lb. to half the toxic dose per 2.2 lb. Up-to-date some 22 million sprayings have been carried out without any cases of poisoning, nor have skin lesions been caused by the treatment. The chief advantage of toxaphene, compared with other ectoparasiticides, is its greater persistency. The campaign is welcomed by the stock farmers because of the benefits it has brought to them in the control of ticks, bot flies and other external parasites of livestock.
Literature Cited Regarding Disease and Parasite Control


General Considerations

Poultry have received inadequate attention in many American countries in relation to their value as a source of animal protein. This seems to be the case particularly in those countries where the average intake of animal protein per person, per day, is estimated to be below 30 g. Data were included in the report of the Baurú meeting (Phillips, 1953) on the intake of animal protein per person, per day, and of the 12 countries for which data were available in the Western Hemisphere, Argentina, Uruguay, the United States of America and Canada had an intake higher than 30 g., while Brazil, Chile, Colombia, Cuba, El Salvador, Honduras, Mexico and Peru have average intakes below this. The Second Inter-American Meeting on Livestock Production in Baurú, therefore, recommended that governments should study the adequacy of existing programs and give increased emphasis to intensive programs for poultry improvement wherever this proves to be desirable.

The wide differences which exist in the state of development of the poultry industry in the various countries may be illustrated by tables recently prepared by the Statistics Branch of the Economics Division of FAO showing that average egg production per hen, per year, is estimated to vary from about 38 to 175 eggs in American countries (see Table 17). The data for Argentina and Brazil are official estimates, while the figure for Mexico is unofficial. There is also a great variation in the average consumption of eggs per person, per year, in the different countries; 4.4 to 15.4 lb. in Latin America, and 37.4 to 46.2 lb. in Canada and the United States of America. Similar variation exists in the consumption of poultry meat, which is highest in the United States.

The importance of poultry husbandry is often underestimated although it offers great possibilities for providing, rapidly and economically, protein of high quality, essential vitamins, and of improving the farmers’ income. The efficiency of poultry production mainly depends upon the level of production of each individual, whereas the actual number of birds is of minor importance. The fact is often overlooked that fast growing birds and good layers are far more efficient than birds with a low level of production. The utilization of nutrients by laying hens is a typical and striking
example. When the percentage of egg production is related to the respective consumption of "total digestible nutrients" (1 g. "total digestible nutrients" corresponds to 4.1 digestible calories) required for the production of 100 g. of eggs, variants similar to those shown in Table 18 occur (Engler, 1936).

The outstanding point of practical importance in this is that the hen which lays only 40 eggs per year may need up to 850 g. of grain and other dry feed to produce 1 normal sized egg. If a hen lays 120 eggs per year, then the total feedingstuffs required for 1 egg decreases to about 300 g. With an annual production of 240 eggs, only 180 g. of grains and layers mash are needed. Byerly (1954), based on his former experimental work, stated that a hen of 4 lb. body weight required about 60 lb. of feed for maintenance per year. For each dozen eggs produced it would require an additional 1½ lb. of feed. Thus, such
TABLE 18 - VARIATIONS IN EFFICIENCY OF EGG PRODUCTION IN RELATION TO LAYING CAPACITY

<table>
<thead>
<tr>
<th>Percentage Egg Production</th>
<th>Average maintenance and production requirement expressed as total digestible nutrients needed to produce 0.22 lb. of eggs by birds from about 4(1/4) lb. liveweight</th>
<th>Improvement of Utilization Index</th>
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<td>100% laying capacity = 365 eggs weighing each 58 g. (about 2 oz.)</td>
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A hen requires about 75 lb. of feed if it lays 10 dozen eggs in a year, or 90 lb. if it lays 20 dozen eggs. In the first instance each dozen eggs costs 7.5 lb. of feed (290 g. per egg), in the second only 4.5 lb. (170 g. per egg). In actual practice, of course, these figures would be subject to some variation on account of the body weight, the inherited laying capacity and phenotypical conditions of birds, the contents of nutrients of the ration, and the possibly available quantities of feedingstuffs found in the runs or field which will differ regionally and seasonally.

In many cases where scavenging birds pick up their food wherever they can, these nutrients would otherwise be entirely lost or even detrimental, e.g., weed seeds and insects, if there were no birds. Although under certain conditions even low production may temporarily be justified, the fact should always be kept in mind that low level of production means an unfavorable feed conversion rate.

Since production level and efficiency of poultry production are influenced by many factors, some of which are of a personal nature such as interest of the farmer in the birds, sense of order and perseverance, the following points are of particular importance:

(1) Besides adequate housing and management, frequent culling of unthrifty birds is recognized as an efficient step towards reducing wastage of feeds and reducing the output and income per bird. On small farms and in backyards in particular, birds are frequently kept until they are too old for normal egg production. This, moreover, leads to a progressive decline in meat quality and renders disease control more difficult. Therefore, training courses for culling experts are recommended.
(2) The fight against poultry diseases needs to be reinforced on a national scale in many countries by diagnosis, advice, treatment and sanitary regulations. Veterinarians with special training in poultry pathology, including some practical work in poultry husbandry, are essential in the development of work in this field.

(3) In order to improve production capacity of utility birds and to increase the number of poultry keepers possessing healthy and efficient birds, accredited breeding stations are most useful as has been proved, e.g., in the United States of America, where a "National Poultry Improvement Plan" has been operating since 1935. Its objectives are to improve the breeding and production qualities of poultry and to reduce losses from hatchery disseminated diseases. This is being accomplished by:

(a) the development of more effective state poultry improvement programs;

(b) the identification of the quality of breeding stock (e.g., random sample tests), hatching eggs and chicks by authorized terms that are uniform and applicable in all parts of the country, and

(c) the establishment of an effective co-operative program through which newer knowledge and practical experience can be applied to the improvement of poultry and poultry products.

Progress in the production of efficient layers and quick growing table birds (broilers) may also be achieved by selection of inbred lines and their crossing. In principle, it is necessary not only to increase average egg and meat production capacity, but also natural resistance to certain diseases. The work of utility breeders' associations should be financially encouraged by governments.

(4) The rearing of healthy birds as well as an increase in egg and meat production also depends largely upon feeding. Though in many cases it would be possible and desirable to utilize more locally produced feedingstuffs for poultry, it is, however, indispensable to eliminate feeding deficiencies resulting from the biased use of certain products like grains and other carbohydrate feedingstuffs. Even a small amount of mash, rich in protein, minerals and vitamins may often help to overcome some nutritional deficiencies. This will result in an improved feed conversion rate, better health and thus considerably increased output and revenue. Hence,
special attention to the optimal use of indigenous feed-stuffs is desirable. This involves the collection of information on the possibilities and status of poultry feeding in the various countries and experimental and extension work. Well balanced commercial compound feeds are recognized as an efficient means of increasing output rapidly and reducing losses considerably. The increased use of antibiotics and other medicants as parts of compound feedingstuffs for poultry has brought along with its gains, additional responsibilities to the industry (Levine, 1954). The nature of the medication and its innate toxicity, particularly its safety factor, should be kept in mind.

(5) Further impetus should be given to research work, particularly in breeding, feeding and disease control. Careful planning and co-ordination of experimental work as well as the use of statistical methods in the interpretation of results are becoming more and more indispensable. This involves the necessity for adequate scientific and practical training of capable specialists and reliable personnel as well as the establishment of well equipped and sufficiently financed experiment stations.

(6) In all countries where the poultry industry is well advanced, such as Canada, Denmark, Israel, the Netherlands, the United Kingdom and the United States of America, extension services exist through which poultry keepers and breeders are assisted in putting into practice improved technical methods adapted to the existing conditions. Advisers should be well trained and as independent as possible. Their work should be supported by the distribution of good and inexpensive leaflets and other material for demonstration, such as plans and models of suitable and cheap poultry houses and waste-reducing feeding troughs, etc.

Governments, co-operative organizations and private firms, should pay particular attention to the level of quality and prices of poultry products, collection and marketing of eggs and table birds in countries where the industry is not highly developed. In many cases, attempts might be successful to interest the public in higher consumption of eggs and poultry meat.

Statistics and estimates on poultry numbers and production are often out-of-date, incomplete and unreliable. Also, owing to the diverse methods employed by different countries, it is extremely difficult to compare these figures. Therefore, such statistics need to be standardized and revised at regular intervals in order to complete the basic data for food balance sheets and facilitate economic and technical planning.
Current Situation and Recent Technical Developments in Various Countries

Information regarding the present status of the poultry industry and possible programs for improvement in American countries, is summarized in the following paragraphs.

In Argentina, poultry husbandry is usually carried out subsidiary to other agricultural activities. Out of a total of approximately 50,000,000 birds, about 60 percent are kept on peasant farms. Argentina offers favorable conditions for poultry production almost throughout the whole country. The main production period is July to November, with peaks in August, September and October; in this period, about 70 percent of the production is obtained, and 30 percent during the period from December to July. A notable increase in poultry production took place during recent years, and particularly near the big cities there are several specialized poultry establishments in which breeding stock, table birds (broilers) and eggs are produced. Originally, most of the imported birds were White Leghorns, especially bred for egg production, but more recently a tendency towards dual-purpose breeds became apparent, and other breeds, like Rhode Island Reds, Wyandottes, Sussex and New Hampshires were imported. The State supports the poultry breeders' activities by assisting in distributing improved breeds, particularly to farmers. Housing, feeding and management have also been considerably improved during the last few years. There are 30 accredited feed manufacturers in the country. According to a decree which the Government made in 1951, commercial mash-formulas must be officially approved.

Poultry diseases are reported to be efficiently controlled; this relates particularly to specialized establishments for egg and poultry meat production on a large scale, and to the 1,500 accredited breeding stations which are included in the state herdbook. The herdbook is open to the offspring of registered birds, to duly certified imported birds and to the offspring of non-registered hens with a minimum production of 180 eggs in the first year, mated with registered cocks which have to comply with standards. Special attention is given to the eradication of pullorum disease, and its control is extended also to poultry exhibitions. All birds showing a positive test reaction have to be eliminated. The direct control activities are complemented by extension campaigns, through meetings, publications and demonstrations.

In the main poultry zones, which coincide with the cereal zones of Argentina, the Provinces of Buenos Aires, Entre Ríos, Santa Fé and parts of the provinces of Córdoba and La
Pampa and where about 80 percent of the birds are located, buildings and other installations are usually of sufficient quality. In the north and central parts of the country, the open-front-house is most frequently adopted, whereas in the south, according to the environmental conditions, closed structures are preferred. Small incubators with a capacity of about 200 eggs are frequently used. On the large breeding establishments, incubators up to 60,000 egg capacity are available.

There are no specialized poultry experimental stations or schools in Argentina, but some general experimental stations, as well as certain agricultural schools and animal breeding stations have established poultry sections and are also dealing with advisory work in the poultry field. No important poultry co-operatives exist; however, the State has taken a very active interest in the establishment of co-operatives for all branches of animal husbandry and many of the agricultural co-operatives have poultry sections. The Government is at present carrying out a plan for the development of the poultry industry which covers extension work by means of meetings, publications, demonstrations, courses, exhibitions, direct advisory service, experimental work, disease control and marketing.

In Canada, 95 percent of the stock are purebreds or crosses of the following breeds: Single Comb White Leghorns, Barred Plymouth Rocks, Light Sussex, Rhode Island Reds, New Hampshire, White Rocks, Columbian Rocks and White Wyandottes. About 90 percent of poultry raised on farms, or in specialized commercial poultry establishments, are fed balanced mash. It is estimated that approximately 60 percent of the birds are fed commercial mash, and that an additional 25 percent get mash made of home-produced feedstuffs mixed with a high protein supplement manufactured and distributed by feed companies. The poultry are kept in houses varying from those made of straw bales in the prairie provinces to the industrial type with a capacity up to 15,000 birds in one unit; however, the one-storey, gable roof house with southern exposure and constructed of wood is the most popular type being used. The present tendency is to make this house deeper. Houses being constructed at present are about 40 ft. deep. The walls and ceiling are usually insulated and the floor is covered with deep litter. In large pen units, electric lights are frequently used. Automatic watering and feeding are used to a lesser extent.

A program for the eradication of pullorum disease in poultry has been in progress for 20 years. Under this program the incidence of positive pullorum reaction has been reduced to 0.12 percent. Virus and other contagious diseases of poultry are reportable under the Animal Diseases Act, and a control program
by vaccination is in progress. The manufacture and distribution of vaccines are controlled by permit. The experimental farms of the Canadian Department of Agriculture carry out extensive research work in poultry at the experimental farm, Ottawa, and on 23 branch stations spread throughout the country. Egg laying contests were operated in Canada from 1911 until the beginning of the last war. Since they were given up, the breeding of poultry has been stimulated by the “National Poultry Breeding Policy.” It provides advice for the mating, pedigreering and testing of families on the breeder’s own farm. This work has now grown to proportions where it has become necessary to establish a central testing station. Accomodation is under construction for bringing samples of hatching eggs from the breeders’ farms to a central place where the eggs will be hatched and the birds reared under uniform conditions which will allow comparisons of the efficiency of the various strains.

Breeder organizations have been established in each province in Canada. The poultry hatching industry has developed to a point where each province also has a hatchery association as well as a poultry products committee, made up of representatives of the breeding industry, hatching industry, feed industry, producers organizations, etc. There has also been organized a poultry products center which is financially supported by the industry for the purpose of popularizing eggs and other poultry products. There exist also feed manufacturers’ associations. In addition to the organizations maintained by the industry, each provincial department of agriculture and the Canadian Department of Agriculture maintain poultry divisions staffed with qualified poultry personnel. Besides the educational and extension work done by provincial and federal departments of agriculture, there are seven universities with poultry departments, staffed by qualified specialists. There are also several agricultural schools where poultry instruction can be obtained. Numerous publications on poultry production in all its aspects have been issued. The industry is well served by several co-operative sales organizations. A large volume of the production in Alberta, Saskatchewan, Manitoba, Ontario and Quebec is marketed through producer-owned and operated co-operative organizations.

In Colombia, poultry production is usually carried out on a small scale. In most cases, the flocks which belong to farmers, have from 10 to 100 birds, mostly chickens and some turkeys and ducks. As a rule, poultry have to find their own feed, but sometimes this feeding is supplemented by small quantities of maize or inferior wheat. Few special poultry houses exist. The native birds produce about 60 eggs per year on the average, this low production being due to bad feeding and poor selection.
Nevertheless, poultry production occupies fifth place in economic importance in agricultural and livestock production in Colombia, coming after coffee, milk, beef and maize. Imports in 1954 were: chickens for breeding, 1,672,293 head; eggs for breeding, 240,000 units; eggs for consumption, 19,790,000 units; and chickens for consumption, 105,204 lb. Three years ago, after the appearance of Newcastle disease, imports of eggs and chickens, which had not formerly taken place, became necessary. Colombia has good possibilities for poultry development but it is necessary to instruct farmers on the improvement of installations, selection and feeding methods and to control diseases.

