

BREEDING AND IMPROVEMENT OF FARM ANIMALS

Eighth Edition

**J. E. LEGATES
EVERETT J. WARWICK**

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BREEDING AND IMPROVEMENT OF FARM ANIMALS

EIGHTH EDITION

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PREFACE

Professor Rice began “Breeding and Improvement of Farm Animals” in 1928. Six decades later we are pleased to continue the eighth edition of his popular undergraduate classroom text. Both the knowledge and substance of animal breeding have changed markedly since the first edition. In the eighth edition the authors have focused on principles but hopefully have suggested sufficient examples to show where these principles can find application.

Students undertaking a study of animal breeding represent so many different backgrounds that it is not possible to fashion a text that will optimally match their prior preparation. It has been assumed that most students will have had previous instruction in genetics and reproductive physiology. Since this assumption will not be true for all students, Chapter 2 is intended to provide an update and review of genetic background and principles. Students without a previous course in genetics should, with careful study, gain sufficient undergirding for understanding the subsequent chapters. Chapter 3 has been revised and much reduced to focus primarily on the important function of reproduction in the generational transfer of inheritance.

Chapter 4 on qualitative genetics covers concerns with various polymorphisms and undesirable recessives which are frequently a matter of interest and question. While not considered a major thrust, they are deserving of consideration to provide a balanced view of animal breeding.

It is difficult to chart a course that is acceptable by all when the integration of genetics, mathematics, and statistics is sought. We have attempted to chart a middle road. Chapters 5 and 6 are intended to provide a beginning appreciation. Rigorous proofs are not provided; although, it is hoped that certain of the appendixes will provide stimulus to students with a mathematical bent. Those without such interest should be able to gain a working comprehension of the subject matter, even without an intricate understanding of these developments.

The next six chapters dealing with selection, mating systems, and performance and progeny evaluation are intended to give the student a feeling for what can be expected from the application of animal breeding in the changing of populations. Although these chapters are devoted to the genetic aspects of improvement, it is hoped that the student will sense the underlying concept that progress and profits come from a balanced consideration of genetic, environmental, and economic considerations.

In a book of this nature it is not possible to recognize all persons who have contributed in one way or another. However, we must mention the following reviewers: David S. Buchanan, Oklahoma State University; Richard R. Frahm, Virginia Polytechnic Institute and State University; Truman G. Martin, Purdue University; Robert R. Shrode, University of Tennessee; and Charles W. Young, University of Minnesota. We know that we could not have prepared this book without the assistance and encouragement of many colleagues and friends. Their advice and counsel have assuredly been responsible for many improvements in this edition, although the authors accept the responsibility for any shortcomings. Many individuals and organizations have graciously provided illustrative materials for which we are much indebted.

Our present effort could not have been accomplished without the encouragement and support of our wives. We extend to them a special measure of gratitude.

J. E. Legates

Everett J. Warwick

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ANIMAL BREEDING: FOUNDATIONS AND CONTRIBUTIONS

The primary goals of humans since their emergence on earth has been to secure sufficient food to satisfy hunger and nutritional needs. During early times food was obtained by hunting and fishing and by gathering the fruit and seed of plants in their natural habitat. Sufficient area was roamed near critical sources of water to provide the needed food and the hide or fur for clothing. Truly, the human was “a hungry animal in search of food.”

Much of human success in improving the quality of life can be attributed to the animals that have provided food, clothing, and power. Animal agriculture is a most advanced and specialized form of agriculture. Historically, the leading nations and societies have had well-developed livestock enterprise for their times. Three-fourths of the protein, one-third of the energy, most of the calcium and phosphorus, and a substantial share of essential vitamins and other minerals in the American diet come from animal products.

Animal agriculture has been supportive of the conservation and fullest utilization of our natural resources for the human good. It contributes to maintaining the delicate balance of nature. It provides an opportunity for the addition of increments of value in three ways. First, from the production of feed grains, by-products, and forages, a direct contribution from the land and related natural resources is realized. Second, by processing feed grains, by-products, and other feedstuffs through our animals, an additional increment of value is added in refining these raw materials. A third increment of value to society is added by the processing of our animals and animal products for distribution and utilization by the consumer.

DOMESTICATION OF ANIMALS

With the domestication of animals and plants the early nomadic tribal life gradually evolved to a more stationary culture as domestication and cultivation

progressed. These developments have been of reasonably recent origin. Most records and archaeological evidence suggest that the domestication of animals, with the possible exception of the dog, began approximately 10,000 years ago. Prior to domestication, natural selection chose those individuals which were best adapted for survival and reproduction. Those types which survived most effectively reproduced more abundantly and dominated the local or environmental niches available to them.

