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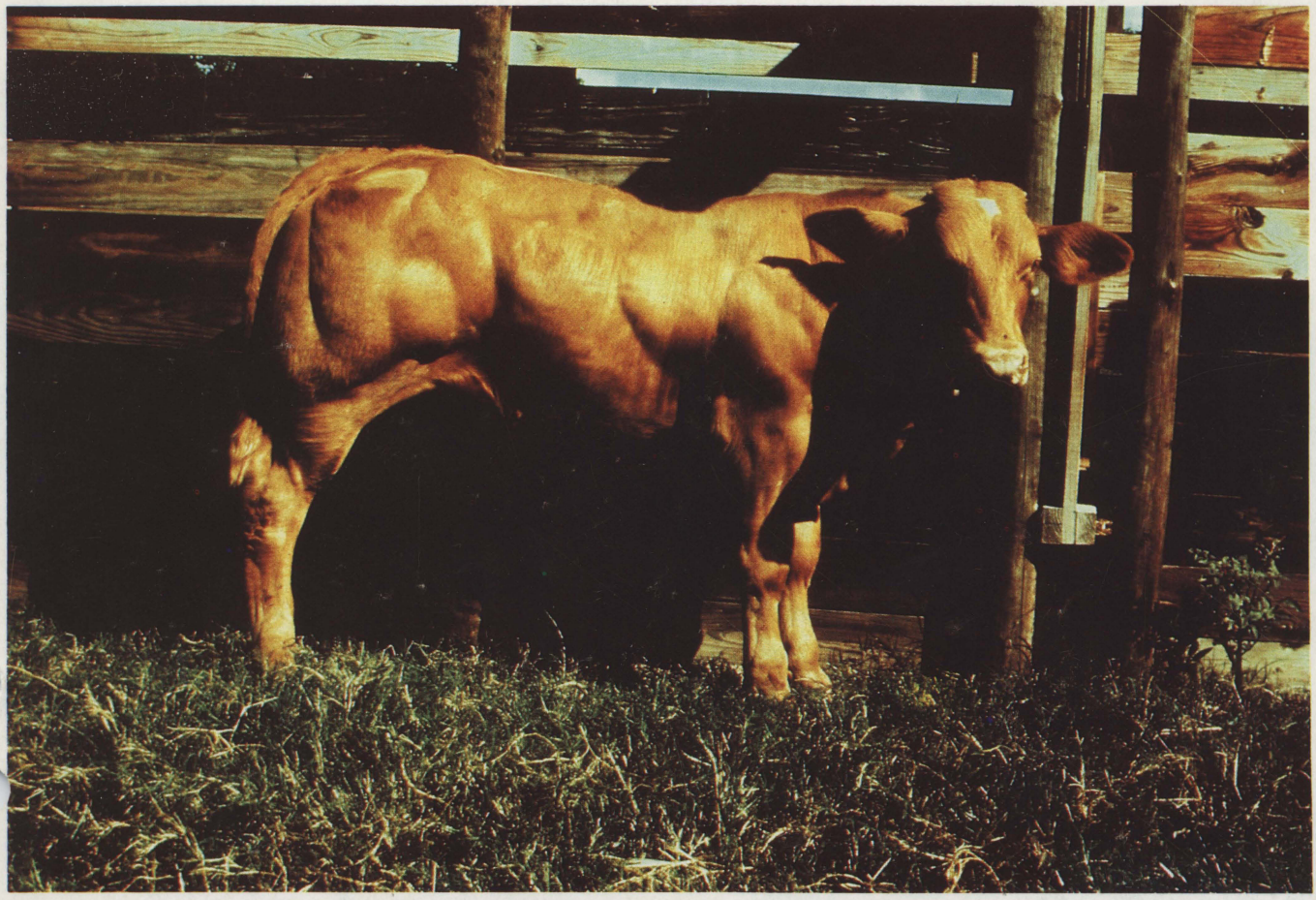
Double Muscling In Cattle



The Texas Agricultural Experiment Station, Neville P. Clarke, Director, College Station, Texas, The Texas A&M University System

Cover photo:

This 10-month-old bull is the product of a two-breed cross. He shows classic symptoms of double muscling and illustrates that the double-muscled gene is the same in different breeds of cattle.

Double Muscling In Cattle

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Contents

Summary

Double muscling in cattle is a genetic condition which reduces the overall suitability of the animal for beef production. Difficult calving, low viability of double-muscled calves at birth, poor milk production, and slowness of females in reaching sexual maturity are the most serious problems associated with double-muscled cattle. The heterozygote, or carrier of the double-muscled gene, is superior to normal cattle for most carcass traits and is equal to normal cattle for feedlot performance. In appearance the carrier animal exhibits to a lesser degree many of the same characteristics of the homozygous or pure double-muscled animal. In some cases, the carrier animal may be quite similar to normal animals, whereas in other instances it may resemble double-muscled animals. However, in most instances the double-muscled carrier is distinctly different from the normal and double-muscled animals, and the breeder can with experience become proficient in recognizing it. Although reproductive problems limit the usefulness of double-muscled cattle in a commercial beef operation, the double-muscled carrier is a superior beef animal, and its potential in a specialized system of production should be exploited.

Introduction

Throughout the years, the qualities most desired in beef have been tenderness, juiciness, and flavor. Prior to 1960, abundant fat covering on cuts of meat was not a significant point of consumer dissatisfaction as long as quality was obtained. Presumably, excessive fat was either eaten or trimmed off, according to individual taste, without too much complaint about the dwindled original purchase. However, beginning in the early 1960's, cuts of meat with excessive fat were discriminated against by the consumer regardless of whether the meat met traditional palatibility requirements. As a result, the concept of the meat-type steer quickly became of age, and its prototype was an animal which presented an overall trim appearance and displayed prominent muscling throughout. Trim animals with thick, bulging muscles were considered highly desirable because they were likely to yield an acceptable ratio of lean to fat in the carcass. There was great demand for herd bulls with thick, prominent muscling. The philosophy among many breeders seemed to be that if a moderate amount of muscling is good, then more muscling will be better. The era of the great muscle hunt began and, with it, an upsurge in the incidence of double-muscling in all breeds of cattle of European origin.

Historical Background

In 1834, Youatt, quoting a Mr. Marshall from the Yorkshire region in the northeast of England, described a situation in which butcher dissatisfaction with the local cattle led to the breeding of cattle similar to present day double-muscled cattle. Mr. Marshall stated in part that "the Holderness breed[1] of cattle were thin quartered, too light behind, and too coarse before; large shoulders, coarse necks and deep dewlaps. This form being found disadvantageous to the butcher, the breeder endeavored to enlarge the hindquarters and had he stopped when he got to a happy medium, he would have wrought a good work. However, the fashion was set — cloddy buttocks were in estimation." Continuing, Mr. Marshall further stated that "the first variety of this species of cattle I can recollect was a thick, large-boned, coarse, clumsy animal; remarkably large behind, with thick gummy thighs; always fleshy, but never fat, and the flesh being of bad quality. This however, was not the worst; the monstrous size of the buttocks of the calf was frequently fatal to the cow and numbers of cows were lost annually in calving. These monsters were stigmatized by the epithet, 'Dutch buttocked' and they were probably the worst breed the vale ever knew." History repeats itself, but its lessons are largely ignored.

Exactly one century after Youatt's quote of Mr. Marshall, Weber and Ibsen (1934) reported the occurrence of the double-muscled character in purebred beef cattle in the United States. According to Weber and Ibsen, the term "double muscled" was applied by a breeder of purebred Herefords in eastern Nebraska to a particular type of animal that had been appearing in his herd. These animals were abnormally thick and full in the thighs, with deep grooves appearing between the muscles. The rumps tended to droop, and the twists were sometimes without depth and fullness. These faults, together with the large thigh muscles, made the hindquarters of these Herefords very striking in appearance.

One of the double-muscled Herefords was sent to the Department of Animal Husbandry, University of Nebraska, for further study. It was placed on a fattening ration and later slaughtered. Professor William J. Loeffel examined the carcass and stated that it closely corresponded to a type known for a number of years to the packers as "Yorkshires." The term "Yorkshires" undoubtly is in reference to the "improved" Holderness breed of the Yorkshire region of England referred to by Youatt in 1934. Quoting Weber and Ibsen further, "another more common

[1] According to Wallace (1907) the Holderness cattle were foundation cattle of the present Shorthorn breed and were variously designated as Durham, Teeswater, Yorkshire or Holderness.

descriptive term has been used by the packers but it would not be advisable to render it literally in print. This term, somewhat modified by us, is "bottle thighed." Animals possessing the character (double muscling) are not favored by the packers because there is such a scanty covering of fat in the region of the round that the meat readily dries out, and the keeping quality is thereby reduced. There is also a lack of marbling and a tendency toward coarseness of grain in the meat."

According to Wriedt (1929), the occurrence of double muscling was also reported in Germany as early as 1888. Other European countries with an early history of double muscling in certain breeds of cattle were France, Belgium, Holland, Denmark, Norway, Switzerland, and Italy.