In Ecuador, the New Hampshire, Plymouth Rock, Rhode Island Reds, Jersey Black Giant and Orpington appear to be the best adapted improved breeds for the country. They have also been used for crossing with native birds. About 80 percent of the poultry in the country are scavengers. In some establishments, the construction of special types of buildings has been started; however, for the greater proportion of poultry, no special houses or equipment are available. Some preventive vaccination is carried out against the most important diseases, such as fowl cholera, Newcastle disease; and ecto- and endoparasites are controlled to some extent. There are no poultry co-operatives in the country.

In El Salvador, poultry raising has always been an important sideline with rural families. However, in the last five years the industry has made a very unusual growth. In the principal cities (San Miguel, Santa Ana and San Salvador) there are 40,000 laying hens under official supervision. When the poultry program was initiated, nothing was known of the performance of the leading breeds in the tropical climate of El Salvador. Therefore, eight different breeds were introduced and placed under test for three years (1949-51) at the experiment station of the National Center of Agronomy at San Andres. The New Hampshires and Leghorns proved best. Recently it was shown that Leghorns produce more eggs than New Hampshires and since the price of eggs is high in relation to meat, the Leghorns are rated highest under present conditions. The supervised flocks are fed exclusively on balanced diets, while the flocks commonly kept by farmers depend entirely on grain and the insects they may obtain. Feed constitutes about 70 percent of the total costs in egg production. Three firms supply feeds. Two of these prepare balanced mash with home products, using the minimum of imported concentrates. The third imports concentrates of high protein value, to be mixed with local feeds.

Poor nutrition and disease are the chief factors limiting production generally, and there is no national program of disease control. There are two poultry specialists working with 19 extension agents.
to advise and assist the poultry breeders. There is only one publication devoted to this industry, but generally two articles per month on poultry keeping appear in the local press.

In Jamaica, there is an increasing number of farmers rearing poultry intensively. Most of the farmers use purebreds or crossbreds. During 1953, approximately 1,100 tons of feed were mixed and sold locally as compared with 2,000 tons imported. This gap can be expected to become narrower. Housing for poultry varies considerably. Deep litter is becoming increasingly popular for laying birds, and most of the broilers are now raised on wire. Only a few peasants provide proper housing for their birds, but there is no doubt that fairly cheap housing could be produced from local materials. Housing, in turn, implies intensive feeding and rearing and is thus unpopular with most of the small scale poultry farmers who prefer their birds to forage for part, at least, of their livelihood.

The presence of Newcastle disease, infectious bronchitis and chronic respiratory disease have recently been confirmed. Vaccination of all birds against Newcastle disease and fowl pox is recommended to farmers and is carried out on all chicks sold from the government hatchery. No program backed by legislation is in force, and, in view of the sporadic losses attributed to these diseases, it seems doubtful whether an expensive, comprehensive scheme is justifiable.

There are one major station and three minor stations where a limited amount of demonstration and research work on poultry is carried out. An accredited poultry scheme has recently been prepared in conjunction with efforts to make the island self-supporting for day-old chicks, and it is hoped that the scheme will be accepted and implemented in the coming year. The Department of Agriculture has one full-time poultry officer with two assistants. In addition, the 13 Livestock Extension Officers in the field are competent to give advice on elementary poultry husbandry. Extension circulars have been issued on "Starting in the Poultry Business," "Housing and Feeding Poultry" and "Common Diseases of Poultry." These are written in simple terms but deal with the subjects to a reasonably advanced level. There is a small co-operative which markets eggs and, to a limited extent, poultry meats. Other marketing is at present haphazard, but the Government is considering the promotion of an expansion of the present co-operative. There are two poultry keepers' organizations, but neither is firmly established or representative of the industry. An official accredited poultry scheme is soon to be launched.

In Panama, the most common improved breeds are Single Comb White Leghorns, Plymouth Rocks, New Hampshires and
Rhode Island Reds. The results obtained with heavy breeds have not always been satisfactory, whereas White Leghorns have proved to be more successful, but only where due attention was given to adequate feeding and protection against endoparasites. Leghorns have been less successful in ordinary small holdings, where the most adaptable breeds have been Rhode Island Reds and New Hampshires and, to a lesser degree, Plymouth Rocks. The New Hampshire is now the most common breed, both for egg and meat production, but particularly for the latter. Very little balanced feeding is done at present, and the majority of birds depend on waste grains and table refuse. However, a certain number of producers have already started to use balanced mash, based on locally produced feedstuffs and, to a certain extent, on imported high protein concentrates. The production of compound feedstuffs is comparatively small, and is not supervised by the Government. It is supposed that the use of commercial mash could be considerably increased if manufacturing would be standardized and officially supervised.

In poultry husbandry, little experimental work is carried out in Panama at present, but the National Institute of Agriculture keeps a flock of birds for teaching and experimental purposes.

In Paraguay, the poultry industry has not been developed to any significant extent for a number of reasons, among which the most important are: little official support, lack of adequate technical knowledge on the part of the farmers, the almost exclusive use of native breeds, several diseases which cause heavy losses, deficient feeding and inadequate housing and equipment, low quality of locally produced poultry meat and eggs, marketing difficulties, inadequate transport facilities, particularly for areas located at considerable distance from the consumption centers.

The native type of hen on the average produces not more than 60 eggs per year and is not precocious; however, its replacement by imported breeds or by adequate crosses is very slow, because the farmers believe that native birds are more resistant to the environmental conditions and diseases. The first significant imports of improved breeds were made in 1951, when some Rhode Island Reds came into the country, and appeared to be satisfactorily adaptable. An official breeding farm was established, which now has approximately 3,500 birds, the eggs of which are distributed for incubation. The official credit agency of the Government distributes breeding stock from this station on credit. The Rhode Island breed has certain disadvantages, however, mainly a certain susceptibility to diseases. Furthermore, low hatchability often occurs. The recently improved Leghorn breed has proved to be very adaptable to the existing conditions in the country; however, it is less satisfactory than the Rhode Island Red, which is a dual
purpose type. Recently also Sussex and New Hampshires have been imported.

Since there is little balanced feeding in Paraguay, poultry depend practically entirely on grains and pasture. Just recently, an attempt was made to produce poultry mashes from locally produced feedstuffs and imported meat meal. There are several diseases of considerable importance, such as fowl cholera, pullorum and fowl pox, but so far Paraguay is free of Newcastle disease, and precautions are taken by the Government to prevent its introduction.

In Trinidad and Tobago, Rhode Island Reds, White Leghorns and New Hampshires are being used to a considerable extent in broiler production. A large part of the poultry in the Colony is owned by peasants and the birds are allowed mostly free range. However, there is a noticeable trend towards the purchase of improved locally produced feeds. On the other hand, the large broiler producers feed, almost exclusively, imported feeds. There is one local firm manufacturing feed and the Marketing Division of the Department of Agriculture also sells poultry feeds.

No standard types of poultry houses are used. Peasant-owned birds roost in trees. Certain poultry raisers have their own plans for houses. Batteries are used for broiler production, but one raiser runs a series of broiler houses. A few are adopting the deep litter system. In view of the diversity of ownership and management, the possibility and need of standard housing is questionable. Specific regulations deal with the control of Newcastle disease. Regulations also cover the importation of live and dressed poultry. Vaccination against Newcastle disease, fowl pox and infectious bronchitis is practised. Two stations within the Department of Agriculture also give attention to poultry problems. Laying tests have not yet been carried out, and no poultry experts at present are included in the extension service. The Department of Agriculture has published bulletins on “A Few Practical Suggestions on Poultry Keeping in Trinidad and Tobago,” and “Observations on Simultaneous Vaccination in the Control of Fowl and Newcastle Disease.” There is a local poultry association which has a beneficial influence on the industry. Co-operative societies do not exist.

In the United States of America, poultry production provides approximately 10 percent of the gross farm income. There are highly specialized production establishments where many thousands of birds are produced on one “farm,” and chickens are raised on 78 percent of all farms. The principal grain producing states are also the leading states in volume of poultry and eggs produced, yet most poultry are fed manufactured feeds. Of all laying hens 31 percent are in flocks of less than 100 birds, 25 per-
cent in flocks of 100 to 200 birds and less than 10 percent in flocks of over 1,600 birds.

The great majority of chickens produced in the United States of America come from five breeds: New Hampshire, White Leghorn, White Rock, Barred Rock and Rhode Island Reds, in that order. In recent years a significant number of birds have come from cross-matings. It is estimated that approximately 20 percent of current chick production is from cross-mated parent stock. Five years ago this percentage was probably no greater than 12.

There are only a relatively small number of primary breeders and there is a tendency for the number to decrease and the size of operation to increase. Perhaps the most significant recent development is that many primary breeders are now employing highly trained geneticists to conduct their breeding programs. This trend has increased the rate at which research information from experiment stations and the U.S. Department of Agriculture is put into practice. In addition, the geneticists employed by commercial breeders are contributing to the general fund of knowledge on poultry genetics and breeding methods.

There are many poultry breeders' organizations. The oldest is the American Poultry Association which was organized for the purpose of standardizing varieties.

The U.S. Record of Performance Federation is strictly a breeders' organization comprising the Record of Performance (R.O.P.) breeders participating in the National Poultry Improvement Plan. In most states there is an organization of the breeders and hatcheries participating in the National Poultry Improvement Plan. The members have a voice in determining the provisions of the Plan on a national basis, and in the establishment of state-operating rules.

Breeders and hatcherymen are represented in two national trade organizations: the American Poultry and Hatchery Federation, and the National Turkey Federation. There are state affiliates to these organizations, and numerous other state and regional organizations in which poultry breeders are an integral part.

State and area poultry breeders' schools have been an important stimulus to poultry breeding in the United States of America. The Massachusetts Poultry Breeders School, one of the first, has been held annually since 1927. Two of the well established regional schools held annually are the Midwest Poultry Breeders Conference and the Pacific Poultry Breeders Round Table. The National Poultry Breeders Round Table, sponsored by a group of large private breeders, is another well established breeders organization.

There has been no substantial trend toward breeders co-operatives. The breeding is handled almost exclusively by private breeders, many of which are large corporate organizations. Of
the estimated 8,000 baby chick hatcheries, only a little over 100 are co-operative hatcheries.

Standard egg-laying tests, comprising 13 selected pullets per entry, have demonstrated the possibilities of high egg production, and thus contributed to the development of the poultry industry in the United States. The first tests were established at Storrs, Connecticut, and Mountain Grove, Missouri, in 1911. Within the next 20 years, more than 40 tests were opened, but the number declined to 15 in 1950 and 8 at present. Results in the standard laying tests, which were based on highly selected samples of birds, did not accurately reflect the average production of the entrant's stock. Random sample tests were started with an objective of overcoming this weakness. The entries in such tests are a random sample of hatching eggs or chicks, taken by a disinterested party, of the grade of stock to be tested. There is no culling and the tests are usually continued for 500 days from the date of hatch. The first random sample egg production tests were conducted at Pomona, California, in 1947/48 and 1948/49. The acceptance of such tests is indicated by the fact that there were in operation 6 tests of this type, and 2 additional tests have been announced for 1955.

Consistent with the interest in commercial broiler production in the United States, 8 meat production tests have been established. There is a growing interest in random sample turkey production tests. One such test was conducted in Texas in 1954, and at least 1 additional test was being planned for 1955.

The National Poultry Improvement Plan, a federal/state program initiated in 1935, has been a major factor in the development of the poultry industry. Approximately two-thirds of the nation's hatching egg flocks and hatcheries voluntarily participate in the Plan. The program provides for the classification of flocks, hatching eggs, chicks and poult's with respect to disease control (Pul lorum and typhoid) and breeding improvement. Four of the breeding improvement classifications are based on Record of Performance. The R.O.P. program includes supervised trap-nesting and pedigree breeding on the breeder's farm and performance records in random sample tests.

Approximately 61 percent of the estimated 1,680 million chickens raised in the United States of America in 1954 were broilers reared in confinement on commercially mixed food. The other 39 percent, comprising 621 million chickens, which include 414 million laying hens and pullets, were raised on farms. These chickens consumed an estimated 21.8 million tons of feed. Mixed feed supplied about 13 million tons, leaving 8.8 million tons to be supplied by grain grown on the farm, home-made mashes and pastures. It is reasonable to believe that the smaller farm flocks
and backyard flocks (under 50 layers) obtained some feed as table scrap, bugs and insects. However, in the over-all production of meat and eggs, the quantity of food the chicken obtains by scavenging is negligible. In the smaller farm flocks, the value of good pastures as a feed supply should not be overlooked. Although the proportion of grass that the chicken can effectively utilize is small, it is of economic importance because it is estimated to save 10 percent of the grain requirements and supply vitamin A and riboflavin. However, feed from a carefully prepared and planted pasture cannot be considered scavenger material.

The great majority of turkeys are raised under commercial systems, and do not have access to any food other than the mashes and grains fed them.

An estimate of the poultry population and of the total food consumed when compared with the estimated production of formula feeds indicates that at least 60 percent of the feed consumed by poultry is supplied by commercially mixed feed.

Owing to the varied climates encountered in the United States of America, poultry houses are not limited to one or two types. Factors, such as kind of operation, and size of flock, also enter into the planning of poultry houses. Building design differs somewhat for broiler production from that for egg production. A noteworthy shift in recent years is to keep hens confined in individual cages. For farm flocks, poultry houses are relatively small one-storey structures; for many of the larger flocks the houses are multiple storey. Light construction has been used for many years, but considerable loss has been suffered in those structures during the past few years owing to storms. This experience seems to be resulting in more substantial design for poultry houses, effectively tied from roof to foundation.

In the southern part of the United States of America, individual cages are placed under comparatively simple shades. Side-walls and floors are not used. The nests and supports are so arranged that removal of droppings may be done easily. Poultry houses in the colder parts of the country are enclosed and frequently well insulated, but most of these houses are equipped with windows on at least two sides. These are opened for cross-ventilation during summer months. In some of the northern states, houses are designed to keep the chickens occupied most of the time over utility pits. Feeders, waterers and perches are located so that waste and droppings fall into the pits. These pits may be cleaned either manually or mechanically.

Although poultry houses design has been linked closely with the protection of birds from cold, there is accumulating evidence that protection from excessive heat is fully as necessary. Extremely hot weather (above body temperatures) often kills large
numbers of birds. Protection sometimes is provided by spraying the roofs with water during the heat of the day. A plan exchange service is maintained whereby plans for poultry houses developed in any part of the country are catalogued so that interested poultrymen may select a design most suitable to the particular climate. The catalogs are held in county agricultural agents' offices and plans considered suitable for a given state are available through the Agricultural Extension Service of that state.

