BREEDING OF FARM ANIMALS

MERRITT W. HARPER

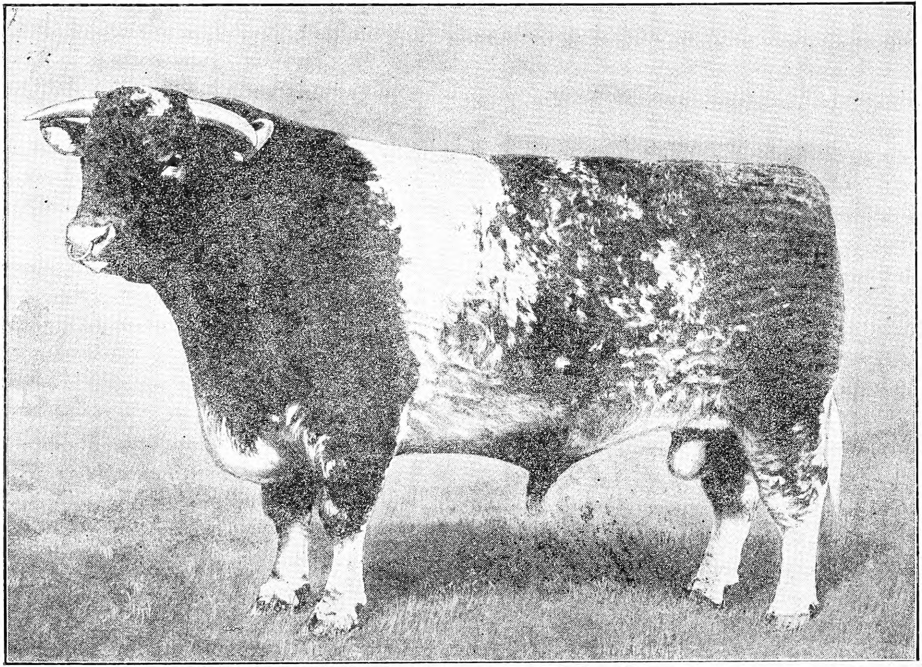

Fig. 1—The Shorthorn Bull "Avondale"

This illustrates the accomplishment of suitable environment, judicious selection and heredity.

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By

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PREFACE

This book is an attempt at arranging useful information concerning the breeding of farm animals and adapting it to the needs of the farmer, breeder and student. It includes a brief discussion of the fundamental principles underlying animal breeding, such as development, selection, variation and heredity, together with the more practical phases of the work.

The book represents experience, both as a breeder and instructor. It differs from other books on the breeding of animals in that special emphasis is placed on the importance of proper care and management of the parents, together with the proper development of young stock, as these are of the utmost importance to the practical breeder, and in connection with selection give advancement. An attempt has been made to direct attention away from the speculations that characterized the earlier books and to center interest in the more practical features of breeding farm animals.

To get the essentials involved in animal improvement clearly before us, extended use has been made of the facts disclosed by the Advanced Register for Holstein-Friesian cattle and by Wallace's Year Book for horses, as the advancement gained by the methods here employed is significant. Because of the nature of the material it has been found necessary to present a few rather long and complicated tables. These should be carefully considered by the reader in order that he may learn to analyze and generalize of his own accord. This will stimulate interest and lead to closer observation of farm animals generally.

To promote interest in correct type and breed characteristics many photographs of the several classes of farm animals have been used. Untouched photographs have been employed, as they show type and breed features to advantage.

Realizing the many difficulties that present themselves in the breeding of farm animals, the writer will be glad to correspond with those persons into whose hands the book may fall concerning such difficulties and also to receive suggestions that may make the book more useful as a practical guide and text.

M. W. HARPER.

Cornell University,
Ithaca, N. Y., August 3, 1914.

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CHAPTER I

INTRODUCTION

The breeding of animals and plants is receiving much attention from the practical as well as the scientific man. This activity is due to a realization of the economic importance of plants and animals on the part of our foremost men of affairs. The well being, indeed the very existence, of man rests ultimately upon his ability to produce cultivated plants and domesticated animals in abundance. Possibly never before has any question attracted an interest so universal as that of the reproduction of plants and animals, including man.

While man makes economic use of many species of animals, this discussion is limited to that of breeding farm animals, including horses, cattle, sheep, swine and poultry, although other species occasionally may be used as illustrations and examples.

Farm animals provide labor, food and clothing.—Few realize the extent of our dependence upon farm animals. The horse has fought our wars and won our battles and is our principal beast of burden. In connection with improved machinery, he has increased man's productive power many fold. It is estimated that the horses of the United States are equal in productive industry to that of 100,000,000 laborers. In America, it is the horse that enables us to make farming an attractive business, rather than a peasant's drudgery, as in many of the older nations of the world.

In the United States, approximately one-half of the amount spent for food by the average family goes for the purchase of meat, eggs and dairy products. Our standard foods are bread and potatoes, meat, milk and eggs, three of which are provided directly by farm animals, while the other two are largely dependent upon the horse or ox to furnish the labor necessary for their propagation and cultivation.

The wool of the sheep and the fiber of the cotton and flax furnish the materials out of which we clothe ourselves. Again, the first of these materials is a direct by-product of the body of one class of farm animals, and the cultivation of the others is accomplished very largely by means of horse labor.

Number and value of farm animals.—We possess a greater number of farm animals than any other single country in the world, although some nations, including their dependencies, excel us in some classes, particularly the British Empire in the case of sheep. Of all of the farm animals in the world approximately one-fifth of the horses, one-half of the mules, one-sixth of the cattle, one-twelfth of the sheep and two-fifths of the swine are to be found in the United States. This represents a vast

NUMBER AND VALUE OF FARM ANIMALS

	Census 1900		Census 1910	
Class	Total number	Average* value per head	Total number	Average value per head
Human population..........	75,994,575		91,972,266	
Horses, mules and asses.....	24,752,436	$50.80	27,618,242	$111.72
Cattle, dairy................	18,108,666	29.68	21,795,770	34.56
Cattle, other than dairy....	51,227,166	21.78	41,886,878	24.50
Swine......................	64,686,155	3.69	59,473,636	6.88
Sheep......................	61,735,014	2.77	52,838,748	4.44
Poultry....................	250,624,038	0.34	295,880,190	0.52
Total value of farm animals	$3,035,005,586†		$5,451,084,839†	
Total value of farm crops..	2,998,704,412		5,487,161,223	

*Farm value. †Includes goats.

amount of wealth, as is illustrated in the foregoing tabulation, which gives the total population for the United States, both human and animal, and the average value per head for the several classes of farm animals as given in the twelfth and thirteen censuses.

Human population increasing, number of farm animals decreasing.—While the average value per head of all farm animals has increased immensely during the past decade, the number has materially decreased. This is significant, especially when compared with the increase in human population. Exclusive of poultry, the twelfth census shows that in 1900 there were almost three head of farm live stock for each human inhabitant, whereas the thirteenth census shows that in 1910 there were approximately two head of stock for each inhabitant. The year book of the department of agriculture gives further reduction in the number of animals on farms, particularly cattle. It is important to note this decrease has taken place in the meat-producing animals—cattle other than dairy, sheep and swine. Horses, dairy cattle and poultry show increase about in proportion to that of the human population. We may well inquire why this is true and its general significance.

Farm animals costly.—Few persons realize the expense of maintaining farm animals. We need but to reflect a moment and the enormity will become apparent to us. Practically every farmstead throughout this broad land is devoting much of its energies to animal production. Farm animals not only consume vast quantities of expensive food, but require labor in caring for their needs as well as shelter for themselves and their food. Further, the loss from death among our extensive animal population is great, running into many millions of dollars in the case of swine alone.

An idea of the cost of farm animals may be gained from the following tabulation, which gives the food of maintenance and production for the several classes of farm animals, as well as the approximate daily product and total annual cost for each class:

FOOD OF MAINTENANCE AND PRODUCTION

Animal weight	Maintenance		Production		
	Daily food lbs.	Annual cost*	Daily food lbs.	Daily product	Annual cost*
Horse 1,250	4 grain 18 hay	$47.45	15 grain 20 hay	Moderate work	$91.25
Cattle 1,250	25 hay	45.60	30 silage 12 hay 8 grain	25 lbs. milk or 2 lbs. beef	73.00
Sheep 120	3 hay	5.50	1.5 grain 2.0 hay	0.4 lb. mutton	9.15
Swine 100 to 200	1 grain to 2 grain	3.65 to 7.30	4 grain to 6 grain	0.75 lb. pork to 1.50 lbs. pork	14.60 to 21.90
18 fowls 100 lbs.	3 grain	10.95	5 grain	8 eggs, 1 lb. or 0 .75 lb. meat	18.25

*Because of the fluctuating price of feed, the cost is estimated with grain at $20 a ton and hay at $10 a ton. These prices afford a convenient basis, as they are easy to add to or take from, according to local conditions.

Relation of food to production.—There are approximately three pounds of edible dry matter in the 25 pounds of milk; seven-tenths of a pound in the two pounds of beef; one-eighth of a pound in the .4 pound of mutton; an average of two-fifths of a pound in the pork; one-fourth of a pound in the .75 pound of fowl meat; and approximately one-fourth of a pound of edible dry matter in the eight eggs.

According to this computation, the following amounts of dry matter in the food will be required by the several classes of farm animals, to produce one pound of edible dry matter in the product. Because of the variation among the individuals of the several classes, this calculation is supplemented by data from Jordan's "Feeding

Animals," which includes the digestible organic substance required to produce one pound increase in edible solids.*

RELATION OF FOOD TO PRODUCTION

Class of animal	Dairy cattle,	Swine,	Fowls		Sheep,	Beef cattle,
	milk	pork	eggs	meat	mutton	beef
Dry matter in the food required to produce one pound of edible dry matter in the product	5 lbs.	8 lbs.	14 lbs.	15 lbs.	17 lbs.	23 lbs.
Digestible organic substance producing one pound increase edible solids	5.5 lbs.	6.4 lbs.	19.6 lbs.	23.4 lbs.	37.9 lbs.	36.3 lbs.

Since a pound of product in the shape of beef and mutton costs three to four times as much as in milk and pork, it is little wonder that beef cattle and sheep are decreasing. It is evident that, with the increasing human population, the time will come when it will be difficult, if not impossible to support as many animals as we do at the present. True, some classes of animals, particularly fowls and swine, can be kept, in part, upon refuse, but an immense acreage of corn, oats and hay is necessary to maintain our farm animals. Before long much of this land will be required to support our increasing population in a more economic manner than we have hitherto been able to produce beef and mutton.

Distribution of farm animals.—The high food cost of beef and mutton does not mean that such meat cannot be produced at a profit. There are certain regions in which both products make a liberal return on the investment, particularly when we consider the wool, the hide and like by-products. As would be expected, because

*W. H. Jordan's "The Feeding of Animals," p. 404.

of the density of the population, we find poultry and dairy cattle most numerous in the Middle Atlantic and North Central states where food is high in price. Fifty per cent of the dairy cattle in the Union are in the North Central states. In like manner we find the meat-producing animals, particularly cattle and sheep, very numerous in regions that are sparsely populated and where food is cheap, although large numbers of meat animals, particularly swine, are to be found in the Central states. This is because of the abundance of meat-producing foods. Thus 45 per cent of our beef cattle are in the South Central states, 42 per cent of the sheep in the Mountain states and 60 per cent of the swine in the North Central states, while 54 per cent of the mules are in the South Central states.

Improving farm animals.—Since our animals are very costly, indeed so expensive that they are decreasing in number, it would seem well worth our time to give serious attention to methods of increasing their efficiency. While there are many factors entering into the improvement of farm animals, many of which are little understood, yet the experience of successful breeders gives us abundance of evidence to suppose that environment, selection and heredity are by far the most important means by which farm animals are improved, as they control development, give efficiency and purify the blood. (Fig. 2.)

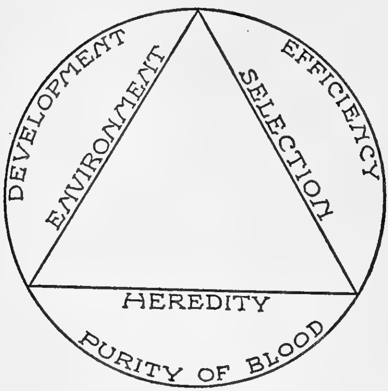

FIG. 2—DIAGRAM SHOWING RELATIONSHIP OF THE PRINCIPLES INVOLVED IN ANIMAL IMPROVEMENT.

Environment.— This term is used to denote the conditions of life as a whole, both good and bad, into which the animal comes and by which it may be either advanced or retarded, but with which it must live and compete. The environment consists largely of food, shelter and care, including training and developing. To obtain greatest advancement the animal must be well fed at all times, but more especially while young, since the individual retarded at this age will never reach that degree of perfection which it otherwise would had it been properly nourished during the days in which growth was possible.

The shelter required for advancement necessarily varies much with the several classes of farm animals and with the climate, but should be sufficient to keep the animal in comfort. Exposure to very hot sun, as well as to cold rains and storms, is especially harmful to all classes of farm animals. The care should be such as to encourage greatest development at all times. Many persons fail in breeding animals by depending on heredity alone to maintain and improve their stock.

While greatest advancement cannot be obtained without suitable food and care, training and development are even more important. There seems to be a tendency on the part of some breeders to overlook this fact. It must be remembered, however, no matter how suitable the conditions, indeed no matter how pure the heritage, maximum usefulness in many economic attributes or features of farm animals cannot be attained without proper training and development. This fact is well illustrated in the case of Standardbred horses and dairy cows, the only two classes of farm animals in which we have accurate records of performance. We know exactly what these animals can do and know definitely when progress has been made. Further, we know positively that maximum efficiency depends upon proper training and development, as such is necessary to bring out all of the possibilities of the individual.

Heredity.—This term is commonly defined as the tendency of the offspring to *resemble* the parent. In the main, therefore, the individuality of the offspring is similar to that of the parent. Thus in common usage we have the expression "like begets like," although in an exact sense no animal is like either parent. The idea of heredity signifies the transmission of the determiners of individuality from parent to offspring. Walter briefly defines environment as what the animal *has*, training as what he *does*, and heredity as what he *is*, thus denoting purity of blood. Further, he says that while what an animal *has* and *does* are of great importance, especially to the individual, yet what he *is*, is of far more importance in the long run.* This is probably true, but we will never know exactly what an animal *is;* that is, what his capabilities are, unless the environment and the training have been such as to develop all of the potentialities with which the individual is endowed. Of course, it is recognized that the animal must be capable of development, or the effect of suitable environment and proper training will come to naught.

Selection.—Heredity does not distinguish between the good and the bad, and so far as it is concerned the offspring may obtain either or both from the parent. Here is where selection plays a very significant part in the improvement of our farm animals. The successful breeder selects and propagates animals with desirable attributes, features or characters, by which is meant detail of form or function, and eliminates those individuals that fail to come up to expectation.

As suggested, not all animals are endowed with the same capabilities for development, even under suitable environment, as some individuals make remarkable advancement, while other individuals fail to equal their predecessors. Here, again, selection proves the key to efficiency, for all animals that fail to develop up to the standard are disregarded, and only those that come up to expectation are retained for breeding purposes. Thus

*H. E. Walter, "Genetics," p. 3.

the average efficiency of the animals retained is superior to the average of those born into the herds. Since the degree of selection employed in practice is the controlling factor in the efficiency of our living farm animals, it would seem well worth while to give careful consideration to the methods whereby selection can be used more effectively.

Propagation of animals.—So important are environment, selection and heredity in the development of our farm animals that the influence of many factors operating to decrease the number of normal births, as well as proper development while young, are often overlooked. These very factors often are of greatest concern to the practical breeder. The dairy farmer with a herd of 40 cows is more concerned in having his cows freshen regularly and normally than in the individuality of the offspring. The same is true in breeding horses, beef cattle, sheep and swine, with added interest in methods whereby the many fatal diseases of the young may be avoided and proper development secured. The proper growth of the new individual, both before and after birth, is beset by many difficulties. The number of animals that fail to breed as well as those that give birth to premature young is great. This is a source of immense financial loss in dairy cattle and all pure-bred animals. Further, it has been stated that approximately one-fourth of all the young animals born die before they are one month of age. Surely it is well worth our time to consider methods whereby this great loss may be avoided.

CHAPTER II

REPRODUCTIVE ORGANS AND GERM CELLS

In sexual reproduction the formation of the new individual is the result of a union of material contributed by each parent—male and female. A general knowledge of the location and construction of the organs that furnish this material, and in which the young originate and develop, is necessary to an understanding of the conditions which have to do with bearing normal young. Further, a knowledge of the material itself is of the very utmost importance, since it is the only part passing from the parents to the new individual, and must, therefore, contain the determiners of heredity.

Female reproductive organs.—The generative organs of the female consist of the vulva, vagina, os uteri or neck of womb, uterus or womb, Fallopian tubes or oviducts, and the ovaries, as well as of the milk glands and udder. The vulva is the external opening of the female reproductive organs. The vagina is the passage from the vulva to the uterus. In the mare it is 8 to 12 inches in length and capable of lateral distention to the full size of the pelvic cavity. The os uteri or neck of the womb projects into the forward end of the vagina as much as 2 or 3 inches in the case of the mare. Because of the nature of its walls this neck is ordinarily closed except when the animal is in estrum or breeding condition and during parturition. It is very important that the opening to this organ should dilate at the time of breeding, as through it the material from the male must pass in order to reach the uterus or womb. The uterus lies in front of the vagina. In the unbred mare it is oblong, varying from 5 to 8 inches in length and from 1½ to 2½ inches in width. (Fig. 3.)

The ovaries are the essential female reproductive organs in that they produce the female reproductive bodies commonly called ova or egg cells. The detail of ova formation is known as oögenesis. The ovaries are

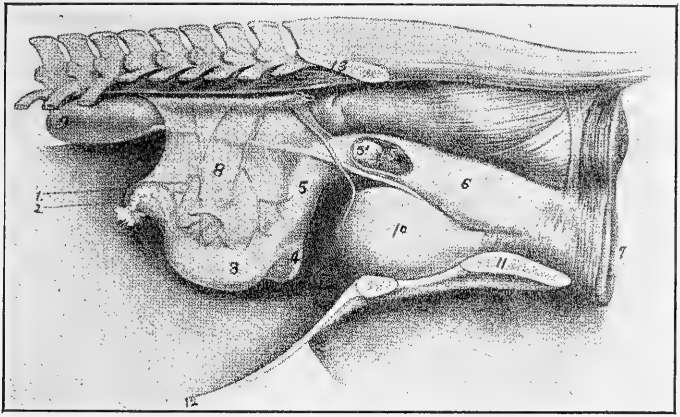

FIG. 3—REPRODUCTIVE ORGANS OF THE MARE

1. Left ovary. 2. Fallopian tube or oviduct. 3. Right horn of uterus. 4. Left horn of uterus. 5. Body of uterus or womb. 5″. Neck of uterus. 6. Vagina. 7. Vulva. 8. Broad ligament. 9. Left kidney. 10. Urinary bladder. 11. Floor of pelvis. 12. Abdominal wall. 13. Roof of pelvis (after Leisering's "Atlas of the Anatomy of Domesticated Animals").

two in number, one being situated on the right side of the body and one on the left. They are connected with the uterus by the Fallopian tubes or oviducts. The ovaries vary greatly in size and form according to age and individuality. The ovary of the young mare, which is the largest among farm animals, is usually 3½ to 4 inches in its greatest diameter, and weighs about four ounces, while in the aged mare it may shrink to 1½ inches in its greatest diameter and its weight to one-half ounce. The normal ovary of the cow is much smaller, being about ½ inch in its greatest diameter and weighing less than one-half ounce.

The udder and milk glands are essential organs of reproduction. They constitute a necessary source of nutritive supply to the new-born animal. Under domestication, the activity of the milk glands has been highly developed, particularly in the cow and goat, as they provide an important food supply for man. The number of glands vary according to the class of animals, thus the mare has two, the cow four, the ewe two, the sow 8 to 12, and the cat and bitch 8 to 10 each.

The milk glands consist of a cluster of cells about a duct, much as grapes cluster about the stem. These ducts unite and form larger canals which empty into one, two, or more milk cisterns, from which the milk is drawn through the teat by the sucking of the young or by various milking processes. The milk is secreted in the epithelial milk cells, and while, no doubt, some passes into the cisterns, yet the major part is stored in the milk cells. Under the excitation of milking or sucking the milk flows freely into the cisterns and teats, and thence is readily extracted.

Male reproductive organs.—In reproduction the male reproductive organs are, of course, equally as important as the female organs. For present purposes, however, it is sufficient to know that the testicles of the male are analagous to the ovaries of the female, and that they produce the male reproductive bodies called spermatozoa or sperm cells. The details of spermatozoa formation is known as spermatogenesis. When discharged from the body the sperm cells are contained in a white fluid which is alkaline in reaction. This material is commonly called the semen or seminal fluid.

It is noteworthy that both spermatozoa and ova are products of metamorphoses taking place in the epithelial structures, the former being derived from the spermatogenic cells found in the seminiferous tubules of the testicles, while the latter come from the germinal epithelium of the ovaries.

The cell.—All organisms, both animal and plant, are made up of cellular units, much as a brick is the unit of a wall. By a consideration of these units we can gain a clearer idea of the part the sperm—and egg—cells play in heredity as well as in forming the new individual. The size of animal cells varies to a considerable degree, although, with certain minor exceptions, the sperm cells are the smallest elements, while the egg cells are the largest. The form of the cell is likewise exceedingly variable. Free living cells, where the form is not determined by the environment, are usually spherical or oval, as the egg cells show; while those united into tissue may be pressed together into any shape and with many projections.

A typical cell is represented diagrammatically in Fig. 4. Near the center of the cell the *nucleus* is shown

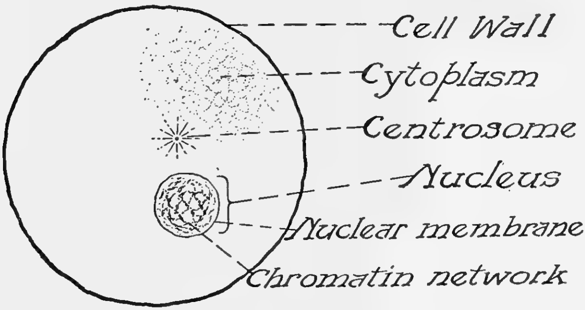

FIG. 4—DIAGRAM OF A TYPICAL CELL*

enveloped in the nuclear membrane. Because of the behavior of the nuclear contents during cell division it is considered of unusual significance. To add clearness to the cell contents, when under examination, the scientist stains it with a chemical preparation. When this is done the nuclear material takes on a deeper and more striking color than the other parts of the cell, indicating a peculiar composition. For this reason the nuclear sub-

*Figs. 4, 5, 6, 7, 8 and 9 are made up from "The Cell," by permission of the author, E. B. Wilson, and the publisher, The Macmillan Co.

stance is called *chromatin.* Surrounding the nucleus is the cytoplasm, in which is located the centrosome. The nucleus and the cytoplasm are made up of living substance called protoplasm. Surrounding the whole there is usually a wall which serves to separate one cell from another.

Cell division.—Body growth consists of an increase in the number of cells, and not of an increase in their size. Large animals do not have larger cells than small animals, but they have more of them. The ordinary process of cell division is termed *mitosis,* and in animals is made possible by the material carried to the growing part by the blood. It occurs constantly during growth. The process of simple cell division is shown diagrammatically in Fig. 5.

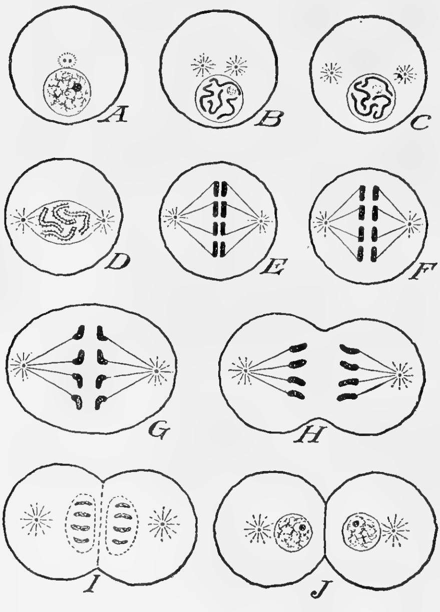

Fig. 5—Diagram Illustrating Cell Division or Mitosis

A. The resting cell. B C. Early stages, chromatin collecting into ribbons. D. Chromatin segmenting, forming chromosomes. E. Chromosomes arranged end to end along the equatorial plane. F. Chromosomes splitting lengthwise. G. Chromosomes emigrating to asters to form the new nucleus. H I. Cell wall becoming constricted to form new cells. J. New cells entering into resting stage.

As division is about to take place the chromatin appears as a fine network running through the mass of the nucleus, not unlike beads strung upon a thread. This network usually condenses into a thread or ribbon and then breaks up transversely into a definite number of segments, known as *chromosomes*. In the meantime the centrosome has divided, and the two new bodies thus formed have migrated to opposite sides of the nucleus, each surrounded by its radiating lines, known as asters.

The chromosomes arrange themselves end to end along the equatorial plane of the spindle, at right angles to its axis, and each chromosome splits lengthwise, one group migrating to each aster, forming a new nucleus. The cell wall becomes constructed, dividing the cytoplasm between the two new cells, and the resting stage ensues during which preparation is made for another division.

The chromosomes.—In the process of cell division which attends all growth there are three significant facts established concerning the behavior of the chromosomes, which are to play a very important part in our study of hereditary materials. First, the number of chromosomes is constant for all individuals of the same species. In farm animals the number is 16. Second, in all forms arising by sexual reproduction the number is thought to be even; and, third, cell division consists essentially in a splitting of the chromosomes in such a manner that each daughter cell secures an exact equivalent of what is received by the other daughter cell of the same division. Cell division is, therefore, an exceedingly orderly procedure, whereby each daughter cell not only receives its share of the mass, but receives exactly the same number and kind of chromosomes as that of the other cell of the same division.

THE GERM CELLS

Not only is the individual composed of cells, but these cells are highly differentiated according to the function they perform. In the study of heredity we recognize two distinct groups of cells—first, the sexual or germ cells of which the reproductive bodies and the organs producing them, both male and female, are composed; and, second, the somatic or body cells, of which the remainder of the body structure is composed. The former are capable of indefinite existence in a suitable medium, whereas the latter are destined to die and disintegrate with the body.

Castle and others have shown that the germ cells are distinct from the body cells, although dependent upon them for nutrition and growth. Castle removed the ovaries from a white guinea pig just attaining sexual maturity, and inserted into her body ovaries from a black guinea pig not yet sexually mature. This grafted animal was mated with a white male. Now, numerous experiments have shown that white guinea pigs mated with white, without exception, produce only white young. In the course of a year, however, this grafted white animal, mated successively with a white male, gave birth to three litters of young which together consisted of six individuals, all black.*

The egg cell.—Among farm animals the ovum of the female is remarkable for its enormous size when compared with the spermatozoon of the male or with body cells generally. This is especially true in the case of poultry. In structure the ovum presents the parts of a typical cell containing a large nucleus, in this case called the "germinal vesicle," with its chromatin network. The ovum is distended with stored nutrients to which its large size is due and upon which the young embryo subsists for a time. The egg cells are discharged, either singly, as in the case of the mare and cow; or in twos and threes, as is frequently observed in sheep and goats; or in varying numbers, as in swine and carnivora.

The sperm cells.—The spermatozoa of the male present a striking contrast to the ova of the female. The former

*W. E. Castle, "Heredity," p. 31.

is very minute, many thousand times less than the bulk of the latter. The sperm cell resembles a minute, elongated tadpole, swimming very actively about by the vibrations of a long slender tail. This locomotion is

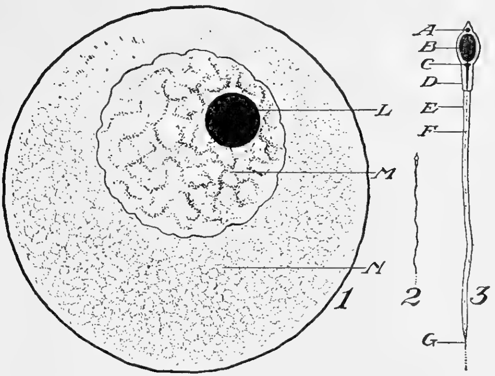

FIG. 6—DIAGRAM OF THE GERM CELLS

1. Egg cell. 2. Sperm cell size to compare with egg cell. 3. Sperm cell enlarged to show parts. A. Apical body. B. Nucleus. C. End knob. D. Middle piece. E. Envelope of tail. F. Tail piece. G. End piece. L. Nucleolus or germinal spot. M. Nucleus or germinal vesicle containing network of chromatin. N. Cytoplasm.

necessary to bring the two germ cells together, as the egg cell is practically stationary because of its great bulk. In structure the sperm cell contains all the parts of a typical cell, but arranged in a different form and containing very little cytoplasm. The nucleus is the important part. The nuclear network is much more dense than in the egg cell. While the egg cells are discharged singly or in comparatively small numbers, the sperm cells are discharged from the testicles of the male in practically countless numbers, although but one is used in the act of fertilization. This is due in part at least to the distance the sperm cells must travel as well as to the difficulty in reaching the egg cell.

Spermatozoa possess remarkable vitality, remaining active in the genital passages of the female for days and in some cases possibly for weeks. When mounted and protected from evaporation, they have been known to show vibratile motion after the lapse of nine days. Weak alkaline solution renders them more active, while acids, even very dilute, destroy them.

Chromosome reduction.—Since the number of chromosomes in a given class of animals is constant, and since fertilization requires the union of a sperm cell from the male with an egg cell from the female, each containing 16 chromosomes, is it necessary that the number be reduced in the germ cells before fertilization, in order to

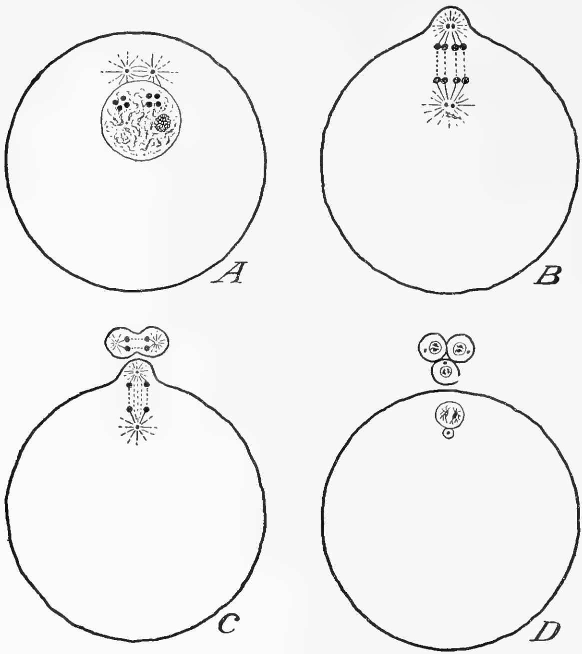

Fig. 7—Diagram Illustrating Maturation in the Egg Cell

A. Initial phase. B. Formation of first polar body. C. Preparation for second division. D. Final results, three polar bodies and the egg after maturation.

prevent a doubling up in the new individual. This chromosome reduction takes place during cell division, and is termed maturation (Fig 7). In the egg cell the process is known as *oögenesis* and in the sperm cell as *spermatogenesis*. The mature egg—or sperm—cell, with half its normal number of chromosomes is termed a *gamete*, while the fertilized egg which is formed by the union of two gametes—male and female—is called a *zygote*, or yoked cell.

In the male this reduction process is continuous, and mature sperm cells are stored in considerable numbers. In the female, however, the reduction takes place very rapidly and just prior to uniting with a mature sperm cell. In fact, in some instances, it is known to have occurred after the sperm cell has passed through the wall of the ovum. A diagrammatic representation of the process of maturation is shown in Fig. 8.

The number of chromosomes (not shown in diagram) undergoes division, and thus remains constant in number in each germ cell until the maturation division, or immediately before the formation of the mature sperm and egg cell, when they separate into two groups without splitting, each group going into a different cell. In this way the chromosomes are reduced to one-half the normal number. It is noteworthy in the case of the female that the mass of food is retained in the mature egg cell and

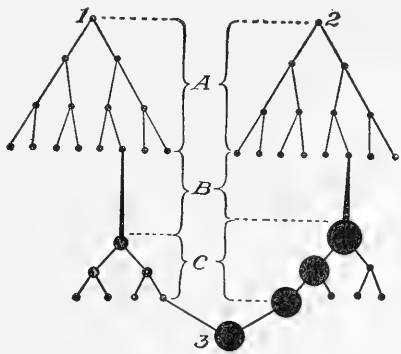

FIG. 8—DIAGRAM SHOWING THE ESSENTIAL FACTS IN THE MATURATION OF THE GERM CELLS

1. Sperm cell. 2. Egg cell. 3. Fertilized egg. A. Primordial division period. B. Growth period. C. Maturation period.

the other three cells perish, whereas in the male the four mature sperm cells are similar in appearance and each have the same possibilities.

Fertilization.—The mature sperm cell or male gamete, by virtue of its power of locomotion, finds its way to the mature egg cell or female gamete, their chromosomes flocculate, thus restoring the normal number and completing the zygote, in this case the embryo of the new animal.

During the act of copulation the semen of the male is discharged into the vagina of the female, a part of the fluid passing through the dilated os uteri or neck of the womb. The spermatozoa work forward through the uterus into the Fallopian tubes or oviducts. Here they meet and surround the ovum from the ovary. Though many sperm cells may attach themselves to the exterior of the egg cell, but one penetrates to the interior. Which one enters is simply a matter of chance. This union of male and female reproductive bodies constitutes fertilization. The fertilized ovum now migrates back into the uterus, where with favorable conditions growth and development ensue.

CHAPTER III

THE DETERMINERS OF HEREDITY

The resemblance between the new individual and the parent is not due to a direct transfer of the characters in question, but to some kind of "determiner" of heredity. Thus blood relatives do not inherit characters in the manner that real estate or personal property passes from one generation to another.

There have been many theories advanced attempting to explain the phenomena of heredity, two of which are of special interest since they serve as the basic principle governing animal breeding. It is only fair to warn the reader that these theories are conflicting, and that the principle involved has been the most discussed question in modern times. The first of these theories advanced was that by Charles Darwin, and known as Darwin's pangenesis. The second was that by August Weismann and known as Weismann's germ plasm.

Darwin's pangenesis.—Although not the first to attempt a theoretical explanation of the phenomena of heredity, Darwin set forth a provisional hypothesis which seemed so probable a speculation that it attracted world-wide comment. In view of the importance formerly attached to this theory of heredity, the hypothesis is given as stated by Darwin:

"It is universally admitted that the cells or units of the body increase by self-division or proliferation, retaining the same nature, and that they ultimately become converted into the various tissues and substances of the body. But besides this means of increase, I assume that the units throw off minute granules which are dispersed throughout the whole system; that these, when supplied with proper nutriment, multiply by self-division, and are ultimately developed into units like those from which they were originally derived. These granules may be called gemmules. They are collected from all parts of the system to constitute the sexual elements, and their development in the next generation forms a new being; but they are likewise capable of transmission in a dormant state to future generations and may then be developed. Their development depends on their union with other partially developed or nascent cells which precede them in the regular course of growth. Why I use the term union will be seen when we discuss the direct action of pollen on the tissues of the mother plant. Gemmules are supposed to be thrown off by every unit, not only during the adult state, but during each stage of development of every organism, but not necessarily during the continued existence of the same unit. Lastly, I assume that the gemmules in their dormant state have a mutual affinity for each other, leading to their aggregation into buds or into the sexual elements. Hence, it is not the reproductive organs or buds which generate new organisms, but the units of which each individual is composed. These assumptions constitute the provisional hypothesis which I have called pangenesis."*

He later states: "I am aware that my view is merely a provisional hypothesis or speculation; but until a better one is advanced it will serve to bring together a multitude of facts which are at present left disconnected by any efficient cause."

Weismann's germ plasm.—In view of the importance of an intelligent idea of the source of the hereditary substance and its subsequent behavior the hypothesis is given as stated by Weismann:

"According to my view, the germ plasm (the hereditary substance of a germ cell) of multicellular organisms is composed of ancestral germ plasms or ids—the vital units of the third order—each nuclear rod or idant

*Charles Darwin, "Animals and Plants Under Domestication," Chapter 27.

being formed of a number of these. Each id in the germ plasm is built up of thousands or hundreds of thousands of determinants—the vital units of the second order—which, in their turn, are composed of the actual bearers of vitality, or biophors—the ultimate vital units. The biophors are of various kinds, and each kind corresponds to a different part of a cell; they are, therefore, the 'bearers of the characters or qualities' of cells. Various but perfectly definite numbers and combinations of these form the determinants, each of which is the primary constituent of a particular cell, or of a small or even large group of cells (e. g., blood corpuscles).

"These determinants control the cell by breaking up into biophors, which migrate into the cell body through the pores of the nuclear membrane, multiply there, arrange themselves according to the forces within them, and determine the histological structure of the cell. But they only do so after a certain definitely prescribed period of development, during which they reach the cell which they have to control.

"The cause of each determinant reaching its proper place in the body depends on the fact that it takes up a definite position in the id of germ plasm, and that the latter, therefore, exhibits an inherited and perfectly definite architecture. Ontogeny (development) depends on a gradual process of disintegration of the id of germ plasm, which splits into smaller and smaller groups of determinants in the development of each individual, so that in place of a million different determinants, of which we may suppose the id of germ plasm to be composed, each daughter cell in the next ontogenetic stage would only possess half a million, and each cell in the next following stage only a quarter of a million, and so on. Finally, if we neglect possible complications, only one kind of determinant remains in each cell, viz., that which has to control that particular cell or group of cells."*

Opposite views.—According to Darwin, the deter-

*August Weismann, "The Germ Plasm," Part I, "The Material Basis of Heredity."

miners of heredity, the gemmules, are given off from the body cells and dispersed throughout the whole system. While some of these gemmules are active and when properly nourished, multiply by self-division and ultimately develop into cells like those from which they were originally derived, other gemmules are dormant, and, having a mutual affinity for each other, collect into the sexual organs.

According to Weismann, the determinants proceed from the germ plasm, the hereditary substance of the germ cell. These determinants control development by breaking up into biophores which migrate into the cell body, multiply there by self-division, and arrange themselves according to forces from within. His idea of the "Continuity of the Germ Plasm" regards the hereditary material as passing from generation to generation with the minimum of influence from, or association with the body of the parent. According to this view the many changes which animals undergo from time to time are accounted for on the basis of selection. (Fig. 9.)

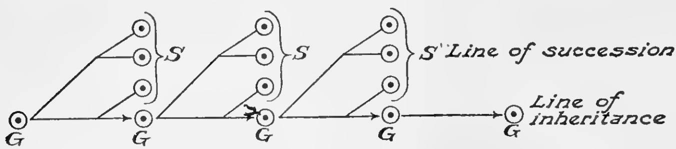

FIG. 9—DIAGRAM ILLUSTRATING WEISMANN'S THEORY OF DESCENT

G. The germ cells, which by division give rise to the body cells (S), and to new germ cells (G), which separate from the body cells and repeat the process in each successive generation.

Approved practice not involved.—These are the two main theories on the subject of heredity. Actual experimentation to determine the facts seems impossible. The intense interest has arisen over the assumption that if the hereditary determiners follow the Darwin hypothesis it is easy to explain the possibility of acquired characters being inherited; whereas, if the hereditary bearers proceed according to the Weismann theory, it is difficult to understand how a modification acquired by the parent can be transmitted to the offspring.

This question is of vital importance to the student of genetics and has been the object of much careful study. No doubt it is one of the most discussed questions of the present time, as scientific men are divided in their opinion, many stating with much emphasis that under no condition can a modification acquired by a parent be transmitted to the offspring; while others are equally as positive that such modifications may be inherited. Interesting as this question is to the student of genetics, it is only fair, at this time, to assure the breeder of animals that in actual practice it is of secondary importance.

The hereditary bridge.—Having briefly reviewed the major theories of heredity and the principles involved, we will now pass to a consideration of the most approved ideas, giving them in as much detail as possible in the space at disposal. While little is definitely known of the determiners of hereditary characters which appear in successive generations, yet it is obvious that, in any event, such determiners are obtained from the two germ cells—male and female—and that they pass to the new organism in the fertilized egg. This single cell is the actual bridge between parent and offspring, and it is the *only* bridge. The only actual fragment of the paternal organism given over to the new individual is the single maturated sperm cell which in fertilization unites with the maturated egg cell, the only fragment from the maternal parent. The entire heritage is packed into this single cell.

The matter appears all the more wonderful when we consider the small as well as the unequal size of the two germ cells, for it has been shown conclusively that the egg cell and the sperm cell are equal in their hereditary influence, even though the former contains many thousand times the bulk of the latter. Thus the minuteness of the sperm cell is apparent when we reflect that the egg cell is about $\frac{1}{125}$ of an inch in diameter. When we recall the marvelous array of characters which make up the sum total of what is obviously inherited, the amazement grows that so small a cell can contain such an enormous load.

The fact that the heritage is completed at the time of fertilization is significant. Formerly there was much confusion in this matter. The statement was often made that the young animal's heritage was complete at birth. Now we understand the heritage to be completed, not at birth, but at a much earlier time, in fact at the time of conception. True, the subsequent development of the new individual may be retarded or accelerated by the care and nourishment of the maternal parent, before birth, as well as by the nourishment and training after birth. This is a matter of environment and development and cannot be considered as in any sense a hereditary relation.

The hereditary material.—The course of the hereditary determiners from their probable origin in the reproductive organs of the male and female to the mature sperm cell and egg cell respectively over the hereditary bridge—the fertilized egg—to the embryo and thence to the new individual, seems clear and the route easily followed. However, the material nature and physical make-up of these determiners is little understood and probably exceedingly complicated.

FIG. 10—SHORTHORN BULL "SHENSTONE ALBINO"

It is conceded that there is something within the fertilized egg that controls the unfolding of the developing organism. This control is complete with respect to both quantity and quality, and governs the time and rate of appearance of its various characters so that certain combinations rather than others shall come about in definite sequence. But just what are the determiners of these hereditary qualities? Can they be discovered by the aid of the microscope, or are they chemical rather than morphological in their nature, such as enzymes, which only the chemist can detect?

The enzyme theory.—It has been suggested that heredity may ultimately be reduced to a series of chemical reactions depending upon the manner in which various enzymes initiate, retard or accelerate successive chemical combinations occurring in the protoplasm. Thus it has been found that the blood of closely related varieties of dogs is chemically different, although from a morphological point of view it is apparently identical. Possibly these differences extend to individuals of the same variety.

The possibilities in this direction seem unlimited when we reflect that an albumen compound having only 40 carbon atoms, a number by no means unusual, would make possible millions of combinations of atoms. At present, however, all that can be said for the enzyme theory is that it is a bare possibility. It is suggested in this connection with the thought that it might aid in a clearer understanding of the possible nature of the determiners of heredity.

The chromosome theory of heredity.—Since the nuclei of sperm cell and the egg cell are the only portions of these cells that invariably take part in fertilization, it has been suggested that the entire factor of heritage is packed into the nuclei of these germ cells. Although not fully demonstrated, it is entirely probable that the chromatin is the main seat of heredity and that the hereditary determiners are to be located in the chromosomes.

There are many reasons for this assumption, three of which are worthy of consideration.

Notwithstanding the great relative difference in size between the sperm cell and the egg cell, they are practically equivalent in their hereditary influence. This has been repeatedly shown by making reciprocal crosses between the two sexes. The only features that are alike in the two cells are the chromosomes. The inference is, therefore, that they contain the hereditary determiners.

The process of maturation by which the number of chromosomes is reduced one-half, as a preliminary step to fertilization, at which time the normal number is again restored, is just what is needed to bring together an entire complement of hereditary determiners, out of the partial contribution of the two parents. Since, in fertilization, no other part of the cells plays so consistent and important a part as the chromosomes, during this series of complicated changes, it would seem very probable that they contain the determiners of heredity. Moreover, maturation is practiced by germ cells only.

The fact that certain chromosomes in the fertilized egg have been identified with particular features or combination of features in the adult developing from that egg lends favor to the chromosome theory. This is strengthened by the probable existence of an extra chromosome in connection with the determination of sex, as will be pointed out later in the discussion of sex in animal breeding.

Such evidence as the foregoing has convinced many that in the chromosomes we have visibly before us the carriers of heredity. In fact, the supposition that the chromosomes, with certain chemical reservations, are the physical carriers of hereditary determiners forms an excellent working hypothesis. The determiners of heredity have been given a variety of names by various investigators, but it is sufficient for our purpose to consider the chromosomes as the physical basis of heredity.

Chromosome combination.—Little is definitely known concerning the makeup of the chromosomes or the distribution among them of the control of the various portions of the body. Whether one chromosome could of

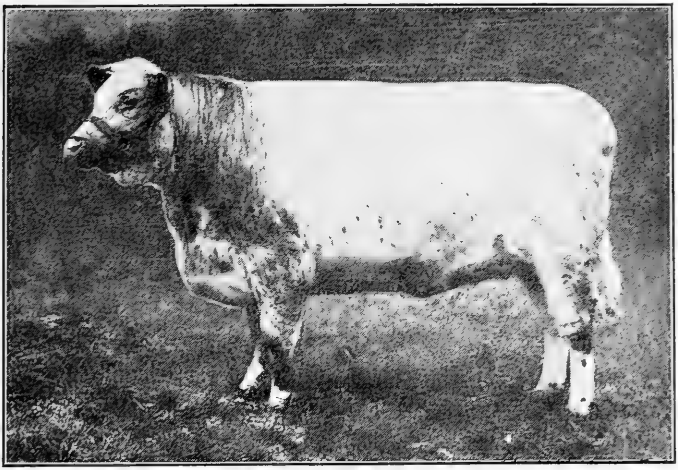

FIG. 11—SHORTHORN COW "MAXWALTON MISSIE"

itself, if necessary, direct the development of the entire body, or whether the determiners of different parts or organs are carried in separate chromosomes, is largely a matter of conjecture. True, certain chromosomes in the mature egg have been identified with particular features in the adult, but this is by no means sufficient data to warrant the general assertion that each particular character in the body is always governed by a certain chromosome in the mature egg. At present all we can conjecture is that the combined chromosomes carry the determiners of heredity.

In this connection the chromosomes that go astray in maturation are significant. The possible chromosome combination in the maturation of the germ cells—male and female—as well as their union in fertilization may explain much of the chance that attends all animal breeding.

Origin of hereditary material.—Little is definitely known of the origin of the hereditary material. Mention is made of it at this time to show the difference in time of the development of the egg cells and the sperm cells and to point out the exact place of origin. The egg cells, we recall, are produced in the ovaries of the female. They are formed from specialized peritoneal cells known as germinal epithelium. In our domestic animals all permanent ova or egg cells are formed *during fetal life,* or very soon after birth, although they do not attain sexual maturity for some time, the period varying with the class of animal. The sperm cells are produced in the testicle of the male. These cells are produced in the specialized spermatogenic cells and are formed *continuously throughout the productive period* of the animal's life.

Basis of controlling determiners of heredity.—To obtain the greatest possible control over heredity is the aim of the breeder. But, if the hereditary bearers largely are conveyed in the chromosomes of the germ cells, then no degree of human influence is conceivable. To find a basis of controlling heredity to improve farm animals we must consider the source of hereditary determiners. We have shown that whatever the determiners may be, they come from the parent, although, as we shall see presently, they are influenced by previous ancestors. In animal improvement, therefore, we must concentrate our attention and efforts upon the parents and the ancestors. They should be carefully developed in order to bring out their possibilities, and they should be of proven worth as breeders. By the selecting of animals containing the hereditary material with maximum possibilities of desired features and the minimum of those undesirable, we can achieve a general control over the hereditary characters of the offspring.

CHAPTER IV

HEREDITY IN ANIMAL BREEDING

The behavior of characters as they pass from parent to offspring has been the object of much careful study. In considering the advisability of mating two animals it is exceedingly desirable to know the possibilities of the offspring. From time to time many attempts have been made to deduce laws which would serve as guides to the breeder. The complicated nature of heredity makes the formation of such laws exceedingly difficult. This is exhibited in the six fundamental propositions suggested by Brewer, late professor in the Sheffield Scientific School of Yale University.

Brewer's fundamental propositions—These proposals were given as suggestions in the breeding of farm animals, before the rediscovery of Mendel's law of heredity, hereafter to be considered, and are as follows:

1. Every animal must have two parents, and every animal resembles its parents in most of its characteristics. There is a force or tendency to keep offspring like their parents or descendants like their ancestors. This is called the law of inheritance (like produces like).

2. No two animals are alike or identical in all respects. Hence offspring are never precisely like their ancestors. This is known as the law of variation.

3. Vastly more animals are produced than are needed for breeding, and only those having the highest aggregate of good points should be used in breeding. This is called the law of selection.

4. By training, environment and selection in pairing, the form may be modified and the relative value of the various points or characters changed so as to better suit

the use or the fancy of the breeder. This is called breeding to points.

5. By continued breeding to points, the characters may be increased beyond what they were in the ancestry. This is called improvement of breeds.

6. The more uniform the ancestry in character and the more restricted in number, the more uniform and certain the resulting descendants. The converse holds equally true. The former is known as inbreeding, the latter as out-crossing.

Complex nature of heredity.—Among animals reliable data illustrating the free play of heredity are exceedingly meager. The advanced registers contain much valuable material for the guidance of breeders, but it is selected material, as the animals failing to meet requirements are not recorded. Possibly the most complete data that have been collected, illustrating the free play of heredity, are those of the English scientist Galton. He worked upon the stature of English people. This material is used in this connection, as it illustrates as nothing else can the relation between offspring in general and their parentage. Later the principles involved will be confirmed in studies among dairy cattle and horses of speed.

These data are given in the tabulation, in which the heights of 928 adult children are classified and compared with the heights of their parents. The heights of the adult children are listed at the top, and those of the midparents on the left. By midparental height is meant one-half of the combined heights of father and mother after increasing the mother's height by one-eighth. In his studies Galton found that women are one-eighth (12.5%) shorter than men. Thus he multiplied all female heights, both mothers and adult daughters, by 1.08 to convert them into male equivalents. By way of explanation we see that of the 928 persons whose heights were taken, 138 were 67.2 inches high. Of these, four were born from 71.5-inch parents; three from 70.5-inch

Children of Various Heights Born of Midparents of Various Heights*

HEIGHTS OF ADULT CHILDREN

Heights of Midparents: Inches	Below	62.2	63.2	64.2	65.2	66.2	67.2	68.2	69.2	70.2	71.2	72.2	73.2	Above	Totals	Average†
Above	—	—	—	—	—	—	—	—	—	—	—	1	3	—	4	72.9
72.5	—	—	—	—	—	—	—	1	2	1	2	7	2	4	19	71.4
71.5	—	—	—	—	1	3	4	3	5	10	4	9	2	2	43	69.9
70.5	1	—	1	—	1	1	3	12	18	14	7	4	3	3	68	69.5
69.5	—	—	1	16	4	17	27	20	33	25	20	11	4	5	183	68.6
68.5	1	—	7	11	16	25	31	34	48	21	18	4	3	—	219	68.0
67.5	—	3	5	14	15	36	38	28	38	19	11	4	—	—	211	67.6
66.5	—	3	3	5	2	17	17	14	13	4	—	—	—	—	78	67.1
65.5	1	—	9	5	7	11	11	7	7	5	2	1	—	—	66	66.8
64.5	1	1	4	4	1	5	5	—	2	—	—	—	—	—	23	65.6
Below	1	—	2	4	1	2	2	1	1	—	—	—	—	—	14	65.6
Totals	5	7	32	59	48	117	138	120	167	99	64	41	17	14	928	
68.6 Average†		66.6	66.8	67.8	67.8	67.7	67.9	68.3	68.5	69.0	69.1	70.2	70.2			68.0

*Made up from Galton's "Natural Inheritance," p. 208.
†True average or mean, see page 84.

parents; 27 from 69.5-inch parents; and so on for the shorter parents. A careful analysis of the data in the table illustrates the very complex nature of heredity.

In the discussion the relative terms low and high are used to designate short and tall stature respectively. In his study the breeder may substitute any character he has under consideration, such as low and high milk yield, late and early maturity and like characters.

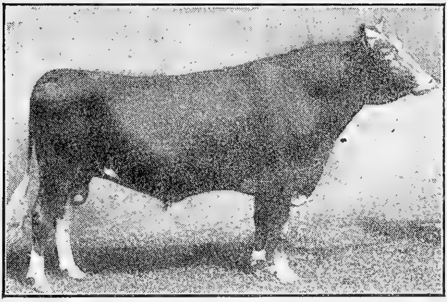

FIG. 12—GUERNSEY BULL "HAYES CHERUB 2D"

Offspring in general resemble parents.—Since the measurements of the midparents are recorded at the one-half inch and the adult children at the two-tenths of an inch, exact comparison is not possible. However, if we compare the heights of the midparents with the heights

OFFSPRING IN GENERAL SIMILAR TO PARENTS

Parental height	Low offspring	Similar offspring	High offspring	Total offspring
72.5	4	11	4	19
71.5	16	23	4	43
70.5	19	39	10	68
69.5	65	78	40	183
68.5	60	113	46	219
67.5	37	102	72	211
66.5	11	36	31	78
65.5	10	23	33	66
64.5	2	9	12	23
Total	224	434	252	910
Per cent.	25	48	27	100

of the three nearest groups of adult children, we will observe that there is general similarity between the parents and offspring. This is shown in the preceding tabulation, in which the parent is compared with the offspring, the latter being divided in three parts—similar, low and high—the similar including the sum of the three groups nearest the parental height, the low the sum of those below, and the high the sum of those above.

This division of offspring slightly favors the tall stature, giving the high group a larger per cent than the low group, which no doubt would be reversed were exact comparison possible. The significant fact is that the similar, although including but three groups, contains 48 per cent of the total number of offspring.

Particular offspring unlike the parent.—While in the main the new individual resembles the parent, in particular cases, that is the best that can be said for it. The most striking feature of the table is that offspring are unlike their parents. There is limited similarity between specific parents and their particular offspring. In other words, like parents as well as the same parents, in successive generations, produce unlike offspring, see any row in the table; and like offspring are produced by unlike parents, see any column in the table (p. 33).

Every new individual inherits all of the characters of the race to which it belongs. Not all characters, however, will be inherited with the same intensity. Some will be evident in the make-up of the new individual, while others will not be apparent. The visible characters of one parent, or even of both, give no assurance of what will appear in the offspring. In fact, there is no true guide whereby we may know for a certainty what will happen in individual cases. It is only fair to assure the breeder, however, that sufficient data have been collected to show how offspring in general compare with the parentage, and how general as well as specific improvement may be accomplished.

Some offspring higher and some lower than their parents.—The table indicates that no matter what the parents, whether low or high, some of the offspring will be lower and some higher than their parents. Thus, if we divide the table (p. 33) into two parts, as indicated by the diagonal line, placing those offspring that are superior to their parents below the line and those that are inferior above the line, we get the following results:

	Inferior to parents	Superior to parents
Number of offspring............	517	411
Per cent. of offspring...........	55.7	44.2

Due to the difference in recorded heights between parent and offspring, it is not possible to divide the table exactly. The results obtained, however, show clearly that 44 per cent of the offspring are superior to their parents, while 56 per cent are approximately equal or inferior to their parents.

Medium offspring the most frequent.—A careful study of the table reveals the fact that mediocrity seems to be the common lot. This is indicated when we compare the average height of the midparents, which is 68.6 inches, with the average height of all adult children, which is 68.0 inches. Observe how the population clusters about the number 34, which is the nearest representative of the average height of both the midparent and adult children. This is shown by the number of offspring contained within the light dotted lines, which includes 47

FIG. 13—GUERNSEY COW "DOLLY DIMPLE"

per cent of the total population. The principle involved here is that whatever the parent—high or low—the offspring tend strongly toward the average of the race.

The high parent and his offspring.—High parents produce both low and high offspring. This is well illustrated in the case of the 70.5-inch parents, which are 2 inches above the average for all parents. Of the entire offspring, 68 in number, one is almost a dwarf and 51 are lower than their parents, with seven distinctly below the average of the race. This tendency toward inferiority is known as *regression*. On the other hand, there are 17 offspring, or exactly one-fourth, superior to their exceptionally good parents. The higher we go among the exceptional parents the more this is true and the larger is the percentage of superior offspring. This tendency toward superiority is known as *progression*.

The high offspring and his parents.—We now come to a consideration of the production of superior animals, the goal of all animal breeding. The table shows that superior animals may be produced in various ways. For example, while the offspring in the 72.2-inch column are clearly superior, ranging over six feet in height, yet they were produced by all kinds of parents, from the very tallest down to 65.5. While the parents were thus distributed the greatest percentage of superior offspring came from extremely tall parents, although the greatest number came from medium parents. Thus the greatest number—11—came from a medium population of 183, or less than one in 17, whereas next to the highest—seven in number—came from a high population of 19, or more than one in three. In other words, we stand one chance in 17 to get a high offspring when selecting for breeding purposes from medium parents, and one chance in three when selecting from high parents.

High parents produce both high and low offspring, and low parents produce both high and low offspring. But under suitable environment high parents produce more high offspring and fewer low offspring, while low parents produce more low offspring and fewer high offspring. Thus, if we divide the table into four parts as indicated by the heavy lines we get the following results:

	Low offspring		High offspring	
	Number	Per cent.	Number	Per cent.
High parents..................	241	45	295	75
Low parents...................	296	55	96	25
Total.....................	537	100	391	100

Of the 537 offspring classified as low, 55 per cent of them are produced by low parents, while but 45 per cent are produced by high parents. The interesting fact is that of the 391 offspring classified as high, 75 per cent of them are produced by high parents, while only 25 per cent of them are the get of low parents.