Physical Characteristics of Double-Muscled Cattle

Table 1 lists the characteristics most easily seen in double-muscled cattle. Double-muscling (DM) is syndromic, and thus, as the term syndrome suggests, double-muscling is a collection of several characteristics; together they lower the overall fitness of the animal. However, only rarely will an individual animal exhibit all the characteristics listed in Table 1. Actually, the term "double-muscled" is a descriptive misnomer, since the various skeletal muscles do not occur in duplicate. Rather, the large muscle size of the double-muscled animal is a result of each muscle having approximately twice as many fibers as does the muscles of non-double-muscled cattle (Swatland and Kieffer, 1974). Each of the 12 characteristics of double-muscling listed in Table 1 is discussed in the description of the animals shown in Figures 1-12. Figures 1-6 require additional comment at this point. It is often difficult for the breeder to perceive differences between double-muscled carriers and normally muscled animals. A few years ago a series of illustrations was made to help the breeder see these differences. These are shown in Figures 2, 3, 5, 6, and 12. Figures 1 and 4 are accurate representations of an actual double-muscled bull and heifer. These double-muscled animals have been redrawn to resemble typical double-muscled carriers (Figures 2, 5). In general, the characteristics of the pure double-muscled animal are expressed to a lesser degree in the carrier, and Figures 2 and 5 represent a scaling down of some of those features of double-muscling listed in Table 1. The double-muscled carrier is not always intermediate between pure double-muscled and normal animals. In some cases it may be quite similar to normal animals, whereas in other instances it may resemble pure double-muscled animals. However, in most instances the double-muscled carrier is distinctly different from normal and double-muscled animals, and the breeder can with experience become proficient in recognizing it. Figures 3 and 6 represent normal animals; they were derived by making certain conformational changes in Figures 4 and 5. These changes are discussed in the description following each figure.

TABLE 1. SOME PHYSICAL CHARACTERISTICS OF THE DOUBLE-MUSCLED SYNDROME

1. Thick tongue
2. Front legs bucked over and bowed out at knees
3. Large muscular quarters and shoulders
4. Forward tail setting and at a steep angle
5. Short tail
6. Overall trim appearance
7. Fineness of bone
8. Underdeveloped external genitalia
9. Hocks are extremely straight (post-legged) or in some cases may be crooked (sickled-hocked)
10. When standing, the animal assumes a stretched stance
11. Muscles which occupy the external space of the lower jaw tend to sag below the profile of the jaw
12. Open shoulders

Genetics

A substantial amount of data collected by the Texas Agricultural Experiment Station, the University of California at Davis, and European scientists show the inheritance of double muscling to be of monofactorial nature. This means that double-muscling has a genetic origin and that it is inherited by a single pair of genes. The authors' position, as well as that of Rollins *et al.* (1972), has been that the double-muscled condition is inherited by a single pair of recessive genes. However, the double-muscled gene does not conform to all of the criteria of the classical Mendelian recessive gene since carrier animals are usually different in conformation when compared with normal cattle. This has led some scientists to suggest that the double-muscled gene is incompletely recessive to the gene for normal muscling. The amount of double-muscled conformation expressed by the carrier may vary widely from one animal to the next, depending upon such factors as breed, age, sex, and physical condition. This aspect of gene action need not concern us here, since from the standpoint of practical transmission genetics, the double-muscled gene follows the rules of recessive Mendelian inheritance. The most important of these rules, which permits one to predict the results of a given mating are (1) double-muscled bulls mated to double-muscled cows always produce double-muscled calves; (2) double-muscled bulls or cows mated to normal cows or bulls produce all carrier animals with varying degrees of double-muscled conformation; (3) carrier bulls mated to carrier cows produce double-muscled, carrier, and normal calves in a ratio of 1:2:1, respectively; (4) double-muscled bulls mated to carrier cows produce double-muscled and carrier calves in a ratio of 1:1; and (5) normally muscled bulls mated to normally muscled cows produce only normally muscled calves.

Occasional exceptions to these rules may appear, but they are usually more apparent than real. Most often the discrepancy between the expected and the actual result of a given mating occurred because a double-muscled parent was confused with a carrier or

a carrier was mistaken for a normal parent. The latter of the two errors occurs more frequently and is usually a result of greater appeal of the double-muscled carrier bull (over normally muscled bulls) to the average breeder.

At Texas A&M University, approximately 50 double-muscled calves have been produced from double-muscled × double-muscled matings, and well over 100 carrier calves were produced in cooperator herds under supervision of University personnel. Only two calves from apparent double-muscled matings failed to show typical double-muscled conformation. The failure of these two calves to conform to the expected double-muscled conformation was considered to have resulted from mistaking their dams for genetically double-muscled cows when in fact they were genetically double-muscled carriers. Hanset (1967) has stated that in Belgium breeders may wrongly classify as double-muscled or non-double-muscled as many as 10 percent of newborn calves. Considering the variable expressivity of the double-muscled gene in the carrier state, it is not unlikely that such mistakes in classification will occasionally be made even by experienced breeders. Also, since the double-muscled gene appears to enhance the expression of normal muscling, it does not seem far-fetched to believe that cattle with an abundance of natural muscling might in some instances appear genetically double-muscled when in fact they are only carriers.

Double-muscled cows of four and double muscled bulls of two purebred breeds are represented in the double-muscled herd at Texas A&M University. All four breeds of cows have been crossed with each of the two breeds of bulls, and double-muscled calves have been produced from each cross. These results indicate that the double-muscled gene is the same in each of the four breeds represented in the University herd. Also of interest in this respect is that double-muscled embryos transferred to normal-muscled cows express the double-muscled conformation as if they had been carried *in utero* by double-muscled cows. This indicates that interaction of the maternal environment with the genotype of the calf is relatively unimportant in the expression of the double-muscled trait.

Reproduction and Growth

Even if double-muscled cattle excelled in all other characteristics by which merit is measured, slow sexual maturity and dystocia due to both the cow and the calf would seriously limit their usefulness as commercial beef animals. Double-muscled cows reach puberty later than do normal and carrier females. The average age at first breeding of the double-muscled cows in the Texas A&M University herd has been approximately 22 months. One extremely double-muscled cow did not conceive until she was 30 months of age, and some double-muscled cows remained barren for as long as they were in the herd. However, once double-muscled cows have reached puberty, they tend to be regular producers. Table 2 shows the circumstances at birth over a 4-year period of the double-muscled herd at Texas A&M University. This table makes clear the basis for the authors' position on the limited usefulness of pure-breeding double-muscled cattled in a commercial beef cattle enterprise. Of the 25 calves listed (Table 2), 9 were taken by Caesarean section, 10 were given a hard pull with a calf puller, 2 were assisted with a hand pull, and 4 were born without assistance. Ten of the calves were dead at birth, with deaths resulting from trauma associated with birth. In one of four cases where the cow calved unassisted and unobserved, death of the calf was due to dystocia.

The calving records of cows sired by known carrier bulls are shown in Table 3. Of the 67 cows recorded, about one-half would be expected to be double-muscled carriers and the other one-half normal since carrier bulls transmit both the normal and double-muscled genes with equal frequency. Carrier cows bred to double-muscled bulls have the genetic capability of producing double-muscled, carrier, and normal calves, whereas normal cows bred to carrier bulls can produce only carrier and normal calves. In Table 3, both carrier and normal calves are classified

TABLE 2. REPRODUCTIVE PERFORMANCE OF A HERD OF DOUBLE-MUSCLED COWS BRED TO DOUBLE-MUSCLED BULLS

Cow No.	Phenotype of calf	Birth weight (lb.)	Sex	Calving score[1]
801	DM	100	M	4, Died
801	DM	93	M	4
802	DM	70	F	1
901	DM	65	F	4
902	DM	80	F	4
904	DM	57	F	2, DAB*
906	DM	87	M	3**, DAB
907	DM	83	M	4
925	DM	—	F	1
931	DM	90	F	3, DAB
931	DM	95	M	3
933	DM	55	M	1
933	DM	110	F	3, DAB
934	DM	—	M	3, DAB
934	DM	110	M	3, DAB
934	DM	105	M	3
935	DM	100	M	3, DAB
935	DM	125	F	1, DAB
935	DM	75	F	2
936	DM	87	F	3, DAB
936	DM	70	F	4
936	DM	87	M	4
937	DM	92	M	3** DAB
938	DM	55	F	4
938	DM	110	M	4

[1]1 — Parturition not observed and/or no assistance given.
2 — Light assistance-mechanical aids not used.
3 — Mechanical aid necessary for delivery.
4 — Caesarean section.

*Dead at birth.

**Cow died from calving difficulties.

TABLE 3. REPRODUCTIVE PERFORMANCE OF COWS PRODUCED BY CARRIER BULLS AND BRED TO CARRIER BULLS

Items	Double-muscled calves		Non-double-muscled calves	
	Males	Females	Males	Females
No. Calves	6	3	32	26
Average age of dams (years)	3.5	2.7	3.0	3.1
Average birth weight (lb.)	102.3	95.7	94.6	84.9
Average calving score[1]	3.0	2.7	1.94	1.40

[1]Calving Scores:
1 = Parturition not observed and/or no assistance given.
2 = Light assistance — mechanical aids not used.
3 = Mechanical aids necessary for delivery.
4 = Difficult birth, cow lost and/or calf. Includes Caesarean section.

as non-double-muscled. The average calving scores of carrier cows which produced double-muscled calves was 3.0 for bull calves and 2.7 for heifer calves. Normal and carrier cows which produced non-double-muscled calves had average calving scores of 2.70 and 1.94 for bull and heifer calves, respectively. Since the same bulls sired double-muscled, carrier, and normal calves, sire effects on birth weight of the different kinds of calves should be minimal.