National disease control programs developed by the U.S. Department of Agriculture for the prevention of poultry diseases are the pullorum disease and fowl typhoid eradication programs, which are a part of the national poultry and turkey improvement plans, and are conducted under the auspices of the Animal and Poultry Husbandry Research Branch of the Agricultural Research Service, U.S. Department of Agriculture, the co-ordinating agency for the entire program. They are conducted within 47 of the states on a voluntary basis. The Department also sponsors research for the control of such other diseases as infectious bronchitis, chronic respiratory disease, tuberculosis, and avian leucosis on a co-operative basis with some of the states; however, the organization for such control is limited to the states. Basically, the control of all poultry diseases is a problem left to the individual states and is only done on a national basis, as in the case of pullorum disease and fowl typhoid, when it is mutually agreed upon, except in the case of imports of fowl of all kinds. Department regulations designed to prevent the introduction and dissemination of poultry diseases of foreign origin include:

1. for poultry intended for importation from any part of the world (except Canada), the importer is required to obtain a permit before such poultry are shipped from the point of origin;
2. all poultry offered for importation must be accompanied by a certificate from a salaried veterinary officer of the national government of the country of origin, showing freedom from certain diseases and exposure thereto for 60 days before shipment;
3. veterinary inspection at a designated port of entry;
4. quarantine (except for poultry from Canada) for not less than 15 days at the first port of entry in the United States of America.

Statutory authority is available, to eradicate certain diseases, should they gain entrance to the United States and threaten the poultry industry. In 1924, an outbreak of fowl plague (European fowl pest) was eradicated through strict quarantine measures, and
in 1950, an outbreak of Asiatic Newcastle disease was quickly eradicated through quarantine and slaughter of diseased and exposed birds, with indemnities to owners of such birds.

Regarding recent advances in poultry research, the following summary of information is indicative of some of the major developments in the United States of America.

The united attack of the state agricultural experiment stations in each of the four regions of the country — North Central, Southern, Western and Northeastern — in close co-operation with the U.S. Department of Agriculture appears to be the logical way to reach a sound and more rapid solution of poultry breeding problems too hard to solve by individual breeders and institutions. In two of the regions, testing stations have been established for evaluating, under uniform conditions, the inbred lines of chickens developed in the various states, as to combining ability to form hybrids with high economic qualities. In two regions the co-ordinated research is on chickens exclusively; in another turkeys only, and in the fourth region, both chickens and turkeys.

A short cut in the breeding procedure is now being studied at the Indiana Station by research workers of the U.S. Department of Agriculture and Purdue University. Using the very prolific fruit fly as a test animal, instead of the chicken, the relative effectiveness of various systems of breeding according to egg size and production is being determined.

Normally, in prolonged breeding programs the qualities for which selections are made increase up to a point, after which, in many instances, the rate of improvement levels off. In order to break through the leveling-off period and to obtain additional gains, X-ray treatments are administered to produce mutations in the chromosomes. These treatments will be given through five generations, and the genes and chromosomes of different individuals, unified and recombined.

A non-broody line of Rhode Island Red chickens has been developed by the Massachusetts Station, which has shown complete freedom from the broody instinct through several generations. The Maryland Station is breeding flightless chickens that have wings, but lose the long pinion feathers permanently at the time of first molt. New breeds of chickens that thrive well at high altitudes are being developed at the Wyoming Station.

The recent use of radio-active isotopes in poultry has been found advantageous by the Florida and Tennessee stations and the U.S. Department of Agriculture in studies on problems involved in growth, development and reproduction. When S35-labeled sodium sulphate was injected into newly hatched chicks, about 32 percent of the sulphur was still present in the chick six days later. The sulphur was divided between two fractions: about 10 percent
has taurine and about 22 percent associated with connective tissue. No radio-active cystine was detected. When 0.5 percent sodium sulphate was fed to chicks on a sulphur deficient diet, a growth stimulation was obtained. The results obtained by U.S. Department of Agriculture workers shed some light on nutritional metabolism in the chick which is at present very poorly understood.

A vast amount of new knowledge about growth factors and antibiotics has opened up a wide horizon of research activities that are bound to bring great changes in poultry production. According to the New York (Cornell) and Washington stations, the growth promoting factor, B₁₂, seems to exist in several forms. A number of other factors, most of them important for growth of birds, are still unidentified. Four such unidentified growth factors have been found in a liver preparation. In addition, a "whey" factor and an "alfalfa" factor are known to exist. Also chicks have a dietary requirement for either specific fatty acids, or for an unknown vitamin or vitamins present in vegetable oils, or both. A biological assay was developed by the U.S. Department of Agriculture workers for determining the presence of an unidentified chick growth factor in feeds. Using this method, a factor(s) in condensed fish solubles was found. Efforts to isolate the factor(s) have resulted in a concentrate which, at 0.009 percent of the diet, gives a growth response equal to 4 percent fish solubles (a 250 to 300 fold concentration). Progeny performance trials showed that the unidentified factor is transferred from the hen to the chick when the breeder diet contained fish solubles. Further work is in progress to concentrate the fish solubles factor and possibly establish its identity.

Although, according to the Illinois, Maryland and Washington stations, the value of "surface active agents" in stimulating growth is still doubtful, that of antibiotics is well established, as shown by research at the California, Pennsylvania, Texas and other stations. Antibiotics apparently do not serve as nutrients but improve the microflora of the digestive tract, thus encouraging synthesis of nutrients or permitting more complete utilization of those in the diet. Research at the Maryland and Texas stations, and at the U.S. Department of Agriculture shows that the feeding of antibiotics does not appreciably improve the growth of chicks reared in a very clean environment, whereas it causes a marked response in a normal environment.

The Storrs, Connecticut, Maryland, Utah stations and the U.S. Department of Agriculture have shown that a significant increase in growth rate, improvement in feathering, and increase in efficiency of feed utilization can be obtained by supplementing certain diets with additional methionine, one of the essential amino acids.
The growth depression of alfalfa meal seemingly is due to saponine, which can be counteracted largely by cholestrol or removed by extraction of the meal with hot water, as indicated by research at the California Station. The U.S. Department of Agriculture has shown that the growth-inhibiting properties of alfalfa vary widely with location of production, variety and cutting.

Successful growth and reproduction of chickens has been obtained on a diet of only ladino clover (as range), ground corn, and minerals, according to the Ohio Station. That grassland economizes on feed is concluded from research by the Michigan, Pennsylvania and Vermont stations.

At the Storrs, Connecticut station, a high incidence of encephalomalacia has been produced in chicks, hatched from hens deficient in Vitamin E and raised on a low Vitamin E diet containing 2 percent "Vitamin A and D feeding oil," but a remarkable protection is obtained by feeding an antioxidant (diphenyl-para-phenyl-enediamine) used to protect carotene in feeds.

The Wisconsin Station has found that a wood waste product from the paper industry, torula yeast, when replacing part of the soybean oil meal in a chicken diet, will produce good growth. Wood sugar molasses, corn molasses, and low grade sugar, will replace a part of a cereal grain in hen and chicken rations successfully, according to the Arkansas, Hawaii and Oregon stations. Vegetable wastes, such as discarded broccoli, kale, rhubarb, spinach and carrots, when converted into meal or a homogenized fermented mixture, have been found by the Delaware and Maryland stations to substitute well for alfalfa meal. Chicken scrap has compared favorably with other protein concentrates in a chick diet at the Iowa, Nebraska and Wisconsin stations.

According to the Hawaii Station, brackish water containing as high as 400 grains of salt (NaCl) per gallon, given to chickens in addition to a diet having 0.5 percent salt, had no adverse effect on feed consumption, body weight, or survival. Thus, it will be possible for poultry to be raised on land in Hawaii where the salinity of the water is high (up to 100 grains of salt per gallon of water).

Regarding physiology, there are four different families of blood group characters in chickens that reflect hereditary biochemical differences in the protein structure of their blood cells. By comparing the performance of chickens with these different blood types, the Texas Station has found it possible to determine whether the blood group genes also affect characters of economic importance. Hens whose eggs show low fertility, usually are able to maintain live spermatozoa in their reproductive tracts only about one day, whereas those with high fertility can maintain spermatozoa for 14
days or more. The New York (Cornell) Station discovered that, by pretesting the females, it is possible to eliminate those in which duration of fertility is low.

The Puerto Rico Station also found that time of hatching has an important bearing on sexual maturity and egg production of pullets, regardless of the relatively uniform climatic conditions on the Island which has no seasonal extremes. Female chicks hatched in February, for example, had earlier sexual maturity than those hatched in March. The poultry breeder in Puerto Rico, therefore, must consider a correction or allowance for date of hatch when breeding for early sexual maturity.

The reticulo-endothelial system is concerned with blood-cell formation, bile formation, straining off fatty materials, phagocytic destruction of blood cells, and the metabolism of iron and pigment. On the theory that this system can filter congo red particles from the blood stream in very much the same manner as disease-producing viruses, the Alabama Station has compared the ability of different breeds of chickens to filter out such particles. The evidence thus far indicates that disease resistance may be associated with the reticulo-endothelial system.

It has been demonstrated by the U.S. Department of Agriculture that the ruptured follicle plays an important role in controlling time of lay of the egg (or ovum) which it previously contained. Following removal of the ruptured follicle, the egg was retained in the uterus far beyond the time of normal lay. It has been shown recently that removal of a part (approximately half) of the ruptured follicle results in a contrary effect, the egg being laid prematurely by 12 to 17 hours before the hour of expected lay. These findings afford additional evidence that the ruptured follicle normally participates in the control of oviposition. Work is being continued to ascertain the manner in which the ruptured follicle exercises its regulatory function.

Management problems are also receiving full attention. According to the Pennsylvania Station, the replacement of small, scattered laying pens with larger units in a more orderly compact arrangement; the removal of partitions between pens; the grouping of nests near the pen doors or the addition of nesting rooms; the installation of floor feed-boxes with overhead chutes, or, in large units, of a mechanical mash feeder; and the use of feed carrier trucks and frost-protected automatic waterers — all have proved to be valuable as labor and time savers. A utility unit consisting of an automatic feeder and waterer installed between the roosting perches so that the chickens eat, drink and roost over a droppings pit, together with a mechanical cleaner for removal of droppings, has been designed.

The Ohio Station has found that the long-time use of compost
litter for chickens under proper conditions causes no "build-up" of diseases or parasites. Actually, less difficulty is experienced from coccidiosis with compost litter than with bi-weekly replacements. Also, compost litter apparently is a source of special nutritional factors for confined birds. For turkeys, however, compost litter is dangerous, so fresh litter should be used and changed frequently.

A number of the diseases that formerly plagued the poultrymen of the United States of America are now being successfully combatted. Roup, aspergillosis, tuberculosis, pox, pullorum and coccidiosis are no longer considered major problems. Rickets, perosis, gout and other nutritional disorders also cause little concern. Nevertheless, losses appear to mount and new diseases are being recognized. Lymphomatosis or leucosis has been a cause of loss among adult chickens. U.S. Department of Agriculture researchers have recently found a test to detect visceral lymphomatosis (big liver disease) in live chickens. Respiratory disease and air-sac infection (chronic respiratory disease) are important. The U.S. Department of Agriculture and the states have extensive cooperative research programs on these diseases.

In Uruguay, probably more than 75 percent of the total amount of poultry and eggs produced comes from general farms on which the poultry enterprise is only a side-line business. Chickens are kept in complete liberty, usually in flocks between 50 to 200 birds, scattered around the barns and being almost entirely dependent upon loose grains or any other feed they can pick up in the field; supplementary rations are given in some cases and during certain seasons.

There is a common belief among farmers that "criollos" (indigenous) hens are hardier and even more productive than pure-breds. The introduction of valuable production breeds like New Hampshires, Rhode Island Reds and Single Comb White Leghorns, also appears to be hampered by the diffusion of fancy birds. Since 1951, the Bureau of Animal Industries prohibits the importation of hatching eggs or chickens from all countries, that are officially declared free from Newcastle disease.

There is a close relationship between the corn crop and its price and the number of chickens kept on general farms during the same year. Farmers seldom buy any feed for their chickens. There are no specialized commercial poultry feed manufacturers, but some firms, as a side-line, supply customers with ready-to-use feed for their birds. Commercial poultry farms depend almost entirely on a subsidized ration sold by the Government at different price levels and limited to those who have been operating poultry farms for several years.

Corn is the main grain for poultry followed by oats, barley,
sorghum, and wheat milling by-products. Owing to the relative abundance of animal proteins (meat scraps, tankage, liver meal, bone meal, fish meal), there is little use of plant protein foods, of which sunflower and linseed oil meals are mainly available. Brewer’s dried yeast and dried whey are also produced in the country.

On general farms, neither special poultry houses nor equipment are used, whereas specialized poultry farms make comparatively large investments in buildings and equipment. In view of the favorable climate, there is no need for closed poultry houses, except brooder houses, which must protect the chicks against heavy rainfall and strong winds that occur from time to time.

The Bureau of Animal Industries has set up a laboratory in which, among other work, poultry diagnostics are performed and vaccines and pullorum antigen prepared. Disease diagnostics are also made by the College of Veterinary Medicine in Montevideo.

The Government of Uruguay has also established within the Department of Agriculture a poultry service, which is operating a poultry plant on one of the state-owned farms. This station sells limited numbers of hatching eggs, baby chicks and breeding stock at low prices. It is also in charge of the R.O.P. program. Laying contests are organized each year. There is not yet any organized extension service on poultry in the country. Efforts are being made to issue leaflets and other publications relating to poultry. There are three main poultry organizations in the country. Poultry co-operatives have not been successful so far, and none exists at present.

Experimental work has been carried out on the increase of weight and feed conversion rate of New Hampshire chickens and their crosses from 8 to 14 weeks of age. Four hundred and thirty-seven chickens, New Hampshire, Plymouth Rock/New Hampshire and White Leghorn/New Hampshire, in two groups, both coming from the same stock and bred in the same form, were controlled periodically in their weights from the amount of feed consumed and finishing after 14 weeks (Achenbach, 1954). Up to 14 weeks, the feed conversion rate was 4.67 and 4.78, respectively, for both lots. To the 12th week, this relation was more favorable and below 4. In the partial period from the 12th to the 14th week, it increased to almost 10 in one case and to more than 11 in the other. This would indicate the advisability of initiating the marketing of the chickens at about 12 weeks, if the market conditions were favorable. The average weight after 14 weeks was 4 lb., with a maximum of 5 lb. for the first lot and 3½ lb. for the second. The average weight of the pure New Hampshire chickens was higher than the crosses in the first lot, but lower in the second, in which the crosses exceeded the purebreds by more than
10½ oz. each. The finishing of the pure New Hampshire was inferior to the crosses, especially in lot No. 1. The best chickens resulted from the crosses between a White Leghorn cock and a New Hampshire hen.

