GENETIC IMPROVEMENT OF BEEF CATTLE
IN THE UNITED STATES: CATTLE, PEOPLE
AND THEIR INTERACTION1,2

R. L. Willham

Iowa State University, Ames 50011

Summary
The purpose of this essay is to develop a historic perspective of the beef cattle population and the legion of people directing its genetic change so that future leadership can increase the rate of breeding technology assimilation. Use of cattle for beef to feed millions is relatively recent. The beef industry of the United States has a rich, romantic heritage that combined Spanish exploitation with British tradition. Spanish cattle became adapted as the Texas longhorn and the European cattle became indigenous. Breeds developed in Britain replaced both. The Zebu was introduced to produce cattle adapted to the Gulf Coast. Selection for early maturity in the British breeds promoted by livestock shows was ended by the dwarf gene. The Charolais breed demonstrated growth potential. Then in 1967, Continental European breeds were imported, giving an array of biological types from which to select. Beef cattle breeding research expanded after the second world war through the three regional projects. Performance Registry International was the focal point for performance. The Beef Improvement Federation produced guidelines for recording beef performance including those for national sire evaluation. U.S. Meat Animal Research Center evaluated the several newly introduced breeds. To date, breeding researchers have developed breeding technology for use by the breeder.

Introduction
"There is no higher form of art than that which deals with the intelligent manipulation of animal life; the modeling of living, breathing creatures in accordance with the will and purpose of a guiding mind. It rises in its boundless possibilities to heights that are fairly God-like. The world of human endeavor presents no nobler field of action, no realm of thought demanding a higher order or ability."

(Sanders, 1915)

While breeding mystic originated from the closed lips of Bakewell (Pawson, 1957), the elegant prose of Sanders ennobled the "golden age of stockbreeding" through his publication of the Breeders' Gazette. Five years later, Wright, an early population geneticist, wrote the following:

"It is often believed today that successful breeders have some mysterious method of which others are ignorant. Instead, the principles of the successful breeder have been exceedingly simple. The difficulty lies not so much in knowing the principles as in applying them."

(Wright, 1920)

The major breed associations are keeping and utilizing performance records. The genetic structure of the beef breeds is being altered by the use of AI such that genetic change can be made rapidly by the use of superior sires evaluated on their progeny in many herds.

(Key Words: Beef Cattle, Genetic Change.)

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This essay traces the history of genetic improvement (change) of beef cattle in the United States. The word, improvement, needs definition. Improvement, like beauty, is a function of its historical context. Therefore, to reduce confusion, this essay will consider genetic change, which describes a fact rather than improvement, which implies a value judgement.

Genetic change has an impact on what and how change can be made in the future. Both cattle and people are involved. Cattle people who understand the lessons of their heritage are best able to introduce new breeding technology and get it used (Weber, cited in Swaffar, 1967).

**Chronology**

What follows is a record of genetic change in the beef industry. It is chronological so that the subtle interactions in the industry can be understood in their historical context (Burke, 1978).

**Pre-colonial**

Cattle have been with man throughout history (Towne and Wentworth, 1955). The humanities began with the cave paintings depicting cattle as hunted (Bronowski, 1973). Symbiosis developed between Artiodactyl herds and man in a transhumant life where the herds became mobile food reserves (Laas, 1972). Root words for money, coming from the name cattle, reflect this use (Fraser, 1972). Cattle worship echoes through mythology and the cattle cults of the Mediterranean basin (Cole and Ronning, 1974).

The ox yoked to the plow produced the surplus food on which civilization was built (Bronowski, 1973). The Romans wrote about cattle husbandry (Harrison, 1913). The “butter eating gentry” that took Rome practiced a livestock-based agriculture (Tannahill, 1973). Beef eating was brought to Britain by the Norman lords whose guards were “beefeaters” (Laas, 1972). The demise of the warhorse and the Chinese collar released the ox from the ard or plow and allowed cattle to diverge into milk or beef types (Burke, 1978).

**Colonial**

The Spanish conquistadors founded a livestock-based aristocracy that was the envy of all Europe (Tannahill, 1973). Spanish cattle exploded on the North American continent from 1510 onwards (Rouse, 1977). Our ranching heritage comes directly from the feral husbandry of the Spanish in the Southwest (Willham, 1980b). In less that 300 yr, Spanish cattle evolved into what Dobie (1941) called the Texas longhorn. Their increase belies the low reproductive rate of cattle.