The law of ancestral heredity.—We have seen that the new individual inherits all of the characters of the race to which it belongs, but that many of these characters are not evident in the make-up of the animal. We now come to a consideration of the probable resemblance between the new individual and his parents and to the extent to which he resembles more remote ancestors. Galton and Pearson have given much study to this question, and although working along independent lines, they have arrived at practically the same conclusions.

They state that on the average the two immediate parents contribute between them one-half of the effective heritage, the grandparents one-fourth, the great-grandparents one-eighth, and so on to infinity, so that the total heritage would be represented by one. This is called "Galton's law of ancestral heredity," and applies to generations and not to individual offspring. According to this law, the effective heritage contributed by each generation and by each separate ancestor may be represented as follows:

GALTON'S LAW OF ANCESTRAL HEREDITY

Generation of ancestors	Number of ancestors	Hereditary contribution of each generation	Hereditary contribution of each ancestor
1	2	1/2	1/4
2	4	1/4	1/16
3	8	1/8	1/64
4	16	1/16	1/256
5	32	1/32	1/1024
6	64	1/64	1/4096

This table is significant, as it indicates clearly the great importance of the immediate parents as well as the value of pure ancestors. Not infrequently, especially in animal

FIG. 14—CHEVIOT SHEEP OF GOOD TYPE

breeding, much stress is placed on some noted remote ancestor. According to the table, a superior ancestor in the fifth generation has but one chance in over one thousand in stamping a character upon the offspring.

The table also indicates the importance of pure ancestors, if we wish to foretell the characteristics of the offspring. If all the lines are pure, then we may be reasonably sure that the offspring will be like his ancestors. On the other hand, if the ancestors are mixed, no one can foretell what the offspring will be like.

Reversion and atavism.—These two terms are used to designate characters reappearing in the offspring, but not visible in the parents. Unfortunately these terms are used more or less interchangeably. Best usage warrants defining atavism as "grandparentism;" that is, skipping a generation, with the result that a character in the offspring is unlike that of either parent, but similar to the character in one of the grandparents. Good examples are furnished by the frequent occurrence of red calves among Aberdeen-Angus from black parents, as well as of red and white Holstein-Friesian calves from black and white parents.

On the other hand, reversion may be defined as the reappearance of a character which has not been manifest perhaps for many generations, although it was actually present in some remote ancestor. A good illustration is seen in the occurrence, now and then, of stripes or bars on the shoulders and legs of the horse. The appearance of a case of either atavism or reversion is interesting, but neither has any practical significance in animal improvement, as they can be discarded by selection the same as any other undesirable character.

Blended, exclusive and particulate inheritance.—Sometimes the offspring will be intermediate between the parents, showing a blend; sometimes it will resemble one or the other parent, showing exclusive inheritance; while at other times the offspring will show traces of both parents, each distinct and separate, which is known as particulate inheritance. A good example of these three types of inheritance is furnished in the case of color among farm animals. In the coat color of horses blended and exclusive inheritance is common, while particulate inheritance is occasionally observed. White and black parents often produce a roan or a gray of varying shades; at other times the offspring will inherit the color of one parent to the exclusion of the other, and thus be white or black; while occasionally, especially in the case of ponies, the new individual inherits the color of both parents, and is black and white or piebald. In such cases possibly the type of inheritance depends in a large measure on the purity of the coat color of the parent. The best illustration of particular inheritance is observed in the case of swine, where spotted offspring from black and white parents are very common, owing to the impurity of the coat color in the case of the parents, due to extended crossing in the formation of the breeds.

CHAPTER V

MENDEL'S LAW OF HEREDITY

The most promising law for the guidance of breeders at the present time is that discovered by Gregor Johann Mendel, a teacher of the physical and natural sciences in a monastic school at Brűnn, Austria, in the second half of the last century. For eight years Mendel made a series of studies, mostly with peas, on the behavior of certain hereditary characters, from which he drew some general conclusions now known as "Mendel's law of heredity," which deals with the inheritance of contrasting or allelomorphic characters in animals and plants. Although brief accounts of these experiments were published in 1865, they attracted no attention until 1900, when three botanists, de Vries of Holland, von Tschermak of Austria, and Correns of Germany, working independently, came to much the same conclusions as those formerly stated by Mendel. Since 1900 Mendel's law has easily held first place among biological workers.

The law when one pair of characters is involved, monohybrids.—To get the essential features of this law before us, we will consider an illustration. The case of coat color among guinea pigs furnishes a good example. If we mate a black guinea pig of pure descent with a white one, the offspring will all be black, similar to the black parent, and none will be white. The black color dominates in the cross, and, as Mendel says, the white recedes from view. The black character, therefore, is called the *dominant* character, and the white the *recessive* character.

Now, if two of these cross-bred black guinea pigs be mated with each other, one-fourth of the offspring will be of the same color as the white grandparent, one-fourth the same as the black grandparent, and one-half the same as the cross-bred black parents. In other words, one-fourth will be pure white, and when mated with each other will produce only white offspring; one-fourth pure black, and when mated with each other will produce only black offspring; and one-half cross-bred black, similar to their black parents, and will behave in a similar manner when mated with each other. Such an experiment is difficult, as we cannot tell the pure black from the cross-bred black until they have been mated and their offspring observed.

FIG. 15.—BLACK AND WHITE GUINEA PIGS SHOWING MENDELIAN PHENOMENA

1. Black female guinea pig and her young. 2. White male guinea pig, father of black young. 3. Two of the grown up young of a black and white guinea pig. 4. A group of four young produced by the grown up animals above.*

This phenomenon is not difficult of explanation when but one pair of allelomorphic characters are involved. The mature germ cells or gametes which united in the original cross were one black and the other white in character. Both characters were present in the cross-bred offspring, but black, from its nature, dominated. When the cross-bred black individuals produce germ cells, the black and white characters separate from each other and pass into different cells. Thus the egg cells formed by a female cross-bred black are half of them black and half of them white in character. The same is true of the sperm cells formed by a male cross-bred black. The egg cell that is fertilized is as likely to be one as the other, and the

*Figs. 15 and 17 from "Heredity," by permission of both the author, W. E. Castle, and the publisher, D. Appleton & Company.

sperm cell sharing in fertilization has similar possibilities. The results, therefore, would be as follows:

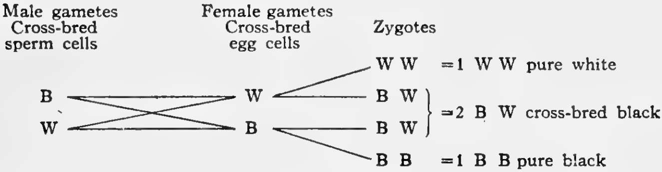

Diagram illustrating the union of male and female gametes, resulting in the occurrence of offspring in Mendelian proportions.

Perhaps the most convenient way of representing the supposed causes of Mendelian segregation, especially where more than one pair of characters is involved, is by the use of the four-square table. Along the top of the table are written the two kinds of characters that occur in equal numbers among the male germ cells of the cross-bred and along the left of the table are written the same factors for the female germ cells.

Black x white = black cross-bred

Cross-bred male gametes

		B	W	
Cross-bred female gametes	B	B B pure black	B W cross-bred black	Zygotes
	W	B W cross-bred black	W W pure white	

Diagram illustrating the union of male and female gametes, resulting in Mendelian proportions when one pair of characters is involved.

Dominants and recessives.—When two distinct varieties are crossed, in which one is dominant with regard to a certain character, while the other is recessive, the first hybrid generation (F_1) is an impure dominant. On interbreeding the second generation (F_2) can be divided into four parts—one pure dominant, two impure dominants and one pure recessive. The impure dominants on interbreeding split into the same proportions, while the pure dominants and recessives each time breed true for all successive generations. This may be illustrated diagrammatically as follows:

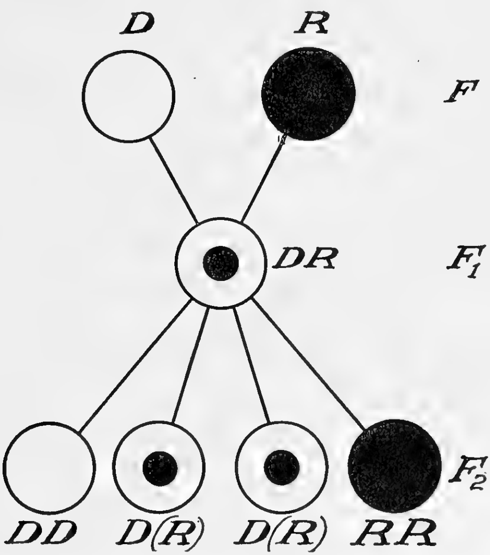

FIG. 16—DIAGRAM ILLUSTRATING MENDELIAN DOMINANTS AND RECESSIVES, IN WHICH DD STANDS FOR PURE DOMINANTS, RR FOR PURE RECESSIVES AND D(R) FOR IMPURE DOMINANTS (AFTER HERBERT)

It is important to remember that this discussion applies to characters and not to individuals. Thus when we say that an animal arising from cross-bred parents breeds true or pure, we mean only as to the single character involved.

The law when two pairs of characters are involved, dihybrids.—For convenience we will continue the illustration with guinea pigs, contrasting long and white hair with short and dark hair. If we mate a short-haired dark guinea pig of pure descent with a long-haired white one, the offspring will all be short-haired and dark. Thus short hair and dark hair are dominant, while long hair and white hair are recessive. If two of the cross-

Short—dark×long—white=short—dark cross-bred

Cross-bred male gametes

		S D	S W	L D	L W
Cross-bred female gametes	S D	S S D D short dark pure	S S D W short dark cross-bred	S L D D short dark cross-bred	S L D W short dark cross-bred
	S W	S S D W short dark cross-bred	S S W W short white pure	S L D W short dark cross-bred	S L W W short white cross-bred
	L D	S L D D short dark cross-bred	S L D W short dark cross-bred	L L D D long dark pure	L L D W long dark cross-bred
	L W	S L D W short dark cross-bred	S L W W short white cross-bred	L L D W long dark cross-bred	L L W W long white pure

Diagram illustrating the union of male and female gametes, resulting in the occurrence of Mendelian proportions when two pairs of characters are involved.

bred animals be mated with each other, four kinds of offspring will result: Dark and short-haired, like one grandparent; white and long-haired, like the other grandparent; dark and long-haired, a new form; and white and short-haired, a second new form.

The segregation in the germ cells resulting in these forms can be clearly illustrated diagrammatically by the use of the sixteen-square table on the preceding page.

Now, the four kinds of guinea pigs obtained from such a cross will not be equally numerous. Since, as we have seen in the black-white cross, dominants are three times as numerous as recessives, we should, therefore, expect the short-haired to be three times as numerous as the long-haired ones, and the dark ones to be three times as numerous as the white ones. Further, animals which are both short-haired and dark should be 3 times 3, or nine times as numerous as those which are not. Thus, we have the Mendelian proportion, nine short-haired dark, three long-haired dark, three short-haired white, and one long-haired white, which is closely approximated in actual experience.

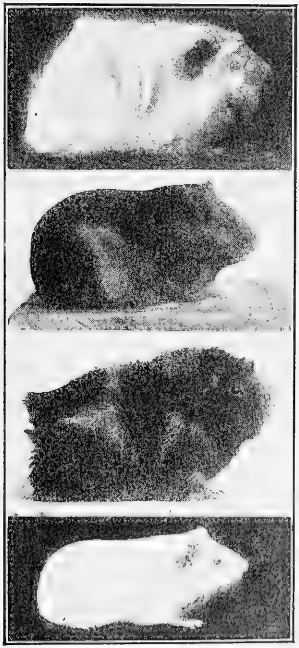

FIG. 17—GUINEA PIGS ILLUSTRATING MENDELIAN PHENOMENA WHEN TWO PAIR OF CHARACTERS ARE INVOLVED

1. Long-haired white parent. 2. Short-haired dark parent. 3. Long-haired dark, a new form arising when offspring of types 1 and 2 are interbred. 4. Short-haired white, a second new form arising when offspring of types 1 and 2 are interbred.

The breeding powers of these four forms are exceedingly complicated. The double recessive long-white is the only individual that will breed true. All other forms require trial breeding to establish their identity. This breeding power may be most conveniently exhibited in tabular form as follows:

Distinguishable types	Zygotically different types	Number	Breeding properties when mated with each other
9 S D Short Dark	(1) S S D D	1	Produces short-haired dark only
	(2) S S D W	2	Produces short-haired dark, about 75 per cent. and *short-haired white** about 25 per cent.
	(3) S L D D	2	Produces short-haired dark, about 75 per cent. and *long-haired dark* about 25 per cent.
	(4) S L D W	4	Produces short-haired dark; *short-haired white*; *long-haired dark;* and long-haired white in the ratio of 9 : 3 : 3 : 1
3 S W Short White	(5) S S W W	1	Produces *short-haired white* only
	(6) S L W W	2	Produces *short-haired white* about 75 per cent. and long-haired white about 25 per cent.
3 L D Long Dark	(7) L L D D	1	Produces *long-haired dark* only.
	(8) L L D W	2	Produces *long-haired dark* about 75 per cent. and long-haired white about 25 per cent.
1 L W Long White	(9) L L W W	1	Produces long-haired white only.

Diagram illustrating the breeding properties of Mendelian offspring when two pairs of characters are involved.
*New forms in italics.

Three Mendelian principles.—Mendel's law as illustrated in the crossing of pure animals with contrasting characters depends on three factors—unit-characters, dominance and segregation. In the illustration it was apparent that there was no relation between the length of hair and its color; each was transmitted entirely independent of the other. The length of hair, therefore, is one unit-character, while the color of the hair is another. In the germ cells there are certain determiners of unit-characters which dominate others during the development; thus they determine the apparent character of the individual by causing that character to become visible. This constitutes the dominant characters, as in the cross-bred black guinea pig in the illustration.

The idea of segregation depends upon the conception that the animal is made up of a bundle of unit-characters which may be rearranged without disturbing the identity of the various characters. When like characters are joined together, as B with B (p. 44), the animal is said to be *homozygous*. On the other hand, when unlike characters are joined, as B with W, the individual is said to be *heterozygous*. Recessive individuals are always homozygous, as W W, for example. They do not contain the dominant character, otherwise they would show it.

Creation of new forms.—When short-haired dark guinea pigs of pure descent are mated with long-haired white ones and the hybrid form resulting therefrom interbred, two new varieties arise—long-haired dark and short-haired white. New varieties may be created by gain, loss or transfer of characters from existing forms. Having obtained a new variety, the next step is to fix it so that it will breed true from generation to generation. To fix these new forms so that they will breed true is somewhat involved, especially when there are a number of dominant characters, although it would be comparatively simple if dealing with a combination containing only recessive characters, as they are always homozygous and hence breed true from the beginning.

The most direct method of fixing a new variety would be to test by suitable mating the unit-characters of each individual to determine which are homozygous, and breed from those, as they show only the desirable combination of characters, and to reject all heterozygous individuals, as they contain undesirable characters. Thus, if we were to fix the short-haired white variety, we would determine by mating the S S W W individuals in the tables (pp. 46 and 48), and select these for breeding, rejecting all others. In this way a pure race may be established. Such a method, though sure, is likely to be very slow, as the numbers are limited, and it involves the application of the breeding test to many individuals in order to determine the homozygous individuals, most of which must then be rejected.

It is, therefore, often better in practice to breed from all animals showing the desired characters—in this case short-haired white—and eliminate from their offspring such individuals as do not show the proper combination of characters. The short-haired white variety will thus be gradually purified and a large stock of it can be built up much more quickly.

Application of Mendel's law.—The examples show that the coat color character and the length of hair character can be transferred from one guinea pig to another when separate animals possessing these particular characters are mated according to Mendel's law. The long-hair character of the original white animal was transferred to the dark animal; and the short hair of the original dark animal was transferred to the white animal. Likewise, the white coat of the original long-haired animal was transferred to the short-haired animal, and the dark coat of the short-haired animal was transferred to the long-haired animal.

In plants this transfer of characters from one individual to another has been demonstrated to be of great economic importance. Thus the stiff character of the straw of low-yielding varieties of wheat has been transferred to high-yielding varieties, in which much trouble had previously been experienced from broken straw. Likewise, immunity to rust in wheat has been transferred to varieties which formerly were very susceptible to rust. There are numerous examples of this sort among plants.

Among animals fewer cases of the Mendelian phenomena have been reported, although it is stated that the trotting and pacing habit among horses behaves according to Mendel's law, also that chestnut color is a Mendelian recessive. The red and white color of Shorthorn cattle is said to be transmitted in Mendelian proportions, as is also the hornless character when appearing in horned breeds of cattle. Many features of the comb, the plumage and the rumpless condition of poultry have been shown to be inherited in accordance with Mendel's law. Poultrymen experience difficulty in breeding blue Andalusian fowls. When blue Andalusians are mated together, the offspring are of three colors—black, blue and white—in the Mendelian proportion of 1:2:1, while the result of crossing a black and a white is a blue Andalusian. This shows conclusively that the blue Andalusian is a cross-bred, and the significant point to remember is that it will not breed true.

Transferring characters.—At the present time there is very little data available to show to what extent the more economic factors, such as high fertility, early maturity, rapid fattening, high quality in milk and like characters, follow the Mendelian proportions in transmission. In this connection James Wilson of the Royal College of Science, Dublin, Ireland, makes some interesting observations. He says: "There are many cases of the transference of characters from one race to another. Modern Aberdeen-Angus cattle got their size, and probably their fattening capacity, from English Longhorns and Shorthorns; their color from the old Celtic cattle; their hornlessness from cattle brought from Scandinavia by the Norsemen, and probably also the shortness of the leg and the high quality of milk which they frequently manifest, from the same source. Shorthorns got their flecks from Dutch cattle and their white color from the white cattle existing in the North of England in the 18th century. The roans are crosses between the white and the red. The North Devons probably got their shortness of leg from Norse cattle. The American polled Herefords and Durhams got their hornlessness chiefly from Norfolk polled, and some of it from Aberdeen-Angus cattle."*

Wilson also gives an example of transferring the Jersey high quality milk, testing about 5 per cent, to Red Danish cattle, testing about 3.3 per cent butter fat, by practically the same method as that suggested in the discussion on creation of new forms (p. 49).†

Possibilities of Mendelism.—The discovery of the Mendelian phenomena opens a vast field of research. Among animals practically nothing has been done to determine the possibilities of Mendelism. Few accurate observations have been made, and those of Wilson are very suggestive. Think of the advantage to be gained could the high flow of the Holstein-Friesian, the high quality of Jersey milk and the early maturity of the Aberdeen-Angus be transferred to the Shorthorn, or could the vigor and fertility of the Large Yorkshire and the quality of the Cheshire be transferred to the Poland China! Likewise, think of the economic advantage to be gained could the quality of the Arabian, the endurance of the mustang, the action of the Standardbred, and the fertility and longevity of the Thoroughbred be transferred to the Percheron! Hitherto we have held such to be physically impossible, and no doubt much of it is, although, so far, exact proof is wanting.

On the other hand, if we place reliance in Wilson's observations, then the triple-purpose cow—beef, butter, milk—not only seems to be a possibility, but very probable. We now have abundant data to show that fat cows give as much and more milk and butter fat than lean cows. Now, if high-quality fat can be transferred to the high-milking cow, then there is no physical reason why we cannot develop a triple-purpose cow; that is, a

*James Wilson, "The Principles of Stock Breeding," pp. 95, 96.
†James Wilson, "The Principles of Stock Breeding," pp. 126-132.

cow yielding a Holstein-Friesian flow of Jersey quality and at the same time producing Shorthorn beef.

In view of the vast opportunity before the Shorthorn breeders, together with the strong demand for dual-purpose cattle, it seems strange that this is the only breed whose adherents are advocating dairy or dual-purpose cattle that has not established a system of advanced registry in which to record dairy performance. There seems to be no reason to doubt phenomenal development in dual-purpose and possible triple-purpose Shorthorns were the breeders given encouragement similar to that given the Holstein-Friesian breeders.

Mendelism and reversion.—Mendel's theory explains why reversions appear and why they gradually decrease with time. Take, for example, the red color among Aberdeen-Angus cattle. Among the original stock there were many colors, such as red, yellow, dun, brown, white and the like, although black predominated. However, red was the only color which was recessive to the desired color, black, and the only one which could be carried by a black animal without the animal showing its presence. Thus, by avoiding the other colors, they were rapidly eliminated. Not so with the red; it, being a recessive, was frequently concealed beneath the black. Red and white among Holstein-Friesian cattle act in a similar manner.

Black animals which produce red calves are impure blacks. They contain both red and black determiners. When such a reversion appears the breeder usually eliminates the cow, lest some of her descendants may be similarly marked. No blame is placed on the bull with which she was mated; nevertheless, he is equally responsible, for unless both are impure blacks or recessives, they could not have produced a red calf. In fact, the possible damage the cow could have done is very small when compared with the bull. On the average, when mated with pure black bulls, she could have produced only one impure black every two years, while the bull, even though mated with pure black cows, could have left 30 or 40 times that number. The breeder, of course, can have no suspicion that his stock is impure in color until two impure blacks are mated, for then only will the red appear, and that but one in four on the average.

Limitations of Mendelism.—Practically all of the animal characters that have been mentioned as unit-characters, following Mendel's law, are external ones. These are of little importance in animal breeding. Few experimental attempts have been made to determine unit-characters of the body-form or function. Such factors are exceedingly difficult to investigate. In a consideration of the inheritance of such factors the chief difficulty lies in the possibility that a number of characters are concerned, many of which, for various reasons, do not seem to follow the Mendelian phenomena. In fact, the importance of Mendel's law has been retarded rather than advanced by the attempt at universal application on the part of its adherents generally. Among farm animals experience in crossing types to improve the form or function has thus far proven very disastrous. This is a very common practice of the American farmer, but certainly does not seem to be a wise one.

As has been seen, when but two pairs of unit-characters are involved the offspring are of four sorts, two of which are exceedingly difficult to fix (p. 49). This difficulty increases rapidly as the unit-characters involved increase. This is well illustrated by mating two guinea pigs with three pairs of characters, as color, length and direction of hair. Thus if we mate a short-haired, dark, smooth guinea pig with a long-haired, white and rough one the resulting offspring will be short-haired, dark and rough, these being the three dominant characters, two derived from one parent and one from the other.

Now, if these short-haired, dark and rough cross-bred animals be mated with each other the offspring will be of eight sorts and in the following proportions:

27 short-haired, dark, rough	3 long-haired, dark, smooth
9 short-haired, white, rough	3 long-haired, white, smooth
9 short-haired, dark, smooth	3 short-haired, white, smooth
9 long-haired, dark, rough	1 long-haired, white, smooth

Likewise, if four pairs of characters are involved, the offspring will be of 16 different varieties and in the proportion of 81 : 27 : 27 : 27 : 27 : 9 : 9 : 9 : 9 : 9 : 9 : 3 : 3 : 3 : 3 : 1.

The large number of new types and the difficulty of fixing them seems very remote, especially when we contemplate the crossing of fixed breeds of farm animals. The trial breeding and the elimination necessary to fix new types, when only a few pairs of characters are involved is so great as to make it impractical. When but one pair is considered, only one in four is pure for one character, and the number of pure stock produced grows rapidly smaller as the number of characters increases, as shown in the tabulation:

1 pair	1 animal in 4	is pure for one character
2 pairs	1 animal in 16	is pure for any two characters
3 pairs	1 animal in 64	is pure for any three characters
4 pairs	1 animal in 256	is pure for any four characters
5 pairs	1 animal in 1024	is pure for any five characters

The number of characters involved in crossing any of the breeds of farm animals is great, and the number of animals necessary for the trial breeding, as well as the very large elimination, places the practical working of Mendel's law in a very different light from that in which it appears to the plant breeder, where numbers are of no consequence.

CHAPTER VI

SELECTION IN ANIMAL BREEDING

The breeding of useful farm animals depends very largely upon our ability to select animals with skill and judgment. In the discussion on heredity it was stated that the offspring inherit all of the characters of the race to which they belong. The offspring of given parentage, therefore, may be low, medium and high in any particular character in which improvement is sought. In the discussion on Mendel's law it was also indicated that the best way to secure a given type so that it would be transmitted with reasonable certainty from parent to offspring was to select for mating those animals possessing in the most perfect form the characters which we wish to secure in the offspring. Selection is, therefore, the all-powerful agent in controlling the characters of farm animals generally.

Objects of selection.—As has been suggested, the necessity for selection is based on the tendency of offspring generally to vary, in all important characters, from their parents. Inferior animals should be eliminated from breeding, as they tend to reproduce themselves. On the other hand, superior offspring should be selected for breeding, as they also tend to reproduce themselves and to show still further improvement. Thus one of the primary objects of selection is to improve the ancestry, preventing, so far as possible, the birth of unwelcome individuals not suited to the purposes of man. The animal breeder can prevent the birth of unprofitable individuals approximately in proportion as he is skilled in selection.

Among our farm animals, especially meat-producing animals and males, more individuals are born than can

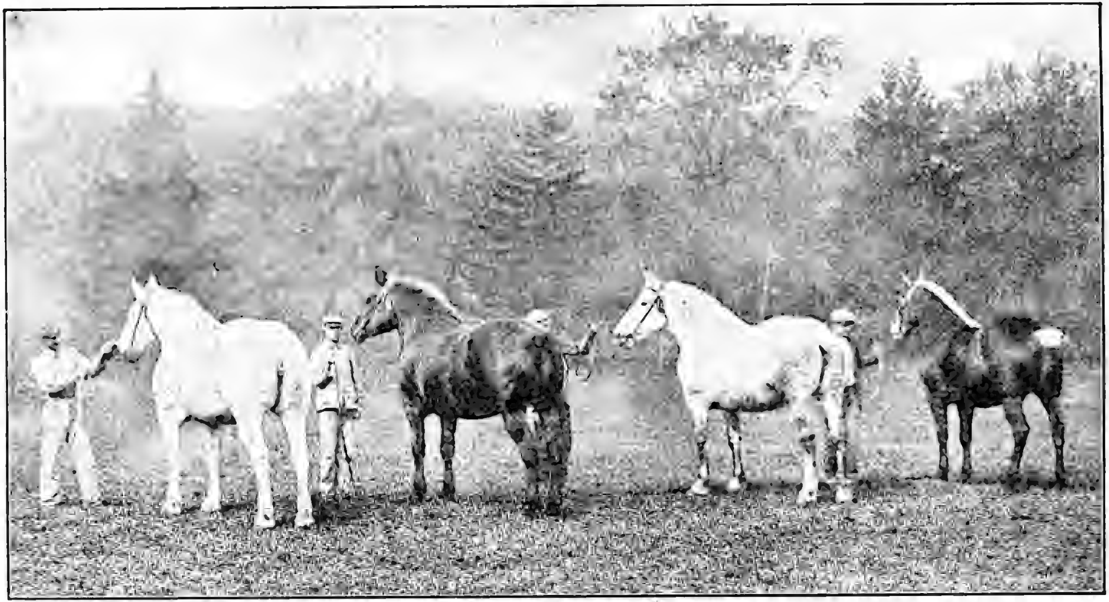

FIG. 18—PERCHERON MARES OF EXCELLENT TYPE

be used in breeding, so that it becomes necessary to reduce the number. A second object of selection, therefore, is to reduce numbers. This affords the breeder an opportunity to influence the character and type of his animals, as only superior ones should be retained for breeding purposes. While selection is a very important factor in establishing type, it does not greatly reduce variability. This necessitates watchfulness on the part of the breeder, as he must eliminate all animals from breeding that do not meet the requirements of the given type.

Standards of excellence in selection.—The breeder must have a definite ideal or a standard of excellence for his guidance in selecting his breeding animals. Among the great run of variation which every breeder will encounter, he must know which are useful, which are fanciful and which are mere novelties. The standard must not be altered by fancy considerations or by novelties, no matter how curious or attractive.

The standard must be fixed in advance. It should be wisely chosen in the light of what is needed. Due consideration should be given to every influence. Once chosen, however, the standard should be preserved unchanged. Blood lines must be kept pure, not only within the breed, but within the strain or family with which we are working. This is emphasized by the law of ancestral heredity and by the fact that no matter what the parent, the offspring tends strongly toward the average of the race to which it belongs.

History of the breeds.—When the breeder selects the individuals that are to reproduce, it must be done in the light of all the knowledge available. He must know the weak characters as well as the strong points of the breed with which he is working. This necessitates a thorough knowledge of the history of the breed. The absence of such intelligence is responsible for many failures.

This is well illustrated in the case of the Percheron draft horse and in Berkshire swine. Most of the breeds of draft horses, particularly those native to the British Islands, are rather heavy in bone. This has led the English draft-horse breeders to select for refinement in bone. Not infrequently a Percheron draft horse breeder selects his animals on the same basis, which results in too light a bone and lack of endurance in the limbs. The explanation of this is that the light horse of Arabia played a very important part in the formation of the Percheron breed, which, therefore, is predisposed to light bone. The same is true of Berkshire swine. This breed of swine resulted largely from crossing the small, refined, quick-maturing Neapolitan hog upon the large English hog; and many are the Berkshire herds that have been ruined by selecting for breeding purposes the most attractive, refined and quick-maturing pigs.

Breed peculiarities.—Not only is a knowledge of the history essential, but one must be familiar with the inherent faults of the breed with which he is working. He needs to know, for example, that the Clydesdale is often deficient in the rear ribs, which gives the body a rangy appearance; that the Shire is often rather straight in the pastern, with heels low and flat; and that the Belgian is often criticized for lack of substance in the bones of the legs.

The breeder of Jersey dairy cattle should realize in advance that individuals are often extremely delicate, and the Holstein-Friesian breeder should know that the breed is rather rough, possessing a short tail. He who expects to breed Shorthorns needs to know that the breed is of many types, varying widely in excellence, while the Galloway breeder should not be surprised at considerable roughness, particularly in aged animals.

When breeding swine it is important to know that the Berkshire is naturally deficient in ham, and the Poland China in the shoulder; that the Chester White is a bit coarse in the bone; and that the Duroc-Jersey is uneven in type. These and the numerous other breed peculiarities, both desirable and undesirable, should be in the mind of the breeder before he begins his breeding operations.

Vigor, longevity and fertility.—We are so interested in securing a desired type or character that we often operate against valuable physical qualities, such as general thrift, endurance and fertility. This is best illustrated in the case of swine, although true of farm animals generally. Since the early-maturing, heavy-fleshed swine win in the show ring, they are selected for breeding. Such animals are often so refined that they lack vigor and fertility. Under such practice it is not surprising that many of our breeds of meat-producing animals lack vigor and longevity as well as fertility.

Contrast with this the endurance and prolificacy of a few individuals that developed under more natural conditions. The noted Angus cow Old Granny (No. 1 in Angus Herd Book) produced 25 calves, the last one in the 29th year of her life, and she lived to the ripe old age of 36 years. The famous English Thoroughbred mare, Old Fanny Cook, produced 15 foals, giving birth

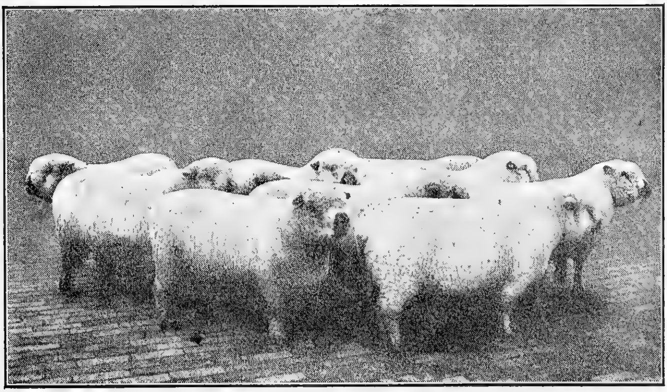

Fig. 19—Shropshire Sheep Uniform in Type

to twins at 22 years of age, and she lived to be 33 years old. From a profitable point of view, the importance

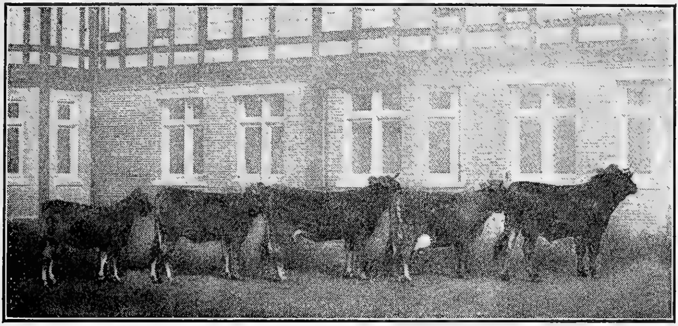

FIG. 20—BROWN SWISS HERD TRUE TO TYPE

of selecting to promote such physical properties, need not be dwelt upon.

Large numbers promote uniformity.—Since our farm animals are so variable, in all important characters, large numbers are necessary in order to provide sufficient material to secure uniformity in type. This was suggested in our study of heredity, where it was stated that the offspring inherit all of the characters of his race. Suppose that we have a small uniform herd of even very exceptional animals—say, four cows and a bull. Since the offspring vary throughout the limits of the race, we would find it difficult to preserve even a single character on a uniform basis from generation to generation; and the herd once exceptional and uniform would rapidly lose its identity.

In this connection the practice to pursue will depend entirely upon the conditions. Thus the dairy breeder possessing a common herd of cattle varying in productivity, some individuals scarcely paying for their keep, while others are paying a good profit, is often at a loss to know what disposition to make of the inferior individuals, particularly if they are regular breeders. In this case the inferior animals should be eliminated, even though the number of animals in the herd be materially reduced, as such individuals tend to reproduce others of their kind.

The exceptional breeding animal.—Of even greater importance than uniformity in type, large numbers are absolutely necessary to secure the maximum value of the exceptional breeder. This is significant, since the excellence of any herd or breed is usually due to a few exceptional breeders. We have examples of this on every hand. The Hambletonian family of Standardbred trotting horses owes its high speed development to a very few exceptional animals descending from Hambletonian 10 and his noted son George Wilkes. Of the thousands of Standardbred stallions recorded in Wallace's Stud Book, there are but 11 with 150 or more performing offspring to their credit; that is, offspring that have trotted a mile in 2:30 or better, or paced one in 2:25 or better. Now, of these 11 stallions, five are sons of George Wilkes and three are grandsons, while all are sons, grandsons or great-grandsons of Hambletonian 10, with all but one in the paternal line. In a similar manner, the Hal family of Standardbred pacers descended from Tom Hal, the Morgan family descended from Justin Morgan, and the American saddler descended from Denmark.

Equally as good illustrations of the value of the exceptional breeder and the importance of large numbers is found among dairy cattle. The De Kol strain of Holstein-Friesian dairy cattle owes its high milk and butter fat production to a very few exceptional animals descending from De Kol 2d. Of the thousands of bulls recorded in the Holstein-Friesian Herd Book, there are but five with 100 or more advanced register daughters to their credit; that is, daughters capable of making the requirements for admission to the advanced register

—producing 12 pounds of butter fat per week at 5 years of age. These five bulls are sons, grandsons or great-grandsons of the phenomenal cow, De Kol 2d. While such remarkable breeding records depend on opportunity, it serves to illustrate the importance of having large numbers of animals available with which to mate such exceptional breeders in order to secure maximum advantage.

Comparative value of sire and dam.—Considering the offspring of a single mating, neither parent has any particular advantage over the other, and both are practically equal in controlling the characters of the offspring. On the other hand, the sire has a decided advantage over the dam in that he can influence large numbers in a breeding season, whereas the dam can control but one, or at most a few, as is the same of swine. The real difference, therefore, is one of numbers.

This principle is well illustrated in the case of the 11 Standardbred stallions referred to above, each with 150 or more performing offspring to his credit, whereas there are but few mares that have 10 or more performing offspring in the list. The Holstein-Friesian bull, Lord Netherland De Kol, has 120 advanced register daughters, whereas Aaltje Salo 5th's Netherland, with eight advanced register daughters, is the leading cow of the breed in the number of performing offspring to her credit (1913).

Influence of the sire.—From the foregoing it is evident that the upper limit of the sire is comparatively very high and the dam very low. The statement is often made that the sire is half the herd, whereas he is far more than that. He is one-half the herd the first generation, three-quarters the second, seven-eighths the third and fifteen-sixteenths the fourth. So powerful is the influence of the sire that if careful selection be maintained for a few generations, he will mold the character of the entire herd. This fact should warn us of the necessity of exercising extreme care in the selection of the sire.

The great influence of the sire is of advantage to the practical breeder, as he can improve his herd cheaply by the use of a good sire. Possibly the beginner with limited means should procure a number of rather plain females and a male of as good quality as he can afford, rather than to start with a small herd of good females and a male of fair quality.

Fig. 21—Poland-China Sow of Good Type

Suitability for mating.—Two animals to be suited for mating should be as nearly alike in general physical characters as it is possible to obtain. Since no two animals are exactly alike, we must strike an average between the characters of the parents and what we desire to get in the offspring. It is a serious but common error to suppose that the bad points of one parent can be overcome by good characters in the mate. The foundation of successful breeding lies in the mating of two animals each of which is as nearly perfect as possible. When the offspring shows good qualities, the mating of the parents is considered a fortunate *nick*. The success or failure of the breeder often depends on his ability to discover these nicks and to make use of them. Some persons become very skilled in these matters.

CHAPTER VII

UNIT OF SELECTION—CHARACTER

The unit of selection is not the individual, but some particular attribute or character of the individual. Thus, in the selecting of dairy cattle for breeding purposes, capacity to secrete milk is one of the chief characters sought; in selecting beef cattle, ability to fleshen rapidly; in selecting draft horses, weight; and in selecting swine for breeding, capacity to fatten rapidly is one of the chief characters taken into account. Of course, in each case, many other factors or characters must be considered, as certain characters are more or less dependent one upon the other.

Character defined.—In common usage the term "character" is loosely applied and has a variety of meanings. When one animal differs from another, we say he has different characters. Thus we say of one horse that he has speed, and of another that he has not speed; whereas both have some speed, but only one has enough to be worthy of note. What we really mean, therefore, is that the character, speed, differs in the degree of development in the two animals. Now, when the speed has been improved, we speak of introducing a new character, whereas the improvement simply consisted of modifying a character already present.

Such modification or development may be brought about by intensifying useful characters or by the subordination of those that are less desirable. The fact that characters do not differ in kind, but only in degree, must be kept clearly in the mind of the breeder when selecting animals for breeding. The term character may be defined, therefore, as consisting of one of those details of form or function which, taken together, constitute the individual animal.

Germinal, acquired and congenital characters.—Attempts have been made to group characters into classes according to their mode of origin. Best usage warrants defining germinal characters as those having their origin in the germ plasm itself, as in the case of white, short-haired guinea pigs descending from dark, short-haired and white, long-haired guinea pigs (p. 47). Acquired characters are defined as those that originate within the individual under suitable environment, as the increased speed of the race horse, due to continuous training. Congenital characters are defined as those arising within the individual also, and usually in spite of anything it can do to prevent them, such as parental disease, the result of uterine infection; unsoundness in horses, the result of inherited weakness; and the like. However, it is often difficult to differentiate between these three groups, as the mode of origin cannot always be determined with certainty.

Correlated characters.—In our selection to improve desirable characters or to subdue those that are undesirable we should keep in mind the fact that certain characters seem to be so correlated as to move together, while others move in opposite directions, and still others move independent of each other. For example, there is a high degree of correlation between a capacious udder and high milk production, while there is a negative correlation between the amount of milk produced and the per cent of fat that it contains; for, as the milk production increases, the per cent of fat usually decreases. On the other hand, there is entire lack of correlation between the color of a cow and the amount of milk she gives, since black cows give as much and no more milk than white cows.

This relationship is one of degree only, but it often becomes an important factor in selecting breeding animals. For example, delicacy is often associated with refinement, and sterility with early maturity. Thus, continued selection for refined, early-maturing animals often leads to barrenness and lack of vigor. In like manner the exceeding fineness of the Merino fleece has been attained at the cost of diminished vigor. There is a high degree of correlation between excessive fatness and sterility in both sexes, as well as between fatness and troubles attending parturition in the female once she becomes pregnant. We have numerous examples of such relationships, both good and bad, and the breeder will do well to acquaint himself with the more important of them before he selects his breeding animals.

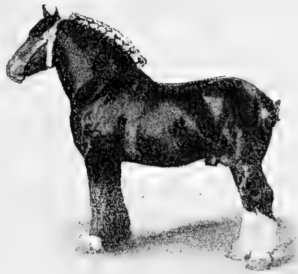

FIG. 22—SHIRE STALLION "LOCKINGE HINGIST"

Limit selection to useful characters.—In each of our breeds of farm animals we have so increased the number of characters that we are no longer able to find a very large proportion of them in any one individual. In selecting our breeding animals we are often obliged to take those possessing some undesirable characters in order to get sufficient animals that meet the requirements. This makes real progress very slow.

Among the great number of characters which every breed presents, the breeder should know which are useful. He should decide upon a very limited number of these and put all of his energies into their improvement. This will have the decided advantage in that they will be found in a large number of animals, and he can, therefore, make his selection more rigid for the particular characters in question. A little effort in this direction would soon work wonders, as is exemplified in the speed of the trotting horse, where the time has been reduced from 2:48½ in 1810 to 1:54½ in 1913. In this case speed alone was the requirement. Even more striking results have been attained with Holstein-Friesian cattle, where the butter fat yielded in seven days has been increased from 21.2 pounds in 1894 to 35.3 pounds in 1913. In this case ability to produce butter fat was the requirement.

Base selection on limited number of characters.—As suggested in the case of the trotting horse and dairy cow, where we base selection on one point, improvement comes rapidly. Of course the particular character involved depends on many subordinate factors, such as vigor, capacity, endurance and the like, but all unessen-

Fig. 23—Dutch Belted Herd of Excellent Type and Characteristic Markings

tial points, as size, style, action and conformation, have been disregarded for the one object—speed in the trotter and high milk and butter fat production in the cow.

On the other hand, difficulties in selection increase rapidly with the increase in number of factors on which selection is based. Let us assume a case where two characters are involved. If one of the required factors can be found in one-half of the individuals, then one-half of the animals are available for breeding. To this let us add a second character that can be found in one-third of the individuals. Now, the probability of finding the two characters in the same individual becomes $\frac{1}{2} \times \frac{1}{3}$ or $\frac{1}{6}$, so that but one animal in six meets the requirements. This is particularly true of characters that do not correlate, as color and milk production, or color and tendency to fleshen rapidly. Notwithstanding this fact, many of our breeds exhibit just such handicaps as is illustrated in the black color and white belt, a breed requirement of Dutch Belted cattle and Hampshire swine (Figs. 23 and 24).

Records of performance.—After deciding upon the economic characters we are to strive to improve, a record of these characters should be kept, as such is invaluable in mating our animals. Such records are essential to highest development, as we are unable to tell what an animal can do simply by a physical examination. No one is so base as to claim to be able to tell how fast a horse can trot, or how heavy a load he can draw by looking at him, likewise no one can tell how much milk and butter fat a cow will produce, or how much wool a sheep will grow, on the basis of a physical examination alone.

With a record of the economic character in question available for each individual, we are able to distinguish the high-producing from the medium and low-performing animals. Such records enable us to mate the best with the best, and thus improve the particular character with which we are working. The remarkable success attained in breeding dairy cattle in recent years has been due in a large measure to the fact that the breeders kept a record of the milk and butter fat produced. Thus the breeders were able to know for a certainty, not only the records of the animals they mated, but the records of their ancestors as well. With most of our breeds of farm animals the difficulty comes in devising a scheme for measuring the particular characters for which the animals are produced.

Actual breeding test valuable.—In selecting breeding animals we are confronted with the fact that certain individuals transmit their qualities with a high degree of certainty while others do not. This is all the more confusing because the exceptional breeder is not necessarily the exceptional individual. Neither Hambletonian 10 nor De Kol 2d were remarkable performers in themselves, although the former founded a great family of trotting horses, while the latter is the ancestress of the most remarkable strain of milk cows the world has ever seen.

FIG. 24—HAMPSHIRE SOW WITH CHARACTERISTIC MARKINGS

The only method by which we can ascertain the actual breeding value of an animal is by a breeding test. In testing young females they should be mated with a male of known worth, or in testing a young male he should be mated with females whose breeding value is well known. The offspring of young animals thus mated will indicate which should be retained and which should be eliminated, although in the case of dairy cows it is necessary to have the performance of the offspring before we can know for a certainty. To save time, the young animals may be tested at a comparatively early age, especially males. The common practice of putting a new, young sire into full service in a large herd, without a test of his breeding capacity, cannot be too strongly condemned, no matter what his individuality or his pedigree.

Breeders' fancy points.—Many of our leading breeders have adopted breed standards that operate as a check upon the maximum development of useful characters. A very good example of this is observed in the color markings of Dutch Belted cattle, already mentioned. According to this requirement every cow must first have a white belt about the body, which certainly adds nothing to her ability to produce milk. Many high-producing cows are eliminated from breeding simply because they are deficient in this character. Possibly this serves to keep the breed behind its competitors as milk-producing animals.

The same principle is involved in nearly all of our leading breeds, as their standard of perfection calls for similar fancy points. Thus the Clydesdale and English Shire draft horse must have long hairs growing from the back of the cannons and fetlocks; chestnut color is favored among Suffolk draft horses and Hackney coach horses; the Holstein-Friesian cow must have a large escutcheon, a long tail and be black and white in color; the Jersey cow must have a black tongue; the Ayrshire cow must have characteristically shaped horns and a straight back from base of horn to tail head; and Hampshire swine must be black in color with a white belt, while Poland China and Berkshire swine must be black in color with six white points, as well as free from curling hair along the back. Such fancy points add nothing to the usefulness of the individual; they simply serve to complicate selection and act as a check upon maximum development of economic characters.

Fashionable breeding.—It often happens in the careers of a breed that fashionable strains or families make their appearance. Such families may owe their reputation to certain notable animals, or they may result from the activity of some promoter, and the popularity may, or may not be due to real merit. For a time animals belonging to such families command a high price, and not infrequently many small breeders become actively interested, in the belief that they can make a large sum of money and sell out before the popularity wanes. They

FIG. 25—HEREFORD CATTLE WITH CHARACTERISTIC MARKINGS

often pay a very large sum of money for an animal to be placed in a small herd where there is utter lack of opportunity. Under such conditions the breeder seldom realizes his money even though the individual animal may be an excellent one. It will be to the financial advantage of the small breeder, as well as to the economical advantage of the breed, for him to handle the best animals within his reach, and leave to the large breeder, with every advantage at his command, the promotion of fashionable strains.

Passing fads.—The breeder's work is often complicated by fads and fancies of the public. A good illustration is observed in case of the shape and size of hen's eggs. Some markets, especially New York City, pay more for white eggs, while other markets, as Boston, pay more for dark eggs; some markets demand a roundish egg, while others prefer those of oval shape. The same principle is involved in many other characters, such as action and color among horses, and the like. This is a serious consideration, as the breeder must supply the demand or his products will remain unsold. Since the breeder must sell his products or go out of business, there is nothing left for him to do but supply the demands of passing fads and fancies with as little destruction to his breeding animals as possible.

Such demands can often be met by training, fitting and conditioning, especially in cases like the action and carriage of horses. A passing fad can often be supplied by the sire, thus enabling the breeder to retain his female stock. No matter how pressing the fad, a few of the original breeding animals should be retained as a protection against the day when the particular character involved shall no longer be in demand.

CHAPTER VIII

BASIS OF SELECTION—VARIATION

In the discussion of heredity it was stated that in the main offspring resemble parents, but in an exact sense the new individual is never like either parent. This variation between parent and offspring is at once the hope and despair of the breeder, who seeks to hold fast to whatever he has found that is good, and at the same time tries to find something better. The practical breeder must keep clearly in mind the very important fact that offspring are exceedingly variable, and while a few may be superior to their parents, more will be inferior to them. In order to improve or even maintain our animals in their present excellence we must reject those offspring that are inferior and select for mating those that are superior to their parents.

Variation general among farm animals.—The most invariable thing about living beings is their variability. Not only are no two animals equal, but no two characters are exactly alike. To those unfamiliar with sheep, each animal of a flock may look exactly like the others, yet the trained eye readily recognizes differences and can describe each so that those with equal training may recognize them. These differences extend to all characters. Two cows of like breeding may differ widely in the richness of their milk as well as in the amount produced; two horses of the same breed may differ in conformation, action and pulling power; two steers of like breeding differ in their ability to fatten, and the meat may also differ, the loin of one being fine and tender while the other may be coarse in grain. Sheep, swine and poultry differ similarly.

Variation basis of improvement.—If characters were absolutely fixed and unchangeable, then no improvement could be secured. The richness of milk as well as the amount produced could neither be increased nor diminished, and the egg-laying capacity of hens would remain constant from generation to generation, and the off-

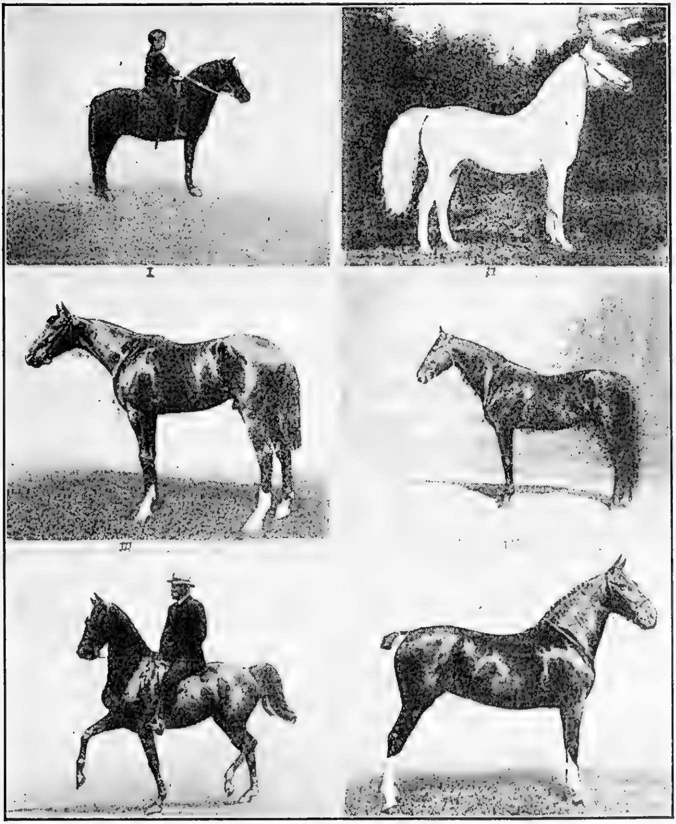

FIG. 26—VARIATION AMONG LIGHT HORSES

Shetland pony. Arabian.
Thoroughbred. Standardbred.
American saddler. Hackney.

spring would be no better or poorer than the parent. As it is, with variability everywhere, our animals are both capable of improvement and liable to decline, since both are the logical consequence of free variability. It is obvious that a high degree of variability is favorable to advancement, as it gives free materials with which to use selection to advantage. Since variation is the controlling factor in the improvement, as well as the degeneration of our farm animals, we should make a careful study of the kinds, as well as the nature, the extent and the causes that control its appearance and determine its permanency.

Nature of variation.—While there is much confusion among breeders, both plant and animal, as to the nature of variation, there are two kinds that the practical breeder must keep clearly in mind. In our discussion of the character as the unit of selection, it was shown that to be sure of the breeding capacity of an animal, we must have, not only a record of the performance, but a record of the breeding capacity as well. The statements there made carried the suggestion that a record of performance was not sufficient data to judge an animal's breeding capacity, as the offspring of some individuals are uniformly good, while the offspring of animals apparently as good are uniformly inferior.

In other words, some individuals transmit their good qualities to their offspring, while others apparently do not. Further, some animals transmit the ability to show still further improvement *under suitable environment,* while others do not transmit such ability to their offspring. Thus we have two kinds of animals—one class transmitting its good qualities, however attained, and a second class that does not transmit them. These two classes of animals give us the distinction between the two classes of variations. Thus we have one class of variation that is passed down from generation to generation, and another class which is not thus handed down from parent to offspring. The class that is not transmitted is called *non-inheritable* variation, while the class that is transmitted is called *inheritable* variation, although the former is often called somatic variation and the latter germinal variation.

Non-inheritable variations.—From the breeder's point of view the distinction between non-inheritable and inheritable variations is significant. The former, while of inestimable value to the individual, is of no consequence in breeding. Whether desirable or undesirable such variations have no opportunity to affect the breed as a whole either favorably or unfavorably. On the other hand, from the standpoint of economic production alone, non-inheritable variations may be of prime importance. Good examples are observed in the case of high-producing cows in a commercial dairy where no attempt is made to raise the calves, as well as in the case of high egg-laying hens on a poultry farm where all of the eggs are sold for consumption. Thus, where the product of the individual is the sole object sought, non-inheritable variations are as important as inheritable. In this connection it should be noted that frequently the very phenomenal producers are of the former sort, for rarely do they transmit their qualities to their offspring; particularly is this true in case the product is of such a nature as to draw heavily upon the constitutional vigor, as in the case of egg-laying hens.

Inheritable variations.—As this term is used to denote all variations, whether large or small and of whatever origin, that are transmitted from parent to offspring and from generation to generation, it is obvious that such variations are of prime importance to the breeder, as they are destined in time to exert a more or less permanent influence upon the breed, whether for good or evil. True, it may not be possible for the breeder to distinguish between inheritable and non-inheritable variations at the time of their appearance. He may have to try them out to differentiate between them, but such is the case in all forms of breeding, as has been clearly illustrated in the discussion of Mendel's law. It is this that makes records of performance, both in production and breeding capacity, so essential to successful breeding.

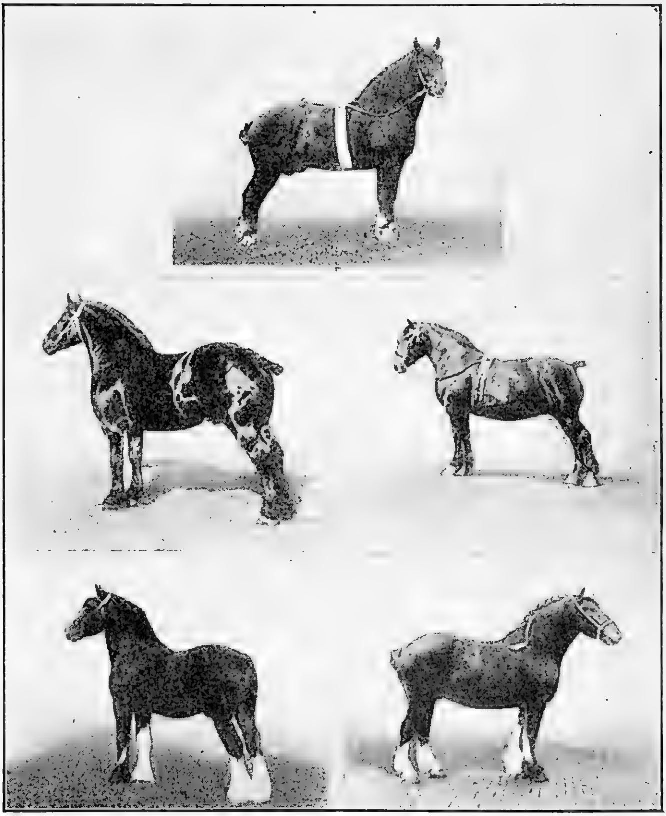

FIG. 27—VARIATION AMONG HEAVY HORSES

Suffolk Punch

Percheron. Belgian.
Shire. Clydesdale.

The breeder must not become confused by the endless number of variations, involving all shades of differences, that present themselves to his view as generations come and go. He must learn to consider them, with the full realization that few will have a permanent influence upon the breed. He must become skilled, not alone in detecting useful characters, but those that are connected with transmission, since they are to mold the type. This calls for extended and careful observations as well as the keeping of accurate records of production and breeding capacity.

Variations distinguished from the nature of the characters involved.—The breeder can gain an idea of the nature of variations by a careful consideration of the characters involved. Certain distinctions exist, which, if overlooked, will result in more or less confusion in selecting breeding animals. For sake of clearness useful characters may be divided into four groups:

1. *Quantitative variations.*—These relate to differences in form and size. They are the simplest of variations, and we observe evidence of them on every hand. For example, two horses of the same breed may be practically alike, except one may be large and the other small; even on the same horse one foot may be larger than the others, the two ears may not be of the same size, one eye may be larger than the other, and so on—all variations in size. In a similar manner, one cow may have a symmetrical udder with four full quarters and with the teats well placed, while the other cow may have a very irregular udder with the hindquarters larger than the fore ones, and with the teats very unevenly placed—all variations in form independent of size.

2. *Qualitative variations.*—Such relate to differences in quality. These are distinct from size and form and refer to the composition of the body, or to the inherent nature of the character involved. While not so simple as quantitative, evidences of qualitative variations are also very

abundant. For example, of all the cows of a given breed, no two yield milk containing the same amount of fat; in fact, the individual cow varies widely from day to day in the percentage of fat contained in the milk. Of two steers of like breeding, the meat of one may be fine in grain, high in flavor, tender and juicy; while the meat of the other may be of coarse grain, tasteless, tough and dry. The same is true of all meat-producing animals. Again, the quality of no two horses is alike. One has coarse, rough hair, thick hide and heavy, coarse bone; the other has smooth, soft hair, soft pliable hide and fine smooth bone. While qualitative variations are not so easily detected, as a rule, they are of greater significance to the breeder than are those of either size or form.

3. *Functional variations.*—Such relate to deviations in the normal activity of the various organs or parts of the body, such as muscular activity, glandular secretions and the like. This group refers to variations in what the animal can do, and may be quantitative or qualitative.