In Venezuela, specialized poultry production is relatively new, since the establishment of well equipped poultry farms was started only about ten years ago. Earlier, poultry production was of a purely domestic type and complementary to other agricultural activities. Since 1946, however, the demand for eggs and meat has considerably increased, and large amounts had to be imported. Hence, the Government decided to support the import of baby chicks, which were then reared in the country. At the same time, the Government allocated credits for the establishment of poultry farms for meat and egg production. These measures resulted in a reduction of imports, first of frozen poultry meat, and then of baby chicks; and since 1949, it has no longer been necessary to import table birds; however, chicks are still imported. The most common, improved breeds are New Hampshires, Plymouth Rocks and Rhode Island Reds, but there is still a large stock of native breeds in the country. Balanced feed rations are used in industrial establishments, but they are not yet applied on domestic farms. At present, there are six plants, for the production of compound feeds.

The Government of Venezuela takes an active interest in the control of diseases through its veterinary services. Furthermore, certain vaccines, particularly against Newcastle disease, are available, and there is a laboratory which carries out some research work in poultry diseases. However, there is no specific poultry experimental station in Venezuela. Experiments are carried out at the Faculty of Agronomy of the Central University of Venezuela, and at the Agricultural School at Maracay. At present, work is in progress on a cross between Leghorn and “Piroca blanca” which is a native breed. Favorable results have been obtained in the fifth generation, i.e., a monthly average of 21 eggs, sufficient body weight, resistance to certain diseases and, in general, a good adaptability to the environmental conditions.

The most efficient support of the poultry industry has been of an economic nature, i.e., credits for the establishment of poultry plants, and import duties. Furthermore, the Ministry of Agriculture organizes a certain number of poultry courses throughout the country, and livestock shows usually include a poultry section. Most of the poultry producers of the country are members of one of the following associations: Co-operativa Nacional de Granjeros (Caracas), Asociación Venezolana de Agricultura (Caracas), Asociación de Granjeros de Miranda (Estado de Miranda) and Asociación de Granjeros de Zula (Estado de Zula).
Literature Cited Regarding Poultry


The object of this chapter is to present an outline of the manner in which statistics may be used to increase the efficiency of animal husbandry and veterinary experiments and to aid the research worker in making his interpretations of the results obtained. It is based on a paper prepared by Dr. H.O. Hetzer, in connection with the Buenos Aires meeting.

Increasingly successful use is being made of the science of statistics in the various biological sciences, and the established statistical methods can play an important part in solving many of the problems faced by the livestock industry, whether the problems relate to breeding, feeding, pasture or disease control investigations. Many animal husbandmen and veterinarians have not had detailed training in statistics. However, with a general understanding of the principles outlined below and with the assistance of mathematicians, they can readily apply the simpler techniques in their research work. Such applications are already being made in many institutions, and the importance of more attention to the application of statistics was recognized in the Baurú meeting.

Fisher (1930) defines statistics as a branch of mathematics applied to observational data, statistics being concerned primarily with (1) the study of populations, (2) the study of variation, and (3) the study of methods of the reduction of data. Snedecor (1948) says:

Statistics have been called the technology of the scientific method. In the sequence constituting that method — hypothesis, experiment, test of hypothesis — the final stage is statistical... Unless the hypothesis is precisely stated, and unless the experiment produces unambiguous information about it, the test is futile and conclusions are unclear.

Variability is one of the common characteristics of all living matter. Even when dealing with individuals raised under similar environmental conditions, or with individuals who are identical in their inheritance, such as identical twins in cattle, for example, no two such individuals are ever exactly alike. As Cochran and Cox (1950) point out, it is this sort of variation which introduces a degree of uncertainty into any conclusions that are drawn from...
experimental results. The implication here is that results obtained under one set of conditions are never duplicated exactly under another set of conditions or, if obtained under the same conditions, the results from trial to trial may be so different at times as to leave their reliability in doubt. The development of methods for evaluating this element of uncertainty and applying statistical tests for the accurate summarization and interpretation of experimental data, constitutes one of the principal functions of statistics, as applied to the various biological sciences. Another field in which statistics have been increasingly helpful to the research worker in the plant and animal sciences is in the planning and designing of efficient experiments. Statistics may thus be considered to aid research in two important ways. One of these concerns the design of experiments and the principles which must be observed in order to permit the drawing of valid conclusions. Space will not permit mention of more than a few of the large number of statistical methods currently being used by research workers, but some discussion is included of the rules or steps that must be considered in planning experiments. Examples illustrating some of the experimental designs which appear to be particularly applicable to problems in livestock research are noted later.

Planning of Experiments

Consideration should first be given to the essential steps which are basic to successful experimentation. Cox (1951) once remarked that an ideal situation would be for every experimenter to know his science and the science of statistics. A similar view was expressed by Snedecor (1950). In discussing the steps involved in planning an experiment, Snedecor pictures the situation as follows:

The experimenter specifies the conditions in which the trial (or experiment) is to be performed — materials and treatments, together with genetic and environmental circumstances — and the measurements that can be made. The statistician selects or invents a plan (experimental design) which will furnish unbiased and unconfounded estimates with adequate precision. The experimenter conducts the laboratory or field work, taking pains to eliminate as nearly as possible all extraneous effects. If he is successful, the ensuing measurements will contain the information for which the experiment is set up. The statistician uses appropriate methods for extracting all the information brought into the data. Finally, the experimenter interprets this information in the light of existing knowledge in his science.
It should be noted that Snedecor places considerable emphasis on the selection of an experimental design which, as he expresses it, "will furnish unbiased and unconfounded estimates with adequate precision." In other words, the experiment should be designed so as to yield results which are both accurate and free of extraneous effects, as well as precise in that they must be repeatable under similar conditions. There is a very important reason for this which should be kept in mind at all times. The point is that whatever statistical methods are used, they are only tools. To use these tools successfully, or to extract the desired information from an experiment requires that the experiment be so designed as to yield results which provide reliable information on the points at issue; i.e., regardless of how refined or how elaborate the statistical methods employed, they are powerless if applied to inadequate data or to data from faulty experimental designs.

Consideration should be given to the individual rules or steps that should be observed in planning experiments. They are (1) a statement of the objective, (2) a description of the experiment, and (3) an outline of the statistical analysis of the results. There are, of course, other things that should be considered before starting an experiment, such as applicability of the results to the solution of a particular practical problem (i.e., economic justification), approximate total cost and availability of the necessary personnel and materials, including animals, feeds, housing, pastures, instruments, tools, etc. While all of these latter items are important, it is assumed here that they have been resolved before the experiment actually gets under way.

The first step in planning an experiment is to state clearly the purpose of the work. The principal objective may be in the form of a question to be answered, a hypothesis to be tested, a relationship to be measured, or treatment effects to be estimated.

To illustrate the importance of sound planning, a statement by Cox (1951) may be quoted as an example of faulty experimentation. The results were brought to a statistician with a question about testing the effect of different protein supplements on rate of growth in chickens. That is, the investigator wanted to know if the treatment differences were statistically significant, or, stated in more practical language, if the differences he attributed to treatments were real in the sense that they could not reasonably be attributed to the vagaries of mere chance. The experimental material being chickens, and knowing that males grow at a faster rate, on the average, than females, and that quantity, as well as quality, of protein may affect rate of growth, there should be no difficulty in recognizing the fallacies of the experiment described below.
The layout of the experiment, as described by Cox (1951) was as follows:

Six kinds of protein supplements were fed to young chicks to estimate their relative effects on gain in weight. All the chicks receiving treatment A were kept in Pen A, and similarly chicks receiving each of the other five protein supplements were kept in separate enclosures. The sexes were mixed in unknown ratios, and the supplements were used in equal weights irrespective of protein content. No record was kept of individual food consumption. Based on the statistical analysis, if the lot having Treatment A gained significantly more than the lot having Treatment B, the answer might be (a) that the concentration of protein in A was greater than in B, or (b) that there was a larger proportion of males in Lot A than in Lot B, or (c) the environmental conditions were more favorable in Pen A, or (d) supplement A was more appetizing than B. This man came to the statistician to ask about the merits of various tests of significance, and he was seemingly unaware that the differences he was testing could not be identified and, therefore, were meaningless.

The reason, of course, is not that the man failed to state his problem correctly, but that he did not plan his experiment or select his materials in such a way as to exclude or properly account for the variability caused by differences in the amounts of protein eaten, the general sex differences in rate of growth, and environmental differences due to location.

The second step which should be considered in the planning of an experiment is, as previously mentioned, a description of the experiment. In other words, there should be an outline of the plan of work, including a statement of the specific treatments or methods to be tested, number and kinds of experimental animals to be used, size and kind of housing, pastures or paddocks, variables or performance characteristics to be studied (body weight, milk and fat production, etc.), duration of the experiment and, finally, but no less important, an outline of the experimental design including a statement of the methods to be used in selecting and allotting the experimental units and treatment. It should be emphasized that a description of the experiment covering the various points listed above is perhaps the best insurance against failing to reach the particular objectives of an experiment. Needless to say, the experiment should be so designed and conducted as to provide the desired information in the shortest possible time, and at a minimum cost in labor and equipment. Also, the experi-
mental design should be as simple as is consistent with the requirements which must be met to arrive at accurate answers.

Regarding the selection of the treatments, it is, of course, necessary for the investigator to determine how they provide information on the point at issue. The term ‘treatment’ as commonly used by professional statisticians, may cover a variety of operations, such as determining the effects of continuous versus rotational grazing in a pasture experiment or of self-feeding versus controlled feeding in a swine feeding trial, determining the nutritive value of different protein concentrates, evaluating the protective power of various biological products to a particular disease, estimating the response of different breeds to a particular set of climatic conditions, or testing the effects of a combination of different factors in the same experiment. Investigations of the latter type call for the use of factorial experiments. An important feature of factorial experiments is that the effects of two or more factors may be studied simultaneously with the same precision as where the effects of only one factor are studied. Another feature of factorial experiments is that, in addition to providing estimates of the main effects, they provide information on interactions among treatments, which is impossible in single factor studies. A factorial experiment might, for example, involve the testing of various intensities of grazing in combination with the application of various concentrations of a given fertilizer.

Once the objectives and plan of work have been stated, it is next desirable to indicate in outline form the method of analysis that will be used in processing and summarizing the experimental results. This means that the experimenter should have sufficient knowledge of statistics as to enable him to select the methods appropriate for testing a particular hypothesis, demonstrating inter-relationships and drawing inferences as to the generalization and applicability of the experimental results. There are various textbooks which illustrate the statistical analysis appropriate for various experimental design, some of which are cited at the end of this chapter.

Methods for Increasing Accuracy of Experiments

Cochran and Cox (1950) distinguish two main sources of experimental errors as follows: “The first is inherent in the experimental material to which the treatments are applied... The second source of variability is lack of uniformity in the physical conduct of the experiment, or, in other words, failure to standardize experimental techniques.” Since either of these two sources
for errors may introduce considerable uncertainty into both the accuracy and the precision of the results, it is highly desirable that the investigator incorporate into his experiment any method or combination of methods that will increase its precision. The basic methods, as suggested by Cochran and Cox (1950) are (1) increasing the size of the experiment, (2) refining the experimental technique, and (3) handling the experimental material so that the effects of variability are reduced.

Size of Experiment

The usual method of increasing the size of an experiment is to include a larger number of replications. This has the effect of decreasing the error associated with the treatment provided that the experimental units are allotted entirely at random to the treatments. The reason for this is to ensure that one treatment is no more likely to be favored in any replicate than another.

An idea of how the number of replications affects the probability of detecting a real difference between the average effects of two treatments, or, in other words, how many replications are necessary in order that a difference of a given size is likely to be detected as significant, can be obtained from tables as suggested by Cochran and Cox (1950). Inspection of these tables shows that, in general, there is very little guarantee of detecting differences of 10 percent or smaller with two replications. It is also apparent that the larger the error that affects the observation for the individual unit, the larger number of replicates required for detecting a given size difference at a given probability. The larger the true difference in the average effect of two treatments, the smaller, in turn, is the number of replicates generally required for a given probability of obtaining significant results. Thus, if we postulate the true difference to have a certain value, and if we have some idea of the experimental error of our observations, we can, within certain prescribed limits, ensure the most efficient size for the experiment by estimating the required number of replications, as suggested by Cochran and Cox (1950). It should be emphasized in this connection that the values given by Cochran and Cox for the number of replications required for obtaining a significant result are estimates based on statistical theory. Consequently, the number of replicates required in actual practice may vary somewhat depending partly on the precision of the estimate of the experimental error, and partly on the magnitude of the true difference.

With regard to the subject of replications, attention should be called to a paper by Lucas (1950), in which he outlines the steps in determining the size of paddock and the number of ani-
mals per paddock necessary in studies on pasture and grazing. Based on expressions involving variances, cost factors and carrying capacity, Lucas has developed formulae which make it possible to arrive at the optimum number of animals per paddock, and the optimum number of replications for a number of different conditions, such as where the variance, cost, total number of animals, or total number of paddocks, are specified. On applying estimates for the various factors represented in the equations, Lucas finds the optimum number of animals per paddock to be about 7 for nutritive value studies, about 3 for yield studies with other animals such as non-milking dairy cattle or beef cattle. This number is considerably lower than those customarily used in grazing work. As Lucas points out, the common situation has been to carry as many as 10 to 20 animals per paddock, and to use but one paddock per treatment.

As regards the number of replications or paddocks per treatment, Lucas states that there is little chance of detecting differences of 25 percent or less where only 2 replications are used. He estimates that, as a general rule, at least 4 or 5 replications are necessary if the true difference between two treatments is 20 percent or more. It appears that the number of replications required would be twice as large, at least, if the real difference were 10 percent or less.

Refining Experimental Techniques

Another method of increasing the accuracy of experiments consists in refining the experimental technique. Faulty or inaccurate scales may result in weight records that are continually biased, or increase the experimental errors to a point where they may actually mask the difference between treatments. To avoid biases such as those introduced by faulty equipment, or by improper handling of the experimental material such as would result if a particular treatment were continually favored in successive replications by some extraneous source of variation, it is essential that the principle of randomization be carefully considered in planning the layout of an experiment.

As was first indicated by Fisher (1947), both replication and randomization are necessary to obtain valid estimates of experimental error. While various restrictions may be imposed on the randomization, one occasion where there is need for randomization is whether treatments are allotted to the experimental material. In other words, care should be taken that each experimental unit included in the trial has an equal chance of being subjected to the different treatments. Sometimes, the experimenter may find
that there is need for the application of randomization to other operations as, for example, in experiments in which the equipment introduces variation. It should be realized, however, that the need for randomization does not dispense with the use of systematic design for, as we shall see a little later on, many of the experimental designs being used today involve several restrictions on the randomization, which is indicated by a knowledge of potential sources of bias.