The effects of double-muscled conformation and weight on difficult birth are evident in comparisons of the data presented in Tables 2 and 4. The same double-muscled bull sired both the calves out of the double-muscled cows (Table 2) and the calves produced by the normal cows (Table 4). Double-muscled calves (both sexes) born to double-muscled cows had an average birth weight of 87 pounds, whereas calves sired by the same double-muscled bull and out of normal cows had an average birth weight of 95 pounds. In the latter herd, no calving difficulty was observed. After the first few calves were lost in the double-muscled herd, the decision was made to routinely perform Caesarean sections. The decision accounts for the birth by Caesarean section of light-weight calves (Table 2). These calves most likely could have been born without surgery, but on the basis of experience and the inability to predict birth weights, the decision to do Caesarean sections was felt to be justified.

Seemingly, two main factors contribute to the high incidence of dystocia associated with double-muscled births. First and most important is the shape of the calf. Double-muscled calves have massive hips and shoulders which make passage through the birth canal difficult (dystocia due to the calf). Secondly, the birth canal of the double-muscled cow is smaller than the birth canal of the normal cow, and dystocia due to the cow results. Thus, an abnormally shaped calf coupled with reduced size of the maternal birth canal makes normal birth very difficult. Large calves, whether double-muscled or not, tend to have more difficulty being born than light calves, but the large double-muscled calf presents a special problem because of the exaggerated size of the hips and shoulders. Seldom is a double-muscled calf having a birth

TABLE 4. REPRODUCTIVE PERFORMANCE OF NORMAL COWS BRED TO A DOUBLE-MUSCLED BULL

Cow No.	Breed	Phenotype of calf	Birth weight (lb.)	Sex	Calving score[1]
13	Mixed	Intermediate	82	M	1
34	Mixed	Intermediate	92	M	1
45	Mixed	Intermediate	91	F	1
47	Mixed	Intermediate	90	M	1
61	Mixed	Intermediate	104	M	1
71	Mixed	Intermediate	100	M	1
74	Mixed	Intermediate	82	F	1
155	Mixed	Intermediate	102	F	1
94	Mixed	Intermediate	100	F	1
69	Mixed	Intermediate	90	F	1
65	Mixed	Intermediate	90	M	1
75	Mixed	Intermediate	98	M	1
48	Mixed	Intermadiate	108	F	1
44	Mixed	Intermediate	92	M	1
74	Mixed	Intermediate	110	M	1
64	Mixed	Intermediate	82	F	1
57	Mixed	Intermediate	102	M	1

[1]No assistance given during birth process.

weight of more than 90 pounds born without assistance even when the calf is produced by a carrier cow. For the past few years, the authors have used a double-muscled bull from a medium-size beef breed. Large double-muscled cows bred to this bull have calved double-muscled calves weighing 65-75 pounds without assistance.

Often double-muscled calves have low viability at birth even when physical trauma associated with the birth process is not a factor. The calves appear to be quite strong at birth, but their condition deteriorates rapidly and they become weak and unable to stand and nurse. These calves tend to have higher than normal blood acidity levels, and the administration of a buffer, usually sodium bicarbonate, is effective in lowering blood acidity and improving viability. However, the most serious problem with newborn double-muscled calves is not high blood acidity, but large, thick tongues (macroglossia). The tongue is a prehensile organ that functions in the newborn calf by forming a "cup" so that the teat of the cow may be grasped in the nursing process. When the tongue is large and thick, "cupping" cannot be effectively accomplished and the calf cannot nurse satisfactorily. The newborn calf usually has a strong hunger impulse and attempts to nurse repeatedly. After a few hours without having nursed, the calf becomes tired and weak and will usually make no further attempts to nurse. Bottle feeding or feeding by a stomach tube is then necessary if the calf is to survive until the tongue regresses so that the calf may nurse naturally.

The pre-weaning growth potential of double-muscled calves is difficult to evaluate accurately because most double-muscled cows produce less milk over a similar time period than do carriers or normally muscled cows of the same breeding. It is not uncommon for double-muscled cows to be essentially

"dry" 90 days into the lactation period. There has been no attempt to analyze weaning weights because of year-round calving, variable lengths of time the calves received milk from their dams, artificial rearing of the calves, and effects of difficult calving on the subsequent milk production of dams. The general impression from observing double-muscled segregants (calves that had carrier dams) and artificially raised double-muscled calves is that they grow well until about 12 months of age. However, other researchers have noted that double-muscled cattle reach maturity at an earlier age and weight than do normal cattle.

Feedlot Gain and Carcass Characteristics

The average daily gain of double-muscled, carrier, and normal cattle is shown in Table 5. All three genetic groups made acceptable gains. The double-muscled carrier is of particular interest because it is superior to the normal animal for most carcass traits and equal for growth characteristics. It would seem a simple matter to breed carrier to carrier to reproduce their likeness, but since they are hybrids they do not breed true for their superior carcass characteristics. When mated together, carriers will produce on the average about 25 percent double-muscled, 50 percent carrier, and 25 percent normal cattle. Since double-muscled cattle have serious reproductive problems, mating carriers to carriers is not an acceptable way to produce carrier cattle. The most efficient breeding system for producing 100 percent carrier cattle is to mate double-muscled bulls to normal cows as a terminal cross. Since all calves would be slaughtered in a terminal cross, replacement females would have to be purchased or produced in a separate herd. Production costs likely would be higher in a terminal-cross mating scheme, but the potential for developing a demand for an animal with the carcass qualities of the carrier exists and should be exploited.

The carcasses of double-muscled cattle are characterized by small amounts of fat and large muscle masses. Table 6 shows certain slaughter and carcass characteristics of double-muscled, carrier, and normal cattle. Reduced fat deposition in the double-muscled animal prevents the carcass from grading in the choice and prime grades on the basis of USDA quality grades. However, recent feeding trials have shown that while fat deposition takes place at a slower rate in double-muscled cattle when compared with conventional and double-muscled carriers, the double-muscled animal will deposit substantial amounts of fat under prolonged feeding conditions. The large muscle masses of the double-muscle animal have approximately twice the number of muscle fibers per muscle as does the normal animal. The meat from double-muscled animals is tender and palatable, although it is drier and less favorable because of reduced fat content. The carrier tends to be intermediate in most carcass characteristics, and fat deposition is sufficient to satisfy those who like the flavor that fat imparts to muscle and yet who do not like meat with excess fat.

TABLE 5. AVERAGE DAILY GAIN OF DOUBLE-MUSCLED, CARRIER AND NORMAL CATTLE

	Steers		Bulls		Heifers	
Item	Carrier DM dm	Normal DM DM	Double-muscled dm dm	Carrier DM dm	Double-muscled dm dm	Carrier DM dm
Number	14	6	5	4	4	5
Days on feed	182	200	107	138	263	194
Final weight, lb.	1018	1017	1097	1096	1019	1019
ADG on feed, lb.	2.46	2.31	3.76	3.78	2.32	2.45

TABLE 6. SLAUGHTER AND CARCASS CHARACTERISTICS OF DOUBLE-MUSCLED, CARRIER AND NORMAL CATTLE[1]

	Steers		Bulls and Heifers	
Item	Carrier DM dm	Normal DM DM	Double-muscled dm dm	Carrier DM dm
Number	15	8	10	10
Slaughter weight, lb.	954	948	973	1008
Dressing %	62.2	61.8	65.4	63.8
Conformation	Choice	Good +	Prime −	Choice +
Marbling	Slight	Slight	Practically devoid	Trace
USDA quality grade	Good −	Good	Standard +	Standard +
Fat thickness, inches	.23	.38	.11	.17
Ribeye area, sq. inches	13.3	11.7	16.1	14.1
USDA cutability, grade	53.6	51.4	56.2	53.8
Shear force, lb.[2]	10.9	16.3	13.3	13.1
Cooking loss, %	31.4	33.02	31.7	33.1

[1]Adapted from West (1974).

[2]Shear is an objective test of tenderness, the lower the value the more tender.

Although reproductive problems limit the usefulness of double-muscled cattle in a commercial beef cattle operation, the double-muscled carrier is a superior beef animal, and its potential in a specialized system of production should be exploited.

Literature Cited

Hanset, R. 1967. Le probleme de l'hypertrophie musculaire ou caractere "culard" dans la race bovine de moyene et haute Belgique. Annls. Med. Vet. 111:140-80.

Rollins, W. C., Moira Tanaka, C. F. G. Nott and R. B. Thiessen. 1972. On the mode of inheritance of double-muscled conformation in bovines. Hilgardia. 41, no. 14.

Swatland, H. J. and Nat M. Kieffer. 1974. Fetal development of the double-muscled condition in cattle. J. Anim. Sci. 38:752.

Wallace, Robert. 1907. Farm livestock of Great Britain. 4th ed. Oliver and Boyd, Edinburgh.

Weber, A. D. and Herman L. Ibsen. 1934. The occurrence of the double-muscled character in purebred beef cattle. Proc. Am. Soc. Animal Prod. 27:228.

West, Roger L. 1975. Carcass traits and the organoleptic, chemical and histochemical characteristics of muscles from double muscled and normal cattle. Ph.D. dissertation. Texas A&M University.

Wriedt, C. H. R. 1929. Die verebung des droppellender-characters bei rindern. Z. indukt. Abstamm.-u Vererblehre. 51-482-86. (Cited by Weber and Ibsen).

