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CROSSBREEDING AS A MEANS TO IMPROVE
DAIRY CATTLE IN PUERTO RICO

by

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A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Dairy Husbandry

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1947

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INTRODUCTION

Livestock breeding has long been recognized as one of the arts. Only until recently has it started to be systematized as a branch of science. Man's attempt to breed livestock which would better serve his purposes goes far back into man's own history. The more concentrated and fruitful efforts date from the beginning of the work of Robert Bakewell in England.

The rediscovery of Mendel's law in the year 1900 reopened the fields of both plant and animal improvement. Study soon revealed that, although the original principles were perfectly sound, considerable elaboration was required before breeders would be able to use them extensively. Animal breeders have been slower to recognize the true significance of this principle. However, since the year 1920, considerable progress has been made and much more is to be expected during the following two or three decades.

The field of production is generally divided into three parts: first, breeding; second, feeding and management; and third, marketing and servicing for consumption. The problems of reproduction and improvement are the beginning and therefore fundamental in livestock production.

The conversion of rough feeds into human food and the management of herds with a maximum efficiency are becoming more increasingly important due to the continual relative decrease in the agrarian population. This requires efficient animals. Efficient animals are produced only by those having a thorough understanding of the principles and practices of animal breeding. This includes the environmental factors, thought to be of prime importance in

considering the developmental programs of breeds in a new country where they are going to be reared. The environmental factors under which the animals will be forced to live usually constitute a limiting factor. It is responsible for the variations in production when the animals are of the same or similar heredity. The climate is considered of paramount importance in solving the cattle problems; besides, it is contemplated as affecting the quantity and quality of the plant products used as feed and affects the physiological functions in the maintenance of normal body temperature of animals reared under tropical conditions.

Another important point affecting the cattle industries is the high degree of specia lizatim together with the division of labor, characteristic of all agricultural industries. The marketing and servicing problems in the cattle industry year after year are becoming more complicated due to the increasing cost in its distribution.

Purpose

Puerto Rico is an eminently agricultural country with a few enterprises of economic possibilities. That is why an intensive utilization of the land is essential to the general welfare of its people. The extent to which agriculture is commercialized may be shown by the fact that nearly four-fifths of the total value of our export items, by far, are sugar and its by-products. Sugar-cane production, however, is the only enterprise in which an intensive utilization of the land has been partially attained. This means that Puerto Rico imports most of its consumption needs and materials for the productive effort from outside sources. This

economy of exchange as a means of maintaining a high income for the island, is undoubtedly economically and socially desirable, but there are certain flaws for which adequate correctives should be found. The danger attachable to a single-crop economy protected by tariffs subject to possible adjustments is obvious. The island should be prepared to face such adjustments for a more efficient agricultural industry, able to withstand competition from abroad or to develop enterprises that will compensate for any loss of income from sugar (31), p. 36.

The dependence of the island on outside sources for a large proportion of its foodstuffs and materials essential to the productive effort is, to a certain extent, one of the evils of an overspecialized exchange economy. This is true in relation to foodstuffs of which there has been a deficiency in quantity and quality. The evils of this condition became more evident during the postwar emergency. The normal supply of foodstuffs to the island was sharply curtailed by the war hazards and needs. The crisis in this respect was further aggravated by the lack of animal foodstuffs and fertilizers normally imported to the island. Animal foodstuffs are the mainstay of commercial fresh milk and meat production, from which most of the urban population of Puerto Rico is supplied. Fertilizers are necessary to maintain the high yield per acre of the principal crops, such as sugarcane.

As a consequence of these varying conditions, the amount of food produced by the cattle is insufficient to cover the demand, and is mostly characterized to be of a very poor quality. This explains the large amount of imports of meat and dairy products to

the island (31), p. 72.

The conditions of production in Puerto Rico show that sugar is the principal industry. The livestock industries have been sadly neglected, especially cattle. Practically all the research work for the improvement of agriculture has been done in the field of sugarcane cultivation. Under this aspect of utter abandonment of such a great source of food as the dairy and meats industries are, an analysis of the conditions under which cattle and their products are obtained in the island should be of interest, and a study of the various ways in which the social problem of raising the low level of nutrition of the Puerto Rican people must be intriguing.

To consider this aspect of the island's economy in the broad sense, other critical problems will cause this study to deviate from its major purpose; that is, the increase of the production of milk and meats to raise the level of nutrition of the Puerto Rican people directly by undertaking programs of crossbreeding to improve the cattle of the island.

The economy of the cattle industry of Puerto Rico must be analyzed like that of any other enterprise of any other region of the world. It should be considered the interplay of the physical, social and economic factors in their environment. In any region of the world whose economy is essentially agricultural, such as in Puerto Rico, the cattle industries are of greatest importance.

They contribute to the general welfare by providing a large variety of food products of high nutritional value, furnish numerous farmers with steady incomes, and also they help in the maintenance of soil fertility.

Because the solution, of course, depends on the increase of cattle production and a betterment of the quality of its products, the role that crossbreeding is playing and will continue to play in the improvement and development of Puerto Rican cattle cannot be expressed in a few words, but in terms of economical benefits and healthfulness of the people.

The standard dairy and beef cattle in the United States and Europe are not adapted to the tropical climate of Puerto Rico, and their management under this condition is very difficult and expensive. The native cattle, although adapted to the climatic conditions of the island, are very low producers and are degenerated due to a continued poor selection through the years. These main factors greatly limit the possibilities for their exploitation by the average farmer.

The problem of the cattle industry is great and, besides, an effective program of crossbreeding involving the principal economical breeds with the native and Brahman strains, it rests upon the limited area of pasture land, in the need for producing high-quality feeds other than good roughages; in the lack of highly productive cattle; in that the farmer does not use either private or government technicians as he should; and in part in the lack of legislation specifically affecting the cattle industry.

This is one of the main reasons why a study of this nature is necessary. It is not intended to prove that the cattle industry in Puerto Rico can reach such a point of development as would eliminate importations of food products derived therefrom entirely. That may become a desirable consequence in the future, but for the

time being the aim should be merely the improvement of the low status of the cattle industry and together improve the low level of nutrition to which the native cattle in Puerto Rico have been so well adapted and make possible the exploitation of new economical animals. Figure 3 in Plate III shows some of the inadequate pastures heavily infected and of a low yield per acre.

Scope

There are three main approaches that may help to solve the problem of low productivity of cattle in Puerto Rico. They are to be discussed in this report. The first is the increase of purebreeding of the dairy and beef breeds under the conditions more suitable for each of them; second, the crossing of the dairy breeds with the native and the Brahman strains; and third, the intermating of the beef breeds with the native and the Brahman strains. Some aspects of the improvement of pastures are included to make a program of crossbreeding more effective and finally to make the study more reliable and, because of the lack of sufficient data on the cattle enterprise in Puerto Rico, a general review of the work done outside of the island, and the work under way related to crossbreeding, will be given, as well as that experimental work started by the government of the island in an attempt to find a solution to the problem concerned. Unfortunately, the work on crossbreeding is incomplete and only that published will be used here.

At present meaningful and reliable statistics in Puerto Rico are not easily accessible. Students must spend long hours searching for them from different sources. However, the Puerto Rican

government has greatly expanded its activities recently in order to translate into action an ambitious social program. This means that Puerto Rico is now emerging from the pioneer stage, when the kind of livestock was of little importance. It seems to be the era of developing local strains and a wide range of experimentation with purposely introduced breeds. This latest work, although incomplete, will be included in this study.

Review of Literature

Crossbreeding has been in the United States and in the European countries of relative importance when beef cattle are raised commercially. So far it is, or at least is believed so, because no practical breeder can adjust to any kind of breeding program under this system. It is also considered a very expensive way of improving our dairy and beef animals, and such task should be left to the governments of the respective countries to assume the responsibility. Another factor worthy of consideration is that the time required is very valuable to breeders when a large sum of money is involved. However, crossbreeding is very valuable when the object is to determine or study the genetic mechanism of meat and milk propensities.

The beef and dairy cattle of today meet more efficiently the requirements than those of the past, so for the farmer with limited time, capital and number of animals, the use of crossbreeding is discarded. However, the question is raised often as to how cows may be produced that would yield more milk and butterfat or that would gain more weight per dollar of feed invested in them. This

is one of the basic reasons for all beef and dairy cattle improvement programs. Even though our cattle in general seem to have reached some sort of an upper production limit, nevertheless, in the last 10 years there has been a gain of 340 pounds of milk and approximately a 15 percent increase in the butterfat when referring to the dairy type. It has been observed that there has been a lag in raising the level of production of dairy herds by the use of the so-called conventional breeding methods (23), p. 15.

If we study carefully these significant facts, it can be concluded that in the United States, like in European countries, the opinion as to whether crossbreeding is adapted to the dairy enterprise is divided. In most instances, it is even inclined to favor the improvement of existing breeds with absolute disregard of crossbreeding. This is because in these countries the existing breeds perform or accomplish their purpose well. However, when the problem of cattle improvement arises in countries like Puerto Rico, where the beef and dairy breeds are of inferior quality and where these imported breeds cannot adapt themselves to the level of nutrition and to other environmental factors, then crossbreeding suggests itself as a promising solution for the development of new breeds.

Marvelous changes may be induced in animal breeding to justify any procedure that does not involve a loss. When crosses of two well-defined breeds which have inherited from generation to generation certain characteristics that enable them to act as pure strains, after being mated by the appropriate system of crossbreeding, their offspring may attain the same high degree of pure

strains, even if they are not genetically the same. When the problem of pure strains in milk production is presented, it can be said that nature itself does not block the way to attain a relative degree of purity. Yet, changes in ideal types and commercial factors tend to make the road to follow much longer.

To a certain extent, the final result of the development in cattle is due to qualities inherent in the germ-cells, but at the same time individuals can grow and develop when the external conditions are just right. So the final qualities of an animal are due to the way it develops, and this development is the result of the cooperation of many different things, which are called factors in this development.

These developmental agents are always of two kinds, inherited and non-inherited. The nature in an animal's life is wholly different, although in a general way it is not possible to say that either one is more important than the other. It can be said that at no time is it possible for a young animal to keep growing normally, when both kinds of factors do not cooperate in this development. Thus the amount of milk a cow produces is partly influenced by her age, feeding and care, all non-inherited developmental factors, but also by inherited ones transmitted from parents to the offspring. Likewise, the effect of the environmental influences is almost restricted to the individual. This can be analyzed in the following way: if two bulls are compared, one that is young and vigorous and the other feeble and old, the former will not necessarily transmit his vigor, nor the aged his weaknesses; actually things may happen differently. So, once it is realized that ani-

mal qualities are as much due to environmental influences as to their genetic composition, it becomes evident that the ordinary variability which often is experienced in a group of imported breeds is partly due to other influences, such as management and climatic conditions (10), p. 159.

Pondering over the disappointing performance of excellent breeds of cattle in raising the level of production of dairy herds when raised in tropical countries, and the failure in part of farmers to make a measurable progress, a series of investigations has brought to light the real motive of these unfavorable results.

Lush (15), p. 34, in the United States, and Schutte, in South Africa, demonstrated that beef cattle on the range are directly influenced by seasonal changes in weather due to the effect of climate on pasturage. Hammond (11), p. 311-315, on conditions in Trinidad and Jamaica, and Rhoad (28), p. 509, on conditions in Brazil, have shown that dairy cattle under long periods of drought characteristic of many regions of the tropics materially reduced the production and the quality. Carneiro (2), p. 177, found that when dairy cattle are properly fed during a drought season there apparently is no reduction in their production.

Hodgson (28), p. 509-511, reported that the improvement of the native dairy type in tropical America, first by crossing with Brahman strains to increase the size and resistance to tropical diseases and then crossing them with imported purebred dairy breeds, has been remarkable, so far as the quality and production of the crossbreds are concerned. Furthermore, Howe (28), p. 509-511, reported that purebred cattle of the United States, when

raised under tropical conditions, showed a lack of growth and development combined with lower milk production; besides, a high mortality rate results from tropical diseases to which such animals are susceptible.

To develop animals resistant to such climatic conditions, the Jamaica Department of Agriculture started a series of crosses involving Brahman animals imported from India and some of the northern breeds. Best results were obtained when these particular crossbreds were backcrossed to purebred Jersey bulls until they had approximately one-eighth to one-fourth of the Brahman blood (11), p. 311-315.

