IMPROVING LIVESTOCK THROUGH BREEDING

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.

Institution	*Facilities*
INTER-AMERICAN INSTITUTE OF AGRICULTURAL SCIENCES (Turrialba, Costa Rica)	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.

Agricultural and Mechanical College of Texas (College Station, Texas, U.S.A)	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.
Johns Hopkins University (Baltimore, Maryland, U.S.A.)	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.
University of Missouri (Columbia, Missouri, U.S.A.)	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.

University of Illinois (Urbana, Illinois, U.S.A.)	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.
Louisiana State University (Baton Rouge, Louisiana, U.S.A.)	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.
North Carolina State College (Raleigh, North Carolina U.S.A.)	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 tolerante 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 (Ittner, 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° and 100°F. (22° 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° to 48°F. (7° 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° 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; Korff, 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-Sulsona, Hammon and Ramírez, 1952). A further map, outlining the major types of production areas in Paraguay is shown in *Figure 2*.

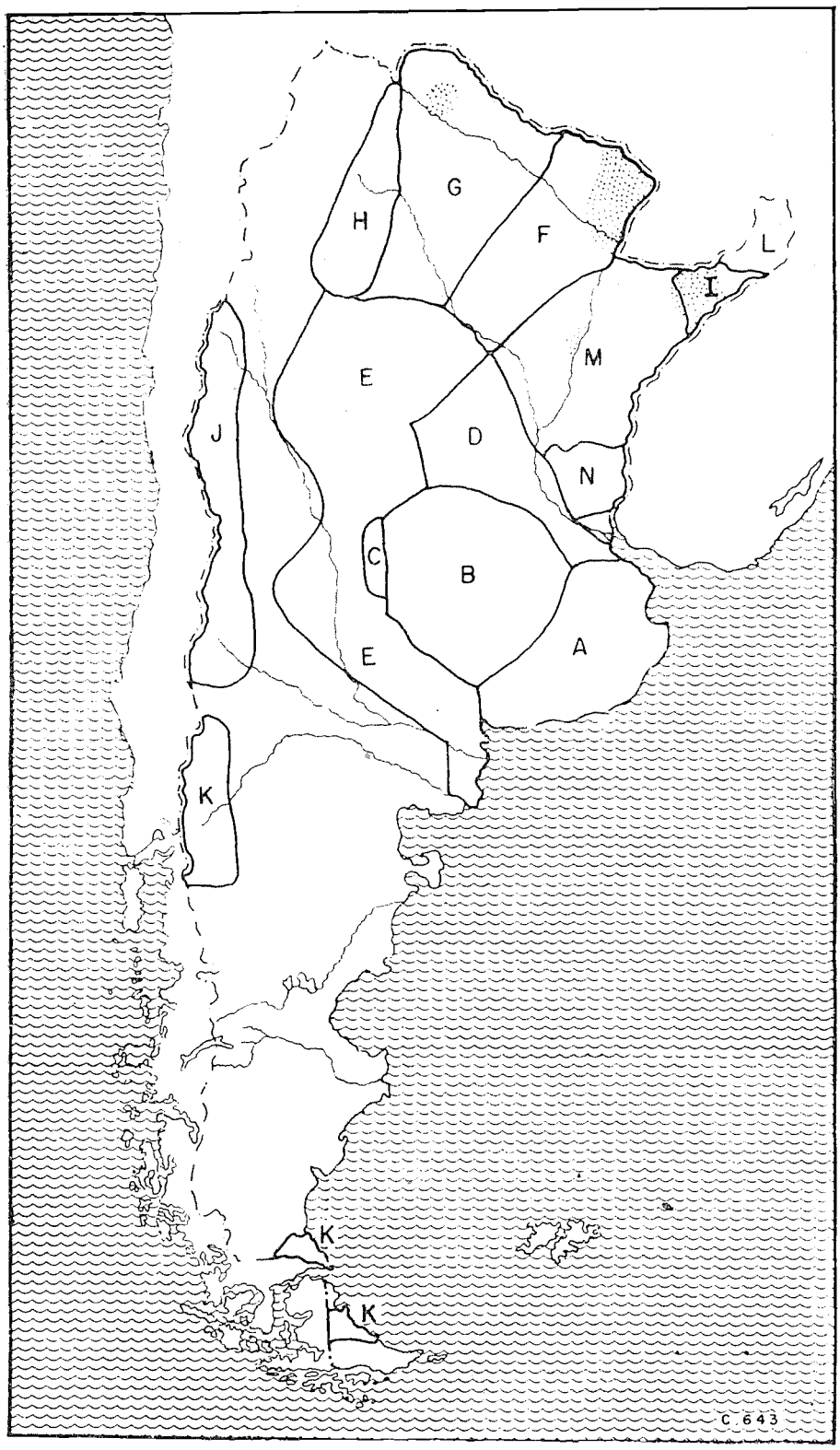

Figure 1. Map showing the major types of areas for cattle production in Argentina: **A.** Breeding zone; **B.** Fattening zone; **C.** Marginal fattening zone; **D.** Dairy area; **E.** Marginal livestock area; **F.** Northern breeding zone; **G.** Marginal breeding zone; **H.** Marginal dairy area; **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.

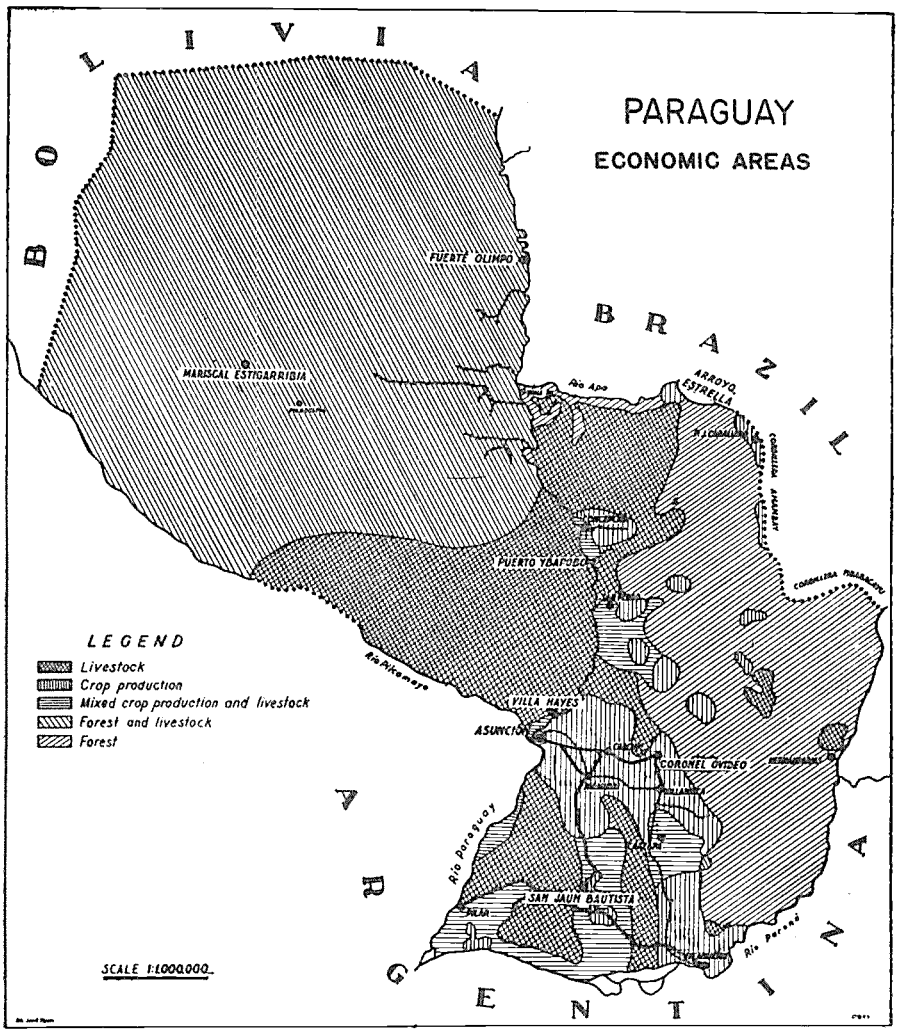

Figure 2. Map showing the major types of animal production areas in Paraguay (Courtesy Government of Paraguay).

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.