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Figures 1 through 12 were drawn by James E. Smallwood, associate professor, Department of Veterinary Anatomy, College of Veterinary Medicine, Texas A&M University.

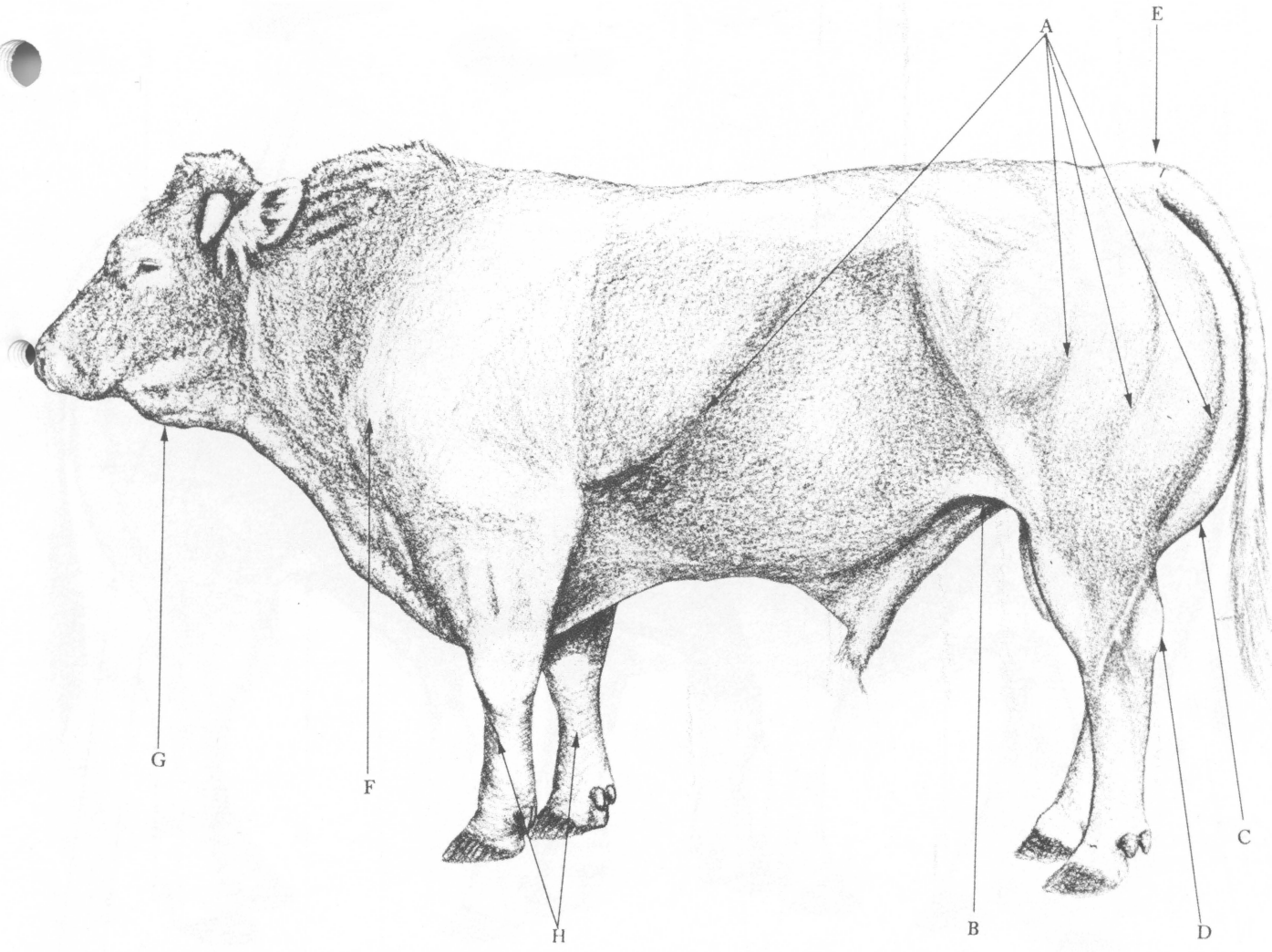

Figure 1. Actual double-muscled bull.

The most obvious departure from normality of the double-muscled animal is the enlargement of the skeletal muscles. Although all muscles are enlarged, the increase in muscle mass is most apparent in the muscles of the rear quarters. In the above figure, the muscles are delineated by deep creases (A). One of the reasons for the apparent sharp separation between different muscles is the almost total lack of external fat to smooth out the creases between the different muscles. The double-muscled animal is very trim and is often "cut-up" in the flanks (B). In profile, the rear quarters describe the arc of a circle (C). The hocks are often very straight (D), causing the animal to stand on its toes. This is called the post-legged condition, although the opposite, or sickled hocked condition is sometimes seen (Figure 11). The tail head is attached farther forward than in non-double-muscled animals (E). The shoulders are prominent because of increased muscle mass (F). Double-muscled animals often have "open" shoulders because muscles medial to the shoulder blades tend to push the shoulders away from the body. Double-muscled animals are light boned, and the reduction in bone is most apparent in the cannon bones (H). The muscle which occupies the space between the two halves of the lower jaw tends to sag prominently below the jaw bone (G). The head of the double-muscled bull is often plane and "cow like" and may lack the overall masculinity of non-double-muscled bulls. Double-muscled animals (both males and females) within a given breed are usually smaller at maturity than their contemporaries even though they may grow more rapidly than normal during the first 12 months of life.

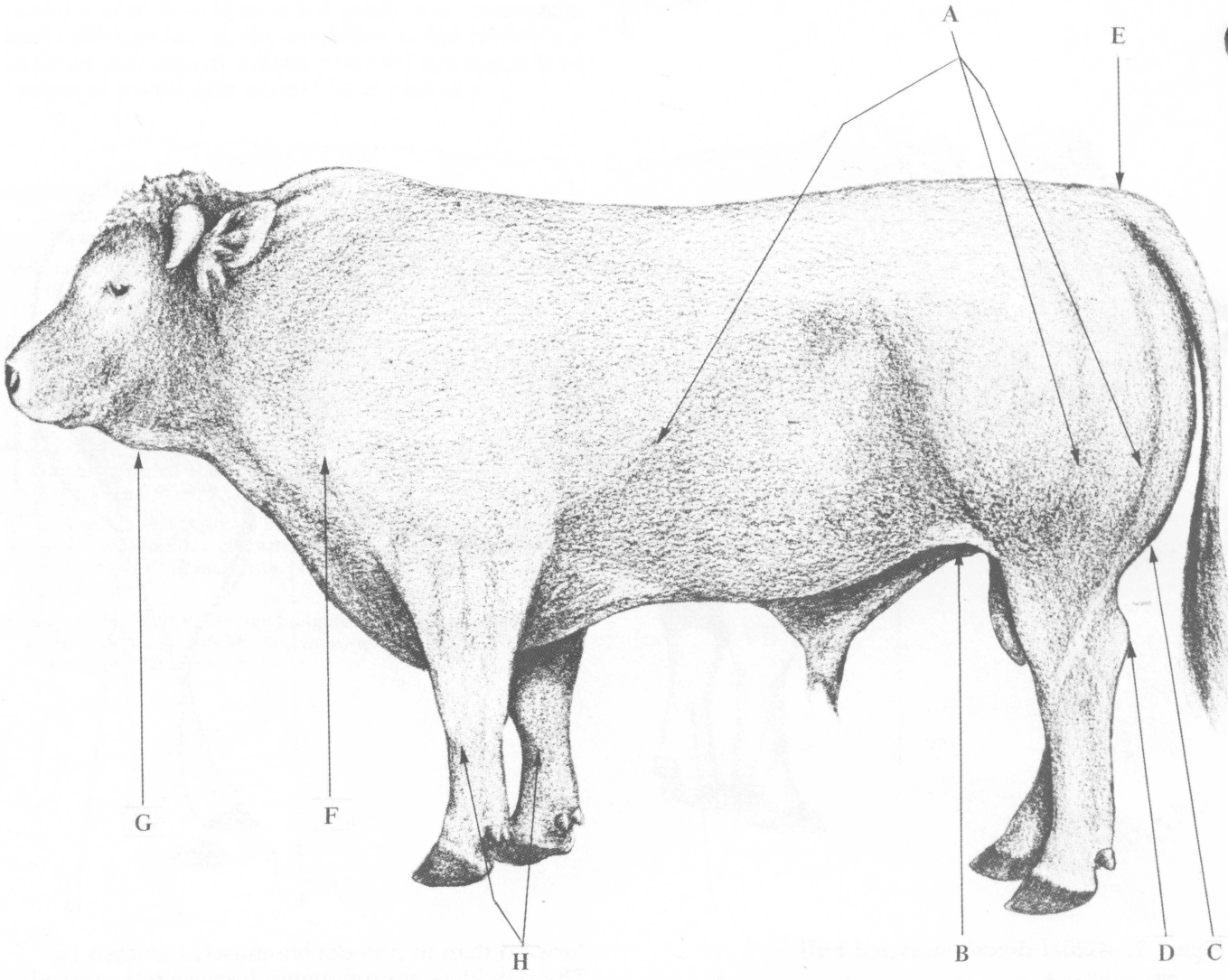

Figure 2. Diagrammatic representation of a double-muscled carrier bull.