Colonization by the British and others on the Eastern seaboard, gave North America a mix of cattle from the points of embarkation (Rouse, 1973). Durham derivatives were the rule on the commons. Adaptation was made to the needs of small farms, including the cowpen people of the Carolina piedmont. The colonies were self-sufficient in cattle by 1650 (Rouse, 1973).

**Pioneer**

After independence, the pioneers crossed the Appalachians into the fertile Ohio Valley and onward with their cattle.

The renaissance in British agriculture (Thom- as, 1979) allowed the industrial revolution to begin in Britain. The use of power and automation produced vast cities that provided markets for beef. Enclosure and landlord-tenant laws gave the landed gentry the opportunity to breed stock as they desired and continuity to make changes in cattle.

Breed formation started with a useful local type (Briggs and Briggs, 1980). A few gentlemen in an area, following the lead of Bakewell, selected the best and inbred them until a degree of uniformity of type was attained and then popularized the breed at livestock shows (Wright, 1978). Ancestry was recorded in herdbooks because near complete reliance was placed on heredity at the time. Breed societies were formed to protect purity (Lush, 1945). Beef breeds were selected toward the perceived needs of the industrial revolution. Between 1750 and 1850, the Hereford, Angus, and Shorthorn breeds were developed (Sanders, 1925).

Back in the United States, pioneers were moving Westward from the Mississippi to new land (Schlebeck, 1975). Commerce involved oxen. Chicago became the hub of commercial agriculture and the East industrialized quickly after the Civil War.

**Empire**

Texas cowboys returning from war found the longhorn herd increased from four to six million head. Longhorns were driven north to populate the Great Plains, where before their
slaughter 40 million head of bison roamed (Brayer and Brayer, 1952). Such replacement of species is astounding! The plains became vast cattle empires through the sweat of cowboys and Scottish capital (von Richtofen, 1964). In 20 yr the hungry “sod buster” spelled the end of the cattle empires, but not of the cowboy (Gray, 1968). Rail transport, live cattle drives to river towns for slaughter and chilled carcasses to Eastern Cities began the beef industry as we know it (Willham, 1980b).

**Purebred**

By 1900, livestock breeders of the Midwest had imported enough British stock to become breeders and provide ranches first with Short-horn and later Hereford sires (Johnson, 1975). Grading up to Herefords was accomplished largely in less than 20 yr. This replacement brought earlier maturity and the move to decrease the slaughter age from 4-yr-old steers to long yearlings today. Cornbelt cattle feeding enhanced the product.

The International Stock Show opened at Chicago in 1900 (Sanders, 1915). The purebred shows compared the expertise of the many Scotch herdsmen and the cattle. The “International Grands” became smaller, thicker and fatter (Anonymous, 1975). The land-grant colleges of the Midwest had staff who were stock judges. Darlow (1958) states, “In placing the animals, ... the judge helps crystallize the thinking and opinions of breeders.” Judges were master teachers. Convinced that the British breeds were developed in response to Britain’s industrial revolution, livestock people logically graded up to these because the United States was rapidly surpassing all Europe in industrial might (Warwick, 1958).

The rise in influence of the breed associations, an adopted heritage, was monumental! Breed associations subscribed to the principle that pedigree, allied with the use of eye judgment for securing adherence to formalized breed type, was the basis of successful breeding (Lerner and Donald, 1966). Beef husbandry settled into a content mold (Grigg, 1974). The industry was cyclic with booms and busts (Ensminger et al., 1955).

The Gulf Coast needed more than the British breeds could offer. Zebus were imported and found to produce crossbreds with either British or indigenous cattle that were better adapted, yet produced beef (Warwick, 1958). In the 1920’s, the King ranch developed the first American breed, the Santa Gertrudis, with 3/8 Zebu and 5/8 British blood (Rhoad, 1949). The book edited by Cunha et al., (1963) was a milestone in the development of cattle in the Gulf Coast.

The end of the purebred epoch occurred in an industry-shattering way! Extreme selection for the compact bovine increased the incidence of at least two dwarf genes (Marlow, 1964). McCann (1974) and Swaffar (1972) give accounts of the pedigree screen adopted by the Hereford Association. The search for clean germ plasm began and was successful (Stewart, 1961). University animal breeders were called on for help (Lush and Hazel, 1952). This was one bright spot; these researchers developed a rapport with the breeders that was later to benefit the industry.