As was indicated above, the principal objective in refining the experimental technique is to prevent errors such as those caused by faulty equipment. Mention was also made of randomization as the device commonly used to provide unbiased measures of the experimental error, as well as of the treatment effects. Other refinements may involve the development of more accurate methods of measurement, more adequate control over external environmental influences such as those due to changes in seasonal or climatic factors, or greater care in the selection of the experimental materials and treatments, so as to ensure that the experimental animals, pastures, soil types, etc., are a representative sample of the population about which inferences or generalizations are to be drawn. While many examples could be given to illustrate the above points, two examples are cited which are of particular interest because of their potential value in improving the quality of livestock research. One of these pertains to the improved methodology which is now being developed in estimating grazing capacity of ranges, as discussed by Stoddart (1952), and the other concerns the increase in the efficiency of feeding experiments with dairy cows, by use of the method of equalized feeding, as reported by Lucas (1943). There appear to be no published data as yet regarding the relative increase in accuracy that might result in estimating stock carrying capacity in terms of digestible nutrients, for example, but Lucas finds that to demonstrate a given difference between treatments in dairy cattle as statistically significant it would require only about one-fourth as many animals when using equalized feeding as when using the ordinary method. This is an excellent example of how gains in precision, obtained by refinements of technique, may substantially reduce the cost of an experiment.

Another method by which precision may be increased is by eliminating or controlling the variation due to tangible factors over which the experimenter has no immediate control. In certain experiments, it may be possible to obtain measurements on variables which are known to affect the performance of the experimental unit. In an experiment designed to determine the effects of different protein supplements on the rate of growth of pigs, for example, their initial weights may affect their subsequent performance. As it may not be possible or desirable to equalize the initial
weight of the pigs on the different treatments, adjustment of the observed increases in weight by the technique known as the analysis of co-variance will largely eliminate the effect of this variable from the estimates of the treatment effects. A similar approach involving the analysis of co-variance technique would be appropriate in studies on milk production in cattle, for example, where factors such as age of cow, initial production rate or stage of gestation, contribute to the variation of milk yield.

Proper Handling of the Experimental Material

This is the third important method by means of which the experimental error may be reduced. The approach is essentially that of choosing or inventing an experimental design which will provide the maximum amount of information per unit of cost. Since there may be limitations on funds and facilities, the choice of a particular design may be more or less dictated by prevailing conditions. It is impossible, therefore, to single out any one design as most efficient. Also, the relative efficiency of a given design will depend on the uniformity of the experimental material, as well as the number and relative importance of extraneous sources of variation. Before deciding on a particular design, it will usually be desirable, therefore, to secure as much information as possible on all potential sources of variation so that provisions be made for their control in planning the final layout. Frequently, it is on the basis of such information that a particular design is finally selected.

An example of the type of exploratory work which may help in selecting a design is the study on “Factors Affecting Rate of Gain and their Relation to Allotment of Pigs for Feeding Trials,” by Miranda, Culbertson and Lush (1946). These workers reported that 21 percent of the total variance in their data was associated with differences between breeds. Litter differences accounted for 29 percent of the total variance, or 37 percent of the variance within breeds, while 9 percent of the variance within litters was due to the difference between sexes. The intra-litter correlation between initial weight and gain was 0.24. Based on the above findings, Miranda et al. concluded that, in-so-far as rate of gain is concerned, breed and litter might well be considered in allotment but that the effects of sex and initial weight were too small to be of practical importance or to need correction. It would seem, therefore, that a feeding experiment with pigs might be improved by allotting an equal number of pigs from each litter to each of the treatments, thereby balancing the treatment groups with regard to litter. By allotting the treatments on this basis,
other factors, such as breed, age and pre-trial environment are automatically balanced.

Experimental Designs

Only a few of the experimental designs from which one may choose are discussed here, with emphasis on those which are generally considered to be most useful in livestock research. Treatises as those by Cochran and Cox (1950), Goulden (1952), Lucas (1948) and others have been drawn upon for this purpose.

As Lucas points out, animal science experiments of the feeding and nutritional types may be considered as falling into either of two classes, i.e. "continuous trials" and "change-over trials." In the continuous type of trial, an animal is subjected to a single treatment throughout the duration of the experiment, while in the change-over type, an animal receives in sequence two or more treatments. It is easy to visualize situations where both types of experiments might have a place in management studies, pasture and grazing studies or disease and parasite control studies. It is not possible here to go into the advantages and disadvantages of the two types of trials, except to point out that by using change-over trials, the number of observations per treatment and/or the number of treatments can be increased, without having to increase the number of animals.

Complete Block Designs

Within both types of trials as mentioned above, a number of different designs may be employed. To avoid confusion, it is desirable to discuss these, using the names by which they are described in most statistical textbooks. Classified broadly, experimental designs fall into one of two classes, (1) complete block designs, or (2) incomplete block designs. Applied to animal experimentation, the term "block" generally denotes a group of animals similar with respect to one or more factors, either inherent to the animals, or associated with the environment (Lucas, 1948). Complete block designs are characterized by the fact that each block or replicate contains a complete set of treatments, whereas in incomplete block designs the number of treatments is larger than the number of units per block.

In a completely randomized design, which is the simplest type, the animals are allotted to the treatments completely at random. This type of design has certain advantages in that any number of treatments and replicates may be used. The principal disad-
vantage is that there is no attempt to reduce the experimental errors, as might be the case if randomization were restricted so that all animals receiving a given treatment were similar in every major respect to those receiving another treatment. In order to take care of the situation, some investigators have followed the practice of allotting the animals so as to “balance” the effects as factors such as breed, age, sex, condition, initial weight, etc., among the treatment groups. This procedure has been criticized on the grounds that the variation within lots is made larger and that between lots is made smaller than it would be if the animals were allotted entirely at random. It is maintained, therefore, that the variation within lots is no longer valid for testing the significance of the treatment effects.

Randomized block designs differ from completely randomized or ungrouped designs in that the animals are first divided into groups coinciding with some major source of variation. Sub-division is made so that the number of animals in a group is equal to the number, or a multiple of the number, of treatments. The animals within each group are then allotted to each treatment at random. Usually several such groups are needed to obtain an estimate of experimental error. This is probably the most commonly used design in livestock research and many examples could be cited to illustrate its usefulness. In studies involving different breeds of cattle or sheep, e.g., animals belonging to the same breed would logically be considered as constituting a block. By applying the proper statistical methods, variation due to breed effects could thus be removed from the experimental error and thereby from the errors of treatment effects. Other applications of this type of design might be appropriate in situations in which insufficient numbers of animals at a given time or place make it necessary to conduct experiments over a period of intervals or at several places. In such cases, the periods or locations would constitute the blocks.

The latin square design is basically a randomized block design. In the latin square, however, the treatments are arranged in complete replications in two ways, the grouping being done so as to provide for control of two different sources of variation simultaneously. Another feature of the latin square is that the number of replications always equals the number of treatments. Thus, if four treatments were being compared the design would be as follows:

A B C D
B C D A
C D A B
D A B C
where the letters represent the treatments. It will be noted that each row and column contains a complete set of treatments, thereby fulfilling the requirements of double restriction. In an animal feeding experiment of the continuous variety, the rows may correspond to four different farms or four breeds, while the columns may represent four kinds of housing or pastures. With an arrangement of the treatments, as indicated above, possible sources of error due to variation between farms, breeds, housing or pastures, will automatically be eliminated from the estimates of treatment effects. In replicating the experiment, it is, of course, desirable to use a different arrangement of the treatments so as to minimize the danger of confounding. While there is a definite place for latin squares in livestock experiments, it should be noted that they are usually impractical when the number of treatments is large. The same is true if the number of treatments being combined is less than four, unless the plan provides for two or more replications.

The simplest change-over trials involving application of the latin square, are the so-called switch-over or reversal designs, in which two treatments, A and B, are compared in two sequences, as follows:

\[
\begin{array}{c|cc}
  \text{Period 1} & A & B \\
  \text{Period 2} & B & A \\
\end{array}
\]

This design is basically a 2 x 2 latin square, with the provision for control of expected time trends in the animals' behavior. The plan usually involves a group of animals, one half of which is allotted at random to each of the two treatments. An extension of this design is the "double-reversal design" which, like the former, compares two treatments in two sequences, the only difference being that the double-reversal design is continued through 3 or more periods.

Experiments illustrating the use of the latin square design in change-over trials have been published by several workers, notably Cochran et al. (1941), Lucas (1943) and Patterson (1950). The particular design used by Lucas was a 4 x 4 square in which 4 rations were compared in a feeding experiment with dairy cows. The 12 cows available for study were first divided into three groups of four, on the basis of their producing abilities. Four sequences of treatments, each consisting of four five-week periods, were then allotted at random to the four cows of each group, with the provision that no two cows in a group would receive the same treatment during the same period.
By subdividing the cows into three 4 x 4 squares, and choosing the cows so as to have all cows within each group as similar as possible, Lucas was able to demonstrate a substantial reduction in experimental error, as compared with the error that would have been obtained had the animals been assigned to the treatment completely at random.

Another example illustrating the application of the Latin square in change-over trials has been proposed by Lucas (1950) for grazing studies in which three different rates of feeding protein supplement constitute the treatments. The design is given as follows:

\[
\begin{array}{c|c|c|c}
| & \text{Sequence Set I} & \text{Sequence Set II} |
|---|---|---|
| 1 & 2 & 3 |
| 2 & 3 & 1 |
| 3 & 1 & 2 |
| 1 & 2 & 3 |
| 2 & 3 & 1 |
| etc. as needed | etc. as needed |
\end{array}
\]

Where the rows represent periods, the columns represent paddocks, and the numbers represent the three rates of feeding protein supplements. The design calls for six groups of animals with two groups receiving each supplement during a given period, and the animals rotated from paddock to paddock within each sequence set.

\textbf{Incomplete Block Designs}

These designs are particularly adapted for situations where large numbers of treatments are to be tested as well as where the number of experimental units falling into a natural grouping, such as litters or breeds, for example, is not large enough to include all treatments. Thus, an incomplete block design may be defined as a design in which the number of experimental units in a block is smaller than the total number of treatments being compared. Statisticians speak of "balanced" and "partially balanced" incomplete block designs, but workers in animal science generally have made use only of the balanced type of designs. It should be noted in this connection that, while incomplete block designs do not provide as much accuracy between certain treatment comparisons as complete block designs, balanced incomplete block designs are characterized by the fact that all comparisons among pairs of treatments are made with equal precision. Another feature of balanced incomplete block designs is that, while there is no limit regarding the number of treatments or the number of units per block, the number of replications is fixed by these variables.
Using 4 treatments, A, B, C and D, in blocks of three experimental units each, a balanced incomplete block design would look as follows:

<table>
<thead>
<tr>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A B C</td>
<td>A B D</td>
<td>A C D</td>
</tr>
<tr>
<td>B C D</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It will be seen that each pair of treatments occurs within a block the same number of times, filling the requirements of balance. However, in the above example, the blocks cannot be grouped in separate replications since four is not divisible by three, the number of units per block.

The usefulness of incomplete block designs is best illustrated by reference to an actual experiment. The example chosen is from a feeding trial with swine, described by Comstock et al. (1948). The particular design used was a $3 \times 3$ balance lattice design for 9 treatments in blocks of three litter mates. The design, using four replications, was as follows:

<table>
<thead>
<tr>
<th>Replication 1</th>
<th>Replication 2</th>
<th>Replication 3</th>
<th>Replication 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3</td>
<td>3 4 8</td>
<td>1 4 7</td>
<td>3 5 7</td>
</tr>
<tr>
<td>4 5 6</td>
<td>2 6 7</td>
<td>2 5 8</td>
<td>2 4 9</td>
</tr>
<tr>
<td>7 8 9</td>
<td>1 5 9</td>
<td>3 6 9</td>
<td>1 6 8</td>
</tr>
</tbody>
</table>

Note that the blocks are incomplete, since each contains only 3 of the 9 treatments being compared. Also note that each treatment occurs once in the same incomplete block or litter with each of the other treatments. By removing the variation due to litter differences, the gain in efficiency of the incomplete block design as used in this particular experiment, compared to randomized complete blocks designs, was about 20 percent. Other situations in which incomplete block designs may be found useful is where the number of animals at any one time or at any particular place is smaller than the number of treatments.

There are many questions about experimental designs which remain open for further discussion as well as for further study. What has been attempted here has been to survey the designs which appear to be most useful in animal science experimentation, and to point out how different designs are necessary to meet different experimental situations. It might be well also to re-emphasize that the efficiency of a particular design will vary with the nature of the experimental material, as well as with the conditions under which the experiment is conducted. Another important
point to remember is that the experimental design should be as simple as is consistent with the requirements necessary to obtain reliable answers.

Analysis and Interpretation of Results

Having collected all the data necessary to obtain the information for which the experiment was conducted, the next step in carrying the experiment to its logical and successful conclusion is to select the appropriate statistical methods for summarizing and interpreting the results. As Cox (1951) points out, "the analysis of data calls for clear thinking and for careful selection of the statistical tools to be used." Also, "... the statistical analysis cannot increase the validity of the data." This adds emphasis to the point stressed earlier, i.e., regardless of how refined or how intricate the statistical methods employed, they are powerless if applied to data lacking the necessary precision, or to data derived from faulty experimental designs. Assuming then that the experiment was properly planned and conducted, the next important step is that we use the proper statistical methods in order to extract all the pertinent information contained in the data. Proper use of these methods, such as those employed in the computation of averages, standard deviations, coefficients of variability, or t, the quantity commonly used in testing the significance of the difference between two averages, generally does not require more than a working knowledge of statistics. As a general rule, however, the parameters to be estimated and the relationships to be determined are more complex than the statistics just mentioned. In order to obtain the desired information from such data, it would be necessary for the investigator to know something about the scope and flexibility of the various statistical methods, including the basic assumptions underlying their use. Fortunately, there are several textbooks available on statistical methods as applied to experiments in the agricultural sciences. Anyone intent on improving the quality of his research accomplishments in the animal sciences can learn a good deal just by studying these books. In the great majority of cases, however, the most effective way of dealing with the situation would be for all agricultural institutions giving training at a graduate level to include in their curricula at least one course on experimental designs and statistical methods. In the meantime, everyone concerned with quantitative studies in livestock research should be encouraged to seek the advice of a qualified statistician before embarking on an experiment. Experience shows that a person taking advantage of the experimental designs and statistical me-
methods that are available for his use not only has less of a problem analysing and interpreting his results, but also contributes towards reducing the cost of experimentation.

In addition to the material on statistical techniques summarized above, attention should be drawn to the importance of statistical analyses in pointing to new clues in the solution of problems. Use of the appropriate statistical methods not only provides a means of interpreting the results in terms of existing knowledge, but also may actually point to new and important clues regarding the solution of a particular problem. Also, if the experiment were properly designed and conducted, the results might serve as a basis for prediction which, after all, is the ultimate purpose of any experiment.

In other words, an experiment can be considered a success only if the results are such as to make it reasonably certain that similar results will be obtained under similar conditions at some future date. It should also be emphasized in this connection that it is important and desirable that the investigator report negative as well as positive results. By so doing, he not only helps to clarify knowledge regarding certain phenomena, but also serves the scientific cause by preventing duplication of effort on the part of other investigators who, with this information, could devote their energy to other more fruitful tasks.