The bull shown in this figure is a diagrammatic representation of a heterozygote (carrier) for double-muscling. The bull in Figure 1 served as the model for construction of the bulls shown in both Figures 2 and 3. The heterozygote shows many of the same characteristics of the homozygous (pure) double-muscled animal, but to a lesser degree. The carrier has one copy of the gene for double-muscling and one copy of the gene for normal muscling. The homozygous or pure double-muscled animal has two copies of the double-muscled gene and none for normal muscling. As a rule, the carrier tends to resemble the non-double-muscled animal a bit more than it does the double-muscled animal. However, there is considerable variability among carrier animals. Some carriers may be almost as extreme in muscling as pure double-muscled cattle while others may overlap with normal cattle. In Figure 2 the muscle creases (A) are still visible, but not to the degree as in the bull shown in Figure 1. The flank is lower (B), and the overall trim appearance is not as marked as in pure double-muscled animals. Trimness is associated with leanness, and fullness is an indication of fat deposition. The arc (C) described by the rear quarters is not as pronounced, and the hock (D) is not quite so straight as in Figure 1. The tail head (E) is not set as far forward as in the double-muscled (DM) animal, and bone development (H) may approach that found in normal cattle. However, while bone development is usually less than for normal animals, the amount of bone as an indicator of double-muscling must be used with caution because of differences in availability of minerals from one area to another. The shoulders (F) of the carrier are not as prominent as in the DM animal, and the muscles occupying the space between the two halves of the lower jaw are less prominent (G). The carrier bull is more masculine, showing (usually) more crest development and a shorter, broader head. The testicles are of normal size and contrast markedly with the testicles of the double-muscled bulls which tend to be very thin.

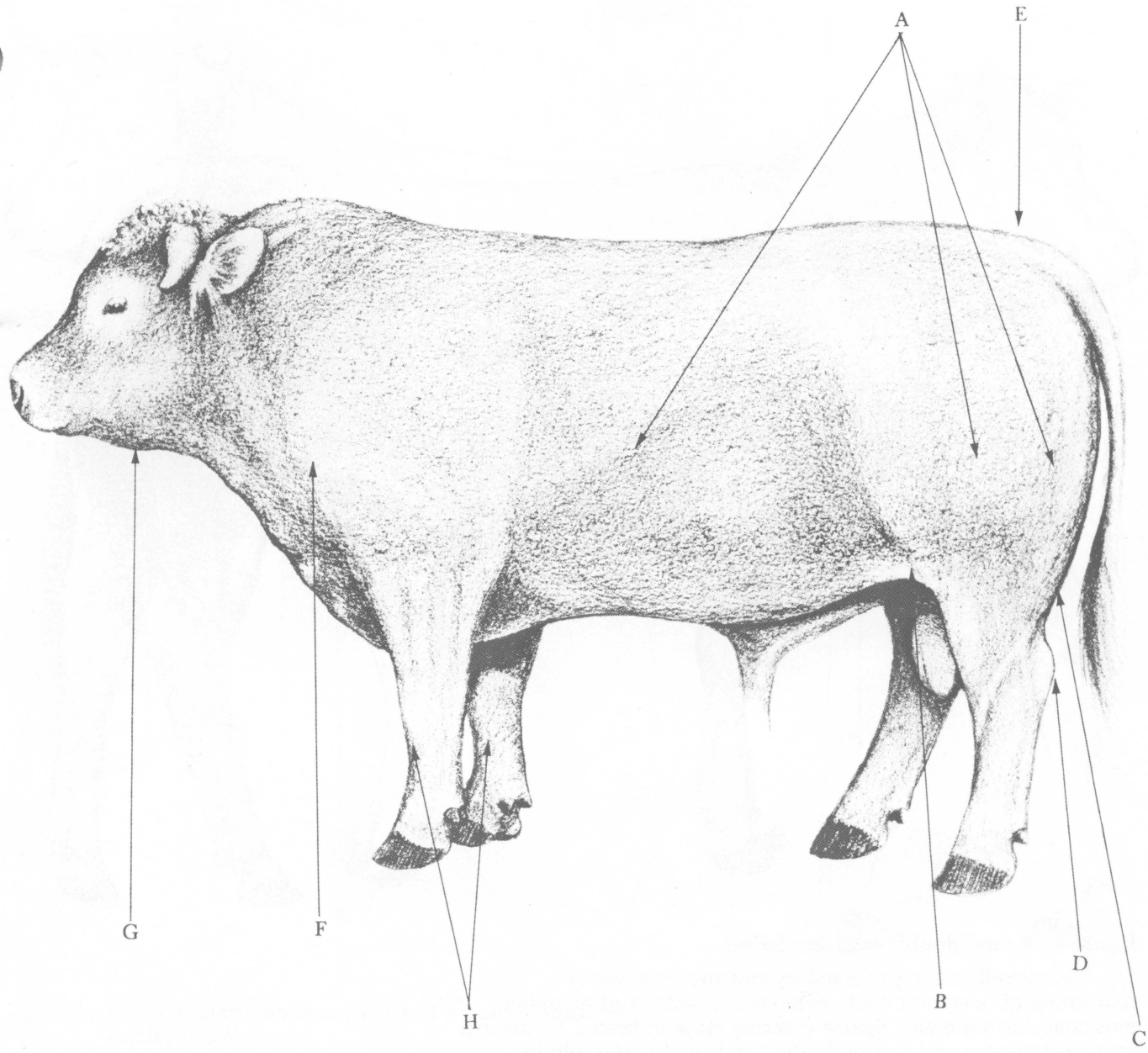

Figure 3. Diagrammatic representation of a normally muscled bull.

This bull differs markedly in several important characteristics from the bulls shown in Figures 1 and 2. First, the muscular creases are barely perceptible (A). The bottom line is deep and level and the body is full throughout (A,B,C). There is more "set" to the hocks (D), and the muscling of the rear quarters carries down to the hocks. The pronounced curvature of the rear quarters is diminished (C), and the tail head is smooth (E). The shoulders are "laid in" (F) so that the body width is uniform throughout. Bone development (H) is in keeping with normal body proportions, and the head and neck show normal masculinity. The lower jaw muscles sag only slightly below the profile of the jaw (G). The testicles are larger than for the pure double-muscled bull, but are not necessarily larger than the testicles of the carrier.

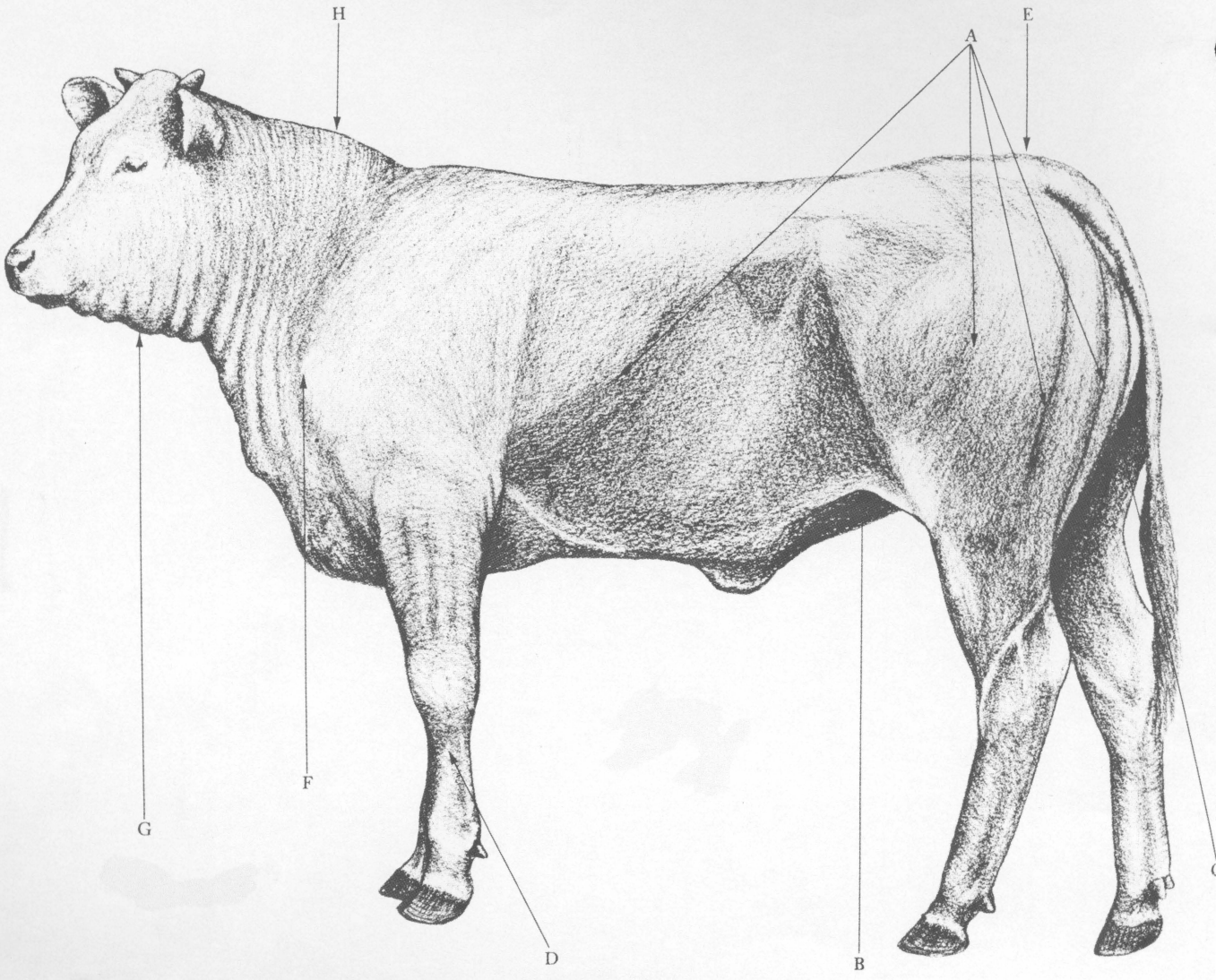

Figure 4. Actual double-muscled heifer.