**Scientific**

Beef breeding research conducted at the USDA range station in Montana from 1924 on was to change the direction of the beef industry in unforeseen ways. Lush (1936) and Black (1936) called for objective measures of merit in beef cattle. Heritability estimates for growth by Knapp and Nordskog (1946) and Koger and Knox (1945) on weight adjustment stimulated research interests. Three regional beef breeding projects were initiated and beef research began in earnest (Willham, 1977). Warwick (1958) summarized the work of the pioneer researchers. These men and those to follow had research herds that gave them a rapport with breeders.

Performance evaluation was started by a handful of breeders, extension men, and researchers on a “one-to-one” basis. Examples are Ellis (1973), Lingle (1976) and Rouse (1979). From 1940 to 1960, the elite breeders of today developed; they were outside the “in crowd” of the beef world.

Central bull testing began in Texas in 1941 (Maddox, 1967; Melton et al., 1973). The tests proved to be a successful demonstration of competition based on performance. The gift of Charolais (King, 1967) in the 1930’s clearly showed all breeders, especially in the central tests, that cattle could gain rapidly (Willham, 1974a). The Babcock fat test was the promotional device that moved the dairy industry into recording milk weight and test. The Charolais breed was the “Babcock test” of beef performance recording (Willham, 1974b).
Between 1945 and 1950, extension beef cattle improvement programs (BCI) were started. The first were in California, New Mexico and Montana and were run by extension specialists. In 1955, Virginia organized the first beef cattle improvement association run by breeders with extension help (Mast, 1967). In the same year, extension leaders gathered the growing number of performance cattlemen together in Texas and formed Performance Registry International (PRI). This organization became the focal point of the industry for performance. A codified program was patterned after the several growing state programs. Set weight standards for certification were used. The real innovation of PRI was the certified meat sire (CMS) program started in 1961. Ten progeny were compared to standards. The program caught the interest of the beef industry.

The first breed association to require weaning performance for registry was the Red Angus Association, formed in 1954. The growing strength of PRI and the many state associations prompted the British breeds to develop performance programs. By the early 1960's, they had illustrated handbooks and were giving performance "lip service" as a within-herd tool.

Close to 80% of the beef was being fed as a result of the Southwestern commercial feedlots. Longtail yearling (OKIES) from the South, were turning more profit than were British steers. With the Charolais becoming the third largest breed and the industry still smarting from dwarfism; larger framed, growthier cattle became the judge's choice by the middle 1960's. To move faster, expert showmen acquired cattle from performance herds. They won. In the Angus breed, at least, this popularized performance cattle and helped move the breed toward performance.

Several bull studs began buying and testing beef bulls from reputation performance herds. In the livestock press, Forrest Bassford and Charles Koch did an excellent job promoting performance. The National Association of Animal Breeders' beef AI conference held before the Denver show gathered those interested in performance. The exotic Charolais Congress under the direction of Litton promoted performance as did the development of the LCR-Breeding Value analysis in the Litton herd. Publications such as Gregory (1961) and Cundiff and Gregory (1968) helped.

In 1965, the U.S. beef cattle records committee report was released. This report, developed by Baker (1967), attempted to standardize beef records. Then in January 1967, Carpenter, a PRI member, called a meeting of all cattle people interested in performance. The conference was exciting (Anonymous, 1976). Strong performance groups simply stated that, if performance measures were recorded as they did, they would go along. The meeting ended in chaos! That evening, Baker got key leaders together, and the Beef Improvement Federation (BIF), an organization of organizations, was formed to establish uniformity, assist in developing programs, encourage education and establish confidence in performance (Baker, 1975).

The first meeting was at Kansas City in 1968. It did not use a show as a crutch. Baker was responsible, with help, in establishing this unique organization. BIF published guidelines for uniform beef improvement programs; the updates have become the performance "bible" for the beef industry (Anonymous, 1974). At each meeting, a symposium is held in which relevant research is presented. This interface has speeded adoption dramatically. It has stimulated research and thus is synergistic.