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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 intensified 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 bred. The future improvement of the breed is left to the breeders' discretion. This slight guarantee given by the term " registered " as far as it concerns 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 specimens 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 assuming 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 registration 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' association – 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 Agriculture 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 registrations; first, second and third preliminary registrations; and final registrations for certain breeds already established and whose enlargement 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 herdbooks, 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 approval of the type, and upon the basis of a fixed minimum milk production. The offspring of those animals registered in the preparatory 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 automatically 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

Breed	Year Herdbook Founded	Total Numbers Registered since Founding of Herdbook		
		Males	Females	Both Sexes
Shorthorn	1888	385 609	380 023	765 632
Polled Shorthorn	1909	360	394	754
Aberdeen Angus	1901	162 967	128 246	291 213
Hereford	1889	121 554	128 246	249 800
Polled Hereford	1944	4 363	4 486	8 849
Holstein-Friesian	1920	28 719	31 454	60 173
Brahman	1920	149	170	319
Dexter	1920	114	148	262
Flemish	1920	1 640	2 267	3 907
Galloway	1920	127	102	229
Jersey	1920	726	866	1 592
Normandy	1920	1 199	1 326	2 525
Red Polled	1920	2 505	3 432	5 937
Brown Swiss	1920	873	932	1 805
West Highland	1920	147	157	304

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 accomodation 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 tattoed 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

Association	Registrations 1953	Total Registrations
Canadian Aberdeen Angus Association	7 329	128 568
Canadian American-Saddle Horse Breeder's Association	35	619
Canadian Ayrshire Breeder's Association	12 778	408 849
Canadian Belgian Horse Association	138	10 941
Canadian Cattle Breeder's Association	866	36 333
Canadian Horse Breeders' Association	21	3 568
National Chinchilla Breeders of Canada	8 074	28 848
Clydesdale Horse Association of Canada	86	94 710
Canadian French Coach Horse Breeders' Association	—	158
Canadian Galloway Association	80	3 618
Canadian Goat Society	237	5 443
Canadian Guernsey Breeders' Association	4 169	68 864
Canadian Hackney Horse Society	54	3 975
Canadian Hereford Association	33 537	398 647
Canadian Holstein-Friesian Association	67 650	1 351 200
Canadian Hunter Society	59	405
Canadian Jersey Cattle Club	12 715	387 207
The Canadian Kennel Club	13 905	332 464
Canadian National Silver Fox Breeders' Association	377	472 806
Canadian Palomino Horse Association	391	391
Canadian Percheron Association	144	43 213
Canadian Pony Society	66	2 320
Canadian Red Poll Association	315	21 038
Canadian Sheep Breeders' Association	13 550	537 768
Canadian Shire Horse Association	—	3 424
Canadian Shorthorn Association	20 301	783 053
Canadian Standard Bred Horse Society	757	12 822
Canadian Suffolk Horse Society	3	766
Canadian Swine Breeders' Association	15 019	651 213
Canadian Thoroughbred Horse Society	488	14 526
General Stud Herdbook		
Arabian Horse	27	132
Brown Swiss Cattle	64	3 722
Devon Cattle	5	5
German Coach Horse	1	23
Highland Cattle	48	247
Jacks and Jennetts	—	1
Lincoln Red Shorthorn	—	45
Morgan Horse	5	24
Tennessee Walking Horse	—	13

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 3 – NUMBERS OF CATTLE OF VARIOUS BREEDS REGISTERED BY CHILEAN AGRICULTURAL SOCIETIES IN 1954

Breed	National Agricultural Society (S.N.A.)	Agricultural Society of Temuco (S.O.F.O.)		Agricultural Society of Osorno (S.A.G.O.)		**Total**	
	Purebred	Purebred	Grade	Purebred	Grade	Purebred	Grade
Dutch Lowland	1 143	121	121	1 300	347	2 564	468
German Lowland	23	473	957	603	694	1 099	1 651
Holstein-Friesian	—	17	17	—	—	17	17
Brown Swiss	—		7	—	—	—	7
Norman	68	21	50	—	—	89	50
Simmenthaler	—	—	—	22	—	22	—
Durham Shorthorn	2	—	—	—	—	2	—
Aberdeen Angus	30	—	—	—	—	30	—
Hereford	10	—	—	—	—	10	—
Total	**1 276**	**632**	**1 152**	**1 925**	**1 041**	**3 833**	**2 193**