The overall image projected by this heifer is one of coarseness of head and neck, trimness of body, and excessive muscular development. Sparse external fat is indicated by distinct muscular creases and a very "tight," trim body. Masculinity, which is characteristic of the double-muscled female, is readily apparent in this heifer. There is excessive neck development (H), the head is bullish, and the muscles occupying the space between the two halves of the lower jaw are excessively developed. Fine bone is evident in the front cannon bones, (D) but the rear cannon bones appear more nearly normal in development. The tail head setting (E) is placed much farther forward than for normal cattle. In general, the double-muscled female exhibits many of the same characteristics exhibited by the male. However, muscular development is accented more in males than in females. This results because males are normally heavier than females, and the presence of the double-muscled gene tends to magnify sex differences in muscling.

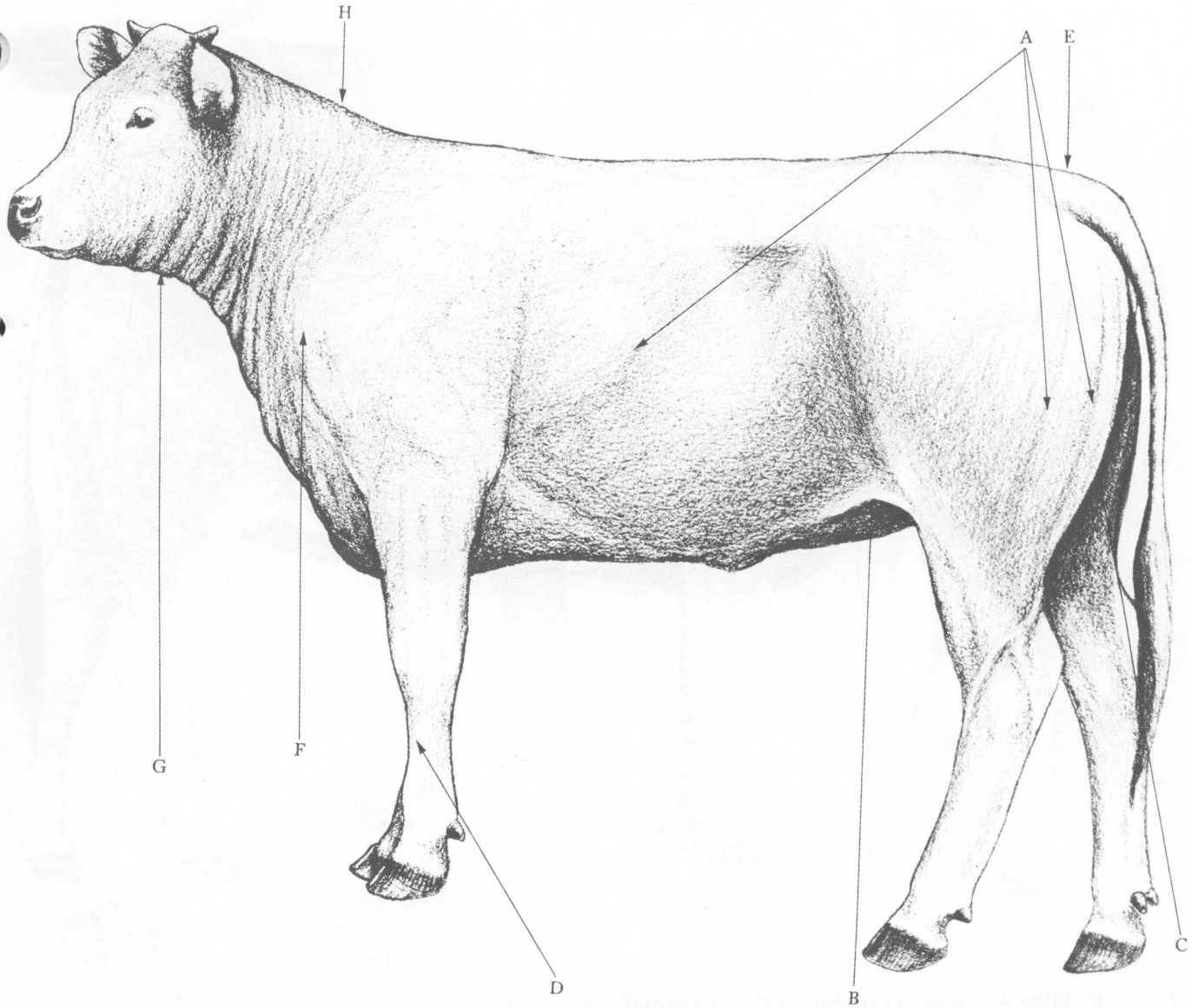

Figure 5. Diagrammatic representation of a double-muscled carrier heifer.

The features of double-muscling so prominently displayed by the heifer shown in Figure 4 have been scaled down to a degree consistent with their expression in the carrier for double-muscling. This heifer is not nearly so trim as the double-muscled heifer and yet she is not "wasty". The muscle creases are still apparent (A), but decreased muscle size coupled with increased fat deposition has greatly reduced their prominence. The heifer is more feminine, especially about the head and neck, than the double-muscled heifer. The front cannon bones (D) are more refined than in the normal animal, and the flank is "raised" (B), which is consistent for animals having inheritance for double-muscling.

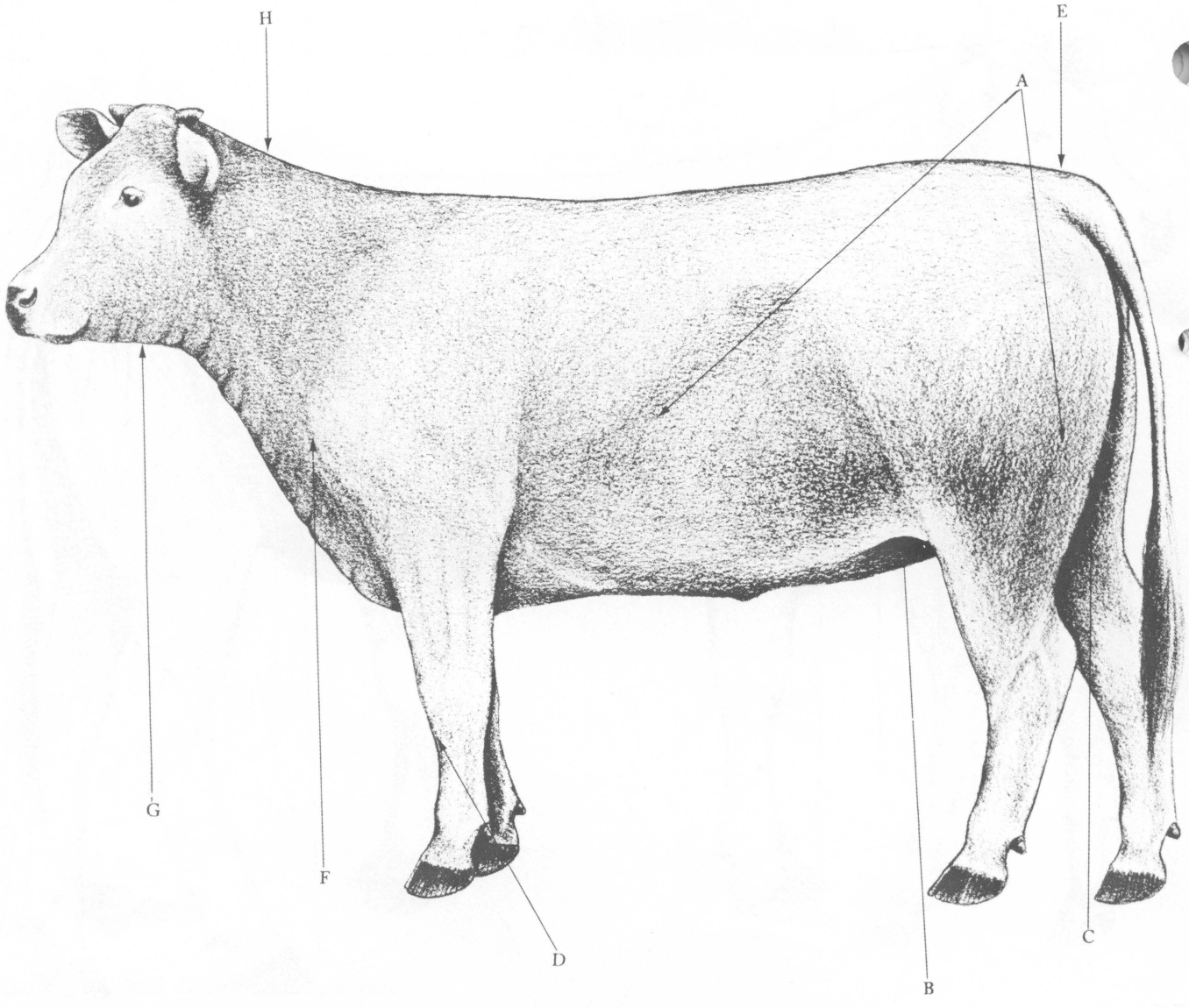

Figure 6. Diagrammatic representation of a normally muscled heifer.