After years of academic interest (Phillips, 1961; Stonaker, 1961) and many dollars on the part of breeders in the U.S., Canada opened the importation of cattle breeds from Continental Europe. Excited breeders and bull studs promoted these newly introduced breeds. The Dutchess Shorthorn Boom of the late 1800's was repeated all over again. Entrepreneurs, who failed to see Charolais and some of them as well, established breed associations that require performance records for registration. Some bull studs developed importation and testing programs. These breeds differed from the traditional British breeds. The industry had "high-priced" germ plasm with no comparative data. One of the first U.S. Meat Animal Research Center beef projects was germ plasm evaluation. At no time have research reports been more widely anticipated, read and then acted on. Willham (1976) gives an account of this research and the impact. The "exotic" boom continued until 1974 when the cattle cycle turned down.

One of the working committees of BIF was national sire evaluation. In 1971, guidelines were approved that incorporated the use of reference sires as the basis of comparison of sires (Willham, 1979). Both field data evaluation by the newly introduced breeds using AI
and designed programs for the established breeds were forthcoming. The American Simmental Association published the first sire summary in 1971. There are now some nine programs. Most are descriptive.

In the early 1970's, the British breed associations realized that their major reason for being was their performance programs. The speed with which they have become involved in real performance evaluation has been amazing. Weight breeding values, based on own and relative performance, were introduced to the industry as a part of the computer cow game (Willham, 1973) played by BIF members attending the 1970 meeting. These values were incorporated into breed programs in 1971 and in 1974 maternal breeding values (milk production reflected in the weaning weight of calves of daughters of the sires in the pedigree) were being used. The sophistication of the breed programs coupled with breed-wide national sire evaluation programs have enhanced the position of breed programs and reduced the relevance of PRI and many of the state programs.

Several state programs are strong; namely those of Virginia, Montana, Iowa, South Dakota, and Missouri. The survivors have programs such as central bull tests, feeder calf programs and custom progeny testing for the breeds. PRI exists. Bull studs have been major contributors to the breed sire evaluation programs.

BIF is a bit awed by its success (Willham, 1979). It is a real vehicle by which new breeding technology can be introduced to the leadership of the beef industry. The fact that member organizations keep their own records is important, especially breed associations. Lerner and Donald (1966) may not be correct in their prediction of breed association inaction, at least in the United States. Approximately 50% of the calves registered have records in the British breeds while some newly introduced breeds still require records for registration. However, shows remain a powerful promotion tool. Hip height, popularized in Missouri, is used to objectively look at frame size and composition. Tallness is in vogue, while total efficiency in production systems generally is ignored even with the Texas research on beef systems (Long et al., 1975).

The newly introduced breeds have caused the beef industry to use AI more extensively. Systematic crossbreeding is accepted, with about 50% of the producers practicing some crossing. However, crossbreeding still is difficult to manage in some operations. Recent research results have emphasized the matching of genetic potential to resources (Willham, 1976).

Recently researchers have had the opportunity to study beef field data amassed by several breed associations (Willham, 1980a). Field data from several breeds have been examined for breed-specific correction factors, evidence for sire interactions and other information.

During 1980, both the field data from the American Angus Association and the American Hereford Association have been analyzed using a mixed-model procedure for sire evaluation. The sire birth-year group constants show a very linear genetic trend for the two breeds over two generations (1965 to 1978) of +1.2 and +1.5 kg/yr in yearling weight for the Angus and Hereford breed, respectively. The Angus breed published a sire report of 564 bulls with at least 20 effective progeny (lead diagonal) in 1980. Details of the analysis appear in Berger and Willham (1980). From the genetic trend, it appears breeders are capable of making genetic change when given signals by commercial producers, as they were in the middle 1960's.

My colleague, Freeman, told me some years ago that, when sires were no longer confounded with herds, the beef industry could make genetic change comparable to that in the dairy industry. Beef breeds now recognize AI as a breed improvement tool; 89% of the sires are directly or indirectly fed. With these ties and the relationship ties that will be created by the inclusion of the relationship matrix, new analysis procedures can be used to evaluate yearling bulls over herds (Willham and Leighton, 1978; Slanger, 1979; Quaas and Pollak, 1980). Performance records were sold initially as a within-herd tool, but soon can be used over herds. It appears the beef industry is poised on the threshold of a new era where the potential for making genetic change is fantastic! It is imperative to give breeders the facts necessary to make correct direction decisions.

