Improvement of BEEF CATTLE *Through Breeding*

Extension Bulletin 802
Extension Service

Revised August 1972
Oregon State University

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Improvement of Beef Cattle Through Breeding

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The Principles of Genetics

If you examine thin sections of animal and plant tissue under the microscope you find it is made up of cells. Within each cell is a body called the nucleus, and inside the nucleus are several rod-shaped bodies. These are chromosomes, carriers of the genes or determiners that govern how a trait will develop. The chromosomes are in pairs, one member having come from the father, the other from the mother.

An animal or plant begins with one cell, which divides to make two cells. These two also divide to make more cells, and so on. As development takes place, groups of cells specialize to form various tissues or organs. The total number of cells in one animal is enormous. Cells continue dividing, renewing tissue as long as life exists in an animal.

The chromosome pair duplicates itself in most cells, carrying on in identical form from cell to cell.

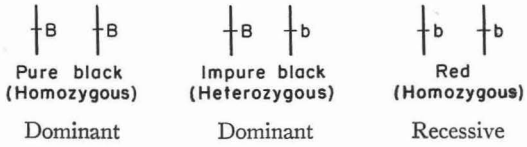
In only one specialized group—the germ cells—does the chromosome division process differ. The germ cells are in the testicles of a male animal and in the ovaries of a female, and when such a cell divides—preparatory to possible fertilization—the members of a chromosome pair separate, one member of each pair going into a germ cell. Thus in fertilization when male and female germ cells meet, they join to form one complete new cell with its pairs of chromosomes reestablished. The new pairs produce new combinations of genes in the developing individual.

Inside the chromosomes are tiny areas of activity, called genes or determiners. They determine how traits or characters in an individual will develop. Two genes are present for each trait, one in each member of the chromosome pair. Thus an individual's eye color, for instance, can be influenced by two genes, one from each parent.

In printed material a chromosome usually is illustrated by a vertical line or rod. The gene usually is indicated by a letter, placed so as to show its location in the rod. For example, the gene for black cattle is illustrated as follows:

Keep in mind that the chromosomes are in pairs and that the genes also are in pairs. Thus, a pure black is illustrated in the following manner:

In cattle B = black is dominant over b = red so that a pure black animal and a black animal that also carries the one gene for red are not distinguishable. Three kinds of cattle (illustrated below) can exist as far as red and black are concerned.



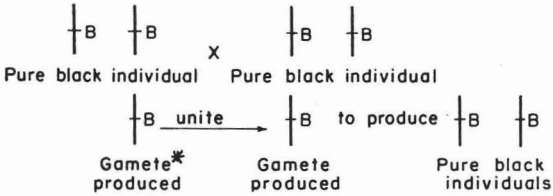
The dominant individual can be either pure (homozygous) or impure (heterozygous) but the recessive is always pure. It must be pure to show. Therefore, it can be said that recessive traits are always in the pure (homozygous) condition.

Simple Inheritance

Six types of matings can be made when one pair of genes is involved.

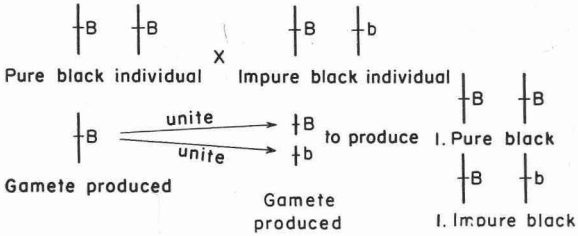
If the genes B = black and b = red are used, the following combinations are possible.

1) Homozygous dominant x homozygous dominant.

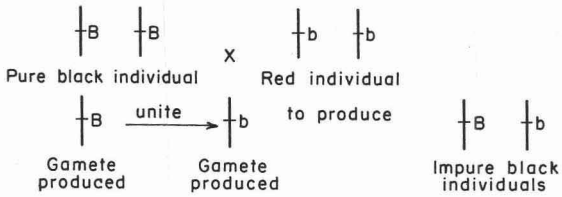


* A gamete is a germ cell, either the sperm or the egg.

2) Homozygous dominant x heterozygous dominant.

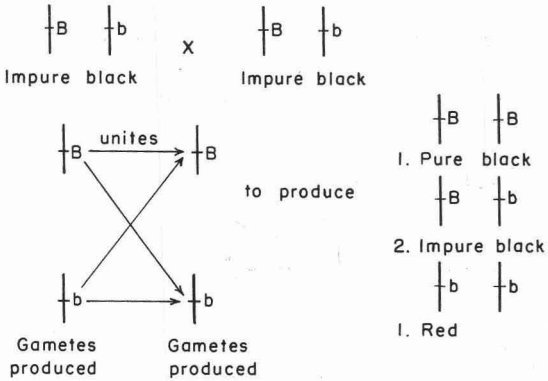


3) Homozygous dominant x recessive.



The homozygous dominant always produces offspring showing the dominant regardless of the kind of animal with which it is mated.

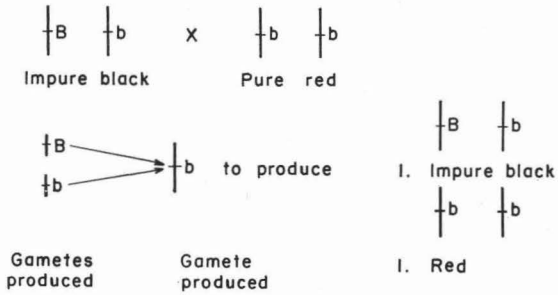
4) Heterozygous dominant x heterozygous dominant.



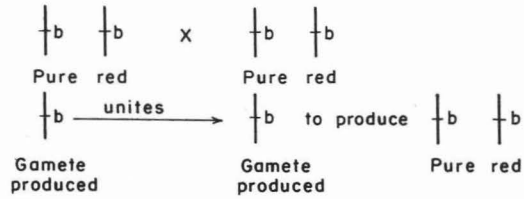
Genetically there is a ratio of 1 pure dominant: 2 impure dominants: 1 recessive. This is known as the genotypic ratio. The appearance of the offspring gives a ratio of 3 black (dominants): 1 red (recessive). This is known as the phenotypic ratio. The reason why the

genotypic and phenotypic ratios are different is that the dominance of the black gene places the pure and the impure black animals into the same classification on appearance.

5) Heterozygous dominant x recessive.



6) Recessive x recessive.



Recessives always breed true when mated together, and the recessive is the logical animal to use in matings to test a dominant individual to determine if the dominant is pure or impure. If the dominant is pure, all its offspring will be dominant. If it is impure, it will produce approximately equal numbers of dominant and recessive offspring when mated to a recessive.

More Complicated Inheritance

The situation becomes more complicated when more than one trait at a time is considered.

In cattle P = polled and p = horned;
B = black and b = red.

If impure animals for both black and polled are mated, offspring result in the following ratios:

1 BB	1 PP 2 Pp 1 pp		1 BBPP 2 BBPp 1 BBpp
2 Bb	1 PP 2 Pp 1 pp	=	2 BbPP 4 BbPp 2 Bbpp
1 bb	1 PP 2 Pp 1 pp		1 bbPP 2 bbPp 1 bbpp

Phenotypically (appearance)

3 black	3 polled 1 horned	=	9 black polled 3 black horned
1 red	3 polled 1 horned		3 red polled 1 red horned

If double heterozygous individuals (impure for black and polled) are mated to double recessive individuals (red, horned) the following ratios occur among the offspring:

Genetically

1 Bb	1 Pp 1 pp	=	1 BbPp 1 Bbpp
1 bb	1 Pp 1 pp		1 bbPp 1 bbpp

Phenotypically

1 black	1 polled 1 horned	=	1 Black polled 1 Black horned
1 red	1 polled 1 horned		1 red polled 1 red horned

Expected ratios from different types of matings are closely approached but seldom exact. They resemble results obtained by tossing coins. A coin when tossed would be expected to show "heads" and "tails" in equal numbers, but this exact ratio of 1 head to 1 tail seldom occurs.

Many people want to obtain an animal possessing a combination of several traits by combining two breeds or individuals each of which possesses some of the desired traits. It is felt that such a combination

and the interbreeding of the offspring should result in a wide array of desired traits in some of the animals. Although this concept is sound, the numbers needed to obtain animals of this nature must be considered. For example, if two heterozygous animals for black, Bb, are mated, a minimum of four offspring is required to obtain all the kinds of genotypes and phenotypes. If two double heterozygotes, Bb Pp, were mated, a minimum of 16 offspring would be required to obtain all the kinds of genotypes and phenotypes. The mathematical equivalent is $(4)^n$ where n equals the number of pairs of genes involved. For example, a mating of heterozygotes where 10 pairs of genes are involved would require a minimum of 1,048,576 offspring to get all the possible kinds of genotypes and phenotypes.

When two heterozygotes, Bb, are mated 1 BB to 2 Bb to 1 bb as the genotypic ratio is obtained, and 3 black to 1 red is obtained as the phenotypic ratio. Thus, three genotypes and two phenotypes are produced by such a mating. If two pairs of genes are involved, when heterozygotes are mated, nine genotypes and four phenotypes are obtained. These can be expressed mathematically as $(3)^n$ for the number of genotypes that are produced and $(2)^n$ as the number of phenotypes produced. All of this is summarized in tabular form in the table below.