**Literature Cited Regarding Statistics**


The Baurú meeting recommended that governments should carefully review the adequacy of their existing extension services, particularly those for the livestock producers, who often operate in more remote areas than the farmers, who specialize in the production of cash crops; they should make every effort to so strengthen these services that livestock producers may have ready access to help and guidance on all types of livestock, pasture and range management problems. To this end, FAO decided to ask member countries to participate in a comprehensive survey of all national organizations devoted to servicing and improving the livestock industry, the results of which would be discussed at the Buenos Aires meeting. Accordingly, a questionnaire was circulated among member countries to obtain information on physical facilities, personnel, financing, scope of the work in the case of ministries of agriculture, agricultural colleges, agricultural experimental stations and organizations of agricultural producers, distributors and processors of primary livestock products. The number of answers to this questionnaire received was insufficient to permit the drawing of over-all conclusions as to the adequacy of government services to the livestock industry, or to compile the information in a comparable way which could serve as guidance for future action. However, a considerable amount of useful information was assembled, which is summarized in this chapter together with supplemental information presented at the Buenos Aires meeting.

This survey is part of a broader one, which covers government services to all branches of agriculture. It was initiated by FAO three years ago, and was first discussed in the Americas during the Third FAO Regional Meeting on Agricultural Programs and Outlook in Latin America, held in Buenos Aires in September, 1954. Since the two surveys are closely interrelated, the conclusions drawn at the Regional Meeting from the results of the over-all survey, and the recommendations which followed them are of interest. These are likely to apply in the same measure to government services to the livestock industry. The Regional Meeting, having examined the needs of the farming populations of the countries of the Latin American region, and having noted with regret the fact that, in relation to the importance of agriculture in economic development and in proportion to the population engaged in agriculture, budgetary appropriations for agri-
cultural development are extremely low, recommended that governments consider the need to increase their budgetary allocations, and that government services to agriculture be strengthened in order to carry out efficiently the plans and programs for this section of the national economy.

There are major problems which are still to be overcome in relation to the improvement of national services. However, much progress has been achieved in recent years, particularly in the technical aspects of such services, also in the social, institutional and economic field. The number of agricultural schools, experiment stations, etc., has increased throughout the region, and a better staffing of such institutions has permitted an intensification of the programs they carry out. In many countries the ministries of agriculture have been reorganized to adapt themselves better to modern requirements, and budgetary allocations have been, on the whole, increased. On the institutional side, steps have been taken in many countries to increase the security of tenure of farmers, and to improve the possibilities of private ownership, improving, as a consequence, the investment conditions on the farms. Furthermore, many countries have established or improved their credit systems and given active support to co-operatives. On the economic side, marketing, with its related aspects, such as transport, storage, etc., has been the object of surveys and studies which have resulted in measures for its improvement.

Nevertheless, it must be recognized, as was done at the Regional Meeting, that in most instances this progress has only laid the basis for an over-all improvement, and that much remains to be done, also because progress has frequently been unbalanced and has lacked co-ordination. These latter are possibly among the basic problems, since, in order to achieve effective results, co-ordination and simultaneous development of all related aspects are essential. Increased production requires improved marketing facilities, including transportation; livestock research requires adequate extension services to make the practical application of its results possible, and extension in turn requires good agricultural schools to provide technicians of a satisfactory level of training.

In response to the questionnaire sent by FAO to all the governments of the region enquiring about expenditures on, and staffing of, government services to the livestock industry, several countries have submitted figures. These are shown in Tables 19 to 23, and give indications of the levels to which services to the livestock industry have been developed in the countries listed. Data on expenditures for various types of agricultural work are shown in Table 19, for eight countries or territories, and the numbers of trained workers employed in these same countries or territories in agricultural work are shown in Table 20. Data on training in
recent years are summarized in Tables 21, 22 and 23, since the
degrees awarded and nature of the data submitted are such that
they could not be summarized in a single table. Data on num-
bbers of workers and students trained are for 1954, except in

<table>
<thead>
<tr>
<th>TABLE 19 – EXPENDITURE ON GOVERNMENT SERVICES IN CERTAIN COUNTRIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>Colombia</td>
</tr>
<tr>
<td>Ecuador</td>
</tr>
<tr>
<td>Honduras, British</td>
</tr>
<tr>
<td>Jamaica</td>
</tr>
<tr>
<td>Paraguay</td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
</tr>
<tr>
<td>U.S.A.</td>
</tr>
<tr>
<td>Venezuela</td>
</tr>
</tbody>
</table>

*Exchange rates in terms of U. S.$ in March 1954 were: $ 1.00 = 2.50 Pesos Colombianos; 17.30 Sucres; 0.3571 £ sterling; 1.4285 $ B. A.; 1.70 $ B W. I.; and 3.35 Bolivares.

For 1954, except Trinidad and Tobago, where figures are for 1953.

<table>
<thead>
<tr>
<th>TABLE 20 – NUMBERS OF TECHNICAL EMPLOYEES IN CERTAIN COUNTRIES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Country</strong></td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td>Colombia</td>
</tr>
<tr>
<td>Ecuador</td>
</tr>
<tr>
<td>Honduras, British</td>
</tr>
<tr>
<td>Jamaica</td>
</tr>
<tr>
<td>Paraguay</td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
</tr>
<tr>
<td>U.S.A.</td>
</tr>
<tr>
<td>Venezuela</td>
</tr>
</tbody>
</table>

*In addition to these officers with degrees, there are officers with diplomas as follows in Jamaica: 130 for all agricultural work, 32 for animal husbandry (except veterinary and forage) work, 9 for veterinary work and 3 for pasture, range and fodder work.
### TABLE 21 – NUMBERS OF MEN TRAINED IN RECENT YEARS IN CERTAIN COUNTRIES

<table>
<thead>
<tr>
<th>Country</th>
<th>“Peritos agrónomos”</th>
<th>“Ingenieros agrónomos”</th>
<th>Average Numbers of Men Trained Annually in Percent Years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All phases of agriculture</td>
<td>Animal husbandry except veterinary and forage work</td>
<td>Pasture, range and fodder production</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Colombia</td>
<td></td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Ecuador</td>
<td></td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Honduras, British</td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Jamaica</td>
<td>24 1</td>
<td>15 3 16 6</td>
<td>25</td>
</tr>
<tr>
<td>Paraguay</td>
<td>560</td>
<td>3 16 32 1</td>
<td>3</td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
<td>25 20 32 1</td>
<td>10 13 49 58</td>
<td>15</td>
</tr>
</tbody>
</table>

1 Diploma students from Farm School.
2 None trained in Jamaica, but 6 to 10 are sent annually for study abroad.

### TABLE 22 – DEGREES CONFERRED IN EDUCATIONAL INSTITUTIONS IN THE UNITED STATES OF AMERICA IN AGRICULTURAL AND RELATED SUBJECTS IN THE SCHOOL YEAR 1952/53

<table>
<thead>
<tr>
<th>Subject</th>
<th>Degree</th>
<th>Bachelor’s</th>
<th>Master’s</th>
<th>Doctor’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Husbandry</td>
<td></td>
<td>1 140</td>
<td>143</td>
<td>40</td>
</tr>
<tr>
<td>Other agricultural subjects,</td>
<td></td>
<td>6 659</td>
<td>1 200</td>
<td>409</td>
</tr>
<tr>
<td>excluding forestry</td>
<td></td>
<td>9 707</td>
<td>1 807</td>
<td>966</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td></td>
<td>878*</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td>Veterinary Medicine</td>
<td></td>
<td>7 517</td>
<td>608</td>
<td>47</td>
</tr>
<tr>
<td>Home Economics</td>
<td></td>
<td>10 414</td>
<td>2 711</td>
<td>1 714</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td></td>
<td>36 315</td>
<td>6 582</td>
<td>3 185</td>
</tr>
</tbody>
</table>

* D.V.M.

### TABLE 23 – NUMBER OF TECHNICIANS GRADUATED IN 1950-1954 IN VENEZUELA

<table>
<thead>
<tr>
<th>Year</th>
<th>“Ingenieros agrónomos”</th>
<th>Veterinarians</th>
<th>“Peritos agrónomos”</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>13</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td>1951</td>
<td>5</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>1952</td>
<td>4</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>1953</td>
<td>22</td>
<td>4</td>
<td>49</td>
</tr>
<tr>
<td>1954</td>
<td>13</td>
<td>13</td>
<td>58</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>41</td>
<td>155</td>
</tr>
</tbody>
</table>

161
Trinidad and Tobago where they are for 1953, and in Ecuador where they constitute an average for the five recent years.

Advances in animal production and agriculture generally must be measured in terms of improved practices adopted by farmers and ranchers. By this standard of measurement it is apparent that much progress is possible. There is a fundamental need for speeding up the process of adoption of improved practices through a closer relationship among research workers, extension workers, educators and producers. This means that the research worker must know and study the problems being faced by the producer, the extensionist and the educator must be well acquainted with, and actively disseminate, the research knowledge to the new generations of students and especially to the farmers and ranchers. Clearly this can only be done when there is a close understanding and co-operation among these groups which so vitally influence agricultural development.

Information on recent developments in a number of countries, in addition to that tabulated in Tables 19 to 23, is summarized in the following paragraphs.

The Government in Argentina has taken action to improve livestock production under the second Five Year Plan. This includes all breeding, feeding and veterinary aspects of the livestock industry, and its object is to improve the quality of the herds through the utilization of high-bred animals; to increase livestock numbers by supporting the creation of new ranches, through a better utilization of the existing ranches, and finally to improve feeding through better pastures and a more intense and rational use of the land. This action is complemented by a national supervised credit system and by measures to improve the marketing of livestock products. Under the breeding aspects, in spite of the high level reached by Argentine livestock, it has been considered advisable to continue to import high quality animals of the different species. For this purpose, the Government allocated considerable amounts of foreign exchange for the import of animals from Canada, France, the Netherlands, Switzerland, the United Kingdom, and the United States of America. Thus, in 1954, more than 1,000 high-bred cattle were imported, among which were many first prize animals of cattle shows in the United Kingdom and other countries. In addition, substantial numbers of high-bred sheep and horses were imported.

The national plan for the improvement of livestock in Argentina gives high propriety to the development of artificial insemination. For this purpose, two artificial insemination stations have been created which provide semen without charge to 43 sub-stations, which are formed by producers and supported by the state. Both the official and private stations receive technical advice and lab-
oratory facilities from the state. Parallel to this, special courses have been organized to train personnel in artificial insemination. So far, 598 certificates have been given. Through these measures, complemented by inspection of semen used on private establishments, artificial insemination is now widely accepted, particularly among breeders of dairy cattle.

Other measures for the improvement of livestock in Argentina include the organization or enlargement of regional breeding stations. About 30 such stations have been created in co-operation with provincial governments and breeders’ associations. These stations are located in outlying areas, and are provided with pure-bred animals of different species by the Ministry of Agriculture. In addition, high-bred animals are given on loan to small livestock breeders, particularly in the outlying areas.

In regard to feeding, pastures of very high quality are abundant in the central zone of Argentina. However, in order to improve further the land use as well as the quality of the pastures, several experimental stations, such as those of Pergamino and Manfredi, carry out studies on the improvement of pastures and range management. In the outlying areas of the country, such as the extreme north and Patagonia, forage problems are more difficult. In these areas, the experimental stations of Canadon Leon (Santa Cruz) and Las Brenas (Chaco) are working on adaptation experiments of national and foreign species, as well as on range improvement. Furthermore, a new experimental station has recently been set up in the Province of La Pampa, with an area of 2,000 ha. which will work particularly on the improvement of cropping methods and on the improvement of the carrying capacity of pastures, as well as on disease resistance of fodder crops. In addition to the locally produced seed, a substantial amount of seed of foreign pastures is imported and multiplied in the country by private farmers under the inspection of the Government. The Government also purchases seeds and sells them under favorable conditions to farmers. The multiplication fields, at the same time, serve the purpose of demonstration farms.

As to the sanitary protection of livestock, the Argentine Ministry of Agriculture has at present 130 regional veterinarians who carry out direct campaigns against certain diseases and give advice to farmers. The important national campaigns include those against foot-and-mouth disease, scabies, ticks, brucellosis and trichinosis. In the case of the first of these diseases, vaccination is now well established and livestock breeders have recognized the importance of this preventive measure. In addition, the State has carried out demonstration campaigns during which 92,416 cattle and 17,795 sheep were vaccinated, with very satisfactory results. During the period 1942-1952, ticks were eradicated from more
than 6 million ha., and in 1953/1954 the campaign became more intensive with another substantial area freed from this parasite. More than 3½ million sheep were treated for scabies during 1953/1954 over an area of about 10 million ha.

The sanitary measures in connection with brucellosis include control of the import and export of cattle, identification of brucellosis infestation areas, calfhood vaccination and, finally, control of dairy establishments. Of these latter 536 were inspected during the period 1949-1954, and more than 145,000 cows were vaccinated. Brucellosis is detected by use of the "ring test," which was applied to 2,739 dairy establishments on which 566,785 liters of milk were examined. All these campaigns, and particularly those against diseases common to man and animals, are complemented by intensive extension activities.

Supervised agricultural credit was originally established by the National Bank in Argentina, but has recently been extended to include all banks of the country. This credit system is based on the national ecological map, as well as on economic studies of the different agricultural areas of the country. This enables determination of the most advisable crops or types of agriculture, and systems of priority are established. In 1954, the National Bank allocated credits for agricultural purposes totaling 6,197 million pesos, compared to 5,974 million pesos in 1953. In addition, the proportion of agricultural credit in relation to credit for all purposes has continuously increased. Thus, in 1950, agricultural credit was 18.2 percent of the total credits allocated by the National Bank, rising to 36.4 percent in 1954. Further, the Central Bank includes in its yearly foreign exchange budget allocations for the import of elements required by agriculture and the livestock industry. These include mainly machinery, spares, certified seed, fertilizers, products for the fight against animal and plant pests and diseases, pedigree animals and semen. For these latter two items, yearly allocations amount to 30 million pesos and imports are regulated in accordance with a plan prepared yearly by the Ministry of Agriculture and Livestock.

There is also a policy in the field of colonization and land tenure which tends to give ample opportunity to farmers to become owners of the land they work either through the purchase of public lands or private land, considered unsuitable to fulfil a social function.

In Bolivia, there has been a long evolution of the social and economic aspects of agriculture since the Spanish colonization and it has had its consequences on the national economy. Particularly in the social aspects the evolution is reported to have been such as to prevent the full and economic utilization of the national resources, due to the prevalence of extremely large estates of more
than 10,000 ha. which concentrated more than 70 percent of the
total cultivable area of the country, and on which agriculture
and livestock breeding were carried out in a primitive way.