**Synthesis**

Permanent genetic change in a biological population is the result of gene frequency change. Li (1976), in his summary of the theory of gene frequencies states that, in very large populations without subdivision, selection is the primary force. In populations subdivided into small groups (20), chance is the predomi-
nant force while, in populations subdivided into partially isolated, medium-sized (200) groups, all the forces that change gene frequency are operative simultaneously. This latter population can change most rapidly in response to economic or environmental shifts. Thus, cattle populations with their subdivisions of types, breeds within types, and herds within breeds are structured to accommodate rapid genetic change.

The cattle population of the United States started with repeated, small samples of diverse germ plasm that had tremendous opportunity to expand in numbers. Spanish cattle came from Iberia, where the terrain and climate was like that of the Southwest. In some 300 yr of natural selection, these cattle developed into the longhorn.

A rich mixture of cattle types originating from the points of embarkation in Britain and Europe arrived in repeated, small samples to the Eastern seaboard (Rouse, 1973). Durham derivatives predominated. The terrain and climate to which they came and the "Commons" husbandry that they received was like that of the homeland. Adaptations occurred. The "commons" died with the pioneer movement West, so herds introduced an additional subdivision. Spanish and "native" cattle comprised two distinct subpopulations in the United States at the end of the Civil War.

The importation of British breeds, pedigree isolates, further subdivided the cattle population in the East and Midwest. The breed and herd-within-breed structure with its directional gene flow produced opportunity for genetic change. Adaptation occurred, but husbandry practices also were imported through the Scotch herdsmen. Definite beef type was evident.

Grading-up to the British breeds in both the indigenous and Texas longhorn subpopulations virtually obliterated any useful adaptations. Cattlemen were convinced that these breeds were superior in meeting the needs of the industrial revolution. The relatively small numbers imported, their rapid expansion as purebreds and the speed of grading-up of the indigenous populations was phenomenal. Genetic change was made. Selection within breeds concentrated on increasing the rate of maturity while grade Herefords underwent adaptation to the West.

The introduction of Zebu to the Gulf Coast wrought improvement in adaptation to a harsh environment. Grading to Zebu was not a solution because it was the crossbred that performed and gave the heterosis. This stimulated the first conscious attempt to establish new breeds that contained blood of both types (Rhoad, 1949). The formation of new breeds from a crossbred foundation produced genetic change of adaptive significance.

The continuing pressure applied by breeders to produce earlier maturing cattle increased the frequency of the dwarf gene. The heterozygote must have been favored (Marlow, 1964). Selection against the dwarf gene was an exercise in genetic change. Lines were lost as a result of pedigree screening and name condemnation.

The introduction of the Charolais breed from Mexico via Texas, gave the beef cattle population of the U.S. a new biological type. This continental European breed was big and grew rapidly. High-concentrate feeding gave the Charolais crosses an advantage. Besides its contribution of new, diverse germ plasm; the Charolais became the "Babcock test" of beef performance testing.

British breeds began reverse selection to increase the size and growth ability of their cattle (Berger and Willham, 1980). The early performance "nuts" provided germ plasm for the breed populations, illustrating the plasticity of a population consisting of partially isolated subgroups (herds) when migration is possible (Li, 1976). The speed of the genetic change for increased size was swift. If germ plasm from breeds with size was introduced into the British breeds, it just was. The show ring and performance evaluation both contributed to the genetic change.

The recent importation through Canada of numerous continental European breeds of diverse biological types has virtually restructured the beef population. The industry now realizes that breed differences are a genetic resource to be used in commercial production. A much wider genetic base now exists from which to select.

Today, the beef industry has a diverse population of pedigree isolates, breeds, from which to select commercial germ plasm. Systematic crossbreeding is economically sound, but difficult to practice in small herds. Selection within breeds must become that which will make that breed most relevant to the commercial industry.

The beef industry has struggled with ways of fairly comparing (evaluation) germ plasm. Using mixed model procedures (Henderson,
1973), it will soon be possible, through the use of sires in many herds, to evaluate the breeding values of individuals over herds, including the use of relative information (Henderson, 1976).

Lerner and Donald (1966) note that replacing the static idea of show ring type with the notion of a population (not individuals) moving by selection in an economically sound direction is difficult for breeders to comprehend. Perhaps sire evaluation that includes the majority of the sires in a breed will create real monetary reward for breeders who compete with the products of their creative breeding programs conducted over time.

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