Table 1. The Number of Genotypes and Phenotypes Increase with the Number of Genes Involved

Number of pairs of genes involved	*Number required to obtain ratios*	*Number of genotypes*	*Number of phenotypes*
1	4	3	2
2	16	9	4
3	64	27	8
4	256	81	16
5	1,024	243	32

It is apparent that with five pairs of genes involved, a minimum of 1,024 offspring would be needed to obtain all the possible kinds of genotypes and phenotypes. There would be 243 genotypes produced but only 32 different phenotypes. Since the phenotypes can be seen and not the genotypes, the homozygous genotypes desired cannot be differentiated from those that are heterozygous for the desired phenotypes.

Actually, most traits of economic importance are influenced by numerous genes rather than just one affecting the trait. Such traits are growth rate, feed efficiency, milk production, and others. The simply inherited traits usually are those affecting color, horns, or some of the lethals and abnormalities. Some traits may be governed by genes

that are in the chromosomes that govern sex, and, therefore, one sex may have a greater tendency than the other to show such a trait. Generally in farm animals, sex-linked recessive traits are much more frequent in the male than in the female. The male does not have sex-linked genes in pairs so he must show the sex-linked gene he inherits. The female has sex-linked genes in pairs. She can carry a recessive in the impure state and not show it. The male offspring generally expresses the sex-linked genes of his dam while the female obtains sex-linked genes from both her sire and dam.

Gene Interactions

Genes interact in many ways to produce a trait. Genes may interact with their alleles (dominance interactions), with genes in other chromosomes (epistatic interactions), with the cytoplasm, or with the environment.

The allelic[1] or dominance interactions involve three major types of dominance: complete dominance, lack of dominance (or incomplete dominance), and overdominance. It may be said that each allele at a particular locus of a heterozygous (impure) animal is attempting to affect the trait. If dominance is complete, the dominant allele completely overpowers its recessive partner, and the result is that only the effect of the dominant allele is evident. A good example is in the expression of black in cattle that are heterozygous, Bb, for black. Such a black animal is indistinguishable from the pure black. A good example of lack of dominance in cattle is found in roaning. The heterozygous animal is roan while one homozygous type is white and the other homozygous type is red; roan x roan produces 1 white: 2 roan: 1 red and white x red produces all roans.

If A equals one allele and a the other, and if a line is used to represent the spread in expression of a trait, the types of dominance can be diagrammed as shown below:

Complete dominance

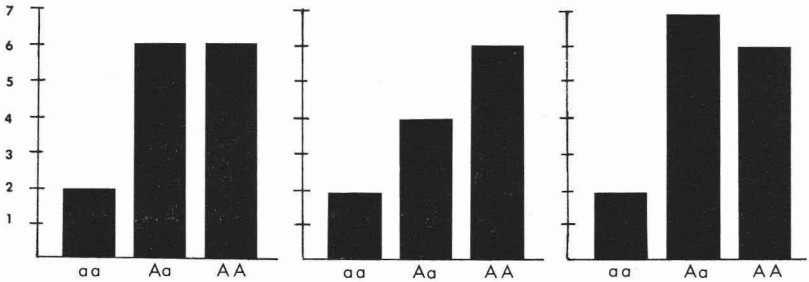
Lack of dominance

Over-dominance

[1] When the individual is heterozygous † B † b, one gene, the B, attempts to create black while the other gene, the b, attempts to produce red. Black is produced so we say that black is dominant. These genes having contrasting effects are called allelic genes.

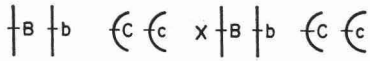
There would be a selective advantage for the heterozygous in the case of overdominance. Examples of overdominance are seen when crosses are made and the crossbreds are much superior to either of the straightbreds.

One can also illustrate the various types of dominance by use of bar graphs if one assigns a numerical value to each genotype. If one assumes that a = 1 and A = 3, then with complete dominance A gives the same effect as AA; therefore, AA and Aa would have a value of 6 while aa has a value of 2. With lack of dominance AA = 6, Aa = 4 and aa = 2 in values. With overdominance AA = 6 and aa = 2 but the heterozygous Aa is superior and equals 7. These are shown below in bar graphs.



Complete dominance Lack of dominance Overdominance

Another form of interaction is for one gene to cover up the expression of another gene. This is represented easily by albinism. If C = color, c = albino, B = black, and b = red, and if two animals are heterozygous or impure for both pairs of genes, a ratio can be expected of 9 showing both dominants; 3 showing 1 dominant and 1 recessive; 3 showing 1 dominant and 1 recessive; and 1 showing both recessives. Actually, a ratio of 9:3:4 is obtained.



3 black	3 colored		9 black
	1 albino	=	3 red
1 red	3 colored		4 albino
	1 albino		

Both the red and the black that are pure for albinism will be albino.

Genes also interact with the cytoplasm—and with the environment. Examples of interacting with the environment are illustrated by citing show-cattle under rugged range conditions. Although such cattle may be superb under ideal conditions, they might make a poor showing on sparse range.

The interaction of genes with one another, with the cytoplasm, and with the environment, and the inheritance of traits in which many genes influence their development make it very difficult to manipulate the genes to obtain a chosen type of inheritance. It is not as difficult to test for and eliminate an undesirable trait that is controlled by one pair of genes. It is very difficult to improve traits controlled by numerous genes. To improve such traits, selection methods and breeding systems must be used, aimed at building and utilizing genetic material without knowing much about the action of any specific gene.

The Function of Purebred Breeders and Commercial Producers

The functions and objectives of purebred and commercial breeders differ so greatly that it is well to state them as a background before discussing breeding systems and selection methods. The function of the purebred breeder is to develop breeding stock possessing the highest predictability for transmitting the most desirable inheritance possible. The function of the commercial breeder is to make use of this build-up of genetic material in a manner that will give the most efficient, rapid, and economical production of the quality of meat most desired by the consumer.

Breeding Systems

Several systems of breeding can be used. To simplify the information, two general systems will be presented for purebred breeders and two will be presented for commercial breeders.

Purebred Breeders

Breeders of purebred livestock may use males continuously that are unrelated to the females in the herd (continuous outbreeding) or they may close the herd and select breeding males and females from within the herd (closed-herd breeding).

Continuous outbreeding

The continuous use of unrelated bulls in the purebred cow herd maintains the greatest possible amount of genetic impurity or heterozygosity. As a result, the performance in such a herd may be at a high level. However, because of the lack of genetic purity, breeding animals from such a purebred herd may not transmit their desirable performance with a high degree of certainty.

Closed-herd breeding

When a herd is closed to outside breeding stock and when all breeding animals, both bulls and cows, are selected from within the herd, a certain amount of inbreeding occurs. The amount of inbreeding will depend on the number of sires used within the herd. The fewer the bulls the more the inbreeding. Inbreeding is simply the mating of related animals.

Inbreeding tends to produce genetic purity or homozygosity. It does not change the genes or determiners in any other way. Because purity or homozygosity is produced by inbreeding, some decline may occur in vigor and some very poor individuals may be produced. The latter is likely to occur if the herd carried genes for undesirable recessive traits, since such traits show only when the genes determining them are in the homozygous or pure condition.

Breeding animals have been marketed largely on their appearance and production records. This is probably a sound method of choosing breeding stock if they are selected from outbred material. However, breeding stock from closed herds may not appear as desirable as outbred animals even though they likely will be superior to the outbreds in the offspring they produce. Thus, with closed-herd breeding a breeder should advertise on the basis of performance in the herds of breeders who use his bulls rather than entirely on the appearance and performance records of the bulls themselves.

In general, traits affected most adversely by inbreeding are those having to do with fitness of the animal for survival in its environment. Such traits are fertility, milking ability, and vigor of young in early life.

Some breeders may find it necessary to introduce breeding stock into a closed herd to overcome certain weaknesses. If breeding stock is introduced into a closed herd, it should come from another superior closed herd. Unrelated, outbred breeding stock introduced into a closed herd may result in loosing improvements already made, rather than making improvements. Any introduction of breeding stock into a closed herd should be done with caution. Some breeders mate a few of their best cows to an unrelated bull from a superior closed herd, producing young bulls to go back into the herd.

A herd developed by closed-herd breeding will transmit with a great deal of certainty. Bulls from closed herds in which rigorous selection has been practiced, when used on unrelated cows, generally will sire calves having superior performance.

Factors influencing success with inbreeding—Four factors generally will determine the degree of success with inbreeding.

- Genetic merit of foundation stock.

If the herd is relatively free from deleterious or undesirable recessive genes, inbreeding should not show marked detrimental effects. However, a herd possessing deleterious and undesirable genes in high frequency will show immediate detrimental effects from inbreeding. If a herd is closed and selection of all breeding stock is from within the herd, the extent that undesirable inheritance is present can be determined in a few years. If undesirable or abnormal offspring show at a high frequency, unrelated bulls could be introduced from a herd in which closed-herd breeding has been successful, as a means of reducing the frequency of the undesirable genetic material. The herd can be closed again following such genetic introduction without detrimental results.

- Effectiveness of selection.

In a closed herd it is essential to select for traits having to do with fitness, such as fertility, suckling ability, and early-life vigor, as well as selection for other traits deemed important to production. Effective selection aimed at reducing the genetic material that interferes with successful inbreeding will go a long way in making such a program possible. This may mean a careful study of related animals, some progeny testing, and the culling of whole segments of a herd that carry a high frequency of undesirable genetic material.

- Rate of inbreeding.