TABLE 4 – NUMBERS OF HORSES OF VARIOUS BREEDS REGISTERED BY CHILEAN AGRICULTURAL SOCIETIES IN 1954

Breed	National Agricultural Society (S.N.A.)		Agricultural Society of Temuco (S.O.F.O.)	Agricultural Society of Osorno (S.A..G.O.)	**Total**	
	Purebred	Grade	Purebred	Purebred	Purebred	Grade
Chilean	1 589	—	56	154	1 799	—
Thoroughbred	7	—	—	—	7	—
Belgian	16	2	—	—	16	2
Percheron	30	—	—	—	30	—
Hackney	3	—	—	—	3	—
Total	**1 645**	**2**	**56**	**154**	**1 855**	**2**

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

Breed	National Agricultural Society (S.N.A.)		Agricultural Society of Temuco (S.O.F.O.)		Agricult. Society of Osorno (S.A.G.O.)	Breed Association of Magallanes	Total	
	Purebred	Grade	Purebred	Grade	Purebred	Purebred	Purebred	Grade
Hampshire Down	730	10	46	36	8	5	789	46
Oxford Down	—	—	—	—	—	7	7	—
German Merino	669	69	—	—	—	—	669	69
French Merino	619	233	—	—	—	—	619	233
Australian Merino	328	—	—	—	—	20	348	—
Corriedale	82	—	—	—	18	1 446	1 546	—
Suffolk Down	88	69	—	—	—	—	88	69
Ideal	18	—	—	—	—	—	18	—
Isle of France	10	—	—	—	—	—	10	—
Romney Marsh		—	—	—	167	371	538	—
Total	**2 544**	**381**	**46**	**36**	**193**	**1 849**	**4 632**	**417**
Anglo Nubian	16	—	—	—	—	—	16	—

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

Breed	National Agricultural Society (S.N.A.)	Agricultural Society of Temuco (S.O.F.O.)	Agricultural Society of of Osorno (S.A.G.O.)	Total
Berkshire	384	27	171	582
Duroc	42	—	—	42
German Landrace	70	292	4	366
German Saddleback	—	—	52	52
Total	**496**	**319**	**227**	**1 042**

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.

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

Time	Number of Herds	Number of Animals			Total (Cows)
		Pure	Mixed	Criollo	
February 1953	3	35	30	–5	65
January 1955	34	154	286	951	1 391

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 Novermber 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:

Name	Animals Registered	
	Males	Fermales
Jamaica Brahman Breeders' Society	300	1 630
Jamaica Black Cattle Breeders' Society	30	400
Jamaica Hope Cattle Breeders' Society	210	1 550
Jamaica Red Cattle Breeders' Society	220	1 610

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 numer 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

Purpose	1953	1952	1951	1950	1949
Beef	828 952	872 701	736 277	657 309	565 300
Dairy	396 448	421 450	403 108	394 746	381 130
Dual purpose	30 181	35 963	40 139	35 799	34 000
Total	**1 255 581**	**1 330 114**	**1 179 524**	**1 087 854**	**980 430**

TABLE 9 – HORSES REGISTERED IN THE UNITED STATES OF AMERICA

Purpose	1953	1952	1951	1950	1949
Draft	357	311	364	403	606
Light	33 994	29 795	19 576	15 627	14 831
Total	**34 351**	**30 106**	**19 940**	**16 030**	**15 437**

TABLE 10 – SHEEP REGISTERED IN THE UNITED STATES OF AMERICA

Purpose	1953	1952	1951	1950	1949
Medium wool	77 242	97 061	89 721	87 207	80 595
Fine wool	10 182	13 810	14 664	14 383	8 594
Coarse wool (long)	19 931	19 622	18 384	16 543	14 530
Fur (Karakul)	323	301	320		661
Total	**107 678**	**130 794**	**123 089**	**118 133**	**104 380**

TABLE 11 – GOATS REGISTERED IN THE UNITED STATES OF AMERICA

Purpose	1953	1952	1951	1950	1949
Mohair	5 463	4 708	5 269	4 265	3 454
Milk	7 153	6 847	2 275	2 760	6 976
Total	**12 616**	**11 555**	**7 544**	**7 025**	**10 430**

TABLE 12 – SWINE REGISTERED IN THE UNITED STATES OF AMERICA

Purpose	1953	1952	1951	1950	1949
Bacon	16 077	14 574	4 715	18 859	13 376
Lard	531 694	225 515	313 400	325 404	343 417
Total	**547 771**	**240 089**	**718 115**	**344 263**	**356 793**

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 throughbred 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 1½ 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.

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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 co-operation 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 occurences 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, co-operative 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 form 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.

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