The domestication of animals and plants provided the foundation on which civilization could be built. Without a productive agriculture it seems reasonable to conclude that social and scientific progress would have been extremely limited. Domestication very likely began at the end of the New Stone Age. Each domestic animal has had a rather restricted and humble origin, yet through constant selection for one or another character numerous forms have evolved—some useful, some ornamental, some having both qualities, and some neither.

The Horse

The name *horse* is equivalent to the Anglo-Saxon *hors*, which means "swiftness," and it is logical to suppose that this genus was able to survive the vicissitudes of time and enemy attack chiefly because of its speed.

The horse was probably the last animal to be domesticated, but its immediate ancestry as well as the date of its domestication is still a matter of dispute. It seems probable that at least two, or perhaps three, wild types have made their contribution to our domestic horse. One of these was probably the *steppe horse*, now known as the fossil representative of Przhevalski's horse. This was a small, sturdy, short-legged horse with a moderately long, heavy head. Another was the so-called *desert horse*, standing, as did the *steppe horse*, about 13 hands, or 130 centimeters (cm), high and corresponding closely to the now-extinct tarpan, or Mongolian horse. This strain was somewhat more slender than the steppe horse and had a shorter head. The third contribution was that of the *forest horse*, a type standing about 15 hands (150 cm) high with longer but stout limbs and having a long, narrow head and long body. It seems probable that all three types made a contribution to our modern breeds. The horse was apparently domesticated separately in Asia and Europe, probably earlier in Asia. A Turanian folk tamed the Przhevalski horse around 3000 B.C.

The earliest record of the horse dates back to Paleolithic times, about 25,000 years ago. Around an open camp at Soultré in France are found the remains of several thousand horses, indicating that horses may have served as a source of food. In later Paleolithic times, rock carvings of the horse were made, but they do not show it harnessed, ridden, or attached to any sort of vehicle; so we assume the horse was not yet fully domesticated.

The earliest trace of the horse hitched to a chariot goes back to about 2000 B.C. in Greece, whereas the first Egyptian records of the domestication of the horse date from about 1600 B.C. These were small horses, about 13 hands high,

similar to Przhevalski's horse. The horse evidently grew in size and importance in Persia and Mesopotamia during the intervening years, and after about 750 B.C. it began to serve as a mount. Mounted riders were first given a place in the Olympian games in 648 B.C. The Arabs did not use horses until after the time of Christ.

The ancestry of the horse has been traced back about 55 million years by means of skeletons found in descending layers of the earth's crust. The forerunner of our present horse was an animal about 25- to 50-cm tall with four toes on the front feet and three on the back. Twenty million years later this horse stood about 60- to 65-cm tall and had three toes fore and back. It has since been reduced to but one toe (with two splits), but the overall size of the horse has increased, and its teeth have developed into more efficient tools for grinding feed.

Cattle

It seems probable that cattle were domesticated during the New Stone Age in both Europe and Asia. There are two types of domestic cattle: *Bos indicus*, the humped cattle of tropical countries, and *Bos taurus*, the cattle of the more temperate zones. Humped cattle were domesticated as early as 2100 B.C. Cattle played an important part in Greek mythology; they were sacred animals in many older civilizations, and their slaughter was therefore forbidden. The great ox, or aurochs, *Bos primigenius*, which Caesar mentioned in his writings, is generally considered to be one of the progenitors of our modern-day breeds. This was a very large animal, described by Caesar as "approaching the elephant in size but presenting the figure of a bull." The wild park cattle of Britain are considered by some authorities to be the direct descendants of *B. primigenius*. Another progenitor of our modern breeds is *Bos longifrons*, a smaller type, with a somewhat dishlike face. This is the Celtic Shorthorn, which has been found only in a state of domestication. It was the only ox in the British Isles until 500 A.D. when the Anglo-Saxons came and brought the great ox, or aurochs, of Europe.

It is doubtful whether any of our present-day European or American breeds trace back solely to either one of these ancient types. It seems much more probable that our present breeds are the results of various degrees of crossing between them. The cattle of India and Africa, *B. indicus*, are characterized by a lump of fleshy tissue over the withers sometimes weighing as much as 15 to 25 kilograms (kg). They also have a very large dewlap, and the voice is more of a grunt than a low. They are thought to be descended from the wild Malayan banteng.

It seems probable that primitive humans first used members of the family Bovidae as a source of food. Domestication perhaps began when these animals were used as draft animals, probably in the first steps of the tillage of the soil. In their wild state there was little tendency to store excess fat on the body, as this would have been a hindrance rather than a help under the conditions then

existing. Milking qualities also were most sufficient for the rearing of the young. As civilization developed, feed became more abundant, methods of caring for livestock improved, and the latent possibilities for rapid growth and milk production began to be realized under selection by humans.