Each organ or part of the body has its own work to do, which is essentially different from that of any other organ or part. The activities of these various organs are not constant but exceedingly variable. Such deviations are of prime importance to the breeder who is interested in increasing the efficiency of the organs or parts as well as in their permanent improvement. While functional variations are often complex, in that a number of characters are likely to be involved, yet illustrations are observed on every hand. Among cows of the same breeding, no two give the same amount of milk; in fact, the individual cow does not give the same amount from day to day. Likewise, animals vary in fertility, the average cow or horse giving birth to but few, while, as we have seen, the Angus cow, Old Granny, produced 25 young, while the Thoroughbred mare, Old Fanny Cook, gave birth to 15 foals. These animals both lived to a ripe old age, indicating great vitality of all the organs.

4. *Variations in pattern.*—These have to do with repeated parts, such as extra teats on cattle and swine, extra toes in cats and dogs, and the like. This group of variations is not common among animals, but evidences are everywhere observed among plants, as stooling of wheat, oats, corn and the like.

In selecting animals to improve definite qualities, the breeder should distinguish between these four groups, as it will give him a clearer idea of the nature of variations and how to take advantage of them in his endeavor to improve animals for the service of man.

Further, it is important to remember that each group may be of the non-inheritable sort, and thus affect the individual only; or each may be inheritable, and thus influence the herd or breed.

FIG. 28—RAMBOUILLET RAM "OHIO BOY"
Fine wool type

Degrees of variations.—Animals are not only exceedingly variable, but there is great difference in the degree which one individual deviates from another. A clear understanding of this is necessary to gain an idea of the nature of variations, and hence to be able to take advantage of such deviations as do appear.

Continuous variations.—Darwin supposed that variations were by nature continuous, and that new forms originated by the gradual accumulation of very small differences through a long period of selection. According to this theory if all of the individuals that ever lived could be so arranged as to bring nearest together those that are nearest alike, it would then be found that they would grade into one another by insensible differences. For a long time such was commonly assumed to be the case, and no doubt is true of much of the variation among our animals. This, of course, means that the breeder must exercise great caution in selection so as to take advantage of each slight improvement, as well as to eliminate undesirable forms, even though the difference be small.

Discontinuous variations.—It is now definitely known that not all variations are continuous, but that many are discontinuous; that is, the new individual differs from the parent by a wide margin. According to this idea, we should not expect to find all nature united by insensible gradations. This class of variations is far more numerous than is commonly supposed, and our animals deviate widely often in the line of improvement, but possibly more often in the line of deterioration. This necessitates even greater vigilance on the part of the breeder.

Mutations.—This term was formerly used to denote a wide and discontinuous deviation from the type; in fact, forming a new type, which bred true from the beginning. The common example was the case of the peach tree bearing nectarines. At present there is a tendency to employ the term mutant to signify any variation, whether large or small and of whatever origin, that is transmitted from parent to offspring and from generation to generation. In the latter sense it denotes practically the same as inheritable and germinal variation.

Sports.—Wide deviations from established types were noted by Darwin, who called them "sports." Some persons consider sports and mutants synonymous. However, the term sport is used here to denote a sudden and wide departure from the normal type that is not transmitted from generation to generation.

Abnormality.—This term is used to denote a variation of greater magnitude than a sport. An abnormal part is distinctly different from the rest of the species. It may be transmitted for a few generations, but will soon disappear because of lack of adaptation.

Malformation.—A variation so great as to interfere with the usefulness of an animal is called a malformation. Since the individual seldom reaches maturity such deviations are of no economic importance to the breeder.

Monstrosity.—This term is used to denote a variation of so great a degree as to render the life of the animal impossible, or possible for a short time only, such as an individual with two heads.

FIG. 29—RAMBOUILLET EWE
Fine wool type

These terms simply represent increasing degrees of deviation from the normal type of the race. While abnormalities, malformations and monstrosities are often of interest, they have no permanent value and the breeder should eliminate them at once.

DISTRIBUTION OF COWS AS TO PER CENT OF BUTTER FAT

V*	F†
2.6	1
2.7	2
2.8	1
2.9	5
3.0	16
3.1	20
3.2	43
3.3	40
3.4	51
3.5	39
3.6	29
3.7	26
3.8	19
3.9	13
4.0	9
4.1	5
4.2	2
4.3	2
4.4	1
	324

cent. of fat called value = V.
†Cows in groups called frequency = F.

Study of variation.—So universal is variability that when considering a large number of animals it is difficult to compare individuals by the usual methods of observation. Thus in a study of the quality of milk or the percentage of butter fat, taking a breed as a whole, it is difficult to determine whether advancement is being made from generation to generation, or indeed to determine with exactness whether the breed is holding its advantage. This has led to the adoption of the statistical methods of study often called *biometry*.

To illustrate the method let us make a study of butter fat among Holstein-Friesian cows, taking the semi-official records in volume 23 of the advanced register. The different individuals differ greatly in the percentage of fat produced, and to obtain an idea of the rank it is necessary to group them according to the per cent of fat produced, as in the tabulation on preceding page showing distribution of cows as to per cent of fat produced.

Finding the type.—The distribution table shows a total of 324 cows, varying from 2.6 to 4.4 per cent of fat, with 3.4 the most common per cent. This most common value is called the *mode.* Thus we say the 3.4 per cent of fat is the mode for the semi-official Holstein-Friesian cows entered in volume 23 of the advanced register.

To find the type it is not sufficient to know the most common value, but the average value as well. The average value is called the *mean.* The average per cent of fat yielded by the 324 cows may be an entirely different value from the most common value. To ascertain this average value or mean multiply each group of the frequency distribution (F) by its corresponding value (V), add the results and divide by the total number of cows, as in the accompanying tabulation showing method of finding the mean.

FINDING THE MEAN

V	F	FV
2.6	1	2.6
2.7	2	5.4
2.8	1	2.8
2.9	5	14.5
3.0	16	48.0
3.1	20	62.0
3.2	43	137.6
3.3	40	132.0
3.4	51	173.4
3.5	39	136.5
3.6	29	104.4
3.7	26	96.2
3.8	19	72.2
3.9	13	50.7
4.0	9	36.0
4.1	5	20.5
4.2	2	8.4
4.3	2	8.6
4.4	1	4.4
	324	1116.2

1,116.2 ÷ 324 = 3.44 mean = M.

This gives an average per cent of 3.44, differing slightly from 3.4, the most common value. In a similar manner the mode and mean may be determined for the flow of milk, and like characters that permit of definite measurement. The mean or average value is usually accepted as the best representative of a typical individual.

Variability or deviation from type.—In a critical study of variation we must determine the average deviation; that is, the average tendency for each cow to deviate from the mean or average, which is 3.44 per cent. From the mean the lowest cow, which is 2.6 per cent, deviates .84; the next group of two cows each deviate .74, or a total deviation of 2 times .74=1.48. Continue down the distribution, and calculate the deviation of each group, then add all together to obtain the total amount by which all cows deviate from their average per cent of fat. Now, by dividing this amount by the number of cows, we shall obtain the average deviation of the cows, as in the tabulation showing method of finding average deviation.

Finding Average Deviation

V	F	V−M	F (V−M)
2.6	1	−.84	0.84
2.7	2	−.74	1.48
2.8	1	−.64	0.64
2.9	5	−.54	2.70
3.0	16	−.44	7.04
3.1	20	−.34	6.80
3.2	43	−.24	10.32
3.3	40	−.14	5.60
3.4	51	−.04	2.04
3.5	39	.06	2.34
3.6	29	.16	4.64
3.7	26	.26	6.76
3.8	19	.36	6.84
3.9	13	.46	5.98
4.0	9	.56	5.04
4.1	5	.66	3.30
4.2	2	.76	1.52
4.3	2	.86	1.72
4.4	1	.96	0.96
	324		76.56

76.56 ÷ 324 = 0.23 + = average deviation.

This gives 0.23+ as the average amount by which each cow deviates from the average. Thus it gives a good measure of the variability in this particular lot of cows.

The mean and the average deviation give a very good measure of the type as well as its stability, and afford a very convenient basis for comparing one year's work with another or one generation of animals with another where large numbers of individuals are involved.

Plotting a frequency curve.—Such frequency distributions as the above gradually rise from the low value to the mode and then descend to the high value. This is best illustrated by a system of plotting in which the distribution is put into the form of a curve known as a "frequency curve."

To plot such a curve, rule a sheet of paper both ways, arranging the values along the bottom and the frequency distribution on the left, preferably standardizing it. Connect the points where the perpendicular lines from the values cross the horizontal lines from the frequencies with a curved line. This irregular line constitutes the frequency curve and gives a true picture of the variation that exists among cows in the per cent of butter fat produced, as shown in Fig. 30. In this case the curve is not smooth, due to lack of sufficient numbers to make it regular and uniform.

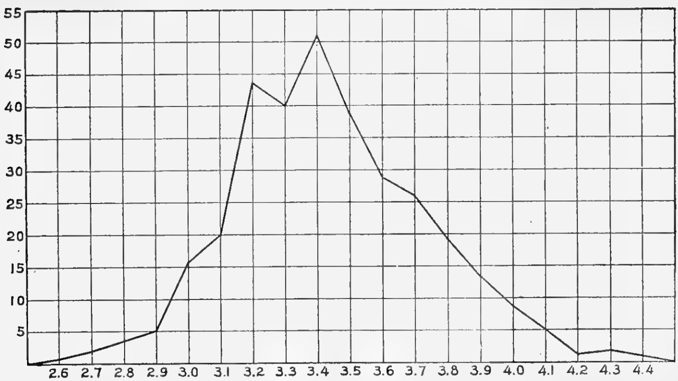

FIG. 30—PLOTTING A FREQUENCY CURVE

CHAPTER IX

SOME CAUSES OF VARIATIONS

Variations constitute the basis of all improvement as well as that of all decline. Because of this the breeder is especially interested in the causes of variations in animals, as well as in methods of their possible control. While exact causes are little understood, past experience has taught us that certain practices can be relied upon to give good results. The general causes of variations may be divided into two classes, those that arise within the body, largely in the form of inherited differences, and those that are external to the animal, such as differences in the environment. The breeder can influence the former but little, if at all; while over the latter he has practically complete control.

SOME EXTERNAL CAUSES OF VARIATIONS

Everywhere about us we observe that animals of the same species vary widely according to the environment. The climate and the food, as well as favorable and unfavorable conditions, generally exert a profound influence upon living beings. We can often tell the conditions under which an animal was grown simply by a physical examination. That the conditions in which an animal is obliged to live exert a direct effect upon his development is beyond question.

In a general way our animals are the result of their environment, and improvement is possible only when the conditions of life are made more suitable. Good examples are observed in the case of early maturity and increased fertility among cattle and swine. In nature the cow does not reach full maturity until five or six years of age; she does not breed until well along in years, and she usually gives birth to but few calves in her lifetime. On the other hand, when properly cared for, the cow may give birth to young before she is two years of age without injury to herself or the calf; she attains her growth at a much earlier period than in nature, and when properly managed may produce a number of calves.

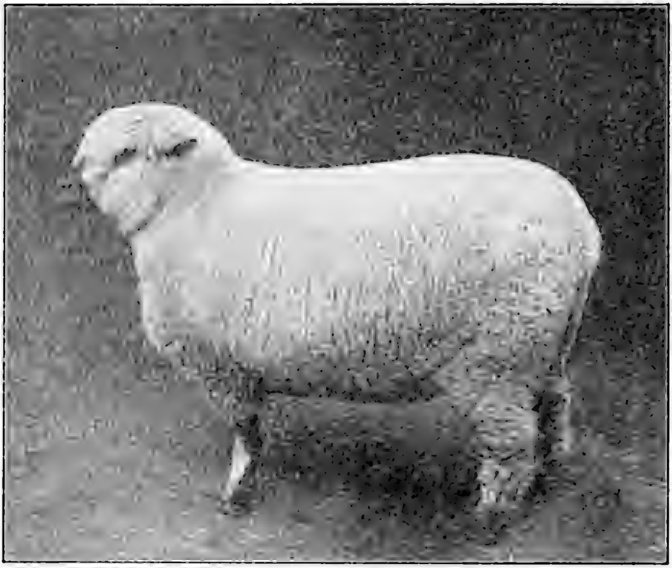

FIG. 31—SHROPSHIRE EWE. Medium wool, mutton type.

Swine show even greater improvement. In nature the sow gives birth to but one litter of one to four young each year, and it requires three to five years for these animals to attain full development, while under man's care the sow may annually give birth to two litters of six to ten young each, and in six months the pigs attain sufficient development to be bred again, as well as to be marketed to advantage.

Climate and locality.—In nature there is a correlative influence between the climate and the kind of animals that exist under it. The characters that are most often affected are those that have to do with size and the external covering of the animal. The natural relation of climate to size is that animals inhabiting cold climates are usually small as compared with those of the same species inhabiting warm climates. When animals are exposed to cold, damp weather the hair becomes long and thick. In some instances the exposure produces a double coat of hair—an upper one being long and wavy and an under one short, fine and furlike. Galloway cattle furnish a good example.

Formerly we were accustomed to associating a high degree of constitutional vigor with animals that were developed in rather cold or severe climates. It was also stated that they could not be transplanted to another climate without impairing their vigor. Experience disproves this, as many animals show ease of acclimation to wide changes of climatic conditions. There are numerous illustrations of where animals have been exported from their own country to other countries and climates, and have shown as marked a degree of vigor as in their native land. In fact, in many cases they have shown marked improvement in constitutional vigor over the original animals. For example, Merino sheep were developed in the dry climate of the tablelands of Spain, where they were famous for the quality of their fleece. In the latter part of the eighteenth century they were exported to Germany, France and the United States. Although in each of these countries the climate is very different from that of Spain, yet the sheep rapidly improved in vigor and fleece covering until they far surpassed the original Spanish animals.

In like manner, Jersey and Guernsey cattle of the

Channel Islands have been exported to England, Europe and to the United States. In each of these countries they have become perfectly acclimated and have shown no loss in constitutional vigor, and, in fact, they have improved wonderfully over the original cattle.

While the influence of climate and locality is great and the factors at work are exceedingly complex, yet from a practical point of view we may consider the food supply and more favorable conditions generally, such as sufficient shelter, proper care, including training and developing, as the more important causes of variation.

Care and management.—In the breeding of animals the conditions of environment are changed or enlarged by man, who provides his animals with favorable conditions. The improvement derived from proper care and management is not fully appreciated by the average breeder. The development attained by our high-class animals is largely due to the favorable conditions provided by man. A good example is observed in the speed of the trotting horse. In 1810, Boston trotted a mile at Philadelphia in 2:48½. This was the fastest mile ever trotted in harness and was not exceeded for 16 years. In 1912 Uhlan trotted a mile at Memphis in 1:58.

The conditions under which these records were made are significant. Boston was in training but a few months each year and was not worked out as trotters are at present. At the time he made the memorable mile he was driven to a high, wooden-wheeled, steel-tired, straight-spindled clumsy cart; the harness was heavy and ill adapted to trotting; and the track over which he was driven was not as well constructed as are present-day tracks. On the other hand, Uhlan was in training practically throughout the year; he was perfectly worked out, and in prime physical condition; he was driven to a low, wire-wheeled, pneumatic-tired, ball-bearing, perfectly balanced cart; the harness was light and perfectly adapted; and the track was the fastest in the world.

Food supply.—The food supply is of prime importance in effecting improvement among animals. No other conditions influence development to a greater extent. Large breeds are developed from small ones largely by increas-

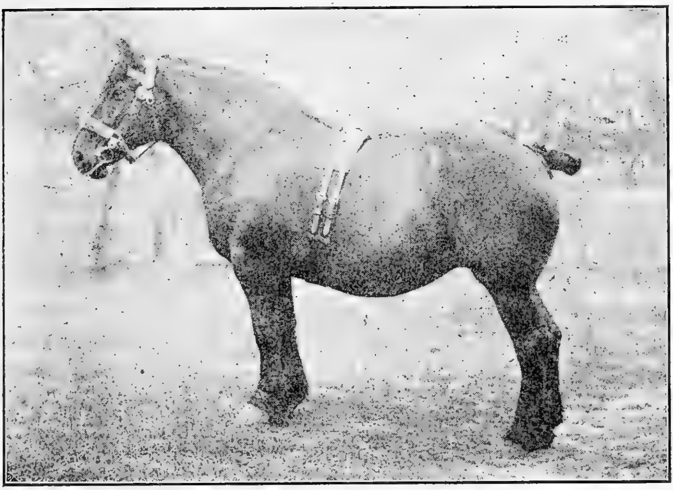

FIG. 32—BELGIAN MARE "BELLA"

ing the food supply. In addition to the increase in size, there is also an increase in the constitutional vigor when the animal is well fed.

In order to secure increased development of all of the productive functions, the animal must be supplied with more food than is required for the performance of the normal functions. A good example is observed in the increased yield of dairy cows. In the early days of official cow testing a weekly yield of 18 pounds of butter fat was considered exceptional. At the present time (1914) the record stands at 35.3 pounds of butter fat in seven days, practically double the record of a few years ago. Let us note the conditions under which these records were made.

Formerly the cows on test received no special preparation before calving or subsequently. The daily food consisted of a moderate amount of one or two kinds of concentrates or grains, all the hay they would consume with the run of pasture when in season. During inclement weather the animals were stabled, but never blanketed. They were fed and milked twice daily. Contrast such conditions with present-day methods. The cows are especially prepared for the test and often excessively fat; they are closely stabled and often heavily blanketed; they are fed all of the food they will eat, often as high as 40 or more pounds of concentrates, consisting of a dozen foods variously mixed, in addition to all of the silage, roots, cabbage, clover and alfalfa hay they will consume, the total daily ration often exceeding 100 pounds of food. Further, the cows are fed and milked four times each day.

Training and development.—Just how much of the increased speed of the trotter is due to training, to favorable conditions and to breed improvement is an open question. Likewise, just how much of the improvement in dairy cows is due to special preparation and development, to favorable conditions, and to general improvement of the breed is a matter concerning which we lack sufficient data to answer with any degree of accuracy. Certain it is, however, not least of these factors is training and developing. In fact, they are the chief agents in bringing out efficiency, otherwise we would never know the fastest trotting horse or the highest-producing cow.

Training and developing are not only useful agents in bringing out differences in the capacity of our farm animals, but they must be continued to keep the animals up to maximum efficiency. Thus, if we wish to breed a strain of fast-trotting horses or of high-producing cows, we must not only train the horses and develop the cows during the formation of the stud or herd, but we must continue to train and develop them as long as we remain in the business. The same is true of most characters which the animal breeder is seeking to improve, and in this they differ from unit-characters, as color, presence or absence of horns on cattle and sheep, and the like. It was stated in our discussion of Mendel's law that once we obtained a pure color strain it would breed true from generation to generation. While sufficient evidence is lacking to say that such is not true of speed among trotters, pulling power among draft horses and high milk and butter fat production among cattle, yet the facts will certainly remain unknown unless the animals are trained and developed so as to bring out their maximum efficiency.

Use and disuse.—It must be evident to all that use stimulates and disuse dwarfs the development of many organs. The training of the race horse and the developing of the dairy cow are good examples of normal development, but by constant use it is possible to stimulate some organs beyond the normal. There are many examples of this in the human family, such as the blind reading by the touch of the finger tips, the deaf carrying on conversation by watching the lips, and using the toes to write. This is putting parts to entirely new use and requires constant and painstaking effort to accomplish the task.

That disuse dwarfs organs is well illustrated in the case of the disappearance of legs from snakes and from whales, the lessening of the wings in certain birds and the loss of toes in many mammals including the horse, the prototype being a five-toed animal.

Injuries and mutilations.—Not infrequently injury to a part sets up cell division which results in a local growth to support the injured parts. In the horse such growths are spoken of as blemishes. Notwithstanding popular opinion, the breeding animal is none the worse for blemishes the result of *accidental* injury.

Formerly there was much discussion among animal breeders as to the importance of mutilations, by which is meant the removal of parts after they have developed. The frequent appearance of tailless kittens gave credence to the belief that such mutilations were often transmitted, notwithstanding the fact that there is a breed of cats naturally tailless, which is no doubt responsible for the tailless kittens. For countless generations it has been the custom to remove the tails from lambs, with no signs of tailless sheep as the result, and from the remotest times the Jews have practiced circumcision, and are still at it.

While of little interest to the breeder, male castration is a fertile cause of variation to the individual. In the castrated animal the general development of the head and neck will be arrested, he will remain lighter and finer, lacking the general coarseness of unaltered males. In fact, there is a profound difference in the development, extending to practically every character, the animal approaching the general conformation of the female. Likewise, females when deprived of their ovaries develop to some extent the characters of the male.

Chemical agents.—While of little or no economic value, it is nevertheless interesting to note the influence of certain dyes and chemical agents in producing variation. Long ago Darwin reported that swine feeding upon madder root possessed flesh abnormally red in color. Gage reports that feeding poultry with an aniline dye (Sodan Red III) resulted in eggs tinted with the red dye, and that chicks hatched from such eggs also were tinted. Riddle reports similar results with guinea pigs. In such cases the dye is held in suspension in the fats, and the coloring matter disappears with the fat.

It has long been known that certain agents stimulated secretions and glandular activity. Hill reports that the injection into the veins of a thoroughly milked dairy cow of a saline extract of the pituitary bodies of cattle resulted in an immediate secretion of from 12 to 25 per cent of the normal flow, and the milk thus secreted contained 50 to 100 per cent more fat than normal stripping, although the flow was materially depressed at the next milking.

Breeders' control of the external causes of variation.—Among successful animal breeders the opinion prevails that greatest development of useful characters and attributes can be attained only by providing animals with favorable conditions. Chief among these are suitable food; protection from cold, heat, enemies and all annoying influences; proper management; and suitable preparation, including training and developing. So far as it is positively known, we have attained highest development of useful characters in no other manner. The breeder of animals should clearly understand this; otherwise, he may be misled by the occasional individual that shows great improvement, as well as by those individuals that are exceedingly prepotent in transmitting their characters to their offspring.

SOME INTERNAL CAUSES OF VARIATIONS

There is little doubt but that the exact cause of the great bulk of variability is due to factors internal to the organism, mainly in the form of inherited tendencies. However, these internal influences are dependent, in part, at least, upon outside conditions for their opportunity. The external conditions must be favorable in order to promote the development of inherited tendencies. Unfavorable conditions dwarf development, no matter how pure the heritage.

Maturation a cause of variation.—The process by which the number of chromosomes in the germ cells—both male and female—is reduced to half is a preliminary step to fertilization is a very significant internal cause of variation.

For the sake of clearness in illustrating the significance of this reduction, consider the case of a species in which four is the regular number of chromosomes, two of which are eliminated at maturation. It is obviously impossible to know which two of the four bodies will be preserved. Let us consider the four chromosomes of the female to bear numbers from one to four, any two of which may be eliminated. Likewise, consider the four chromosomes of the male to bear numbers five to eight, any two of which may be split off at maturation. In this case any one of the following combinations is equally as likely as any other to be preserved in the germ cells during maturation:

Possible Chromosome Combination in Maturation

Female germ cell		Male germ cell	
1+2	2+3	5+6	6+7
1+3	2+4	5+7	6+8
1+4	3+4	5+8	7+8

Thus there are six possible combinations in a female of a species of four chromosomes. But our farm animals each possess 16 chromosomes in the germ cells, eight of which are eliminated at maturation. Calculated on the same basis, this would give 12,870* possible combinations in the maturation of the ovum.

Reduction is similar in the male. While all four divisions of the spermatozoon remain functional, only one is utilized in fertilization, thus the possibilities are the same as in the female.

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*Suppose a female has 2 K chromosomes, of which half only are available, K Now the number of possible ways of selecting K among 2 K is $\frac{|\underline{2\,K}}{|\underline{K}\cdot|\underline{K}}$, Thus in case the number of chromosomes is 16 we have

$$\frac{1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot9\cdot10\cdot11\cdot12\cdot13\cdot14\cdot15\cdot16}{1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8\cdot1\cdot2\cdot3\cdot4\cdot5\cdot6\cdot7\cdot8} = 12{,}870$$

Likewise the male chromosomes share similar possibilities.

Fertilization a cause of variation.—The process of fertilization in which the remaining chromosomes in the maturized germ cells flocculate to restore the original number is also an important internal cause of variation. Continuing with the illustration, we now have six possible maternal combinations and six possible paternal combinations of chromosomes any one being equally as likely as any other to unite in fertilization, thus giving the following combination of chromosomes:

Possible Chromosome Combinations in Fertilization

1 + 2 × 5 + 6	1 + 4 × 5 + 6	2 + 4 × 5 + 6
1 + 2 × 5 + 7	1 + 4 × 5 + 7	2 + 4 × 5 + 7
1 + 2 × 5 + 8	1 + 4 × 5 + 8	2 + 4 × 5 + 8
1 + 2 × 6 + 7	1 + 4 × 6 + 7	2 + 4 × 6 + 7
1 + 2 × 6 + 8	1 + 4 × 6 + 8	2 + 4 × 6 + 8
1 + 2 × 7 + 8	1 + 4 × 7 + 8	2 + 4 × 7 + 8
1 + 3 × 5 + 6	2 + 3 × 5 + 6	3 + 4 × 5 + 6
1 + 3 × 5 + 7	2 + 3 × 5 + 7	3 + 4 × 5 + 7
1 + 3 × 5 + 8	2 + 3 × 5 + 8	3 + 4 × 5 + 8
1 + 3 × 6 + 7	2 + 3 × 6 + 7	3 + 4 × 6 + 7
1 + 3 × 6 + 8	2 + 3 × 6 + 8	3 + 4 × 6 + 8
1 + 3 × 7 + 8	2 + 3 × 7 + 8	3 + 4 × 7 + 8

There are 36 possible combinations of chromosomes in a species with four chromosomes. Thus it is possible for two parents with four chromosomes to have 36 offspring, no two of which are identical. In the case of farm animals in which the regular number of chromosomes is 16 we find there are 165,636,900* possible combinations of chomosomes in fertilization.

In view of the assumption that the chromosomes bear the hereditary determiners, it is not surprising that we never find two animals exactly alike, even when of the same parentage. Since we cannot control the chromosomes in the vital processes of maturation and fertilization, there is undeniably a large element of chance in breeding. It is not justifiable, however, to assume that each chromosome is entirely different from all the others

*Continuing our problem as in maturation, the possible combinations of chromosomes in fertilizations is

$\left[\frac{\lfloor 2K}{\lfloor K \cdot \lfloor K}\right]^2$ which in this case is the same as $[12{,}870]^2 = 165{,}636{,}900$.

in the same parent. The fact that there usually is a general resemblance between parent and offspring, as well as between offspring of the same parents at different periods, leads to the assumption that the chromosomes are largely similar.

Mendelism a cause of variation.—The most significant internal cause of variation under the control of the breeder is that brought about by the Mendelian phenomenæ. In the discussion of Mendel's law it was clearly indicated how variations could be produced and how new forms could be established (p. 49). This is a comparatively simple matter where few unit-characters are considered, although it becomes exceedingly complex in the more economic attributes, especially those involving many unit-characters.

Atavism and reversion, both internal variations in which the individuals skip a generation or more in their inheritance and resemble former ancestors more than the immediate parents, can be accounted for on the basis of the Mendelian hypothesis.

Cross-breeding a cause of variation.—Among farm animals the new individual is the product of two parents —male and female—and is of necessity unlike either, being a product of both. This is considered an internal variation, and is slight if the blood lines are similar.

On the other hand, the mating of dissimilar animals results in radical differences. Formerly this was the chief means by which improvement was sought. It was observed that the mating of unrelated animals, or those which had existed under a different environment, resulted in offspring possessing increased constitutional vigor, greater prolificacy, and often individual improvement. The great difficulty came, however, when an attempt was made to breed these cross-bred animals. The offspring of such cross-bred animals varied widely, some were good, more were inferior, and no one could foretell which way the offspring would develop. While productive of variation, cross-breeding is objectionable as a system of breeding.

Cell division a cause of variation.—Growth is the result of cell division. The individual cells of giants are no larger than those of normal animals, but they are more numerous. Likewise, the cells of dwarfs are not smaller, but fewer in number. Thus it follows that size, and to some extent the form, are dependent upon cell division If too few cells are formed, the animal will be small; if the cells are many, the animal will be large; while if too few in some parts or too many in others, the animal will be thrown out of proportion, which may be so serious as to result in a malformed animal. What the influences are that decide how far cell division shall proceed and when it shall stop in the case of each part we do not know. Certain it is that favorable conditions, such as food and care, exert a profound influence, especially while the animal is young and cell division is active. Aside from this, however, there are certain internal forces at work upon the normal exercise of which all typical development depends. Thus it follows that while cell division, and hence development, can certainly be influenced by favorable conditions, it is also manifest that absolute control is largely beyond the power of the breeder.

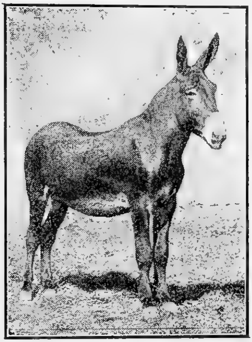


FIG. 33—CATALONIAN JACK

Relative fertility and longevity.—While not ordinarily classified as causes of variations, relative fertility and longevity are important factors in the make-up of the characters of any particular breed. Animals are not equally fertile. Occasionally desirable attributes are lost through low fertility and sterility. A good example of this was observed in the Duchess family of Shorthorns, in many respects the most remarkable family of beef animals in the world. On the other hand, there may be certain characters that are correlated with highest fertility. If unrestricted, these will soon become the dominant characters of the breed. It is important, therefore, that the breeder understand this, so that, if the fer-

FIG. 34—SPAN OF EXCELLENT MULES

tile animals possess undesirable characters he may eliminate such characters, in so far as possible, by rigid selection; and if the shy breeders possess very desirable attributes, he may take pains to preserve them, although there is little use in attempting to breed a strain, however desirable, that is not at least fairly prolific.

The make-up of the characters of a breed depends as much upon longevity as upon fertility. There is little use in attempting to breed a strain of short-lived animals, particularly of milk cows and horses, the former of which is valuable in proportion to her productive age, and the latter to the age to which he retains his vigor.

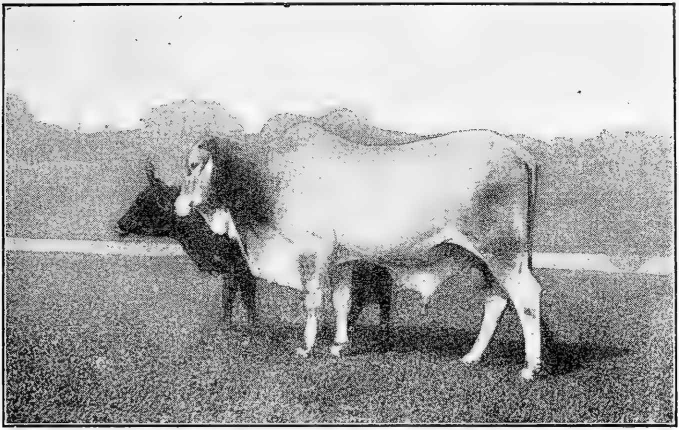


FIG. 35—ZEBU CATTLE, NATIVE OF TRINIDAD

CHAPTER X

INDIVIDUAL MERIT AND SELECTION

The animals selected for breeding should be good representatives of the type and breed to which they belong. In recent years breeders have been attracted by the demand for purely bred stock and have often selected their breeding animals on the basis of the pedigree and without personal inspection. This is often a questionable practice, as many individuals find their way to the books of record simply because animals thus recorded are in very great demand, irrespective of their fitness for breeding purposes. In selecting foundation animals, they should be carefully examined, as animals lacking type or breed characteristics are likely to prove disappointing in the end.

Not only should the animals themselves be carefully inspected, but their parents and offspring, if available, should also be critically noted. Especially is this true of the offspring, as they indicate the breeding capacity, and give us an idea of what to expect. So important is this that when selecting animals of our own breeding, it is suggested to breed those under consideration at an early age, so as to learn their breeding capacity as early in life as possible. If they should prove undesirable individuals, we are able to discard them early and thus save needless expense in their maintenance. On the other hand, if they should prove desirable, we know it in time to secure maximum benefit. When young individuals are bred to determine the breeding capacity, they should be mated with animals of proven merit.

The breeder a judge.—In animal breeding success depends very largely upon the ability to select animals with skill and judgment. There are three important factors to be considered in choosing breeding animals—individual merit, pedigree and, when available, the performance of the animal. Among expert judges as well as breeders there is much confusion as to the part each should play in making a choice. A few breeders place individual excellence first, a few the pedigree, and a few others the performance, while the mass of breeders seem to have no very clear idea of the relationship between the factors.

FIG. 36—PERCHERON STALLION "IDLEFONSE"

The progress made in recent years in breeding trotting horses and dairy cattle is gradually changing our ideas of judging. Formerly we tried to estimate the capacity of a cow to give milk by a physical examination of her external characters. This was often disappointing, as many cows proved to be very good producers that were lacking in general appearance, and many cows that were of typical dairy form failed to make a good showing as producers. In other words, we cannot tell for a certainty how fast a horse can trot or how much milk and butter fat a cow can produce by a physical examination. This can be determined only by trial—racing the horse and milking the cow. This is significant, and the breeder should distinguish clearly between individual merit and performance. The former is a matter of judgment, while the latter cannot be definitely known until a trial has been made of the animal's capacity.

Types of animals.—While we cannot tell for a certainty what an animal can do without test, yet animals assume rather characteristic forms or types because of the demand made upon them in the performance of their functions. Certain types, therefore, became correlated

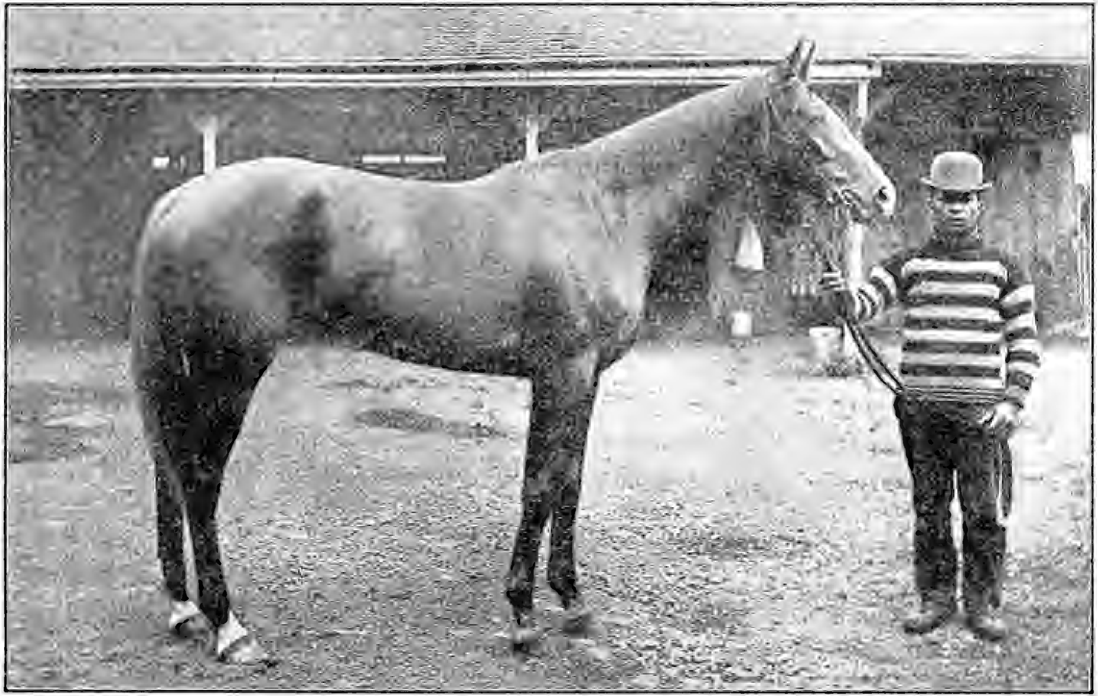


Fig. 37—Thoroughbred Mare "Blue Girl"

with certain functions. For example, in beef production it is very important that the animals take on flesh and that the body be plump and full, whereas in the production of milk this would be considered an objection, as the food should go to the production of milk and not to body fat. Thus these two classes of animals are of necessity widely different in type. The beef animal is compact and blocky and in general appearance resembles a brick set on edge, the top and bottom lines being parallel, and there is an even covering of thick flesh throughout the body. On the other hand, the large digestive and milking capacity of the dairy cow gives her a wedge shape as viewed from the side. She is deeper through the hips, flank and udder than through the shoulders and chest. She is lacking in flesh, spare and angular, with prominent shoulders, hips and rump. Likewise, horses, sheep, swine and poultry vary in type according to the purpose for which they are produced. Thus we have light, coach and draft types of horses; wool and mutton types of sheep; and lard and bacon types of swine, as well as dairy, beef and general-purpose types of cattle. (For complete list of types and breeds, see appendix.)

Within a given type there is often much variation, and the breeder should study the demands of the market in order to produce that which is most desired. Not infrequently the demands of the market vary according to the locality. A good example is observed in the case of draft horse type. New York City being a great shipping port, where much heavy hauling is done, demands a large and upstanding horse, whereas the dray work of Boston being much lighter, the market demands are for a low-set, massive drafter of good conformation.

Utility of types.—Since certain types are associated with certain functions, in a general way, they are useful in estimating the capacity of our animals. This is particularly true in those cases where no record of performance is available, as in all meat-producing animals, as well as all horses other than trotters and pacers. The breeder must make a careful study of those types that are correlated with the particular products which he is trying to produce. Thus when the production of meat is the principal product sought, he must know the type associated with early maturity and with rapid fleshing, as well as that most sought by the butcher and packer, as such commands the highest price on the market. In all such cases the type is exceedingly useful, as it serves as the only guide at the disposition of the breeder in selecting his animals.

Uniformity in type.—The animals selected for breeding should be uniform in size and type. This is of special importance in meat-producing animals and horses other than racers. Butchers and packers desire cattle, sheep and swine uniform in weight, so that the cuts of meat will run uniform as their trade demands. If the animals vary in size and type, the weight of the cuts of meat will likewise vary, and to this the butcher objects, as he cannot find a ready market for cuts of meat varying in weight. Likewise, uniformity is of importance in the wool-producing sheep, as an even uniform clipping of wool is to be desired.

In the breeding of horses uniformity in size and type as well as color and quality is of prime importance. This is emphasized by the fact that a well-matched team will sell for a very much better price than when the two animals are sold singly. The market demands teams uniform in type, weight, quality, color and age, and it is the business of the breeder to supply the market demands. To obtain uniform offspring, it is essential to breed animals that are uniform in type, as this character has a tendency to be transmitted from parent to offspring.

Breeds of animals.—Within each type there are a number of breeds of animals, all of which conform to the general type to which they belong, but differ in respect to breed characteristics. In breeding pure-bred animals it is as important to select individuals possessing the characteristics of the breed to which they belong as it is to select those true to type.

The breed to select in founding a stud, herd or flock will depend entirely upon the attendant conditions, as

FIG. 38—HEREFORD BULL "POINT COMFORT 14TH"

there is no best breed for all conditions. The intending breeder should make a careful study of the situation, taking account of the market demands, the general environment, as well as his own limitations, and select the breed best suited to his particular conditions, as certain breeds are not well adapted to certain conditions. A good example of the principle involved is observed in the case of dairy cattle. A careful study of the dairy industry reveals the fact that in general large cows are replacing small ones in localities where the land is level and easily grazed; while small cows are replacing large ones in hilly communities where grazing is difficult.

Standard of perfection.—Each of the more important breeders' associations have established a standard or a scale of points for the guidance of breeders. This standard denotes the characteristics that each individual of the breed should possess. The scale of points, known as the score card, gives a percentage value to each part of the animal and designates the desirable conformation. This is illustrated in the following scale of points:

SCALE OF POINTS FOR HOLSTEIN-FRIESIAN COWS

	POINTS.
Head—Decidedly feminine in appearance; fine in contour	2
Forehead—Broad between the eyes; dishing	2
Face—Of medium length; clean and trim, especially under the eyes, showing facial veins; the bridge of the nose straight	2
Muzzle—Broad with strong lips	1
Ears—Of medium size; of fine texture; the hair plentiful and soft; the secretions oily and abundant	1
Eyes—Large; full; mild; bright	2
Horns—Small; tapering finely towards the tips; set moderately narrow at base; oval; inclining forward; well bent inward; of fine texture; in appearance waxy	1
Neck—Long; fine and clean at juncture with the head; free from dewlap; evenly and smoothly joined to shoulders	4
Shoulders—Slightly lower than hips; fine and even over tops; moderately broad and full at sides	3
Chest—Of moderate depth and lowness; smooth and moderately full in the brisket; full in the foreflanks (or through at the heart)	6
Crops—Moderately full	2
Chine—Straight; strong, broadly developed, with open vertebræ	6
Barrel—Long; of wedge shape; well rounded; with a large abdomen, trimly held up (in judging the last item age must be considered)	7
Loin and hips—Broad; level or nearly level between the hook bones; level and strong laterally; spreading from chine broadly and nearly level; hook bones fairly prominent	6
Rump—Long; high; broad with roomy pelvis; nearly level laterally; comparatively full above the thurl; carried out straight to dropping of tail	6

Thurl—High; broa	3
Quarters—Deep; straight behind; twist filled with development of udder; wide and moderately full at the sides	4
Flanks—Deep; comparatively full	2
Legs—Comparatively short; clean and nearly straight; wide apart; firmly and squarely set under the body; feet of medium size, round, solid and deep	4
Tail—Large at base, the setting well back; tapering finely to switch; the end of the bone reaching to hocks or below; the switch full	2
Hair and handling—Hair healthful in appearance; fine, soft and furry; the skin of medium thickness and loose; mellow under the hand; the secretions oily, abundant and of a rich brown or yellow color	8
Mammary veins—Very large; very crooked (age must be taken into consideration in judging of size and crookedness); entering very large or numerous orifices; double extension; with special developments, such as branches, connections, etc.	10
Udder and teats—Very capacious; very flexible; quarters even; nearly filling the space in the rear below the twist, extending well forward in front; broad and well held up	12
Teats—Well formed; wide apart, plumb and of convenient size	2
Escutcheon—Largest; finest	2
Perfection	100

General vigor—For deficiency inspectors may discredit from the total received, not to exceed eight points.

General symmetry and fineness—For deficiency inspectors may discredit from the total received, not to exceed eight points.

General style and bearing—For deficiency inspectors may discredit from the total received, not to exceed eight points.

Credits for excess of requirement in production—A cow shall be credited one point in excess of what she is otherwise entitled to for each and every ten per cent that her butter-fat record exceeds the minimum requirements for her age.

The breeder should make a thorough study of the standard as well as the scale of points so as to be able to recognize desirable as well as undesirable characteristics. Not infrequently these breed standards call for certain fancy points of little or no economic value, such as escutcheon in the Holstein-Friesian cattle; feather on the cannons and fetlocks of Clydesdale and Shire horses; six white points in Poland China and Berkshire swine; and the like; but if the breeder is producing pure-bred animals, he is obliged to conform to breed standards, otherwise he will not be able to dispose of his animals to financial advantage.

Value of breed characteristics.—For convenience of study we may divide the characteristics of a breed into two classes, basing our division upon the economic value of the feature in question. Thus we have breed characteristics that are useful and those that are not. To the latter group belong such features as color. So far as is known a red and white Holstein-Friesian cow is capable of yielding as much milk and butter fat as a black and white one, but according to the rules of the Holstein-Friesian Herd Book the former cannot be recorded, as only black and white animals are admitted. The same is true of color markings of Dutch Belted cattle, Poland China and Hampshire swine, and the like. The economic value of such characteristics should be clearly understood by the breeder, notwithstanding the fact that he must select his animals to conform to the breed standard, otherwise his animals will be discriminated against on the open market.

On the other hand, many of the breed characteristics are exceedingly useful. This class is well exemplified in case of egg production in White Leghorn and Plymouth Rock poultry, the former laying a white egg, the latter a dark one. Some markets, notably those of New York City, prefer white eggs and pay a very high premium for them, while other markets, especially those of Boston, demand dark eggs, although they do not pay so high a premium for them. Another notable example of useful breed characteristics is that of milk and butter-fat production in Jersey and Holstein-Friesian cattle. The former gives a medium flow of milk very rich in fat, while the latter gives a large flow which is only medium in the fat content. The breeder should make a careful study of all breed characteristics, valuable as well as otherwise, in order that he may select his breeding animals with judgment.

Age and individual merit.—The standards of perfection as well as the scale of points of the various breeds were designed to apply to animals in the prime of life. As animals increase in age they lose much of their former symmetry, become more and more angular, the abdomen often becomes rather pendulous and the back more or less swayed. Such changes are not taken into account by the standards, and it frequently happens that aged animals are discriminated against. This may be permissible in the show ring, where animals are judged largely in accordance with the manner in which they present themselves.

On the other hand, breeding animals should not be discriminated against on account of age so long as they retain their reproductive powers and vigor. The age of the parent does not affect the functions of the offspring. Males frequently become difficult to manage as they increase in age and are usually disposed of irrespective of their breeding qualities and a young and often unproven male substituted in their place. This is a serious mistake, as it often happens that some of the best blood of the breed is lost in this manner. However, when the productive powers begin to wane, the animals should be disposed of, unless very exceptional breeders, as it is not economical to keep animals for breeding unless they are fairly fertile.

Constitutional vigor.—While the standards of perfection and scales of points lay considerable stress upon constitutional vigor, in many cases they unconsciously operate against it in that more weight is placed upon other characters, such as early maturity, refinement, and the like. This often proves a serious matter, as is demonstrated in many herds of swine where the dams have become so refined that they are very low in fertility as well as constitutional vigor. Where breeding animals are selected on basis of the standard of perfection, the vigor often declines and in a few years the

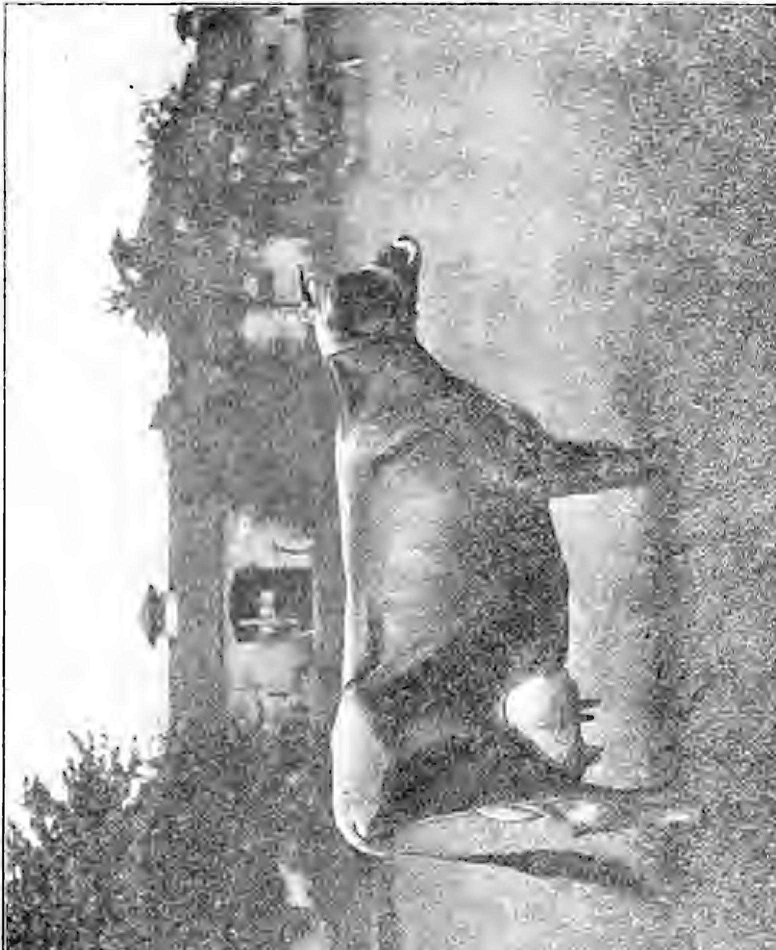


FIG. 39—JERSEY COW "BOSMAN'S ANNA"

breeder finds his animals deteriorating in their productive functions.

In selecting animals for breeding the constitutional vigor is one of the most important characteristics to be considered. No animal lacking in thrift should find its way into the breeding herd, no matter how excellent, no matter what the pedigree and no matter how high may be the record of performance.

CHAPTER XI

PEDIGREE AND SELECTION

The capacity of the individual to reproduce itself depends largely upon the purity of the ancestors. If the ancestors have been good for several generations, it is reasonably certain that the offspring will be good; if the ancestors have been poor for several generations, it is likewise reasonably certain that the offspring will be poor; whereas if the ancestors have been mixed, some good and some poor, it is impossible to predict with any degree of certainty what the offspring will be like. In view of such facts the character of the ancestors becomes a very important factor in selecting breeding animals as, in a general way, characters will be transmitted in proportion to the degree with which they have become fixed in the parents.

Form and contents of a pedigree.—For their guidance in selecting animals breeders long ago established stud, herd and flock books in which the ancestors of pure-bred animals were recorded. Such a record is called a pedigree. It consists of the name of the animal, which is usually designated by a serial number for convenience in tracing the pedigree, although in some of the books the females are arranged alphabetically within the volume. The pedigree also records the date of birth, usually the color and markings, the name and number of the sire and dam, together with the name and address of both the breeder and owner.

Most of the breeds have but one requirement for admission to the books of record, which is that both sire and dam shall be recorded, although some breeds require in addition certain breed characteristics, as black and white color in the case of Holstein-Friesians.

The following pedigrees, one of King of the Pontiacs, a noted Holstein-Friesian bull, the other of the famous Percheron stallion Calypso, illustrate the form and gives the data covered in the ordinary registered pedigree:

39037. King of the Pontiacs. B., Eastern Michigan Asylum, Pontiac, Mich.; O., The Stevens Brothers-Hastings Co., Lacona, N. Y.; March 5, 1905; Pontiac Korndyke 25982-Pontiac Lunde Hengerveld 51585.

Calypso 25017 (44577)

Black; foaled May 6, 1897; imported in 1900 by Dunham, Fletcher and Coleman, Wayne, Ill.; bred by M. Brossard, Department of Sarth, France.

Sire, Theudis 25015 (40871) by Besigue (19602) by Brilliant III 11116 (2919). See Brilliant III (2919).

Dam, Fatma (25787) by Brilliant III 11116 (2919). See Brilliant III 11116 (2919).

Second dam, Rose (11158) by Brilliant 1271 (755).

Third dam, Madelon.

In general the pedigree is a guarantee of the purity of the animal, although application for registry rests solely with the breeder. For this reason the value of a pedigree is largely dependent upon the reliability of the owner. When a breeder files a pedigree with the request that it be published, the secretary of the breeders' association is in a position to know whether the sire and dam mentioned are really owned by the breeder, and to this extent the secretary can vouch for the accuracy of the pedigree. While some errors creep in through careless methods of record keeping, it is very rare, indeed, for a breeder to falsify a breeding record or substitute an inferior animal for the one mentioned in the pedigree.

Tracing and writing pedigrees.—Since most pedigrees give but one generation of ancestors, they do not provide the breeder with all of the desired information in selecting his breeding animals. To get this information in a comprehensive form, breeders trace down and write out the pedigree of the particular individuals which they choose to consider. There are two methods of writing pedigrees in common use in breeders' catalogs, sales' papers and other advertising mediums, in which owners familiarize breeders with the breeding of their animals. In one method the dam's line is presented in detail, although the other ancestors are not taken into account. Formerly this method was used extensively. In the other method all of the ancestors are considered,

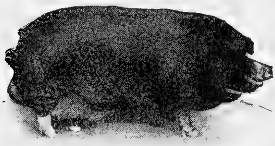


FIG. 40—POLAND CHINA BOAR

NONPARIEL MARQUIS (55757)

Roan. Calved January 13, 1905. Bred by W. C. Edwards & Co.

Dam	Bred by	Sire	Bred by
		Marquis of Zenda (26064)	W. S. Marr
Rose of Forthton	G. & W. Forth	Border Chief (18128)	J. & W. Russell
Kathleen 2d	J. Forth & Sons	Defiance (8244)	Lt.-Col. Tyrwhitt
Kathleen	J. Forth	Sir William (7928)	John Miller
Nonpariel 43d	Jas. Russell	British Statesman (42847)	S. Campbell
Nonpariel 36th	Jas. Russell	High Sheriff 2d (702)	W. Isaac
Nonpariel 33d	John Isaac	Inkerman (31414)	S. Campbell
Nonpariel 31st	S. Campbell[1]	Sir Christopher (22895)	R. Booth
Nonpariel 26th	S. Campbell	Scarlet Velvet (16916)	A. Cruickshank
Nonpariel 24th	A. Cruickshank	Lord Sackville (13249)	A. Cruickshank
Nonpariel 23d	A. Cruickshank	The Baron (13333)	R. Chaloner
Nonpariel 17th	A. Cruickshank	Matadore (11800)	W. Smith

LORD NETHERLAND DE KOL 22187

Lord Netherland De Kol 22187 B. Dec. 12, 1894 Bred and owned by E. C. Brill	Netherland De Kol's Perfection 17713	Pietertje 2d's Koningen 10625	Koningen Von Friesland 5th's Netherland 3515
			Pietertje 2d 3273 H. H. B.
		Netherland De Kol 10605	Netherland Alban 4584 H. H. B.
			De Kol 2d 734
	Susie De Kol 33688	De Kol 2d's Netherland 11584	Netherland Alban 4584 H. H. B.
			De Kol 2d 734
		Daisy De Kol 20201	De Kol 2d's Prince 2767
			Belle Barnum 2422

and for convenience in study the pedigree is arranged in tabular form.

The preceding pedigrees, one of Nonpariel Marquis, a Shorthorn bull, and the other the Holstein-Friesian bull, Lord Netherland De Kol, illustrate the two forms in common use.

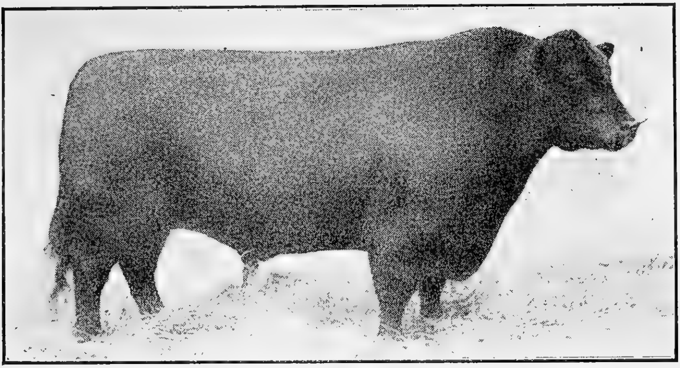


FIG 41—ABERDEEN ANGUS BULL "LEROY OF MEADOWBROOK"

In the case of Nonpariel Marquis we note that the pedigree runs entirely on the dam's side, and the ancestors are given for 11 generations. Were all of the ancestors included for this period the pedigree would contain 4,094 individuals instead of 23, as in the present form. Manifestly such pedigrees give little information for the guidance of the breeder. In the case of Lord Netherland De Kol all of the ancestors are given for the generations covered by the pedigree, which, of course, could easily be extended to the foundation animals of the breed. Such a pedigree gives a complete list of all the ancestors and is of the greatest significance in selecting breeding animals.

Comparative value of ancestors.—The former practice of recording ancestors entirely on the dam's side encouraged the idea of extending the pedigree to include very remote ancestors. Not infrequently pedigrees extended for twenty generations, as breeders associated great length of pedigree with high breeding qualities. We now have sufficient evidence to show that breeders formerly placed too high a value on extreme length of pedigree. Many of our best individuals that show a high tendency to reproduce their characters have secured their qualities from a comparatively short line of ancestors. It is the animals making up the pedigree for the first four or five generations that are of great influence in giving any individual the power to transmit qualities. So great is the influence of the first four or five generations that it makes little difference what the individuals were back of that period.

In our discussion of the law of ancestral heredity it was stated that the two immediate parents contributed between them one-half of the effective heritage, the grandparents one-fourth, and the great-grandparents one-

Total heritage	*Sir* 1/4	G. sire 1/16	G. G. sire 1/64	G. G. G. sire 1/256	all 1/16 others
				G. G. G. dam 1/256	
			G. G. dam 1/64	G. G. G. sire 1/256	
				G. G. G. dam 1/256	
		G. dam 1/16	G. G. sire 1/64	G. G. G. sire 1/256	
				G. G. G. dam 1/256	
			G. G. dam 1/64	G. G. G. sire 1/256	
				G. G. G. dam 1/256	
	Dam 1/4	*G. sire* 1/16	G. G. sire 1/64	G. G. G. sire 1/256	
				G. G. G. dam 1/256	
			G. G. dam 1/64	G. G. G. sire 1/256	
				G. G. G. dam 1/256	
		G. dam 1/16	*G. G. sire* 1/64	G. G. G. sire 1/256	
				G. G. G. dam 1/256	
			G. G. dam 1/64	*G. G. G. sire* 1/256	
				G. G. G. dam 1/256	
Total	1/2	1/4	1/8	1/16	1/16

eighth, and so on to infinity, so that the total heritage would be represented by one. For convenience of study the preceding table is arranged in accordance with this law, and it shows the heritage contributed by each ancestor for four generations.