In consequence, the large Indian population had access to only
a limited part of the arable area and was furthermore forced to
work without adequate remuneration on the large estates. This
situation has changed substantially since 1952 when several econo-
mic and social measures were enacted among which was land
reform. The more important objectives of this land reform were
to enable the indigenous population to become landowners, on the
condition that they worked the whole area allocated to them, and
to co-operate with them in the modernizing of their cropping me-
ths. Wherever possible, the traditional collective system was
retained, hoping thus to stimulate higher production and improved
marketing. Other aspects of the reform aimed at facilitating in-
vestment of new capital, supporting the operation of co-operatives
and providing technical help and credit. Measures have also been
taken to stimulate internal migratory movements, in order to obtain
better distribution of the population throughout the country.
National services of benefit to the livestock industry include in-
tensive action in the northeastern cattle area of the country,
where foreign technicians have been engaged and substantial
numbers of pure zebus introduced. Agricultural co-operatives
for the rational exploitation and multiplication of sheep have also
been established.

The Government of Ecuador is carrying out, through the De-
partment of Livestock Breeding, several programs of livestock
improvement. At the higher elevations of the country dairy
cattle prevail and in this area purebred Holstein and Brown Swiss
have been imported for crossing with native cattle. The low
tropical areas specialize in cattle for meat production. Experimental
crosses have been made with zebus which are then followed with
crosses to Hereford, Shorthorn and Aberdeen Angus. Crosses with
zebus have been satisfactory, but no definite results are so far
available on the others. The Government has initiated a credit
program in support of livestock production, for which a total of
U.S. $ 2,800,000 have been allocated for two years. These credits are
given for terms of 5 years, and carry an interest of about 8 percent.
Further action is related to advisory and extension services.

The recently created Livestock Research Institute in Guayaquil,
will carry out research in diseases, artificial insemination, breeding,
pastures, etc. The buildings and equipment of this institute were
to be completed by the end of 1955. A similar institute exists al-
ready in Quito for the high areas. The Quito institute produces
vaccines, which are sold at low prices, in disease control campaigns.
Both institutes will carry out intensive studies on the livestock
development possibilities of the country, on which a national plan will be based in the near future.

In El Salvador, there has been established an Integral Demonstration Area by the Ministry of Agriculture and Livestock. This area covers approximately 38.6 square miles and is believed to be representative of the region where it is located. On it studies are carried out concerning the management of livestock, as practised in the area, and on the cost of livestock production.

Agricultural maps of El Salvador are also being compiled. So far, a land-use map showing the distribution of crops and pastures has been completed as well as several others concerning the location and size of dairy farms, their distance from consumption centers and the types of roads the milk has to pass over between the farm and where it is consumed. The Government is also making intensive efforts to open up the tropical coastal lowlands by constructing a bridge over the Rio Lempa and a coastal highway and by providing the area with electricity. In addition, attention is being paid to the legal and practical measures for the fight against animal diseases and pests. At present, all cattle entering the country are vaccinated unless accompanied by sanitary certificates, but no quarantine period to observe the results of the vaccination exists. The Ministry of Agriculture and Livestock employs four veterinarians and six vaccinators whose services are free to the livestock industry. It also sells vaccines at cost prices. The official vaccinators carry out the following vaccinations: cattle, against anthrax, blackleg, haemorrhagic septicemia and pneumo-enteritis; horses, against anthrax and with mixed bacterin; hogs, against cholera, haemorrhagic septicemia and with mixed bacterin.

The new National Livestock School of Santa Ana, El Salvador, was inaugurated on 10 March, 1954. Up to May, 1955, there had been seven terms from which 137 people graduated. The school is having wide acceptance by farmhands and farmers who want their people to learn how to produce cleaner milk and take better care of animals. The school has accommodation for 40 students, a service area of roughly 24,000 sq. yds. and 5 ha. for cultivation and to keep the 11 animals it owns. These include one bull of each of the following breeds: Holstein, Brown Swiss, Guernsey and Jersey and seven cows. Instruction, quarters and food are provided free of charge and the only requisites for admission are good health, good conduct and ability to read and write. The teaching staff is composed of employees of the Ministry who do not receive any extra pay for this work. The courses are of a duration of three weeks and cover theoretical and practical aspects of the management of dairy cattle and of the production of milk. The Ministry also offers a two weeks’ course on artificial insemination.

In the French territories in Latin America, the services to agri-
culture and livestock industry are undergoing a process of reorgan-
ization, following a change of status of these territories in relation
to France. As a consequence, whereas the technical departments
formerly were all responsible to the Ministry of Colonies, each of
them is now directly responsible to the specialized ministry con-
cerned. In French Guiana, the Agriculture and Forestry Agency
was recently created dependent on the Ministry of Agriculture of
France. This Agency, which will be responsible for action in agri-
culture in French Guiana, is at present engaged in surveys on
which to base its program, and it has recently created an experi-
ment station for livestock and fodder research. This station has
initiated a program of crosses of local cattle with Brown Swiss,
which appears to be giving good results. This station is still
rather modest, but enlargement is expected. The Agency will
also assist private enterprise through advice, demonstrations and
other extension activities.

In Peru, the need for more adequate staffing of national ser-
VICES of the livestock industry is recognized. Well trained and
capable technicians can only become available if the educational
institutes of the countries are well organized and equipped, and
if their programs are adapted to real needs of the countries. The
observation applies equally to many countries in which adequate
numbers of trained workers are not yet available.

In Venezuela, the Livestock Division of the Ministry of Agri-
culture comprises three departments which are responsible for
dairy cattle and hog development and for herdbooks respectively.
The Ministry has established a program to increase the number
of animals also the yield per head. The first of these objectives
is very difficult due to the lack of adequate pastures on the
sabanas of the cattle areas. For this reason, it is essential first
to improve and extend the pastures and to solve the problem
of periodical floods, and then to carry out complementary measures,
such as fencing and adequate water provision. An intensive cross-
breeding campaign to raise production is at present under way,
and has already given very good results. Thus, for instance, the
4-year-old native animal gives a carcass yield of 352 lb. while
the native zebu crossbreeds of 2 ½ years yield 484 lb. It is ex-
pected that the number of crossbreeds will be increased by 400,000
at the end of five years. The Ministry of Agriculture has imported
a substantial number of zebu bulls which are crossed on native
cows at the experimental stations of San Carlos and Pariaguan;
the offspring of these crosses are sold to livestock breeders at low
prices or on credit.

In British Honduras, owing to the limited facilities and avail-
able staff, only preliminary studies of the problems affecting the
livestock industry have so far been carried out. The general
recommendations on the subject of the Baurú meeting are, however, borne in mind.

In Trinidad and Tobago, the need for the establishment of an adequate and efficient extension service of the Department of Agriculture on the livestock side is appreciated and efforts are being made to provide officers with increased training in animal husbandry. Also, arrangements are now under consideration whereby financial assistance will be given to approved livestock owners in the form of subsidized prices for certain classes of livestock.

In the United States of America, a number of improvements in the extension or education services to the livestock industry have taken place in recent years.

The Federal Market News Service was created as a neutral agency to obtain information on marketing, movements, prices and price trends on livestock and meats, for dissemination to all interested persons. From its inception nearly 40 years ago at eastern wholesale meat centers and Chicago, it has gradually been expanded to its present coverage of 35 public livestock markets, 6 large wholesale meat centers and the national wool trade reported from a central point. The gradual drifting of the slaughter industry into some of the leading livestock producing areas of the country resulted in an increased proportion of all livestock being sold direct from producers to packers. In order to report such transactions, the Market News Service extended its coverage into two such direct marketing areas. Information on country trading in important cattle and sheep range areas in the western part of the United States of America is assembled in a single report each week. At present about 150 persons, including the clerical and statistical staff, are employed in Federal Market News work. This service includes the collection and distribution of information number of livestock received at the markets each day, prices paid by species, grade and weight, and the price trend compared with the previous day. Information is also collected on the supply, demand and price situation in the wholesale meat and wool trades. This information is disseminated through press associations, newspapers, by direct mail and on radio and television. There is considerable demand for an expansion of the service to include more reports on direct sales, as well as more coverage of local livestock markets and auctions. The development of thousands of local livestock auctions during the past 25 years makes market news coverage both difficult and expensive. There are a number of projects designed to study these needs for additional market news services, and to suggest practical methods of effecting increased coverage.

A second service in the United States of America is the Federal Meat Grading Service. This is voluntary and available to packers, wholesalers and retailers on a fee basis. During World
War II and the recent Korean conflict, federal grading was conducted on a compulsory basis. At present there are about 350 persons grading meat and another 50 persons employed in a supervisory capacity. Nearly 50 percent of the commercial production of beef, veal, lamb and mutton is federally graded. Many firms in the meat packing, wholesaling and retailing industry use federally graded meat as a basis for comparing values and for trading in the market places. In addition, some of the larger retailing chain organizations rely on federally graded meats for developing consumer confidence in their retail meat merchandizing program. Improvements in the grading service have been largely in the area of improved understanding of what are the standards for grades; and what the grade means in terms of variations in cooking techniques for each cut from each grade. Many in the meat industry feel that the increased percentage of the consumer’s meat dollar being spent for beef is in part a result of increased use of beef grades as a basis for retail selling. Some students of the problem feel that the establishment and use of grades on pork cuts might help the swine industry recover some of the consumer confidence that has been lost through the sale of pork cuts containing an excessive amount of fat.

A third major service provided for the livestock industry is the livestock disease and pest control work, including the quarantine activity. During 1954, the Federal Government provided approximately 1,330 man-years on disease control and disease eradication work. The total expenditure of funds on this particular program would amount to somewhat less than one-tenth of one percent of the value of the livestock sold by farmers during the year.

Another service provided the livestock and meat industry is work with packers and stockyards. Financial, weight and price protection is furnished the producers of livestock and poultry at public stockyards, livestock auction yards and poultry markets, through enforcement of the Packers and Stockyards Act. This Act is designed to assure producers of livestock the full true market price for their animals. The following measures assist in accomplishing the purpose of the Act: open competitive bidding, accurate weights, correct accountings, adequate marketing facilities, services at reasonable rates, protection against unjust practices and full bond protection of their proceeds of sale. This latter bond protection is an insurance against losses due to misuse of proceeds of sale. There are more than 2,000 scales on which livestock and poultry are weighed, must be tested and inspected at regular intervals. Bonds are required of about 4,000 agencies selling livestock on a commission basis, as well as all dealers buying livestock. Approximately 80 employees are engaged in administering the provisions of this Act at 62 terminal stockyards, 271 auction yards, and 8
designated poultry markets. The total cost of this protection totals about 1/1,000 of one percent of the value of all livestock sold.

In the field of livestock and meat research in the United States of America the federal and state governments combined provide a vast amount of service to the livestock industry. Much of the work in breeding, feeding and management is done in the state experiment stations and sub-stations; these former are doing livestock research under local pasture, roughage and grain production conditions. The U.S. Department of Agriculture provides some co-ordinating services for this research work. In addition, the Department as well as the state colleges do research in livestock and meat marketing. Improvements in the research work for livestock are many and varied. One example is in the methods of evaluating hog breeding stock for muscle versus fat. At least one midwestern state university has recently developed an electronic needle for measuring the depth of back fat on hogs. This might well be a major factor in the improvement of the method of selecting hog breeding stock for meatiness. In the beef industry much attention is being given to the problem of breeding animals that will produce a higher percentage of the more desirable beef cuts, make gains with less feed costs and make better use of pasture in the hot and humid areas in the Gulf Coast. In the marketing field, much research is being done to find out what consumers want in their meat supply. Of particular interest to research is the problem of getting the livestock and meat marketing system to more accurately reflect in the live animal market consumer preferences for the various grades of meat.

The educational services rendered to the livestock industry involves the application of research results in all fields, from breeding to marketing. It also includes the educational work involved in interpreting the regulatory activities of the federal and state governments as they apply to the livestock and meat industry. This educational program poses the very real problem of how to transfer facts and skills developed by the research workers in such a manner that they can be understood, learned, remembered and used by farmers, marketing agencies, processors and retailers. In the United States of America in 1954, country agricultural extension workers devoted a total amount of time equivalent to 1,370 man-years to work with the 4 million livestock producers. There have also been approximately 130 persons devoting full time to livestock production and marketing work on the 48 state extension staffs. The combined work of these state and country workers amounts to only 1 person for each 2,500 livestock producers in the whole country. It should also be noted that these workers also devote some time to the educational work.
with market agencies, meat processors and meat retailers.

During the last 8 years the United States has also expanded its educational program among consumers. The general objective of the consumer education program is one of providing consumers with information which will enable them to utilize their meat dollars better in retail stores. More specifically, this educational program among consumers is designed to provide them with information on grades and cuts of meat available, as well as information on seasonal fluctuations in price and supply. Production of red meats has expanded at a much greater rate than the population. Thus, while consumption was less than 130 lb. per capita in the 1930's, it is now well over 150 lb. of red meat. With an ever expanding industrial or urban population, the demand for meat has increased. If the livestock industry is going to provide the meat that is so essential for a vigorous and productive working population, livestock production and meat distribution will need to be expanded and improved at an ever increasing rate. It should be pointed out that, as the slaughter of livestock moves closer to production areas, there is an increased need for market news and meat grading, as well as improved transportation. All of these things facilitate the merchandizing or marketing of meats in consuming centers some distance from the point of production, marketing and slaughter.

A review of the history of the educational program would indicate that the demonstration technique still holds great promise. The educator must find the job that needs to be done, the research that needs application and then provide the industry, or individuals in the industry, with a picture of those needs. There must be found some way to make those improvements wanted. Possibly, they may be wanted to provide a new pair of boots for the producer or a new dress for his wife; the main point, however, is that he must "want" an improvement. The extension job among livestock producers is one of getting producers to understand the value of better breeding, feeding, management and marketing. It has been found that the educational worker must have the vision to look a long way ahead for results. He must have the knowledge to realize what is sound in the long run. He must know what is good business, what is practical, he must have the sympathetic understanding of the people with whom he is working. Thus, to get results, to get application of research, it would seem essential that people be trained who have an understanding of the persons to be taught. They must be given that training which will enable them to transfer facts and skills developed by the research workers in the livestock industry. The educator must know how to be understood, how to get people to learn, remember and use facts if this program is to be effective.
PROPOSALS TO FACILITATE CO-OPERATION AMONG THE COUNTRIES

Glossary of Animal Husbandry Terms

It became apparent during the Turrialba meeting that there was a definite need for a glossary of the animal husbandry terms used in English and Spanish, both to facilitate understanding of the more or less comparable terms used in the two languages, and to help in clarifying the meanings of the varying Spanish terms used in different parts of Latin America. This need found specific expression in a recommendation of the Baurú meeting that the Food and Agriculture Organization of the United Nations should consider the preparation and publication of such a glossary.

A similar need had been felt in Europe, and the Sixth International Congress of Animal Production, held in Copenhagen, Denmark, in July 1952, had recommended the preparation of a multilingual glossary of animal husbandry terms. Arrangements have been made between FAO and the European Association of Animal Production to co-operate in the preparation of such a glossary in English, French and German, following the recommendation of this congress.