Intense inbreeding fixes the genetic material (creates homozygosity or genetic purity) very rapidly. As homozygosity is produced, selection becomes less effective because it is only due to genetic segregation that any progress can be made. If intense inbreeding reduces the amount of effective selection that can be done, inbreeding at a rapid rate is not desirable. The use of several bulls in a closed herd will result in a very slow increase in inbreeding. A herd size that justifies the use of 6 to 10 bulls is of sufficient size to close the herd with no great increase in inbreeding. In fact, so little inbreeding should result in such a closed herd that little or no difficulty should be experienced. At the same time, the use of closed-herd breeding in a herd

of this size, along with selection, should result in fixing of genetic material so that breeding stock should transmit with a high degree of predictability.

It is doubtful if a breeder of a small herd can afford to use a sufficiently large number of bulls to close his herd and yet keep the rate of inbreeding down to where sufficient selection can be practiced to make improvements. Small breeders are better advised to use bulls continuously from a closed herd in which the size of operation permits the program without markedly increasing inbreeding.

Perhaps the smallest herd size safe for closed-herd breeding uses four bulls. This normally means a cow herd of 100 breeding animals because of economical bull cost per calf produced. However, it might be practical to breed a smaller number of cows than 100 by using the four best yearling bulls in the herd each year and then selling them as breeding bulls at two years of age the following year. Since many buyers prefer 2-year-old bulls ready for heavy service, these bulls should sell readily. The use of yearling bulls is sound even in a larger closed herd because of the speed-up in improvement. However, it is wise to retain a bull for more service in the herd if he has sired outstanding calves. Keep in mind that use of an outstanding bull at the expense of the other bulls is sound from the standpoint of selection, but it may result in inbreeding at a rate that will interfere with future selection. Thus, judgment must be used in determining how extensively a superior bull should be used in a closed herd.

- Care and management.

Proper care and management are exceedingly important in a closed herd because of the tendency for inbreeding to reduce fertility and early-life vigor. The selection that can be done is dependent on the number of suitable animals raised. Thus, it follows that every effort should be made through proper care and management to obtain and raise a large calf crop.

The purebred breeder is the key to the success in beef production. If the purebred breeder develops breeding stock of high genetic merit that will transmit outstanding performance in a predictable manner, such breeding stock can be used in grading up and crossbreeding in commercial operations. Commercial producers can not produce animals with high performance unless the bulls they use have the inheritance which makes this possible. Thus, the purebred breeder has grave responsibilities to the beef cattle industry.

Commercial Producers

Commercial breeders are concerned with obtaining maximum productivity of a desirable product at minimum costs. Normally, therefore, there is no place for inbreeding in a commercial production program even though inbred bulls not related to the cows of the herd might be valuable in the breeding program. Two breeding systems are possible for commercial producers

Grading up

The continuous use of good purebred bulls of the same breed along with replacing older cows with heifers in a herd will substitute the inheritance of the purebred animals for that of the herd on which such purebred bulls are used. The first generation of calves from a purebred bull will possess 50% of the inheritance of the purebred. The second generation, which is produced by mating these heifers to another purebred bull of the same breed, will contain 75% of the inheritance of the purebred. Four generations of use of purebred bulls will give about 94% of the inheritance of the purebred. This is so similar to the situation existing in the purebreds that it approximates the purebred level.

The use of production-tested bulls that are above average in performance in a commercial herd can grade it up not only to a general purebred level but to a high level of production.

The commercial breeder should not use bulls from the same herd continuously as this will tend toward lower performance level in certain traits. He should use bulls alternately from two good production-tested herds. In this way the general inheritance level of the cow herd can be increased for production traits, and the calves produced will show greater hybrid vigor. If bulls can be obtained from production-tested herds in which closed-herd breeding is practiced, even more hybrid vigor can be expected.

Crossbreeding

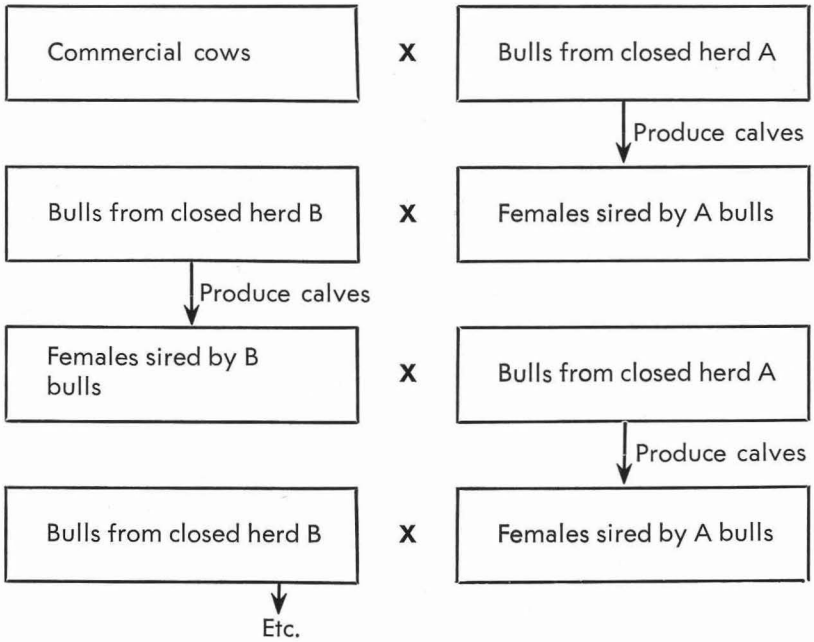
The crossing of strains or lines within a breed or the crossing of breeds may be classed as different kinds of crossbreeding. Several types of crossing exist. In general the genetic diversity is greater in wider crosses and should lead to greater hybrid vigor.

The continuous use of bulls that are unrelated to the cows of the herd is "outcrossing" or outbreeding. Also the combining of two unrelated outbred strains of cattle is outcrossing. If herds have been closed with all replacements selected from within the herd for three to five generations, such closed herds will have become more pure genetically (homozygous) and might be called inbred lines. The crossing of inbred lines is line-crossing.

The crossing of two breeds is called crossbreeding. Actually the crossing of two species such as Brahman x Hereford is also called crossbreeding. In fact, some people refer to all types of crossing as forms of crossbreeding.

With beef cattle, it is not practical to maintain lines of inbred cattle and converge them to produce hybrids in the same fashion as producing hybrid corn. However, bulls from closed herds used on groups of outbred cows transmit with a high degree of predictability.

Rotational use of bulls from closed herds—A commercial producer can use bulls from two closed herds by rotating from one herd to the other. In this manner, the commercial producer can obtain the high transmitting ability of bulls from the closed herds. Also, by breeding heifers that are sired by bulls of closed-herd A to bulls from closed-herd B, hybrid vigor can be obtained. Thus, the breeding of cows to bulls from the closed herd not providing their sires, will maintain in the cows and in the calves as much hybrid vigor as can be expected within a breed. This breeding system is outlined schematically below.



This system provides a means of obtaining a certain amount of increased vigor in the producing females and in their calves while

staying with a breed. Producers who do not like to cross breeds of cattle may find this system of breeding a very useful one.

Crossing breeds—Most herds of cattle have certain strong attributes as well as some weaknesses. Crossing two breeds for market-calf production is one way to capitalize on the strong points of both breeds.

The combining of two breeds makes it possible to utilize the strong features of each for increasing efficiency of production. If breed A is extremely high in fertility and milking ability and is large in size, females of this breed could be bred to bulls of breed B, which is very strong in postweaning rate of gain and in quality of carcasses. This cross should produce a calf crop that is well nourished until weaning. Inheritance from the sire would add to the animals' feedlot rate of gain and to the quality of their carcasses and result in marked overall improvement of production. However, this type of program has some practical difficulties because it involves the use of two breeds and marketing of all calves produced. It is also evident that making the cross in the opposite direction would be detrimental.

A good illustration of the importance of the way in which the cross is made is Angus x Holstein for producing "baby beef." Holstein cows x Angus bulls is a very desirable cross because calves are large at birth and Holstein cows supply them with an abundance of milk. The inheritance contributed by the Angus bull results in uniformly colored (solid black) calves. In addition, the beef type contributed by Angus bulls results in desirable slaughter animals.

A cross in which Angus cows are bred to Holstein bulls is undesirable because Angus cows deliver smaller calves and give less milk than Holsteins, but Holstein sires contribute inheritance for large, growthy calves. With greater growth stimulus and lowered milk supply, such calves tend to make skeletal growth satisfactorily, but they will show reduced muscle development and will not finish at the young age that is necessary.

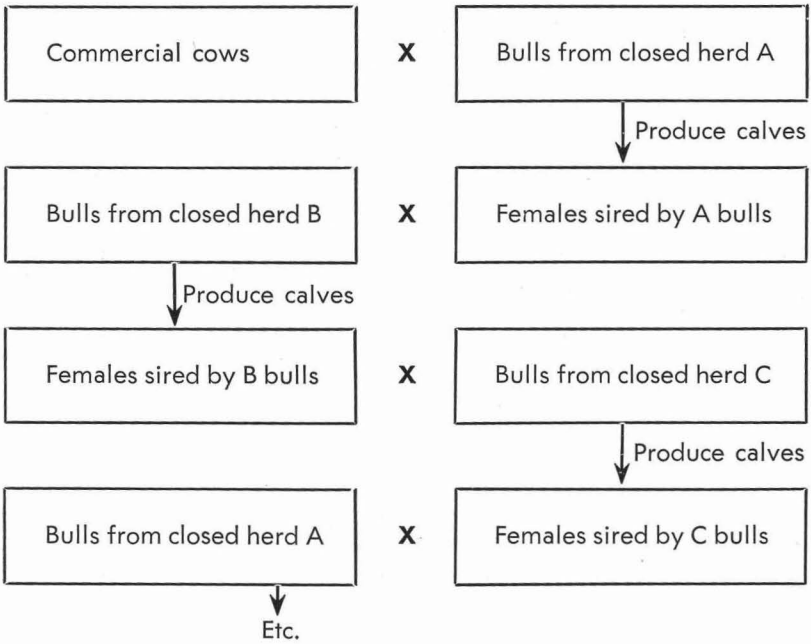
Perhaps the greatest use that can be made of this system of breeding dairy cows x beef bulls is in the production of milk-fat calves. Calves made to weigh 700-900 pounds in 9 to 12 months usually command a good price. Calves of this breeding sell at a discount as feeders because they show the influence of dairy type and, therefore, bring less money when finished at older ages.