Dairy farmers have long been interested in the probable results of crossing breeds of dairy cattle. However, the published material on cattle breeding contains very little conclusive information based on experimental work in crossing dairy breeds. Some work was done at the Maine Experiment Station nearly 30 years ago involving the Ayrshire, Guernsey, Jersey and Holstein dairy breeds and the Aberdeen-Angus beef breed. Most of the matings were between the beef and the dairy breeds. Although other experiments have been performed in Massachusetts, Illinois and Wisconsin, the milk production level of the experimental animals was not clearly established, particularly the level of milk production the sires were capable of transmitting.

Besides this organized but not well-planned crossbreeding work, breeders in certain sections of the United States, frequently in the New England states, upon the demand on the part of milk companies for a higher fat content of the milk, have been induced

to attempt mating animals of the Holstein breed with those of either the Jersey or Guernsey breeds. The main object of the crosses was to obtain a breed with a higher percentage of butterfat than the Holsteins and a higher milk production than that of either the Jerseys or Guernseys. All the efforts of the breeders in finding a beneficial way of employing crossbreeding have been worthless merely because they have not been able to perpetuate the good characteristics of the crossbreds.

An analysis made by Edwards (4), p. 281, of the butterfat production of Registry of Merit Jersey cows in Maine and Georgia demonstrated that climate influences the production of dairy cows similarly fed. He suggested that their Registry of Merit records eliminated the nutritional factor. During midwinter the barns were warmed, so the difference in production of the experimental animals on test was attributed to this fact and to the direct influence of climate on them.

Regan (24), p. 73, and Richardson have shown that dairy cattle, under controlled conditions consisting of an increased atmospheric temperature of 95° F., milk production gradually dropped 12 pounds a day. Rhoad (28), p. 509-511, in Brazil, reported similar results when purebred European dairy cattle imported to that region of the tropics produced only about 56 percent of their apparent capacity.

Kelley (28), p. 509-511, and Rupel gave an account in relation to winter barn temperature, manifesting that temperatures as low as 45° F. did not reduce the production of milk and suggested that the optimum stable temperature is about 50° F. Corresponding

to these results, Villegas (28), p. 509-511, in Singapore kept Holstein cows at 70° in an air-conditioned barn with a resulting 15 pounds milk over the production of a similar group kept in an open, ventilated barn exposed to tropical temperatures. In addition he observed that high temperatures have a profound effect on the reproductive efficiency of cattle, when 58 percent of the first lot conceived within five months as compared to 25 percent in the ventilated barn. Dawson (28), p. 509-516, observed similar results with the proved sires used in the southern experiment stations of the United States Department of Agriculture. He stated that sires in that section had an average fertility of 36 percent, while those bulls in the western and northern stations averaged 49 percent, attributing it to the higher summer temperatures and humidity of the south. Results having a general likeness were reported by Bonsma (28), p. 509-516, in South Africa. He imputed sterility during the hot months of a large percentage of the bulls of imported breeds to the high temperatures and explains in part why breeding is seasonal in some classes of livestock.

Edwards (4), p. 281-293, has shown in Jamaica that when the low-producing but highly adaptable Zebu type of cattle was crossed with European dairy cattle, the offspring were frequently much better producers than their parents. His explanation was that crossbreeding had given them a constitution permitting the expression of their productive capacity under a tropical environment. An excellent example of this sort of work was the development of the Santa Gertrudis, the first strictly American breed of beef cattle created by the fruitful efforts of the Kelbergs of King Ranch,

Kingsville, Texas, by crossing Shorthorn and Brahman cattle.

This early experiment and observations ascertain the weather as having a marked influence on the plane of nutrition of grasses in tropical regions; a profound effect on the growth and production innate in the animals introduced from other regions, and a definite consequence of the reproductive performance of the animals. A more specific work has been performed in regard to the length of the day and sunlight. Cattle moved from the shade, causing a rise in their respiratory rate and body temperature which indicated the difficulty in disposing of their body heat. This is an important factor affecting the adaptability of farm animals to the climatic environment. Nevertheless, cattle can tolerate small variations in their body temperature through their ability to keep heat production balanced by a heat loss and have an efficient heat-regulating mechanism that makes them more apt to survive and perform more efficiently than those not satisfactory in this respect. The ability of Zebu cattle to maintain normal body temperature under tropical surroundings makes them valuable in crossbreeding experimentation. Figure 2, Plate I, illustrates animals under this test.

To attempt a complete review of the literature pertinent to the problem under discussion is almost impossible. However, it can be seen that much of the success of the dairy and beef industry depends on the ability of man to furnish a favorable environment for his animals as long as he can. Under conditions where it is not economical for him to do so, he shall resort to the tool of crossbreeding in a last attempt to modify his animals to fit the

EXPLANATION OF PLATE I

Fig. 1. Cattle for hot climates have been a subject of study at the Iberia Livestock Experiment Farm at Jeanerette, Louisiana, for a number of years. Tests have demonstrated that animals having an efficient heat-regulating system like the Zebu are more apt to survive and perform satisfactorily in the subtropics than the local breeds of the United States. They are also superior to European cattle so far as ability to withstand warm humid climate is concerned (6), p. 177.

Fig. 2. A. O. Rhoad checks the amount of perspiration under the discs strapped around each of the two cows shown. Both have been exposed for the same length of time to the Gulf Coast sun. The animal at the left is a Zebu cow, the other is half Zebu and half Aberdeen-Angus. The Zebu showed less evidence of perspiration (6), p. 177.

Fig. 3. Experiments also have shown that cattle with Africander blood are better than Angus in the subtropics. The yearling shown is a halfbreed Africander x Angus bull (6), p. 177.

PLATE I



Fig. 1



Fig. 2



Fig. 3

natural environment of which climate is a major part.

Climate in Puerto Rico

So far, the failure on the part of the farmer to exploit economically the imported breeds of cattle to the island has been attributed to its climate. An attempt will be made to describe the climate of Puerto Rico to give an idea why in some particular regions also some of the imported cattle may be adapted.

Puerto Rico is less than 20 degrees north of the Equator, rather small in area, and is far from any large land masses. It has, as may be expected, a tropical, uniform oceanic climate. Ideal conditions exist for heavy precipitation over most of its area. The northeast trade-winds blow almost continuously during the day. As the rain clouds move southwest across the island, they gradually give up their moisture. The average annual precipitation ranges from less than 30 inches in the southwestern part of the island to nearly 200 inches on the highest peaks in "Sierra de Luquillo". A rainfall of 30 inches in Puerto Rico is equivalent in effectiveness to about 15 inches in the United States. The high evaporation with high temperatures, low relative humidity and constant winds tends to cause semiarid conditions, even where the average annual rainfall is 45 inches. Also as the crops grow throughout the year, irrigation is sometimes necessary, even in areas having an average annual rainfall of 65 inches.

The temperature, although tropical, is coolest during the day due to the moisture-laden trade-winds, and at night by the land breezes that blow from the cool mountains on the coast. The mean

EXPLANATION OF PLATE II

Fig. 1. Map of Puerto Rico showing the different types of farming. Pastures rank third. Commodities in general rank as follows: coconut, sugarcane, pastures, trees, pineapple, tobacco, grapefruit, subsistence crops, and coffee (30), p. 41.

Fig. 2. Map of Puerto Rico showing the distribution of cattle in the island (30), p. 46.

PLATE II

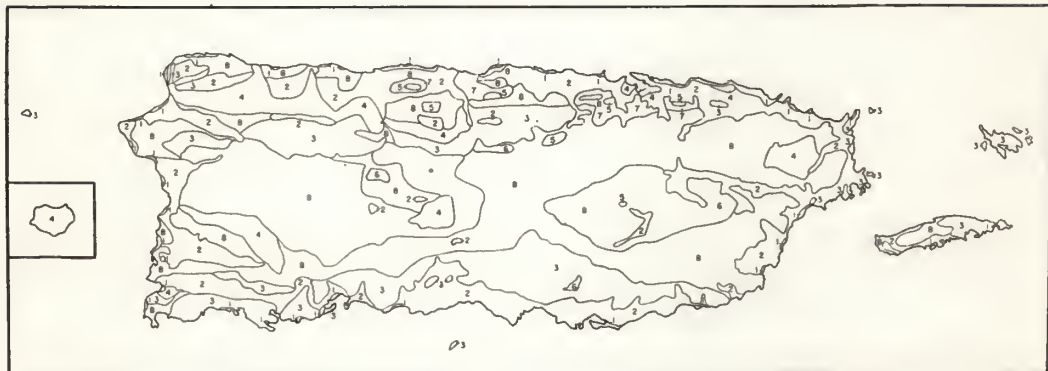


Fig. 1

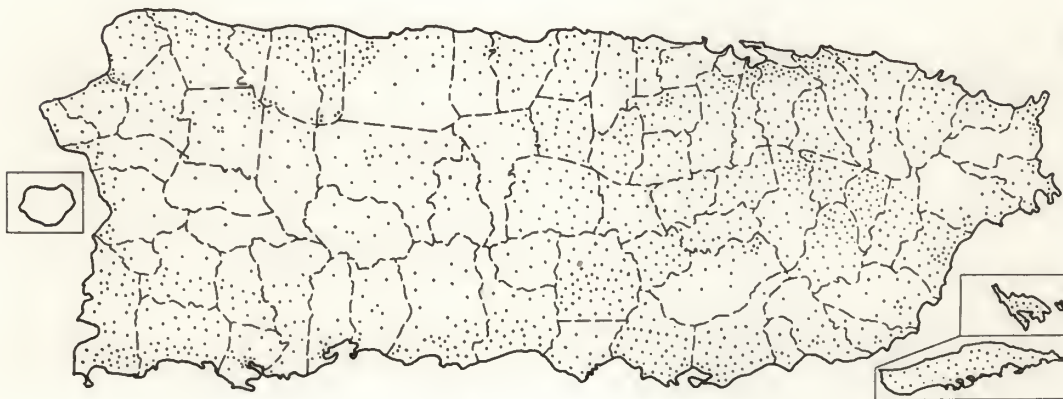


Fig. 2

monthly temperature along the warmer, dry coast ranges from about 75° F. in the winter to about 80° F. during the summer. However, the temperature seldom rises higher than 90° F. and even in the highest, coolest parts of the island it seldom falls below 50° F. The mild, uniform temperature, low relative humidity combined with invigorating breezes, and the mountainous character of most of the island, make it a very agreeable place in which to live. Although the climate is nearly ideal for the 12 months growing period for many tropical crops, the imported dairy cattle, hogs, goats and poultry suffer because of the climate. Nevertheless, the climate has had very little effect on the distribution of most of the cattle in Puerto Rico. Figure 2, Plate II, shows the distribution of Puerto Rican cattle.

Early History and Present Status of Cattle in Puerto Rico

The native Puerto Rican cattle were introduced from the Dominican Republic, another of the islands comprising the Western Antilles, in the year 1602 by Juan Ponce de Leon, first governor of the island. The first Spanish settlers brought with them such animals as they thought to be more useful. Shortly after the discovery of the Western Hemisphere, the introduction of cattle continued and most of them came from the same communities in Spain. However, little in detail is known about these animals except that most of the cattle in Puerto Rico are descended stock of these early introductions. Aside from other importations of improved cattle to the island and the introduction of the Brahman strain from Texas to increase the size and better the working qualities of the native

EXPLANATION OF PLATE III

- Fig. 1. A herd of cattle on a ranch north of "Central Aguirre". Most of the animals have some Zebu or Brahman blood. In this way the size of the native cattle is increased (30), p. 158.
- Fig. 2. Plowing land for sugarcane with oxen. Note how the yokes are attached to the animal's poll and forehead. Most of these animals have been improved by crossing them with Brahmans brought from Texas (30), p. 74.
- Fig. 3. A pasture heavily infested with cattle ticks, Margaropus annulatus. The variety of grass, called guinea grass, is the most common in the island (30), p. 74.

PLATE III



Fig. 1



Fig. 2



Fig. 3

strains, no further attempt was made to improve the local strains during the period Puerto Rico was under Spanish rule (30), p. 153.