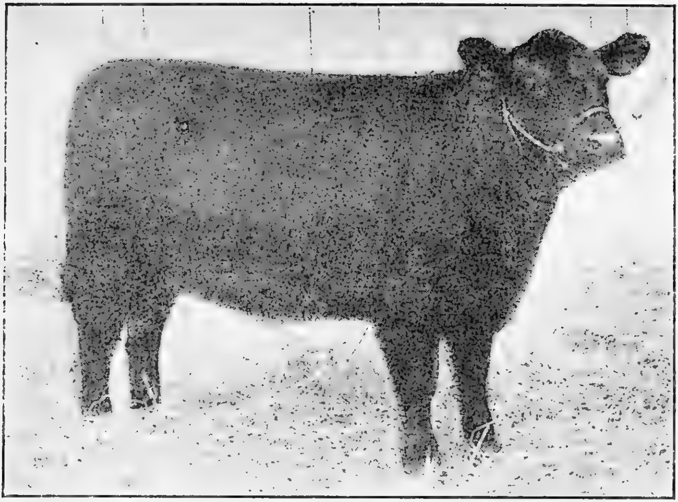


FIG. 42—ABERDEEN ANGUS COW "GLENCARNOCK ISLA"

The table shows conclusively the fallacy of selecting an animal when only the female line is represented in the pedigree, as only the ancestors in italics would appear. Thus of the thirty ancestors in the four generations only seven would be represented and together they would contribute only about 40 per cent of the total heritage.

Animal with inbred pedigree.—The relative influence of an animal in an inbred pedigree is a much-discussed question among animal breeders. Such a pedigree limits blood lines to few and closely related lines of descent. it increases prepotency, gives stability to the family, favors uniformity and intensifies characters both good and bad. The pedigree of the famous Jersey bull Polonius gives a good illustration of an inbred pedigree.

Polonius 2513	Sarpendon 930	Mercury 432	Jupiter 93	Saturn 94
				Rhea 166
			Alphea 171	Saturn 94
				Rhea 166
		Europa 176	Jupiter 93	Saturn 94
				Rhea 166
			Alphea 171	Saturn 94
				Rhea 166
	Ledy 799	Jupiter 93	Saturn 94	
			Rhea 166	
		Europa 176	Jupiter 93	Saturn 94
				Rhea 166
			Alphea 171	Saturn 94
				Rhae 166

In a common pedigree there would be 26 ancestors in the four generations, representing 14 lines of descent, whereas in the pedigree of Polonius there are but eight individuals, representing two lines of descent. Saturn and Rhea each appears seven times, Jupiter four, Alphea three, Europa two, while each of the other three appears but once. According to the law of ancestral heredity these eight ancestors collectively contribute $^{15}/_{16}$ of the total heritage, each individual contributing as follows:

Males	Females
Sarpendon $^1/_4$	Ledy $^1/_4$
Mercury $^1/_{16}$	Europa $^1/_8$
Jupiter $^7/_{64}$	Alphea $^3/_{64}$
Saturn $^3/_{64}$	Rhea $^3/_{64}$

A still more remarkable case of condensing blood lines is observed in the pedigree of Alphea Czar. This pedigree traces back from four to eight generations and represents 106 ancestors with 52 lines of descent, whereas there are actually 14 ancestors with but two lines of

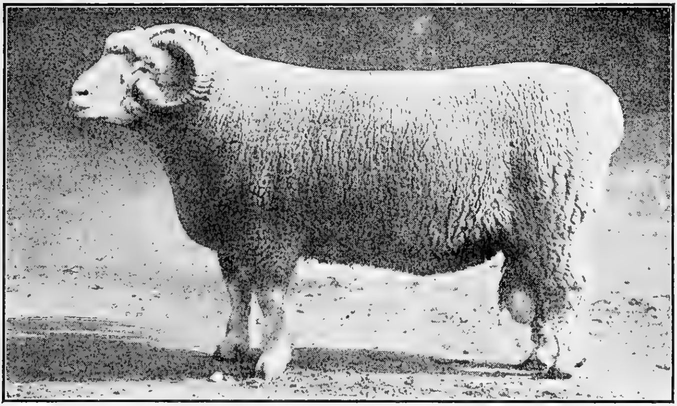


FIG. 43—DORSET-HORNED RAM

descent in the pedigree. Saturn and Rhea, the original animals, each appears 27 times, Jupiter 15, Alphea 12, Mercury 7, Europa 5, Phædra and Leda 3 each, Nymphæa 2, while Splendor the bull, Splendor the cow, Elevator, Hark Comstock and Mercury, Jr., each appears once.

Pedigree with exceptional animal.—Our former methods of writing pedigrees encouraged the idea of placing much stress upon an exceptional ancestor, even though he appears many generations back in the pedigree. Manifestly, in the light of the law of ancestral heredity, this practice seems unwarranted. This is particularly true in case the individual in question has gained the notoriety through a show yard career, as this signifies little save that the animal was an exceptional individual. It gives us no assurance that the good qualities will be transmitted to the offspring. In fact, it very frequently happens that the reverse is the case, as there are few exceptional show animals that have produced offspring famous as breeders or show animals. We should not, therefore, place too much stress upon the exceptional animal unless the breeding powers have been fully demonstrated by an actual breed test.

Value of family names.—In the development and improvement of a breed of animals it not infrequently happens that the descendants of some famous individual assume a family name. Such families are sometimes founded by a sire, but more frequently by a dam. Good examples of where families were founded by the sire are observed in the case of Standardbred horses where the Hambletonian family descended from Hambletonian 10, the Clay family from Henry Clay 8, and the Morgan family from Justin Morgan. Among the more noted families founded by dams, we have the Duchess family of Shorthorns descending from Duchess I by Comet and the De Kol family of Holstein-Friesians descended from De Kol 2d by Willem III. Animals belonging to such families frequently become very popular and their descendants in very great demand. There is usually keen rivalry among the breeders. Under such conditions breeders with unlimited means frequently pay fancy prices for the more promising individuals, with the idea that they can sell the offspring to advantage and make money on the transaction. This is more or less of a speculation, as a special market must be found for each animal sold. For the man who has the means and the executive ability to conduct such a business, it may prove exceedingly profitable. The average breeder, however, should understand the matter thoroughly before paying a fancy price for a single individual simply because the animal happens to be a member of a family in great public favor.

Significance of breeder's name.—The reward that occurs to the breeder who persists in his efforts to develop a strain or improve a breed of animals is unexcelled by that of any other profession. Everywhere we find breeders whose reputation is known far and wide. The mere fact that an animal was bred by them is sufficient recommendation to establish its worth. Such men first make a careful study of the business, decide upon a strain and breed, then work out a definite method of procedure which they adhere to persistently. In such cases the breeder's methods are a guarantee that none but good animals were used in the business, and that these were selected after a thorough consideration of the individual merit, pedigree and record of performance.

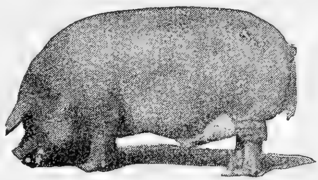


FIG. 44—DUROC JERSEY BOAR

Proportion of pure-bred animals.—Such statistics as have been collected show that there is a close relationship between the number of pure-bred animals in a locality and the general excellence of farm stock. Of the twenty counties in New York State containing the largest number of dairy cattle those with the largest number of purely bred animals include the counties in which the average production was highest and the counties which made the largest increase in yield during the past decade.

In this connection it is interesting to observe that such statistics as are available in a few states show that the majority of stallions standing for public service are not recorded. No doubt some of these unrecorded animals are useful sires. It is safe to say, however, that most of them are of little credit to the country, for many, even of those that are recorded, are unsuited for the service they are allowed to perform. The meager statistics that are available for cattle, sheep and swine indicate that a very large percentage of the males used for service are not recorded.

In 1905, the Bureau of Animal Industry issued a report in which it estimated that of all horses in the United States 1.02 per cent were registered. For dairy cattle the per cent was given as 1.07, beef cattle 1.05, sheep 0.46 and swine 0.45. This gives evidence that a very large proportion of the sires in use throughout the country are unregistered. This no doubt accounts for much of the indifference attending animal breeding in this country.

CHAPTER XII

PERFORMANCE AND SELECTION

It must be clearly recognized that, as a basis for estimating the breeding powers of an animal, nothing compares with an accurate test of just what the animal can do. While individuality and pedigree are important factors for the guidance of breeders, they both become secondary to a record of performance, the result of an actual test. In considering such a record, however, it is necessary to have full regard for the conditions under which it was made. Thus an individual with a moderate record made under adverse conditions may be just as valuable as one with a high record made under the most favorable circumstances. On the other hand, an increase of a fair degree of merit under limited opportunities is not a satisfactory assurance of the ability to produce excellent results when accorded the most favorable opportunity.

For many years we have kept an accurate record of the speed of trotting and pacing horses. These speed records have been recorded in Wallace's Year Book. More recently a system of testing milk and butter-fat capacity of dairy cows has been inaugurated. The results of such tests are recorded in the advanced register. We now have the speed records of thousands of horses as well as the milk and butter-fat records of thousands of dairy cows, going back many generations. These data, accurately collected and properly interpreted, furnish invaluable aids to breeders in selecting their animals.

Standards of performance.—Before an animal can be admitted to the advanced register it must first prove its worth by fulfilling certain requirements in an actual test. This is very different from the requirements of the stud, herd and flock books, where an animal is eligible to admission providing its sire and dam are recorded, although the animal must be thus recorded before it is qualified to enter the test for the advanced register. For the most part these standards of performance are not difficult. They were established with a view of encouraging large numbers of animals to enter the test, as it was thought more

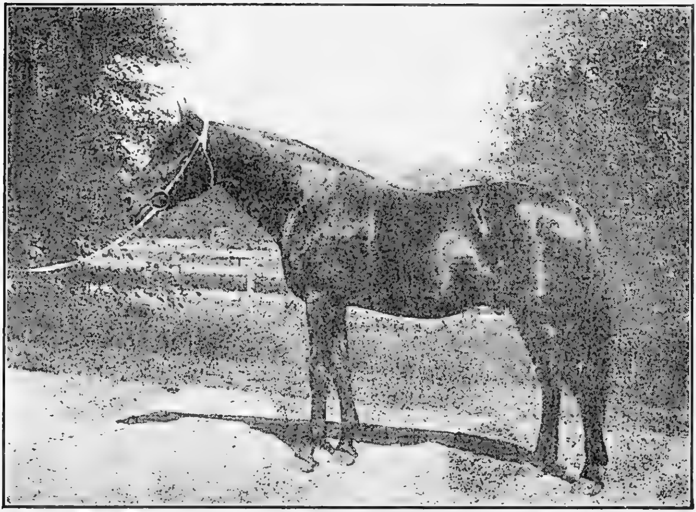


FIG. 45—STANDARDBRED STALLION "KREMLIN," 2:07¾

good would result from large numbers of fairly efficient animals than small numbers of highly efficient ones.

Trotting and pacing standard.—When an animal meets these requirements and is duly registered, it shall be accepted as a standard-bred trotter or pacer:

1. The progeny of a registered standard trotting horse and a registered standard trotting mare.

2. A stallion sired by a registered standard trotting horse, providing his dam and granddam were sired by a

registered standard trotting horse, and he himself has a record of 2:30 and is the sire of three trotters with records of 2:30 from different mares.

3. A mare whose sire is a registered standard trotting horse, and whose dam and granddam were sired by registered trotting horses, providing she herself has a trotting record of 2:30 or is the dam of one trotter with a record of 2:30.

4. A mare sired by a registered standard trotting horse, providing she is the dam of two trotters with records of 2:30.

5. A mare sired by a registered standard trotting horse, providing her first, second and third dams are each sired by a registered standard trotting horse.

The pacing standard is similar except the word "pacer" is substituted for the word "trotter;" "pacing" for the word "trotting" and the speed standard 2:25 for 2:30, and the addition of a sixth paragraph, which is as follows:

6. The progeny of a registered standard trotting horse out of a registered standard pacing mare, or of a registered standard pacing horse out of a registered standard trotting mare.*

Holstein-Friesian seven-day standard.—When a cow meets the following requirements and is duly registered she may be admitted to the advanced register:

A cow calving on or before the day she is two years of age shall make a record of not less than 7.2 pounds of butter fat in seven consecutive days; and for every day that she may exceed two years of age at date of calving the requirement for the butter-fat record shall be increased .00439 of a pound.

If calving on the day she is five years of age, she shall make a record of not less than 12 pounds of butter fat in seven consecutive days; and no increase in production for increased age at date of birth shall be required for any cow calving subsequently.

*Wallace's American Trotting Register.

Holstein-Friesian seven-day requirement by classes:

Junior two-year-old	7.2 pounds
Senior two-year-old	8.0 pounds
Junior three-year-old	8.8 pounds
Senior three-year-old	9.6 pounds
Junior four-year-old	10.4 pounds
Senior four-year-old	11.2 pounds
Full age	12.0 pounds

Holstein-Friesian, Jersey and Guernsey yearly standard.—If a test for the period of one year is commenced the day the cow is two years old, or previous to that day, she must produce, within one year from the date the test begins, 250.5 pounds butter fat. For each day the cow is over two years old at the beginning of her year's test, the amount of butter fat she must produce in the year is fixed by adding 0.1 (one-tenth) of a pound for each such day to the 250.5 pounds required for the two-year-old. This ratio of increase applies until the cow is five years old at the beginning of her test, when the required amount will have reached 360 pounds, which will be the amount of butter fat required of all cows five years old or over. These standards are based upon one complete year's record from the time of beginning, regardless of any time which may be lost by being dry or calving during that period.

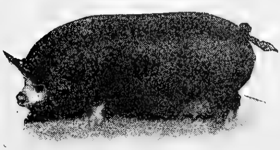


Fig. 46—Berkshire Sow

Ayrshire yearly standard.—This calls for 214.3 pounds of fat at two years of age, with the addition of .06 of fat for each succeeding day up to three years of age, when the standard calls for 236 of fat, with the addition of .12 for each succeeding day up to five years of age, when the requirement is 322 pounds of fat.

Brown Swiss yearly requirement.—This call for 222 pounds of fat at two years and six months of age, with the addition of .09 of fat for each succeeding day up to six years of age, when the requirement calls for 337 pounds of fat.

The advanced register record.—A pedigree consists of the name and number of an animal, the name and number of the sire and dam, together with the name and address of the owner. These data tell us nothing of what the animal has done and gives us no assurance of what it is capable of doing. True, it signifies that the animal is purely bred, and in the case of famous families and noted owners adds commercial value, but as to actual producing and breeding power it leaves us as much in the dark as we were before. Contrast with this the data given in the advanced register.

The following Holstein-Friesian advanced register records, one of the noted cow, Belle Korndyke, the other a partial record of the bull, Lord Netherland De Kol, illustrate the form and give the data covered in the advanced register.

The first number following the name is the advanced register number and the second the herd book number. The first figure in the parenthesis indicates the number of advanced register daughters that each animal has; the second figure the number of sons that are sires of tested daughters; and the third figure the number of daughters that are dams of tested daughters.

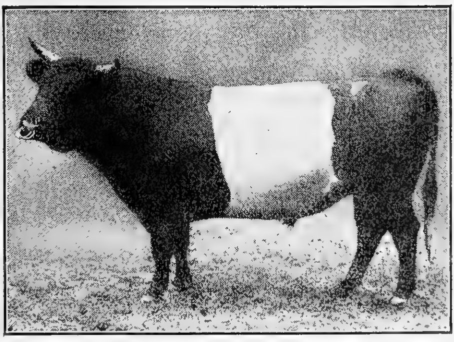


FIG. 47—DUTCH BELTED BULL "AUTEN"

Under each animal's name will be found a list of tested daughters, together with their milk, butter fat and butter

Belle Korndyke 1449-13913 (4-6-5)

	Y	M	D	Milk	Fat	80% B
A. & G. Korndyke 1664-13-50532	5	2	9	465.3	17.981	22.476
Belle Korndyke's Daughter 3054-18-54085	6	11	28	627.5	20.336	25.420
30-day record	6	11	28	2,565.4	82.104	102.630
Korndyke Queen 1271-8-40580	4	1	9	518.3	16.558	20.697
Korndyke Queen De Kol 1549-14-41934	6	7	19	501.4	19.535	24.418
30-day record	19	4	3	2,230.1	78.681	98.351

Belle Korndyke Beryl Wayne 32,386, *Belle Korndyke Butter Boy* 27856, *Earl Korndyke De Kol* 24954, *Karel Korndyke* 42872, *Korndyke Wayne Paul De Kol* 32571, *Pontiac Korndyke* 25982, — *A. & G. Belle Korndyke* 50532, *Belle Korndyke's Daughter* 54085, *Korndyke Queen* 40580, *Korndyke Queen De Kol* 41934, *Pietertje Korndyke* 23479.

Lord Netherland De Kol 245-22187 (120-31-99)

	Y	M	D	Milk	Fat	80% B
Aaggie Beauty Pietertje De Kol 3919-16-63093	3	0	4	313.5	12.558	15.697
Aaggie Netherland De Kol Wayne 7285-21-69216	6	7	26	480.4	18.641	23.301
Alice De Kol Netherland 8640-20-74462	4	5	4	363.7	14.454	18.067
A. Lilly De Kol 6130-18-66314	3	5	11	335.1	11.216	14.020
Annie De Kol 4280-18-53382	7	4	26	410.8	17.720	22.150
Beauty Jewel De Kol 10021-24-92906	6	6	10	536.3	20.353	25.441
Beauty Mechthilde De Kol 15911-23-78248	6	8	25	434.2	16.049	20.061
Beauty Pauline De Kol 11617-21-69652	7	11	0	426.0	19.344	24.180
Beauty Wayne Pauline 2d Lady 20370-24-121308	5	9	19	463.8	14.152	17.690
Bessie De Kol Wayne 14829-22-72838	7	11	13	313.3	13,457	16.821
Bisque De Kol 9126-20-65626	6	2	8	557.1	18.580	23.225
Bodora Delle De Kol 5346-17-63345	2	10	9	260.2	10.135	12.668
Bodora Pride De Kol 8824-20-59976	7	2	21	466.7	15.810	19.762
Brimsma De Kol 7413-19-50636	9	2	7	466.6	15.998	19.997
Brimsma De Kol Pauline 4136-20-64209	6	4	16	492.1	14.980	18.725
Cassie Jewel De Kol 2d 5383-17-67614	2	6	9	316.9	9.072	11.340
Cassie Koningen Pietertje De Kol 8234-20-61054	7	0	26	424.4	13.107	16.383
Christmas Queen De Kol 4036-16-74060	3	11	28	322.5	13.041	16.301
Christmas Queen De Kol 2d 6531-20-92646	4	3	29	467.3	18.249	22.811
Eight months after calving, -19-	3	1	9	269.4	9.664	12.080

And so on, including a complete record of the 120 advanced register daughters, together with a list of all sons and daughters that are the sires or dams of tested daughters.

record, as well as the age at which the record was made, and following the list of daughters with records will be found, printed in italics, the names and herd book numbers of the sons that are sires of tested daughters, and of the daughters that are dams of tested daughters.

Following the name of each tested daughter will be found three numbers. The first is the animal's advanced register number, the second is the number of the volume of the advanced register in which the record given may be found, and the third the herd book number. Following this is the milk, fat and butter record; also the age at which it was made.

Value of advanced register record in selection.—To get the data contained in an advanced register record before us in a more concrete form, let us tabulate the pedigree

PEDIGREE OF LORD NETHERLAND DE KOL 22187, INCLUDING THE ADVANCED REGISTER RECORDS*

Lord Netherland De Kol 22187 120-31-99	Netherland De Kol Perfection 17713 14-14-23	Pietertje 2d's Koningen 10625 1-3-0	Koningen Von Friesland 5th's Netherland 3515
			Pietertje 2d 3273 H. H. B.
		Netherland De Kol 10605	Netherland Alban 5484 H. H. B. 1-3-5
			De Kol 2d 734 536.8 milk, 21.261 fat 2-7-5
	Susie De Kol 33688 475.5 milk 20.245 fat 5-4-8	De Kol 2d's Netherland 11584 22-21-28	Netherland Alban 5,484 H. H. B. 1-3-5
			De Kol 2d 734 536.8 milk, 21.261 fat 2-7-5
		Daisy De Kol 20201	De Kol 2d's Prince 2767
			Belle Barnum 2422

*Made up from Vol. 24 of the Holstein-Friesian Advanced Register.

of Lord Netherland De Kol, similar to that on page 116, but including the advanced register data.

This means that Lord Netherland De Kol has 120 daughters with advanced register records; that 31 of his sons have daughters with records; and that 99 of his daughters are the dams of daughters with advanced register records. His sire, Netherland De Kol's Perfection, has 14 daughters with records; he has 14 sons that have daughters with records; and he is the sire of 23 dams that have advanced register daughters. His dam, Susie De Kol, has a record of 475.5 pounds of milk and 20.245 pounds of fat in seven days, as well as five daughters with records; she has four sons that are the sires of daughters with records; and she has eight daughters that are the dams of daughters with records. Like data are given for each ancestor that has an advanced register record.

In like manner, to get the data contained in Wallace's Year Book before us in a more concrete form, let us tabulate the pedigree of the Standardbred horse, Allerton, who leads the list with 257 performing get to his credit. (P. 133.)

This gives us practically the same data as that given in the Holstein-Friesian pedigree. It signifies that Allerton has 199 trotters and 58 pacers to his credit in the year book; that 85 of his sons have sired 197 trotters and 116 pacers; and that 61 of his daughters are the dams of 63 trotters and 19 pacers, making a total of 395 performers in the second generation. Similar data are given for each ancestor in the pedigree. The sire, Jay Bird, has a total of 706 performers in the second generation; George Wilkes, the grandsire, has 3,394, and Hambletonian 10, the great grandsire, has 1,836, while both parents have 964, the four grandparents 3,641, and the great-grandparents have 5,620 performers in the second generation of offspring, making a total of 10,225 in the three generations of ancestors. Of course, wherever the same ancestor occurs twice the performers are counted twice.

Exact measure of breeding capacity.—This standard is an absolute one, and gives an exact measure of the breed-

Pedigree of Allerton 5128, Including Records of Performance*

- **Allerton 5128** — 199 trotters, 58 pacers; 85 sires; 197 trotters, 116 pacers; 61 dams; 63 trotters, 19 pacers
  - **Jay Bird 5060** — 127 trotters, 18 pacers; 58 sires; 428 trotters, 153 pacers; 83 dams; 112 trotters, 13 pacers
    - **George Wilkes 519** — 72 trotters, 11 pacers; 103 sires; 2,105 trotters, 1,082 pacers; 110 dams; 148 trotters, 59 pacers
      - **Hambletonian 10** — 44 trotters,—; 150 sires; 1,493 trotters, 224 pacers; 80 dams; 101 trotters, 8 pacers
      - **Dolly Spanker** — 1 trotter, 2 pacers
    - **Lady Frank** — 1 trotter; 2 sires; 130 trotters, 19 pacers; 3 dams; 4 trotters, 1 pacer
      - **Mambrino Star 585** — 2 trotters,—; 8 dams; 9 trotters, 2 pacers
      - **Lady Frankline** — 1 trotter,—
  - **Gussie Wilkes** — 2 trotters,—; 2 sires; 200 trotters, 58 pacers
    - **Mambrino Boy 844** — 12 trotters, 3 pacers; 6 sires; 8 trotters, 9 pacers; 33 dams; 41 trotters, 8 pacers
      - **Mambrino Patchen 58** — 25 trotters,—; 57 sires; 166 trotters, 47 pacers; 110 dams; 146 trotters, 20 pacers
      - **Roving Nelly** — 1 trotter,—
    - **Nora Wilkes** — 2 trotters, 2 pacers; 5 sires; 13 trotters, 13 pacers; 1 dam; 1 trotter
      - **George Wilkes 519** — 72 trotters, 11 pacers; 103 sires; 2,105 trotters, 1,082 pacers; 110 dams; 148 trotters, 59 pacers

*Made up from Vol. 29, Wallace's Year Book.

ing capacity of the particular individual in question. True, such records depend on opportunity, although Lord Netherland De Kol was chosen to illustrate the value of a record of performance in selecting animals for breeding purposes because, so far as known, he did not have exceptionally favorable conditions. Nevertheless, at the present time (1913), he leads the list of Holstein-Friesian sires with advanced register daughters, although De Kol 2d's Butter Boy 3d's 74 sons lead the list of sons with 581 daughters in the register, while Lord Netherland De Kol's 31 sons have only 105 daughters with records. In this respect De Kol 2d's Butter Boy 3d is followed by Hengerveld De Kol, whose 54 sons have 447 daughters in the advanced register, and by King Segis, whose 50 sons have 340 daughters with records.

FIG. 48—DUTCH BELTED COW "JENNIE"

Manifestly, so far as ability to produce performers is concerned, such a record as this is of vastly more importance to the breeder than individuality or pedigree. While, theoretically, successful animal breeding depends largely upon the law of chance, such records as these practically eliminate the chance, and we can predict the outcome within the limits of accident in animal life. True, this again depends on chance, but not in the same sense as when we mate animals of unknown breeding capacity.

Vigor and performance.—In selecting animals on the basis of their performance, constitutional vigor becomes of prime importance. Many of our high-performing animals seem to produce so heavily as to undermine their constitutional vigor. If such animals are selected for breeding, the offspring are likely to lack vigor, and of course will be unable to equal the performance of their parents. We are not without examples of this, as both dairy cattle and hens have been selected for breeding purposes on the basis of their production alone, with disastrous results. When choosing his breeding animals, therefore, the breeder must clearly recognize that in the absence of vigor and thrift all else may come to naught, even though the particular animal selected be a good individual, well bred, and with a high record of performance to his credit.

Meat, wool and egg production.—Up to the present time we have recorded performance among race horses and dairy cows only. Speed and milk production are easily measured, and our breeders have seized upon them in the hope of gaining some light in the mysteries of breeding. There seems to be no difficulty, however, in measuring and recording wool production among sheep, and but little difficulty is encountered in measuring egg production among poultry; in fact, most of the agricultural experiment stations and a few breeders keep accurate account of both functions. This provides equally as valuable data in selecting breeding animals as advanced register records among cattle. No doubt in the course of the next few years a concentrated effort will be made by the various breeders' associations to keep an accurate account and record all such useful functions.

There are a few functions that cannot be measured with any degree of accuracy. Chief among these is meat production. It would be difficult, if not impossible, to measure such attributes as early maturity and economic fleshing qualities among our meat-producing animals. In selecting such breeding animals the breeder must rely upon his own skill in estimating such attributes.

Value of show awards.—In the case of meat-producing animals and horses it has been suggested that the show-ring decisions be recorded and that this be used as the basis in selecting breeding animals. In all probability such records would be of very little value in detecting, or even in estimating breeding capacity. In reality this constitutes selecting animals on the basis of individual merit. As has been stated, individual excellence gives us no indication of the breeding capacity of an animal.

CHAPTER XIII

IMPROVEMENT DUE TO SELECTION BASED ON PERFORMANCE

The development attained by each of our breeds of animals has resulted from many co-ordinated influences, no one of which has played so great a role as that of selection. In the past there has been much confusion among breeders in the matter of selecting animals. Much of this was due to lack of understanding as to what constituted breed excellence. Breeders were divided in their opinion as to the most important characters. Some breeders were selecting to advance one set of characters, while other breeders were trying to advance another set. Not infrequently these characters were negatively correlated, and as one improved the other declined. True, each breed had its scale of points and standard of excellence, but the interpretation of these was left to the judgment of the individual breeder, and in the absence of a definite feature, attribute or character to measure there was utter lack of concentrated effort. As would be expected under such conditions of affairs the standard of excellence and scales of points have been modified from time to time to suit the ideas of breeders. These changes have not always worked to the advantage of the particular breeds affected.

Characters considered and methods of presentation.—To get the essentials involved in animal improvements clearly before us, it is proposed to present and discuss facts disclosed by the advanced register for Holstein-Friesian cattle and by Wallace's Year Book for horses. In view of the remarkable advancement attained in speed development and milk production some of the data are considered in detail, particularly that related to milk and butter-fat production. The dairy cow and the race horse are the only classes of farm animals in which records of performance are kept, and hence the only ones concerning which we have definite knowledge of the exact advantage gained. However, the same principles are involved and the same suggestions apply to other characters, such as meat and wool production, the development of the draft horse, the coach horse, and the like. Because of the vast amount of data considered and to get the facts clearly before us it is necessary to present a few rather long and complicated tables. These should be carefully considered by the reader in order that he may analyze, generalize and synthesize of his own accord, thus stimulating thought, which will lead to closer observation throughout nature generally.

DEVELOPING THE TROTTER

Records of performance were first recorded among race horses. In the beginning, this was a private undertaking, the time of the horse being recorded in racing calendars. This was for the information of the men who wagered their money on the race, rather than for the guidance of breeders in selecting horses for breeding. Later, the value of such records became apparent to the breeder, and the year 1839 witnessed the beginning of methodic recording time of horses in the more important races. From that time until the present we have a more or less complete and fairly accurate record of each horse taking part in the more important racing events in this country.

Influence of time records.—Such records have been a most important factor in developing extreme speed in the trotter and pacer. This method not only enables us to distinguish the slow and fast horses, but from the records we can determine those horses that are actually producing fast animals as illustrated in the pedigree

(p. 133). Thus in selecting breeding animals, the slow ones are eliminated, and the fast ones are mated, which, in connection with improved conditions, enables us to get even faster horses. Again, the slow-producing animals are discarded and the fast ones mated, which results in a still greater increase in speed.

At the close of the 1913 racing season there were listed in the year book approximately 50,000 performers, of which about 30,000 were trotters and about 20,000 pacers. These performers were sired by approximately 10,000 stallions and out of 25,000 mares. This gives an average of five performers to a sire and two to a dam.

Breeding of great sires.—Of the thousands of sires recorded in the great table of the year book there are but 30 credited with 100 or more performers; that is, horses good enough to meet the requirements for admission. While the average of all sires listed is approximately five performers, the average of the 30 great sires is approximately 150 each. These great sires, therefore, are thirty times as efficient as the average sire. Manifestly the breeder should be interested in the history of the breeding of these noted animals so as to be able to produce others if possible. Fortunately, the record of performance as kept in the year book gives us a complete history of the breeding power of each ancestor, providing it was meritorious enough to gain admission.

It is interesting to observe, of these 30 noted horses, that the sire, paternal grandsire and great-grandsire each has performing get to his credit; that each dam, with two exceptions, has performing get; that each maternal grandsire, without exception, has performing get; and that each paternal granddam, with seven exceptions, has performing get to her credit.

The following tabulation shows the *average* number of performing get for each ancestral form for three generations of ancestors for the 30 great sires:

Average Performance of 30 Great Sires and Their Ancestors*

30 great sires 109.5 trotters 38.1 pacers 147.6	30 sires 76.1 trotters 13.1 pacers 89.2	30 G. Sires 47.0 trotters 4.6 pacers 51.6	30 G. G. sires 22.5 trotters .7 pacer 23.2
			30 G. G. dams 1.1 trotters
		30 G. dams 2.1 trotters	30 G. G. sires 7.6 trotters .4 pacer 8.0
			30 G. G. dams .16 trotter
	30 dams 2.9 trotters .2 pacer 3.1	30 G. sires 19.3 trotters 2.6 pacers 21.9	30 G. G. sires 15.5 trotters .5 pacer 16.0
			30 G. G. dams .2 trotter
		30 G. dams 1.0 trotter .1 pacer 1.1	30 G. G. sires 9.8 trotters 2.2 pacers 12.0
			30 G. G. dams 03 trotter

*Made up from Vol. 29, Wallace's Year Book.

This tabulation is significant. It illustrates the exact breeding power necessary to produce the greatest of Standardbred sires. It also shows the increased efficiency from generation to generation. The 30 famous animals averaged 147 performers each, while their sires averaged 89, their paternal grandsires 51, and the great-grandsires 8 and 23 each, while the granddams average two each, with both great-granddams represented. Again, the dams of the 30 noted animals averaged three performers each, the maternal grandsires almost 22, and the great-grandsires 12 and 16 each, while the granddams averaged one each, with both great-granddams represented.

No doubt many factors are involved in this remarkable development, but the significant fact remains that of the thousands of sires listed in the great table of the year book not a single animal stands high in the list, but that is backed up by high-performing ancestors for many generations.

DEVELOPING THE DAIRY COW

While cattle have been bred for dairy purposes for more than a century, marked improvement in milk yield and butter-fat production is of comparatively recent date. It is associated with the development of our present system of keeping records of the milk yield and the butter fat produced for the individual animal. Formerly dairy cattle were selected on the basis of their conformation, which, as has been stated, is not a true guide to efficiency. This resulted in slow progress. Not satisfied with such progress a few breeders began to keep an accurate account of the milk yield and churned butter that their animals produced. Such remarkable progress followed that the dairy cattle breeders' associations took up the matter of keeping records. They standardized the work and established the advanced registers in which the performance is recorded.

Influence of butter-fat records.—While the Jersey cattle breeders' association have encouraged the keeping of records since the early '70's and the Holstein-Friesian since the early '80's, it was not until 1894 that the Holstein-Friesian breeders' association began the official supervision of records. Although the work has been in progress but two decades great advancement has been made both in regard to the number of animals tested and the results obtained.

As in the case of time records among horses, the records of dairy production not only enable the breeder to distinguish the low from the high producing, but from the records he can determine which individuals are actually getting high-producing animals. In selecting breeding animals the breeder has but to eliminate the low performing and mate the high performing which, in connection with improved conditions, results in even higher producing animals, and the general improvement of dairy cattle.

FIG. 49—HOLSTEIN-FRIESIAN COW "GLISTA OMICRON"
25.285 pounds of butter fat in seven days.

Breeding of cows with advanced register records.—Manifestly, the breeding of cows that can meet the requirements for admission to the advanced register is of interest. To illustrate this a tabulation is made of all of the Holstein-Friesian cows admitted to the register during the two years ending May 15, 1911. This includes 7,443 cows, of which 5,072 were first entries and 2,371 re-entries; that is, cows increasing a previous record. Inasmuch as the re-entries may be considered a second selection, they will be considered separately. Since the requirements for admission to the advanced register are not very difficult the table is divided into three parts, the first division including those cows that exceed the requirement by less than 50 per cent, the second those that exceed the requirement by 50 to 100 per cent, and the third division those cows that exceed

BREEDING OF HOLSTEIN-FRIESIAN COWS, FIRST ENTRIES, THAT EXCEED THE REQUIREMENT BY LESS THAN 50%; BY 50% TO 100%; AND BY 100% AND ABOVE.

Character of matings	Number of cows	Per cent. of cows
Cows that exceed the requirement by less than 50%, 3,856; 76% of total number		
Both sire and dam in register	1,316	34.
Neither sire nor dam in register	1,020	27.
Sire in register, dam not	1,003	26.
Dam in register, sire not	517	13.
Totals	3,856	100.
Cows that exceed the requirement by 50% to 100%, 1,090; 22% of total number		
Both sire and dam in register	491	45.
Neither sire nor dam in register	196	18.
Sire in register, dam not	224	21.
Dam in register, sire not	179	16.
Totals	1,090	100.
Cows that exceed the requirements by 100% and more, 126; 2% of total number.		
Both sire and dam in register	82	65.
Neither sire nor dam in register	4	3.
Sire in register, dam not	22	18.
Dam in register, sire not	18	14.
Totals	126	100.

the requirement by 100 per cent or more. The cows were arranged in four classes according to the possible kinds of mating. (See table on p. 143.)

In the first division more than one-third of the cows have both parents in the advanced register, while almost three-fourths of them have at least one parent in the register. Note how this percentage increases as the standard is raised. In the second division approximately one-half have both parents in the register, while about five-sixths have one parent in the register; whereas in the third division, where the standard is doubled, prac-

Breeding of Holstein-Friesian Cows, Re-entries That Exceed the Requirement by Less Than 50%; by 50% to 100%; and by 100% and Above.

Character of matings	Number of cows	Per cent. of cows
Cows that exceed the requirement by less than 50%, 1,534; 65% of total number		
Both sire and dam in register	780	51.
Neither sire nor dam in register	177	12.
Sire in register, dam not	425	27.
Dam in register, sire not	152	10.
Totals	1,534	100.
Cows that exceed the requirement by 50% to 100%, 724; 30% of total number		
Both sire and dam in register	438	61.
Neither sire nor dam in register	53	7.
Sire in register, dam not	169	23.
Dam in register, sire not	64	9.
Totals	724	100.
Cows that exceed the requirement by 100% and more, 113; 5% of total number		
Both sire and dam in register	86	76.
Neither sire nor dam in register	4	4.
Sire in register, dam not	16	14.
Dam in register, sire not	7	6.
Totals	113	100.

tically two-thirds have both parents in the register, and practically all have one parent in the register, but three in 100 having neither parent in the register.

In the first division of the re-entries (p. 144) more than one-half of the cows have both parents in the register and all but 12 in 100 have at least one parent in the register. Again, observe how this percentage increases as the standard is raised, until in the third division more than three-fourths of the cows have both parents in the register. These tables emphasize the fact that if we wish to select the highest producing cows we must look for them among the offspring of advanced register animals.

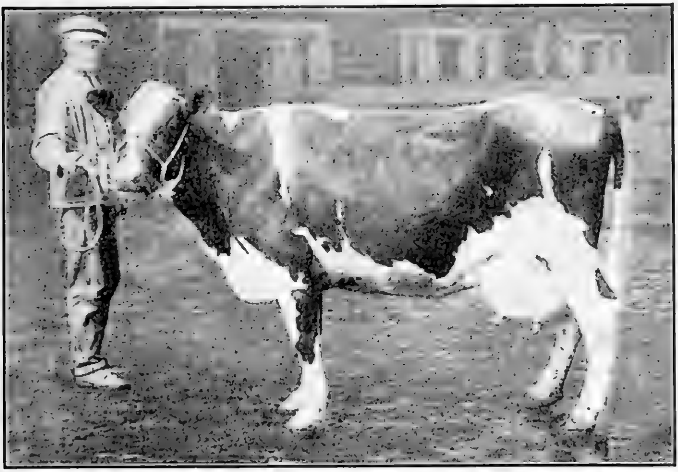


FIG. 50—HOLSTEIN-FRIESIAN COW "GLISTA EGLANTINE"
25.912 pounds of butter fat in seven days.

Holstein-Friesian cows with records as breeders.—In this study the number of performing offspring produced by cows with records is of much importance. To illustrate this a tabulation is made of all the Holstein-Friesian cows that are the dams of two or more advanced register daughters. On May 1, 1913, there were 4,183 such dams.

For convenience of study this table (see below) is divided into four parts, the first division including those dams with two and three daughters, the second those with four and five, the third those with six and seven. and the fourth division

BREEDING OF HOLSTEIN-FRIESIAN COWS WITH 2 AND 3, 4 AND 5, 6 AND 7, AND 8 A. R. O. DAUGHTERS*

Character of matings	Number of cows	Per cent. of cows
Cows with 2 and 3 A. R. O. daughters, 3,786; 90.5% of total number		
Cows with 2 and 3 A. R. O. D *and* records...	2,182	57.6
Cows with 2 and 3 A. R. O. D *no* records....	1,604	42.4
Totals..............................	3,786	100.0
Cows with 4 and 5 A. R. O. daughters, 375; 9% of total number		
Cows with 4 and 5 A. R. O. D *and* records...	286	76.2
Cows with 4 and 5 A. R. O. D *no* records....	89	23.8
Totals..............................	375	100.0
Cows with 6 and 7 A. R. O. daughters, 20; .4% of total number		
Cows with 6 and 7 A. R. O. D *and* records...	13	90.0
Cows with 6 and 7 A. R. O. D *no* records....	2	10.0
Totals..............................	20	100.0
Cows with 8 or more A. R. O. daughters, 2		
Cows with 8 or more A. R. O. D *and* records..	2	100.0
Cows with 8 or more A. R. O. D *no* records...	0	0
Totals..............................	2	100.0

*Made up from Vol. 24 of the Holstein-Friesian advanced register.

those with eight daughters each. The cows are arranged in two classes, those that have records and those that have no records.

In the first division, dams with two and three advanced register daughters, approximately 6 out of 10, themselves have records. Observe how this number increases as the number of calves produced increases. In the second division, dams with four and five advanced register daughters, three-fourths have records; in the third division, dams with six and seven daughters in the advanced register, nine-tenths have records; and in the fourth division, dams with eight daughters in the register, all have records. This is significant in a consideration of the transmission of high-producing qualities from the maternal parent to the female offspring. It gives conclusive evidence of the desirability of high-producing dams in breeding for high production among dairy cattle.

Breeding of advanced register bulls.—Among dairy cattle the bulls are admitted to the advanced register on the performance of their daughters. When a Holstein-Friesian bull has four daughters in the register, he is admitted automatically. From the breeder's point of view such data are even more valuable than when an animal is entered on its own performance, as such indicates breeding ability. In this connection, therefore, the breeding of bulls that make the requirements is of vital importance. To illustrate this a tabulation is made of all of the Holstein-Friesian bulls admitted on the performance of their daughters up to May 15, 1912 (p. 148). There were 1,191 bulls thus admitted, 126 having been entered before the present standard was adopted. Since the requirements for admission are not difficult the table is divided into five parts, the first division including those with 4 to 14 daughters each; the second, those with 15 to 24 daughters; the third, those with 25 to 49 daughters; the fourth, those with 50 to 74 daughters; and the fifth, those with 75 or more daughters each. The bulls are arranged in four classes according to the character of the mating.

This table is significant in a consideration of methods for obtaining transmitting efficiency. In the first division, sires with 4 to 14 A. R. O. daughters, 50 per cent

Breeding of Holstein-Friesian Sires with 4 to 14, 15 to 24, 25 to 49, 50 to 74, and 75 or More A. R. O. Daughters.

Character of matings	Number of sires	Per cent of sires
Sires with 4 to 14 A. R. O. daughters 948; 79.6% of all with records		
Both sire and dam in register	482	50.8
Neither sire nor dam in register	192	20.2
Sire in register, dam not	191	20.2
Dam in register, sire not	83	8.8
Totals	948	100.0
Sires with 15 to 24 A. R. O. daughters 155; 13.1% of all with records		
Both sire and dam in register	118	76.1
Neither sire nor dam in register	4	2.6
Sire in register, dam not	16	10.3
Dam in register, sire not	17	11.0
Totals	155	100.0
Sires with 25 to 49 A. R. O. daughters 65; 5.4% of all with records		
Both sire and dam in register	47	72.3
Neither sire nor dam in register	0	.0
Sire in register, dam not	8	12.3
Dam in register, sire not	10	15.4
Totals	65	100.0
Sires with 50 to 74 A. R. O. daughters 13; 1.1% of all with records		
Both sire and dam in register	10	77.0
Neither sire nor dam in register	0	.0
Sire in register, dam not	1	7.7
Dam in register, sire not	2	15.3
Totals	13	100.0
Sires with 75 or more A. R. O. daughters 10; .8% of all with records		
Both sire and dam in register	10	100.0
Neither sire nor dam in register	0	.0
Sire in register, dam not	0	.0
Dam in register, sire not	0	.0
Totals	10	100.0

have both parents in the register, 20 per cent have sire only, and 9 per cent have dam only, while but 20 per cent have neither parent in the register. Note how rapidly the per cent with both parents in the register increases, and how those with neither parent in the register decreases. In the second division, sires with 15 to 24 A. R. O. daughters, 76 per cent have both parents in the register, 10 per cent have sire only, and 11 per cent have dam only,

FIG. 51—HOLSTEIN-FRIESIAN COWS WITH HIGH RECORDS OF PERFORMANCES 25.282, 24.416, 25.912 and 24.129 pounds respectively of butter fat in seven days.

whereas but 2.6 have neither parent in the register. In the third and fourth divisions, sires with 25 to 49 and 50 to 74 A. R. O. daughters respectively, about 75 per cent have both parents in the register, and all, or 100 per cent, have at least one parent in the register. Likewise in the last division, sires with 75 or more A. R. O. daughters, all have both parents in the register.

Thus there is not a bull in the advanced register with 50 or more daughters to his credit but that has at least one parent in the register. Further, there is not a bull with 75 or more daughters in the register but that has both parents in the register. This gives conclusive evidence of the advantage of a record of performance for the guidance of breeders in selecting their animals.

Registered animals without registered parents.—As the advanced register for Holstein-Friesian cattle was established in 1894, it must of necessity follow that the animals admitted the first few years had neither parent in the register. As years went by the offspring of the animals first admitted made records and were themselves admitted, with the result that, at present, after the register has been in existence for a number of years an increasing percentage of the animals in the register has parents in the register also. To illustrate this a tabulation is made of all of the Holstein-Friesian bulls admitted to the advanced register each year for the decade ending May 15, 1912. This includes a total of 1,115 bulls. These animals are arranged in four classes as before.

Breeding of Holstein-Friesian Bulls Admitted to the Advanced Register Each Year for the Decade Ending May 15, 1912.

Year	Both sire and dam in register		Neither sire nor dam in register		Sire in register dam not		Dam in register sire not		Total number of bulls
	Number of bulls	Per cent of bulls	Number of bulls	Per cent of bulls	Number of bulls	Per cent of bulls	Number of bulls	Per cent of bulls	
1903	9	22	16	39	11	27	5	12	41
1904	15	32	16	32	11	22	7	14	50
1905	28	43	19	29	13	20	5	8	65
1906	32	41	16	20	26	33	5	6	79
1907	37	49	14	18	16	21	9	12	76
1908	47	54	20	23	18	20	3	3	88
1909	57	55	20	19	17	16	10	10	104
1910	83	63	12	9	27	20	11	8	133
1911	141	67	22	10	35	16	16	7	219
1912	175	67	26	10	33	13	26	10	260

In 10 years the percentage of bulls in the register that have both parents in the register has increased from 22 to 67, while the percentage with neither parent has decreased from 39 to 10 in the same period. The percentage with but one parent in the register has also slightly decreased.

There are many Holstein-Friesian cattle not in the advanced register, simply because they have never been tested. They could make the requirements for admission, but are not given an opportunity. Thus the percentage of animals in the register without advanced register parents will simply depend upon the number of animals admitted from without.

The number of cattle tested for admission to the advanced register is not large. During the past few years only about 13 per cent of the cows and 1.3 per cent of the bulls have been admitted to the register. This is significant. When the small number of cows tested and in the register is taken into account, and the large percentage of high-producing animals coming from the register is considered, the chances of finding a maximum producer from without the register are not very encouraging. The breeder attempting to produce a cow capable of making a seven-day record of 35.3 pounds of fat, or a bull that can sire 100 or more advanced register daughters, is likely to encounter much difficulty unless he selects parents from the advanced register.

In this connection it may be stated that the advanced register plays no part in increasing the production of dairy cows; it neither adds to nor detracts from production, but is simply an instrument in which records of performance are kept and from which records of transmitted efficiency can be obtained.

CHAPTER XIV

IMPROVEMENT DUE TO SELECTION THE RESULT OF PREPOTENCY

The parents are not equally powerful in transmitting characters to their offspring. The parent that has the superior power in determining the characters of the offspring is said to be prepotent. This is of much practical importance to the breeder because of the direct influence which it has upon improvement. It is our lack of definite understanding of factors governing prepotency, however, that is responsible for much of the discussion on the transmission of modified or "acquired" characters, sex limited inheritance and like subjects. While little understood, enough is known regarding prepotence to enable the skilled breeder to select animals possessing it with a reasonable degree of certainty. This is especially true when records of performance are available.

Prepotency is considered from two points of view, first, breed prepotency, by which is meant that animals of a breed are all possessed of much power in transmitting the characters of the breed; and, second, individual prepotency, in which the individual has much power in transmitting its characters to the offspring.

Breed prepotency.—There is much difference in the prepotency of the various breeds. This is clearly brought out when two distinct breeds are crossed. Among beef cattle, if a Hereford-Shorthorn cross is made, the most of the offspring will inherit the color and markings as well as the early-maturing qualities of the Hereford, whereas their general conformation and feeding qualities will be similar to that of the Shorthorn. Among sheep, the American Merino has much power in transmitting its characters when crossed upon other breeds, and more especially when crossed upon grades. In fact, the prepotency of the pure-bred over the common animal is the significant factor in breed prepotency, as it enables us to quickly transform the common animal to the type of the breed from which pure-bred males have been selected. In this connection it must be remembered that some breeds are much more prepotent than others, and hence will effect changes more rapidly, whereas some breeds may be so low in their potency as to be unable to effect the desired changes.

Individual prepotency.—This is of vastly more consequence to the animal breeder than breed prepotency. It is the agency through which individuals are improved, and hence lies at the base of both herd and breed development. Indeed, individual prepotency and selection, based on records of performance, are the most powerful agencies for the improvement of herds as well as the several breeds of farm animals, at the command of the breeder.

So influential are the more prepotent animals that we are likely to confuse prepotency and fertility. This is often due to the fact that the prepotent animal is given the better opportunity, because of the individual merit of his offspring, which naturally increases the number of his get. However, an individual may be very prepotent and low in fertility. In such cases it is often a question as to the wisdom of continuing the potent animal in service, as no animal should be retained for breeding that is not fairly fertile.

Prepotency among horses.—The significance of selection, the result of prepotency in general improvement, is clearly and forcibly illustrated in the case of speed records among Standardbred horses. Of the 10,000 stallions siring the 50,000 performers at the close of 1913 there were 11 that had sired 150 or more performers each, their average being 185. These phenomenal sires, therefore, were 37 times as efficient as the average sire. So important are these sires in a study of prepotency that a tabulation is made, giving their name, stud book number and their sire and dam as well as the number of their performing get, both trotters and pacers.

BREEDING OF 11 PHENOMENAL SIRES, INCLUDING THE NUMBER OF THEIR PERFORMERS—TROTTERS AND PACERS*

Name of horse	Sire	Grandsire	Trotters	Pacers	Total
Allerton 5128	Jay Bird 5060	George Wilkes 519	199	58	257
Gambetta Wilkes 4659	George Wilkes 519	Hambletonian 10	110	121	231
Onward 1411	George Wilkes 519	Hambletonian 10	155	45	200
Red Wilkes 1749	George Wilkes 519	Hambletonian 10	133	45	178
McKinney 8818	Alcyone 732	George Wilkes 519	142	34	176
Alcantara 729	George Wilkes 519	Hambletonian 10	121	54	175
Nutwood 600	Belmont 64	Abdallah 15	137	37	174
Ashland Wilkes 2291	Red Wilkes 1749	George Wilkes 519	93	76	169
Electioneer 125	Hambletonian 10	Abdallah 1	158	2	160
Prodigal 6000	Pancost 1439	Woodford Mambrino 345	127	28	155
Baron Wilkes 4758	George Wilkes 519	Hambletonian 10	119	35	154
Total			1494	535	2029
Average			136	49	185

*Made up from Vol. 29, Wallace's Year Book.

This table is significant, not alone in the number of performing offspring represented, but in the breeding of the phenomenal sires. George Wilkes is the sire of five of these animals and the grandsire of three others; while one of the remaining animals is sired by Hambletonian 10, the sire of George Wilkes, another by Belmont, a grandson of Hambletonian 10 and the remaining one traces to Hambletonian 10 in the maternal line of descent. Of this number, those that were sired by George Wilkes produced 638 trotters and 300 pacers, a total of 938 performers, which is almost one-half of the entire number.

In a study of all such data, and in the comparison of individuals there are three factors that must be borne in mind: First, some individuals were too young for their entire breeding record to be completed; second, some had access to better mares and more of them than did others; and, third, some had enjoyed less opportunity than others owing to their racing engagements.

The famous grandsires.—A study of the more important grandsires shows even more remarkable results. There are seven stallions in the list that have the distinction of being grandsire of over 1,000 performers each. So important are these in a consideration of prepotency that a tabulation is made of them on page 156 showing the number of performers got by each, the number of sons that are sires of performers and the number sired. the number of daughters that are dams of performers and the number dammed, also the total number of performers produced by the sons and daughters.

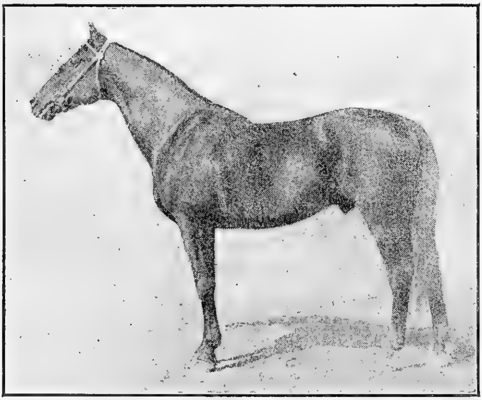


FIG. 52—STANDARDBRED STALLION "MCKINNEY," 2:11¼

It is interesting to observe that five of the famous grandsires are also phenomenal sires, although the animals that stand first and third as grandsires are not represented in the table of phenomenal sires. The seven

FAMOUS GRANDSIRES HAVING MORE THAN 1,000 PERFORMERS EACH IN THE SECOND GENERATION*

Name of grandsire	Year born	Performers	Sons and their performers		Daughters and their performers		Total performers of sons and daughters
			Sires	Performers	Dams	Performers	
George Wilkes	1856	83	103	3,187	110	207	3,394
Electioneer....	1868	160	104	1,851	115	185	2,036
Hambletonian	1849	40	150	1,717	80	119	1,836
Nutwood	1870	174	155	1,306	177	385	1,691
Red Wilkes	1874	178	149	995	174	297	1,292
Onward	1875	200	176	997	194	288	1,285
Baron Wilkes	1882	154	75	870	109	239	1,109
Total		989	912	10,923	959	1,720	12,643
Average		141	130	1,560	137	246	1,806

*Made up from Vol. 29, Wallace's Year Book.

stallions are the sires of 912 sons that sired 10,923 performers, and of 959 daughters that are the dams of 1,720 performers—in all 12,643, one-fourth of all performers listed in the year book. In this consideration the relative age is an important factor. No doubt when the breeding records of some of the younger horses that have had better opportunities are complete we shall have a large increase in the number of stallions with 1,000 or more performers in the second generation.

Breeders of performers and breeders of breeders.—A study of the records of performance among horses reveals the fact that some individuals are notably sires of speed which ends in that generation, while other animals, not especially notable for siring performers themselves, yet produce sires and dams of extreme breeding power. Possibly this is due, in part at least, to the fact that the animals possessing extreme speed are worth more as racers, and thus are not given the same chance in the stud as some other well-bred animals which lack the extreme speed and, therefore, are worth more for breeding than for racing. The fact that some animals seem to be breeders of performers, while others are breeders of breeders, is well illustrated in the following tabulation which includes the seven famous grandsires as well as the 11 phenomenal sires noteworthy for their performers.

PHENOMENAL SIRES AND FAMOUS GRANDSIRES AND THE NUMBER OF THEIR PERFORMING DESCENDANTS*

Name of horse	Year born	Performers	Sons and their performers		Daughters and their performers		Total performers of sons and daughters
			Sires	Performers	Dams	Performers	
Allerton	1886	257	85	313	61	82	395
Gambetta Wilkes	1881	231	74	345	90	152	497
Onward	1875	200	176	997	194	288	1 285
Red Wilkes	1874	178	149	995	174	297	1,292
McKinney	1887	176	48	318	31	38	356
Alcantara	1876	175	79	490	97	183	673
Nutwood	1870	174	155	1,306	177	385	1,691
Ashland Wilkes	1882	169	57	259	50	60	319
Electioneer	1868	160	104	1,851	115	185	2,036
Prodigal	1886	155	15	62	41	61	123
Baron Wilkes	1882	154	75	870	109	239	1,109
George Wilkes	1856	83	103	3,187	110	207	3,394
Hambletonian	1849	40	150	1,717	80	119	1,836
Total		2,152	1,270	12,710	1,329	2,296	15,006
Average		165	97	977	102	177	1,154

*Made up from Vol. 29, Wallace's Year Book.

Compare the performers, those gotten directly, with the total performers of sons and daughters, recording the second generation of performers. It will be observed that seven of the 13 individuals stand high in the second generation, while six are low, although in some cases their ages are against their second generation record. Attention is especially directed to Allerton and Gambetta Wilkes, the most famous producers of speed the world has seen, although their sons and daughters stand low as breeders, and to George Wilkes and Hambletonian, neither famous as direct producers of speed, probably due to lack of opportunity, but both are phenomenal as breeders of sires and dams of speed.

In this connection, it is interesting to note that while there are 30 stallions with 100 or more performers to their credit, there are but six with 100 or more sires, two of which are not included in the list of 30 stallions. There are but 56 stallions that have sired 25 or more sires of performers, whereas there are approximately 300 stallions that have sired 25 or more performers.

Prepotency among dairy cattle.—The records of performance among dairy cattle furnish us better examples of the importance of prepotency in improvement than do those of speed among horses. This is due to the fact that milk and butter-fat production are connected with breeding, whereas the racing engagements of the horse interfere with the breeding. In the dairy cow, therefore, performance and breeding are associated; while in the race horse they are antagonistic. On the other hand, at the present time the dairy cows are handicapped by the fact that we have only a few years' records, as the advanced register was not established until 1894, whereas we have authentic race records since the year 1839.

While advanced register records are of recent origin, the cows are gaining rapidly on the horses. On May 1, 1913, there were 22,720 Holstein-Friesian cows in the advanced register. These were sired by 5,720 bulls, an average of slightly less than four performers to the sire. At the same time, there were 10 bulls that had sired 75 or more performers, their average being 97. These famous bulls therefore, were twenty-five times as efficient as the average sire. The tabulation on page 159 gives the names of these famous bulls, their advanced register number and the number of their performing get, together with the number of sons that are sires of advanced register daughters and number of daughters that are dams of advanced register daughters.

The extended pedigree of each of these famous bulls reveals the fact that they trace to De Kol 2d in much the same manner that the phenomenal sires trace to

FAMOUS BULLS WITH NUMBER OF ADVANCED REGISTER DAUGHTERS AND NUMBER OF SONS AND DAUGHTERS THAT ARE SIRES OR DAMS OF ADVANCED REGISTER COWS*

Name of bull	Number advanced register daughters	Sons that are A. R. O. sires	Daughters that are A. R. O. dams
Lord Netherland De Kol 245	120	31	99
Hengerveld De Kol 136	116	54	73
De Kol 2d's Butter Boy 3d 147	113	74	47
Paul Beets De Kol 113	103	40	80
Homestead Girl De Kol Sarcastic Lad 518	99	19	23
Pietertje Hengerveld's Count De Kol 135	98	46	47
Aaggie Cornucopia Johanna Lad 473	90	41	41
King of the Pontiacs 702	82	27	10
King Segis 558	77	50	23
Pontiac Korndyke 177	77	36	36
Total	975	418	479
Average	97	42	48

*Made up from Vol. 24, Holstein-Friesian advanced register.