Because of certain color discriminations, Angus bulls might be preferable to use on some dairy breeds, since brindles may be produced if Hereford or Shorthorn bulls are bred to Ayrshire, Jersey, or Brown Swiss cows. No brindles would be expected from Holstein or Guernsey cows bred to bulls of either of the three major British beef breeds.

This system of breeding has certain limitations. It is of value only in the production of slaughter calves that are to be marketed at a young age. The system also fails to capitalize on hybrid vigor in the producing female. It also means the use of straight-bred animals for their productive lives with no replacement females being kept, which means the continuous purchase of cows and bulls.

Another system of crossing breeds uses bulls of different breeds in rotation to capitalize on heterosis (hybrid vigor) of cow and of calf.

The rotational use of bulls from three different breeds results in hybrid vigor in the females and in the calves they produce. Hybrid vigor in the females results in greater fertility, milk production, and ability to withstand adverse conditions. Hybrid vigor in the calves results in reduced mortality in early life, greater vigor, more rapid growth, and the ability to withstand adverse conditions.

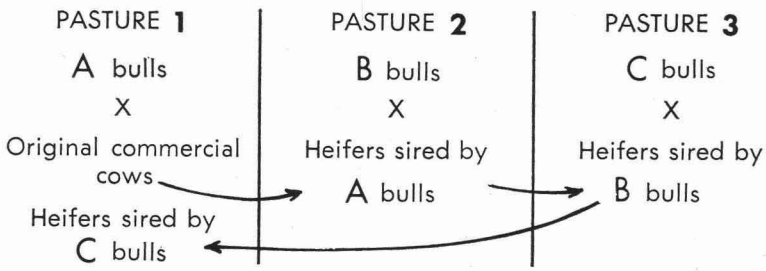


This system of breeding provides replacement females and requires only the purchase of purebred bulls. Its value is increased greatly if bulls used in rotation are obtained from closed herds so they will transmit with a high degree of predictability. Highly heritable traits can be capitalized on if the closed herds from which bulls

are obtained are under strict production testing as the basis for selection. Such traits as rate of gain, feed efficiency, and certain carcass characteristics are examples of the highly heritable traits that can be incorporated into the production program by using top production-tested bulls from closed herds of the three breeds.

Perhaps the greatest single obstacle to rotational use of bulls from three different breeds is color discrimination shown by buyers. This discrimination once had considerable basis because mongrel colors indicated lack of improved breeding. However, there is no real basis for color discrimination when purebred bulls of superior performance are used in a planned crossbreeding program. Difficulties in color discrimination can be overcome by selling slaughter animals on the rail-grade basis. However, the producer who has feeder animals to market is faced with the problem of educating feeder buyers regarding the feedlot merit of his cattle.

Consideration must be given to practical difficulties that arise from a rotational crossbreeding program. Obviously, the objective of such a program can be met only when the crossbred replacement females are mated to bulls of the proper breed to give continuity to the rotational scheme. This requires separate breeding pastures for each breed of bulls used. For example, a rotational breeding program in which bulls of three breeds are used, as previously outlined, requires three breeding pastures. The program for such rotational breeding is outlined schematically below.



With this type of program, bulls may be used as long as they are serviceable, because inbreeding will not result from their use. Also, once cows are placed in a breeding group their mating plan is determined. Heifers from any combination can be grown together and separated at breeding time into appropriate groups. All cows can be pastured together except during the breeding season.

If a producer previously has used only one breeding pasture, he can construct fences during the early part of his program because

only one breeding pasture will be needed the first two years. Two will be needed the third year, and three will be needed the fifth year. This gives adequate time for fence building and spreads the costs over a number of years.

A producer can identify a heifer calf at regular branding time by a brand denoting the breed of bull to which she is to be bred. The letter A could be used for breed A, B for breed B, and C for breed C —or numbers could be used. To make it easy to identify heifers for their respective breeding groups, their ears can be notched, locating notches differently for each group. Or, V, U, and □ types of notches can be used. It is suggested that notches be cut in the lower side of the left ear for breed A, in the lower side of the right ear for breed B, and that no notch be used for breed C.

Ranchers who along with other ranchers use public domain land as pastures for breeding need to cooperate as a group in deciding (1) whether they will use any type of rotational crossing program; (2) if a rotational-crossing program is to be used, what breeds will be chosen; and (3) how to fence to make the best use of the pasture as well as to provide the number of breeding pastures needed.

One other factor that may influence producers who normally market feeder cattle is the fact that hybrid vigor in the cow herd generally results in more milk production. Hybrid vigor of the calves also usually results in greater suckling gains. Both of these are highly desirable, but they lead to the production of calves that are heavier than usual at weaning. Larger weaners may sell for less per pound because feeder buyers prefer smaller feeders on which cheap gains can be made prior to finishing. Even though smaller weaners may sell for more per pound, the total income per cow usually will be lower than when larger weaners are produced. Although larger weaners could make cheap gains, the resulting slaughter animals might be too heavy and be penalized on the market. Producers may find it more profitable to finish their calves for slaughter instead of selling feeders. Custom feed lots make this possible for cattlemen who do not have feeding facilities. Large hybrid weaner calves can be finished for slaughter with a shorter feeding period.

Some breeds of cattle from Continental Europe offer considerable promise for use in crossbreeding because of their large size and heavy muscling. These breeds grow rapidly and they are rather distantly related to the British breeds common in this country which should result in considerable hybrid vigor. Also, some of the breeds of dairy cattle may have a place in crossbreeding for the production of beef.

There are two ways that the large Continental breeds or dairy breeds could be utilized: 1. Use one of these breeds as one of the three

breeds of sires in a three-breed rotation. Here one would find the Holstein and Brown Swiss useful dairy breeds. Such large breeds as Charolais and Simmental would be useful Continental breeds. 2. Use a dairy breed for creating a crossbred cow for mating to bulls of a large breed as a terminal cross for producing market animals.

If one uses a dairy breed of bull as one of the three breeds in a three-breed rotation, such breeds as the milking Shorthorn, Red Dane, Holstein, or Brown Swiss would be preferable to Jerseys, Guernseys, or Ayshires. Some brindles can be expected where Brown Swiss, Jerseys, and Ayrshires are used in combinations with Hereford or Shorthorn.

Any of the large Continental breeds such as Charolais, Simmental, Limousin, and Maine Anjou can be used as one of the three breeds in a three-breed rotation system. There may be some problems with fertility with some of the European or Asiatic breeds; therefore, one may want to breed about 10-15 percent more cows than he intends to have calve in the spring. The cows can be palpated for pregnancy in the fall and all open cows marketed. There may also be some calving problem when heifers are bred to bulls of the large breeds.

One of the costs in the production of beef cattle is winter feed for the brood cows. Larger cows eat more than smaller cows. What would be desirable would be small cows that could raise big, growthy calves. Angus bulls mated to Jersey cows would produce small to medium-sized crossbred cows that should produce an abundance of milk. If these crossbred cows were mated to a bull of a large breed such as Charolais, Simmental, or Limousin, the calves should grow rapidly and have a high percentage of lean with a low amount of fat. The crossbred Jersey x Angus cows should not experience great calving difficulty because the Jersey is unique in being able to deliver a large calf.

There are some problems with this system because it is based on marketing both heifers and steers produced when the bull of the large breed is used to sire calves produced by Jersey x Angus crossbred cows. Thus, one must either produce his own crossbred cows for replacements or purchase them. When Jersey bulls are mated to Angus cows, the steers produced will not be profitable; consequently, the cost of producing the Jersey x Angus crossbred heifers will be high.

If this system of crossbreeding becomes important, it is likely that some cattlemen will produce Jersey x Angus crossbred heifers that will be sold to other cattlemen who will use them for terminal crossing with bulls of large breeds. The latter group of cattlemen would market for beef both the steers and the heifers.

Selection

Definition of Selection

In both purebred and commercial herds the most effective method for increasing inheritance for desirable traits and decreasing inheritance for undesirable traits is through proper selection. Keeping the best and getting rid of the worst animals in the herd is not necessarily proper selection. What is best for man may not be best for the animals. It might be more appropriate to think of selection as keeping what we want and getting rid of what we don't want. There may be error in this concept because it is the number of young an animal leaves in the herd that determines how much selection pressure has been applied. We may illustrate this in the following way:

Suppose a man has kept two bulls—one that gained 2.5 and the other that gained 3.5 pounds per day. The owner probably feels that he has selected equally for these two bulls. Let us assume that 10 heifers by the bull gaining 2.5 pounds per day and 2 heifers by the bull gaining 3.5 pounds per day were used as replacements. In this case five times as much selection pressure was applied for a gain of 2.5 pounds per day as was applied for 3.5 pounds per day. Consequently, selection is differential reproduction.