The normally muscled heifer is characterized by having a deep, level bottom line, increased bone, absence of muscular creases, and greatly increased refinement about the head and neck. The shoulders are smooth, and there is more "set" to the hocks. The tail head attachment is not as far forward as for the heifers in Figures 4 and 5, and the rear quarters are long and straight and tie in smoothly just above the hock.

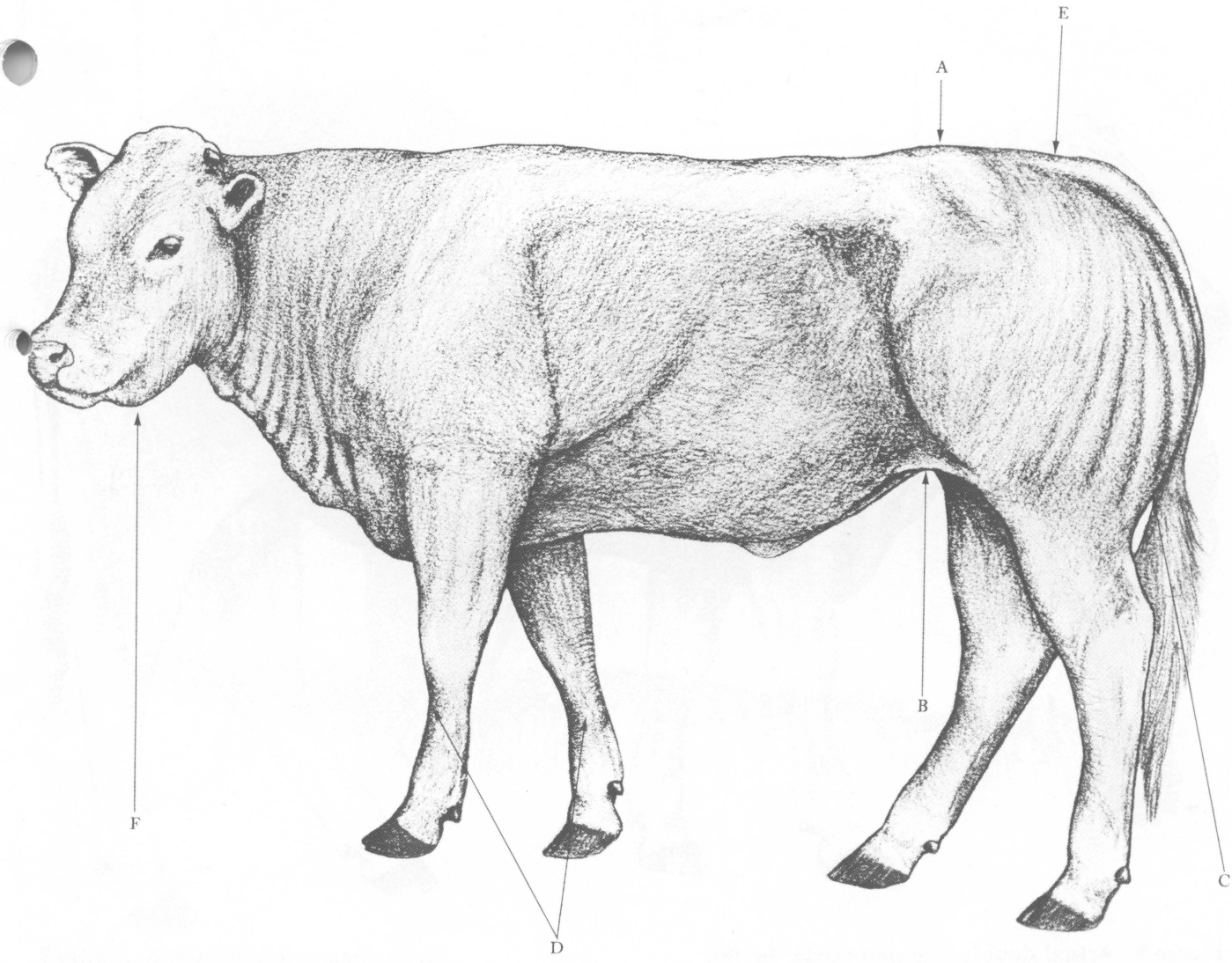

Figure 7. Actual double-muscled heifer.

Considerable variability may exist among individuals who have identical heredity for traits which are conditioned by one or more pairs of genes. In the case of double-muscling, variation among animals may be due to the interaction of the double-muscled gene with other genes which also affect the amount of muscling. Likewise, the rearing of different animals under different management practices can affect the degree of muscling. The heifer shown in Figure 7 is extremely heavy muscled, although her inheritance for double-muscling is thought to be identical to that for the heifer shown in Figure 4. However, the features of double-muscling are very similar for both heifers, and one could not fail to see strong similarities. For example, sagging lower jaw muscle (F), light bone (D), tucked up flank (B), and the arc-shaped rear quarters (C) are all symptoms of double muscling. The degree of expression may vary from one double-muscled animal to another, but usually not to the extent that one would mistake the animal for anything other than double-muscled. The tail head (E) of the heifer shown above has the most forward setting one is likely to see in double-muscled animals. Also the medial gluteal muscles (A) (baseball-like muscles on either side of the center line in the loin area) may be very prominent, and they tend to move up and down in an exaggerated fashion when the animal walks.

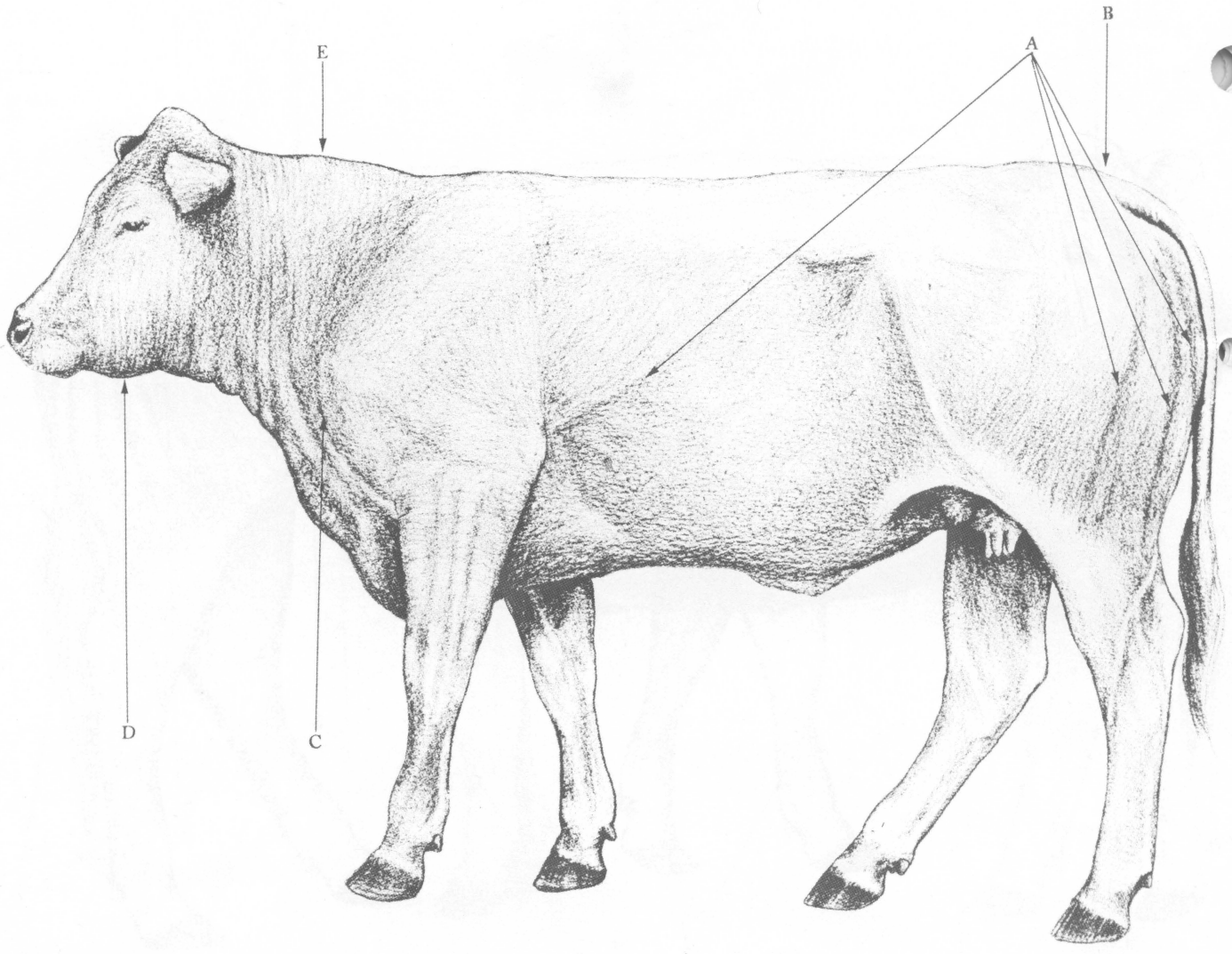

Figure 8. Actual double-muscled carrier heifer.