In Puerto Rico, cattle by far constitute the most important kind of livestock raised. During the years between 1877 and 1905, from 10,400 to 17,297 head of livestock were exported. Most of them were cattle, but since 1906 very few have been exported. The increasing demand for cattle, owing to the expansion of the sugarcane industry which required more work oxen, the increasing population which needed the beef animals formerly exported, the decreasing number of cattle produced because hundreds of acres of level fertile land formerly cattle ranches have been converted into sugarcane fields, are the chief reasons why cattle have not been exported any more (30), p. 155.

The oxen used for the work on most farms have been selected for draft purposes for such a long time that they are powerful. The predominant color is light red, although some are black and others dark red. Very few roans or spotted animals are found. Most of the cattle ranches have some Brahman and native blood. A one-third Brahman and two-thirds native blood is recommended for draft purposes by many of the progressive ranchers. These animals are kept in a fenced strip of land that supports from 1,000 to 2,000 head on approximately 3,000 to 4,000 acres of pasture land. The common practice is to put about 50 head in a 60-acre pasture for several days, then change them to another pasture. An example of this condition is shown in Fig. 1, Plate III.

However, more modern practices are executed by dairy farmers. Most of the dairy farms are concentrated near large cities where

the system of soiling crops is used and cows are kept on 30- to 40-acre farms. There are also many large combination dairy and other livestock ranches in the arid districts. On some ranches from 100 to 200 cows are milked. The range cows are milked once a day, the strictly dairy cow is milked twice a day to give about 17 quarts daily in contrast to two quarts given by range cows, but always the calves are allowed to suckle. Many of the regular dairies have very good animals and up-to-date equipment, but the cows mostly are milked by hand. Some dairy farms are neither efficiently operated nor very sanitary. The cost of milk varies from 12 to 20 cents a quart in the cities. Figure 1, Plate IV, is an example of the dairy barns near the coast, Fig. 2, Plate IV, one of the common cattle ranches in the semiarid regions.

Puerto Rico possesses a livestock wealth for food production of 2,502,388 head, of which 315,835 are cattle and calves; 375,761 are hogs, 1,751,292 are poultry and 61,500 are sheep and goats. This livestock produces yearly 39,437,410 quarts of milk; 28,261,429 pounds of meat; 50,000,000 eggs yearly (3), p. 15.

The total area of Puerto Rico is 3,423 square miles, with a population of 2,141,462 (3), p. 17. If a contrast is made between these figures, it can be concluded that the annual production of livestock is not sufficient for the supply of this enormous population.

As a direct result of the Spanish-American War, Puerto Rico was ceded to the United States in the year 1898. Shortly after the occupation of the island on November 19 of the same year, some cattle belonging to the Jersey, Guernsey, Holstein and Ayrshire

EXPLANATION OF PLATE IV

Fig. 1. An open-sided modern barn in the northern coast of the island. Most of the dairy cows kept have some Holstein blood (30), p. 44.

Fig. 2. A large cattle ranch in the arid southwest section near "Faro Cabo Rojo". The cows are milked once a day and also suckled by the calves. About one gallon of milk is obtained from each cow. The feed consists of guinea grass and a few other grasses (30), p. 45.

PLATE IV



Fig. 1



Fig. 2

breeds were introduced into Puerto Rico. At first, small numbers of animals of the above-mentioned breeds were brought but, since 15 to 20 years ago, the importation of larger numbers has increased with the attempt to improve the native dairy strains. With the great increase in demand for milk and meat during the last 20 years, the problem of cattle is still puzzling farmers because of the inadequacy to exploit economically either the native or imported strains as it should be done. Under such circumstances farmers thought the condition could be solved by the continual introduction of these purebred animals. Many thought it illogical to undergo all the troubles of improving the existing strains by means of crossbreeding.

Even though the introduction of several superior dairy breeds has increased and crosses with native dairy stock show some improvement in appearance and production, the island still must continue to face the problematical status of the cattle in Puerto Rico. This is to select the dairy and beef breeds to continue a well-planned importation on a larger scale. Yet, no records have been kept or observations reported of the performance of these imported dairy strains, but only individual efforts of dairymen to raise better stock to obtain more profits. There has always been a demand for young improved breeding stock, but this does not necessarily mean or prove that so far any of the ready-made imported breeds may solve the problems of all cattlemen. It is generally recognized that the variability of these animals is slight in regard to their type, but a lack of vigor is very commonly observed in them, which is not so marked in their imported dams. This lack

of vigor of the youngs as compared to their imported parents has been traceable to the inadaptability of the latter to the climatic conditions of the island. One classical example which is worth while mentioning is that of the Dutch-Friesian breed introduced into East Africa. The idea was to improve the size and quality of native cattle, but it was found that, although the imported European stock retained their size and general qualities, the young calves born in East Africa never grew to a good size, and at an early age showed the same general lack of quality of the native young calves. Thus oversight of the fact that the European breed was not adapted to the climate led to this failure (13), p. 39. Yet it has been very unfortunate that the dairy farmers in Puerto Rico have followed the example set by some importers who unwisely started to bring animals in large numbers without taking the simple precaution of first trying out a small representative group and actually rearing their youngs under Puerto Rican conditions. The failure to observe this precaution has resulted in serious economical losses to many dairymen in the island.

Definition of Crossbreeding

Cattle breeders practice certain systems of matings, which when understood and applied properly will shorten the time required to effect improvement of their animals. These systems of breeding may be divided into two major groups: first, those matings between related animals; second, those matings between unrelated animals. There are two main categories in which these two groups may be further subdivided: they are inbreeding under the

first, and outbreeding under the latter. Inbreeding itself consists of two different types but closely associated; the first is closebreeding and the second linebreeding. As to outbreeding, there are other different types considered. Under this category, they are mainly outcrossing, grading and crossbreeding.

The following description shows the relationship of crossbreeding to the different methods of matings.

Related Animals-- Inbreeding	{	{ Closebreeding	{ Sire to daughter { Son to dam { Full brother to full sister	
		{	{ Linebreeding	{ Half brother and sister { or matings of animals { more distantly related
	Unrelated Animals-- Outbreeding	{	{ Outcrossing	{ Purebreds of same breed { but of different strains
{			{ Purebred sire with { grade cow of same breed { or with a scrub cow	
{ Crossbreeding			{ Sire and dam of two { purebred breeds	

New breeds may be created when it is necessary by combining the characters of different breeds through the system of crossbreeding followed by selection and inbreeding; even animals of a different breed with undesirable economical disadvantages can be improved. In the course of this study we will refer to crossbreeding in the strict sense of mating of purebred animals belonging to different breeds and in some cases to the mating of purebred sires of one breed with native scrub cows of Puerto Rico. It is of some significance to clear out these points, because seldom, in a sense, has outcrossing, grading and hybridization been called crossbreeding.

CROSSBREEDING IN THE UNITED STATES

The systematic crossing of breeds has been much more prevalent in many of the European countries than in America. In the year 1939 90 percent of Great Britain's commercial livestock was produced by the intensive use of crossbreeding. It is of general knowledge that many, perhaps most of the existing breeds, were developed from crossbred foundations. Yet if one considers the precarious mode of life the European people are experiencing, a shortage of animal food is detected at first sight. Since during the war years an almost complete destruction of cattle resulted, obviously new breeds will continue to be produced. For many years experiments designed to test the merits of crossbreeding have been instigated, but frequently were on a small scale and poorly planned; nevertheless, if it were possible to take them collectively, they could yield valuable information. At all events, there are indications that this sort of breeding of beef cattle is increasing in the United States, but when referring to the dairy type it has not been so popular as in other classes of livestock. Unfortunately, there were no experimental data available regarding the merits of crossbreeding with the dairy type until recently. One of the main reasons why crossing dairy breeds has not proved popular is the difficulty of maintaining a uniform herd; besides, the present dairy herds in the United States seem to meet the requirements to a large extent (13), p. 168.

Undoubtedly crossbreeding is the chief source of variation; that is what makes it so useful as a means of starting a program of cattle improvement. Another cause of variation consists of inher-

ited differences which originate spontaneously, often called mutations, but unlike the variations motivated by crossbreeding they are not due to the recombination of genes, and have not played an important part in the formation and domestication of animal breeds. This is the fundamental reason why the discussion will deal more with those variations produced by crossbreeding. However, taking everything into consideration, it is very probable that animal breeders are almost never concerned with mutations. Frequently the statement that existing breeds of cattle are relatively stable units when protected from crossbreeding comes to the minds of breeders. This as a whole is very true, but still there are many breeds which cannot be considered pure for all the characters, even though they have been selected and bred for that purpose for many years. The probable reason for it is that the animals have not attained the degree of purity because of the use of conventional methods of breeding and the constant changes of opinion as to what is the ideal type of animal to breed for.

At this moment careful thought on the problem of uniformity should be given, because of its relation to any experimentation dealing with the crossing of breeds. It is clearly understood that it is much easier to get maximum profits from a group of cows that react in the same way under the same conditions, than to work with a group of cows that have to be fed and treated in a different way. This is the main reason why the use of crossbreeding and its actual experimentation have been hindered for so long a time. However, this conclusion does not mean that crossbreeding is always harmful. There is definite proof at present which points to

the fact that under adverse conditions of environment crossbreeding has been very useful. Still, actual experimentation tends to demonstrate that there is a possibility for breeders to take advantage of the variations caused by this method of cattle breeding from a commercial standpoint. Moreover, more specifically, in a country like Puerto Rico there exists an immediate need of the development of cattle. Variations are necessary if the goal is to be achieved. However, at this stage in which crosses of different breeds break the uniformity that characterizes the different breeds to obtain an individual which fills the ideal, it would be necessary to fix these desirable characteristics. It is claimed by some authorities in the particular field that it is almost impossible to stop at a desirable stage in the process; but there are several ways thought to be of some help in checking this difficulty. They are mainly selection in every crossbred generation of those animals that suit the ideals combined with a modified backcrossing to make the future generations more uniform.

Previous experiences obtained in beef cattle raising show that even in the United States breeding is sectional; more emphasis is given to the uniformity than to the external features of an animal in one section rather than to the constitution characteristic of other sections. When two different breeds are crossed the product of these matings are termed first-generation hybrids or crossbreds. It is generally granted that crossbreds may possess certain advantages over purebred beef animals. This is especially true where great uniformity is desired, for it is a general rule that crossbred groups of animals are more uniform

than purebred lots. Yet, purebred animals are often impure for some valuable characters, as already stated in this study. This condition may be due to these impure characters because they are imparted to one-half the offspring. Occasionally, these individuals which are said to be impure are mated, producing 25 percent of their offspring in which the character in question is lacking and hence there is variation. The impurities referred to are very difficult to eradicate from a breed. The example previously mentioned is an instance where the use of crossbreeding would produce uniformity in the first generation crossbreds, providing there is a correction by one parent of the causes of variability due to the other parent. This is the chief reason for the uniformity in lots of first-generation crossbreds and why among the beef breeds some combinations have an excellent reputation.

Hammond (11), p. 160, reported that the crossbreds between Shorthorn bulls and polled Angus have a peculiar color, caused by the combination of the roaning factor from the Shorthorn with the black coat color of the Angus. The coat color of the crossbreds serves as a trade-mark for the calves, thought to be of excellent quality for fattening. However, the subject of uniformity seems to work quite different as to the external features of an animal of the dairy type when dealing with crosses of the types mentioned.

Not until recently has the topic been clarified. Actual experimentation manifests that the production of crossbred cows significantly increases and no variation is noted between individuals, as was thought, when the foundation animals are properly selected.

One of the characteristics often displayed by first-generation hybrids from the crossing of two different pure strains is hybrid vigor or heterosis. Part of the increased yield of the crossbreds is due to this factor. The exact cause of this phenomenon is still questioned, although some investigators have attempted to give an acceptable explanation of it.

A superficial explanation is that vigor is dominant to lack of vigor, individual animals differ in certain factors which contribute to vigor. Another theory rests on the assumption that hybrid vigor is not to be explained as a mere summation of the factors contained in the two gametes, but that the hybrid state itself is a source of metabolic energy in the zygote. The most acceptable of all the theories is that hybrids are quite heterozygous; this in itself is the cause of vigor. Thus far, no strains that are homozygous and, in addition with vigor, have been produced from the descendants of the crossbreds equal to the hybrids. Other investigators think that heterosis may be due to the fact that all breeds or varieties carry in the germ plasm along with their desirable genes some inhibiting genes, and that in crossbreeding the inhibiting genes in each species or breed are neutralized by genes from the other species or breeds (32), p. 122.