Heritability

Certain traits will respond to selection to a greater extent than others. Traits that show marked response to selection are highly heritable. Heritability is defined as the amount of response obtained from the selection that was applied for the trait. If a herd of cattle averaged a gain of 2.0 pounds per day from which breeding stock was selected that gained 2.5 pounds per day, selection has been made for an increase of 0.5 pound in gain per day. If these selected breeding animals produced young that gained 2.3 pounds per day, a 0.3 pound increase has been obtained in gain per day. To determine heritability, divide the increase obtained by the increase that was selected for and multiply the dividend by 100.

$$0.3 \div 0.5 \times 100 = 60\%$$

This trait is 60% heritable because 60% of what was reached for in selection was obtained. Environmental variations and differences in environments between animals tend to mask genetic differences and result in less progress from selection. Thus, environmental variations reduce heritabilities. It is imperative that standard condi-

tions be established and that environmental differences between animals being compared be kept at a minimum.

One other factor needs consideration. A producer must not overlook an important trait in a selection program, because selection for one trait may lead to a decline in another unless selection for it also is applied. On the contrary, emphasizing a trait of no particular value reduces the amount of selection pressure that can be applied for the more important traits. Thus, a producer is faced with the problem of selecting for as few traits as possible without overlooking any important ones.

A trait that is lowly heritable will not respond effectively to selection. If a trait is lowly heritable due to wide environmental variability, one can increase heritability by standardizing the enviroment after which selection will be more effective. Low heritability resulting from dominance and epistatic* gene actions will result in little improvement from ordinary selection. Also, some traits are expressed only in the female (milk production, for example) even though the male transmits genes for such traits. To ascertain the genetic makeup of a male for traits expressed only in the female or for traits of low heritability, one may use progeny testing. One can define progeny testing as the evaluation of an animal on the basis of the performance of its offspring. There is no method of evaluating an animal's genetic merit that equals progeny testing in accuracy; however, it does take time and money to do progeny testing. To be effective, one must progeny test several males so that there can be a possibility of locating a few that are truly outstanding genetically. Also, for a progeny test to have accuracy, one must have a minimum of 8 to 10 offspring from each sire tested. One can probably justify progeny testing for evaluating bulls on their genetic make-up for milk production, inherited defects, and carcass merit. Traits that are easily measured and highly heritable such as rate and efficiency of gains can be improved more effectively by selecting on the basis of performance of the individual rather than by progeny testing. It is possible to notice that particular bulls or cows produce exceptionally good or bad offspring and retain or cull them on this basis. This is a modified form of progeny testing.

Traits to Emphasize and Consider

In general, the relative emphasis to be placed on various traits in selection depends largely on their relative economic importance and their heritability. The greater the economic importance, the greater the returns derived from each unit of improvement. The greatest overall return from selection is obtained by balancing the emphasis given to the various traits according to their heritability and economic importance.

Economic importance of various traits depends a great deal on the type of program followed in production. The man who is marketing weaner calves either for slaughter or as feeders finds suckling ability of his cows extremely important. However, if feeder calves are to be desirable in the feedlot, they must possess the ability to make rapid gains, to make efficient use of feed, and to possess desirable beef conformation. A producer of feeder animals must emphasize rate and efficiency of gains with acceptable conformation in his breeding stock if he expects to produce calves that command a premium.

In a commercial production program in which selected bulls are used in rotation from production-tested closed herds, the highly heritable traits are obtained through the bulls. Producers using such selected bulls can concentrate on selecting heifer replacements based on cow productivity. This means culling the cow herd on the basis of calf production. Cows are culled on the kind of calves produced to weaning, using weight and grade of calves as the basis. Replacements are kept on the basis of their records of weight adjusted for age and grade. This system of production is sound when bulls of superior productivity, particularly for postweaning performance, are used in rotation from closed herds or in rotation from different breeds.

A commercial producer who is grading up by selecting his best replacement heifers and using outbred bulls of the same breed must consider more than weight and grade of the heifers at weaning. He needs to keep at least two-thirds or preferably three-fourths of his heifer calves to obtain records of postweaning gains on them, so he will have information from which to make intelligent selections. He needs about 40% of his heifers as replacements annually, because some cows will be culled on production and some will be lost because of accidents or other reasons. Such a commercial producer can cull one-fourth to one-third of his heifers at weaning, make another culling at breeding time, and complete his heifer culling in the fall after the breeding season. These later cullings should emphasize weight-for-age, because one of the most important traits indicative of good cow productivity is weight at 15-18 months of age.

As stated earlier a purebred breeder producing bulls for use in commercial herds and having a herd of 75 or more cows that are acceptable in conformation, above average in performance, and relatively free of inherited lethals and abnormalities should consider closing his herd. The need might arise for introducing an occasional bull from another closed herd to correct a common weakness in his cow herd but no introductions would be necessary if a need did not develop. Selection based on performance of economically important traits within a closed herd tends to produce homozygosity or purity of desirable traits. Bulls from such closed herds used on commercial

cows will sire more uniformly desirable calves than will bulls from outbred or open purebred herds.

There is no advantage in closing an inferior herd because the production of purity for inferiority has no merit.

A purebred breeder developing useful breeding stock for commercial producers should emphasize all important production traits in his selection. This necessitates emphasizing fitness traits, even though they may be low in heritability. It also necessitates a desirable and uniform management program. Purebred breeders need to select for fertility, suckling ability, rate of gain, feed efficiency, carcass merit, and freedom from inherited defects. Most of the calves should be kept until they have been feed tested, although calves that are abnormal or undesirable at weaning should be culled. Excessive early culling will limit the amount of culling that can be done later; consequently, only limited culling should be done at weaning. Some ranchers may find it difficult to follow the complete program, but they should approach it as closely as practical situations permit. Some improvement will result if only a part of the program is followed.

The traits of greatest importance in beef cattle production along with heritability estimates of each are presented below.

Fertility

Fertility concerns the ability of females to breed and to drop calves early every year and the ability of males to breed and settle cows. This is a trait of low heritability but very important economically. No one factor contributes more to returns from a cattle operation. (See Figure 1, page 26.)

It is important to have a limited breeding season. Such a season, of 45-60 days, results in a calf crop of uniform age which should help in marketing. One of the hazards of year-round breeding is that cows of low fertility or those with a late calving pattern may not be noticed. Such cows may be overlooked in culling. A limited breeding season immediately brings these cows to a producer's attention.

Suckling ability

Suckling ability is measured by calf gains during the nursing period provided there is no supplemental feeding. It can be calculated as suckling gains by taking birth weight from weaning weight and dividing by the age in days at weaning. For example—

Birth weight	=	80 pounds
Weaning weight	=	480 pounds
Age at weaning	=	200 days

$480 - 80 \div 200 = 2.0$ pounds per day.

Since it may not be practical for commercial cattlemen to get birth weights, weaning weight minus average birth weight for the breed is recommended. For comparative purposes, weaning weight should be calculated to a common age. For example, the weaning weight of this calf can be adjusted to an age of 205 days as follows:

205 x 2.0 + 80 = 490 pounds = adjusted 205-day weaning weight.

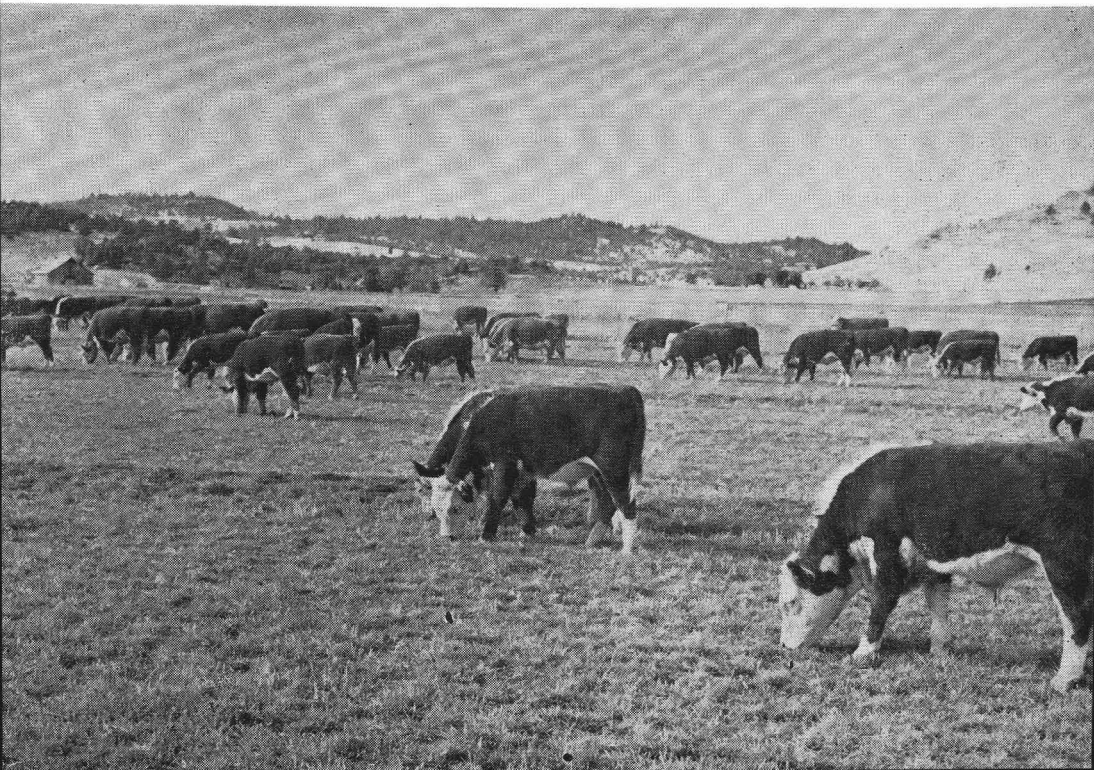
Suckling gains are lowly to moderately heritable, but they are very important economically because gains during the suckling period usually are obtained by use of cheap feed sources such as pastures and ranges. It takes very little more pasture for a cow that raises a large calf than for one that raises a small calf to weaning (Figure 2).