George Wilkes. De Kol 2d appears at least once in the first four generations of ancestors in each of the famous bulls except the last two.

Sires of performers and sires of breeders.—While the advanced register is of too recent origin to show famous grandparents, yet the records reveal the fact that some bulls are notable sires of performers which end in that generation, while others are remarkable for producing sires and dams of extreme breeding power. This is well illustrated in the tabulation on page 160, which includes all bulls with 100 or more advanced register daughters. While the bulls involved are few in number, the results are significant. In all these studies it should be remembered that marked prepotency is not of great frequency, and that some individuals enjoy much greater advantages than others.

Compare the performers, those gotten directly, with the total performers of sons and daughters recorded in the second generation. It will be observed that two of the four stand high in the second generation, while two

FAMOUS BULLS AND THE NUMBER OF THEIR PERFORMING DESCENDANTS*

Name	Year born	Performers	Sons and their performers		Daughters and their performers		Total performers of sons and daughters
			Sires	Performers	Dams	Performers	
Lord Netherland De Kol	1894	120	31	100	99	122	222
Hengerveld De Kol	1897	116	54	447	73	132	579
De Kol 2nd's Butter Boy 3rd	1897	113	74	581	47	73	654
Paul Beets De Kol	1893	103	40	162	80	157	319
Total		452	199	1,290	299	484	1,774
Average		113	49	322	75	121	443

*Made up from Vol. 24, Holstein-Friesian Advanced Register.

are very low. Attention is especially directed to Lord Netherland De Kol, who leads the list of performers, yet in the second generation of offspring he stands at the foot of the list and is far below De Kol 2d's Butter Boy 3d, who leads the list as a grandsire of performers, followed by Hengerveld De Kol.

FIG. 53—POLLED DURHAM BULL "THE CONFESSOR"

Performers and prepotency.—Again we come to a consideration of the relation between performance and breeding powers. In the discussion of improvement due to selection based on performance examples were given showing that the best breeders were themselves performers, and in the above discussion it was stated that we have breeders of performers and breeders of breeders. The fact that we have individuals not especially noteworthy for getting performers themselves, yet producing sires and dams of extreme breeding power, such as George Wilkes and Hambletonian, as well as the fact that certain other animals are noted for getting performers that end in that generation, such as the stallion, Allerton, and the bull, Lord Netherland De Kol, has served to confuse both practical and scientific breeders. This has resulted in long-drawn discussion, each explaining his point of view.

To get the matter clearly before us, let us make another tabulation (see next page) showing the breeding of the 1,191 Holstein-Friesian bulls admitted to the advanced register on the performance of their daughters. This is not a selected lot, but includes all bulls admitted to the register on the basis of performance up to May 15, 1912. For convenience of study we will divide the bulls into five classes as before: First, those with 4 to 14 daughters, inclusive, in the register; second, those with 15 to 24; third, those with 25 to 49; fourth, those with 50 to 74; and, fifth, those bulls with 75 and more daughters in the register.

Observe how the percentage with both sire and dam in the register increases as the number of offspring per sire increases. Particular attention is called to the rapid decrease in percentage with neither sire nor dam in the register as the number of daughters in the register increases. There is not a single bull that has 25 daughters

BREEDING OF HOLSTEIN-FRIESIAN BULLS ADMITTED TO THE ADVANCED REGISTER ON THE BASIS OF PERFORMANCE UP TO MAY 15, 1912*

Number of registered daughters per sire	Both sire and dam in register		Neither sire nor dam in register		Sire in register dam not		Dam in register sire not	
	Number of bulls	Per cent. of bulls	Number of bulls	Per cent. of bulls	Number of bulls	Per cent. of bulls	Number of bulls	Per cent. of bulls
4 to 14	482	51	192	20	191	20	83	9
15 to 24	118	76	4	3	16	10	17	11
25 to 49	47	72	0	0	8	12	10	16
50 to 74	10	77	0	0	1	8	2	15
75 and up	10	100	0	0	0	0	0	0

*Made up from Vol. 24, Holstein-Friesian advanced register.

in the register but that has at least one performing parent. Further, there is not a single Holstein-Friesian bull that has 75 daughters in the register but that has both of his parents in the register.

The same is true of the dams of advanced register daughters. To illustrate this a similar tabulation is made of the breeding of all dams with two or more registered daughters up to May 15, 1912.

BREEDING OF HOLSTEIN-FRIESIAN COWS WITH TWO OR MORE ADVANCED REGISTER DAUGHTERS UP TO MAY 15, 1912*

Number of advanced register daughters per dam	Dams with records		Dams with no records	
	Number of daughters	Per cent. of daughters	Number of daughters	Per cent. of daughters
2 and 3	2,182	58	1,604	42
4 and 5	286	76	89	24
6 and 7	18	90	2	10
8	2	100	0	0

*Made up from Vol. 24, Holstein-Friesian advanced register.

In a consideration of the relationship between performance and breeding power these tables are significant. Note how rapidly the percentage of daughters with dams with records increases as the number of daughters per dam increases; likewise the percentage decreases as rapidly when the dams have no records. This shows conclusively that the most prepotent animals descend from parents with records of performance without a single exception.

FIG. 54.—POLLED DURHAM BULL "SULTAN'S CREED"

Famous Holstein-Friesian cows.—In this connection the performance and breeding record of De Kol 2d 734 and Belle Korndyke 13913 are of interest, as these are perhaps the two most famous cows of the breed, at least from the breeder's point of view. De Kol 2d has two daughters in the advanced registry, seven sons that are sires of advanced register daughters, and four daughters that are dams of registered daughters. Belle Korndyke has four daughters in the register, six sons that are sires of daughters in the register, and five daughters that are dams of registered daughters. Both of these cows were famous performers, De Kol 2d exceeding the requirements for admission to the register by 77 per cent and holding the world's record for butter-fat yield from 1894 to 1897; while Belle Korndyke exceeded the requirements by 72 per cent. The sons of these two cows proved remarkable breeders, as is illustrated in the accompanying tabu-

FAMOUS HOLSTEIN-FRIESIAN COWS AND MALE DESCENDANTS*

Belle Korndyke			
Name of Bull	Performers	Sons that are sires	Daughters that are dams
Belle Korndyke Beryl Wayne	45	8	21
Belle Korndyke Butter Boy	1	2	1
Earl Korndyke De Kol	54	11	13
Karel Korndyke	6	4	1
Korndyke Wayne Paul D. K.	19	11	8
Pontiac Korndyke	77	36	36
Total	192	72	80

De Kol 2d			
Name of bull	Performers	Sons that are sires	Daughters that are dams
De Kol 2d's Alban	13	19	14
De Kol 2d's Butter Boy	12	20	18
De Kol 2d's Butter Boy 2d	10	12	13
De Kol 2d's Butter Boy 3d	113	74	47
De Kol 2d's Mutual Paul	39	21	19
De Kol 2d's Netherland	22	21	28
De Kol 2d's Paul De Kol	45	35	32
Total	254	202	171

*Made up from Vol. 24, Holstein-Friesian advanced register.

lation, which gives the number of daughters each son has in the advanced register; also the number of grandsons that have sired registered daughters, as well as the number of granddaughters that are the dams of registered daughters.

Prepotency in sex.—There is a general belief that the sire is prepotent over the dam. In practice this is often the case, for the sire should be and usually is the better bred of the two parents. There is much larger opportunity for selection in males, because so few are needed in the breeding operations. One sire can serve from 10 to 100 females, depending on the class of animals. Thus we can, and usually do, discard nine-tenths, and even more, of all the males born. In most classes of farm animals a very large percentage of the females are needed to maintain the animal population. This should and often does result in the better class of males than females, which accounts for the seeming potency of males.

We are often impressed with the resemblances between offspring and the sire. This is due to the fact that the sire influences the blood of so many offspring, whereas the dam influences the blood of but one in horses and cattle and but few in sheep and swine. Thus, the breeder who wishes to give his animals the most benefit possible of good blood at the least expense will, of course, provide it through the sire's side. For purely economic reasons, therefore, sires in general are prepotent over dams in general. On the other hand, where conditions such as breeding and opportunity are similar, records of performance among horses and dairy cattle fail to show one sex prepotent over the other.

CHAPTER XV

IMPROVEMENT DUE TO ACCUMULATIVE DEVELOPMENT

While the term accumulative development has been given a variety of meanings, here it is employed to denote the general advance made by the offspring over the parent. It is applied to all advances, whether large or small, and of whatever origin. True offspring may and surely will decline unless the parents are judiciously selected, so that we often have accumulative decline. And in the case of some economic characters that are negatively correlated, as in the case of early maturity and high fertility, as well as high egg production and constitutional vigor, it may be difficult in an exact sense to distinguish between breed development and breed decline, for as one character improves, the other may become less efficient. Here, however, is where selection proves the key to the situation. If the herd has been properly founded, a few individuals will show advancement in both characters, and they alone should be retained for breeding and all others should be eliminated. If, perchance, none of the individuals in a given herd show improvement in both characters, it indicates a defective foundation and lack of judicious selection in the original breeding animals.

Modifying characters.—Scientific breeders and biologists generally have entered into an unprecedented discussion over methods of modifying or increasing the efficiency of particular characters. This discussion involves the probable inheritance of modified or "acquired" characters. Students of breeding are about equally divided over the question, one-half stating that much of the improvement attained has been due to the offspring inheriting, in part at least, certain modifications developed by the parent, the other half maintaining that there can be no such thing as the transmission of a modified character. This discussion is involved in a maze of definitions, one side reading certain meanings into words which best suit its argument. Thus the discussion is largely academic, even though the principle involved may be of importance.

It is not proposed to enter into this matter further than to present the conditions as they actually exist for the guidance of animal breeders. Of course it is frankly admitted that a more definite knowledge concerning the control of characters that pass from parent to offspring would be invaluable, but it seems that much of the present discussion is mystifying rather than clarifying the field for the practical animal breeder.

Modified character in heredity.—As brought out in the discussion of the determiners of heredity, there are two views concerning the appearance and transmission of modified characters. According to Darwin, the determiners of heredity are given off from the body cells and dispersed throughout the system, a part of the determiners collecting in the sexual organs, while according to Weismann the determiners of heredity proceed from the germ plasm, the hereditary substance of the germ cells. These theories, or modifications of them, have attracted widespread attention because of the assumption that if we accept the Darwin theory it is easy to explain the possibility of a modification or "acquired" char-

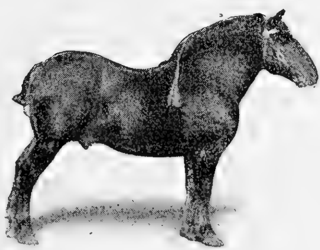


FIG. 55—SUFFOLK STALLION "WESTSIDE CHIEFTAIN"

acter being inherited, whereas if we accept the Weismann theory it is difficult to understand how a modification acquired by the parent can be transmitted to the offspring.

Interesting as this matter is to the student of genetics, it is only of secondary importance to the practical breeder, who is interested primarily in results. According to one theory, when conditions are favorable the modification originates spontaneously in the individual itself, while according to the other the modification originates spontaneously in the germ cells, so that when the animal is born it is capable of undergoing certain modifications under suitable environment. In practice it makes little difference which theory is accepted; in fact, this is the very reason why each theory has such strong advocates. The point for the breeder to keep clearly in mind is the fact that suitable environment is required for the development of the modification, whatever its origin.

Accumulative development in the trotter.—For more than a century trotting horses have been bred for the improvement of the speed character. In the discussion on causes of variations it was indicated that the environment, particularly the care, training and management, resulted in the development of all of the possibilities with which the animal was born, which of necessity brought out the wide variation among trotters, while in the discussion on the influence of time records it was clearly shown that general advancement was accomplished by eliminating the slow and mating the fast, which continued from generation to generation, resulting in some speed marvels.

The gradual reduction in the time of the trotter gives a good example of accumulative development. This is illustrated in the following tabulation, which gives the reduction in time for a mile track with horses in harness during the past century. The table gives the name of the horse, place of the race, time and date.

Trotting Records Reduced

Name of horse	Race course	Record	Date
Boston	Philadelphia, Pa.	2·48½	1810
Trouble	Jamaica, N. Y.	2 43½	1826
Sally Miller	Philadelphia, Pa.	2:37	1834
Edwin Forest	Philadelphia, Pa.	2:36½	1838
Dutchman	Hoboken, N. J.	2·32	1839
Lady Suffolk	Hoboken, N. J.	2:29½	1845
Pelham	Jamaica, N. Y.	2·28	1849
Highland Maid	Jamaica, N. Y.	2:27	1853
Flora Temple	Jamaica, N. Y.	2:24½	1856
Flora Temple	Kalamazoo, Mich.	2:19¾	1859
Dexter	Buffalo, N. Y.	2:17¼	1867
Goldsmith Maid	Milwaukee, Wis.	2:17	1871
Goldsmith Maid	Boston, Mass.	2:14	1874
Rarus	Buffalo, N. Y.	2:13¼	1878
St. Julien	Oakland, Cal.	2:12¾	1879
Maud S.	Chicago, Ill.	2:10¾	1880
Jay-Eye-See	Providence, R. I.	2:10	1884
Maud S.	Cleveland, Ohio	2:08¾	1885
Sunol	Stockton, Cal.	2:08¼	1891
Nancy Hanks	Terre Haute, Ind.	2:04	1892
Alix	Galesburg, Ill.	2:03¾	1894
The Abbot	Terre Haute, Ind.	2:03¼	1900
Cresceus	Columbus, Ohio	2:02¼	1901
Lou Dillon	Readville, Mass.	2:00	1903
Lou Dillon	Memphis, Tenn.	1:58½*	1903
Uhlan	Memphis, Tenn.	1:58	1912
Uhlan	Memphis, Tenn.	1:54½†	1913

*Paced by runner to sulky carrying wind or dust shield.
†Paced by runner to wagon.

The trotting horse has increased its speed by one-third, in a century of racing. Just how much of this increase is due to breed improvement, how much to better methods of training, and how much is due to superior conditions generally, such as improved harness, sulkies and track, cannot be stated even approximately. In fact, it would avail us but little if we knew the relative influence of each, as all are essential to highest development. In this connection there are three facts to be remembered: First, the environment, such as the training and management, developed all of the potentialities with which the horse was born; second, the records of performance enabled us to know for a certainty which were slow and which were fast; and, third, the elimination of the slow and the mating of the fast resulted in present efficiency.

Accumulative development in the dairy cow.—An even more striking example of accumulative development is observed in the case of improvement among dairy cattle. This is because the characters, butter-fat and milk production, go hand in hand with breeding—in fact, they depend upon the normal functioning of the reproductive organs; whereas, in the case of the horse, the development of speed and breeding are antagonistic, as racing interferes with breeding.

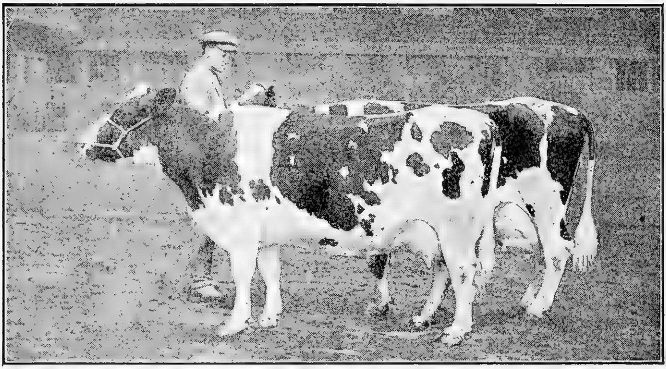


FIG. 56—HOLSTEIN-FRIESIAN COW "GL. OMICRON" AND DAUGHTER, "GL. EGLANTINE" 25.282 and 25.912 pounds butter fat in seven days, respectively.

Although the official testing of dairy cows has been in progress but two decades, great advancement has been made both in milk and butter-fat production, as is evidenced by the tabulation on the next page, which gives the increase in butter-fat production. The table includes the name of the highest yielding cow, her advanced register number, the name of the owner, the yield in milk and fat for seven consecutive days and the year in which the record was made.

This shows phenomenal development, as the cow has increased her butter-fat yield by 60 per cent in less than two decades. Many factors are involved in this remarkable improvement, but chief of them are suitable environment and records of performance, which not only enable us to know the high producers from the low producers, but provide us with data whereby we can determine the animals that are actually producing high-yielding offspring, as illustrated in the pedigree (p. 131). Such information is invaluable in selecting breeding animals, for we can discard the low producers and mate the high producers, which, in connection with more favorable conditions, enables us to get even higher producing cattle.

INCREASE IN BUTTER-FAT PRODUCTION

Name of cow	Advanced register	Name of owner	Butter fat pounds	Year
De Kol 2d	412	H. Stevens & Son	21.261	1894
Netherland Hengerveld	1,133	H. Stevens & Son	21.333	1897
Lilith Pauline De Kol	1,415	H. P. Roe	22.589	1901
Mercedes Julip's Pietertje	2,166	T. S. Tompkins	23.487	1902
Sadie Vale Concordia	1,124	McAdam & Von Hine	24.508	1903
Aaggie Cornucopia Pauline	1,933	H. P. Roe	27.459	1904
Colantha 4th's Johanna	1,849	W. J. Gillett	28.176	1907
Grace Fayne 2d's Homestead	4,422	H. A. Moyer	28.440	1909
Pontiac Clothilde De Kol 2d	5,275	Stevens Brothers	29.766	1910
Pontiac Pet	6,168	E. H. Dollar	30.142	1911
Valdessa Scott 2d	10,780	Bernard Myer	33.500	1912
K. P. Spring Farm Pontiac Lass	11,168	F. M. Jones	35.343	1912

Results accomplished.—When we consider the ancestral forms from which our farm animals have been developed, the results attained in individual instances seem truly phenomenal. The progenitor of the horse was a small, sure-footed but rough-gaited animal; that of the cow, a small, active animal, requiring five or six years to mature and giving only enough milk to nourish the young; that of the sheep, a long-bodied, long-legged, sparsely covered animal, producing two or three pounds of coarse wool and requiring three or four years to reach maturity; and that of the pig, a ferocious light-bodied carnivore, requiring four years to attain maturity, while the wild fowls laid only sufficient eggs for a brood.

From such ancestral horse forms descended the modern Thoroughbred, capable of running a mile in 1.37⅕; the modern pacer, able to negotiate a mile in 1.54½; the stylish, high-acting Hackney; the smooth-gaited saddler, capable of going a number of easy gaits; as well as the ponderous drafter, often attaining a weight of more than 1,100 pounds at one year of age, more than 1,600 at two years, and more than a ton at three years of age.

Fig. 57—High Egg-Producing Hens
291 and 303 eggs, respectively, in one year

The cow forms gave us the modern dairy cow, capable of producing annually 28,000 to 30,000 pounds of milk and more than 1,000 pounds of butter fat, which will churn out more than 1,200 pounds of butter, as well as the modern beef cattle, frequently attaining a weight of 1,200 to 1,400 pounds by the time the animals reach 15 to 18 months of age. From the ancestral sheep forms descended the modern wool sheep, often shearing an annual clip of 25 to 30 pounds, as well as mutton lambs capable of attaining a weight of 60 pounds before they are 60 days of age. From the swine forms descended the modern porker, capable of attaining a weight of 300 pounds at six to eight months of age. The wild fowls gave us the modern hen capable of laying 275 to 300 eggs in the year as well as an economic meat-producing animal.

Improvement a slow process.—While remarkable advancement has been gained in increasing the efficiency of each class of farm animals, yet the improvement of economic characters is a slow process, requiring years of careful study and patient effort. When selection and improvement is limited to a single character, advancement may be fairly rapid at first, but as maximum efficiency is approached, the rate of increase rapidly diminishes, and improvement calls for greater effort on the part of the breeder. This is well illustrated in the case of milk and butter-fat production among Holstein-Friesian cattle, and speed development among English Thoroughbred horses. Up to two decades ago little attention was given systematic attempts to improve Holstein-Friesian cattle. Thus when the advanced register was established the cattle responded admirably, increasing their production by 60 per cent in two decades.

On the other hand, consider the case of recent speed records among Thoroughbred horses. This English horse

American Running Records Reduced, Mile Track

Name of horse	Race course	Time	Year
Charley Bell	Lexington, Ky.	1:45¾	1854
Satallite	Lexington, Ky.	1:45½	1859
Mammona	Lexington, Ky.	1:44¼	1862
Revolver	Cincinnati, O.	1:44	1866
Hertog	Cincinnati, O.	1:43½	1869
Alarm	Saratoga, N, Y.	1:42¾	1872
Gray Planet	Saratoga, N. Y.	1:42½	1874
Searcher	Lexington Ky.	1:41¾	1875
Ten Broeck	Hartford, Conn.	1:39¾	1877
Racine	Washington Park, Ill.	1:39½	1890
Chorister	Morris Park, N. Y.	1:39¼	1893
Libertine	Harlem, Ill.	1:38¾	1894
Voter	Brighton Beach, N. Y.	1:38	1900
Allan-a-Dale	Washington Park, Ill.	1:37½	1903
Dick Wells	Harlem, Ill.	1:37⅖	1903
Center Shot	Santa Anita, Cal.	1:37⅕	1908

has been raced more or less systematically for three centuries, and recent progress in reducing the time record has been slow, as indicated by the preceding tabulation which gives the reduction for the last one-half century on a mile track . The table on page 173 gives the name of the horse, the place of the race, the time and date.

The Thoroughbred horse has increased its speed by but eight per cent in one-half a century of racing. During this same period the Standardbred, a comparatively new breed, has reduced its trotting record by 27 per cent (p. 169).

Methods employed.—From the foregoing discussions on improvement due to selection based on records of performance, improvement due to selection the result of prepotency, as well as improvement due to accumulative development, it must be clear that efficiency depends largely on selection; that judicious selection depends on an exact knowledge of development or performance; and that the degree of development depends on the environment, including training, management, and the like. This results in the development, and, therefore, the discovery and retention of the efficient, as well as the elimination of all others that lack ability to show improvement, which results in general advancement. This is continued, and the acquirement or development of one generation becomes, in part at least, a heritage of the next.

Fig. 58—High Wool Yielding Ewe
25 pounds at 15 months of age.

In practice it matters not a whit whether the capacity for greater efficiency is due to a kind of mutant having its inception in the germ cells, or whether it arises spontaneously in the body in the form of an "acquired" character. In his reasoning the student as well as the breeder may choose whichever horn of the dilemma he likes, but in practical operations it must be borne in mind that in the absence of suitable environment and judicious selection the capacity, whatever its origin and however controlled, cannot assert itself and will go unnoticed, and thus eventually be lost.

CHAPTER XVI

SYSTEMS OF BREEDING

There are several systems of breeding, the advantage and disadvantage of which the breeder should fully comprehend. This is particularly true of those systems that rapidly favor purifying the blood, as otherwise undesirable attributes may be intensified along with desirable ones. Since the system to be employed will depend largely upon the purpose, the breeder should first of all have a clear idea of just what he is trying to do, and an accurate knowledge of the limitations of the various systems, so that he may employ the one to achieve his purpose.

Purposes in breeding.—There are two more or less distinct purposes in breeding farm animals that should be clearly differentiated in the mind of the breeder. In the first place, animals are produced for immediate consumption, and in the second place, they are produced for breeding purposes. An attempt to improve those for immediate use may be defined as herd improvement; while the improvement of those for breeding purposes may be defined as breed improvement.

In herd improvement the object is the betterment of the individual. This is purely commercial. It is, perhaps, the cheapest and most convenient of all forms of breeding and productive of the most rapid gains. On the other hand, in breed improvement, the object is the betterment of the entire strain or race. This is creative and constructive. It is, perhaps, the most expensive, although of the very highest style of finished breeding and calls for intelligent, painstaking effort, as in this case the breeder is a true leader in the improvement of types and breeds of farm animals.

Pure-bred breeding.—This system has for its purpose the propagation of animals for breeding purposes, and for the very highest type of production. When judiciously practiced it results in advancing excellence. This constitutes animal improvement in the true sense of the term and is the highest system of finished breeding. It has the disadvantage in that it is rather costly, especially when the purpose is to produce something better than ever existed before. This is because so few individuals materially excel their predecessors or their contemporaries, and so few of these can be relied upon to propagate their own excellence.

If the purpose is only to multiply existing excellence, then pure-bred breeding is comparatively cheap, because a very large percentage of properly selected purely bred animals may be depended upon to equal the excellence of their predecessors. Here is where the commercial aspects of pure-bred breeding works to the detriment of the system.

Purely bred animals command a premium on the market irrespective of excellence, hence practically all pure-bred animals are preserved, and there is utter lack of proper selection. This often operates to the detriment of the system. Many purely bred animals are retained in our breeding herds simply because they are pure bred. Frequently they have no other meritorious characteristics to commend them.

Because of the demand for purely bred animals for breeding purposes the offspring are in great demand, and this system may prove very profitable, particularly if the breeder is so located as to be able to dispose of the surplus stock to advantage. Thus pure-bred breeding commends itself to those who have the capital and experience to go forward with it.

Perhaps the strongest argument in favor of the breeding of purely bred animals lies in the fact that it serves to stimulate the breeder to improved methods of care and management. He takes much more interest in the work, and studies the individual animals very carefully, which leads to general improvement of the herd.

Grading.—This consists in mating a common animal with a purely bred animal. The pure bred may be either sire or dam, but for economic reasons it is usually the

Fig. 59—Brown Swiss Bull "Myone Boy"

sire. This system of breeding is inexpensive, although it can be used only in herd improvement. It is the method to recommend to the great mass of breeders, especially beginners, even though they eventually intend to engage in the business of breeding pure-bred animals. There is no cheaper, quicker or more thorough way to become familiar with a breed than through a familiarity with its grades. Further, in a few generations, grades may be so improved as to be practically equal to pure breds for immediate consumption, although they will be worthless for breeding purposes.

The great advantage of grading is that it is inexpensive, at least when accomplished with the sire. A pure-bred bull in a herd of 25 common cows will give each calf in the herd a pure-bred sire, thus making "half bloods" of the entire crop of calves. If the grading were attempted in the other way it would require 25 purely bred cows and the calves would show no more improvement. In fact, if the improvement were accomplished with the cows, it would be in 25 lines, each with its shade of difference, and not in one line, as would be the case were the improvement done with a bull. This is a significant factor when we consider the value of uniformity among all classes of farm animals.

The chief disadvantage in grading is that the system is not likely to be followed. The first results are likely to be so satisfactory that the breeder is almost certain to choose a promising grade male for a sire, because he looks as good as a pure bred, whereupon by the law of ancestral heredity all further improvement stops except that due to selection and management.

Cross-breeding.—This consists in mating two distinct breeds or families. It is a powerful means of inducing variability, and can be used, with success, only in the propagation of animals for immediate consumption. Up to the time of Bakewell, however, it was the favorite system of breeding farm animals, as it promoted constitutional vigor, increased the size, and favored fertility. This system rendered a valuable service in forming new breeds. Indeed, but few breeds of farm animals have been evolved without more or less cross-breeding among the foundation animals.

At present this system is limited to the breeding of mules, the offspring of a jack and a mare, and to the production of animals for immediate consumption when two breeds possess the particular attributes that it is desired to secure in the offspring. Thus, in the production of beef say, one breed is noted for its excellent form but is late maturing, whereas another breed is noted for its early maturity but possesses a poor conformation. Should the cross between a male and a female of these breeds prove a fortunate nick, the young will inherit the desirable qualities of both parents. In this case the offspring will mature early and possess an excellent form, two attributes highly desirable among meat-producing animals.

Since crossing favors variability, the cross-bred animal should never be used in breeding, as the results cannot be predicted, even approximately. Certain it is the offspring will be exceedingly variable, an undesirable characteristic among animals intended for meat production.

Line-breeding.—This consists of mating animals of a single line of descent. The system is used either in pure-bred breeding or in grading. In the former case the purpose is usually breed improvement, while in the latter it is herd improvement. This system is a favorite in establishing families or strains. In fact, few of the many breeds of farm animals, as well as few of the more noted families or strains of the various breeds, have been formed without more or less line-breeding. Since all breeds are exceedingly variable, for best results, it is not enough to confine selection to the limits of the breed. It must be limited to those lines that most nearly approach the ideal sought.

Line-breeding is a very strong factor in securing uniformity, as it combines animals very similar in their characteristics. It narrows the pedigree to a few and closely related lines of descent, increases the prepotency, and intensifies the characters, thus giving stability to the strain or breed. Line-breeding is free from many of the objections attending other systems of close breeding. It is conservative, and a very useful system for the improvement of farm animals.

The chief disadvantage of line-breeding is that the breeder is likely to select his animals on the basis of their pedigree, and thus fail to consider individual merit and performance. A line-bred pedigree is good or bad, according as the individual animals composing it are good or bad. The breeder who selects by pedigree alone without regard for individual merit or performance is likely to find his herd deteriorating in a few generations. This is especially true with this system of breeding, as both good and bad characters alike are advanced and intensified.

Inbreeding.—This consists in mating animals closely related. It is line-breeding carried to its limits, and may

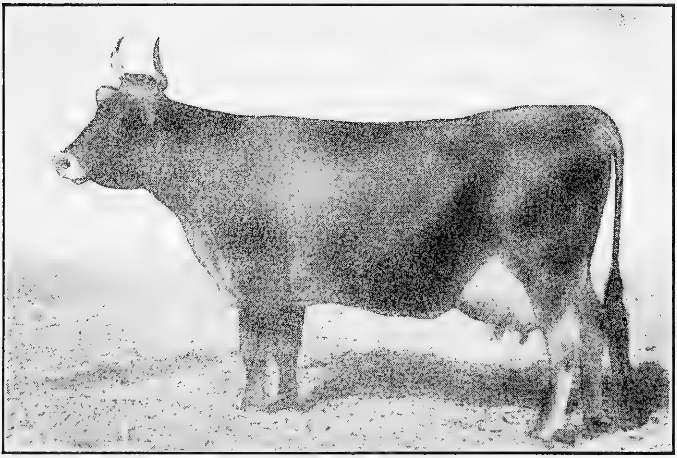


FIG. 60—BROWN SWISS COW "ARLENA"

be employed in grading to improve the herd, or in pure-bred breeding to improve the breed. This system has been used successfully in establishing, as well as improving, practically all of the modern breeds of farm animals. It was first put into regular practice by Bakewell, and since his time has been employed more or less by all successful breeders.

There are three possible forms of inbreeding. First, mating sire with daughter, which results in offspring containing three-fourths of the blood lines of the sire. It is practiced when it is desired to eliminate the characters of the dam and intensify those possessed by the sire. Second, mating son with dam, giving rise to offspring containing three-fourths of the blood lines of the dam. This method is practiced when it is desired to eliminate the characters of the sire and intensify those of the dam. Third, mating brother and sister, a method which preserves the characters of both sire and dam. It is inferior to either of the other two methods in strengthening characters.

This system has many advantages in the breeding of farm animals. It promotes uniformity by combining animals very similar in their general characters. It narrows the pedigree to few and closely related lines of descent (p. 120). It intensifies characters and increases the prepotency. It is recognized as the strongest of all breeding. Since the infusion of new blood lines shatters existing characters, no system equals inbreeding for perpetuating desirable characters, doubling up existing combinations and retaining all there is of good in the exceptional individual.

Capable of producing the great improvement that it is, this system is not without its disadvantages. It does not respect characters, but intensifies both good and bad alike. If persisted in, it is likely to result in loss of fertility as well as constitutional vigor, which may quickly lead to breed extinction. When practicing inbreeding, therefore, too much importance cannot be placed upon the selection of animals for high fertility and much constitutional vigor.

There are two situations in which it may be desirable to practice this system. One is in grading where we have a proven sire that is known to get excellent offspring. It may be entirely permissible to mate him with his own daughters, rather than go to the expense of procuring a new sire, in which the breeding power is not known. The other is when we have an animal possessing a desirable attribute which we wish to retain. In this case the only way we can retain the desirable character is to inbreed, otherwise it may be obliterated and lost. Many a breeder has found himself in just such a position, and by inbreeding has not only retained the desirable characters in question, but has advanced and intensified them, and in a few generations has succeeded in building up the best herds in the breed.

Breeding from the best.—This consists in mating the best individuals without reference to blood lines. The system may be used in herd or breed improvement, though the advisability of employing it will depend in a large measure upon the situation. As a rule, when we are grading, it is advisable to procure the very best animals obtainable. On the other hand, when building up a pure herd, it is equally important to give due regard to the strain or family with which we are working. The breeder who breeds from the best without regard for family lines is likely to bring together a herd of mixed females, out of which nothing of note can be established. Crossing family lines brings about much the same condition as crossing breeds, only on a more limited scale.

In constructive breeding ancestral lines must be given due consideration. To secure uniformity, to intensify desirable characters, and to increase the prepotency of our animals, we must keep the family strains pure. The introduction of new blood, even though superior, shatters existing characters, destroys uniformity and weakens prepotency.

Up to the time of Bakewell, breeding from the best was the system used in both herd and breed improvement. At that time it was favored by the absence of written pedigrees. It often resulted in increased size, advanced fertility and strengthened the constitutional vigor, but then, as now, it lessened uniformity and weakened prepotency, so that it was exceedingly uncertain as to just what the offspring would be like.

Co-operative breeding.—This is a plan of procedure rather than a system of breeding, but it is mentioned in this connection to complete the list of methods. It consists of a number of breeders operating jointly for their mutual benefit. In animal production there are a number of business transactions that can be accomplished to advantage by a number of men working together. Chief of these are purchasing pure-bred stock, especially males; disposing of surplus stock; purchasing supplementary food in large quantities, thus obtaining the advantages of wholesale prices and reduced freight rates; and the forming of cow-testing associations for the purpose of determining the profitable individual cows in the dairy herd.

The strong advantage in this plan of procedure is that it promotes uniformity among the animals of a community. In time the locality becomes noted for the production of animals of this particular type, which serves to attract buyers in quest of such animals, thus increasing the market facilities of the community.

CHAPTER XVII

FORMATION OF BREEDS

When man first propagated animals to meet his needs is not known. Certain it is, however, that he enjoyed their conveniences, such as the labor, food and clothing they provided, from a very early period. Our oldest literature makes reference to the herds and flocks as an established factor in the agricultural industry of the times. Since their propagation seems to have been so thoroughly established, no doubt they had been domesticated for ages. Likewise, we have no definite knowledge as to which class of animals was first domesticated, although it has generally been assumed that the dog and the horse were among the first animals to be propagated in confinement. In the case of meat-producing animals there can be no doubt but that they were hunted and trapped by man for ages before any attempt was made to domesticate them or to propagate them in captivity.

The place of first domestication has been assumed to be on the continent of Asia. This is the largest land area, with the greatest diversity of soil, climate and exposure. It is, therefore, richest in animal life, as well as the oldest in civilization. Here many of our most useful animals were domesticated so long ago that it is impossible to say when, how, or by whom the work was accomplished.

Domestication a necessity.—Primitive man lived on the spontaneous product of nature. Could he have maintained his existence upon these products, in all probability he would never have undertaken the trouble of domesticating the wild animals. Like the other animals about him, man lived under hard conditions. He spent most of his time in hunting something to eat and in avoiding being eaten himself. In this struggle primitive man found himself at no little disadvantage. He was not as strong as many of the animals he hunted, and hence no match for them in battle. He was neither as fleet as most of the game he hunted, nor could he trail by the scent like the wolf.

Man was not long in learning that his chief advantage lay in his wits. He devised weapons and traps to aid him in the hunt. He was severe on the animals he hunted, and they not only diminished in numbers, but gradually learned his methods and became exceedingly wary. Again man was forced to rely upon his wits. Because of its hunting habits, the wolf, the ancestor of the dog, was trained to aid man in the hunt and chase. With his weapons, traps and dogs, man was more severe upon the animals that he hunted, and they grew more and more scarce. It was inevitable that the time should come when he must take care of the animals about him or give up animal products, including food and clothing.

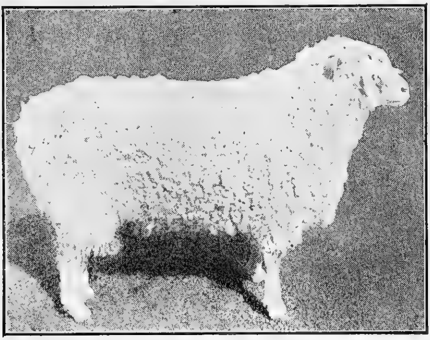


FIG. 61—COTSWOLD RAM. Long wool type.

The first act toward domestication was to hunt and destroy all animals that preyed upon those of value to man; the next was to spare the finest males and all females with young; the next was to provide food for the animals at such seasons as they seemed unable to find it; and, lastly, came the breeding in captivity and caring for them at all times.

Evolution of farm animals.—Development was exceedingly slow at first, but when the necessity for improvement became apparent advancement went rapidly forward. Thus the seventeenth and eighteenth centuries witnessed remarkable strides in the advancement of agricultural interests generally. Now that men had extended their political and religious influence to the ends of the earth they began to devote their attention to economic industries. Agriculture took foremost rank among these industries and during the eighteenth century underwent unprecedented advancement. Since animal production constituted a large part of the agricultural industry, it shared in this remarkable advancement. This century witnessed the introduction of the methods that resulted in the establishment of the modern breeds of farm animals. True, certain localities had long been known for the production of animals of a given type, particularly in England, but these animals were not differentiated as breeds. This general advancement was favored by the spirit of the times, as everything seemed to be in readiness for it.

Origin of breeds.—While animals have been domesticated and at the service of man for a very long time, the breeds of farm animals as we know them at present are of comparatively recent origin. Although systematic animal breeding is of recent origin, mention should be made of the fact that improvement has been under way from the time of domestication and even before. We are told that when the diminishing meat supply became inevitable, man secured his meat, not from the best, as before, but from the common animals, being careful to retain the best for breeding. Later, in choosing animals to breed in captivity, nothing was more natural than that the choicest should be selected, in order that the quality should not deteriorate. In this way improvement was introduced at the very beginning of domestication. This is significant, as it would seem that our ancestors very early learned the fundamental lesson of all breeding—the better the parentage the better the offspring.

Robert Bakewell.—The introduction of the methods that resulted in the establishment of the breeds was due in a very large measure to the ingenuity of Robert Bake-

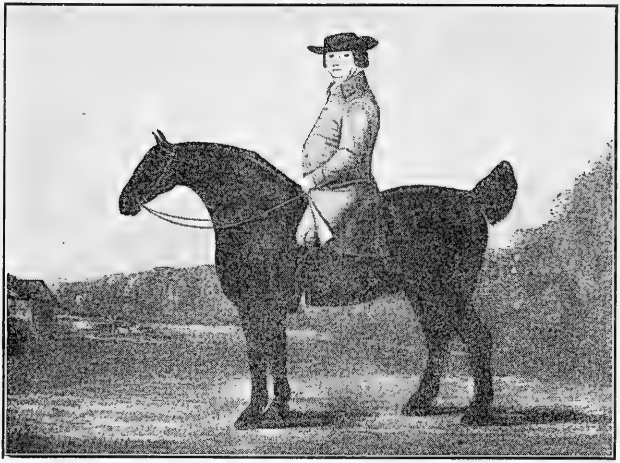


FIG. 62—ROBERT BAKEWELL*

well. He was born in 1726 at Dishley Grange near Loughborough, Leicestershire, England, where he died in 1795 in his 70th year of age. From his father Bakewell received excellent training in practical and experimental methods of husbandry. He made excursions into different parts of England and to the Continent in order to inspect the different herds and to select those animals that were best adapted to his purpose.

Bakewell was very original, and tested the worth of his ideas by frequent and varied experiments. His animals during their lifetime were often submitted to experiments to demonstrate the amount of food consumed to produce a given weight in product. After slaughtering they were carefully

*From the Journal of the Royal Agricultural Society Report, 1894. This report contains a good description of the life and work of Bakewell, pp. 1-31.

examined to determine the quality of their flesh; also to determine the proportion of dressed meat to offal. This was not all, as we are told that skeletons and pickled joints of specimens of the best sheep and cattle formed a little museum, for the comparison of one generation with another, and ancestors with their descendants.

Such careful observations, in connection with proper care, intelligent selection and suitable mating, worked rapid improvement. Thus many years did not pass before Bakewell's animals were unrivaled in plumpness of form, in the small size of bone, and in their ability to acquire external fat, as well as in the small amount of food required to produce a given gain in body weight.

Bakewell's principles.—While we have no account of the precise principles governing Bakewell's practice, yet Culley, Young and Marshall, who were repeatedly favored with opportunities for making observations on Bakewell's practices, give us extended accounts of his methods. From these accounts it would seem that Bakewell's entire attention was centered on the following principles:

The first principle of improvement was that, in general, animals produce others possessing qualities similar to their own. With this in mind Bakewell conceived the idea that he had only to select the most valuable animals such as promised greatest returns, and that he should then be able to produce a breed from which he could derive maximum advantage.

The second principle alluded to the utility of form, as he conceived the form to be related to the function. Bakewell selected for small bone and beauty of form, as he believed that by so doing he could reduce the percentage of offal and increase the relative proportion of meat in the region of the valuable cuts.

The third principle referred to the quality of flesh. In the attempt to improve the quality he gave careful attention to the texture of the muscular parts. He believed that the grain of the meat depended wholly on the breed, and not, as before considered, on the size of the animal.

The fourth principle considered the propensity to fatten rapidly. Thus he favored animals with a natural tendency to fatten at an early age.

The fifth principle alluded to inbreeding. Formerly the practice was to select females from native stock and cross them with males of alien blood. Bakewell imagined that better results would follow uniting superior animals of the same breed than by any mixture of foreign blood. Thus he shocked the modest people of his time by mating animals whose characters he wished to preserve without regard for relationship.

The sixth principle of improvement referred to economic production. We are told that the prevailing idea, and the one which lay at the very root and source of his strength, was economy. This principle, no doubt, was uppermost in his mind when selecting for small bone and light offal as well as for early maturity and for the increased percentage of meat in the region of valuable cuts.

Influence of Bakewell's methods.—Although his most noted success was achieved with sheep known as Dishley Leicesters, his work in breeding English Cart or Shire horses as well as Longhorn cattle has been of inestimable value to all branches of the breeding industry. Bakewell's animals became very distinguished. Breeders and people interested in live stock improvement visited him from various parts of England and Europe. They paid him large sums for the hire of his male animals, particularly rams, he being the first person to establish the custom of renting his animals.

In 1760 rams were hired for a few shillings for the season; ten years later prices varied up to 25 guineas ($131); and within a few years his annual income was said to be 3,000 guineas ($15,750) from the hire of rams alone. His celebrated ram, "Two Pounder," was hired one season for 800 guineas ($4,200), with the reservation that Bakewell should breed one-third of the total number of ewes specified in the contract, which was figured as making the payment equivalent to a rental of 1,200 guineas ($6,300). He rented stallions, bulls and boars on the same general plan.

Such accomplishments served to attract other breeders to his methods, and the Colling Brothers, founders of the Shorthorn breed, the Tompkinses, founders of the Hereford, and Watson, the founder of the Angus breed of cattle, as well as John Ellman, the founder of the Southdown breed of sheep and other early breeders, were close students of Bakewell's methods. The achievements of this one man furnished the stimulant which resulted in the development of our modern breeds of farm animals.

Forming of new breeds.—While new breeds have been formed in many ways and under various conditions, for convenience of study, the methods employed may be grouped into four general classes:

First. Breeds were founded by introducing alien males, which were mated with native females. Previous to Bakewell's time this was the common method, and while extensively employed since, as a rule it has been followed by close breeding to establish the type. This method is well illustrated in the formation of the Thoroughbred or English running horse.

Second. Breeds were formed by the careful selection of native stock, by judicious mating, and by improved methods of care and management. Animals possessing the desirable qualities were often closely bred to establish the type. The formation of the Shorthorn breed illustrates this method.

Third. Breeds were formed by the crossing of two or more distinct breeds after which close breeding was often employed to preserve the desirable qualities. This method is illustrated in the formation of the Oxford breed of sheep.

Fourth. Breeds were formed by the uniting of two and sometimes more existing breeds. The Holstein-Friesian breed of dairy cattle illustrates this method.

Origin of the Thoroughbred.—Stallions were imported from Arabia, Barbary, Persia and other Oriental countries and mated with native English mares. In 1616 Markham's Arabian was imported, Byerly Turk in 1689, Darley Arabian in 1706, and Godolphin Barb in 1728. These stallions, especially the three latter, may be considered the Thoroughbred foundation. From them descended Herod (King Herod), Eclipse, Flying Childers and Matchem, the greatest racing prize winners as well as the most renowned sires of the breed. Herod sired 497 prize winners, Eclipse 334 and Matchem 354, which are estimated to have won for their owners more than £500,000, or over $2,500,000.

Origin of the Shorthorn.—This breed originated in the counties of York, Durham and Northumberland in northeastern England. Hubback, a native bull born in 1777, is regarded as the founder of the breed. His offspring were better feeders, matured earlier, dressed out with less offal and had more constitutional vigor than the older sorts. These characters were inherited by a grandson, Foljambe, who became a great breeder. A son, Bolingbroke, and a daughter, Phoenix, mated together, produced the bull Favorite, one of the most famous of the breed. Favorite, mated with his dam, produced Young Phœnix, which, in turn, he was bred to,

PEDIGREE OF THE SHORTHORN BULL, COMET (155)

Comet (155)	Favourite (252)	Bolingbroke (86)	Foljambe (263)
			Young Strawberry
		Phoenix	Foljambe (263)
			Lady Maynard
	Young Phoenix	Favourite (252)	Bolingbroke (86)
			Phoenix
		Phoenix	Foljambe (86)
			Lady Maynard

resulting in the bull Comet, a very famous animal, who sold for £1,000 ($5,000), which was the highest price paid up to that time.

Origin of the Oxford.—This breed of sheep was developed in Oxford County, England. It is of comparatively recent origin. About 1830 the shepherds of the

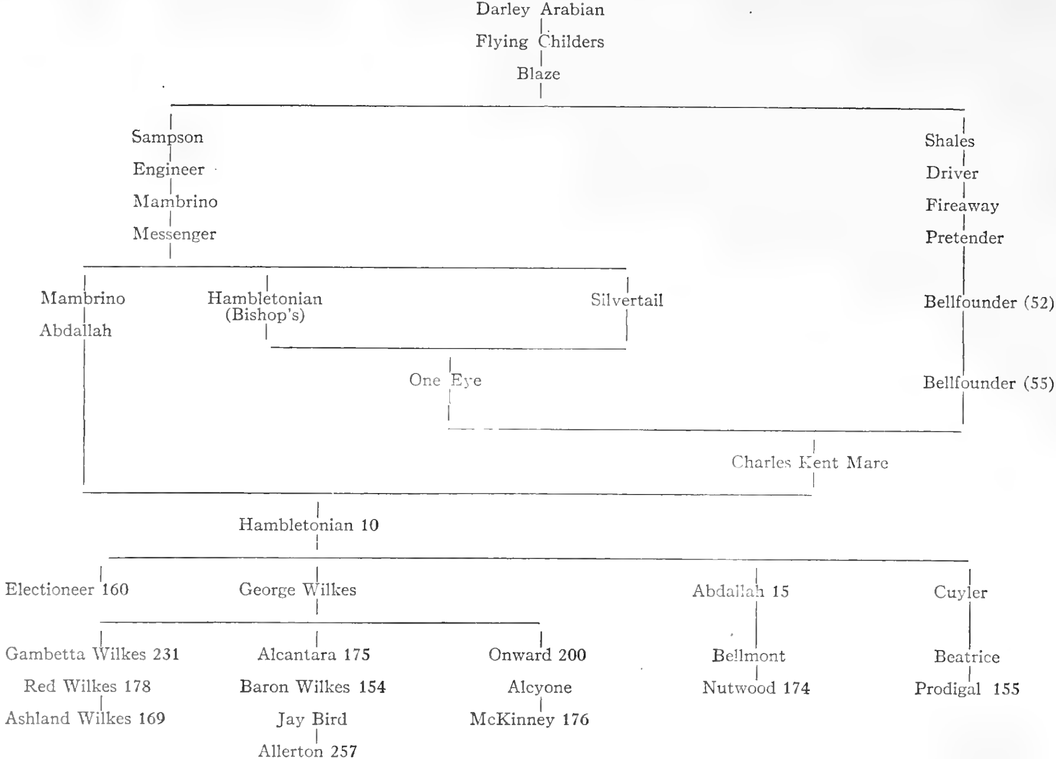
FIG. 63—A PRIZE-WINNING FLOCK OF OXFORD SHEEP

County of Oxford conceived the idea of developing a new breed of sheep combining the desirable qualities of the long-wooled breeds and of the Down breeds. They began by mating compact Cotswold rams with Hampshire ewes. Later Southdown blood was introduced to some extent, although the Hampshire was the chief source of Down blood in the Oxford Down foundation. As would be expected from its Cotswold ancestry, the Oxford has a long and coarse fleece, although from the Hampshire line it inherits desirable mutton qualities.

Origin of the Holstein-Friesian.—This breed name is of American origin, there being no breed of the name in Europe, the native home of the breed. The Friesian cattle originated in the province of Friesland, Holland, where they became so popular that many were exported to Germany, Denmark, Belgium and the United States. The Holstein cattle originated in the province of Holstein, Germany, where they also became very noted and were exported to many countries, including the United States. Thus in Europe the Friesians and Holsteins are separate and distinct breeds. The two breeds, however, have essentially the same origin and are similar in all important characteristics. In order to promote the welfare of the two breeds, the breeders and importers in this country finally came together and united their interests, agreeing to call the breed Holstein-Friesian.

Origin of the Standardbred horse.—The formation of this breed is of interest in the consideration of the origin of breeds, as we can trace present-day Standardbred horses back through the Thoroughbred on the one hand and the Hackney and Norfolk trotter on the other hand, to the time of Darley Arabian. This relationship is illustrated in the chart on opposite page showing the descent of the Standardbred horse from Darley Arabian through the Thoroughbred line on the left and through the Hackney and Norfolk trotter line on the right; also the relationship of the 11 stallions with 150 or more performers, the figures not in parenthesis following the names indicating the number of performers.

Chart Showing Origin of Standardbred



CHAPTER XVIII

IMPROVEMENT OF BREEDS

While breed improvement was due very largely to judicious selection, suitable mating and better care on the part of breeders generally, it is of interest to note the factors that gave encouragement to such methods. In the development of the breeds many factors exerted a favorable influence, chief of which were the establishment of books of record, of breeders' associations, and of live stock shows. Since the books of record gave information concerning the ancestors of a given animal capable of meeting the requirements, it enabled the breeder to select his animals with intelligence, as well as to keep the blood lines pure. Before the introduction of such records it was not possible to learn the merit of a given animal's ancestors, and hence impossible to estimate, even approximately, what the offspring would be like.

Origin of pedigrees.—It was to promote the development and to preserve the purity of the Thoroughbred or English race horse that books of record were established. So far as is known there were no records of breeding or performance previous to the eighteenth century. True, through advertisements, sales' papers, catalogs, and the like, many pedigrees had gained currency, but they were all shaped on fashionable lines, and many, if not most of them, were fictitious. In 1709 a racing calendar of note was published. Others followed, perhaps the most notable being the Racing Register, published by Bailey Brothers. The records were intended largely for the convenience of men who wagered money, and who cared little for blood lines, hence mistakes were of frequent occurrence. Such was the condition of English pedigrees when, toward the close of the eighteenth century, Weatherby and Pick started their stud books.

In 1786, Pick published "A Careful Collection of All the Pedigrees Possible to Obtain," and in 1791 Weatherby published an "Introduction to a General Stud Book." These publications were the forerunners of Pick's Turf Register and of Weatherby's General Stud Book. The first volume of both the Register and the Stud Book was published in 1803. Four volumes of Pick's Turf Register appeared and then the publication was discontinued, while the General Stud Book continued as the official organ of the Thoroughbred in England. This represents the first successful attempt to record genealogy of farm animals.

The second book of record to make its appearance was the Shorthorn Herd Book. Acting upon his own initiative, Coates collected the pedigrees of Shorthorns of note, and after much difficulty in obtaining the necessary financial assistance, published the first volume of the herd book in 1822, although it was not until 1876 that the British breeders, organized as the Shorthorn Society of Great Britain, took charge of the preparation and publication of the pedigree records. Following the lead of the Thoroughbred and Shorthorn breeders, the advocates of each breed of note established and maintained a book of record. The more popular breeders maintain a separate book of record in each country where they are extensively bred. For list see appendix.

Eligibility to registration.—At present in America, practically all books of record limit registration to the offspring of registered parents, although during the formative period of the breeds the standard was less rigid. Thus some breeds admitted animals with five or seven top crosses, and others, providing the animals contained a certain per cent of blood already in the book of record. Such is the case even today in many foreign countries. In addition to the purity of blood, some breed associations require certain breed characteristics. Thus Holstein-Friesian cattle, to be eligible to registration, must be black and white, and a red and white animal, although of pure breeding, is not eligible. To provide the finances necessary to publish the book, there is usually a pro rata charge for each animal recorded.

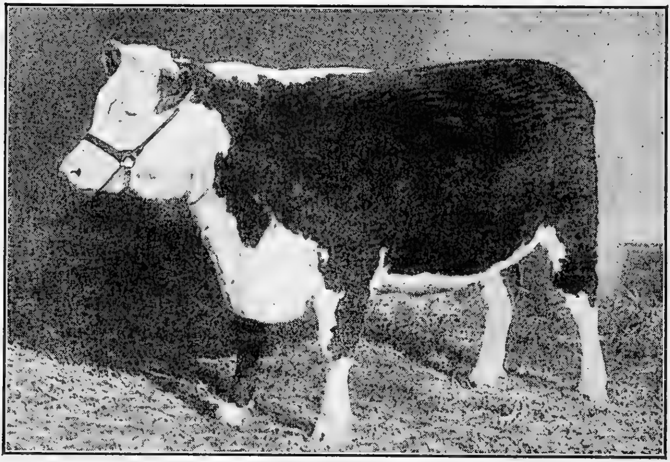


FIG. 64—HEREFORD HEIFER "SCOTTISH LASSIE"

Advanced register.—The ordinary pedigree is merely a guarantee against mixed blood lines and gives us evidence that the individual belongs to a specific breed. It gives us no information as to whether or not a particular individual is a good one. The animal may be the best or the poorest of the breed, but there is nothing in his pedigree whereby we may judge of his merit.

The advanced register gives us the desired information, as the performance of the animal is recorded therein. It is a kind of second registration, based upon performance, and furnishes us a guarantee of quality. Among horses it is based upon their track records (p. 126), and among dairy cattle upon the amount of milk and butter fat produced within a given length of time according to an official recognized test (p. 127).

Breed associations.—Upon their own initiative Weatherby and Coates compiled and published the first volumes of the General Stud Book and of the Shorthorn Herd Book. The business grew so rapidly, however, and there was so much detail connected with the registration, such as tabulation of pedigrees, publication of the books of record, and the like, as well as with financing the undertaking, and later with the management of the advanced register work, that it became necessary to provide some method whereby the work could be done systematically. This led to the organization of associations, the membership of which consisted largely of breeders interested in the development of a particular breed.

Thus the advocates of each breed formed a breeders' association to conduct the business connected with the management of the breed. Upon the payment of a membership fee any breeder may become a member of the association of the breed he handles. In many of the associations the charges for registration of animals owned by members are less than for those owned by nonmembers. These associations are considered the official organs of the breeds and have been very potent factors in the general improvement and advancement of the several breeds of farm animals.

Live stock shows.—One of the most important factors in the early development and improvement of the breeds of farm animals was the live stock show. This is especially true of Britain, where animal fairs have been held for centuries. Following the lead of England, live stock shows have been encouraged and given financial assistance by practically all countries where animal production constitutes a large part of the agricultural industry.

The value of live stock expositions for the purpose of stimulating improvement is emphasized by the interest shown in our town, county, state, national and international expositions. Were they not powerful factors in the improvement and advancement of the breeds of farm animals, they would not be so universally recognized or so extensively patronized by either the exhibitors or breeders.

The fact that a successful show yard career adds greatly to an animal's commercial value as an individual,

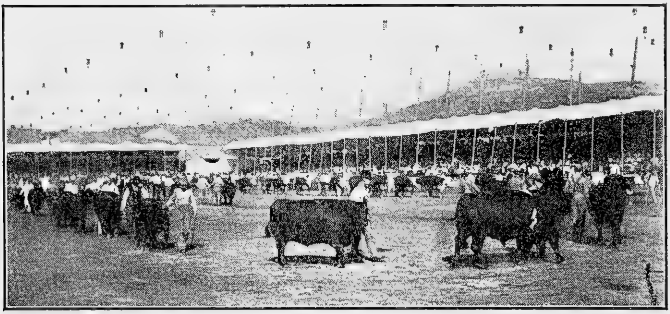


Fig. 65—Beef Cattle Parade on Show Grounds

as well as to the economic value of the get afterwards, stimulates much interest among the exhibitors, and each tries to outdo the other. This competition results in maximum development of the individuals and brings out the best animals of the various breeds. Further, such expositions have been very useful in familiarizing the people at large with breed characteristics and in providing an opportunity to compare one breed with another.

British methods.—Following the formation and development of the Thoroughbred horse, Britain enjoyed an era of live stock improvement which resulted in the organization of more than a score of separate and distinct breeds of farm animals, including horses, cattle, sheep and swine. Since we import from Britain large numbers of four breeds of horses, six breeds of cattle, nine breeds of sheep and four breeds of swine, the methods of breed improvement, on the little group of islands, the total area of which is much less than that of the State of California, are of more than passing interest. Of the 88 breeds listed in the tabulation of breeds of farm animals in the appendix, 44 claim Britain as their native home.