It can be noticed that controversial differences of opinion exist as to the real cause of heterosis. However, the real truth is that the results of crossbreeding rather than the cause of it are of more interest to the farmer.

Crossbreeding Work Under Way
in the United States

Early in this report it was said that crossbreeding is an expensive way of improving dairy cattle. This task has been undertaken by the Bureau of Dairy Industry of the U. S. D. A. Actually, three different experiments are running in the Department Experiment Station. They are: First, the crossing of dairy breeds; second, the crossing of beef breeds, using Brahman strains; and third, the Jersey-Brahman crossbreeding project.

Dairy Breeds. Dairymen in the United States have long been interested in the probable results of crossing breeds of dairy cattle. This interest has been stimulated in recent years by the spectacular success of plant breeders with hybrid corn and by the favorable results obtained in the crossing of poultry, swine and beef cattle.

In order to explore the field of crossbreeding dairy cattle and to develop useful information, the Bureau of Dairy Industry set up a crossbreeding experiment at the agricultural research center, Beltsville, Maryland, early in 1939. In this experiment the foundation stock, both bulls and cows, was capable of high production or was able to transmit high production to its offspring and meet the high performance requirements. Another highly important feature of the plan was the continuous introduction of blood of different breeds into the succession of offspring by the use of sires of breeds other than that represented by the dam and with no culling of individuals.

Four dairy breeds were included in the experiment: Holsteins,

EXPLANATION OF PLATE V

- Fig. 1. Jersey bull No. 1114, proved and with excellent records. His daughters outdid their respective dams in milk and butterfat production (6), p. 177.
- Fig. 2. Holstein sire No. 966 was bred at Beltsville and proved in cooperating herd before he was used in crossbreeding. Thirty-one of his daughters, milked three times daily for 305 days, had an average mature equivalent of 18,416 pounds of milk and 645 pounds of butterfat, compared to an average of 17,772 pounds of milk and 619 pounds of butterfat for their dams. This sire also proved to be heterozygous for color and had sired several red and white calves (6), p. 177.
- Fig. 3. Red Dane No. 501 had been proved with a record of adding 1,139 pounds of milk and 45 pounds of butterfat of his daughters as compared to that of their dams (6), p. 177.

PLATE V



Fig. 1



Fig. 2



Fig. 3

Red Danes, Jerseys and Guernseys. The bulls used in the tests were exceptionally good. Holstein sire No. 966 was a Beltsville-bred bull and was proved on Holstein cows. His daughters averaged 18,416 pounds of milk and 645 pounds of butterfat. Their dams averaged 17,772 pounds of milk and 619 of butterfat on a mature-equivalent basis. The Red Dane sire, No. D-501, had been proved with a record adding 1,139 pounds of milk and 45 pounds of butterfat of his daughters as compared to that of their dams. The Jersey sires were also proved and had excellent records. No proved Guernsey bull was available. The foundation females were not the best in their breeds but were somewhat above the average. (Refer to Figs. 1, 2 and 3, Plate V.)

The first crop of heifer calves were two-breed crosses: Jersey-Guernsey, Holstein-Guernsey, Holstein-Red Dane, Red Dane-Holstein, Red Dane-Jersey and Red Dane-Guernsey. In these crosses the first-mentioned breed in such crosses indicates the sire. During the test all females were weighed and measured periodically. Their producing ability was determined by their first lactation period under uniform environmental conditions (6), p. 178.

The only results presented so far are the production records of the animals that have completed one lactation period. Table A, Plate X, gives the milk and butterfat production records of the various two-breed combinations. The breed of the sire is listed first for convenience.

The average record of 32 females is 12,842 pounds of milk and 592 pounds of butterfat, with an average test of 4.64 percent. The average age at calving was 2 years, 2 months. The extremes in

EXPLANATION OF PLATE VI

Fig. 1. Some of the crossbred cows from Jersey sire No. 1114 and Holstein dams. From left to right: x-41, x-42, x-47. Refer to Table A for their records of production (6), p. 177.

Fig. 2. Some of the crossbred cows from Holstein sire No. 966 and Jersey dams. From left to right: x-11, x-20, x-38, x-5. Refer to Table A for their records of production (6), p. 177.

Fig. 3. Some of the crossbred cows from Holstein sire No. 966 and Guernsey dams. From left to right: x-16, x-33, x-44, x-45. Refer to Table A for their records of production (6), p. 177.

PLATE VI



Fig. 1



Fig. 2



Fig. 3

EXPLANATION OF PLATE VII

Four Outstanding Top Crossbred Cows
Cow No. (5), p. 34

Fig. 1. Left (above). Refer to Table A.

Fig. 2. Left (bottom). Refer to Table A.

Fig. 3. Right (above). Refer to Table A.

Fig. 4. Right (bottom). Refer to Table C.

TABLE VII



Fig. 1



Fig. 3



Fig. 2



Fig. 4

EXPLANATION OF PLATE VIII

Fig. 1. Some of the crossbred cows from Red Dane sire No. D-501 and Guernsey dams. From left to right: x-21, x-52, x-53, x-61. Refer to Table A for their records of production (6), p. 177.

Fig. 2. Some of the crossbred cows from Red Dane sire No. D-501 and Holstein dams. From left to right: x-22, x-56, x-58, x-63. Refer to Table A for their records of production (6), p. 177.

Fig. 3. Some of the crossbred cows from Red Dane sire No. D-501 and Jersey dams. From left to right: x-10, x-18, x-29, x-70. Refer to Table A for their records of production (6), p. 177.



Fig. 1



Fig. 2



Fig. 3

milk production are 9,784 pounds for x-1 up to 16,949 pounds for x-22. In butterfat production the lowest is 449 pounds for x-46 and the highest 683 for x-16. This variation is not unusual for heifers of a single breed sired by one bull. It can be noticed in Table A that not a single individual in the lot is a poor producer. Compared with their own dams, the great majority of these 32 crossbred heifers are better producers. It is thought that the actual increase turned out to be approximately 20 percent more than the estimated increase. This may be the result of heterosis (6), p. 184.

Granted that the first crosses of two breeds may result in good-producing individuals, the question arises as to what would happen if the crossbreds were intermated. For the time being the plan is to mate the two-breed females to a proved sire of a third breed. Some three-breed resulting females have come into production and are listed in Table C, Plate X. So far, their average is 14,837 pounds of milk and 645 pounds of butterfat, with an average test of 4.39 percent. However, these results cannot be considered conclusive. Some other two-breed and three-breed crossbreds are included in the tables (35), p. 102.

Some intermating of crossbreds is now being done in a limited way in order to check on the transmitting ability of the males bred like the females listed above. Although a few cases prove nothing, it seems that the inheritance for milk and butterfat production should be the same in these males as has been demonstrated by the females of similar breeding (35), p. 103.

One of the striking characteristics shown by all of these

crossbreds is their persistency in milk production. The monthly butterfat production varies less than 10 pounds from the high to the low month, and is thought to be one of the factors which adds to the production of the proved sires used. A summary of the first 32 two-breed crossbreds and the first 5 three-breed crossbreds shows an average of 13,095 pounds of milk and 599 pounds of butterfat, with an average of 4.62 percent at the age of 2 years and 2 months (35), p. 57.

The results obtained so far in this experiment definitely indicate that a proved sire has a fine opportunity to demonstrate the power of his genes in crossbreeding. Holstein sire No. 966 proof on his own breed was good enough when an increase of 881 pounds of milk and 43 pounds of butterfat were obtained. Yet, the proof on his first 10 daughters by dams of other breeds was considerably better: 5,274 pounds of milk and 220 pounds of butterfat over their dams. Red Dane No. D-501 plussed his daughters from Red Dane dams with 1,139 pounds of milk and 45 pounds of butterfat, but when used on other breeds the resulting daughters were better than their dams by 5,374 pounds of milk and 193 pounds of butterfat (35), p. 116.

The evidence reiterates the fact that the use of production-tested and progeny-tested animals are the bases of good breeding. It is further indication of the need for progeny-testing purebred dairy sires so that purchasers of such sires will have some production assurance as well as assurance of purity of lineage.

Commercially the possibility of this type of crossbreeding adds new emphasis to the production of proved sires as the force

EXPLANATION OF PLATE IX

- Fig. 1. x-53, an animal considered a good example of a crossbred or hybrid. Refer to Table A for her record of production (6), p. 177.
- Fig. 2. x-50, a great three-breed-combination crossbred cow. Refer to Table B for her record of production. Her dam x-7, refer to Table A for her record of production (35), p. 56.
- Fig. 3. One of the crossbred cows which the U. S. D. A. has loaned to a commercial dairy farm. The manager, Paul B. Strickler, says, "If a bull has a group of daughters producing more than their dams, that's all I need to know." (35), p. 58.

PLATE IX



Fig. 1



Fig. 2



Fig. 3

that keeps the system of breeding going because they are as essential to it as the purebred inbred strains are to the production of hybrid corn. Therefore, it can be said that similar results may be expected only when proved stock is used in making the crosses. This type of crossbreeding holds possibilities, too, for expanding the usefulness of registered cattle. As indicated, the method calls for the use of proved sires of different breeds essential to maintain the high level of production and add hybrid vigor. The commercial application of crossbreeding awaits only the demonstration of superior ability on the part of the hybrid animal. Because many commercial dairymen do not have facilities for raising replacements, they are always in the market for surplus dairy cows and heifers from the areas where conditions warrant raising extra dairy stock.

Besides, when combined with artificial insemination, the method may offer dairymen some interesting developments. Some dairymen in a position to raise replacement heifers in excess of their own needs might find that, by using various breeds of proved sires, available through artificial breeding associations, they could build a market for good crossbred calves.

It is assumed that a dairyman in a region with good pastures and an abundance of cheap home-grown roughage has followed a practice of selling about 10 or 12 extra heifers each year from a herd of milking animals. This represents the surplus females above his requirements for herd replacements. Being a member of an artificial insemination association or by other means he can order semen from proved bulls of other breeds than the one he

EXPLANATION OF PLATE X

Table A shows the production records of crossbred cows of various two-breed combinations with a completed record summary (35), p. 57.