That the ox played an important part in aesthetic development is attested by its use in architectural and interior mural decoration as well as by its frequent use as a subject of poetic fancy. The ox assumed great religious importance in many ancient civilizations; the best members of the breed were sacrificed to propitiate the gods. They were crowned with wreaths and honored in other ways during pageants and holidays. To some extent we perpetuate this custom in our fairs and expositions today. The Romans' term for money was *pecunia*, a word derived from *pecus* meaning "cattle," and in ancient times wealth was measured in terms of the cattle one possessed.

Swine

Swine are ungulates belonging to the suborder artiodactyls (even-toed). They belong to the family Suidae. The Dicotylidae, or peccaries, and the Hippopotamidae, or hippopotamuses, are closely related families, these three families comprising the Suina. These animals have tubercles on the molar teeth, and there is not a complete fusion of the third and fourth metapodials to form a cannon bone. The nose is elongated into a more or less mobile snout.

It appears that our modern breeds, *Sus domesticus*, have descended from at least two wild stocks: the Northern European breeds from the wild boar *Sus scrofa*, and those of Southern Europe, Asia, and Africa from one of the Malayan pigs, possibly the collared pig *Sus vittatus*. The former was a larger, coarser animal throughout than the latter, and it had a denser covering of hair.

Present-day breeds are no doubt the result of varying degrees of crossing between the parent stocks and their offspring. It seems probable that the pig was domesticated later than cattle and sheep and earlier than the horse. Selected for its ability to grow rapidly and economically, the pig is foremost in converting feed into flesh. Several of the breeds of hogs found in America are of our own breeders' making; for example, the Duroc, the Poland China, and the Chester White breeds are strictly American creations.

Sheep and Goats

These two genera of the family Bovidae are very closely related, so closely, in fact, that a naturalist never speaks lightly of "separating the sheep from the goats." The genus *Ovis* includes the sheep and its wild relatives, whereas goats and their kind make up the genus *Capra*. Sheep are distinguished from goats by glands in both forefeet and hind feet, by the absence of a true beard, and by the absence of the strong goatly odors in males. There are also marked differences in the skulls; and the horns generally spiral in opposite directions, the right horn of the sheep to the right like a corkscrew, and the goat's to the

left. The sheep gets its Latin name *Ovis* from the Sanskrit *avi*, signifying “to keep” or “to guard.”

Sheep probably originated in Europe and in the cooler regions of Asia in the Pleistocene or later Pliocene era. Remains of sheep or a goatlike animal have been found at the sites of lake dwellings from Neolithic times in what is now Switzerland. Sheep are thought to have been derived from the antelope-like animals allied to the gazelles because of certain similarities of the molar teeth. It seems certain that our modern breeds trace back to at least two remote ancestors, the mouflon of Europe (*Ovis musimon*) and the Asiatic urial (*Ovis vignei*).

The sheep was originally a hairy animal with an underfur of wool. No doubt people living in cold climates who used skins as clothing were the first to begin the selection of sheep for wool production. As in all our domesticated animals, there is wide variation among sheep. Some, like the African long-legged and Abyssinian maned sheep, bear hair instead of wool; some have spiral horns 50 cm or more in length, and others have no horns at all. The tail of the common domesticated sheep is long and slender; in some other strains it is a fat depot about 30 cm in width; whereas still others have merely a vestige of a tail. The last sort often carry huge patches of fat on their rear quarters, the stored fat in all cases serving to tide the animal over long periods of food shortage. The hunia, a tall, long-legged sheep, is used in India as a fighting animal.

Goats are also versatile in characteristics, yielding the underfur for Cashmere shawls and providing mohair, milk, meat, and draft power; they also provide one means of clearing up brush land because of their fondness for all sorts of tender shoots.

The Chicken

Chickens came from Southeast Asia and were kept in China as early as 1400 B.C. The most authentic information about the origin of the chicken, according to Jull¹ suggests that the existing breeds have descended from one or possibly four subspecies.

- 1 *Gallus gallus*, the Red Junglefowl
- 2 *Gallus lafayette*, the Ceylon Junglefowl
- 3 *Gallus sonnerati*, the Gray Junglefowl
- 4 *Gallus various*, the Java Junglefowl

Charles Darwin studied the origin of the chicken and in 1868 concluded that all the domestic stocks descended from the *Gallus gallus*, Red Junglefowl species. Darwin observed that in this species the voice was more similar to the domestic chicken. Further, when mated with domestic stock it produced offspring more freely, and these hybrids were more likely to be fertile than crosses with any of the other species.

¹ Jull, M. A. 1940. “Poultry Breeding,” John Wiley & Sons, Inc., New York.