The natural conditions such as the uneven topography, the varied climate and the fertile soil, together with the stock-loving habits of the people, favored the propagation and improvement of numerous types and breeds of farm animals. Advancement was also promoted by the system of husbandry and by the relationship between tenant and landlord, the land being rented under such terms as to favor the breeding and improvement of farm animals.

It was recognized that the animals of certain counties were distinct from those of other counties in the rate and manner of growth as well as in fattening qualities. Each of these sections took pride in developing its animals, and there was often keen rivalry among the counties or sections. There was a total absence of indiscriminate crossing of animals from different counties. This resulted in the development of many distinct breeds each with its distinctive characteristics.

As it was in Britain that live stock shows were inaugurated, it was there that they proved their worth in stimulating interest in breeding. From their inception, these shows have been very potent factors in live stock improvement. They were systematized by the Royal Agricultural Society of England, established in 1839, since which time they have attracted world-wide attention, until at present all animal-producing nations hold similar shows.

It is only fair to state, however, that the most significant factor in stimulating improvement is the demand created for the stock by America and other leading animal-producing nations, largely drawing on Britain for improved blood. As the animals are intended for breeding purposes and to introduce new blood into other countries, there seems to be no limit to the price foreign buyers are willing to pay, especially if the animal has a successful show yard career, or in the case of racing horses a successful turf career back of him.

French methods.—Since the Percheron draft horse is so very popular, the methods employed in the improvement of the breed are of interest. In order to provide horses for war purposes the early monarchs interested themselves in horse breeding. Since the establishment of the "Administration des Haras" during the reign of Louis XIV, the French government has made systematic efforts to promote the horse-breeding industry. Notwithstanding the political disturbance and war, the government purchased stallions in large numbers, importing many from foreign countries, notably Arabia.

In 1833, by royal decree, the French Jockey Club was organized and a stud book established. This did much to further the industry. In 1870 the management of the government horses was given over to the Department of Agriculture and Commerce. The general control was placed in charge of a director, who was assisted by subdirectors, inspector, superintendents and veterinarians, all of whom must be graduated from the horse department at Le Pin. This is significant, as it contributes to the uniformity of the horses throughout France, and is in striking contrast to American methods as set forth by the various state stallion laws, where instead of a few inspectors with a common ideal, there are many inspectors with equally as many ideals.

There are three classes of government stallions in France: First, those owned by the government; second, those owned privately, but subsidized by the government—when thus subsidized the owners receive an annual allowance from the Minister of Agriculture; third, stallions owned privately, and, having been passed upon by the officials and found worthy, are approved or authorized for public service. All other stallions are prevented by a law passed in 1885 from standing for public service.

With the exception of some aid to the improvement of fine-wooled sheep, the government has interested itself in horse breeding only and similar aid has not been extended to other classes of farm animals, with the result that other classes of French animals are little known outside of France.

Further improvement needed.—If the propagation of farm animals is to retain its present position in the agricultural industry, the animals must be improved so as to yield larger returns for the expenses involved. The increasing price of stock foods makes this imperative, notwithstanding the remarkable advancement already attained as indicated in the discussion of results accomplished (p. 171). Even in the case of such a phenomenal animal as the pig, weighing 300 pounds at six to eight months of age, each pound of gain will require approximately four pounds of grain or its equivalent, which, with grain at $20 a ton will make a feed cost alone of four cents a pound, to say nothing of the shelter or lots, the insurance or risk from death, the labor and the cost of the parents or their maintenance.

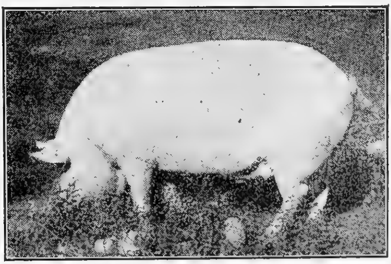


FIG. 66—CHESHIRE HOG OF EXCELLENT TYPE

The need of further improvement is better illustrated in the case of the beef animal that weighs say 1,400 pounds at 18 months, phenomenal individual that he is. In order to force a steer to make such a gain it would be necessary to feed approximately six pounds of grain or its equivalent, and at least one-half as much hay for each pound of gain. With grain at $20 and hay at $10 a ton this would make a food cost alone of 7½ cents a pound, to say nothing of the other expenses incidental to the business of raising and fattening animals for beef. This calculation is based upon the most phenomenal animals of the class to which they belong, yet the food cost is very high, and only a very small percentage of the nutrition or energy of the food is recovered in the product.

Need of extending improvement.—While further improvement will be welcome, the greatest need at the present time is to extend such attributes as have already been attained. Some horses are fast enough, some possess sufficient quality, some stylish enough, some sufficiently smooth gaited, and some large enough; but few, possibly none, possess these attributes in the proper proportion so as to secure maximum efficiency. Surely draft horses are too slow and lack the endurance and quality characteristic of light horses.

While the phenomenal individuals mentioned above produce meat fairly economical, in the main, it is produced only at enormous expense of feed, requiring, roughly speaking, six pounds of grain or its equivalent for each pound of gain in the case of swine; 8 to 10 pounds of grain or its equivalent in the case of sheep; 12 to 15 pounds of grain or its equivalent in the case of cattle. Likewise the hen that lays 275 to 300 eggs in a year is doing much more than we have a right to reasonably expect her to do, but the hen on the average farm lays less than four dozen eggs in a year. If common animals could be improved to even approximate the efficient ones in economic production it would prove a most significant factor in advancing agricultural as well as human interests generally, and would give the propagation of animals a new lease which they could hold for some time to come.

A good example of the need of extending improvement to the common animals is observed in the case of dairy cattle. There is greater variation in the production of dairy cows than that of any other class of farm animals. To illustrate this variation the following tabulation is arranged comparing the average annual production for both milk and butter of all cows in the United States by decades with the monthly and yearly production of the leading high-producing Holstein-Friesian cows. This is not a comparison of the poorest and the best, but of the average for all cows in the United States and the best.

Average Yearly Production Per Cow in the United States

Year	Milk, pounds	Butter, pounds	Year	Milk, pounds	Butter, pounds
1850	1,436	61	1890	2,709	115
1860	1,505	64	1900	3,646	155
1870	1,772	75	1910	3,520	150
1880	2,004	85			

Production for One Month

Name of cow	Milk, pounds	Butter fat, pounds	80% butter, pounds
K. P. Pontiac Lass	2,316	137	171
Valdessa Scott 2d	2,934	131	164
Pontiac Lady Korndyke	2,497	125	157
Johanna De Kol Van Beers	2,764	121	151

Production for One Year*

Banostine Belle De Kol	27,404	1,058	1,322
Pontiac Clothilde De Kol 2d	25,318	1,017	1,271
High-Lawn Hartog De Kol	25,592	998	1,247
Colantha 4th's Johanna	27,432	998	1,247

*May Rilma, a Guernsey cow, exceeded these records in the production of butter fat, producing 1,073.4 pounds of butter fat from 19,673 pounds of milk in 365 days, now the world's record for butter fat.

Thus the leading cows produce approximately as much milk and butter in one month as the average cow in the United States produces in one year. Further, the leading cows produce almost 10 times as much in a year as that produced by the average cow. There seems no reason to doubt that the average cow could be advanced to produce approximately one-third that of the leading cows, providing proper methods were employed in feeding, breeding, care and management. In this case one-half of the present number of cows would give us as much milk and butter as we now receive. This would result in a very great saving of food, labor and shelter and advance the dairy industry to one of the most profitable branches of agriculture.

CHAPTER XIX

BUILDING UP A HERD

The inevitability of the dairy cow warrants a discussion on building up the herd. There is great variation in the productiveness of dairy cows, some producing 10 times that of others. Notwithstanding this variability she responds to judicious care and breeding more perfectly than does any other class of farm animals. This means, of course, that the dairy cow is susceptible to much improvement.

It is safe to say that not over one-fourth of the dairy cows in the United States are capable of producing 7,500 pounds of milk and 300 pounds of butter fat in one year, even if reasonably well fed. The breeder should not be satisfied until the poorest cows in his herd are capable of producing the above amount. If all the dairy cows in the United States were developed to this point, the average production for each cow would be approximately double what it is at the present time. To put it the other way around, and what is more desirable from the breeder's point of view, one-half of the present number of cows would be capable of producing approximately the same amount of milk and butter fat than we now obtain. Such advancement is by no means impossible. In fact, it is within reach of practically all breeders who are willing to practice judicious methods of management, feeding and breeding.

The inevitability of the dairy cow.—If the past and present movements of farm animals may be accepted as a criterion as to future movements, the dairy cow is soon to become our principal source of animal food. There are at least two very significant reasons for this assumption. In the first place, no other farm animal can produce food as cheaply as the dairy cow. As the human population increases this is to become more apparent, as it will be necessary to produce animal food more economically in order to avoid a scarcity of human foodstuffs.

In the second place, at the present time, the products of the dairy cow are practically indispensable as an article of human diet, especially for infants. The principal product, milk, is of such a nature that it cannot be transported a great distance, thus necessitating the keeping of large numbers of dairy cows near the centers of dense population. The importance of fresh, clean, sweet milk as an article of human diet is frequently impressed upon the physicians and health officers in the larger cities during the hot days of midsummer, as at such times there is often a high infant mortality largely due to the lack of fresh, sweet milk, which is often exceedingly difficult to obtain, especially if traffic is partially interrupted for a few days.

The use of pure-bred animals.—It is universally accepted, all things considered, that purely bred animals excel grades. For this reason well-bred animals command a fancy price which often probibits their use; nevertheless they have a number of very strong advantages over grades, chief of which are their capability of higher production, their stimulating effect upon the breeder, thus favoring general improvement, and the increased value of their offspring. These advantages are often sufficient to offset the high price.

It has been shown conclusively that there is a close relationship between the number of pure-bred animals in a community and the general excellence of all farm animals. Of the 20 counties in New York state having the largest number of dairy cattle those containing the largest number of pure breds include the counties in which the average yield was highest and the counties which made the largest increase in yield during the past decade.

The use of grade animals.—While the ideal condition would be to have only high-producing, purely bred animals, at the present time this is impossible because of the small number of such animals available. A very small percentage of the cattle are pure bred, and of this number many are inferior or diseased, which renders them unfit for foundation animals on which to build a future herd. In general, therefore, the breeder must use the best-producing animals available without respect to purity of blood for foundation stock.

By the grading-up process, that is, by continually selecting and breeding the cows that are the best producers to a purely bred bull of proven worth, it is entirely possible and by no means difficult to establish a herd of grade cows that will equal in the production of milk any herd of pure-bred animals. The enterprising and progressive breeder, however, will hardly be content with grades only. In the beginning his bull will be purely bred, and presently he will want a pure-bred cow to match, then one or two more. Thus he will be steadily and properly working toward a pure-bred herd and gaining in knowledge and experience at the same time. This will prove a much more economical as well as more satisfactory plan, especially with the beginner or those unaccustomed to purely bred cattle, than to purchase a pure-bred herd in the beginning, as the risk is too great for those lacking in practical experience.

Foundation animals.—In building up the herd the most important as well as the most difficult animal to select is a suitable bull to head the herd. His breeding, his ability to get uniformly high-producing offspring and his individuality should be carefully considered. It goes without saying that he should be a good individual of the breed to which he belongs, and that he should be of proven worth as well as purely bred.

The most important factor in selecting the foundation cows is a record of performance of each animal under consideration. In building up a herd this is indispensable. Without it, advancement is uncertain and permanent improvement is not possible. Of course, only uniformly high-producing cows should be secured.

If the herd to be improved is already organized, then the first problem is to separate the high-producing from the low-producing cows. At the present time a very large percentage of the dairy cows do not yield sufficient product to pay for the food they consume, when figured at prices obtainable on the farm, to say nothing of the labor and other expenses. Could all such inferior cattle be eliminated, this alone would very materially advance the dairy industry.

After the foundation animals have been decided upon and the herd assembled, it is important that the animals be given the best of care. This is essential to improvement, as highest efficiency depends on maximum development, which, in turn, depends on judicious management.

The first generation.—If the sire has been well chosen, the calves of the first generation are likely to be fairly uniform, even though their dams be of mixed breeding. If convenient, all of the heifer calves should be retained. A great advantage in building up a herd by the grading-up process is the opportunity afforded to raise a large number of individuals up to the time they begin to produce. This provides large numbers from which to select, which results in more rapid improvement than though the numbers were limited. It often happens, however, owing to lack of facilities for rearing calves, that some selection must be made at birth. In this case retain the heifers from the high-producing dams, disposing of those from the low-producing cows.

Breeding the young heifers.—There are many perplexing questions arising in the second generation of the grading-up process. In the first place, the young heifers should be bred and developed much as suggested in the discussion developing the heifer (p. 311).

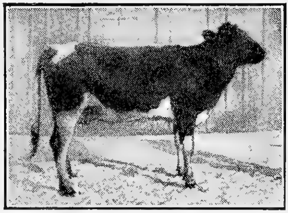
If the original sire was a young one at the time of his purchase, there will be a considerable number of his half-blood offspring ready to breed while he is still in the height of his power. As there has been much said against the practice of inbreeding, most breeders hesitate to breed a bull to his own offspring. But if inbreeding is ever likely to be followed by useful results it will be under just such conditions, and in proportion as both the bull and the half-blood heifers show strong individual vital powers the practice is recommended. In the majority of cases the very best bull to breed to a lot of high-quality, uniform, half-blood heifers is their own sire, especially if it is desired to secure greater uniformity and greater average production in their offspring.

On the other hand, suppose the breeder wishes to change bulls and procures an animal equal in productive capacity but of slightly different type from the original sire. In all probability their second generation calves, even though they are three-fourths pure blood, will not be nearly so uniform a crop as the first generation or half-blood calves. Further, such offspring frequently show little, if any increase, in average production, although a few individuals may show marked improvement. This will prove the skill and patience of the breeder.

Continued judicious selection the means of improvement.—The heifers that show marked improvement are the ones to be relied on to carry the herd forward in improvement. It is the continued elimination of the low-producing and the judicious selection of the high-producing that advances the general average of the herd. As generations come and go, the characteristics of the pure-bred sire will become more fixed and the herd more uniform in type and capacity. From the production standpoint, the herd will become practically equal to purely bred animals, although the male offspring should not be used for breeding, as they would tend to stimulate reversion toward the low-producing and common-bred ancestors.

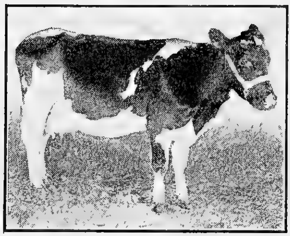
The Glista family.*—This family takes its name from Glista 7857, the ancestress of the Holstein-Friesian herd at Cornell University. Since Glista herself was rather inferior as a producer, the development of this family gives a good illustration of the building up of a herd from a common individual. As would be expected from

GLISTA

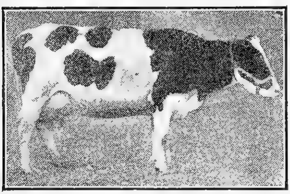


GLISTA 2ND

GL. NETHERLAND



GL. DE KOL



GL. IOTA

GL. ERNESTINE

FIG. 67—"GLISTA ERNESTINE," 24.410 pounds butter fat in seven days and her ancestors.

*"The Cornell Dairy Herd," H. H. Wing; "The Cornell Countryman," Nov., 1913, pp. 44-51.

so common a foundation cow, not all descendants have shown uniformly good qualities. The number of inferior animals is not larger than would usually appear in any course of breeding. By judicious selection these have been eliminated from the herd. It is interesting to trace the advancement of the descendants of this inferior cow up to Glista Cora, with a record of 24.129 pounds of butter fat in seven days as a senior three-year-old, to Glista Ernestine, with a record of 24.410 pounds of butter fat as a junior four-year-old, and to Glista Eglantine, with an aged record of 25.912 pounds of butter fat in one week. Glista Omicron, Glista Eglantine's dam, has a record of 25.282 of butter fat (Figs. 67 and 68).

In the following tabulation the relationship of all the individuals in the family is shown in the line of female descent, together with the length of time they remained in the herd and their average yield in pounds of fat per year during the time they were in the herd. A study of the table reveals some of the uncertainties as well as some of the difficulties with which the animal breeder must work. Glista 2d, the poorest cow in the first generation of offspring, is in direct line of ascent to Glista Ernestine and Glista Eglantine, now considered to be the best cows in the herd, all things considered. Glista Delta, the best cow in the second generation, left no female descendants, and her line became extinct. The table also illustrates very clearly the wide variation in relative fertility and longevity, some of the cows giving birth to but one calf and then failing to breed again, while others remain fertile until late in life, producing 10 calves and remaining productive for 10 years.

Advancement requires time.—While the tabulation shows rapid improvement in the first two generations of offspring, yet in point of time progress was slow, as is likely to be the case in any breeding operations involving the larger animals. Glista 3d produced three bull calves in succession and no heifers, while Glista 4th produced

The Glista Family, Showing Female Line of Descent

- **Glista** 3 Yrs. Av. 188 lbs.
  - **Glista 2d** 1 Yr. Av. 188 lbs.
    - **Gl. Netherland** 5 Yrs. Av. 286 lbs.
      - **Gl. DeKol** 6 Yrs. Av. 303 lbs.
        - **Gl. Gamma** 8 Yrs. Av. 336 lbs.
          - **Gl. Mu.** 6 Yrs. Av. 285 lbs.
            - ***Gl. Francesca** 3 Yrs. Av. 322 lbs.
        - **Gl. Iota** 7 Yrs. Av. 381 lbs.
          - ***Gl. Ernestine** 3 Yrs. Av. 377 lbs.
        - ***Gl. Omicron** 7 Yrs. Av. 359 lbs.
          - ***Gl. Elgantine** 3 Yrs. Av. 264 lbs.
        - **Gl. Tau** 5 Yrs. Av. 255 lbs.
          - **Gl. Eloise** 2 Yrs. Av. 283 lbs.
          - **Gl. Eleanor** 1 Yr. Av. 286 lbs.
      - **Gl. Alpha** 10 Yrs. Av. 294 lbs.
        - **Gl. Pi** 2 Yrs. Av. 198 lbs.
        - **Gl. Phi** 1 Yr. Av. 231 lbs.
          - **Gl. Omega** 3 Yrs. Av. 309 lbs.
            - ***Gl. Flora** 2 Yrs. Av. 207 lbs.
          - ***Gl. Echo** 3 Yrs. Av. 338 lbs.
          - **Gl. Ebony** 1 Yr. Av. 304 lbs.
        - **Gl. Alpha 2d** 1 Yr. Av. 204 lbs.
      - **Gl. Epsilon** 9 Yrs. Av. 312 lbs.
        - **Gl. Nu** 5 Yrs. Av. 317 lbs.
          - ***Gl. Eva** 4 Yrs. Av. 270 lbs.
        - **Gl. Upsilon** 3 Yrs. Av. 163 lbs.
  - **Glista 3d** 2 Yrs. Av. 252 lbs.
  - **Glista 4th** 8 Yrs. Av. 274 lbs.
    - **Gl. Beta** 10 Yrs. Av. 309 lbs.
      - **Gl. Lambda** 4 Yrs. Av. 292 lbs.
        - **Gl. Chi** 4 Yrs. Av. 281 lbs.
          - ***Gl. Elora** 2 Yrs. Av. 310 lbs.
        - **Gl. Dora** 1 Yr. Av. 239 lbs.
      - **Gl. Carlotta** 3 Yrs. Av. 299 lbs.
      - ***Gl. Cora** 2 Yrs. Av. 413 lbs.
      - ***Gl. Coreva** 2 Yrs. Av. 223 lbs.
    - **Gl. Delta** 9 Yrs. Av. 348 lbs.
    - **Gl. Theta** 7 Yrs. Av. 302 lbs.
      - **Gl. Rho** 4 Yrs Av. 301 lbs.
        - **Gl. Duchess** 1 Yr. Av. 220 lbs.
      - **Gl. Psi** 3 Yrs. Av. 345 lbs.
      - ***Gl. Candida** 4 Yrs. Av. 259 lbs.
    - ***Gl. Eta** 10 Yrs. Av. 327 lbs.
      - **Gl. Coriander** 1 Yr. Av. 233 lbs.
        - ***Gl. Draba** 2 Yrs. Av. 298 lbs.
      - **Gl. Corinne** 3 Yrs. Av. 253 lbs.
      - **Gl. Xi** 1 Yr. Av. 180 lbs.
      - **Gl. Sigma** 5 Yrs. Av. 341 lbs.

Average by generations 188 lbs | 238 lbs. | 314 lbs. | 289 lbs. | 268 lbs. | 303 lbs. | 265 lbs.

*Animals in herd at present time.

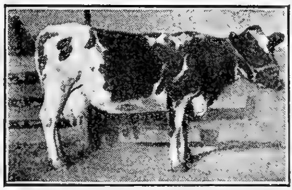
four bull calves before her first heifer was born. This retarded progress at first, although after a time the herd increased rapidly in numbers and improved in general

ADVANCEMENT IN GLISTA FAMILY

Period	Average number of cows in herd	Milk		Fat	
		Average amount produced in one year, lbs.	Average gain, lbs.	Average amount produced in one year, lbs.	Average gain, lbs
1891-1895	1.5	6,258		201	
1896-1900	2.2	8,868	2,610	285	84
1901-1905	6.0	9,065	197	312	27
1906-1910	18.6	8,261	-804*	291	-21*
1911-1913	18.0	9,195	130	324	12

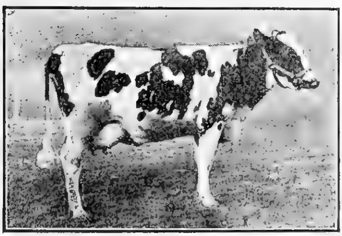
*Decrease.

GLISTA



GLISTA 4TH

GL. BETA



GL. CORA

FIG. 68—"GLISTA CORA," 24.129 pounds butter fat in seven days, and her ancestors

productive capacity. This is shown in the preceding tabulation which gives the average number of cows in the herd, the average amount of milk produced by each animal in a year, the average gain in milk as well as the average amount of butter fat produced by each animal in a year and the average gain in butter fat, in periods of five years each beginning in 1891 and continuing to the close of 1913.

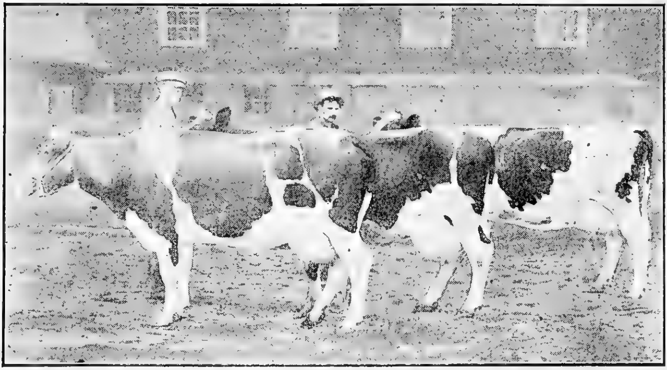


FIG. 69—HIGH-PRODUCING HOLSTEIN-FRIESIAN COWS
Daughters of Prince Ybma Spofford 6th

The tabulation illustrates the major drawback in breeding pure-bred animals. Practically all of the heifer calves were retained in 1906-10, there being little or no selection practiced. This resulted in a rapid increase in the number of cows in the herd and a corresponding decrease in production. The building up of a herd, whether of grades or purely bred animals, depends upon judicious selection.

Influence of the sires.—In the building up of a herd the influence of the sires is of great importance. The advancement in the Glista family has probably come largely through the sires, although in the tables showing female descent there is no indication of this. It is difficult to indicate the exact influence of each sire other than by giving a list of his daughters, together with the production of each, which is shown in the following tabulation:

	Fat, pounds
1 Sired by Netherland Remus	
Glista 2d	188
Glista 3d	252
Glista 4th	274
Average	238
2 Sired by Sir Beets De Kol	
Glista Beta	309
Glista De Kol	303
Glista Alpha	294
Average	302
3 Sired by Earl Korndyke De Kol	
Glista Delta	348
Glista Theta	302
Glista Eta	327
Glista Epsilon	312
Glista Lambda	292
Glista Gamma	336
Glista Iota	381
Glista Nu	317
Glista Mu	285
Average	323
4 Sired by Dutch Hengerveld Korndyke	
Glista Rho	301
Glista Xi	180
Glista Sigma	341
Glista Omicron	359
Glista Tau	255
Glista Pi	198
Glista Phi	231
Glista Upsilon	163
Average	254

	Fat pounds
5 Sired by Small Hopes Korndyke De Kol	
Glista Carlotta	299
Glista Psi	345
Glista Candida	259
Glista Coriander	233
Glista Corinne	253
Glista Chi	281
Glista Eloise	283
Glista Eleanor	286
Glista Omega	309
Glista Francesca	322
Glista Eva	270
Average	285
6 Sired by A. & G. Netherland Piebe De Kol	
Glista Alpha 2d	204
Glista Echo	338
Glista Ebony	304
Average	282
7 Sired by Prince Ybma Spofford 6th	
Glista Cora	413
Glista Coreva	223
Glista Dora	239
Glista Duchess	220
Glista Draba	298
Glista Ernestine	377
Glista Eglantine	264
Glista Flora	207
Glista Elora	310
Average	283

Since the cows are of the same strain in the female line, the average variation in productiveness of the offspring is due largely to the sires. Of the seven bulls, Earl Korndyke De Kol was the individual most impressive and of greatest use in the herd, whereas Dutch Hengerveld Korndyke was the least successful. Special attention is directed to these two sires. Had the herd missed the beneficial effect of the former, the latter, in all probability, would have sent it to oblivion, as many a bull thus has sent many a dairy herd. On the other hand, could the herd have enjoyed the beneficial effect of a second sire relatively as efficient as Earl Korndyke De Kol, the herd would have taken rank among the foremost in the country.

Prince Ybma Spofford 6th gives promise of excelling Earl Korndyke De Kol, as three of his daughters—Eglantine, Ernestine and Cora—have produced more than 24 pounds of butter fat in seven consecutive days and rank high among the cows of the breed (Fig. 69).

CHAPTER XX

COMMUNITY BREEDING

This system has been extensively introduced into a number of foreign countries, and into some of the states of the Union with most excellent results. A number of breeders in a community possessing the same type or breed of animals band together and form a co-operating breeding society. This has for its object the production and improvement of the animals of the community and often of some specific breed, as well as the establishment of cordial relations generally between the members of the society, who agree to practice such methods as will insure the most successful and economic results. It is the duty of each member to improve his animals by mating exclusively with pure-bred sires of the breed represented by his society, to care for his animals in the most approved manner, to co-operate with his fellow-members in the use of approved sires and in buying and selling stock, as well as in promoting the general welfare of the animal interests of the community.

Business of breeding.—The breeding of farm animals is a complicated and many-sided business. The breeder must not only be a student, familiar with the underlying principles of breeding, but he must be a live stock judge in order to select animals judiciously; he must be a feeder and trainer in order to develop maximum possibilities, as well as a business man in the sense of being capable of properly advertising his product in order that he may sell and buy to advantage.

The business of producing farm animals for breeding purposes is too complex for one man to accomplish with greatest efficiency. It calls for the harmonious effort of many minds. In the proposed society some men, by nature, may be scientific breeders, some natural judges, some expert feeders, some natural trainers, and others gifted with business and executive ability, the united effort of which can accomplish vastly more in the way of animal improvement than the wisest man working single handed. True, the lone man, if a genius at business, may make more money than the individuals in the society, but it will be due to his executive ability and not to the quality of his animals. It would be vastly better for the community as well as to his own advantage for such a person to join the society, as in this particular case he would be able to do the entire community's business more efficiently, because he would have a better grade of animals to sell.

Expense of equipment reduced.—The improvement of farm animals is an expensive business, because relatively

FIG. 70—SOUTHDOWN EWE LAMBS, UNIFORM IN CONFORMATION

few individuals excel their parents and very few propagate their own excellence. Among other things this expense is due to the cost of a proven purely bred sire and to the large number of females necessary to allow for rigid selection as well as to provide the proven sire with maximum opportunity. Community breeding reduces or divides this expense, so that the burden does not rest so heavily on any one breeder, as the members co-operate in the purchase as well as the use of the sire. This system also provides a sufficient number of females to allow for rigid selection in the use of the proven sire, thus securing his maximum efficiency. Community breeding enables the breeders of a locality to secure the services of the best proven males at a very nominal pro rata cost for each offspring.

Often a salesman representing a large importing firm enters a community and forms a "company" in order that he may sell a stallion. The company thus formed usually pays a high price for the horse, as the price must cover many expenses. There is no opportunity for selection, and the stallion thus thrust upon a community may not be of the proper type or breed to mate with the local mares. Thus the company plan of purchasing a stallion is objectionable, not alone because of the high price, but because the animal is often unsuited to mate with the mares of the community.

A better plan, for the community in need of a sire, would be to send two or three of the local breeders to a sales stable or breeding farm. They will be given an opportunity to study the business at first hand; they will have a large number of sires from which to select and thus be able to secure one that will mate advantageously with the local females; and they will be able to procure a sire at a very great reduction in price, as the firm is at no expense in selling. Likewise, when females are desired, it will be possible for a committee of two or three men to go and purchase the animals at one time, thus securing them at much less expense than if each member went individually to secure his animals.

Uniformity of animals favored.—Community breeding promotes uniformity, as all the members of the society use the same or similar sires. This is significant in view of the fact that our farmers, individually, have been using pure-bred sires to a greater or lesser degree for more than half a century without the characters of any one breed or type becoming dominant. This has resulted from lack of persistency of effort, due largely to breeders working single handed. It is apparent that there has been no organized effort and that our animals in the main represent promiscuous and haphazard breeding, which, together with the same kind of care, accounts for the large number of inferior and unprofitable animals to be found in the country.

The importance of community breeding and persistency of effort in establishing and perfecting a breed is emphasized by the prominence of Guernsey Island for Guernsey cattle, the Jersey Island for Jersey cattle, the district of Holstein for Holstein cattle, the district of La Perche for Percheron horses, and the like. It is safe to say that these two small islands, as well as the little districts of Holland and La Perche, would never have been so conspicuous or especially prominent in breeding had it not been for the organized efforts of the breeders and their persistency of purpose in the breeding of cattle and horses.

Community organizations for the improvement of animals create a new interest in the subject of breeding. The individual breeder will do well to cast his lot with the majority of his neighbors and breed the same type that they are breeding, even though that type may not be the one that best suits his fancy or even the one that is best suited to the community.

Market facilities increased.—While large numbers of animals may be produced by promiscuous breeding, they neither make a name for the communty as a breeding center nor attract buyers willing to pay appreciative prices. As a rule buyers are in search of animals of a particular type, and in order to locate them in such a locality would be obliged to travel throughout a wide territory and at a great outlay of traveling expenses, locating animals here and there until the lot had been gathered together. Under the community system, where the animals are uniform, the buyer in search of any par-

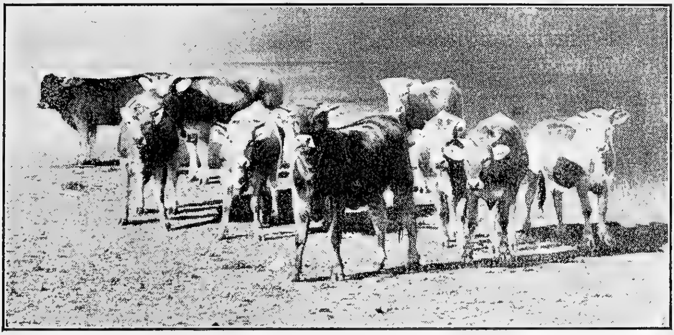


FIG. 71—BROWN SWISS YEARLING HEIFERS OF UNIFORM TYPE

ticular type can go to the district noted for the production of animals of the desired type and there find them in sufficient numbers to meet his needs. This serves to advertise the community, which soon becomes a noted breeding center, attracting large numbers of buyers willing to pay attractive prices.

The breeding of Holstein-Friesian cattle in the vicinity of Syracuse, N. Y., affords a good example of the market facilities enjoyed by a community that has established a reputation for the production of a certain type of animal. From every country Holstein-Friesian buyers are attracted to Syracuse, and in the near vicinity can be found the highest priced cattle in the world.

To establish a world-wide market such breeding operations need not be confined to the vicinity of a large city, as is illustrated in the case of the small town of Lake Mills, Wis. Through the efforts of a few men many Holstein-Friesian herds were established in the vicinity of Lake Mills, which soon established the reputation of being the greatest Holstein-Friesian center in the central west. Buyers are being attracted from all over the country and from foreign lands, and prices rule accordingly.

Disposal of surplus females.—Not infrequently the excellent market facilities created by the community system of breeding proves the undoing of further improvement. This is likely to be the case in a locality just acquiring a reputation. An outside buyer in search of a carload or more of females comes into the community and offers a very fancy price for the best animals. Under such conditions the breeders part with their best females and the advancement gained is lost.

To be most successful the herds of the community should have the first draft upon the female output in order to secure material to replace the aging animals, no matter what price the outside buyer may put upon them. If a certain breeder finds himself in possession of a number of fancy females, more than he needs for his own use, it would be of advantage to the community, as well as to the breeder himself in the long run, to sell his surplus females to his neighbors and let his neighbors sell to the outside buyer. This may look like poor business for the breeder of the fancy females, but it will retain the desired blood in the community. It is simply carrying the advice that a breeder should not part with his good females and saying to the community that it should not dispose of its best blood. Such a practice would raise the general average of all the stock, thus giving the community a better reputation for producing animals of quality. This would increase the market facilities still more, and in the end the breeder who had seemingly made a sacrifice at first would be able to sell his second output to a very great advantage.

Cow-testing associations.—Community breeding promotes the formation of cow-testing associations, which may become powerful agents in the improvement of dairy cattle. The elimination of low-producing animals is the first step toward improvement, and this elimination cannot be brought about successfully unless records of production of each cow are kept systematically. Cow-testing associations are organizations of dairymen having for their object the determination of the production of the individual cows in the herd, thus supplying the information necessary to judicious elimination.

FIG. 72—AYRSHIRE COWS UNIFORM IN TYPE AND COLOR

The methods of procedure in these associations differ widely, as they are organized in various ways and under various plans, each with due regard to its own local conditions. The essential feature in an organization of this sort is to employ a reliable, painstaking man to do the work. The expense to the breeder varies widely, though in a herd of 25 milking cows it will cost, annually, approximately $1 a cow. Associations have been in successful operation in many foreign countries and in several states of the union, and it would seem that dairymen should avail themselves more generally of these organizations, especially in view of the fact that not infrequently members increase the productivity of their cows 25 to 50 per cent during the first year simply through the elimination of animals whose inferiority was revealed by the results of the tests made by the association.

Advanced register testing promoted.—While the testing association increases the productivity of the herd by eliminating the inferior animals, it does not improve the individuals except as it stimulates better methods of care and management. Individual advancement calls for improved breeding, and, as has been stated, to mate dairy cattle judiciously, it is essential to know not only the performance of the animals thus mated, but the records of production of their ancestors as well. To provide this information advanced registers were established.

Community breeding promotes the formation of testing associations, which in turn promotes advanced register testing, by materially reducing the cost of testing for members of the association, since the representative of the co-operative breeders' society supervising the work can make the tests in circuits without loss of time and with a saving in traveling and other expenses. This is especially true of those breeds that require a one or two-day test each month, as the cow-testing association representative can do both the association and the advanced register testing at the same time, providing, of course, that suitable arrangement be made in advance with the various breeders' associations. On account of the importance of official testing of dairy cows to the individual breeder and to the dairy industry generally, the officials in charge of the advanced register work in many of the states favor this co-operative arrangement.

Educational features.—The greatest benefit from community breeding is the friendly spirit which it fosters among the farmers of a community. It tends to stimulate interest in improved methods and provides a means for the education of men in the breeding, feeding and management of their animals. However well educated a breeder may be, he is always confronted with questions which he little understands, and which he must continually seek to comprehend. In order to pursue successfully the business, he must secure all the information that is obtainable. The constant counsel of his brightest and keenest associates will prove invaluable.

A community breeders' society offers its members an opportunity to keep themselves informed on all matters pertaining to success in their work. Through meetings

FIG. 73—BERKSHIRE SWINE TRUE TO TYPE

of the society the members exchange helpful ideas and get the experience of prominent breeders, who may be invited to address and meet with them. The experience of many men makes it possible to avoid and remedy many evils and annoyances with which breeders have to contend.

The community breeding movement stimulates the formation of co-operative societies, through which much of the business of the community is transacted. With a thoroughly competent man in charge of the business, these societies have given excellent results. The members meet at regular intervals to discuss topics pertaining to the business. This stimulates a friendly rivalry and fosters a better social spirit in the community generally.

The young breeder.—Even though a close student of the principles of breeding as well as of types and breeds, the young breeder lacks experience with animals. This he should get by association with a good herd and by intimate counsel with men who are in the active business of breeding.

The young breeder, wishing to make his money go as far as possible, often begins by making the vital mistake of purchasing young stock. Since a very large number of young things come to but little, he soon finds himself in possession of a mixed lot of animals out of which nothing really worthy can be derived. The best way to get a start in the breeding of pure-bred animals is to obtain the foundation stock from a reputable breeder who can be persuaded to part with some of his proven animals, even though it is necessary to take those possessing considerable age, providing they are still fertile. The beginner has no call to pay extreme prices, as he cannot sell to advantage until he has acquired a reputation as a breeder and established himself in the confidence of the general public.

CHAPTER XXI

SEX IN BREEDING

The commercial value of farm animals often depends to a considerable measure on their sex. If a means could be devised, therefore, for controlling the sex of offspring, it would be of much value to the breeder. Endless attempts to do this have been made, but none of the theories have withstood the test of careful experiment. As there is but one alternative in the case, any theory, no matter how absurd, is certain to come true half the time.

The theories advanced for sex determination may be divided into two groups; first, those which depend on controllable external factors such as the food, climate, chemical agents, will power, and the like; and, second, those which depend upon internal factors centering about the germ cells, and which, of course, are beyond the control of the breeder.

Equality in number of the sexes.—Data gathered from various sources seem to indicate that the two sexes are produced in practically equal numbers. The relative number of males per 100 females is given for horses as 99, for cattle 94, for sheep 102, for swine 104, and for poultry 95. In Europe a study involving 60,000,000 human births showed an average of 106 males to every 100 females.

SEX DETERMINATION BY EXTERNAL FACTORS

A few of the more common external theories that have gained popular credence, but which, so far as present knowledge goes, contain no basis in truth, will be reviewed before considering the internal factors. The approximate equality of the sexes in all sorts of natural environments indicates the improbability of sex control by external conditions.

Time of breeding.—It is stated that the sex is determined by the degree of maturity of the egg cell at the time of service. If the service takes place early in the period of estrum or heat the offspring will be a male; if later, a female will result. Some persons say the reverse.

This theory is disproved by the results of ordinary farm practice. When males and females run together, the service always takes place during the early stages of the period of estrum in the female, which should make the offspring practically all of one sex, yet the proportion of males and females produced is approximately equal.

Alternating ova.—It is said that the ova are alternately male and female, and that the sex of the offspring can be controlled by the choice of the proper estrum for service. Thus, if the last young was a male, then mating at the first estrum as well as third, fifth and so on, would produce females, whereas the second, fourth, sixth and so on periods would result in males.

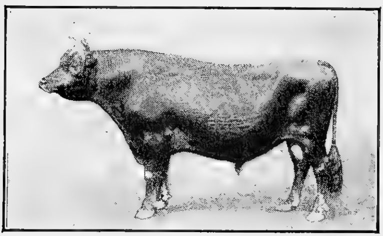


Fig. 74—Jersey Bull "Raleighs Fairy Boy"

This theory is also disproved by the results of farm practice, especially in horse breeding, where males follow males and females follow females without the alternating period of estrum, it being the custom to breed mares on the ninth day after foaling.

Male and female testicles.—The claim is made that one testicle is naturally male and the other female. Thus the sex of the offspring will depend upon the source of the particular sperm cell taking place in the fertilization of the ovum. The same claim is made for the ovaries of the female. These theories have been disproved by the fact that males with but one testicle and females with but one ovary have produced male and female offspring.

Sexual excitement.—It is stated that extreme sexual excitement on the part of the female is certain to result in male offspring, although some persons say the reverse. This theory is rather difficult to prove or disprove, but the strongest argument against it is the fact that the adherents are about equally divided as to the sex of the offspring. Either one is sure to be correct half the time on the average.

Age and vigor.—The claim is made that the older parent will determine the sex. The same claim is made for the more vigorous parent. Both claims are disproved by the results of farm practice, where young as well as old males sire both males and females, and where weak as well as strong males sire offspring of both sexes.

Food supply.—The statement is often made that the sex is determined by the nutrition of the female. The assumption is that the development of the female young demands greater amounts of food and more favorable conditions than does the production of males. To substantiate this, the claim is made that statistics reveal the fact that in countries which have been ravaged by war, and the food supply of the inhabitants diminished, an increased proportion of male children is found.

While there is an abundance of more or less conflicting data upon this matter, we again turn to the results of farm practice to disprove the theory, especially among the higher animals—horses, cattle, sheep and swine. Mares in the lowest state of vitality give birth to offspring of both sexes. The same is true of all farm animals.

SEX DETERMINATION BY INTERNAL FACTORS

In recent years there has been a growing belief that the factors determining sex are internal and that they are connected with the germ cells. This belief is strengthened by studies made with bees, squash bugs, and the like, as well as by the behavior of twins in man.

There are two kinds of twins; first, ordinary twins, which come from two separately fertilized eggs, and, second, "identical twins," that have their origin in one

FIG. 75—JERSEY COW "JACOBA IRENE"

egg cell. Of the former, approximately 30 per cent in man are reported as being of the two sexes, while "identical twins" are always of the same sex. This is given as evidence that the sex is determined at the time of fertilization, and it shows conclusively that neither the nutrition nor the environment determines the sex.

Sex differences slight.—The differences between the two sexes are few and slight, and mostly connected with reproduction. This is well illustrated in the case of animals that have been non-sexed, where it is often difficult to tell one sex from the other by a superficial examination. The differences between the sexes have been much exaggerated by the division of labor. Thus in seeking causes that determine the sex we need not look for such factors as alter characters, other than those that take part in the reproduction of young.

Influence of fertilization.—The sex of bees seems to depend upon fertilization. There are three forms of bees as regards the condition of their sex organs; first, drones or males produced from unfertilized eggs; second, workers or females which are usually sterile and which are produced from fertilized eggs; and, third, queens or fertile females, also produced from fertilized eggs, but developed in special comb cells, where they are provided with large amounts of special food. Here fertilization is the determining factor as to the difference between male and female, and the food supply determines whether or not the female is to be fertile.

This is a sex distinction that cannot hold in the higher forms, where fertilization is necessary to the development, whatever the sex, but it gives us evidence that sex determination is closely associated with the germ cells. Further, it indicates that the ova from which females develop are the equivalent of the ova from which males develop, plus an additional element.

Accessory chromosome theory.—Evidence in support of the claim that sex is determined at fertilization is drawn from recent investigation in the germ cells of certain species of insects. In the case of the common squash bug (anasa) the body cells of the female have 22 chromosomes, while those of the male have but 21. The same is true of the germ cells of both sexes. In the process of reduction, preparatory to fertilization, the mature egg cells will, of course, be reduced to 11 chromosomes each. In the reduction of the male germ cells, however, half are reduced to 10 and half to 11 chromosomes, as the odd one does not split. Now, it has been observed that if a mature egg cell containing 11 chromosomes be fertilized with a mature sperm cell containing 11 chromosomes also, the embryo will have 22 chromosomes and a female will result. On the other hand, if fertilization is accomplished by a sperm cell containing 10 chromosomes, then the embryo will have 21 chromosomes and the offspring will be a male. This is illustrated diagrammatically as follows:

Egg 11 chromosomes + sperm 11 chromosomes = 22 = female
Egg 11 chromosomes + sperm 10 chromosomes = 21 = male

The sex of the individual in such cases depends upon which sort of sperm cell fertilizes the egg cell. The male and female offspring are approximately equal as the mature sperm cells containing 10 and 11 chromosomes are equally numerous. Evidence of a similar nature has been observed from other sources, and in all cases reported the female contains the larger number of chromosomes.

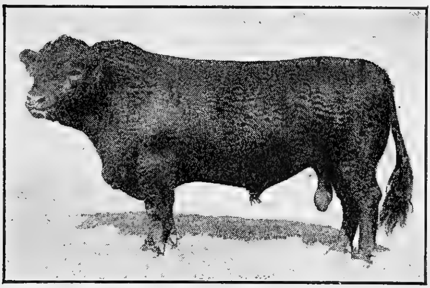


FIG. 76—GALLOWAY BULL, A PRIZE WINNER

From evidence similar to the foregoing, the belief is gaining rapidly that the sex of the individual is in some manner related to an unpaired or odd structural element in the egg or sperm cell. Upon the existence of such an unpaired element in the germ cells may depend the explanation of the unequal transmission of certain characters among the sexes.

Sex limited inheritance.—It seems that certain characters are transmitted to one sex but not to the other. The common example is that of a cross between a barred

Plymouth Rock and a non-barred breed, as Brown Leghorns among fowls, although the same is true of color blindness in man and some other color characters. If a barred Plymouth Rock male is crossed with a Brown Leghorn female, all of the offspring will be barred like the male. But if a Brown Leghorn male is mated with a barred Plymouth Rock female, the results will be different. All of the male offspring will be barred, while all of the females will be dark. In this case the barred Plymouth Rock female transmits the barring only to her male offspring.

Color blindness in man is a sex-limited character. This defect of vision is much more common in men than in women. A color blind man does not transmit color blindness to his sons, but only to his daughters. The daughters, however, are normal provided the mother was, although they transmit color blindness to half their sons. Apparently, therefore, a color blind daughter could be produced only by the mating of a color blind man with a woman who transmitted color blindness, since the daughter, to be color blind, must have received the character from both parents, whereas the color blind son receives the character only from his mother.

The same thing is said to be true of egg-laying capacity among hens. We are told that a male of high egg-laying capacity transmits this character to all of his offspring, both male and female, though the capacity of the male is known only through his female offspring, while the female of high egg-laying quality transmits the character only to her male offspring. Thus it follows that a female can inherit high egg-laying capacity only from her sire, while a male may inherit the character either from his sire, his dam, or both.

With the fact in mind, that under certain conditions color is sex limited, a careful search was made of the records of performance among horses and cattle without any evidence of such limitations in the production of speed and butter fat due to sex, although such limitations may exist in egg production, as this depends on the active functioning of the reproductive organs. True, the sire should be and usually is the better bred, and, therefore, should be prepotent over the common run of females. Under similar conditions, however, the evidence indicates that in speed and butter-fat production the sexes are equi-potent, and that one sex is as likely to be of superior breeding power as the other (p. 162).

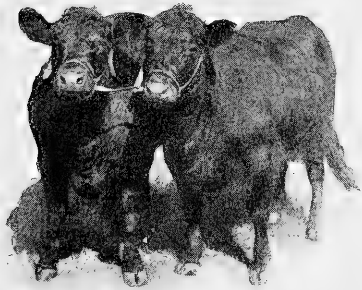


Fig. 77—Galloway Heifers True to Type

Sex control not desirable.—The evidence indicates that the sex of the individual is determined at the time of fertilization, and that control, especially in the higher animals, is beyond the power of the breeder. At first thought this may seem a handicap, but on analysis it appears to be a fortunate state of affairs. It seems undesirable that the sex of farm animals should be under the control of the breeder, especially in view of the comparatively higher values often placed on females. The approximate equality of numbers of the two sexes is of importance in general improvement. It gives a large number of males from which to select. This should and usually does result in a better grade of males than females, which is of advantage because of the relatively large number of offspring influenced by the sire. Greater advancement is secured in this way than would be the case were the number of males born limited to the number needed for breeding, as then there would be no chance for selection.

CHAPTER XXII

PROLIFICACY IN BREEDING

There is a close relationship between the prolificacy of farm animals that are kept for breeding and the profits arising from their production. As soon as the animal reaches the proper age for breeding then the relative profits grow less each day that it is kept without issue. This is due to three factors that deserve attention: First, the food, shelter, labor and risk of keeping an idle animal; second, the absence of offspring and lack of opportunity to make a profit on them; and, third, the probable encouragement of sterility in the case of females that do not breed at an early age. This is especially true of dairy cattle, where there is the added financial loss due to lack of product. The animal breeder should give special attention to fertility and gradually eliminate all animals that are not at least fairly prolific.

Conditions that influence prolificacy.—The productive powers of farm animals are influenced by the environment. All factors that tend to equalize conditions are favorable to high fertility. A uniform supply of nutritious, easily digested foods mixed into properly balanced rations, together with suitable management, influence reproduction favorably. On the other hand, insufficient and improper food, as well as lack of proper care, influence prolificacy adversely.

The training of race horses as well as the racing engagements render it impossible to breed them regularly. The developing necessary to put the dairy cow into condition to make a high record often interferes with the regularity of her breeding. Likewise, the fitting of animals for the show ring as well as their showing engagements interfere with the regularity of their breeding. Not only is a part of the breeding animal's life spent in the preparation and taking part in such events, but the methods employed in training, developing and fitting often favor sterility. In fact, the conditions that influence fertility favorably, as well as unfavorably, are much the same as those that cause sterility.

High prolificacy desirable.—The importance of high prolificacy is often overlooked by the breeder. This is especially true of trotting horses, as well as of animals with notable showyard careers. It is the females that are most affected, as the males can be used for breeding when not on the racing or showing circuit. Among trotting and pacing horses the mare capable of great speed is worth more for racing than for breeding, hence she is often kept on the track until too late in life to breed. Likewise, the value of the show animal is so great that it encourages the breeder to spend months, and often years, in preparation for the show ring, with the result that desirable animals are often never given a chance to reproduce themselves. This often means that the best individual blood of the various classes and breeds of farm animals is lost, which proves a very serious handicap in the general improvement of our animals.

It is highly desirable that the dairy cow be fully fertile. Here there is an intimate relation between the milk-producing powers and those of reproduction, due to the fact that the profitable milk secretion is dependent upon the normal functioning of the reproductive organs. Should the dairy cow fail to breed regularly the breeder loses on the keep of the cow, he loses on her milk production, and he loses the opportunity to make a profit on the calf.

That all animals kept for breeding purposes should be highly fertile is emphasized by the high cost of maintenance due to the price of feed (p. 4). The cost of maintaining a few idle breeding animals will rapidly destroy the profits made by the breeding of animals. Lack of a full realization of this on the part of farm breeders generally has been an important factor in the decrease of farm animals during the past decade.

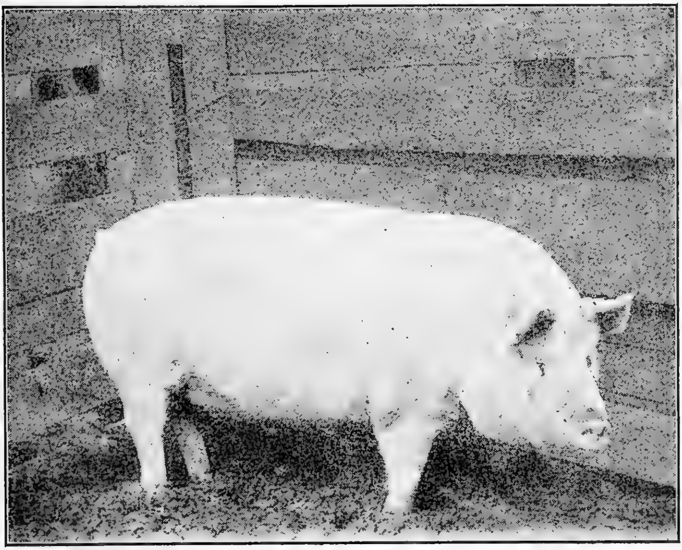


FIG. 78—CHESHIRE BARROW OF EXCELLENT TYPE

Cumulative effect of prolificacy.—The relative importance of fertility can be illustrated by comparing three cows, for example, of different degrees of fertility. Assume these animals to be the foundation stock for given herds, and that one raises two calves and then goes barren; that another raises four; and that the third raises six before she ceases to breed. Also assume that half of the calves are males, half females and that all descendants are fertile in the same degree as the original cows. The following tabulation illustrates results for five generations:

Number of Fertile Females at the End of Various Generations for Three Cows of Various Degrees of Fertility

		Generations				
Cows	Calves	1	2	3	4	5
No. 1	2	1	1	1	1	1
No. 2	4	2	4	8	16	32
No. 3	6	3	9	27	81	243

After five generations there would be but one fertile female descending from the first cow, whereas if all had been kept there would be 32 from the second and 243 descendants from the third cow. Compare the likely profit from offspring, also the opportunity for improvement by selection in the three cases. Of course, the length of a generation may depend somewhat upon the fertility of the cows, and five generations of the first cow's descendants may not require more than one-half as many years as five generations in the case of the third cow.

To avoid the unequal time element, let us assume three similar lots, but that each cow drops a calf at two years of age and one each year thereafter until she goes barren. Now, at the end of ten years there would be five cows in the first herd, one fertile and four barren; there would be 12 in the second, eight fertile and four barren; and in the third there would be 15 cows, 13 fertile and two barren. Further, there would be but five bull calves in the first; eight in the second; while in the third there would be 13 bulls.

Prolificacy in horses.—Both mares and stallions vary widely in prolificacy. Some mares give birth to one or two foals and then go barren, some breed every other year, and some are fully fertile. In general, the light breeds are more fertile than the heavy breeds, although many draft mares are highly fertile. The most productive period of a mare's life is from 4 to 12 years of age, although in many cases this period may be extended both ways. Occasionally a filly will breed at two years of age, and even before, and not infrequently individuals of the light breeds retain their breeding power until past 20 years of age.

There is a difference of opinion as to the advisability of breeding two-year-old fillies. It is stated that breeding at so early an age tends to retard development in both dam and foal. On the other hand, it is stated that early pregnancy has a tendency to stimulate the development of the dam, to increase her fertility, and that the first foal, if from a well-grown filly, stands just as good a chance as the first foal from a mature mare. Perhaps the reason for much of this discussion lies in the fact that fillies at this age breed with much difficulty.

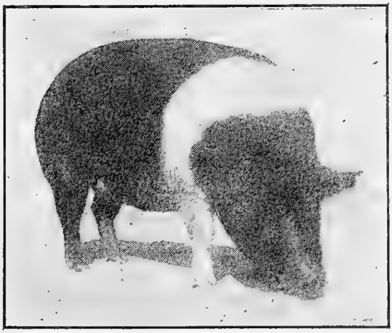


Fig. 79—Hampshire Barrow Showing Breed Marking

At about 12 years of age the productive powers of most mares begin to wane, although some breed freely for a much longer period, as illustrated by the famous mares Green Mountain Maid, that produced 16 foals, and by Old Fannie Cook, that produced 15 foals, giving birth to twins at 22 years of age.

Likewise, stallions vary widely in their breeding powers, some serving 50 mares, some 100, and, in the lighter breeds, some serving 150 and more mares in a single season. There is also much variation in the percentage of mares that stallions pregnate, although this may be due as much, if not more, to the mares as to the stallion. On the average, the stallion pregnates 70 to 80 per cent of the mares served, and approximately 60 per cent drop living foals. In other words, out of every 100 mares served 70 to 80 become pregnated and only about 60 give birth to living foals. Thus it would seem that breeders should give the detailed work of breeding horses careful consideration in an attempt to raise this low birth rate.

Prolificacy in cattle.—Among dairy cattle fertility is of prime importance, as continued milk production depends on the regular functioning of the reproductive organs. Though important in beef cattle also, high fertility is not so essential, as the beef cow that fails to breed may be fattened and sold for beef. The reproductive organs of the heifer mature at a younger age than in the filly, so that cattle breed much younger in life than do horses.

The most fertile period of a cow's life is from one and one-half to eight years of age, although this period may be extended both ways. As with fillies, there is a difference of opinion as to the proper age to breed heifers. Heifers that are vigorous, healthy and well grown should be bred rather young, thus encouraging the milking habit at an early age. This practice has much to commend it (p. 311). Young heifers breed with greater regularity than do young fillies, because of the unconscious selection for young breeders that has been taking place among cattle.

At about 8 to 10 years of age the breeding powers of cows begin to wane, though many of them are reliable breeders until a much later period of life, as observed in the case of the Holstein-Friesian cow, De Kol 2d, who gave birth to 14 calves, the last one in her sixteenth year, as well as in the case of the Angus cow, Old Granny, that produced 25 calves, the last one in the twenty-ninth year of her life.

Bulls also vary widely in fertility, although their management is such that they are seldom given full opportunity. On dairy farms, cows are bred so as to drop calves in the fall of the year, whereas beef cows are bred so as to calve in the spring. In either case the breeding season is short, so that the bull is used but three or four months each year. The number of cows that a bull can pregnate depends, in part at least, upon the breed. Heavy, phlegmatic beef bulls are not so prolific as the lighter and more active dairy bulls. Further, the bulls of the heavy dairy breeds are often less prolific than those of the lighter breeds. The bull should be able to serve at least 25 cows in a season, and when strong and vigorous may far exceed this number.

Prolificacy in sheep.—There is much variation in relative fertility among the several breeds of sheep. A fair

FIG. 80—DORSET HORNED LAMBS

percentage of the ewes of some of the more prolific breeds, such as the Dorsets, produce triplets; the ewes of other breeds, such as the Downs, produce a fair proportion of twins; while in some of the less fertile breeds practically all of the ewes give birth to but a single offspring. Further, there is equally as great variation in prolificacy among the individuals of a breed.