PLATE X

PRODUCTION RECORDS OF CROSSBRED COWS OF VARIOUS
2-BREED COMBINATIONS

Cow No.	Milk		Butterfat		Age	Remarks	Sire
	Pounds	Pct.	Pounds	Y. M.	No.		
Jersey X Guernsey:							
X-13	10,653	5.27	562	2 2			1565
Jersey X Holstein:							
X-1	9,785	4.85	475	2 0			1114
X-3	13,065	4.71	615	1 11			1114
X-17	13,837	3.85	533	2 3			1102
X-32	13,728	3.94	540	1 11			1565
X-35	10,508	5.24	550	2 1	Mastitis		1114
X-41	12,453	4.63	576	2 5			Do.
X-47	12,189	5.13	625	1 8	Barn bred too early		Do.
X-42	9,417	4.90	462	3 3	2nd lactation		1114
Holstein X Jersey:							
X-5	13,032	4.62	602	2 4			966
X-11	12,584	4.82	606	2 4			Do.
X-20	12,383	5.13	636	1 11			Do.
X-30	11,867	5.60	664	2 0			Do.
X-38	11,929	5.09	607	2 1			Do.
X-40	13,690	4.74	649	2 8			Do.
X-51	13,800	4.44	613	2 5			Do.
Holstein X Guernsey:							
X-16	14,577	4.68	683	2 5			966
X-26	11,717	4.84	567	2 0			Do.
X-28	14,052	4.63	651	2 3			Do.
X-33	11,363	5.53	629	2 0			Do.
X-43	11,990	4.12	494	2 4	Mastitis		Do.
X-44	15,284	4.10	627	1 11			Do.
X-45	11,341	4.95	561	2 9			Do.
X-59	9,471	4.75	450	2 9	Incomplete 262 days		Do.
			1 more to calve				
Holstein X Red Dane:							
X-15	12,730	4.04	514	2 3			966
X-85	1,178	3.89	46	2 2	Incomplete 33 days		Do.
X-87	2,177	3.67	80	1 11	Incomplete 59 days		Do.
			3 more to calve				
Red Dane X Holstein:							
X-14	13,643	4.05	552	2 2			D-501
X-22	16,949	3.60	611	2 2			D-501
X-23	14,636	3.77	552	2 0			D-501
X-46	11,103	4.05	449	1 11	Mastitis		D-501
X-56	16,100	4.08	657	2 0			D-501
X-58	13,956	4.27	596	2 4			D-501
X-63	17,393	3.83	665	2 4			D-501
Red Dane X Jersey:							
X-7	12,228	4.80	586	2 7			D-501
X-10	12,561	5.03	631	1 11			D-501
X-18	13,315	5.06	674	2 2			D-501
X-29	12,691	4.56	579	1 11			D-501
X-70	11,579	4.47	518	1 11			D-501
Red Dane X Guernsey:							
X-21	14,614	4.12	602	2 1			D-501
X-52	14,044	4.30	603	2 2			D-501
X-53	14,055	4.79	674	1 11			D-501
X-61	12,463	4.35	542	1 11			D-501
X-73	11,292	4.19	473	2 0	Incomplete, 319 days		D-501
X-74	5,778	4.61	266	2 4	Incomplete, 174 days		D-501
			1 more to calve.				
Jersey X Red Dane:							
X-67	3,994	5.39	215	2 10	Incomplete, 116 days		1114
X-86	5,178	4.71	244	1 11	Incomplete, 152 days		1114
COMPLETED RECORD SUMMARY							
40	2-breed crosses average		12,983		4.56	588	
40	Dams average		10,673		4.60	460	
	Difference		+2,310		-.04	+128	
	Number better than dams		31		18	36	

Table A

EXPLANATION OF PLATE X (cont.)

Table B shows the results up to now in the crossbred dairy cattle experiments undertaken by the U. S. D. A. (35), p. 59.

Table C shows the production records of crossbred three-breed-combination cows (35), p. 58.

PLATE X (cont.)

RESULTS OF UP TO NOW IN THE CROSS-BRED CATTLE EXPERIMENT

GROUPS	AVERAGE FOR 365 MILKING DAYS		
	POUNDS OF BUTTERFAT	POUNDS OF MILK	PER CENT OF BUTTERFAT
Group No. 1 (Foundation Cows) Purebred cows (Holstein, Jersey and Guernsey)	477	11,119	4.37
GROUP No. 2 First Cross (Group No. 1 cows crossed with purebred bulls of breed other than own)	508	12,983	4.56
GROUP No. 3 Second Cross (Group No. 2 cows crossed with purebred bulls)	650	14,953	4.37

PRODUCTION RECORDS OF CROSSBRED 3-BREED COMBINATION COWS							
Cow No.	Breed Combination and number of dam	Actual Production			Age	Remarks	Sire No.
		Milk		Butterfat			
		Pounds	Pct.	Pounds			
Sired by Holstein Bulls:							
X-50	RD X J (X-7)	16,186	3.97	643	1 11		966
X-57	RD X J (X-18)	3,320	5.33	177	3 8	Incomplete, 65 days	966
X-62	RD X J (X-29)	16,862	3.92	661	1 11		966
X-69	RD-J X H (X-39)	13,954	4.27	596	2 1	Incomplete, 336 days	966
X-78	RD X G (X-21)	3,951	4.41	174	2 5	Incomplete, 114 days	966
X-82	RD X J (X-10)	2,032	4.60	94	2 6	Incomplete, 43 days	966
X-88	J-RD X H (X-48)	1,993	4.64	92	2 3	Incomplete, 43 days	966
X-90	RD X J (X-18)	3,113	4.92	153	2 0	Incomplete, 91 days	966
11 more to calve.							
Sired by Red Dane Bulls:							
X-39	J X H (X-3)	13,992	4.35	609	1 11		D-501
X-54	J X H (X-17)	16,500	4.16	686	1 11		D-501
X-55	H X G (X-16)	15,284	4.47	684	2 1		D-501
X-60	H X G (X-26)	15,036	3.98	598	1 11		D-501
X-65	H X J (X-5)	12,896	4.67	602	1 11		D-501
X-66	H X G (X-28)	16,029	4.45	714	1 11		D-501
X-68	J X H (X-35)	10,545	5.09	537	2 3	Incomplete, 300 days	D-501
X-71	H X J (X-38)	11,926	4.62	552	2 0	Incomplete, 331 days	D-501
X-75	H X J (X-20)	9,864	5.19	512	1 11	Incomplete, 305 days	D-501
X-79	J X H (X-17)	2,675	5.02	134	2 5	Incomplete, 93 days	D-501
15 more to calve.							
Sired by Jersey Bulls:							
X-48	RD X H (X-14)	12,668	5.07	643	2 0		1114
X-77	H X RD (X-15)	9,259	4.24	418	2 0	Incomplete, 287 days	1114
X-81	RD X H (X-23)	8,667	4.83	418	1 11	Incomplete, 275 days	1114
X-83	RD X H (X-22)	7,451	4.88	364	2 0	Incomplete, 216 days	1114
X-89	RD X H-H X J (X-49)	3,837	5.37	206	1 11	Incomplete, 138 days	1114
6 more to calve.							
Sired by Red Dane X Holstein Bull:							
X-49	H X J	14,082	4.68	658	2 0		X120
1 more to calve.							
Sired by Red Dane-Jersey X Holstein Bull:							
3 daughters of X-179 to calve.							
Sired by Red-Holstein X Guernsey Bull:							
9 daughters of X-191 to calve.							
COMPLETED RECORD SUMMARY							
10	3-Breed Crosses average			14,953	4.37	650	
10	2-Breed Danis average			13,143	4.56	597	
	Difference			1,810	.19	+ 53	
	Number daughters better than dams			8	3	9	

Table C

owns, to impregnate 20 to 25 cows in his herd. The resulting crossbred calves can be sold as surplus, and it is when the market appreciates the value of well-bred crossbred heifers that they should bring a premium price and will cost no more to raise than straight-bred heifers (35), p. 118.

This type of rotation breeding may also appeal to the man who has spent many years in building up a good-producing grade herd only to find that he is barred by the closed herd book from ever having any of his good cows registered. It is by crossbreeding that he can raise the level of production in his grade herd, and the value of his surplus cows when sold for commercial dairy purposes should be increased correspondingly. Nevertheless, to the average dairyman, crossbreeding may provide a greater incentive through larger and quicker results, for the use of proved sires. It should point the way to cows that are able to raise our now almost stationary levels of output for the average dairy cow.

Beef Breeds. Another crossbreeding experiment undertaken by the U. S. D. A. is at the Iberia Livestock Experiment Farm near Jeanerette, Louisiana. Crossing of breeds for the production of market animals has been practiced in the United States for many years. By this method of breeding beef cattle, the producers have taken advantage of the increased productivity or heterosis that frequently results from the crossing of distinct types and breeds.

Many breeds of cattle have been developed in this fashion, which are thought to vary widely in their traits and adaptability.

However, circumstances arise in which no one breed meets all the requirements satisfactorily and man is not satisfied. Under such circumstances the crossing of breeds may be desirable. At this station the United States government officials are establishing and testing new lines of cattle containing varying amounts of Zebu and Aberdeen-Angus blood. The object is to develop a type of beef cattle that can perform satisfactorily under the subtropical conditions along the Gulf of Mexico. It seems that this task has not been undertaken lightly because persons engaged in the experiment think that for the conditions prevalent there is a definite need for a new type. Besides the facilities available make possible the handling of a large number of animals, making possible to continue the project for many years with the aim of establishing the new type accordingly.

The beef breeds being used so far belong to the Hereford, Aberdeen-Angus and Brahman strains imported from India. The best results were obtained when Hereford sires were mated to native or graded Hereford females and then the first-generation hybrid females were mated to the Brahman bulls. After these two matings, Hereford sires were mated to the second-generation crossbred females to give the animals five-eighths to six-eighths of the Hereford blood and one-eighth to one-fourth of the Brahman blood.

Other crosses were made by using as foundation stock the Aberdeen-Angus females. They were sired by Brahman bulls. The first-generation crossbred females then were mated to Aberdeen-Angus bulls to secure a crossbred with three-fourths Aberdeen-Angus blood and one-fourth Brahman blood.

EXPLANATION OF PLATE XI

- Fig. 1. The half-blood cross, Angus and Brahman from the Norris Ranch, weighs 1040 pounds, and is 19 months old. The Brahman steer weighs 1300 pounds, and is 20 months old (35), p. 52.
- Fig. 2. The Beefmaster is one of the two fixed crosses bred in Texas, the other being the Santa Gertrudis. These Beefmaster calves average $7\frac{1}{2}$ months old and 564 pounds (35), p. 52.
- Fig. 3. A product of crossing Aberdeen-Angus with Brahman. This is Essar 314, three-fourths Angus and one-fourth Brahman. He was bred on the Essar Ranch, San Antonio, Texas. At 30 months he weighs 1650 pounds, and has Angus beef conformation (35), p. 48.

PLATE XI



Fig. 1



Fig. 2



Fig. 3

Another peculiar crossbred animal obtained was one with three-eighths Brahman blood and five-eighths Aberdeen-Angus blood. Similar results were obtained when second-generation crossbred females with one-fourth Brahman blood and three-fourths Aberdeen-Angus blood were mated to bulls with one-half Brahman blood and one-half Aberdeen-Angus blood (2), p. 33, 60.

Results showed that when the average afternoon temperature was 93.2° F. and the relative humidity 71.7 percent, the Brahman strains had an average heat tolerance of 89, the Brahman-Angus crossbred 84, and the Aberdeen-Angus 59 with respect to the abilities of the three types to maintain a normal body temperature of 101° F. Refer to Fig. 2, Plate I. The cause attributed to this variation was that the Zebu or Brahman cattle possess some ability to sweat, offer more surface per unit of body weight and some other basic physiological differences.

In general it can be said that with the establishment of well-regulated breeding methods, the production of a more uniform breeder-stock has resulted. Productivity of cattle in the Southern ranges may be improved by taking advantage of the hybrid vigor that usually results from crossbreeding. In this sense Southern breeders are in an advantageous position because two or more beef breeds adapted to the conditions have been created (20), p. 66. Refer to Figs. 1, 2 and 3, Plate XI.

Another important experiment is being conducted in the U. S. Range Livestock Experiment Station at Miles City, Montana. The purpose is to develop superior strains of purebred Hereford animals by selection of the sires on the results of progeny tests.

Also they will serve as bases for comparison to the crossbreds. These crossbreds will be obtained through continual crossing to maintain heterosis. The first cross was made by mating Shorthorn sires to Hereford females. The first-generation hybrid females in turn were mated to Aberdeen-Angus bulls. Significant results were obtained. The first-generation crossbreds (σ^7 Shorthorn x $\frac{0}{+}$ Hereford) gained more rapidly in the feed, were heavier at the time of marketing, the dressing percentage was higher, and they had fewer digestive disorders when compared to the purebreds. However, the efficiency of gain, slaughter grade and carcass grade were not significantly different.

In the case of the triple-crossbreds (σ^7 Aberdeen-Angus x a $\frac{0}{+}$ Shorthorn-Hereford) the steers weighed more at weaning time and at the end of the feeding period. They were also sold for more per pound, they had a higher dressing percentage, returned much more per head above the feed and their marketing cost than the Hereford steers. It was found, too, that they compared more favorably than the first-cross steers. This tends to prove that when maintaining heterosis in a breeding program of this sort when using good foundation stock to begin with similar results should be expected. However, management of the animals at breeding time and a careful record keeping take considerable time of the breeder in the case of the triple-crosses (20), p. 66.