A very substantial effort is required to produce a glossary even in one language, and the effort required for a glossary in two, three or four languages must usually extend over several years. To avoid duplication of effort, and in view of the fact that considerable progress had already been made on the English-French-German glossary, it was agreed at the Buenos Aires meeting that a number of governments in various geographic areas of Latin America should be asked to designate workers who are competent in the field and who could co-operate with FAO in the completion of the Spanish section, basing their work on the material prepared for the English-French-German sections with adaptations to include any special terms peculiar to Latin America.

In view of the many problems which must be solved in the preparation of a glossary, while avoiding making the task unduly large and the glossary too cumbersome, it seems desirable to give a brief account of these problems here. FAO has already gained considerable experience in the solution of these problems in the preparation of a multi-lingual vocabulary of soil science (Jacks, 1954).

The consultants to FAO and the European Association of Animal Production, and members of the FAO staff themselves who
have been giving attention to the detailed problems of preparing a glossary have become increasingly aware of the need for a glossary since no publication of this kind exists. There are several dictionaries devoted to agricultural terms, but some of them are insufficiently exact. They do not cover synonyms, and they fail almost entirely to explain the nuances of different words. In a number of cases, words and phrases are used in one language which have no corresponding expression in others. In other cases words, which are very similar in different languages, have diverse meanings, and there also exist various synonyms for the same concept. All these differences require study and explanation. In view of this, it is considered that a dictionary which gives merely the corresponding words in various languages would be insufficient, and that a publication is needed in which at least parts of the concepts that could not be easily translated from one language to another are defined. It is felt that the work planned, if executed in the way outlined below, would contribute greatly to the uniformity of understanding which would, of course, be of great benefit to all workers in animal husbandry.

As regards the layout of the glossary, it was originally suggested that it should be assembled in alphabetical order, and not divided up according to subject matter, and with as many sections as languages to be included in the work. This would greatly increase the printing cost, however, and consideration has been given to an alphabetical index in each language to give ready cross reference to terms in other languages, arranged according to subjects. The view has also been expressed that illustrations and diagrams would facilitate the work, and would dispense with lengthy explanations in some cases. However, this would also increase the cost substantially. It has also been emphasized that explanations are necessary where the concepts are not clear, and when they are different in the various languages, as in cases where similar words have different meanings in different languages. If the corresponding word has a wider or more limited meaning, it might be indicated in italics. Where synonyms exist, these would be listed after the word indicated, and the country of origin where they are used would also be given where possible. More commonly used synonyms would be indicated in different type.

It has been decided that, at least for the time being, the work should be limited to the following fields:

(1) animal husbandry in general (breeding, genetics, management, animal nutrition including grazing but excluding range management, organization of, and research in, animal husbandry legal terms, as far as they refer to animal production);
(2) horse production, donkeys and mules; including, to a limited extent, the most important expressions referring to harnessing, but excluding technical racing and sporting terms;

(3) cattle production (including buffaloes and dairy husbandry, but excluding dairy technology);

(4) sheep production;

(5) goat production; and

(6) pig production.

In principle the following will be excluded:

(a) all terms which can be easily found in an ordinary dictionary, and which could not be considered technical;

(b) all terms referring to agriculture in general, and in particular crop husbandry and land and water use terms;

(c) veterinary terms, including anatomy and physiology (however, such terms which are concurrently used in animal husbandry and feeding could be included to a limited extent — these terms which are in very close relation to the physiology of nutrition should also be included, as well as terms of physiology and anatomy which are most commonly used in regard to animal production), and

(d) terms referring to the technology of processing of animal products.

Scientific terms should be included on a limited scale, and only those which are more commonly used in papers referring to animal husbandry. In general, explanation of such terms should be restricted as far as possible, and omitted for terms of basic science, such as pH, vitamins, antibiotics, etc. Scientific names in Latin or Greek or chemical names should be included to a limited extent. Chemical formulae should be employed only where essential in giving explanations.

**Literature Cited Regarding Glossaries**

Proposals for Further Meetings and for a Working Party and Sub-Groups to Facilitate Co-operation between Meetings

Inter-governmental co-operation on animal production problems is a relatively new undertaking. Various types of organizations have been developed to serve the interests of the livestock industry and national bodies for this purpose usually consist of professional workers in the animal husbandry and/or veterinary fields, who have banded together to enable them to exchange more readily information on the results of their research and to strengthen their activities in other ways. In some countries organizations of producers also occupy an important place in the livestock industry. In some instances, organizations are based on a combination of producer and professional participation. In one region, namely Europe, an association has been formed for the benefit of animal husbandry in all the countries of the region. This is known as the European Association for Animal Production, and it is made up of national organizations, one from each participating country. These national organizations vary considerably in their make-up, ranging from organizations of professional workers to producer organizations, and even to scientific organizations having broader academic interests. Still another type of international organization is the international congress. One example is the International Congress on Animal Production, which is now organized at intervals under the auspices of the European Association of Animal Production, and in which most of participants have been from European countries. Another example is the International Veterinary Congress. These congresses are essentially meetings in which scientists present papers on the results of their research and are not intended to serve as a basis for the development of inter-country co-operation at the government level. Two veterinary organizations at the inter-governmental level are mentioned elsewhere in this publication. They are the International Office of Ephizootics, founded in 1924 with headquarters in Paris, and the recently established European Commission for the Control of Foot-and-Mouth Disease, which functions within the framework of FAO.

Thus, within the Kingdom of Pan, there has been a considerable exchange of knowledge and experience at the scientific level, but there have been few attempts to develop inter-governmental co-operation except those aimed specifically at the control of disease. Even at the scientific level a remarkable degree of isolation still exists in many parts of the world.

In an effort to facilitate the exchange of information among
countries, and to provide bases for inter-country co-operation where such co-operation would be mutually beneficial to two or more countries, FAO has organized a considerable number of technical meetings. These have usually been on a regional rather than a world-wide basis, and the three meetings held in a series at Turrialba, Baurú and Buenos Aires are examples. These meetings, held in various parts of the world, have given attention to many phases of agriculture, and the technical workers participating in them as representatives of their respective governments have generally welcomed the opportunities provided for the making of contacts and exchanging information with their colleagues in neighboring countries. There have also been numerous cases where these technical consultations have led to the development of inter-country co-operation on specific problems. One result of such meetings is a demand for some more formal type of organization to ensure the continuation of the contacts and the co-operative efforts arising therefrom.

This latter point is illustrated by the suggestion which arose from the Baurú Meeting that some type of organization should be considered for the continuation of inter-country collaboration on livestock production problems in the Americas. The Buenos Aires meeting, therefore, considered the various methods which might be adopted within the framework of FAO to achieve this objective. These methods include the following:

(1) The formation of informal groups of correspondents, the members of which are designated for each country by their respective governments, to maintain correspondence with the appropriate staff members of FAO concerning developments in their own countries and to receive from FAO staff members and correspondents in other countries information that might benefit them and their colleagues in their work.

(2) The convening of meetings at intervals to deal with specific subjects. For example, in Europe a series of eight annual meetings have been held to deal with hybrid maize and with the development of inbred lines for the production of hybrids. The series of three meetings on livestock production in the Americas held thus far is another example of this type of activity. No formal, continuing organization is involved and the meetings are convened by the Director-General of FAO after having been included in the Program of Work approved by the FAO Conference.

(3) The establishment of continuing working parties which meet at intervals, usually annually or biennially, to deal with specific technical problems. The Working Party on Mediterranean Pasture and Fodder Development is an example
of this kind of activity. It differs from the series of annual meetings mentioned in item 2 in that the organization is somewhat more formal. Governments are invited to designate individuals to serve as continuing members of the Working Party and these members serve as contact points for correspondence and other activities in the intervals between meetings. Formal meetings of such working parties are convened by the Director-General in the same manner as meetings of the type mentioned under item (2).

(4) Formation of committees of the Council or Conference of FAO. The membership in such committees may be open to a selected group of countries for a particular purpose, or may be open to all countries in a particular area. The European Committee on Agriculture, in which all Member Governments of FAO in Europe are invited to participate, either in its meetings or other activities recommended to the Director-General by it, is an example.

(5) Formation of permanent bodies, such as the International Rice Commission, which are arms of FAO. The International Rice Commission is the only such body thus far formed in the field of agriculture. Twenty-six of the Member Governments of FAO, representing countries in all parts of the world where rice is an important crop, have adhered to the Constitution of this Commission. The present practice is to hold biennial meetings and to carry out most of the technical work through continuing working parties or ad hoc groups set up to deal with specific technical problems. The continuing parties in this case differ somewhat from those described under item (3) in that in most cases each government which is a member of the Commission is invited to send a representative to each meeting of a working party and individuals are not named to represent their countries on a continuing basis, although in many cases the same individuals come back to the meetings year after year. The work of the Commission, insofar as it involves time and travel of the FAO staff, is carried out under the Regular Budget of the Organization. However, provision is made in the Constitution of the International Rice Commission whereby governments may make special contributions for co-operative projects, of which the international rice hybridization scheme now in operation is an example, and

(6) Establishing commissions or bodies as arms of FAO to carry out specific action programs, the only example to date in the field of agriculture being the European Commission for the Control of Foot-and-Mouth Disease. This type of commission differs from the one described under item (5) in that
the participating governments agree to supply special funds to finance the work of the Commission, and it is, therefore, not dependent upon funds from the regular FAO budget, although some members of the regular staff of the Organization assist in servicing the Commission.

Representatives of the governments who attended the Buenos Aires meeting gave careful attention to the advantages and disadvantages of the various approaches which might be adopted to follow-up the Turrialba, Baurú and Buenos Aires meetings, and there was general agreement on the following points:

(a) it would be desirable to have some continuing organizational arrangement to ensure regular contacts among livestock workers in the Americas and the ready exchange of information among these workers;
(b) any organizational arrangement which might be developed for this purpose should be informal and should not require action by parliaments to bring it into effect;
(c) full advantage should be taken of existing organizations, both to prevent the development of additional organizations unless absolutely necessary, and to take advantage of the technical competence of these existing organizations; and
(d) the organizational arrangement which might be established should provide for technical consultation on a limited number of selected subjects, and at the same time include provisions for over-all consultation on livestock problems. Technical groups should be set up where needed, by sub-regions or by subjects, in such a way that the varied problems and environmental conditions in the Americas are fully taken into account.

With the above points in mind the representatives of governments assembled at the Buenos Aires meeting recommended that the Director-General of FAO should invite governments to participate in a continuing working party on livestock production to serve during the periods between livestock production meetings, in order to provide a continuing basis for consultation between the technical workers in countries and the staff of FAO between meetings, and for the co-ordination of preparations for meetings within countries, and that that working party's activities be carried on largely by correspondence. Governments should be invited to designate a representative who could speak for the over-all livestock and poultry interests of the respective countries, and who might normally be designated by their governments to attend periodic livestock production meetings convened by FAO at in-
tervals of approximately three years. This working party would consider over-all problems of livestock production, including poultry, in the Americas, and would also have placed before it for consideration the reports of any specialized sub-groups which might be formed. To meet the need for technical discussions of limited subjects, sub-groups should be formed where necessary. Such sub-groups might deal with a variety of problems including:

(i) animal climatology, including improvement of livestock production in the high Andean area, and livestock improvement under tropical conditions;
(ii) improvement of grasslands and management of livestock on grasslands in the temperate zones;
(iii) improvement of grasslands and management of livestock on grasslands in tropical and sub-tropical zones;
(iv) control of foot-and-mouth disease;
(v) preparation of a Spanish section of the glossary of animal husbandry terms, and
(vi) livestock and poultry nutrition,

and others as may be required. The delegates to the Buenos Aires meeting considered that it would be premature to make firm recommendations at that stage concerning either the sub-groups which should be set up or the period for which each such sub-group be established. They recommended, therefore, that following the establishment of the over-all working party on livestock production, FAO should consult the representatives designated by governments, and, on the basis of their recommendations, should then decide which sub-groups should be convened.

The delegates to the Buenos Aires meeting also recommended that the fourth meeting of the series, which had included the Turrialba, Baurú and Buenos Aires meetings, should be held in Jamaica in 1958.

Steps are being taken by FAO to implement these recommendations.
The series of three meetings held in Turrialba, Baurú and Buenos Aires in 1950, 1952 and 1955, respectively, to consider problems of livestock production in the Americas, provided to the members of delegations from participating countries opportunities:

1. to exchange information on their problems and on the steps being taken to deal with them through research, extension, training of technical workers, and other means;
2. to see the production methods, types of livestock, grasslands, and agricultural institutions in three countries, namely, Argentina, Costa Rica and Brazil each with its own characteristic conditions and problems;
3. to establish personal contacts with workers in their own and closely related fields in other countries, thus facilitating the flow of information between countries; and
4. to improve their work in their own countries by applying information obtained from workers in other countries and as a result of the stimulus emanating from the exchange of ideas with their fellow scientists.

The immediately tangible evidence of the work accomplished in these meetings is found in the three reports, and in the present paper which is based to a large extent on the report of the third meeting in Buenos Aires. Through these publications summaries of the most important information presented at the meetings is made available to leaders and technical workers in the livestock industry in all countries. But the intangible results of the meetings are no doubt much more important because, although not readily measurable, they are found in improved services to the livestock industries in the various countries, and in programs which have been initiated or improved as a result of the stimulus of the meetings which will eventually result in improved services.

The participants in these meetings, recognizing the value of the inter-country consultations provided for therein, considered that some more formal arrangement should be made to ensure continued contacts between countries, particularly during the intervals between meetings. They, therefore, recommended at the Buenos Aires meeting that the Director-General of FAO should establish an inter-governmental working party to provide for this
continuing consultation on livestock problems in the Americas. Action to implement this recommendation has been initiated.

At the first meeting at Turrialba, and again at the second one in Baurú, members of delegations had an opportunity of discussing problems relating to all aspects of livestock production. On the basis of the interest shown in various problems, and the nature of the problems which appeared to require special attention leading to their solution, a limited list of topics was selected for consideration at the third meeting in Buenos Aires. After considering these topics, and deciding upon the type of organization that they wished to recommend to ensure continuing consultation, the participants selected a still more limited group of subjects to which attention might be given by specialized sub-groups of the working party mentioned in the previous paragraph. This limited list will be subjected to further review by the working party itself as one of its first major functions after members have been designated by participating governments.

Thus, the three meetings have provided an opportunity for the gradual sorting out of relatively few subjects upon which definite steps may be taken to develop inter-country co-operation, and the work initiated at the meetings will enter a new phase. In the work thus far the emphasis has been on the exchange of information. In the phase which is now beginning through the establishment of a working party and consideration of the establishment of sub-groups, the emphasis will be much more on the development of inter-country co-operation in limited fields, although the opportunities for exchange of information in these and other fields is expected to continue in the series of meetings, the fourth of which has been recommended to be held in Jamaica in 1958. This Development Paper may, therefore, be regarded as a bridge between the two phases of activity, providing an end-point for the first phase, and a point of departure for the second phase which took definite form as a result of the discussions in the Buenos Aires meeting.

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