Postweaning rate of gain

Postweaning rate of gain is measured as gain per day in the following manner: final weight — weaning weight ÷ days from weaning to final weight.

Final weight = 1,080 pounds
Weaning weight = 480 pounds
Days from weaning to final weight = 240
1,080 — 480 ÷ 240 = 2.5 pounds gain per day

Figure 1. A good calf crop contributes greatly to financial returns from a cow-calf operation and enhances the opportunity for selection in any herd. In this herd the percentage calf crop weaned of cows bred was 94. (Early fall photo by J. D. Vertrees.)



This is measured easily if calves are placed on feed immediately following weaning. However, some producers "rough" calves through the winter and put on cheap gains the following summer on pasture. Where this procedure is followed, both summer and winter gains should be used in comparing animals. Cattle tend to compensate during one period for stresses suffered or advantages enjoyed during a previous period. Calves making lower winter gains usually make more rapid summer gains. If only summer gains are used for comparison, differences between animals have little value. Weaner calves should be wintered to gain around 1.5 pound daily in order to make the greatest total winter plus summer gains. Calves wintered under adverse conditions for long periods may be stunted. Young breeding stock should be fed to permit good growth, but heavy grain rations for long periods should be avoided. Test rations composed of two thirds roughage and one third grain when full fed will make comparison of animals valid without creating overfat conditions. Post-weaning rate of gain is hightly heritable and this trait is important economically.

Feed economy

It is necessary to feed animals individually if accurate feed economy is to be obtained (Figure 3). The amount of feed required per unit of gain is the usual way of expressing feed economy; or it can

Figure 2. Heavy weaning weight made on pasture without creep feed or nurse cows measures the milking ability of the cow and the growth capacity of the calf. The calf below weighs over 500 pounds at 205 days of age. (Early fall photo by J. D. Vertrees.)

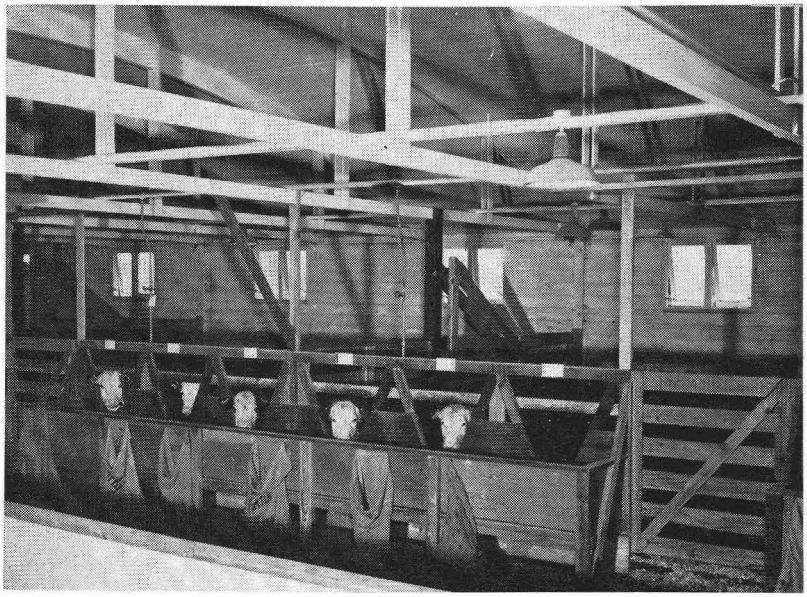


Figure 3. An arrangement for feeding beef cattle individually. Calves are tied by snaps hooked into the links of neck chains. Fed twice daily, they are allowed 3 hours for each feeding; then uneaten food is cleaned from the mangers and placed in sacks. Feed is weighed at each feeding and uneaten food is weighed each week to obtain weekly food intake. In some individual feeding arrangements, swinging panels keep calves from the mangers except at regular feeding times.

be expressed as the amount of gain made per unit of feed. Feed economy is closely related to rate of gain; therefore, selection for increased rate of gain will result in improved feed economy. Selecting for rate of gain is about 65-75% as effective as selection for feed economy itself. A cattle operation that does not permit individual feeding can make substantial improvement in feed economy by selecting for rate of gain. This trait is moderately to highly heritable.

Carcass merit

Selling price is influenced by the kind of carcass the animal produces. Visual appraisal of the live animal gives some indication of the kind of carcass it will yield. The accuracy of visual appraisal of live animals for carcass merit is greatest when appraised at the time animals normally are slaughtered. Visual appraisal alone of mature breeding animals is of little value. The condition of the animal influences the score given for type and conformation (the factors contributing largely to carcass merit). Animals that have suffered ad-

verse conditions or females that are nursing heavily will be lower in condition and will, therefore, score lower. Fat, mature animals will score high, yet they may produce calves that are inferior to calves produced by more productive, lower scoring cows. Since environmental conditions influence score for carcass merit, the heritability is not high.

Heritability of each of the traits previously listed above has considerable range. Heritability estimates are influenced by the amount of genetic segregation, the relative amount of environmental variation, and the types of genes controlling the trait. As a consequence, heritability estimates will vary from herd to herd and from time to time within a herd.

Work done by Oregon State University and others points to the value of "cutability" of carcasses and the fairly accurate estimation of cutability that trained individuals can make from visual appraisal of the live animal. Cutability refers to the boneless, lean meat of the carcass and this depends on the relative amount of fat and lean in the carcass. Muscle development or lean meat of the animal is estimated from development of areas that normally carry a small covering of fat, such as the outside of the lower thigh or round, even in the well finished animal. Waste fat is indicated by heavy covering over the rib, in the cod or udder regions, and on the brisket and flank.

To illustrate differences that are seen in live animals, two steers are shown in Figures 4 and 5. Number 19 (Figure 4) shows inferior development in the round when compared with Number 17, which is plump in the round but does not carry down low in the rear flank. Number 19 is also wasty in the brisket and throat, where Number 17 is fairly trim.

The loins from the two steers show Number 19 to be inferior (Figure 4) to Number 17, particularly in the lower amount of lean and excess amount of fat (Figure 5). Both carcasses graded USDA Choice. On present cutability standards, Number 17 is in Yield Grade 2, and Number 19 is in Yield Grade 4. There is approximately $40 difference in carcass value assuming each carcass to weigh 650 pounds. Thus, it would appear that considerable improvement could be made in lean meat percentage by giving attention to size and muscling when scoring animals.

Freedom from inherited defects

Inherited lethal and abnormal conditions lower production in a beef operation. Few, if any, herds are free from such traits. However, some herds have higher frequencies of genes for undesirable traits than others. Also, certain genes for some abnormal traits occur at a much greater frequency than genes for other abnormal traits. Most of the

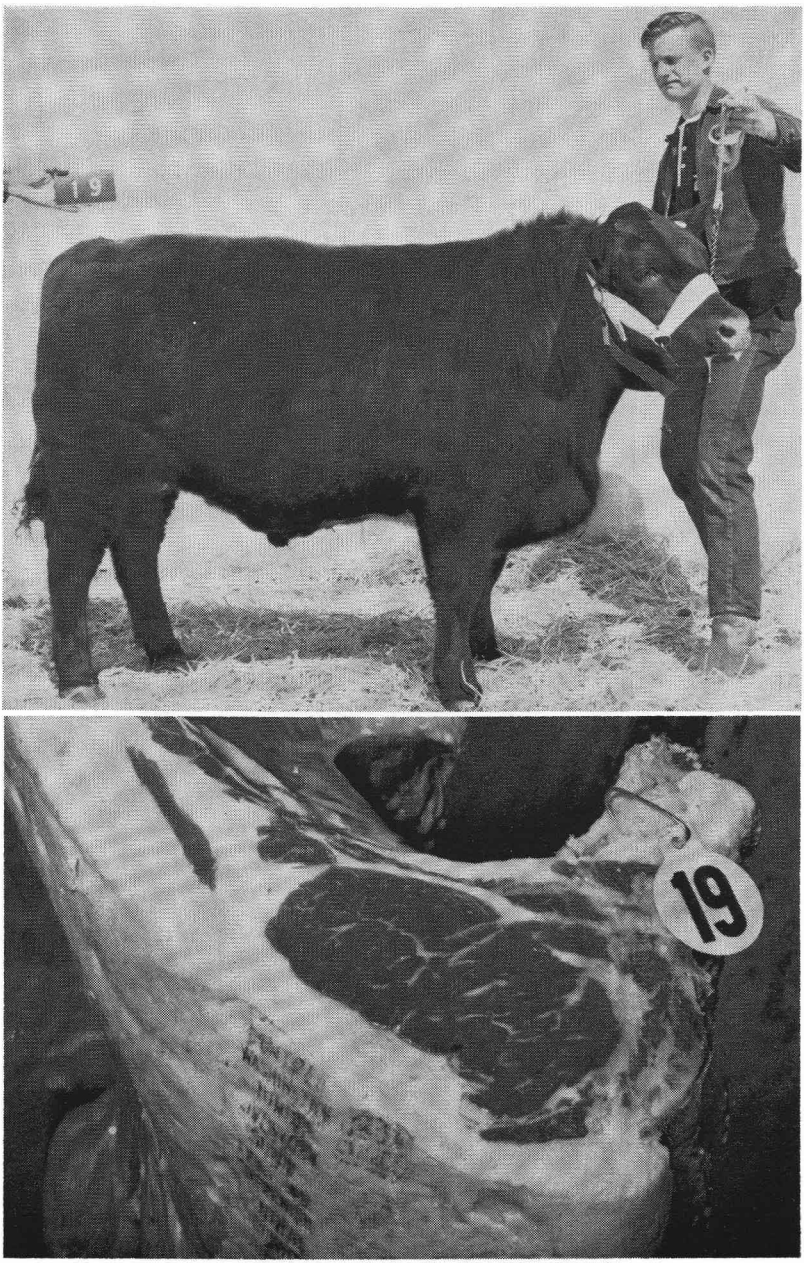


Figure 4. Steer #19 and loin cross section. Note overfatness and lack of lean.
(Photographs courtesy of Ed Reif, Club Agent, Yakima, Washington)