Brahman-Jersey Project. At present the U. S. D. A. is running an experiment, the so-called Brahman-Jersey Project. Its primary object is to determine the possibility of combining the Brahman resistance to insect pest, heat and droughts of the trop-

ical regions of the south with animals of the Jersey breed. They have imported an improved dairy Indian strain to make the crosses. Figure 3, Plate XII, shows animals of this type. Because the Jersey breed seems to be more tolerant to the conditions prevalent in the Gulf Coast States, it has been selected for this project; that way the investigators are more certain of the improvement expected. Very little has been published about this project since it was recently started, but it can be said that dairy farmers will be benefited when meaningful results are obtained because, although they have been practicing this program for some years, no records have been kept or observations reported as to the qualities of the crossbreds. Still it has not been determined what percent of the Zebu blood is the most desirable when dealing with Brahman and Jersey crosses in this particular region.

The U. S. D. A. as in the other cases cited is trying to solve most of the problems encountered by dairymen of the Southern states. The South, especially Florida with its tremendous tourist population, needs a dairy cow that will do well in that climate. Since they have licked the tick in Florida, Guernseys and Jerseys are not faring so badly, but even at that their production is way below that of the Northern states because the humidity and heat are the limiting factors in their performance. It is expected that when Jersey cows are mated to Brahman bulls the crossbred will outweigh them before they are a year old.

The quick growth of the Brahman calves is believed to be largely due to the fact that Brahmans are able to maintain a normal milk supply and of a higher test under conditions of climate

EXPLANATION OF PLATE XII

- Fig. 1. Against a backdrop of moss-hung Florida trees this Brahman bull appears to be a survival from the primeval world. Brahmans like this graze contentedly in the tropical sun (35), p. 45.
- Fig. 2. A Brahman calf is smaller at birth than any beef breed but the seven percent milk of his mother boosts him ahead at six weeks and from then until he is weaned he gains steadily on the British breeds. He will average 500 pounds at five months (35), p. 49.
- Fig. 3. The importation of the red Sindhi dairy cattle marks the start of U. S. D. A. experiments to develop a dairy cow for the deep South. Dr. O. E. Reed, department chief of the B. D. I. (35), p. 52.

PLATE XII



Fig. 1



Fig. 2



Fig. 3

that hinder other breeds of cattle. Refer to Figs. 1 and 2, Plate XII.

The recent importation of four red Sindhi cattle, two bulls and two heifers, from Guam to the Beltsville, Maryland, experiment station marks the beginning of a program to develop better dairy cattle for the South. These are relatively small Zebu-type animals with an average production of 2,500 pounds of milk in 300 days. Sufficient proof has been obtained that when these cattle are crossed with Jersey sires an appreciable increase in milk production is characteristic of the crossbreds. However, many breeders are skeptical about the Brahman as a dairy animal and they think that they are strictly a beef type, but other breeders believe and have found that crossing with Brahmans makes a large cow, good for either beef or milk, and that they give as much milk as a Jersey, maybe a little more for a while, but they do not stay in milk as long.

Significance of Results to the Study

The problem of cattle improvement in Puerto Rico because of the interest put on by the government recently, is gaining momentum so far as its solution is concerned. These previous experiments have been mentioned in the course of this report because actually they are thought to be the cornerstone in establishing a sound breeding program adapted to the conditions of the island. Yet, under the conditions of almost an absolute lack of experimental work in the field of cattle breeding in Puerto Rico, it seems that a discussion of this problem, regardless of its specific na-

ture, could not be done without apparently making reference to similar basic problems under way in the United States to solve definitely the effects of crossbreeding in beef and in dairy cattle.

The trend of thought concerning crossbreeding based upon experimental results so far obtained is directed toward considering it as potentially sound, but nevertheless entailing risks of being harmful if carried out haphazardly without proper guidance. The chief purpose of these experiments is to furnish some lead or guidance, to furnish the proper pattern for this type of breeding of which the cattle industry in Puerto Rico could take advantage.

The status of the commercial breeder in the United States is quite similar in its beginning to the problem subject to be discussed. Because the number of purebred sires imported to Puerto Rico is very small, probably the dairy farmers should organize artificial breeding associations with the cooperation of the government, the only one that could supply the best proved bulls available in the island. From the standpoint of the farmer in Puerto Rico the color of his cows is not as important as to how well the herd produces and its persistence. It would be presumptuous to attempt to discuss this problem at any appreciable length; the following is merely intended to give some fundamental facts which will unquestionably shed considerable light on the problem which is the immediate concern of this report.

It is a well-recognized fact that several pages could be filled with staggering information which has been brought forth as evidence of the irreparable damage brought about by the re-

sults of planless introduction of animals without being first tested under the environmental conditions in Puerto Rico.

CROSSBREEDING IN PUERTO RICO

Since the importation of the northern breeds into the island of Puerto Rico, the commonest method of improving the quality and production of the native dairy strains has been actually the crossing of the imported breeds with them until the animals resemble to some extent the purebred imported strains. The economical advantages possessed by these introduced strains over the existing native strains have been the chief reason to bring about some improvement, but it is clearly understood that our cattle cannot be substituted in all the regions of the island for purebreds due to the fact that the level of animal nutrition varies within districts. Purebreds are not able to subsist under this inadequate level of nutrition. Although the results obtained by individual farmers have not been so promising as it was expected, the introduction of these animals has continued but in small numbers.

The initial high cost of purebred animals has always been a limiting factor when the introduction of a large number of animals is attempted. Furthermore, most of the dairy breeds suffer too much from water transportation. Until recently air transportation had not been resorted to. One outstanding advantage of air over water transportation is the prevention of diseases that is made possible by considerable reduction of the transit time. However, air transportation entails considerably higher costs. Transport

EXPLANATION OF PLATE XIII

Fig. 1. Bulls and heifers of the Ayrshire breed being loaded into the DC-e plane for a long trip to San Juan, P. R., and to other South American countries (5), p. 34.

Fig. 2. Securely stanchioned and racked, these Ayrshires are ready for the take-off to San Juan, P. R., and other South American countries (5), p. 34.

PLATE XIII



Fig. 1



Fig. 2

planes have to be especially converted for this purpose and consequently the rates charged are much higher. Plate XIII shows the conditions under which the animals should be handled in order for them to arrive at their destination in good physical condition.

Another important factor that militates against substitution of the native strains by purebred cattle is the fact that sexual reproduction of cattle as of other large animals is too slow a process, requiring an initially large number of animals used over a considerably long period of time in order to be effective along that line.

The above-mentioned factors have forced farmers to resort to crossbreeding by using a small number of imported purebred sires to improve the native strains. This practice has been carried on to a limited extent since the beginning of the century and to a large extent during the last 15 years. Contrary to what might have been expected, the results as a whole have not been entirely satisfactory and in some cases they have been decidedly disappointing. Failure to get the desired results seems largely to be explained in terms of one major difficulty, namely, that breeding of the animals has been carried beyond the limit that tends to detract from the beneficial effects ordinarily resulting from crossbreeding. That is to say, the usual practice has been to continuously breed the animals until the resulting offspring closely approximate the genetic make-up of the original purebred used. So the resistance gained during the early stages of crossbreeding has been invariably lost when the process of backcrossing to the purebreds has been carried beyond that certain limit. To illustrate

this case may be cited of a prominent farmer of one of the most important dairy districts in Puerto Rico who used purebred Holstein sires to improve the level of production of his herd of native cows. During the first years of his breeding program results seemed encouraging. However, over a period of several years of continuous backcrossing to the purebred Holstein sires the resulting animals began to show increasingly marked resemblance to the Holstein phenotype coupled with a correspondingly noticeable decrease in production to the extent that the latter would represent but negligible improvement over the foundation stock.

These observations point unmistakably to the fact that there is an optimum limit to the percentage of purebred blood that should be incorporated into the native foundation stock.

However, this does not mean that the Holstein breed is unsatisfactory for bringing some improvement. Most of the dairy cattle in Puerto Rico have been influenced by this excellent breed, and almost all the animals in the commercial dairies in the island are composed of purebred Holsteins or animals with a high percentage of Holstein blood. What is considered a probable solution to his problem is to stop the system of crossbreeding when a desirable hybrid has been obtained. At this moment the hybrid animals should be mated within themselves and by the use of selection, use for the following generation matings those animals that look more to the ideal. More specifically, there is desire for a dairy breed that fills these qualifications and at the same time could be raised for profit that all the animals be alike in this respect and when raised under a suitable environment will

continue to produce profit without endangering their real value. It is meant in this sense that when a certain point is reached in the improvement, probably some external qualities will be characteristic of the group, such as size, color and conformation. At this stage the real value of the group should never be lowered out of proportion in regard to the importance that can be given to those external characteristics already mentioned. Unfortunately it can not be cited in any case in which this ideal has been reached. It is much easier to judge these external characteristics than the real value. So there will be always in Puerto Rico a danger of continuing to happen, when referring to the dairy type of cattle, where the real economic value can only be judged in one of the two sexes. A proven or a purebred bull is necessary to make the female to produce other females of a high economic value, but they practically in a sense do not contribute to the economic value of the breed.

It is in this moment, when a desirable animal has been produced, that there will be a place in Puerto Rico for purebreeding of the strain and it will be of much more importance to farming as a whole because of their profits or returns, than to a few prominent breeders can get from any showing.

In Puerto Rico the relative value of milk to the urban population depends on several things. The profit from milk is much more important than that of meat. It is so because of the existing dense population and the good market for the product. Besides, there is sufficient labor and the conditions of food supply can be remedied to some extent by keeping cows to turn pas-

tures and feeds into milk more economically under a program of intensive use of the land which is not very appropriate at present for range beef cattle.

Relation Between Improved and Local Breeds in Puerto Rico

It has been discussed previously that when a problem of such magnitude is encountered which will decide the future of Puerto Rico in raising the low level of nutrition of its people. when deciding to which dairy and beef breeds the efforts should be directed for their improvement, one of the chief difficulties always lies in the circumstance that the standard of what constitutes superiority is often warped by the influence of beautiful animals without actually testing for the actual benefits derived from them under the natural conditions that are going to exist. This is a very superficial way of comparing different breeds of animals. In deciding which two different breeds or a combination of the good qualities of both, it first must be known the object or why the breed is required and actually making comparisons to determine the superiority of one over the other in the actual way they fit the environment in which they are going to live. Then, after actually determining which fits best in a given system of agriculture as a whole, or in other words which produces the maximum monetary gain it can be considered superior because it has demonstrated to fit best into a certain symbiosis-group.

The size of the animal is another important point to consider in that Puerto Rico's agriculture is characterized to be on the basis of an intensive utilization of the land.

According to the 1940 census, in Puerto Rico there were roughly 55,000 farm units and almost three-fourths of all the farms were less than 20 acres in size (3), p. 35. This means that the average farm is by all means large enough to support a small number of dairy cows of a small breed. However, one percent of the farms are large land holdings (3), p. 36. In this case usually the most popular breed has been the Holstein, thought to be one of the biggest of all breeds of dairy cattle. This is an exception, however, if the situation of the small farmer who composes most of the agrarian population is to be solved in this case a certain number of small cows will fit better to their purpose than the same number of large cows. Approximately six-tenths of the large cow number will represent 10 small cows and there will hence be sufficient reason to compare their yield favorably and of much more importance to the farmer under their critical situation of small acreage to raise their foodstuffs. It is true that in the market small cows are worth less than the same number of cows of a large breed but to the farmer with low income and poor soils it would be advantageous to possess small cows.

But when the situation of the commercial dairies near or at a considerable distance from the cities is considered, it should be concluded that to furnish an adequate supply of milk a large breed is more efficient than a small one. This is due to the fact that large cities are located in the lowland, where the soil is more fertile and a system of soiling crops has solved so far the critical situation of pastures and feed scarcities to those people engaged in dairying to supply the milk to the urban population.

These two characteristics of agriculture are a result of an overspecialized exchange economy, and due to a deficiency in the land tenure in the island of Puerto Rico. However, after the problem of deciding which animals are the best under each of these two conditions prevalent in the island, an economical way to make the progress more significant is the practice of a modified community breeding thought by prominent farmers to be advantageous in raising the level of production and in increasing the cattle population.

Constitution and Crossbreeding

It seemingly follows that dairy cattle or animals kept in Puerto Rico for the production of milk and beef are characterized by a lack of constitution and hence of a very low production characteristic of the mountainous regions with very few chances to raise an animal of superior qualities. The native cattle thus do not perform correctly or produce economically when a suitable management is provided because they lack those inherited factors that make possible the showing of an excellent inherited capacity. A crossbreeding on every occasion cited before, particularly in utilizing Brahman bulls to give constitution to the native stock in the tropics and their crossing to European breeds, has made possible the gaining of constitution due to the Brahman blood and of productivity due to the excellent qualities of the European breeds.