The most prolific period of a ewe's life is from one to five years of age, although many individuals continue to breed until much later in life. While breeders differ in their opinion as to the advisability of breeding the yearling lamb, if she is well matured and thrifty, it is probably better to try her out the first season, particularly if she is very promising. If giving satisfactory results, the ewe should be retained in the flock as long as she will breed. After about the fifth breeding season the ewe's reproductive powers begin to wane, although an occasional one will remain fully fertile until 9 or 10 years of age. There are authenticated cases of ewes remaining in the breeding flock for 12 years, giving birth to from 24 to 30 lambs and raising a large proportion of them.

Likewise, rams vary in prolificacy, although the number of ewes they are able to pregnate will depend much on their management at the mating season. The ram should be kept away from the flock of ewes, as this conserves his energy, thereby enabling him to serve twice as many ewes as when running in the field with the flock. Where this plan is followed, the ewes are brought to the ram in the morning or evening while cool, when he is permitted to single out those that are in heat. Such ewes are taken out and allowed a single service. A thrifty ram may be permitted to serve two or three ewes each morning and evening, thus enabling him to care for 100 ewes in a season. This is twice or even three times as many ewes as he can care for if permitted to run with the flock.

Prolificacy in swine.—The several breeds of swine vary widely in fertility. The bacon and semi-bacon breeds are, as a rule, much more prolific than the heavy lard-producing breeds. The more fertile breeds produce two large litters each year, while the less prolific breeds produce but one litter, which often consists of a comparatively small number of pigs, and these sometimes lacking in size and general thrift. Likewise, there is even greater variation among the individuals of a given breed.

It is a rather common practice to breed sows at six or eight months of age, and after raising one litter of pigs to fatten the sows for the market. This is not a good practice, for once a good brood sow is found, she should be retained as long as she continues to breed and to do well. Further, young gilts often give birth to small litters of pigs lacking size and thrift. Of course the

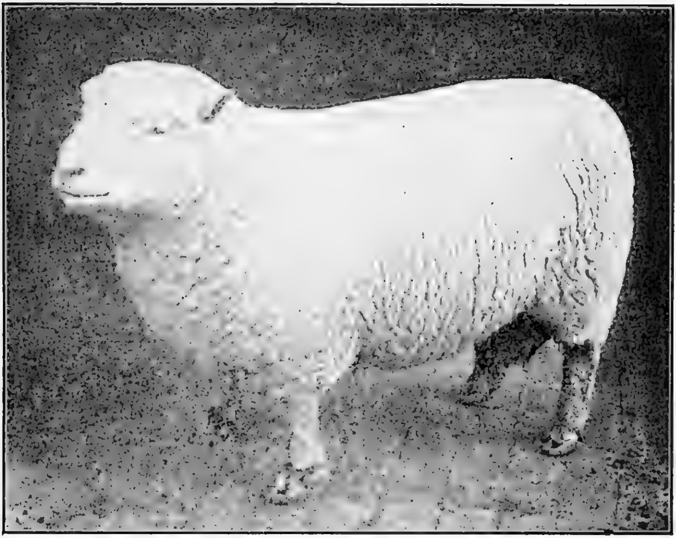


FIG. 81—SOUTHDOWN YEARLING RAM

gilt may be tried out while young, but, if promising, she should be retained in the breeding herd. The most prolific period of a sow's life is from one to five years of age, although many retain their breeding powers much later in life. There are authenticated cases of sows remaining fully fertile until 10 years of age, giving birth to 175 pigs, and raising a large proportion of them.

Boars also vary widely in fertility, although the number of sows that they are able to pregnate as well as the number of pigs that they are able to produce will depend much upon the management. The boar is often overfed on fattening foods and denied proper exercise, which materially decreases his fertility. For best results the boar's management at the breeding season should be much the same as that suggested for the ram.

Prolificacy in poultry.—Poultry differ from other farm animals in that the services of the male are not necessary to the egg-laying function, although, of course, such eggs will not incubate. There is greater variation in prolificacy among poultry than any other class of farm animals. There is much variation among the several breeds as well as among individuals. Entire flocks of the more prolific breeds, such as the Leghorn, average 125 to 150 eggs in a season, with an occasional individual laying as high as 300 eggs in a year. Flocks of the less prolific breeds, such as the Brahma, average only 40 to 50 eggs in a season, with many individuals running very low.

The most prolific period of a hen's life is from eight months to three years of age. Some pullets begin laying at four or five months of age, and some hens retain their egg-laying powers until seven or eight years of age. Usually, but not always, the hen lays her largest number of eggs the first season, and each season thereafter gradually diminishes in prolificacy until she ceases to lay.

Males also vary in fertility, but on the average it is safe to allow one male for each 20 females. When convenient it is a good plan to change males once each week. The male bird will begin to breed at four to six months of age.

Prolificacy hereditary.—The tendency to prolificacy is freely transmitted from parent to offspring, as is evidenced by the fertile strains among each class of farm animals. This is particularly noticeable in the case of sheep and swine. Sheep breeding records show that the ability to produce twins and triplets is transmitted. This has resulted in strains especially noted for this attribute. The same is true of swine, and we have strains noted for their ability to produce two large litters of pigs each year. Likewise, there are strains of both sheep and swine in which the breeding powers are very weak, and it is necessary to keep introducing outside blood to keep them from becoming extinct.

CHAPTER XXIII

STERILITY IN BREEDING

Success in animal breeding depends upon the ability of the animal to produce living young. Individual excellence, pedigree and performance count for nothing in the presence of sterility. From the breeder's point of view it matters little whether the inability to produce young depends upon the failure of union between the male and female germ cells, or to the death of the embryo and fetus, or even to premature expulsion of the fetus before attaining sufficient development to continue life, as each prevents living offspring and practically constitutes sterility. In this discussion, however, sterility is limited to the failure of a union between male and female germ cells. The question of the life of the embryo and fetus, as well as the premature expulsion of the fetus, is considered in the discussion on abortion in breeding (p. 268).

Prevalence of sterility.—Among farm animals sterility is widespread and of much more frequent occurrence than is commonly supposed. It occurs in both sexes, but in the female the genital apparatus is more complex and sterility more common, although of no greater importance than in the male. The function of the male parent ends with the injection of healthy semen into the uterus or vagina of the female. In the female, however, the male germ cells must migrate on through the uterus and oviducts until they meet the female germ cell or ovum coming from the ovary. Here fertilization takes place, after which the female organs must still protect, and provide nutrition to the embryo for a long period of time.

Much variation exists in reference to the prevalence of sterility among farm animals. It seems to be most common in those animals that are kept closely confined, and hence becomes of prime importance in dairy cattle. This is particularly true in view of the fact that the value of a cow depends upon the normal functioning of her reproductive organs. Among work horses and meat-producing animals sterility does not attract so much attention, especially with females, as it makes comparatively little difference to the owner whether they breed, or, in the case of horses, go to work, or, in the case of meat animals, go to the butcher.

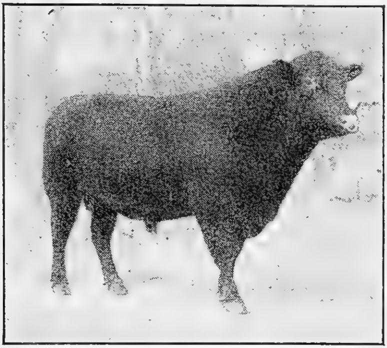


FIG. 82—RED POLLED BULL "TEDDY'S BEST"

The breeder should make a careful study of sterility, as the principal if not the sole value of his animals depends upon their productive powers. In such cases failure to breed may prove a financial disaster. If a number of valuable brood mares, for example, kept exclusively for breeding, are mated with a sterile stallion, no foals will be produced the following season. This results in a total loss of anticipated income. Further, each mare has diminished in value through her increase in age, and having been idle for a year, with the tendency to sterility intensified.

Causes of sterility.—Among farm animals, reproduction occurs as a result of a union, under favorable conditions, of a mature male germ cell with a mature female germ cell. The former are produced in the testicles of the male, the latter in the ovaries of the female. Anything which interferes with the normal physiological activities of either male or female, or with normal sexual intercourse, may result in sterility. The function of reproduction, being exceedingly complex, the causes leading to sterility are correspondingly numerous and exceedingly varied, and not infrequently little understood.

Idleness and overfeeding.—Breeding animals are often closely confined, denied proper exercise, and fed an oversupply of nutritious foods in order to keep them in presentable condition. Under such circumstances they take on fat rapidly and frequently fail to show signs of sexual desire. This is true of the male as well as the female. The tendency to loss of sexual vigor on this account increases with age, although noticeable in young males. The difficulty seems to be of a purely functional nature, and usually disappears under proper management, providing that it be applied sufficiently early.

The sexual vitality of many of our most richly bred animals is often temporarily impaired and sometimes permanently destroyed in the process of fitting them for the show ring. While there is no effective method for overcoming this, yet much could be done to relieve the situation if judges in live stock exhibitions would pay less attention to the amount of fat and more to the general form and natural vigor of the animal in the allotment of premiums. In fitting breeding animals for show it is absolutely essential that an abundant exercise accompany the preparing process, especially if the sexual vigor of the animal is to be preserved.

Overwork and adverse conditions.—Farm animals that are subject to severe work are often inclined to be sterile for the time. It seems that the resources of the animal are exhausted in the physical labor and that no reserve energy remains to provide for the reproductive powers during this period. Likewise, adverse conditions depress the reproductive powers. The animal which does not receive sufficient food to maintain general thrift and afford a moderate reserve for reproduction tends to become sterile.

Likewise, anything which results in profound depression of the general system is often accompanied by suspension of the powers of reproduction. Such disorders not only destroy sexual desire, but also prevent the formation of germ cells, which causes absolute sterility, at least during the period of depression. The remedy for such a condition is to be found in proper management of breeding animals.

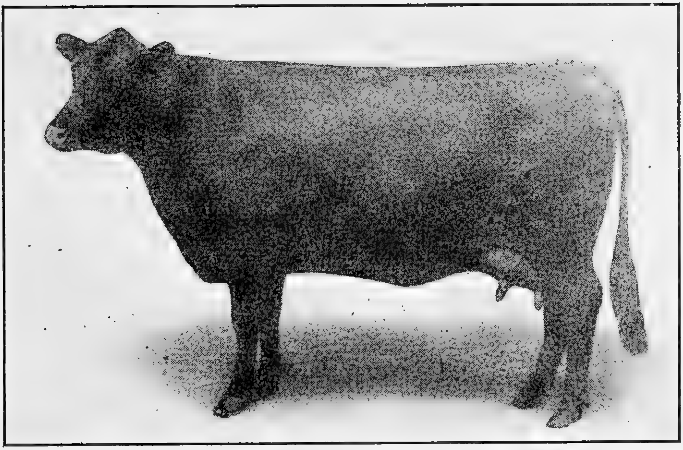


FIG. 83—RED POLLED COW "COSY 2ND"

Excessive sexual use.—Among males partial sterility is frequently due to excessive use. Naturally the breeder is interested in the number of females a male can pregnate in a season, which often leads to excessive use, especially among stallions. When the number of services during a given day is increased the abundance of germ cells in the semen rapidly decrease, and if the services are repeated too frequently the germ cells in the semen become greatly diminished, thereby causing low fertility and sometimes sterility. The stallion and the bull should not be allowed more than three services in one day, and these only under such conditions that the male be given one or two days of complete rest each week. Under like conditions the ram may be allowed two or three services each morning and evening for a short period, while the boar should not exceed two services each morning and evening.

Idle males, particularly stallions, which are closely confined, overfed and denied exercise often acquire the habit of masturbation, which leads to sterility. The same habit is often observed in racing stallions, when sexual debility is brought about by hard work on the track. The remedy is judicious management and especially proper exercise.

Timidity, irritability and excitability.—Not infrequently timid females have a tendency to avoid males and often refuse them entirely. This is especially true of young heifers when approached by a boisterous bull. Since the behavior of the male has much to do with such cases, he should be taught, so far as possible, to approach the females quietly.

Sexual intercourse in the mare and cow is frequently followed by violent expulsive efforts, which result in the loss of a large part or all of the semen. This is due, in some cases at least, to the irritability of the female. Possibly in some cases it is due to excessive pain caused by abnormal males. When the expulsive efforts are due to irritability, the female's attention should be attracted for a time after the service. This may often be done by causing her to move about for a time.

Females with young at their side often become much excited and resist the males because of the maternal instinct. This is especially true of mares with young foals by their side. In such cases the young should be kept out of sight and hearing of their mothers at the time of service.

Size of male and female.—If the male is comparatively either too large or too small sterility may ensue as a result of imperfect or incomplete copulation. This is especially true of young boars trying to serve mature sows. Not infrequently serious accidents result from the use of very heavy bulls on small cows. The nature of the cause suggests the remedy. In case the female is too tall, she may be placed in a pit; or, in case the male is too heavy, breeding stocks, or racks, may be so constructed as to bear the extra weight of the male.

Not infrequently painful diseases of the feet and legs or of other parts which may cause pain during the process of mating serve to render the service uncertain and often to prevent it.

Hybrids among animals usually sterile.—This term is applied to the offspring of a union of two distinct species, the common example among animals being the mule, which results from a cross between a jackass and a mare. The offspring resulting from a cross between a stallion and a jennet is known as a hinny. The mule and the hinny are classed as sterile, although in rare instances well-authenticated cases are reported of female mules giving birth to living young. In general, all degrees of fertility are found among hybrids, from extreme prolificacy in plants to absolute sterility in case of some animals.

Freemartins often sterile.—This term is here applied to designate a sexually imperfect calf born twin with a normal male. In this case it is, of course, always sterile. There are three kinds of twins among cattle; first, those that are both female and normal; second, those that are of different sexes and normal; and, third, those that are both male, in which case one is always abnormally developed, the internal organs resembling the male, and the external organs the female.* In fact, this is a kind of hermaphroditism, and not, as commonly supposed, a heifer born twin with a bull. As indicated, a normal heifer born twin with a bull is as fertile as any other heifer.

Hermaphrodites.—This term is applied to the animal in which both male and female sex organs are each found

*Giddens and Thomson, "The Evolution of Sex," p. 41.

more or less developed. There is wide variation in the degree of development of the organs, one extreme resembling males, the other females. Hermaphrodites are classed as sterile.

Cryptorchids.—This term is applied to the male in which the testicle fails to descend into the scrotum but remains inside the abdomen. This condition is frequently observed in horses, when they are spoken of as "ridglings." Cryptorchids are classed as sterile, although the animal assumes the characteristics of a normal male. In fact, cryptorchid is an arrest in the development of the testicle, the organ being small, soft and flabby. A similar arrested condition is often observed in the ovaries. Likewise, both organs may undergo degeneration, the glands assuming a variable form and size and consisting of a mass of matter devoid of proper tissue.

Diseases of the reproductive organs.—The most frequent and important cause of sterility among farm animals is that of diseased reproductive organs. There are a great number of ailments of these organs that interfere with the reproductive function, many of which are little understood. Probably one of the most important, if not one of the most frequent, diseases causing sterility, especially among the females of certain classes of animals, is that of cystic degeneration of the ovaries. This disease is very common in highly bred milk cows, especially in regions of intensive dairying, where the cattle are constantly stabled, and fed an abundance of artificial foods, such as distillers' grains, malt sprouts, and the like. The exact cause of the disease, however, is not known. Ovarian cysts also occur in mares, ewes and sows.

Other diseases of the reproductive organs tending to cause sterility are persistent hymen; adhesions of vaginal walls; tumors of the vulva, vagina, uterus, broad ligaments and ovaries; tuberculosis of the uterus and ovaries; metritis, both acute and chronic, and the like.

There is little or nothing that the breeder can do to remedy many of these diseases, but his attention is especially directed to them to impress the fact that they constitute the most important cause of sterility among

FIG. 84—BERKSHIRE SOWS AT PASTURE

farm animals, and also to show the fallacy of the promiscuous use of drugs and nostrums in an attempt to overcome sterility. In such cases an expert veterinarian should be consulted.

Drugs as a remedy for sterility.—There seems to be a widespread opinion among breeders that certain drugs arouse sexual desire and hence stimulate sexual powers. From time to time numerous drugs have been credited with this power. The nature of many of the diseases causing sterility would seem to cast reflection upon the value of drugs in this connection.

Sexual instinct is so natural and so universal among healthy farm animals of breeding age that nothing can be gained by exciting sexual desire artificially. Further arousing sexual desire by the use of drugs does not insure or even favor conception. Such attributes belong to every normal male and female of breeding age, and if they are absent it is because of some irregularity in the reproductive system or elsewhere that cannot be removed by the use of drugs.

It is stated also that certain foods, especially those of an aromatic character, have the power of arousing sexual desire. The same claim is made for certain stimulants, such as calamus, pepper, powdered mustard when fed in connection with well-cured and sweet smelling hay. The advice accompanying such claims is to feed the food for two or three days in succession and then omit it for a like period, when it may be given again. Such tonics are valuable only in so far as they restore debilitating animals to health.

Dilation of the os uteri.—There is a rather common belief among horse breeders that much of the sterility in mares is due to a closure of the neck of the womb. Thus, when a mare fails to conceive it is the practice to "open the womb." This is a questionable practice, and should be done only under the most sanitary conditions. As it is ordinarily done it cannot be too strongly condemned. The rough, dirty hand of the groom, with long and rough finger nails, concealing an abundance of filth is forced through the vulva, vagina and neck of womb, with scant regard for their delicacy and tearing the tissues, so that the hand when withdrawn is often covered with blood. Even if the womb did need opening, and so far as is known it does not, this is certainly in violation of all surgical principles.

Yeast solution in vagina.—Another questionable practice in the handling of sterile cows which was formerly held in favorable repute was that of injecting a yeast solution into the vagina. After a careful consideration of the nature of the diseases causing sterility, it is inconceivable how yeast introduced in the vagina could serve as a remedy for sterility.

Management of breeding animals.—The care that has a favorable influence upon the general vigor of an animal must also improve its reproductive powers, as it enables all of the organs of the body to better perform their normal functions, among which is reproduction. The general management of breeding animals should be such, therefore, as will keep them in a thrifty and vigorous condition at all times.

In so far as possible, breeding animals should be given only natural foods, which should be sweet and nutritious. Foods rich in protein and ash, such as oats, wheat bran, clover and alfalfa, are preferred to starchy foods, such as corn and timothy hay. In season, pasture grass cannot be improved upon, although it should be supplemented with grain. A few carrots, roots or tubers is a very valuable addition to the ration, especially in the winter.

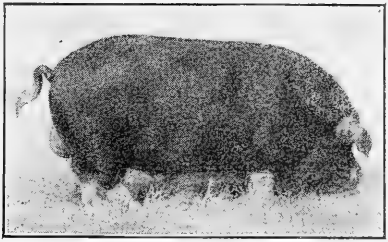


FIG. 85—POLAND-CHINA BOAR OF GOOD CONFORMATION

Special attention should be given to the exercise—and, in the case of horses and cattle, to the grooming as well. The exercise can be provided for in the case of smaller animals by allowing ample range, and in the case of horses by putting them to work. Moderate work is advantageous to horses, provided proper care be taken not to overload them. It is much better than to keep them tied in the stable, or even than to let them run in the fields, where they are exposed to accidents resulting from racing, playing or fighting with each other. The object to be attained in the management of breeding animals is to so feed, exercise and groom them as to keep them up to the very highest pitch of vigor and thrift.

CHAPTER XXIV

CONCEPTION AND DEVELOPMENT OF FETUS

The object of all breeding is that of reproduction. Before reproduction becomes possible, however, the animal must have reached the age of sexual maturity or puberty. Up to this time the reproductive organs are dormant so far as the production of functional germ cells are concerned. At this age sexual desire is established and mature germ cells are discharged. The age at which farm animals reach sexual maturity varies with individuals and breeds as well as with the several classes of animals. Much depends on the size as well as the food supply and the rapidity of development, although puberty usually occurs prior to the completion of body growth.

Estrum, or heat.—The period of irresistible sexual desire is known as estrum, or heat, in the female. It is established as early as the twelfth to the fifteenth month in mares, fifth to the sixth month in cows, third to the fourth month in sows, and sheep born late in the summer will show it the next breeding season, although no farm animal should be bred at so early an age. Pullets often begin laying eggs as early as the fourth month.

The frequency with which heat recurs in farm animals varies within rather narrow limits after once being established, and following parturition. The mare usually comes in heat in seven to nine days after foaling, and each three or four weeks thereafter. The cow varies according to the care. If the calf is taken away she usually comes in heat about three weeks after parturition, whereas if she suckles the calf she seldom comes in heat for six or eight weeks, although in either case the periods recur with considerable regularity each three weeks thereafter. The sow usually comes in heat from three to five days after weaning her pigs, and each two or three weeks thereafter, although the claim is made that she comes in heat every 9 to 12 days. The periods recur in the ewe every two to three weeks. The mare and the ewe come in heat regularly during the spring and autumn months, while at other seasons the period is irregular and often entirely absent. In carnivora estrum ordinarily occurs semi-annually, in the late winter and early autumn.

Ovulation.—Upon the completion of the process of maturation, and as a rule concurrently with estrum, the ovum or ova are extruded from the Graafian follicle of

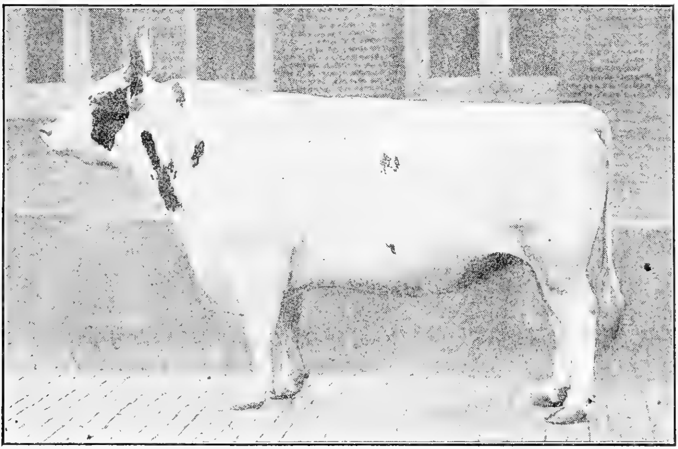


FIG. 86—AYRSHIRE BULL "BARGENOCH GAY CAVALIER"

the ovary. Normally, the ovum or ova pass into the oviducts and are conveyed toward the uterus. In some cases, however, the ovum is not extruded from the follicle, but maintains its connection with the ovary and is fertilized there, constituting ovarian pregnancy.

The exact relation of the period of heat, or estrum, to ovulation, as well as to fertilization, has not been definitely determined, and conflicting views are held. In rabbits it has been observed that when young are born, there already exists in the ovaries of the doe a number of follicles fully mature and ready to rupture. Estrum follows immediately after birth, copulation occurs, and it is not until after 8 to 12 hours have passed that the follicles rupture and discharge the ova into the oviduct, there to become fertilized by the sperm cells already present. Such is probably the case in other animals.

Owing to the brief duration of estrum in the cow, she provides a favorable opportunity for studying the relation between estrum, ovulation, fertilization and menstruation. In her case investigation shows the order of these phenomena to be estrum, ovulation and menstruation, proving this order is not interrupted by copulation and fertilization, in which case the order seems to be estrum, ovulation, copulation and fertilization, although in some cases copulation may precede ovulation. In fact, in the case of many animals, it seems that ovulation is favored and at times possibly hastened by copulation. This is often taken advantage of by the breeder who wishes to bring animals into breeding condition.

Conception.—During the act of copulation the semen from the male is injected into the vagina of the female. In some classes of animals possibly a part of this seminal fluid is injected through the os uteri into the uterus. The essential conditions of conception, so far as the male is concerned, are that normal spermatozoa shall gain the os uteri, traverse the uterus and oviducts and meet the ovum. Here fertilization takes place through the union of one sperm cell with the ovum. Under favorable conditions development ensues, and the fertilized ovum gravitates along the oviduct or Fallopian tube to the uterus and conception is completed.

In farm animals nothing is known of the time required for the spermatozoa to traverse the uterus and tubes, or of the time required to initiate growth after fertilization has been accomplished. Likewise, nothing is known of the time required for the fertilized ovum to gravitate along the tubes to the uterus. In the rabbit fertilization takes place 8 to 12 hours after copulation, and growth or segmentation begins in 10 to 12 hours after fertilization. It continues for 72 hours after fertilization, at which time the ovum reaches the uterus and its segmentation stage has been completed. In farm animals it probably requires a longer time, particularly as the period in woman is stated to be of from four to eight days' duration.

The period of development may be divided into two stages: First, the stage of the embryo, extending from segmentation until the germ begins to assume definite form; and, second, the stage of the fetus, which includes the remainder of the intra-uterine existence.

Artificial impregnation.—In recent years artificial insemination has been widely advocated as a remedy for sterility. Apparently this claim is based upon the theory that sterility is due to imperfect copulation because of physical impediment, although we know now sterility is usually due to other causes (p. 254).

Artificial insemination is a comparatively easy process in some classes of farm animals, particularly in the case of fertile mares, although it is more difficult in cows because of the structure of the organs. While it is a valuable remedy in cases due to physical impediment to natural insemination, some exaggerated claims have been made regarding its efficiency. It has been stated that as high as 60 per cent, and even more, of mares, taken at random, regardless of the presence of estrum, have been fertilized, which, of course, is absurd. However, if the mares are fertile and the artificial insemination is carefully made when the mares are in heat, there is no reason to doubt that 60 per cent and even more may conceive.

Artificial impregnation has a commercial value which is attractive to breeders. A healthy male, under normal conditions, at each copulation discharges sufficient spermatozoa to pregnate a large number of females. Since artificial insemination is so simple an operation, it has been proposed to extend the procreative power of valuable males, particularly stallions, by artificial insemination, and a variety of artificial impregnators have been devised with which to perform the operation.

The chief factor to be observed in artificial insemination are cleanliness, promptness, constant temperature for the semen and its secure lodgment in the os uteri or uterus.

Formation of the embryo.—While the fertilized ovum is passing along the Fallopian tube to the uterus it undergoes repeated segmentation, becoming a more or less globular mass of cells, known as the morula or mulberry stage. Very soon after reaching the uterus there appears in the interior of the morula a little fissure-like space called the cleavage cavity. When this space has increased in size, the germ is said to have reached the blastula stage. At this stage the cleavage cavity is surrounded by a single layer of cells, although in mammalia the inner cell mass is very irregular.

By the invagination of the single-layered blastula at the vegetable pole the double-layered grastula stage is attained. Thus the grastula stage in its typical form consists of two layers of cells surrounding a central cavity, which communicates with the exterior by means of a small aperture. This cavity later becomes the intestinal-body cavity. The outer layer of cells is the ectoderm or epiblast, and the inner layer the entoderm or hypoblast.

Upon the surface of the germ at the beginning of grastulation there is a round whitish spot known as the embryonal area. This area rapidly enlarges, becoming oval and later pear shaped. In the line, on the long axes of the embryonal area, the cells become more dense, forming the primitive streak. Soon a third layer of cells lying between the epiblast and hypoblast begins to develop near the front end of the primitive streak, from which point it spreads out over the germ. This layer is called the mesoderm or mesoblast.

Typically the embryo now consists of three layers of cells known as the three primary germ layers—the outer layer or epiblast, the inner or hypoblast, and the middle layer or mesoblast.

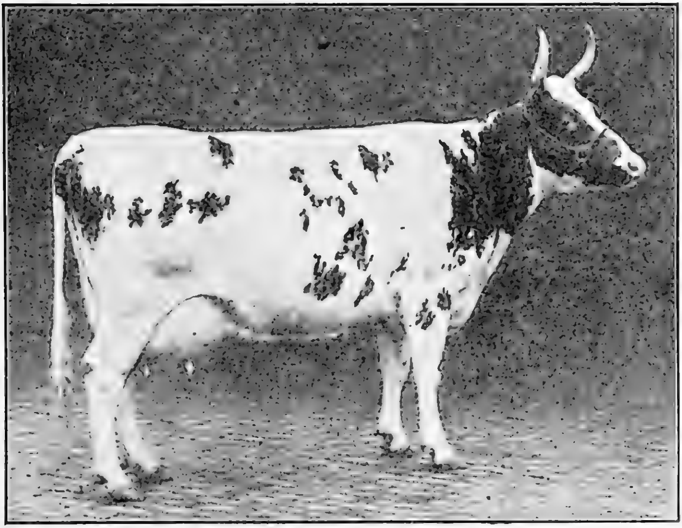


FIG. 87—AYRSHIRE COW "KILNFORD BELL 3D"

Development of the fetus.—From the three primary germ layers are developed the various tissues and organs of the body. This development may be considered as consisting of two fundamental processes, one of specialization, or the adaptation of structure to function, and the other of unequal growth, which results in the formation of the various organs.

In the main, the epiblast and the hypoblast produce the epithelial structures, such as the alimentary canal and its appendages, the glands and their ducts, the respiratory tract, the spinal cord, the brain with its outgrowths, and the like; while from the mesoblast are produced the connective tissue in all its modified forms such as bone, cartilage, lymph, blood, fibrous and areolar tissue, muscular tissue, and the like.

The completeness of the development of the fetus at birth varies widely, and no doubt depends, in part at least, upon the environment of the animal. The rabbit, after four weeks of intra-uterine life, is born very immature, while the guinea pig, after the same duration of intra-uterine existence, is much more completely developed. The young carnivora are born very immature, while those of ruminants and horses are well developed. The rabbit must depend upon flight as a protection against foes, while carnivora must depend upon the chase for food; in either case the animal would suffer a serious disadvantage from increased body weight due to the presence in the uterus of a number of well developed fetuses.

Position of fetus.—The position of the fetus or fetuses in the uterine cavity is determined largely by the form and direction of the cavity. In farm animals the uterine cavity is more or less tubular in form, and normally the long axes of the fetus corresponds with the long axes of the uterine cavity.

At first the circulation is so distributed that more arterial blood reaches the head end of the fetus, which causes the anterior portion to possess greater weight. Since, during early embryonic life, the fetus floats free in the amniotic sack, the greater weight of the anterior portion constantly tends to cause the embryo to rest with its head end lower than the posterior part of the body.

At the beginning of pregnancy, in both single-birthed and twin-bearing animals, the floor of the uterus slopes toward the os uteri. The head end of the fetus, being much the heavier, tends to become directed toward the os uteri. This position of the fetus is also encouraged by the tapering form of the uterus, which is much larger at the os uteri than at the Fallopian tubes. By the time the fetus begins to bear down on the floor of the uterus, it has so enlarged that it cannot turn upon its own axis and thus has become fixed in the uterine cavity so far as changing ends is concerned. In the larger farm animals, therefore, the fetus normally presents the head at the time of birth.

Among multiple-birthed animals, the uterus lies upon the abdominal floor and has much less influence upon the position of the fetuses. Thus we find less uniformity in the presentation of fetuses at birth, although the tendency is for the head to appear first.

Relative size of fetus.—The relation between the size of the fetus and the dam varies with the several classes of farm animals, although within rather narrow limits. In the mare the new-born foal usually weighs from eight to 10 per cent of her body weight. The drain upon the mare in the reproduction of young is very great. She not only carries the fetus a long time, but must nurture the offspring for four to six months after birth. Thus the production of young makes a demand upon her system for practically 18 months.

In the cow there is greater nutritive reserve, and the young is usually larger, as related to the size of the dam, than in the case of the mare, usually weighing about 10 to 12 per cent of the body weight of the dam, although the intrauterine existence is shorter, as is also the period of nursing, which materially decreases the demands upon the system of the dam and favors increased reproductive power.

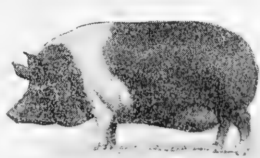


FIG. 88—HAMPSHIRE SOW

In the ewe the relative size of the fetus depends somewhat on the number presented. In the case of single births the fetus weighs from eight to 10 per cent of the body weight of the dam, whereas in the case of twins and triplets their combined weight often runs as high as 12 to 15 per cent of the body weight of the dam. Likewise, in the sow the relative size of the fetuses depends somewhat on the number presented and to some extent on the size of the dam. As a rule, the combined weight of the fetuses runs from seven to 10 per cent that of the dam, although sows usually breed twice annually.

Intra-uterine influences.—There is a widespread tradition that the developing fetus can be influenced through the mental impression or the imagination of the dam. This is especially true in the case of abnormalities and color. Persons with whom the tradition is strong often display a blanket of pleasing color before the eyes of the mare at the time of copulation, in the belief that they can control the color of the foal. Peculiarly marked calves are said to owe their color markings to strong mental impressions created by swine while pasturing with the pregnant dam.

Among humans mental impressions and nervous conditions generally are often invoked to explain birth marks and other abnormalities, such as the loss of a toe, or the presence of two thumbs on the same hand. The same theory is also used to explain abnormalities among animals.

From our consideration of the formation and development of the fetus we know that the supposed assumption on which such claims rest has absolutely no basis in fact. During its development the fetus floats free in the amniotic incasement and is not so intimate with the mother as is popularly supposed. True, it is dependent upon the mother for nourishment, but there is no organic connection or nervous interrelation whatever. Further, if females were so susceptible as this to the surrounding sights, think what a fixture of colors all offspring would possess! Also think what a jumble of deformed offspring would appear, as females are subjected to all sorts of sights and experiences during the many weeks of fetal development, and it would be strange indeed if one out of a thousand escaped contact with some experience sufficiently impressive to "mark" the new born.

Telegony.—This term has reference to the supposed influence of the male upon the female in such a way as to influence future offspring by other sires. It is the same as the influence of previous impregnation, or infection of the germ.

There is a prevailing belief among certain breeders that the influence of the first impregnation is permanent and will affect all future offspring. The claim is made that a female mated with a male of a different breed will never breed pure thereafter. Darwin gave credulence to this belief by reporting a mare bred to a quagga, which resulted in an offspring striped after the manner of the sire. Later the mare bore two colts by stallions, both of which were marked with bars on the shoulders and legs, supposedly showing the effects of the quagga upon the offspring of the stallion. The facts concerning the appearance of bars upon the shoulders and legs are not questioned, but it should be remembered that occasionally such markings appear in young horses of the purest parentage.

Recent investigations by Ewart and others, repeating the same experiment on an extended scale, failed to find trace of the quagga beyond his own offspring. Formerly dog fanciers were strong in their belief in telegony, but experiments show that the influence of the first dog do not extend beyond his own offspring. No doubt this belief gained currency concerning dogs because of their peculiar mating habits, as one can be sure of the sire only in case the bitch is securely isolated. Like intra-uterine influences, telegony has absolutely no basis in fact.

CHAPTER XXV

ABORTION AND PREMATURE BIRTH

By the term abortion is meant the expulsion of the fetus at any period from the date of impregnation until it is sufficiently developed to survive after birth. When a living fetus is expelled prematurely but in a state of development which renders survival possible, it is designated premature birth. These disorders, particularly abortion, are very closely associated with sterility. In fact, many females thought to be sterile actually conceive, but expel their fetuses in such an undeveloped condition that the accident goes unnoticed. Practically the results are the same, but the breeder should make a careful study of his animals, in order to locate those that are aborting so that he may give them proper treatment.

Prevalence of abortion.—While there are no statistics available, yet abortion is far more prevalent than is commonly supposed. Particularly is this true of animals which are closely confined, such as dairy cattle. In the lowering of breeding efficiency among dairy cattle abortion easily takes first place. Its ravages throughout dairy districts exact incalculable toll. Because of the ravages of abortion, it has been estimated that few of the highly bred and closely confined dairy herds exceed 50 per cent of their reproductive capacity. This estimate may be too high, but certain it is infectious abortion works great destruction in large dairy herds. In small herds, however, with two or three heifers being bred each year, the loss is much less and frequently passes unnoticed. Likewise, in herds of mature cows the loss from abortion is ordinarily slight, owing to the fact that infectious abortion is most common in heifers.

Kinds of abortion.—There are two distinct forms of abortion in farm animals which should be clearly understood by all breeders: First, accidental abortion, in which, owing to accident or disease of either the fetus or dam, the fetus may be expelled dead or in such a state of disease as to render it impossible for it to live. Second, infectious abortion, in which an infection of the fetus and its membranes causes the death and expulsion of the fetus, or its expulsion in a living and enfeebled state at any period of pregnancy, without directly inducing material evidence of disease in the mother. Infectious abortion is by far the most troublesome, particularly in animals that are closely confined and highly fed on succulent and artificial foods.

Accidental abortion.—This is produced by any cause operating to disconnect the union of the membranes from the uterus. Thus a pregnant female may abort by reason of almost any cause that very generally disturbs her system, as the influence of too stimulating a diet, or the reverse; the feeding of ergot on rye, the smut of corn or other grains, and iced grasses, as well as large drafts of ice cold water. The more mechanical causes are falls, blows and violent exertion, as in pulling; also traveling on muddy or slippery roads, jumping fences, and the like.

FIG. 89—ABERDEEN ANGUS TRUE TO TYPE

Among dairy cows kept in uncomfortable stanchions, on slippery, wet floors, there may at any time occur a slip or fall which may imperil the life of the fetus. The jamming and jolting suffered by pregnant animals during transportation by rail is liable to bring about injuries which may lead to abortion.

Any disease of the dam may involve the fetus and bring about its death. A miscarriage may leave the organs in so weakened a condition that they cannot retain the fetus, particularly if conception takes place immediately following the miscarriage. Irritation of the vagina is said to cause abortion. Thus instances have been observed where animals thought to be in estrum, although really pregnant, have aborted immediately following copulation.

Fig. 90—Large Yorkshire Boar

It is often difficult to recognize impending abortion, at least until near its completion. Usually the animal aborts before the breeder becomes aware that she is threatened. The first evidence observed is the fact that abortion has taken place, as is shown by the presence of the fetus and membranes. At other times, however, the animal shows more or less of the characteristic signs of parturition (p. 284).

The prevention of accidental abortion is the avoidance of all causes which may have a tendency to produce it. The proper care of breeding and pregnant animals cannot be too forcibly impressed upon the breeder. Pregnant females should be so fed, exercised and groomed as to keep them in the highest possible condition of thrift at all times.

Infectious abortion.—The vast majority of abortions in farm animals is due to infection of the genital organs. Though little understood, infectious abortion is known to be due to a small germ which probably gains access to the uterus during estrum or during parturition. Infectious abortion causes great economic losses among cows and mares and has been observed in ewes and sows. Since the method of infection as well as what is known of the means of control and eradication are similar in all classes of farm animals, and since the disease is more prevalent in cattle, it will be considered from the standpoint of the cow, although the suggestions apply to all farm animals.

Avenue of infection.—The manner in which the infection is carried from one animal to another, as well as the avenue by which the infection reaches the fetus, are very important factors from the standpoint of the control of the disease. The claim is made that the infection not only passes from animal to animal, but that man may carry it from one stable to another. However this may be, no doubt the most important conveyer is the male. A bull after serving a cow possessing the disease is likely to transmit it to all cows with which he subsequently comes in contact.

The chief avenue of infection is the os uteri, and the most favorable time for invasion is thought to be during estrum. As this is the time at which copulation takes place the infection easily passes from the exposed bull into the uterus of the cow. Under favorable conditions, possibly, the uterus may become infected at the time of parturition and inoculate the next fetus, causing abortion. There seems little opportunity for the uterus to become infected at any other time, as the sealed os uteri is no doubt impregnable to contagious abortion germs.

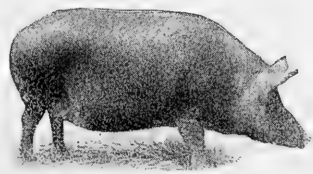


Fig. 91—Tamworth Sow "Oakhill Fancy"

Control of infectious abortion.—There is no sure and reliable method for preventing an animal from becoming infected with contagious abortion, no means of curing a pregnant animal having the infection in her uterine cavity and no means of definitely eradicating the disease. It is stated that carbolic acid, either fed in 4 per cent solution on grain, or given hypodermically in 2 per cent solution acts as a specific against abortion. The same claim is made for methylene blue. This is given in doses of from

10 to 12 grams, preferably in capsules, night and morning early in pregnancy, for seven days, and is repeated at four-week intervals during the period of gestation. No doubt the best methods for combating contagious abortion are precautions against the use of infected bulls, isolation of infected cows, and the free use of disinfectants.

Avoid using infected bulls.—Since the infected bull is thought to be the chief conveyer of the infection, every precaution should be taken to keep the bull free from the infection. As far as possible new cows should not be brought into the herd until known to be free from infection. Further, the bull should not be permitted to serve outside cows.

Isolate infected cows.—The cow that has aborted or shows signs should be removed at once from the stable occupied by other cows and effectively isolated. The section of the stable she occupied should be thoroughly disinfected with a 1 to 1,000 solution of corrosive sublimate. Even with the greatest precaution in this respect, the disease is likely to spread through the stable.

Use disinfectants freely.—Since the infection of contagious abortion is most serious in young heifers, they should receive careful attention to keep them free from infection if possible. It is not known just how early in life the infection of contagious abortion may invade the uterine cavity of the virgin heifer. It seems certain, however, that when once infected the germs lie in wait to cause either sterility or abortion. Dr. Williams, who has made a careful study of infectious abortion in cattle, gives the following advice*:

"The sexual hygiene should begin with the birth of the calf, at least to the extent that it be kept in cleanly surroundings with abundant room.

"Believing that the most favorable date for the invasion of the infection is the period of estrum, the more frequently the virgin heifer is in estrum prior to breeding, the more probable that the infection will have invaded the uterus to cause first, sterility, or

*Dr. W. L. Williams, "Report of the New York State Veterinary College," 1911-12, pp. 107-111.

later, should conception occur, is prepared to cause abortion, premature birth, retained placenta, etc., the breeder should have care that no unnecessary delay occur in breeding. Pending the age and development at which the breeder desires to breed a heifer, it would seem desirable to guard against infection as far as practicable by disinfecting the vagina for three or four days during and immediately following the estrum, while the cervical canal is in a dilated state.

"At present, until more definite knowledge is gained of just how early the infection invades the genital canal of virgin heifers, we advise and urge that vigorous efforts at disinfection of the genital organs of virgin heifers be instituted approximately six weeks prior to the desired date of breeding and continued until conception is assured. That is, when a virgin heifer has advanced to within six weeks of the period when it is desired to breed her, and she is observed to be in estrum, begin special care of the genital organs and continue through the following estrual period until the estrual period when it is intended to breed her, and after breeding continue the disinfection through yet another estrual cycle. If she has conceived from the service, the disinfection during this period has a protective value while the uterine seal is being developed. If she fails to conceive from the first copulation, the continuance of the douching tends to overcome the sterility present and guards against a new invasion of infection.

Admittedly, we cannot entirely disinfect the mucous membrane of the vagina. All we can do is to inject into the vagina a solution of a disinfectant which will not materially irritate the organ. In heifers we cannot ordinarily disinfect the uterine cavity, the cervical canal being so narrow, undilatable, tortuous and irregular that safe penetration is impracticable and we must content ourselves by handling to the best of our ability the available vagina. If infection has preceded our efforts and invaded the uterine cavity, it is beyond the reach of the surgeon and must either be destroyed by the bactericidal power of the organ itself or remain in position to threaten disaster later.

"As in other disinfection work, the selection of a particular agent is not so important as the method of handling the agent selected. It is essential that no great degree of irritation should be caused, since any marked irritation leads to inflammation of the vaginal mucosa, to be followed later by increased infection of the inflamed mucous membrane.

"In our experience we have had the most satisfactory results with Lugol's solution. Next in value have been the soap-containing coal tar disinfectants, especially bacterol The latter has a special value in exterior washing, the soap content materially adding to the cleansing value.

"The highest available type of disinfection calls first for the washing of the vulva, tail, buttocks and surrounding parts with a warm, soapy disinfectant, such as a 1.5 per cent solution of bacterol, which is well borne by cattle.

"After cleansing the exterior, the washing of the vagina with a warm 0.25 per cent to 0.5 per cent of Lugol's solution should follow.

"The mechanism of washing is best and most economically conducted by means of a five-gallon vessel fitted with a metal stopcock near the bottom, over which is slipped a plain pure gum horse stomach tube. The vessel is then elevated and moved along behind the row of cows upon a manure track or a track specially constructed for the purpose. The disinfecting fluid flows by gravity either upon the exterior parts or into the vagina. The pure gum stomach tube is well rounded, even and smooth, so that it is readily pushed into the vagina and is sufficiently elastic to insure against physical injuries to the parts. It is readily cleansed and withstands boiling.

"In washing the vagina the tube should be introduced at least 6 to 8 inches. The mucous membrane of the vagina being disposed in longitudinal folds, a small quantity of fluid or other substance introduced comes in contact with only the summits of the mucous folds and it is therefore essential to good results that the fluid should be allowed to flow freely into the vagina until it is well distended and the mucous folds obliterated, when the fluid is promptly expelled.

"A 0.5 per cent of warm Lugol's solution is well borne, as a rule, daily for one to two weeks, when it begins to irritate the vagina. It then becomes advisable to decrease the strength to 0.25 per cent and reduce the frequency of application to two or three times a week. Care is to be taken in properly measuring the strength of the solution and constant watchfulness exercised that irritation shall not occur. Experimentally we have found that when a heifer is in estrum, the vagina may be freely washed with 0.25 per cent of Lugol's solution one hour prior to copulation without interfering with conception.

"Whenever at all practicable virgin heifers should be bred to a bull which has not copulated with cows nor with other heifers than those which have been handled as above.

"The bull should be handled on parallel lines recommended for the heifers, the same solution sufficing for both sexes. The mechanism of washing the penis and sheath of the bull is analogous to that prescribed for heifers The stomach tube being too large, a pure gum horse catheter is substituted and a small pail of one gallon capacity substituted for the larger pail for cows. The horse catheter being too short, is to be elongated by splicing with another piece of tubing. The vessel containing the fluid is elevated to a height of at least 6 feet, the catheter inserted well into the sheath and the opening of the sheath compressed by the operator's hand until the entire sheath is completely filled and distended, when it is allowed to escape. The bull should be washed both before and after each service in an attempt to guard him alike against infecting and becoming infected.

"When three weeks have elapsed since copulation and estrum does not occur, it may be assumed that the heifer is pregnant, which assumption may be verified by rectal palpation by a veterinarian trained in the work. The uterus is enlarged, elongated, smooth and tense from contained fluid. One horn is distinctly larger than the other (except in twins arising from simultaneous ovulation from both ovaries), and the ovary corresponding to the enlarged horn bears a typical corpus luteum of pregnancy, which may be readily felt.

"Conception having become assured according to the above plan, and having confidence in the efficient guardianship of the placental filter and uterine seal, no further care is required so far as the welfare of the fetus is involved. If the conception has occurred in a clean uterus, a healthy calf will eventually follow; if infection resides in the uterine cavity, and the uterine seal has formed, it is beyond our power to affect its destiny. The pregnant heifer may accordingly be left alone, unless evidences of severe vaginitis or other vaginal disease appears, which may call for special attention.

"If pregnancy proceeds normally, no interference is called for until the date of parturition draws near. At this time the vaginal mucous membrane becomes congested, secretes much mucous and a considerable discharge from the vulva occurs. The uterine seal dissolves as parturition approaches, and the cervical canal becomes open and dilated, offering once more an open and inviting avenue for infection. There again for three to six days one may well renew the washings of the vagina for two reasons. The cleanliness of the vagina lessens the amount of infection present ready to invade the uterine cavity as soon as the uterine seal is destroyed, and even more, immediately after the expulsion of the fetus.

"A second reason of great significance is the danger of infection to the new-born young. Nocard has claimed, and substantiated his claim by strong evidence, that calf scours is due to an infection frequently resident in the vagina and that the calf acquires the fatal infection en route in the vagina, through the freshly ruptured stump of the naval cord. Aside from these, sows and heifers should be kept clean at this time as a part of general cleanliness demanded today in sanitary dairying.

"Should the heifer abort, calve prematurely, or calving at full term suffer from metritis, as expressed by retained placenta or by uterine discharge, immediate and vigorous measures should be taken to restore the uterus to normal conditions at the earliest possible date.

"If the placenta has been retained, its expulsion should be favored as far as possible. Unfortunately, retained placenta is a far more serious condition than most breeders and veterinarians are willing to admit. The mortality is high, much higher today than that of milk fever. It interferes seriously with the milk flow during the ensuing milking period, and in a disastrously large percentage of cases causes obstinate or hopeless sterility. It is a serious infection, commanding the highest veterinary skill and closest attention for its proper handling.

"Behind retained placenta is always metritis, especially placentitis, and the foundation for that in nearly, if not all cases, is the infection of contagious abortion within the uterine cavity. Accordingly, the foundation for retained afterbirth is present before abortion or birth has occurred, and in our judgment, the foundation had been laid for the retention prior to conception, or shortly thereafter, prior to the formation of the uterine seal."

Age immunity in contagious abortion.—While the theory that one or even two abortions immunizes an animal against the infection has no basis in fact, yet the statement that after a heifer has aborted once or twice she is less liable to abort again, is true. Contagious abortion is largely a heifer disease. Thus, the heifer that has aborted twice has advanced two years in age and is that much removed from the most critical period, her first pregnancy, and so is less liable to abort. In this connection it must be remembered that abortion favors sterility, and the animal that has aborted once or twice is less likely to conceive again, and of necessity cannot abort; although should she conceive she is less likely to abort, simply because she is past the critical period. The healthy heifer, however, that has passed through her first and second pregnancy is a far safer breeder in later years than the heifer that has aborted.

CHAPTER XXVI

PREGNANCY AND GESTATION

The terms pregnancy and gestation are synonymous and refer to that period of time during which the young is developing in the uterus of the mother. This period extends from the time of the fertilization of the ovum in the Fallopian tube until the birth of the fetus. The formation of the embryo and development of the fetus was considered in the discussion on conception. We now come to a consideration of the mother. The modifications necessitated by the developing fetus, as well as the ordeal of giving birth, exert a profound influence upon her; and she in turn, is largely responsible for the condition in which the young are born.

Signs of pregnancy.—While there are many signs of pregnancy on which at times we can place more or less reliance, they are all liable to be misleading. Not infrequently an animal presents the general appearance of pregnancy for a long period of time, but later resumes her normal condition without bringing forth young, while in other cases there may be but slight symptoms when, unexpectedly, parturition occurs, to the great surprise of the breeder.

The first sign of pregnancy upon which reliance is placed is the cessation of the periods of heat. As a general rule, fertilization and conception stop the appearance of estrum, which does not recur again during the period of gestation. During this period the female persistently refuses the attention of the male. Such is not uniformly the case, however, as both the mare and cow occasionally show signs of estrum until late in the period of gestation. These females may accept the services of males for months after conception takes place. On the other hand, among all classes of farm animals, there will be found an occasional shy breeder that persistently refuses the attention of the male.

A second sign of pregnancy is the tendency of females to take on fat, which is often very marked during the early stages of gestation. Later the abdomen enlarges, due to the developing fetus, and the pregnant animal becomes very clumsy, and is often incapable of performing certain movements.

A third sign of pregnancy is the development of the milk-secreting organs. In the case of young females with their first pregnancy this begins early in the period of gestation, although among older animals it is not so apparent until later in the period. The development of the mammæ or milk organs is not a sure sign of pregnancy, as in some animals the glands fail to enlarge, and after parturition fail to secrete milk. This is particularly true of old mares which have been bred for the first time. Further, the milk glands may become functional in non-pregnant females, as is frequently observed in the case of young heifers and mare mules.

A fourth and positive sign of pregnancy is the movements of the living fetus. These occur in most, if not all farm animals, but are readily observed in the mare and cow, where the size and strength of the fetus are sufficient to bring about very vigorous movements. Such movements cannot be observed until rather late in the period of pregnancy. While there is no safe and reliable method for inducing the movements, they frequently can be noted while the mother is drinking, particularly in the morning. To make such observations it is not necessary to give ice cold water, as suggested by some persons; in fact, much better results are obtained from water at medium temperature. Further, as stated in the discussion on abortion, disastrous results may follow the giving of ice cold water.

Duration of gestation.—Among farm animals the period of gestation is exceedingly variable. The degree of variability is dependent upon the length of the gestation period. In the rabbit, where the period is approximately 30 days, the variation is slight, rarely exceeding two days, while in the mare, with an average duration of approximately 340 days, the variability is increased to two or three months.

In general, the period of gestation depends on the size of the animal, the larger the animal the longer the period. Thus the period in the mare is more than two and one-half times that of the sow. This, of course, does not apply to the individuals within a given class. The ponderous draft mare requires no longer time than the diminutive pony. The length of the period is somewhat dependent upon the state of development in which the young are born. Thus in the dog the period is slightly more than two months, while in sheep, which in many cases are no larger than dogs, the period of gestation is more than twice as long, although at birth lambs are far more developed than puppies. Further, it is a popular opinion that male offspring require a longer period of gestation, although there is not sufficient evidence to warrant this opinion.

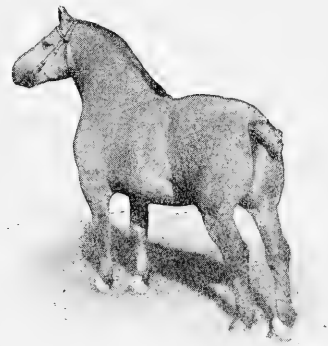


FIG. 92—PERCHERON STALLION "IMPRECATION"

The mare.—The period of gestation in the mare is popularly placed at 11 months, more accurately, perhaps, 340 days, although, as stated, it may vary greatly. Tessier reports 582 cases among mares, with a range of 287 to 419 days, which may be considered the extremes for normal gestation in the mare (pp. 323 to 326).

The cow.—The duration of gestation in the cow is usually placed at nine months, but more accurately, perhaps, 280 days, although it varies widely. Tessier reports 1,131 cases among cows, with a range of 240 to 321 days, which may be considered the extremes for normal pregnancy in the cow (pp. 323 to 326).

The ewe.—The period of gestation among sheep and goats is popularly considered to be five months, more accurately, perhaps, 150 days, although it is variable. Tessier reports 912 ewes, with a range of 146 to 161 days, which may be considered the extreme for normal gestation in the ewe (pp. 323 to 326).

The sow.—Among swine the duration of pregnancy is considered a trifle short of four months, probably about 112 days, although the extremes vary from 109 to 125 days in normal gestation (pp. 323 to 326).

Other animals.—To show the general relation between the size of the animal and the duration of gestation the following tabulation is designed, giving the period of gestation for a number of animals of various sizes:

PERIOD OF GESTATION

Animal	Period	Animal	Period
Elephant	24 months	Sow	4 months
Giraffe	14 months	Beaver	4 months
Buffalo	12 months	Lion	3½ months
Ass	12 months	Dog	2 months
Mare	11 months	Fox and wolf	2 months
Cow	9 months	Cat	50 days
Bear	6 months	Rabbit	30 days
Sheep and goat	5 months	Squirrel and rat	28 days

Poultry.—The period of gestation in egg-laying animals is the same as the period of incubation. The following tabulation is arranged to show the period of incubation in domestic fowls:

PERIOD OF INCUBATION

Animal	Period	Animal	Period
Turkey	26 to 30 days	Geese	27 to 33 days
Guinea	25 to 26 days	Hens	19 to 24 days
Pea hen	28 to 30 days	Pigeons	16 to 20 days
Ducks	25 to 32 days	Canary birds	13 to 14 days

Small breeds hatch earlier than large ones. The average for hens is approximately 21 days, although game bantams hatch at the end of 19 days, while some of the larger breeds require 24 days. Duck eggs hatch earlier under hens than under ducks, probably because of the higher temperature of the hen's body.

Number of young at birth.—Among farm animals there is much variation in the number of young brought forth at a given birth. Domestic animals are grouped into three classes according to the number of fetuses ordinarily produced; the uniparous animals which ordinarily give birth to but a single young at a time, such as the mare and cow; the biparous or twin-bearing animals, such as the goat and some breeds of sheep; and the multiparous animals, which usually give birth to a number of young at a time, such as the sow, dog and other carnivora. The following tabulation shows the approximate number of young brought forth at a given birth among the more important animals:

NUMBER OF YOUNG AT BIRTH

Animal	Number	Animal	Number
Elephant	1	Sow	4-14
Giraffe	1	Beaver	4
Buffalo	1	Lion	2
Ass	1	Dog	4-8
Mare	1	Fox and wolf	4-6
Cow	1	Cat	3-6
Bear	2	Rabbit	4-8
Sheep and goat	1-2-3	Squirrel and rat	3-6

Single-birthed animals occasionally bear twins. All multiple-birthed animals are exceedingly variable in the number of young produced at a time.

Poultry.—The egg-laying animals are also exceedingly variable in the number of eggs produced in a season. Under proper care the hens of the meat type, such as Brahma, Cochin and Langshan, produce from 30 to 60 eggs in a season; those of the general purpose type, such as Plymouth Rock, Wyandotte, Java, Orpington and Rhode Island Red, produce from 75 to 100; while those of the egg type, particularly the Leghorn, average 125 to 150 for entire flocks, with the high individuals running up to 300 eggs in a season. Likewise, turkey hens vary widely in the number of eggs produced, but individuals average from 25 to 40 eggs in a given season. The following tabulation shows the number of eggs in a brood under natural conditions such as when the hen "steals" her nest:

NUMBER OF EGGS IN BROOD

Animal	Number	Animal	Number
Turkey	15-18	Duck	9-12
Hen	15-18	Pea-hen	8-10
Guinea	15-18	Canary	2- 4
Geese	15-18	Pigeon	2

Care of pregnant animals.—In the attempt to favor pregnant animals we often subject them to very adverse conditions. Often pregnant animals are closely confined, fed the most nutritious of foods and denied exercise, particularly in winter, as we are afraid they may slip and injure themselves or their young. Under such conditions these animals take on fat rapidly, they become swollen and stiff and their flesh soft and flabby, all of which serve to increase the difficulties during gestation, but more especially at parturition time.