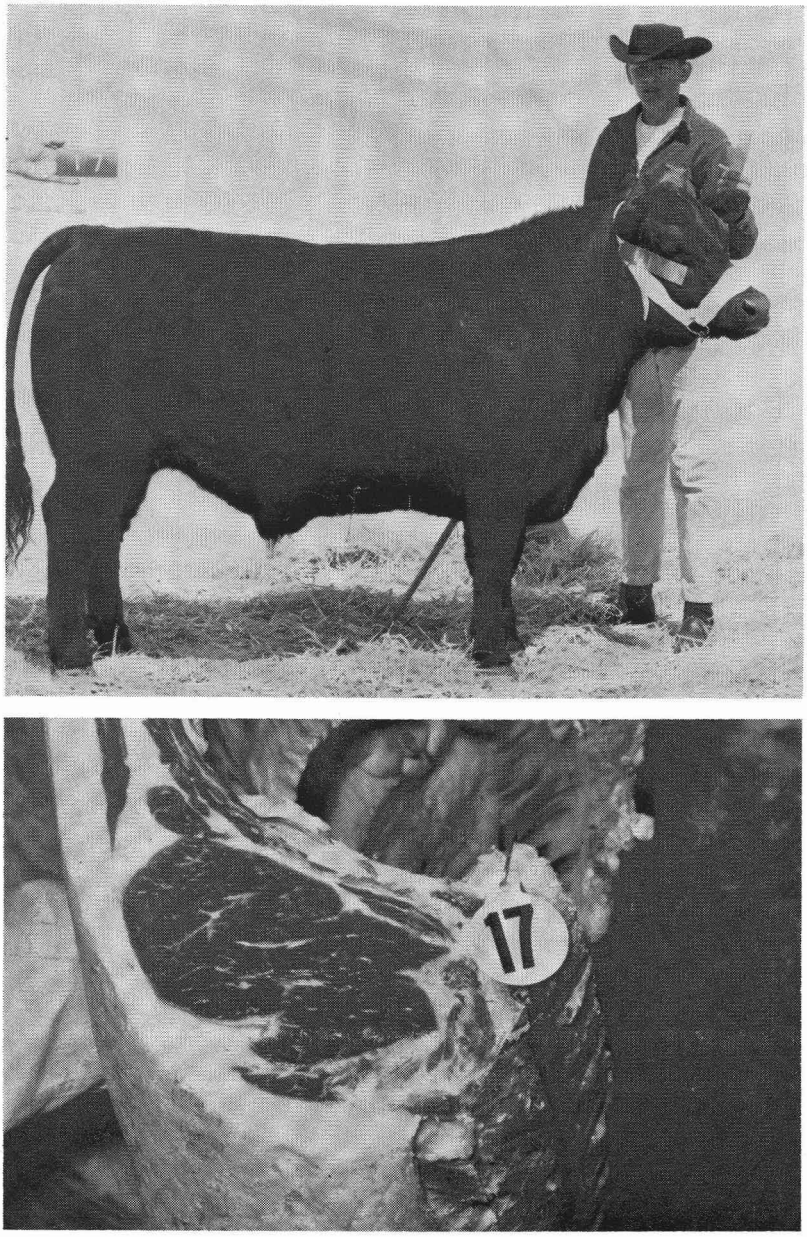


Figure 5. Steer #17 and loin cross section. Note small amount of fat and large loin eye.
(Photographs courtesy of Ed Reif, Club Agent, Yakima, Washington)

lethal and abnormal conditions are inherited in a simple way with only one or two pairs of major genes along with certain modifying genes being involved. About 50 different kinds of such abnormalities have been described in the literature.

Some types of inherited lethal and abnormal conditions that exist in cattle are illustrated below.

Bloating—Chronic bloating in cattle has been shown to have a genetic basis. The incidence of bloating is increased greatly by mating bloaters to bloaters (Figure 6). Chronic bloating is different from acute bloating when animals are on feeds such as alfalfa and clovers.

Cancer eye—Cancer eye (shown in Figure 7) has a genetic basis, but whether or not it is expressed depends on something initiating its development; therefore, cancer eye is much more prevalent in sand-blown and bright-sunlight areas. Animals that show no pigment around the eye, the "white-eyed" Herefords, are more susceptible to cancer eye than those with pigment, the "red-eye" Herefords. There is a temptation to remove a cancer eye from good cows or bulls so that more calves can be obtained from them. One should

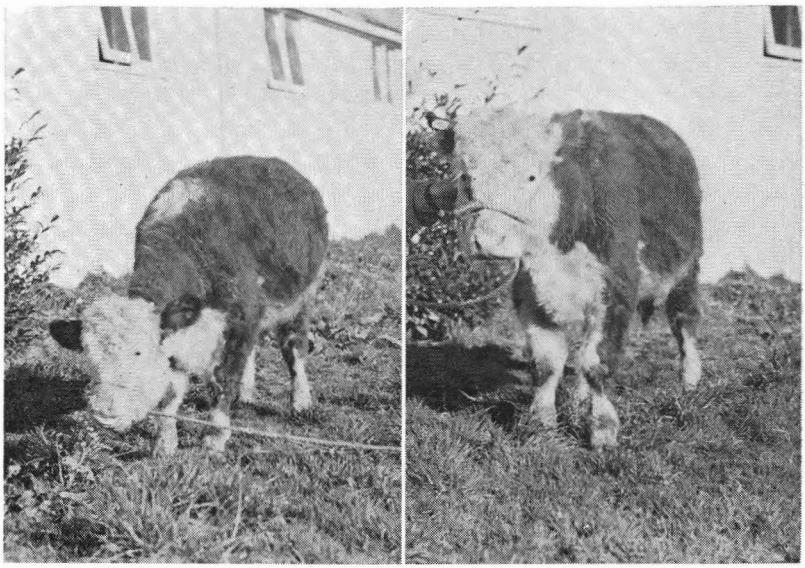


Figure 6. A chronic-bloater calf (left) showing marked distension of the barrel on the left side and acute discomfort before the gas was removed. Inheritance appears important as a causative factor in this type of bloating tendency. The same calf is shown on the right looking more comfortable after gas has been allowed to escape by running a rubber hose down the esophagus and into the rumen.

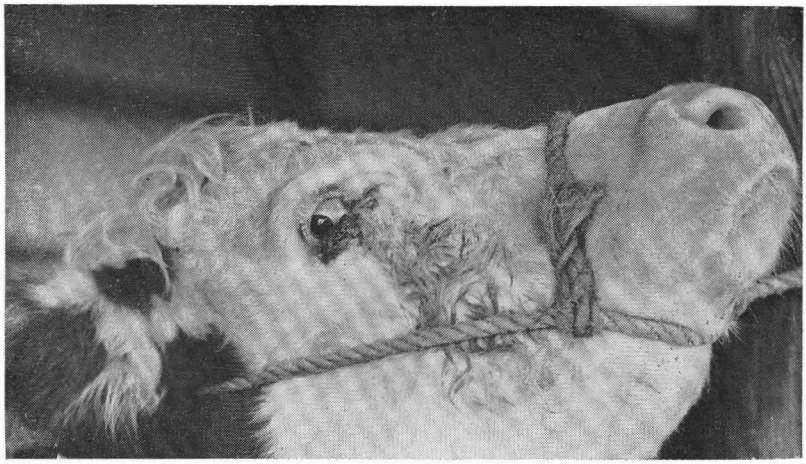


Figure 7. Cancer eye in a cow. This cancer involved the eye itself and had entered the bony structure above the eye. Cancer eye usually occurs at maturity and eventually causes death.

remember that susceptibility to cancer eye is under genetic control and any practice which allows animals with cancer eye to produce more offspring is a selection practice favoring the increase in frequency of this condition in the herd.

Hydrocephalus—Water on the brain is a lethal that apparently is inherited as a simple recessive. Most afflicted calves are born in a coma and never stand or nurse, but some live for a short time although they have difficulty in maintaining balance and show a pronounced bulging of the forehead (Figure 8). Hydrocephalus may not be recognized in calves born dead or that die shortly after birth unless the skulls are opened. Opening the skull discloses internal hydrocephalus (Figure 9) with rather large quantities of fluid in the brain region.

Dwarfism—The problem of dwarfism has been given a great deal of attention. Apparently, there are several kinds of dwarfism and the relationship of one kind to another is not clearly understood. Changes that have occurred in the selection of purebred beef cattle have reduced the frequency of dwarfism greatly. Greater emphasis on growth rate and lean-meat production rather than extreme compactness and short legs, particularly in young animals, tends to discriminate against animals that are heterozygous for dwarfism.