Therefore, to solve this difficulty in which there is a lack of constitution in the native Puerto Rican cattle, a sort of crossbreeding would be of some benefit, in producing animals that

when the conditions of environment are corrected to a certain extent could adjust to it. This way, animals could be judged for their utility and at a glance it could be determined whether or not the system of breeding is resulting in some improvement. Besides, it would be possible to consider those show points that seem to be in correlation to the possible relation of the animal's performance. The economic production is the result of many factors. They are, first, early maturity; second, good production, both quantitative and qualitative; third, economic food-consumption; and fourth, longevity. The native cow of Puerto Rico lacks all these important points; the only desirable advantage they possess is their adaptation to the region.

These reasons show exactly why crossbreeding will be or is so significant in the improvement of cattle in Puerto Rico.

The Environment in Puerto Rico and Crossbreeding

The improvement of the conditions where improved cattle are to live obviously is of paramount importance if the corresponding good results of crossbreeding are to be expected. In Puerto Rico the demand for milk and its products as for beef due to the increasing population year after year, constitutes a menace to the healthfulness of its people. Therefore, this crisis demands the creation of breeds of cattle which can solve this critical situation or at least remedy it to a large extent. It is necessary that besides the improvement of the cattle because of the benefits derived from crossbreeding, a suitable way to furnish a physical and adequate nutrition is essential to the performance of

EXPLANATION OF PLATE XIV

- Fig. 1. The agronomist, A. A. Perez, from Puerto Rico shows the abundant kernels of sorghum produced in Vieques fields. This variety, the Arizona Certified Hegari, gave the best results of 15 varieties tested. The grain is to be used in the cattle ration and the stalk as roughage (22), p. 12.
- Fig. 2. One of the stables the Puerto Rico Development Company built in Vieques, P. R., for the dairy herds. Note it is open on all sides. Columns and the floor are of concrete, the roof is covered with zinc. Stanchions are of the steel type. Thought to be the most modern in the Antilles (22), p. 20.
- Fig. 3. The experiments with "Teosinte" gave excellent results. It resists droughts well and produces about eight tons per acre. Its stalk is sweet and juicy, constituting a favorite for cattle (22), p. 17.



Fig. 1



Fig. 2



Fig. 3

new types.

Naturally the chief reason why only the poorer soils in Puerto Rico are dedicated to pastures is because the sugarcane industry is the chief source of income to the Puerto Rican farmer and the valuable land is used for its cultivation. Another factor is the small territorial extent of the island. Nevertheless, 50 percent of the pastures in Puerto Rico are improved and still a considerable amount could be improved by undertaking a reclamation project. If such animals, thought to be the results of the good application of crossbreeding, are to be obtained, pasture of a very superior quality is needed to permit the animals to produce to their maximum inherent capacity by giving them plenty of rich pastures and feed grains. Some of these aspects are shown in Plate XIV.

The latest statistics about the agriculture in Puerto Rico indicate that there exists a possibility for the expansion and increasing of land for pasturage. This means that a quick turnover of the breeds used at the moment is necessary. A more rapid-maturing animal is desirable when kept at a higher level of agriculture, than those in use at present, but this does not mean that it may be desirable in all circumstances, due to the fact that Puerto Rico has experienced long periods of droughts which have demonstrated their effect on the production of milk and meats. Under this condition a rapid-maturing animal is a great disadvantage, for when the period of starvation arrives, young animals of such breeds become stunted. It is obvious that when another period of plenty of food arrives, after their skeleton ma-

tures, they can never pick up again, but become short and stunted and probably remain so. It is unbelievable that young of excellent breeds as the Holstein is when grown under these unfavorable conditions look so different from the beautiful young when raised under native conditions. Although native cattle in Puerto Rico are low maturing, this constitutes an advantage during a period of starvation. They may stop their growth but not permanently, which enables them to continue some growth and even develop into a beautifully shaped medium animal, while European cattle under similar conditions of pasture grow up stunted and miserable-looking. However, there is a possibility of solving this natural factor by the use of silos for the storage of plant food for cattle. Already, this practice is very popular in the southern part of the island where the droughts are more frequent and severe. Farmers are satisfied with the results so far obtained and this practice will probably extend throughout the island.

Over 1,500,000 acres of land or 70 percent of the total area of Puerto Rico is classified as hills and mountainous soils which are as a rule of low productivity. This characterizes the island topography as very abrupt and of poor soils. Pasture land ranks second to sugarcane cultivation in acreage. Figure 4, Plate II, shows the relation between crop acreage. Pasture land comprises an area of 618,673 acres of which 50 percent is cultivated and improved. An additional 60,144 acres are of fallow land; 97,088 acres of idle grazing land; 150,877 acres of forest land and 200,121 acres of other land, to a certain degree can be improved by appropriate methods (3), p. 23.

It is hard to believe that large areas of tillable land should remain idle in Puerto Rico. As a direct result of the sugarcane quotas, fairly large areas of land fit for cultivation are left to fallow or in pasture on which no cattle are put to feed. This is a misuse of land, for all these areas can be used to feed a large number of animals and incidentally improved with the manure left by the latter. Late statistics tend to prove that livestock products are on the increase and that cattle can be better raised provided additional amounts of concentrated feeds besides more pasture can be supplied. In Puerto Rico, it is true that the feeding of concentrates increases abnormally the cost of production, but it pays the expenditures even where the concentrates have to be imported. The Puerto Rico Feed Company produces feed locally, but with imported raw material mostly. This makes almost impossible any competition with highly productive corporations in the United States because we can not protect our product through discriminating legislation under our present colonial regime. Nevertheless, if importations were restricted to wheat, barley and oats that we can not produce, and an increase in our production of corn, rice, cottonseed, soybeans, lima beans, peanuts, velvet beans and other foodstuffs available were initiated locally and maintained, the cost of producing them for consumption would be reduced greatly; thus a great stimulus to the cattle industry would be evident. Besides, Puerto Rico possesses a good variety of roughages with a very high yield per acre, and still more could be used or tried experimentally to determine their usefulness. As a direct result of these probable improvements in the raising of

the cattle level of nutrition a program of crossbreeding could be more significant to aid in the improvement of Puerto Rican cattle with a concurrent application of the feeding standard to increase production at a lower cost and give adequate use of our idle land.

Crossbreeding and Disease-Resistant Strains

The native cattle of Puerto Rico have been living for a long time in an environment where some diseases are prevalent; that is why they are highly resistant to them. With the introduction of the European dairy type into Puerto Rico tuberculosis became the most important disease affecting cattle in the island. It was accompanied always by a heavy infestation of ticks. At present this menace has been eradicated in almost all the cattle in the island due to effective programs put into practice by the United States agencies in Puerto Rico. However, if the problem of cattle diseases is given its real importance, observations indicate that the northern breeds of dairy cattle in the island are highly susceptible to them. Other diseases such as mastitis, trichomoniasis, and Bang's disease were introduced together with the animals imported because of the inefficient methods of quarantine used at that time, to avoid the introduction to the island of dangerous diseases to cattle like the ones mentioned. Also, it has been noticed that the improved breeds of dairy cattle in the island are likely to be infected more easily with internal and external parasites. However, in practice the native strains of cattle seem to be more resistant to them.

From the foregoing, it follows that the intercrossing of

breeds, or to practice a breeding program in which crossbreeding would play an important part, would be possible to develop cattle in Puerto Rico with an acquired immunity, highly adapted to the diet and the climate. It is thought that some of these diseases are inherited, so crossbreeding in itself is a good tool for the creation of animal strains more resistant to insect pests and parasites or other abnormal conditions. Since there exists a close relation between the natural immunity of the native strains and the food requirements, farmers in Puerto Rico have resorted to mating different breeds as the European and native cattle of Puerto Rico are.

Disease resistance falls into the same category as constitution in regard to its development. A great help to farmers in Puerto Rico has been the opportunity to use Zebu cattle in their breeding programs. These cattle have long been exposed to tick fever organisms (*Babesia Bigemnum*) and to the tick capable of transmitting it, the cattle tick (*Margaropus* or *Boophilus annulatus*). This is why Zebu cattle have acquired a high degree of resistance to it, which they are capable of transmitting to their offspring, when used to improve cattle in this respect of disease resistance. However, in large animals, the process of obtaining resistant strains by selection in an environment of disease would take too long and would be far too expensive to warrant consideration; that is why the crossing of breeds has been so useful to obtain good results more quickly. Crossbreeding makes it possible to obtain a combination of characters that may fit the environmental conditions which perhaps no single dairy breed of economical

animals could be expected to have in a poor-priced level to a good high-priced land. Crossbreeding is practiced to bridge economically the gap between these extremes by creating animals for their hardiness and suitability to the conditions of life in poor, hilly countries like Puerto Rico.

Role of the Government of Puerto Rico in the Improvement of Its Cattle

The government of Puerto Rico through its various agencies has recently launched a long-range program for the development of the island. It comprises among many other phases a program of livestock improvement with special emphasis being laid on cattle, this being the most important livestock enterprise in the island. In financing this program the government takes all the risks that the individual farmers could not afford to take.

There are two main reasons why the government shows special interest in undertaking such a program. In the first place, by this means it aims at helping farmers in getting more profitable breeding stock; secondly, it wants to exercise control over the importation of livestock with a view to preventing the introduction of undesirable types.

The major objective at present is that of increasing the level of production of milk and meats. The government has been particularly active in that phase of the program concerned with furnishing farmers with profitable breeding stock. Considerable progress has been made toward their utilization and consequently toward the improvement.

One of the governmental agencies, the Puerto Rico Development

Company, is directing all its efforts in making this a sound program. This agency was created by law 31 of 1945, with the object of starting different enterprises in the island to industrialize it. Because of these functions the company is developing types of cattle that have demonstrated their adaptability to the conditions of the island; is cultivating grains at a low cost for the establishment of new livestock industries; and is employing a new marketing system that satisfies both the producers and the consumers (33), p. 4.

To solve the cattle problem this agency is using three fundamentally different methods to obtain a good fit between the nature of the breeds and the direct environment in which they are going to live. It has selected breeds from those available in other countries and imported them; it is giving intense use to the existing breeds to make the program more economical; and it is attempting to create new breeds by a deliberate process of recombining the material present in those different breeds.

Another aspect of the program is the selection of trained investigators to carry on this breeding work. Veterinarians have been hired because of their thorough knowledge of the reproductive disorders frequently found in cattle. Besides, they could practice artificial breeding to bring a more rapid improvement. It has long been recognized that the breeding value of males in cattle is of incomparable importance. Because of this fact, not only males but the foundation stock has been selected by considering their breeding value and performance. Besides, the initial cost of a large number of animals to be used in a sort of program like

this is very high and better use could be given to the sires by a program of artificial breeding when it is practiced by skilled persons. Desirable methods of distribution of semen to places where it is needed have been established and so far these methods are working all right on an economical basis.

However, a project of this nature can not be totally successful if there is no improvement of the pastures and roughages. The native roughages to a certain extent satisfy the needs of the cattle, but they do not contain the essential factors to make a ration more cheap and balanced. Some new varieties with a higher nutritive value have been introduced and experimentally the results are promising. Some of them are the tropical Kudzu, Sudan grass, "Cuban Bahia", Australian Rhodes, soybeans and the "Teosinte". Of these the Sudan grass has demonstrated itself to be resistant to droughts, and produces approximately eight tons of roughage per acre in each cutting. The cattle prefer it; besides, an increase of milk production has been observed. The "Teosinte" also resists droughts and has demonstrated similar characteristics to Sudan grass. Australian Rhodes contains a high percent of protein and is capable of resisting droughts. It is preferred by cattle rather than the "Guinea grass", one of the commonest grasses in the island. Other pasture improvement is under way, so it can be concluded that Puerto Rico possesses a good variety of pastures for its cattle because of the initiative taken by the government. Besides, some of the grains have been planted experimentally. The most important so far is sorghum.