Pregnant animals should be given much the same care as other animals. This is particularly true as regards exercise. Thus, in the case of the mare, moderate work is not only harmless, but of positive advantage. Of course, she should be protected from rough treatment, as in fact all animals should be at all times. She should not be roughly jostled by the pole of the vehicle; violent pulling should be carefully guarded against; as should also rapid trotting, galloping, jumping, and the like.

Animals well advanced in the period of pregnancy should not be shipped in railway cars. The unsteady movements of the car jostles the animal about more or less violently. When at pasture pregnant animals should be protected against all undue excitement, as chasing by dogs or other animals. Mules and colts are especially meddlesome. It has been suggested that pregnant animals of different classes should not be allowed in the same field, but this applies only in case they are quarrelsome. Of course, swine should be excluded at the time other animals are parturating, as, being omnivorous, they may devour the young, and, in fact, if the dam is exhausted or injured, she too may succumb to the rapacity of the swine.

FIG. 93—BERKSHIRE BOAR "HANDSOME LEE"

The food of pregnant animals should be such as will stimulate growth and development rather than fat production. Thus foods rich in protein and ash, such as oats, bran, clover and alfalfa, are preferred to starchy foods, such as corn and timothy hay. By the use of proper foods the bowels should be kept in good condition and constipation avoided. The feeding of too stimulating a ration or the reverse, as well as the feeding of harmful materials, as ergot on rye, smut of corn or other grains, moldy hay, iced grasses, and the drinking of filthy, stagnant or iced water should be avoided at all times.

Signs of parturition.—Because of the uncertainty of the period of gestation, pregnant animals should be watched closely for a time previous to the expiration of the average period. The limitations given on pages 279 and 280 suggest a good time to begin observations. There are certain signs of the near approach of parturition that rarely fail.

The most conspicuous symptom of the near approach of parturition is the increased functional activity of the milk glands. There is a tendency for these glands to become gradually enlarged, firm and resistant to the touch as the time for parturition approaches. At first they contain a watery secretion, which gradually becomes more milk-like, and later assumes the characteristics of colostrum. Lastly, the teats fill out to the tips and the milk may escape from them in drops. Much reliance is placed on this symptom, as the young is usually born within 24 hours after wax forms at the teats. On the other hand, this is not a positive sign, as the milk may flow for days before the young is born. Occasionally, however, this sign fails, as under certain conditions the milk glands do not develop, at least noticeably, and even more rarely they are excited to functional activity without pregnancy.

A very important symptom of approaching parturition is the relaxation of the muscles passing over the rump, causing a sinking of the croup. This is due to a softening of the muscles, which favors the ease of bearing young. Another sign is the changes which take place in the vulva. The vulva lips become somewhat thickened and stand apart more loosely than ordinarily. In the cow a discharge of ropy mucus is noticeable. Later the animal becomes uneasy, ceases to eat, switches the tail, lies down, then rises again and may moan, indicating that labor has begun.

Some animals become nervous and more or less excited. This is particularly true of ewes. It is not unusual to see her hunting anxiously about for her lamb before it has been born. Just before parturition the sow spends much of her time in collecting material for a nest. When at large in the field she makes a very cozy nest, and in confinement makes such a bed as the material at hand permits.

Preparation for parturition.—Proper precaution should be taken to avoid injury to the young or to the mother from defective stabling or from the presence of other animals. When the weather will permit, the best place for an animal to give birth to young is in an open, grassy paddock, as there is no danger from infection or mechanical injury. This, of course, is impossible in winter and undesirable during the hot summer months when the flies are annoying.

Parturating animals should be provided with a large, well-lighted and well-ventilated box stall, thoroughly clean and freshly bedded, from which all obstructions, such as mangers and feed boxes, have been removed. If convenient, a little air-slaked lime should be scattered about the stall before the bedding is put down. This disinfects the stall and aids in the prevention of infection, which causes a high mortality among new-born farm animals. Some breeders arrange a special box stall, by constructing a false wall, sloping it upward and outward at an angle of 45 degrees and joining the main wall at a height of 4 feet. This sloping wall prevents the mare and cow from injuring the protruding fetus.

The lambing fold should be provided with a number of panels 3 feet high and 4 feet long, so that when two such panels are hinged together and placed in the corner of the barn they make a pen 4 feet square. When the ewe shows signs of lambing she should be placed in one of these pens, thus separating her from the flock and preventing the lamb from straying away, as it is very likely to do if not restrained or confined with its dam. The piggery should be provided with a fender made of a scantling securely fastened, say 8 inches from the floor and the same distance from the walls. The young pigs soon learn to take advantage of the protection furnished by this device, thus avoiding much of the danger of being crushed by the mother when she lies down.

Normal parturition.—As the labor pains come on, the neck of the uterus largely disappears and the os gradually dilates. The water bag passes into the opening, portions of the fetus soon advance into the vagina, and definite labor pains quickly become established. The pain and suffering depend largely upon the class of animals, being severe in the mare and cow, but much less aggravating in the sow. The water bag aids materially in the expulsion of the fetus. It brings equal pressure to bear in dilation of the passages, which not

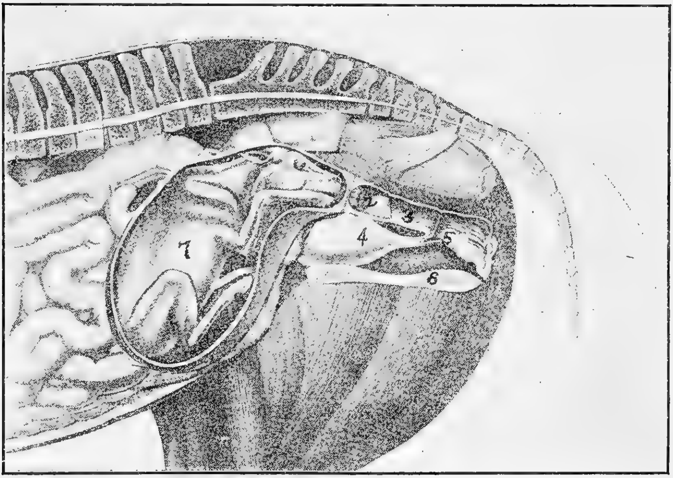


FIG. 94—NORMAL PRESENTATION OF YOUNG AT PARTURITION—

2 Os uteri, 3 Vagina, 4 Bladder, 5 Urethra, 6 Floor of pelvis, 7 The young or fetus in normal position before birth. (Made up from Pilz's Anatomical Manikin of the Horse)

only favors dilation, but no doubt eases the pain. This dilation is also favored by the form of the fetus when normally presented.

Among the larger farm animals, the vast majority of fetuses present the two front feet, followed by the nose. These parts form an elongated cone, which acts as a wedge in gradually dilating the passages. The conditions are essentially the same when the fetus presents the two hind feet, as the legs and thighs serve as a long wedge-like cone. In anterior presentation the head is usually the most difficult, and after it emerges from the vulva the other parts usually pass with comparative ease, although there may be marked resistance as the chest and shoulders enter the passage. In posterior presentation the hips are usually the most difficult.

The time required for normal parturition in farm animals is exceedingly variable. As a rule, it is prolonged in animals with their first birth, as the organs have not previously been dilated. In the mare parturition is rather prompt, but often exceedingly painful, causing sweating. In fact, rapid parturition is essential, as the fetal connections are weak and easily separated, which cuts off the nutritive supply, thus causing the death of the fetus in the case of prolonged parturition. In this respect the cow has a decided advantage over the mare, as the fetal membranes are more strongly attached and not so likely to be disconnected, and may therefore experience prolonged parturition with practically no danger to the young.

In the sow and other multiple-birthed animals, the young usually follow each other rather quickly. A sow may bear 10 or 12 pigs in less than an hour. On the other hand, parturition sometimes becomes extremely tedious and a sow may be a day or more in bearing a litter.

CHAPTER XXVII

AILMENTS OF THE DAM

There are a few diseases that occasionally trouble animals during or immediately following parturition. The breeder should make a careful study of these, not only that he may be able to handle urgent cases, but in order that he may manage his pregnant animals so as to avoid such ailments in so far as it is possible. The suggestions herein given are intended to familiarize the breeder with the nature of the diseases that he may know when to call for the advice of the trained veterinarian.

Difficult parturition.—There are a number of causes of difficult parturition among farm animals. It may be due to a very large fetus, a small passage in the dam, or to some malformation in either the fetus or the dam, as well as to wrong presentation. When an animal has been in intense labor for an hour without progress in delivering the young, an examination should be made to determine the cause of retarded birth. The chances of success are much greater when taken early, before the dam is exhausted from severe straining. If assistance is delayed, the water bag may be ruptured, thus allowing the lubricating fluids to escape and the parts to become dry and swollen.

The operator should be dressed in sleeveless clothing that will not be injured on being soiled. The arms should be rubbed with clean sweet oil, preferably carbolized oil, one part of carbolic acid to 30 parts of oil. This serves to protect both the animal and the operator from infection. The examination can be made much easier if the animal is turned with her head downhill, as the internal organs gravitate forward into the abdomen, thus making more room in which to manipulate the fetus. One of the most frequent abnormal positions is with the head and one foreleg presented but with the other foreleg doubled back. In this case, should the animal be lying down, turn her on the side opposite to that on which the limb is missing, so that there may be more room to arrange the fetus and to bring up the missing member. To avoid losing the parts already in position, double a piece of rope and loop it around the foreleg, and another around the head arranging the rope so as not to injure the young, if still alive; then push the fetus back into the uterus, and bring forward the foreleg that is doubled back, thus securing a normal position.

Fig. 95—Large Yorkshire Sows

No attempt should be made to arrange the fetus during labor pains. After one pain has ceased, then the part may be straightened out before another pain comes on. The operator must be patient and painstaking, remembering that the fetus will not come until in the proper position, and when so arranged it is likely to come fairly easy. If the passages have lost their natural lubricating liquid and become dry, lubricate the interior of the passages and the surfaces of the fetus as far as can be reached with sweet oil.

In assisting the delivery, draw only while the animal is in labor. The natural curvature of both the fetus and the passages are followed and the extraction of the fetus favored by drawing downward toward the hocks as well as backwards. The amount of force that one person can exert is usually sufficient. Avoid injuring the parts, as inflammation and blood poisoning may follow.

Difficult parturition is much more troublesome in the mare than in the cow, ewe or sow. The great length of the limbs and neck of the foal renders it extremely difficult to secure and bring up a missing member which has been turned back. The fetal membranes of the foal are loosely attached to the uterus. The foal becomes separated from its mother at an early stage and rarely survives four hours after the beginning of labor pains.

Wrong presentations.—In addition to normal presentation, the fetus may appear in a number of positions, some of them requiring ingenuity and skill to handle, together

Wrong Presentations of Fetuses*

Anterior presentations	Fore legs	Incompletely extended
		Crossed over neck
		Bent back at the knee
		Bent back from the shoulder
	Head	Bent downward on the neck
		Turned back beneath the breast
		Turned to one side
		Turned upward and backward
	Hind legs	Hind feet turned outward
		Hind feet resting on pelvis
	Transverse	Back of fetus to side of pelvis
	Inverted	Back of fetus to floor of pelvis
Posterior presentations	Hind legs	Bent on itself at the hock
		Bent at the hip
	Transverse	Back of fetus to side of pelvis
	Inverted	Back of fetus to floor of pelvis
Body presentations	With back and loins presented	
	With breast and abdomen presented	

* "Diseases of the Horse," p. 176. Special Report, Bureau of Animal Industry, Department of Agriculture.

with careful study of conditions. When the fetus cannot be secured in any other manner, it is necessary to perform embryotomy, which consists of dismembering the fetus and removing it part at a time. This calls for the services of a trained veterinarian. The tabulation on page 290 gives the more important positions in which wrong presentations may occur.

Eversion of the uterus.—This ailment is frequently observed among cows, and is commonly called "casting the withers." It often follows difficult parturition, the animal continuing to strain until the uterus is forced out and hangs from the vulva. The displaced uterus must be kept scrupulously clean, and carefully sponged with cold water containing a weak solution of carbolic acid. The cold is useful in driving out the blood and reducing the bulk. With the closed fist gradually reinvert the uterus into place. The animal will strain while this is being done, but the uterus must be firmly held in place until the straining is over. A small rope tied tightly around the body just back of the front legs and another just forward of the hind legs will usually allay the straining. The hindquarters should be elevated by raising the rear of the stall some 4 or 5 inches.

The holding of the uterus in place is the next point. Some persons advise taking about four stitches through the lips of the vulva, which are left in for 24 to 36 hours, or until all straining is stopped. Perhaps the safest method is by the use of a rope truss. To make this truss use a long 1-inch rope. Double this rope at its middle and place over the neck of the animal; bring the ends one on either side of the neck, down between the forelegs; then pass back between the hind legs and up to the vulva, tying as necessary, to secure firmly; and then carry the ropes forward along the back and tie into the middle of the rope at the top of the neck.

Retained afterbirth.—Among most farm animals, with the exception of the cow, the afterbirth or placenta comes away when the young animal is born. In the cow, however, it frequently remains attached to the walls of the uterus. This is particularly true after an abortion. When the afterbirth is not removed it decomposes and is discharged as a yellow or reddish fluid, having a disagreeable odor. This discharge is most apparent when the animal endeavors to pass urine. The rear parts become soiled by this discharge, which often contains lumps of decomposing material. The cow presents an unthrifty appearance, loses flesh, and the milk flow is rapidly diminished.

If possible the afterbirth should be removed within 24 or 36 hours after parturition. To do this, a simple method, which is often useful, is to hang a small weight, not to exceed one or two pounds, to the hanging portion of the afterbirth and allow this by its dangling motion as the cow moves along to pull the membranes from their attachments and to stimulate the uterus to expulsive contractions.

Fig. 96—Belgian Stallion "Polo Nord"

If this is ineffective and the afterbirth remains, an attempt should be made to remove the membranes by hand. This should be done within 24 hours after calving. The operator should dress and grease the arms as suggested in difficult parturition. With extreme care the greased arm is introduced and passed on until the places of attachment are reached. The attachments will be found to resemble mushroom-shaped bodies. They should be detached one by one, by passing the thumb between the membrane and the uterus. Should the membranes adhere to the heads of these bodies, under no circumstances tear the membranes loose, as further complications are likely to follow such practice. In removing the placenta extreme care should be taken not to rupture the uterus. After the membrane has been removed disinfect the passages with a weak solution of carbolic acid.

Inflammation of the vagina and uterus.—Simple inflammation of these organs may be the result of bruises, lacerations or other injuries sustained at the time of parturition. It will be shown by swelling of the lips of the vulva, which, together with their lining membrane, become of a dark red hue and the discharge increases and becomes whitish or purulent, and it may be fetid. Slight cases recover spontaneously or under the injections of mild astringents, as a very weak solution of carbolic acid, say one teaspoonful of the acid to a quart of water.

On the other hand, such inflammations, particularly of the uterus, may be of a very serious nature. The general poisoning may extend, so that the inflammation affects the lining membrane of the entire abdominal cavity. Such diseases are known as metritis, and are entirely too complicated for the breeder, calling for the services of the trained veterinarian.

Milk fever.—This disease is also known as parturition apoplexy and parturition fever, though there is usually but very little fever and the temperature is often below normal. This is primarily a dairy cow disease. The best and heaviest milkers are most subject to attack. The disease is more likely to occur when birth has been easy and quick. It usually comes on within two days after calving. The first symptom is uneasiness, the cow is dull, the appetite gone, and the milk secretions lessened or stopped. The eyes possess a vacant stare, she gradually loses control of the hind parts and finally, unable to stand, she falls or lies down. At first she lies with head turned around and nose resting on the flank, but later she may stretch out full on her side. Unconsciousness soon follows, the eyes become glazed, with pupils widely dilated, and often there is a slight moan with the breathing. Relief must follow quickly or the cow will soon expire.

Formerly milk fever was considered extremely serious, but with the air treatment it is seldom fatal. This consists simply of injecting air into the udder and carefully kneading the udder at the same time. There are milk fever outfits on the market with which to force the air into the udder, but if one of these is not near at hand, a very convenient apparatus can be made from a common bicycle air pump and a milk tube. Secure the milk tube to the pump, insert the tube into the teat, and as the air is forced in knead the udder well. Fill each quarter, and in two or three hours milk the air out, rest a few minutes, and pump up again. Make the cow as comfortable as possible and keep her propped up on her brisket, with the head elevated to avoid bloating.

While little is known as to the cause of milk fever, the fact that the air-distended udder gives relief so quickly is significant. The disease seems to be due to absence of pressure in the udder; therefore, to avoid the disease, never milk the high-producing cow dry for some days after calving.

Garget.—This is a congestion of the udder often observed in heavy milkers, before and just after calving. The milk glands are enlarged, hot and tense and the ailment is commonly referred to as caked udder. This congestion usually disappears in two or three days after the secretion of milk has been fully established. This is greatly favored by allowing the calf to run with its dam for a few days, otherwise the congestion must be relieved by drawing the milk frequently by hand. Gently but thoroughly rub the udder.

If the congestion remains, bathe the udder with hot water 15 minutes at a time. After rubbing the udder dry, apply an ointment made by dissolving two tablespoonfuls of gum camphor in a teacupful of melted fresh lard. This may be improved by the addition of one ounce of the fluid extract of belladonna. The udder should be bathed three times daily and the ointment well rubbed in after each bath. If the udder is large and pendulous, support should be given by the use of a wide piece of cloth with holes cut for the teats, and this held in place by arranging a band over the back.

FIG. 97—GROUP OF SWISS TOGGENBURG DOES

Cow pox.—This is a contagious inflammation of the udder, which is usually spread from one cow to another by the hands of the milker. The yield of milk is diminished, the teats become very tender and in two or three days there appear little pealike nodules on the udder. At first these pocks contain yellow pus, which later dries into a yellowish scab. This finally falls, leaving a distinct pit in the skin.

The treatment is to heal the sores and to check the propagation of the germ. This can be done by bathing the udder and teats three times daily with a solution of half an ounce of hyposulphite of soda in a pint of water.

As milking is the chief cause of the persistence of the disease, this should be done as gently as possible.

Mammitis.—This is an inflammation of the udder. It may be due to congestion, to exposure to cold or wet, to injuries of the udder caused by blows or kicks, to insufficient stripping of the udder, and the like. The first observed signs of illness are the swelling, heat, and tenderness of the udder. The inflammation may become so tense as to cause the animal to straddle with the hind legs. When she lies down it is on the unaffected side. The milk flow is suppressed and often replaced by a watery fluid colored with blood. In very bad cases the cow may lose the inflamed quarter.

The treatment varies according to the condition of the animal. If there is only slight inflammation, rub the udder well with camphorated ointment, or a weak iodine ointment. Milk four to six times daily and rub the udder thoroughly each time. The milking must be done with care and gentleness, squeezing the teat instead of pulling and stripping. In case the cow is seen to be shivering, every effort should be made to warm her, by giving warm water in the form of a drench, by warm injections, and by the applications of blankets wrung out of warm water, to the loins. After an hour's sweat, rub dry and cover with a dry blanket.

In case the fever has set in and the inflammation is much more advanced, give a laxative consisting of one to two pounds of epsom salts to which one ounce of ginger has been added. After the purging has ceased this may be followed by daily doses of one ounce of saltpeter. The inflamed quarter should be bathed in warm warter. To do this place a bucket of warm water beneath the udder from which a blanket may be raised and held against the udder, dipping it anew whenever the heat is lost. After this has been continued for an hour, rub the udder dry, then cover with a coating of soap.

Altered milk secretion.—After giving birth, if there is a scant secretion of milk, or if the milk is thin and apparently lacking in fat content, the dam should be fed milk-producing foods, such as bran mashes and alfalfa or clover hay, as these tend to increase the milk flow, improve the quality of the milk up to normal, and have a laxative effect upon the bowels. However, if the udder is swollen and inflamed, such foods should not be given until the inflammation disappears.

Soon after parturition bloody milk is frequently observed. This is often due to a rupture of some of the small blood vessels near the milk cells, or it may be due to an injury or to a diseased condition of the milk glands. The presence of germs in the udder frequently causes blue or bitter as well as slippery and putrid milk. The treatment for such ailments depends upon the cause. When due to a germ it is often necessary to inject a disinfectant into the udder. For this purpose, a solution of boracic acid is used with good results. In simple cases bathing the udder in hot water and frequently milking the glands clean gives good results.

CHAPTER XXVIII

AILMENTS OF THE NEW-BORN

The mortality among new-born animals is very high. It has been estimated that one-fourth of all farm animals born into the world succumb before they are one month of age. Possibly this estimate is too high in the case of foals and lambs, although it is not too great in pigs, or in the case of calves, if the abortions that take place well along in pregnancy be included in the estimate.

In the main, these young animals succumb to diseases that easily can be avoided. The most troublesome of these diseases are due to infection during or immediately after birth. All such troublesome diseases and attendant losses can be avoided if proper sanitation be provided.

Asphyxia.—In retarded parturition, asphyxia is rather common. This is especially true in the case of the foal, where the fetal connection with the uterus is very slight. The placenta may become partially or entirely detached before the fetus is expelled, thus smothering the foal. The navel cord may become tightly compressed between the fetus and the pelvis of the dam in such a manner as to interrupt the circulation. Likewise, the cord may become entangled about one of the limbs or the head of the fetus, and the circulation thus be interrupted, with asphyxia as a result. Sometimes the fetal membranes about the head and nostrils fail to rupture, thus causing partial asphyxia.

In partial asphyxia respiration may be favored by alternately compressing and relaxing the chest with the hands, by vigorously stroking the the chest, and by extending the front legs alternately forward and backward. Suspending animals by the hind legs tends to stimulate respiration and permits the free escape of fluids that may have lodged in the lungs. A sharp blow upon the nose often tends to induce respiration, as does the dashing of cold water upon the skin of the animal.

Constipation.—During the last few days of fetal life there collects in the alimentary tract of the young an excretory debris known as meconium. This material varies in color and consistency, but is usually of a yellowish or greenish hue and appears as a pasty mass, in which condition it is usually promptly expelled without difficulty. In the foal, however, this material is frequently hard and dry, in which condition it is often retained, and leads to further complications, not infrequently causing the death of the young animal. This is especially true of foals whose dams have been confined to the stable, denied exercise, and fed upon dry food during the latter part of pregnancy.

If the alimentary tract has not been cleaned of this meconium within a few hours after birth and the youngster presents the symptoms of illness, standing with the front legs extending forward and the hind legs backward, with back depressed, occasionally looking toward the flank and straining, as if to expel the material, something must be done to stimulate the bowels to action. The colostrum or first milk of the dam is a natural purgative and favors the early passage of the material. The bowels of the foal can usually be stimulated to action by giving internally two ounces of castor oil or four ounces of olive oil, and by an injection of warm water into the bowels. The oil must be given carefully, to avoid strangling the foal. The water used in the injection should have added to it a little glycerine, although some persons prefer the addition of a very little common salt. Inject gently into the rectum with a common hard rub-

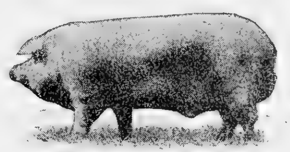


Fig. 98—Chester White Boar

ber syringe, taking care not to rupture the tender membrane. This will soften the meconium, lubricate the passage and stimulate the bowels to action.

Navel infection.—This is another disease common to young foals. It is due to filth germs that gain access to the body of the foal by way of the open umbilical vein of the navel at birth. Soon after these germs enter the navel, they set up irritation and inflammation. The navel becomes enlarged, pus forms and is absorbed into the general circulation. Abscesses form in all parts of the body, notably in the joints of the legs and at the throat and poll. It is comparatively rare that a foal is saved after the disease reaches the pus-forming stage.

The breeder should understand that this disease is due to a simple infection, and that proper hygienic measures will prevent it. The box stall in which the mare foals should be scrupulously clean, well lighted and well ventilated. It should be well bedded with clean, fresh material, preferably straw or shavings. A little lime scattered about the floor before the bedding is put down serves to disinfect and sweeten the stall. Immediately after the foal is delivered the navel should be disinfected with a powder consisting of equal parts of dry or desiccated alum, gum camphor and starch, finely powdered and thoroughly mixed. The navel cord should neither be cut nor tied. If the cord is powdered at intervals of half an hour it will mummify within three hours and all danger from infection will be eliminated.

Diarrhea.—This disease is common among suckling animals. The causes of simple diarrhea are many and varied, although overfeeding as well as too rapid feeding on the part of the young are the most common. The surroundings of the new-born often bring on the disease. Closely crowded, filthy and four-smelling quarters are likely to produce an attack. Young animals kept in the open air where they can obtain sufficient exercise, pure air and sunlight are seldom troubled with diarrhea.

The treatment is to remove the cause, if possible. If the disease is due to an oversupply of milk, the dam should be milked in part by hand, remembering that the last milk is the richer in fat, which is the element causing the disturbance. The dam's ration should be reduced first by one-third, and then by one-half should the large milk flow continue. Avoid all conditions likely to cause such disorders. If the dam is properly fed, exercised and managed, there is very little danger. In treating the young the nature of the disease must be borne in mind, that it is caused by an irritant in the digestive tract, which must be removed before a cure can be effected. The best policy in such disorders is to expel the irritant with a laxative, such as castor oil or linseed oil.

Infectious diarrhea.—This is a serious dysentery common to calves and is often known as white scours. Infectious diarrhea usually appears during the first or second day after birth. It may appear immediately after parturition, and in some instances seemingly exists at the time the young animal is born, and it may perish from the disease without having sucked the dam. The disease is highly contagious, attacking all calves dropped in the same stable. It is caused by a germ, which probably gains admittance to the alimentary tract by way of the nostrils and mouth and through the navel wound. Infectious diarrhea is highly fatal and runs a very acute course.

The symptom is a foul-smelling liquid evacuation, which, at first, is of a yellowish hue, but later changes to a grayish color. At first the liquid is expelled with considerable force, but later the evacuation takes place involuntarily. Sometimes the disease is accompanied by stretching and at other times there are convulsions.

As the disease is highly fatal, chief attention must be given to preventive measures. Before parturition the dam should be placed in a thoroughly disinfected, comfortable box stall. Before she is placed in the stall her posterior parts and udder should be washed with a warm antiseptic, as a two per cent solution of carbolic acid. As soon as the calf is born the navel should be dusted with an antiseptic powder, similar to that of the foal, as suggested in navel infection. The calf should be removed at once to quarters free from previous infection. In drawing the milk and in feeding the calf, every precaution must be taken to avoid infection. The milker should carefully disinfect his hands and the udder. The milk should be drawn and fed in sterile vessels. Likewise, care should be taken that the infection be not carried to the young by other animals, in the bedding or food, or by the caretaker. The stable in which the disease has existed should be thoroughly disinfected with a corrosive sublimate solution.

Sore mouth.—Lambs and pigs are often troubled with contagious sore mouth, which may also affect the teats of their dams. Sores and later scabs form along the edges of the mouth and on the teats of the dam. This prevents proper nursing and interferes with the thrift of the young. In the case of lambs the treatment is to rub off the scabs and wash the parts in undiluted sheep dip. In the case of pigs prepare a solution of permanganate of potash, using one and one-half ounces of the crystals dissolved in one gallon of warm water. Dip the pig headforemost into this solution and hold there a second. This should be repeated for a few days. This disease can be prevented by providing clean comfortable quarters for the youngsters.

Frequently young pigs are troubled with long, sharp teeth. These lacerate the teats of the dam and she will not let the youngster nurse, which interferes with their thrift. The treatment is to cut the sharp points from the teeth with a pair of nippers.

Sore eyes.—Like sore mouth, this is a contagious disease common to lambs. Though it interferes seriously with the thrift of the lambs, it is very easily cured. Sheep dip diluted with 40 parts water used as a wash will work a rapid cure. It is well to see that a little of the diluted dip gets into the eyes. This may start the tears, but it has the desired effect.

Chilled lamb.—Occasionally new-born lambs get separated from their dams and become chilled. This is likely to prove fatal unless they are very thoroughly warmed. A hot bath is the best thing for a chilled lamb. This can conveniently be accomplished by immersing the lamb in water as hot as one can bear the hand. Keep the water hot by adding more to it, taking care not to scald the lamb. When warmed, wipe thoroughly dry with flannel cloth and restore to the dam. A few drops of brandy in warm water is good for a chilled lamb. The lamb should be watched to be sure that it nurses the dam.

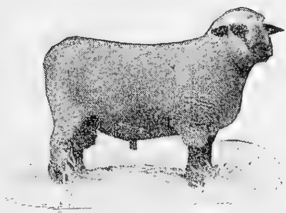


FIG. 99—HAMPSHIRE RAM

Thumps.—This is a digestive trouble common to young pigs, and is due to overfeeding or lack of exercise. The treatment is to compel the pigs to take exercise, and possibly reduce the sow's milk-producing food until the pigs are older. Young pigs may be encouraged to take exercise by arranging a panel, provided with a trap door, across one corner of the pen, thus providing a small triangular pen. On the floor of this small pen scatter a little meal, or provide a trough with a little sweet milk. When the young pigs enter the triangular pen to eat the food thus provided, close the trap door, separating them from their dam. In this manner they may be separated from the dam for three or four hours in the morning and a like period in the evening. When thus separated they will take sufficient exercise to keep them in thrifty condition.

Umbilical hernia.—This is a disease in which the umbilic ring, through which the navel cord passes, fails to close during the development of the fetus. It is rather common in foals and pigs, but may occur among other farm animals. The disease is congenital, though it may not be noticed at the time of birth. The size of the tumor as well as the hernial ring varies greatly. In the pig it ranges from one-half to 2 inches in diameter, while with the foal it ranges from 1 to 6 inches. The causes which operate to prevent the closing of the umbilic ring during fetal development are complicated and the defect is considered hereditary.

Since umbilical hernia usually disappears, at least when not too large, an opportunity should be given for a spontaneous recovery. This is especially true of foals. When the hernial ring is large, it may be necessary to use some means for overcoming the defect, except in the case of animals intended for early slaughter. Before undertaking treatment, however, it is desirable that the young animal shall have acquired some age and considerable vigor.

There are many methods of treatment to overcome umbilical hernia, such as the application of a bandage or truss about the body in such a manner as to press the contents of the tumor up within the abdomen; the application of a mineral acid, thus causing an intense local inflammation with much swelling, which induces closure of the hernial ring, the application of clamps similar to those used in castration; and the application of sutures in such a manner as to encourage closing of the hernial ring. The use of each method calls for the skill of a trained veterinarian.

Fig. 100—Duroc Jersey Boar

Scrotal hernia.—This is a disease similar to umbilical hernia, in which the inguinal ring, through which the testicle cords pass, fails to close during the development of the fetus. It is rather common among foals and pigs. Scrotal or inguinal hernia is primarily a defect of males, although very rarely it exists among females. It is frequently observed among draft bred foals, where it is usually of a temporary character and later disappears. In some instances, however, the inguinal ring is excessively large, so that portions of the viscera protrude through it, and in all such cases some means must be employed for overcoming the defect, animals intended for early slaughter excepted. As in umbilical hernia, treatment calls for the skill of the trained veterinarian.

Castration of males.—Young males not needed for breeding purposes should be castrated early in life, as there is less danger from complications, and the operation can be accomplished with ease. At this age the organs are not mature and the shock to the young animals is much less than if the operation be delayed. Further, if left entire too long, the animal tends to become "staggy" in appearance and will not make as good a feeder as when castration is accomplished at an early age. Thus the colt should be castrated before one year of age, the calf at three or four months, the pig at three or four weeks, and the lamb at 10 days to two weeks of age.

The fact that the male develops stronger features than the female is often taken advantage of by horse breeders, and colts that are rather undeveloped, especially about the head and neck, as well as those that are rather timid in nature, are often left entire six months longer in order that these parts may improve. However, the colt should not be left entire too long, as he may develop vicious habits.

CHAPTER XXIX

DEVELOPMENT OF YOUNG ANIMALS

Possibly no feature connected with animal breeding is of greater importance than the proper development of young stock. While variation is the basis of improvement and selection the key to the situation, yet intelligent selection can be exercised only in case the animals are properly developed. It is as an aid to selection, therefore, that development is of greatest importance. Selection is based in large part on the individuality, and unless the animal has been properly developed estimates of merit will be unreliable. Some inferior animals will be preserved and some superior ones discarded. Intelligent selection, therefore, is possible only when the animal has had a chance to develop those possibilities with which he has been endowed.

There are a number of factors entering into the development of young animals, chief of which are the condition of the parents, proper feeding, sufficient training and judicious management.

Condition of parents.—A lack of proper nutrition on the part of the dam impairs and restricts the development of the fetus. The nourishment of the offspring during its fetal life has just as strong an influence upon its final development as that furnished after it enters upon a separate existence. While careful feeding after birth may compensate, in part at least, for such impaired development, it never can fully atone for the curtailment suffered at the time the fetus was being formed. Further, the dam that is not well nourished during pregnancy usually fails to give a plentiful supply of milk, which also operates to retard development.

To supply the nutrients for the growth of the fetus through the food of the dam calls for a ration rich in protein and mineral matter, as the increase consists mainly of bone, muscle and body tissue. Fat-producing foods do not supply the materials required by the growing young, and should be avoided in making up the ration for the pregnant female. Such foods may lead to serious complications during and immediately following parturition. The proper nutrients would be contained in a ration consisting of oats and bran for the concentrates, and clover and alfalfa for the forage. This may be improved by the addition of a succulent food, such as pasture grass in season, carrots for horses and roots and silage in the case of cows and ewes.

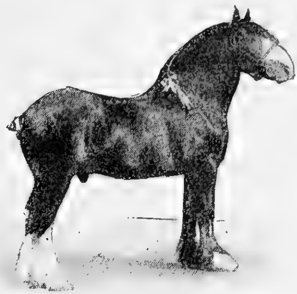


FIG. 101—CLYDESDALE STALLION

Among the smaller farm animals, such as swine and sheep, the relative size of the dam is a controlling factor in determining the birth weight of the young. In the main, large mothers produce large offspring. This is very significant, in view of the fact that lambs and pigs possessing a heavy birth weight develop much more rapidly than those of light birth weight.

Feeding while young.—Growth and development are due to cell division. This cell division is exceedingly rapid during fetal development and immediately following birth, but gradually decreases as the animal attains maturity. *The growing age, therefore, is the age of infancy.* This is a significant fact, which the breeder who would secure maximum development must use to his advantage. Every means should be employed to encourage and promote growth and development while the animal is young. Often the right kind of food is restricted, and before it is realized the period in which growth is possible has passed. In such cases a knowledge of the animal's capabilities is impossible, as no attempt was made to develop them.

At a very early age animals should be encouraged to take food in addition to that furnished by the dam. They will eat only a very little food at first, but the object is to get them accustomed to this supplementary food. As young animals grow they will take the food in increasing quantities. This supplementary feeding has the added advantage that it favors weaning, and the animals will adapt themselves to the changed conditions without loss, providing increasing amounts of food are given.

To supply the nutrients needed by the young animal in securing maximum growth and development calls for a ration rich in protein and mineral matter similar to that suggested for the pregnant dam. A grain ration consisting of equal parts by weight of wheat bran, ground oats and corn meal, to which 10 per cent of linseed oil meal has been added, gives very good results with all classes of

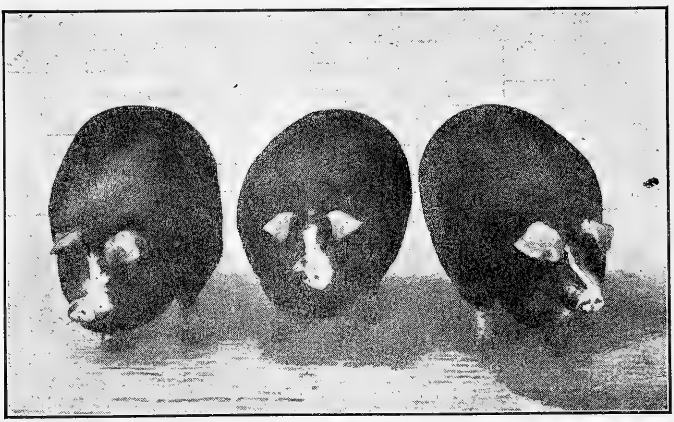


FIG. 102—POLAND-CHINA BARROWS. GRAND CHAMPION PEN

young animals. Since the increase consists mainly of bone and muscle with but little fat, those foods favoring fat formation should be used very sparingly.

Relative development.—In general the weight of the fetus or fetuses of farm animals is approximately one-tenth the weight of the dam. This relative proportion seems to run fairly uniform irrespective of the number of fetuses produced at a single parturition. Thus, in the case of the sow, even though she gives birth to 10 or 12 pigs at a time, their collective birth weight seldom exceeds one-tenth that of the dam. This means that the individuals must be very small, and that development must be exceedingly rapid after birth. No class of farm animals even approximates the pig in rapidity of development. Not infrequently pigs increase their birth weight 150 fold in 9 or 10 months. This is a significant observation in the economic production of meat.

That the age of infancy is the age of growth is well illustrated in the tabulation on this page which shows the

DEVELOPMENT OF FARM ANIMALS

	Horses			Cattle			Sheep			Swine		
Age Mo.	Weight	Gain per mo.	Per cent. gain	Weight	Gain per mo.	Per cent. gain	Weight	Gain per mo.	Per cent gain	Weight	Gain per mo,	Per cent gain
Birth	125			105			9			2½		
1	255	130	104	200	95	90	24	15	166	12	9½	380
2	350	95	37	275	75	37	40	16	66	26	14	116
3	435	85	23	340	65	24	52	12	30	48	22	84
4	515	80	18	400	60	18	62	10	19	78	30	62
5	590	75	14	455	55	14	68	6	10	122	44	56
6	655	65	11	510	55	12	73	5	7	170	48	39
7	715	60	9	570	60	11	78	5	7	222	52	30
8	760	45	6	625	55	9	84	6	7	264	42	18
9	810	50	6	670	50	9	92	8	9	304	40	15
10	850	40	5	725	55	8	100	8	8			
11	890	40	5	770	45	6	107	7	7			
12	925	35	4	820	50	6	114	7	7			
24	1,310	32	3	1,204	32	4	140	2	2			
36	1,660	29	2	1,504	25	2						

average monthly weight, gain and per cent gain from birth to maturity for a representative lot of each class of farm animals.

Note the very rapid growth during the first month in each case, but more especially in the case of swine. This is very significant, for if the individual is neglected at this time its possibilities will remain forever unknown. At six months of age sheep and swine have attained approximately one-half of the normal mature weight. At one year of age horses and cattle that have been well managed will have attained about one-half of their mature weight. Sheep usually reach maturity at less than two years of age, while horses and cattle continue to develop until approximately five years of age.

Developing the young horse.—The methods employed by professional horse trainers in developing trotters and high-acting coach horses indicate the advantage to be gained by suitable training while the animals are young. From birth the foals are fed regularly up to the limit of their appetite in order to keep them strong. If properly groomed and exercised, it is not possible to get a foal too fat. To facilitate early training a small track, similar to a race track, is provided. On this track the foals are exercised as soon in life as they can handle themselves to advantage. At first the youngsters run free and are controlled by attendants provided with whips, to which are attached long lashes; later they are led and finally driven with the single line. This exercise is continued daily from colthood until old enough to put in

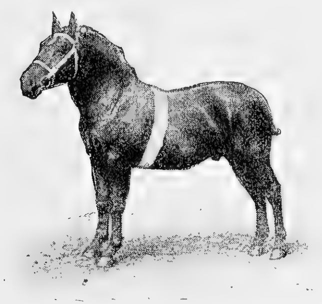


FIG. 103—PERCHERON COLT "MERLIN"
1600 pounds at 2 years of age

harness, with the exception of two or three days each month, when the youngsters are turned to a paddock where they can have perfect freedom, in order to break the monotony of the daily exercise and to freshen them. They are then placed in harness and the daily training continued. Horsemen feel that such continuous training is necessary to develop maximum speed, style and action.

The same principle holds true in the development of draft foals. To encourage growth they should be fed liberally on nutritious foods from birth to maturity, and to promote the development of quality they should be regularly exercised and thoroughly groomed. The breeder who wishes to secure maximum growth and highest quality should remember that it is scarcely possible to overfeed colts, providing, of course, that judicious management accompanies such feeding.

Developing the heifer.—The young heifer that is to remain in the dairy herd should be given extra care from birth, in order that she be well grown by the time she is sexually mature. To develop a high-producing cow it is important that she be bred at an early age, and this can be done to advantage only in case she is well grown. The claim is made by some persons that the demands made on the young heifer by the growing fetus, together with her own growth, are too severe, and that she is likely to be stunted. On the other hand, experience indicates that the constant recurring periods of estrum checks growth and that the condition of pregnancy has a stimulating effect. The assimilation seems to be improved, and if the heifer be supplied with an abundance of nutritious food she will make a greater growth during pregnancy than otherwise.

The breeding of a well-grown heifer at 15 months of age has much to commend it. In the first place, unbred heifers are in estrum two or three days every three weeks, and it is at such times that the reproductive organs are likely to become infected with the germ of contagious abortion, which may cause sterility, or, in case the heifer conceives, it may produce abortion. Thus, the animal bred early in life is likely to escape this infection and prove a regular breeder. In the second place, it is possible to develop the milk-secreting organs of a heifer much more perfectly than of an older animal.

The secreting of milk is a kind of habit, and the earlier in life the young heifer becomes accustomed to it the better producer she will make. Once giving milk, she should be kept at it as long as possible. The cow that dries off after secreting milk a few months is unprofitable. The heifer should not be bred a second time until rather late, as the effect of again becoming pregnant has a tendency to decrease the flow of milk. During this first lactation the object is to keep her in milk as long as possible, in order to develop a persistent milker, rather than to encourage a high production for a short time and then dry her off, as is the usual practice.

Developing meat-producing animals.—This calls for special consideration because of the seemingly conflicting factors involved. In the development of meat-producing animals early maturity is exceedingly important, because the relative rapidity of gains decreases, and the amount of food required to produce a pound of body weight rapidly increases, as the birth period is receded from, until at length a period is reached, after which further gains become impossible. Thus the age of infancy is not only the age of growth, *but it is also the age of economic meat production.*

Early maturity, however, may reduce the constitutional vigor of the animal, thus defeating the object for which it was developed. In the main, when early maturity does affect the constitutional vigor, it is due to the undermining influence of breeding from immature animals, as well as to the extreme artificial conditions which frequently attend such breeding. Thus, in order to avoid much of the adverse effect of early maturity upon the general vigor and thrift of the animal, we have but to refrain from using immature animals in breeding. Further, mature dams favor the rapid development of young in three important respects. In the first place, a mature dam usually provides a more bountiful supply of milk; second, as we have already observed, the larger the dam the larger the offspring at birth; and, third, the larger the birth weight the more rapid and economic gains the young will make, other conditions being equal.

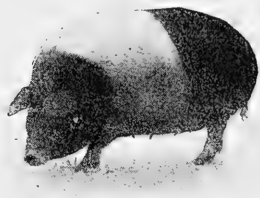


Fig. 104—Hampshire Sow
Wide belt

Inasmuch as the tendency to early maturity is hereditary, the promising females should be tried out at as early an age as possible, even though this practice may operate slightly against the development of the first born. However, once a desirable female is found, she should be retained as long as she continues to do well in the breeding herd.

As suggested, the young animals that are intended for meat production should be encouraged from birth. Early gains are the most economic. The young animal that is permitted to lose its body fat will not make as efficient a meat producer as it otherwise would had it been properly encouraged from birth until ready for slaughter.

Environment, development, selection and efficiency.—Among farm animals development is largely a matter of possibilities. Individual excellence of parents, as well as the purity of the heritage, count for little in the absence of suitable environment. The modern breeds of farm animals have been evolved, in a large measure, by improved methods of care and management. Their superiority cannot assert itself in the absence of the accustomed environment. Therefore, to secure maximum development in farm animals, both young and old, the management must be as favorable as possible to advance all of the potentialities of the individual.

Unless all of the possibilities within the individual have been properly developed, intelligent selection is not possible. Some inferior animals will be retained for breeding and some superior individuals will be eliminated. Farm animals have been improved by continuous selection as well as by better methods of care and management. To secure the maximum advantage of selection, therefore, the conditions must be such as to advance the possibilities that have been intensified through generations of careful selection.

The efficiency of the individuals in hand depends upon vigorous selection based on maximum development of all the potentialities with which the individual has been endowed. Further, selection under such conditions purifies the strain, family, or breed by the elimination of all individuals not possessing the desirable characters.

Thus, the relation between the environment and development, the relation between the development and intelligent selection, as well as the relation between intelligent selection and the general excellence of the individuals in hand, must be clearly evident to the breeder of farm animals. For, in the main, the environment controls the development, the development directs selection, and selection governs individual efficiency and purifies the strains, families and breeds of our farm animals.

APPENDIX

APPENDIX

Breeds of farm animals.—For the benefit of the reader who may wish to obtain detail information concerning a particular breed, the following tabulation is arranged, giving the type, name of the breed, native home, size and common color for each breed; as well as the name and address of the secretary in charge of the breeders' association, who may be addressed for detailed information:

Breeds of Light Type of Horses

Name of breed	Native home	Height, hands; weight, pounds	Color	Secretary	Address
Arabian	Arabia	14 -14½ 800 -1,000	Bay, white	Henry K. Bush-Brown	Newburg, N. Y.
Thoroughbred	England	14 -16½ 800 -1,050	Bay, brown,	W. H. Rowe	5th Ave. and 46th St., New York, N. Y.
American Saddler	United States	15-1½ -15-2½ 950 -1,050	Bay, brown, black	I. N. Ball	Louisville, Ky.
Standardbred	United States	15¼ -15¾ 900 -1,150	Bay, brown, black	W. H. Knight	355 Dearborn St., Chicago, Ill.
Orloff Trotter	Russia	15¾ -16¼ 1,100 -1,300	Gray, bay, black		
Morgan	United States	14¾ -15¾ 900 -1,150	Bay, chestnut	T. E. Boyce	Middlebury, Vt.

Breeds of Coach Type of Horses

Name of breed	Native home	Height, hands; weight, pounds	Color	Secretary	Address
Hackney	England	15½ -15¾ 1,000 -1,200	Chestnut	Gurney C. Gue	308 W. 97th St., New York, N. Y.
French Coach	France	15 -16 1,200 -1,350	Bay, brown, chestnut	Duncan E. Willit	Oak Park, Ill.
German Coach	Germany	16 -16½ 1,350 -1,450	Black, brown, chestnut	J. Crouch	Lafayette, Ind.
Cleveland Bay	England	16 -16¾ 1,200 -1,550	Bay	R. P. Stericker	Oconomowoc, Wis.

Breeds of Draft Type of Horses

Name of breed	Native home	Height, hands; weight, pounds	Color	Secretary	Address
Percheron	France	15½ -17 1,800 -2,300	Black, gray	Wayne Dinsmore	Union Stock Yards Chicago, Ill.
French Draft	France	15½ -17 1,800 -2,300	Black, gray	C. E. Stubbs	Fairfield, Iowa
Clydesdale	Scotland	16 -16½ 1,800 -2,300	Light bay	R. B. Ogilvie	Union Stock Yards Chicago, Ill.
Shire	England	16 -17 1,800 -2,300	Light bay	Charles Burgess	Wenona, Ill.
Belgian	Belgium	16 -17 1,600 -2,300	Bay, black, brown	J. D. Conner, Jr.	Wabash, Ind.
Suffolk	England	16 -17 1,600 -2,000	Chestnut, bay	Alex. Galbraith	Janesville, Wis.

Breeds of Ponies

Name of breed	Native home	Height, inches; weight, pounds	Color	Secretary	Address
Shetland	Shetland Islands	34 - 44 250 - 400	Black, brown, piebald	Miss Julia M. Wade	Lafayette, Ind.
Welsh	Wales	48 - 56 400 - 600	Brown, gray	John Alexander	Aurora, Ill.
Exmoor	Devonshire	48 - 56 500 - 800	Bay, gray		
Arabian	Arabia	Under 56 600 - 800	Bay, white	Henry K. Bush-Brown	Newburg, N. Y
Hackney	England	Under 56 600 - 800	Chestnut	Gurney C. Gue	308 W. 97th St. New York, N. Y.
Mexican*	Mexico	Under 56 600 - 850	Duns, mixed		
Indian*	Western United States	Under 56	Duns, bays, mixed		

*Not recognized as a breed.

Breeds of Jacks

Name of breed	Native home	Height, hands;	Color	Secretary	Address
Andalusian	Andalusia, Spain	14½ - 15½	Gray		
Maltese	Malta Islands	14 - 14½	Brown, black		
Catalonian	Catalonia, Spain	14½ - 15½	Black brown	C. F. Cook	Lexington, Ky
Majorca	Majorca Islands	15 - 16	Black		
Italian	Italy	13 - 14	Blue, black		
Poitou	France	14½ - 15	Black		

Major Breeds of Dairy Cattle

Name of breed	Native home	Weight	Color	Secretary	Address
Jerseys	Jersey Islands	800 - 1,200	Fawnlike	R. M. Gow	324 W. 23d St., New York, N. Y.
Holstein-Friesian	Holland	1,400 - 2,000	Black and white	Fred L. Houghton	Brattleboro, Vt.
Guernseys	Guernsey Islands	1,000 - 1,500	Yellow fawn	Wm. H. Caldwell	Peterboro, N. H
Ayrshires	Scotland	1,000 - 1,400	Red, white	C. M. Winslow	Brandon, Vt.

Minor Breeds of Dairy Cattle

Name of breed	Native home	Weight	Color	Secretary	Address
Dutch Belted	Holland	1,100 - 1,700	Black, white belt	G. G. Gibbs	Marksboro, N. J.
Brown Swiss	Switzerland	1,200 - 1,600	Brown	Ira Inman	Beloit, Wis.
French Canadian	Canada	800 - 1,000	Black		
Kerry	Ireland	600 - 900	Black, red		

Major Breeds of Beef Cattle

Name of breed	Native home	Weight	Color	Secretary	Address
Shorthorn	England	1,400 - 2,000	Red, white roan	John W. Groves	Chicago, Ill.
Hereford	England	1,400 - 2,000	Red and white	R. J. Kinzer	Kansas City, Mo.
Aberdeen Angus	Scotland	1,400 - 1,800	Black	Chas. Gray	17 Exchange Ave., Chicago, Ill.
Galloway	Scotland	1,200 - 1,800	Black	Robt. W. Brown	17 Exchange Ave., Chicago, Ill.

Minor Breeds of Beef Cattle

Name of breed	Native home	Weight	Color	Secretary	Address
Polled Durham	England	1,400 - 2,000	Red, white, roan	J. M. Martz	Greenville, Ohio
Devon	England	1,200 - 1,800	Red	L. P. Sisson	Newark, Ohio
Red Polled	England	1,200 - 1,800	Red	H. A. Martin	Gotham, Wis.
Sussex	England	1,200 - 1,800	Red		
West Highland	Scotland	900 - 1,200	Red, black		

Fine-Wool Breeds of Sheep

Name of breed	Native home	Color of Points	Weight,	Secretary	Address
American Merino	United States	White	100 - 150	Wesley Bishop	Delaware, Ohio
Delaine Merino	United States	White	100 - 150	J. B. Johnson	248 West Pike St., Canonsburg, Pa.
Rambouillet	France	White	150 - 185	Dwight Lincoln	Milford Center, Ohio

Mutton Breeds of Sheep

Name of breed	Native home	Color of Points	Weight	Secretary	Address
Southdown	England	Gray	125 - 175	Frank S. Springer	Springfield, Ill.
Shropshire	England	Dark brown	155 - 225	Miss Julia M. Wade	Lafayette, Ind.
Hampshire	England	Dark brown	180 - 250	Comfort A. Tyler	310 East Chicago St., Coldwater, Mich.
Suffolk Down	England	Black	180 - 240		
Oxford Down	England	Brown	200 - 325	W. A. Shafor	Hamilton, Ohio
Dorset	England	White	150 - 225	Joseph E. Wing	Mechanicsburg, Ohio
Cheviot	Scotland England	White	150 - 225	F. E. Dawley	Fayetteville, N. Y.

Long wool breeds of sheep, see next page.

Pure Lard Breeds of Swine

Name of breed	Native home	Size	Color	Secretary	Address
Poland China	United States	Medium	Black	W.M.McFadden*	Union Stock Yards, Chicago, Ill.
Berkshire	England	Medium	Black	Frank S. Springer	510 E. Monroe St., Springfield, Ill.
Duroc-Jersey	United States	Medium	Red	J. R. Pfander†	Peoria, Ill.
Chester White	United States	Large	White	J. C. Hiles	Cleveland, Ohio
Hampshire	America	Medium	Black, belt	E. C. Stone	Armstrong, Ill.
Essex	England	Small	Black	F. M. Strout	McLean, Ill.
Small Yorkshire	England	Small	White	Harry G. Krum	White Bear Lake, Minn.
Suffolk	England	Small	White		

*A. M. Brown, Winchester, Ind.
*G. F. Woodworth, Maryville, Mo.
†T. P. Pearson, Thorntown, Ind.

Long-Wool Breeds of Sheep

Name of breed	Native home	Color of Points	Weight	Secretary	Address
Leicester	England	White	180 - 240	A. J. Temple	Cameron, Ill.
Cotswold	England	White, spotted	200 - 265	F. W Harding	Waukesha, Wis.
Lincoln	England	White, mottled	275 - 350	Bert Smith	Charlotte, Mich.
Blackfaced Highland	Scotland	Black			

Intermediate Breeds of Swine

Name of breed	Native home	Size	Color	Secretary	Address
Cheshire	United States	Medium	White	Ed. S. Hill	Freeville, N. Y.
Victoria	United States	Medium	White		
Middle Yorkshire	England	Medium	White		

Pure-Bacon Breeds of Swine

Name of breed	Native home	Size	Color	Secretary	Address
Large Yorkshire	England	Large	White	Harry G. Krum	White Bear Lake, Minn.
Tamworth	England	Large	Red	E. N. Ball	Ann Arbor, Mich.

Egg-Laying Breeds of Fowls

Name of breed	Native home	Number of varieties	Weight, pounds	
			Male	Female
Leghorn	Italy	8		
Minorcas	Minorca Islands	3	8 - 9	$6\frac{1}{2}$ - $7\frac{1}{2}$
Andalusian	Andalusia, Spain	1	6	5
Spanish	Spain	1	8	$6\frac{1}{2}$
Red Cap	England	1	$7\frac{1}{2}$	6
Hamburg	Holland	6		

Meat-Producing Breeds of Fowls

Name of breed	Native home	Number of varieties	Weight, pounds	
			Male	Female
Brahma	Asia	2	11 - 12	8½ - 9½
Cochin	China	4	11	9½
Langshan	China	2	9½	7½

General-Purpose Breeds of Fowls

Name of breed	Native home	Number of varieties	Weight, pounds	
			Male	Female
Plymouth Rock	United States	6	9½	7½
Wyandotte	United States	8	8½	6½
Java	United States	2	9½	7½
Dominique	United States	1	8	6
Rhode Island Red	United States	2	8½	6½
Orpington	England	3	10	8
Dorking	England	3	7½ - 9	6 - 7
Houdan	France	1	7	6

Gestation period for farm animals.—For ready reference the following tabulation is arranged, giving the date of service and the date of parturition for the mare, cow, ewe and sow. This provides for a gestation period of 340 days for the mare, 280 for the cow, 150 for the ewe and 112 days for the sow. The rows of figures between the lines give the date of service. Directly below is given a corresponding row of birth dates for each class of animal. Thus a mare bred on January 1 will be due to foal December 6; a cow bred February 1 will be due November 7; a ewe bred November 1 will be due March 30; and a sow bred December 1 will be due March 22. Of course, these figures are only approximately correct, as the period of gestation is exceedingly variable (pp. 279 and 280).

Gestation Period Among Animals

	Jan.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Mare	Dec.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	Jan.
Cow	Oct.	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	Nov.
Ewe	May	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	June
Sow	Apr.	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	May

	Feb.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29			
Mare	Jan.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3			Feb.
Cow	Nov.	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5			Dec.
Ewe	June	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28			July
Sow	May	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21			June

	Mch.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Mare	Feb.	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	Mch.
Cow	Dec.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	Jan.
Ewe	July	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Aug.
Sow	June	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	July

	Apr.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Mare	Mch.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	Apr.
Cow	Jan.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	Feb.
Ewe	Aug.	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Sept.
Sow	July	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Aug.

	May	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Mare	Apr.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	May
Cow	Feb.	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	Mch.
Ewe	Sept.	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Oct.
Sow	Aug.	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Sept.

	June	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Mare	May	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	June
Cow	Mch.	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	Apr.
Ewe	Oct.	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Nov.
Sow	Sept.	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Oct.

	July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Mare	June	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	July
Cow	Apr.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	May
Ewe	Nov.	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Dec.
Sow	Oct.	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Nov.

	Aug.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Mare	July	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	Aug.
Cow	May	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	June
Ewe	Dec.	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Jan.
Sow	Nov.	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Dec.

	Sept.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Mare	Aug.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	Sept.
Cow	June	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	July
Ewe	Jan.	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Feb.
Sow	Dec.	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Jan.

Gestation Period Among Animals—*Continued*

	Oct.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Mare	Sept.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	Oct.
Cow	July	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	Aug.
Ewe	Feb.	27	28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Mch.
Sow	Jan.	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feb.

	Nov.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Mare	Oct.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	Nov.
Cow	Aug.	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	Sept.
Ewe	Mch.	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Apr.
Sow	Feb.	20	21	22	23	24	25	26	27	28	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Mch.

	Dec.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Mare	Nov.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	Dec.
Cow	Sept.	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	Oct.
Ewe	Apr.	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	May
Sow	Mch.	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Apr.

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