Double muscling—The heterozygous (impure) animal for the double muscling trait has a higher percentage of lean and less fat

Figure 8. Calf with hydrocephalus (water on the brain) showing marked bulging of the forehead.

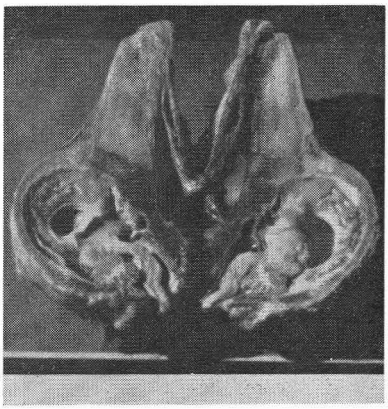


Figure 9. A calf head opened to show internal hydrocephalus. Note the fluid cavity in the brain region.

than animals lacking the gene for double muscling. However, the animal that is homozygous (pure) for double muscling is quite abnormal and has trouble with breeding and with delivery of the calf. Either the beef producer should select against double muscling or he should be certain that heterozygous double muscled animals are mated only to those lacking double muscling so that no homozygous double muscled animals will be produced. The trait is identified by heavy muscling in the round with a definite vertical crease in the round making it appear as two sets of heavy muscles.

Several other abnormal conditions occur. If the reader is interested, he can read more about the subject in publications listed at the end of this bulletin.

Control of Abnormal Traits by Breeding Methods

A lethal gene brings about death of the animal at or near birth. Delayed lethals cause death some time later even though the animal may be quite normal in early life. Partial lethals cause an affliction, but whether death occurs depends on conditions under which the animal develops.

Most genetically controlled lethal and abnormal conditions are inherited as simple recessives. If such conditions were caused by dominants, they would be eliminated entirely from breeding herds by selection against them. Dominant genes always are expressed, whereas recessive genes must be in the pure state for the trait to show. For example, the recessive gene for hydrocephalus (water on the brain)

may be carried in a heterozygous (impure) state in normal animals. When a normal appearing bull carrying the inheritance for hydrocephalus is mated to cows of like inheritance, approximately one calf out of every four will have hydrocephalus and die at birth or soon after. Thus when a hydrocephalus calf is born, it shows that the sire and dam carry the gene for hydrocephalus.

It is quite difficult to eliminate undesirable or lethal genes from a herd, because getting rid of the animals showing the condition will not eliminate the inheritance for the trait. Some method of detecting normal animals carrying the undesirable inheritance is necessary if the gene for the undesirable trait is to be eliminated from the herd. The usual genetic method for detecting normal animals that carry inheritance for an undesirable recessive trait is to mate animals in question to those known to carry the inheritance for the undesirable trait. Any animal that produces an undesirable offspring proves itself to be carrying the inheritance for this undesirable trait. There are three ways to know that an animal has the inheritance for an undesirable trait: (1) An animal that shows the trait itself is known to carry the inheritance in the pure state; (2) an animal that produces an abnormal calf is known to carry the inheritance in the impure state; and (3) an animal can be tested to find out if he or she carries the trait.

A bull can be tested by mating him to his daughters, because they must carry half of his inheritance. Animals possessing any recessive trait that does not cause death or sterility can be used as testers. For example, agnathia, or short underjaw, is an inherited recessive. Animals showing this trait could be mated to normal appearing animals to determine if they also carry the inheritance for agnathia. A normal bull carrying the inheritance for a recessive trait mated to cows possessing this trait should produce one normal to one showing the trait in his offspring.

Some inherited conditions bring about death (are lethal) or result in sterility; therefore, animals having such inherited conditions cannot be used for genetic tests to determine if normal animals carry such a trait. However, any animal that produces an offspring showing such a trait is a carrier and can be used as a tester animal. It can be mated to normal animals to determine if they also carry the inheritance for this trait. The expected ratio when a bull is bred to cows known to carry a recessive gene is 3 normal to 1 afflicted if the bull also carries the gene. All offspring are normal if the bull does not carry the gene.

A bull can be mated to his daughters as a means of testing whether or not he carries the inheritance for recessive undesirable or lethal traits. If he carries the inheritance for such a trait he will

transmit this gene to half his daughters. When he is mated to his daughters, those carrying this gene will produce one out of four calves showing the trait. The daughters not carrying the inheritance for this trait will produce all normal calves. The ratio of normal to abnormal for calves from a sire carrying the inheritance for a lethal or undesirable recessive trait when mated to his daughters is 7 normal to 1 abnormal.

The number of offspring, with no abnormals, necessary for proving with a reasonable degree of accuracy that a bull does not carry the inheritance for an undesirable trait is as follows:

When mated to animals possessing the trait = 7

When mated to normal animals that have proved they carry the recessive gene = 18

When mated to his daughters = 35

The number of offspring necessary to prove that an animal does not carry the recessive gene for an undesirable trait is so great that it is not possible to test cows and still have enough productive life remaining in them for use in an improvement program. Therefore, it is only through the testing of bulls and using only those proven not to carry inheritance for undesirable traits that the frequency of genes for undesirable inheritance can be reduced. This method should cut the frequency of the undesirable gene by half each generation unless there is a selective advantage for the undesirable trait in the heterozygous state.

Management Practices

Any improvement program through breeding methods hinges on effective management practices. It is not possible to breed cattle for superior productive performance without providing them with adequate feed and reasonable care. It naturally follows that improvement through breeding, improvement of pastures and ranges, good nutrition, sanitation, a disease-prevention program, and care in handling should all be considered. This does not mean feeding large quantities of concentrates or keeping the herd in high condition. Maintaining mature cattle in good breeding condition can be done on pasture, range and/or harvested roughage, while young cattle need a sufficient level of nutrition to insure normal growth if they are expected to do well. For example, cattle run on a sparse, poor quality range, as

Figure 10. Cattle grazing on a range in poor condition are thin and the calves are undersized. (Early summer photo.)

shown in Figure 10, cannot produce large, growthy weaners because there is not enough feed of good quality for cows to raise big calves. A good pasture, as shown in Figure 11, offers animals with good inheritance an opportunity to express their superior productive ability. Twenty pounds of grass-legume hay will maintain mature cows during the pregnancy period. After calving, the nutrient requirements increase nearly 100 percent.

The first- and second-calf heifers may be fed together and separated from the mature cow herd. They need as much feed per day as mature cows because they are growing and also developing a fetus. These young and smaller cows can not compete with older cows for feed.

Very low conception results from poor nutrition especially with young cows.

Where conditions are extremely severe, about all that can be done with an improvement program is to select animals best adapted to adverse conditions. It is not possible to select for superior ability to convert feeds into beef under such severe conditions.

Figure 11. Cattle grazing on a good quality range are thrifty and their calves are large in size. (Midsummer photo by J. D. Vertrees.)

Keeping and Using Records

It is essential that records be kept and used in a selection program. A simple record system is preferred if it provides the information needed for making correct decisions on whether an animal stays in the herd. Procedures for record keeping and analysis have been unified throughout the industry by the Beef Improvement Federation.

Oregon beef producers have procedures for record keeping of beef cattle outlined in OSU Special Report No. 315. This report has included the recommended procedures that have been suggested by the Beef Improvement Federation.

Production testing of two- and 3-year-old heifers is outlined in a pamphlet available from Oregon Extension Office and OSU Animal Science Department. The two- and three-year-old procedures may be most applicable to larger commercial herds where it is less practical to keep a record on all cows.

It is advisable to compare cows as a group that have been run under similar environmental conditions, otherwise you may be comparing one management system with another.

The national Beef Improvement Federation is composed of all the purebreed breed associations: Performance Registry International; The American National Cattlemen's Association; The Extension Service, USDA; state Beef Improvement Programs; and other organizations interested in improvement of beef cattle. The Beef Improvement Federation unifies the programs carried on by the breed associations that utilize electronic computer analysis for processing records and providing information to purebred breeders and commercial producers which can be used in their breeding and selection programs.

Purebred breeders are encouraged to cooperate with their breed program. Some purebred breeders will want records on feed efficiency and some purebred and commercial producers will use rate of gain during the nursing period rather than adjusting weaning weight to a constant age. A chart often is useful for calculating 205-day weight.

Records for Commercial Producers

Weaning record

The record sheet can be modified to fit particular conditions. This record form has been found useful by producers to adjust weights of calves to a common age and for age of their dams, thus permitting more accurate evaluation of both.

Identifying calves

The first requirement in a record keeping system is to identify every animal. Several methods can be used for identification. Choice can be made of ear tatoos, ear tags, neck chains with number tags, branding dyes, fire brands, or freeze brands. Neck chains and ear tags may catch in brush and be lost. Ear tatoos are not easy to read, as the animal must be caught and restrained. However, ear tatoo numbers are quite useful when applied as calves are dropped, so cow and calf can be permanently identified together.

Many ranchers prefer to use fire brand numbers at weaning time since such an identification can be read easily even by a man on horseback. Number brands may be placed on either shoulder using three digits (Oregon brand law). This permits numbering a good-sized herd. Branding dyes have value since very large, easily read numbers can be used. This material will last from calving to weaning time and is particularly useful for range operators.

It is emphasized that all information to be most useful in selection must be obtained on every animal. Purebred breeders must record the exact birth date. Commercial operators need birth dates correct within a week to adjust weaning weights to a constant-age basis.

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