The sorghum plant has demonstrated its resistance to the ad-

verse conditions of climate, soil, insect pests and diseases of the tropics. It constitutes an important item in the preparation of the feeds for cattle. It was found that it compares favorably to corn as to nutritive value, a higher yield per acre and a high degree of resistance to insect pests. The variety Arizona Certified Hegari has produced excellent results with a yield of 18 C. W. T. per acre and in the second ratoon produces up to 10 C. W. T. Figures 1 and 2, Plate XIV, show some aspects of the roughages and grains produced experimentally. Because of the excellent results obtained these varieties are used in the feeding of cattle.

Purebreeding Dairy Cattle. The cattle industry in Puerto Rico was and will continue to be one of the important agricultural enterprises in the island. Any logical plan for the rehabilitation of the island must comprise a program of cattle improvement. To attain this terminal point, the Development Company considers that the use of purebred animals is essential for the development of cattle. From the beginning considerable attention was given to those breeds that according to their performance in other countries could be better adapted to Puerto Rico. Like in the United States, in Puerto Rico some of the European breeds, for instance the Jersey and Holstein breeds, may be raised economically, but these particular regions in the island are so small that the fact is not worth mentioning. They thrive well because of the beneficial effects of the prevailing winds; besides, the Jersey breed seems to withstand the hot climate more efficiently than the other European breeds. Undoubtedly, both breeds are influencing to a large degree the cattle of these sections and it can be said that

these places possess cattle of high quality. Another similar case can be cited. The College of Agriculture dairy herd is composed mostly of Guernseys. Because of the favorable location of the farm, of the original purebred stock brought consisting of several European breeds, the Guernseys seem to give better results. Every year young breeding stock of this breed is sold to farmers interested in them.

If this particular situation is analyzed properly, community breeding or any sort of cooperative association would be desirable and is the only way in which the cattlemen of these regions in Puerto Rico could solve the inadequate supply of milk. This sort of breeding is desirable because farmers could have a change of the best sires at a low cost. Although the Extension Service Division in Puerto Rico has been a great help in establishing this sort of facilities to farmers engaged in raising different class of livestock, no fruitful results have been obtained on the part of the farmers. The methods used have been inefficient to get the service of the purebred sires. In this respect the improvement of native cattle of the particular regions has been hindered.

Another fact against purebreeding, besides the limited land available, is that the type of farming practiced in the fertile lowlands is a very specialized one, where the farmer strives to produce the greatest possible income from the sugarcane. These fertile lowlands are exceptional for sugarcane cultivation; for that reason it is very difficult for a farmer to go into a purebreeding enterprise and reduce his sugarcane acreage. Unfortunately, this is land that could be used in any program of purebreeding in Puerto

EXPLANATION OF PLATE V

- Fig. 1. Prince Domino 123, a purebred Hereford bull, one of the 25 that the Puerto Rico Development Company is using in its cooperative plan to rehabilitate the cattle industry in Puerto Rico (22), p. 21.
- Fig. 2. Hereford cattle, adapted to the climatic conditions of Vieques, P. R., were imported from registered herds from Texas. The Agr. Co. is maintaining a purebred herd with the purpose of improving the native cattle (22), p. 22.
- Fig. 3. Cowslips Dreaming Design (455237), a purebred Jersey bull, one of the six bulls imported by the Agr. Co. together with 80 purebred cows to be used in the program of dairy cattle improvement in Puerto Rico (22), p. 11.



Fig. 1



Fig. 2



Fig. 3

Rico because of its fertility and productivity.

However, the government of Puerto Rico, looking forward to serve the necessities of the public, decided that the Brown Swiss breed promised the best results as a dairy animal with an additional advantage that its young stock produces excellent veal. Later, it was decided that the Jersey breed should be tried. This dairy animal has produced the best results in the Southern states of the United States, and, besides, its milk is of a very high quality. The quality of the milk is an important part of the plan for improvement of cattle in Puerto Rico.

The Development Company, as a representative of the government and the public in Puerto Rico, is advancing toward its promises to the people. Up to now this agency owns three herds of dairy cattle, two in "Vieques" and one in "Caguas". The herds of "Vieques" include 153 cows of the Brown Swiss and Jersey breeds, 34 purebred bulls, 63 heifers and 47 calves of both breeds.

The herd in "Caguas" consists of 56 native cows or graded cows in which the Holstein blood predominates. This herd represents the typical average herd found in the island.

At present there are available for sale and at low prices purebred bulls of the Brown Swiss and Jersey breeds. It can be summarized that the dairy project developed by the Puerto Rico Development Company is toward these main objectives: First, the production of purebred animals already adapted to the island, for sale to the farmers; second, the resolution of the best management methods to follow in commercial herds; third, the improvement of the herds by means of crossing with purebred bulls the native cows;

and fourth, the increase of output or much more milk and of higher quality (33), p. 5.

Regularly, 20 purebred bulls of the Brown Swiss and Jersey breeds are used under the cooperative plan. Figure 3, Plate XV, shows a purebred Jersey bull used intensively. The open dairy barn, which will serve as an example of the latest farm constructions in the tropics, and considered one of the best of tropical America, is shown in Fig. 2, Plate XIV.

In 1946 Puerto Rico imported milk and its products that amounted to \$7,206,824. There is a great interest on the part of the government and the public to reduce these imports by producing them in the island (33), p. 5.

Purebreeding Beef Breeds. The cattle used in Puerto Rico for beef are of a very low quality. They are primarily raised to be used in the work at the sugarcane plantations, and after many years, then are used as a source of meat, together with other matured dairy cows that no longer produce economically. Figure 2, Plate III, shows a team of oxen used in plowing the soil.

With the aim of improving this state of unsanitary and low-quality meats for consumption, the Puerto Rico Development Company thought of the possibility of raising in Puerto Rico animals for the only purpose of producing meat. With that intention it imported purebred animals of the Hereford breed. Figure 1, Plate XV, shows an animal of this type. Like in the case of dairy types, the same objectives are desired by the agency in regard to purebreeding of beef types. To reach this goal, the agency has started a large-scale program to produce sufficient purebred breeding stock to dis-

tribute to the farmers. Statistics kept by the government show that in 1945, Puerto Rico imported fresh meat and other meat products valued at \$4,610,050. The principal objective is to reduce to the minimum these importations when possible. Figure 2, Plate XV, shows a view of a group of animals of the Hereford breed showing their physical condition under the tropics.

The results so far obtained, although the activities have been carried on for a short period, demonstrate that purebreeding of dairy and beef breeds mentioned above has been promising in the respective regions where experimental work has been undertaken.

Crossbreeding Projects. No definite experimental data as to the behavior of these purebred breeds imported, or observations aside from the performance of them outside Puerto Rico, were available. Government officials decided that crosses between the Hereford x Brahmans, Hereford x the native strains, Brown Swiss x Brahman and Brown Swiss x the native strains, Jersey x the native strains and finally Brahmans x native dairy strains should be started.

Any program of improvement of cattle in Puerto Rico is a matter of many years. The Puerto Rico Development Company has been functioning for almost three years, and now the first products of their efforts in combining the qualities of different breeds are crystallizing. Figures 1, 2 and 3, Plate XVI, show some of the dams and crossbreds obtained at the beginning of the improvement programs.

EXPLANATION OF PLATE XVI

- Fig. 1. One of the 73 purebred Brown Swiss cows imported by the Agr. Co. of Puerto Rico. It was bred to a Brahman bull. The calves are twins. Note how they suckle the dam (22), p. 7.
- Fig. 2. The cross between a Brown Swiss cow and a Brahman bull produced this calf. It weighed 130 pounds at birth. Calves like this produce excellent veal. It is hoped that the female crossbreds will be good producers and resistant to tropical conditions (22), p. 5.
- Fig. 3. A purebred Hereford cow and her calf, the result of a cross with a purebred Brahman bull. Note the brockle face of the calf. It is expected these calves will develop the Brahman resistance to parasites and to other tropical abnormalities (22), p. 9.

PLATE XVI



Fig. 1



Fig. 2



Fig. 3

CONCLUSIONS

In the light of the foregoing discussion the following conclusions have been drawn:

1. Puerto Rico is an eminently agricultural country, with a dense population and very few enterprises of economic possibilities.

2. An intensive utilization of the land is essential for the general welfare of the people of Puerto Rico. The dairy industry level should be raised, a reduction of exports of sugar and its by-products is to be expected.

3. Cattle industries are under an utter abandonment in Puerto Rico.

4. Meat and milk produced for consumption by the urban population are insufficient and of a very low quality. The average diet lacks such items of high nutritive value as milk and meat.

5. Programs for the increase of production of milk and meat are necessary and should be established immediately.

6. Climate is the principal factor limiting the exploitation of improved imported dairy strains.

7. The native Puerto Rican cattle, although well adapted to conditions of the island, are very low producers. When slaughtered they furnish meat of poor quality.

8. Reclamation programs are indispensable to better the low level of agriculture of the arid and semiarid regions.

9. The conclusive crossbreeding results obtained in the United States with beef cattle and that under way with dairy cattle will serve as an example to follow, of beneficial use, in the de-

velopment and improvement of cattle in Puerto Rico.

10. The improvement of the dairy cow in Puerto Rico has been very slow for the last 20 years. A lack of legislation on the part of the government, and the refusal of dairymen to take advantage of government services, has hindered the process of improvement.

11. Dairymen and the government of Puerto Rico are awakening from the pioneer stage in which the cattle industry was of no importance.

12. A limited area in Puerto Rico is dedicated to purebreeding of the principal economic dairy breeds. There is a possibility of reducing a small amount of the acreage dedicated to sugarcane planting.

13. The system of soiling crops is becoming increasingly important around the limits of densely populated cities. The dairy business is well adapted to it, but more efficient cows are needed to make possible the use of this highly valued land.

14. Programs of crossbreeding to create animals that better serve the average farmer are the only means by which the dairy and beef breeds could be improved.

15. The Puerto Rican government is taking the initial risks to make real a program of cattle improvement. On a cooperative basis it is rendering valuable services to cattlemen in general.

RECOMMENDATIONS

The people of Puerto Rico, through the government, are buying from the corporations all the land in excess of 500 acres stipu-

lated by the Land Law. Part of this land, considered the best, is being redistributed to farmers that wish to establish a new business. Although the value of this land is very high, there is the possibility of using it under programs of soiling crops so prevalent in the lowlands of Puerto Rico. This would make possible the exploitation of the common imported dairy breeds by farmers going into the business. The use of crossbreeding and the use of purebred bulls of the Holstein breed under this condition of a high level of agriculture would make the improvement more sound and economical and furnish a source of income to the farmer.

Purebreeding of the Holstein, Jersey and Guernsey breeds is possible in some sections of the island because of the beneficial trade-winds. The writer recommends the undertaking on the part of the government and those dairymen in the island with resources the risks of importing proved sires of these aforementioned breeds, and females noted for their performance for the production of excellent breeding stock that could be sold to dairymen at reasonable prices.

The crossbreeding work undertaken by the government of Puerto Rico should be put in the hands of competent persons, with a thorough knowledge of the breeding problems. It is unbelievable that after $1\frac{1}{2}$ years of experimentation with new breeds imported to Puerto Rico, government officials in charge of the projects to improve our cattle and determine the possibilities of purebreeding of new breeds, have been able to make public statements in relation to them without actually being raised their youngs under the new conditions. The writer thinks more emphasis should be given to

the crossing of the breeds with native and Brahman strains to obtain animals of the dairy and beef type suited for the use that the small average farmer of the island can give to them.

The establishment of cooperative associations is essential to make the program of improvement more economical and beneficial to all dairymen. The government should make available to all farmers the services of their veterinarians. Artificial breeding should be extended throughout the island when these cooperatives have been organized.

There is a lack of legislation affecting the dairy and meat industries. Adequate regulations should be passed to avoid the introduction of undesirable animals. Regulations also should be passed to make possible the inspection of the premises where milk and meat are produced and handled. This is the only way in which milk and meat can be produced under sanitary conditions. Other measures should include exemption from payment of taxes by persons going into the dairy business during the period of time in which the initial costs are great to stimulate interest in the dairy industry.

ACKNOWLEDGMENT

Grateful appreciation is to be expressed to Professor F. W. Atkeson, Head of the Department of Dairy Husbandry at Kansas State College, for his help and supervision of the work done in this report.

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