The double-muscled carrier corresponds closely to the ideals of the modern meat-type animal both from the standpoint of muscular development and fat deposition. For this reason, the carrier is often unwittingly selected in preference to the non-carrier for breeding purposes. Many of the same characteristics prominently displayed by pure double-muscled animals are exhibited to a lesser degree by the carrier. In the heifer illustrated, muscular creases are evident (A), the tail head attachment (B) is slightly farther forward than normal, and there is a greater than normal bulge of the rear quarters. The muscle between the two halves of the lower jaw (D) sags slightly, and the neck (E) and shoulder (C) are over-developed for a normal female. Compare Figure 4 with Figure 8.

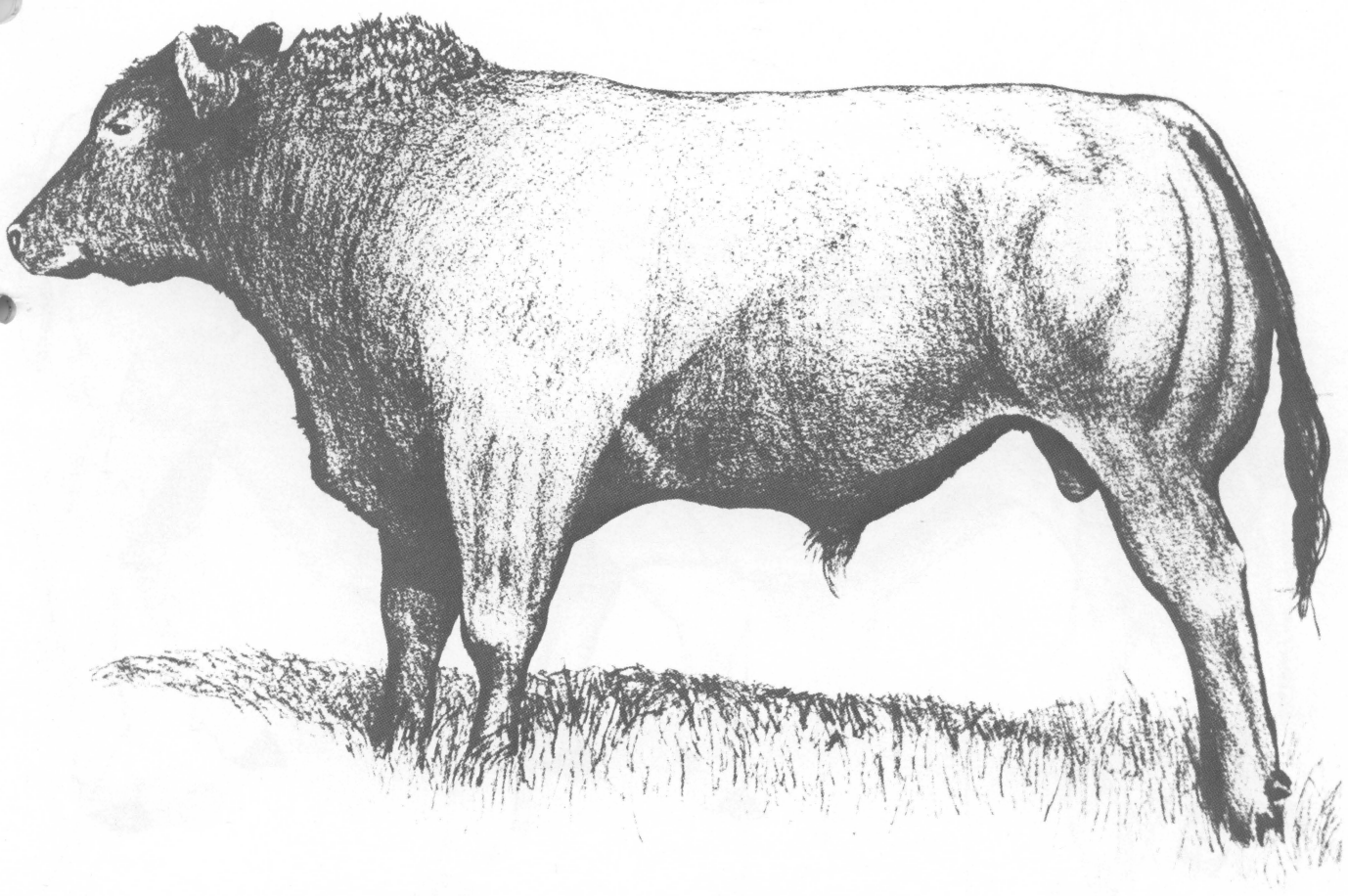

Figure 9. Actual double-muscled bull.

This bull shows, in addition to previously described symptoms of double-muscling, a stretched stance which is unique to the double-muscled animal. When the double-muscled animal (both male and female) stands for a short time, the front legs are almost invariably pulled forward, and the rear legs are pushed backward. Whether or not this is a voluntary or involuntary action is not known, but the characteristic is a good indicator of double-muscling. Carrier animals may also exhibit the stretched stance.

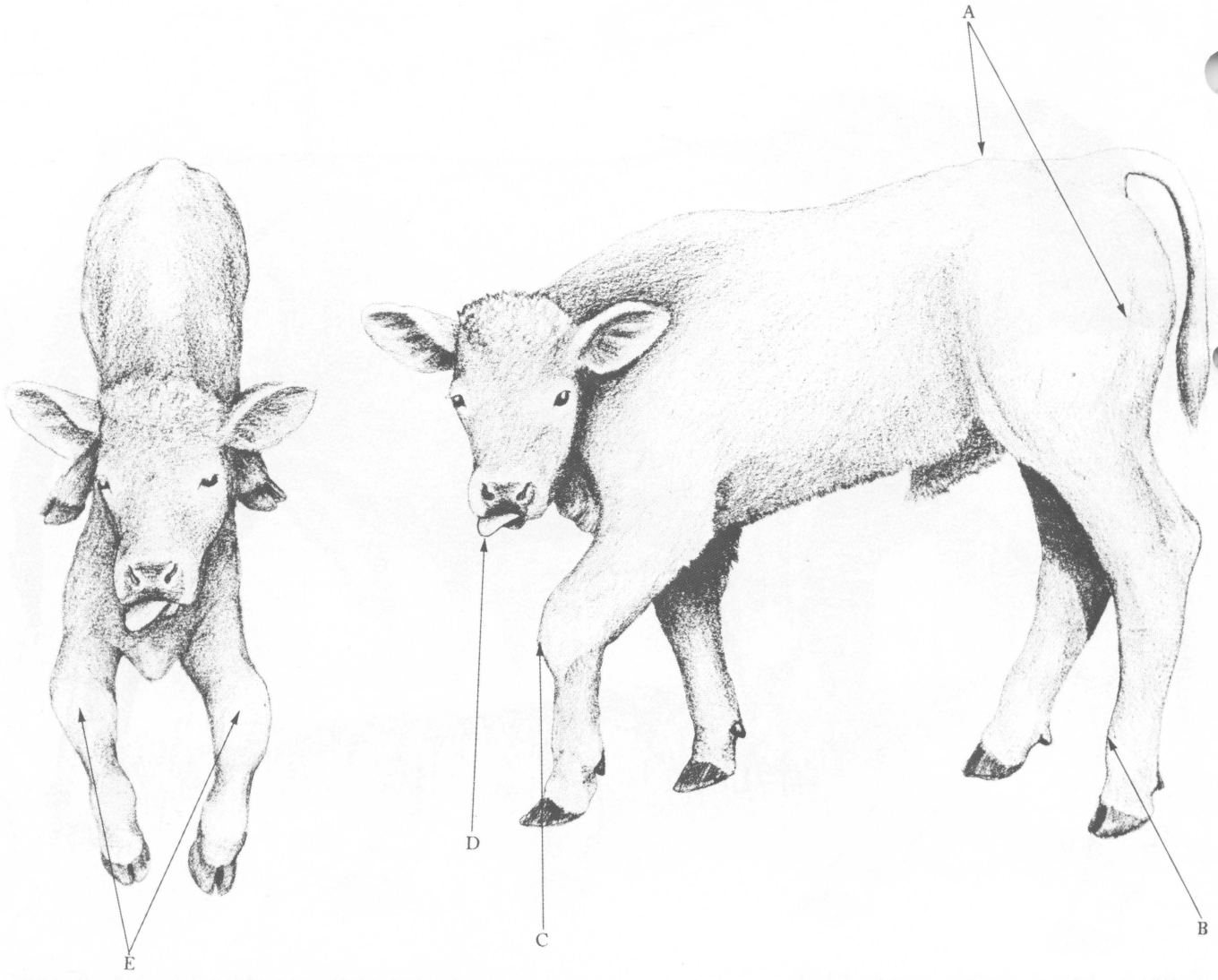

Figure 10. Newborn double-muscled calf.

Newborn double-muscled calves in most cases exhibit the usual symptoms of double-muscling, i.e., large hips and shoulders, increased muscular mass in which the muscles are delineated by creases, and forward tail head attachment, etc. However, some newborn double-muscled calves may have enlarged tongues which protrude from the mouth (D) and bucked-over (C) and bowed-out (E) front legs. The rear ankles may show a tendency to "buckle-over" when the calf walks. In addition to being enlarged (macroglossia), the tongue may be partly or completely "tied" to the bottom of the mouth. Usually the legs become straight, and the tongue assumes normal proportions by the time the calf is 3 months of age.

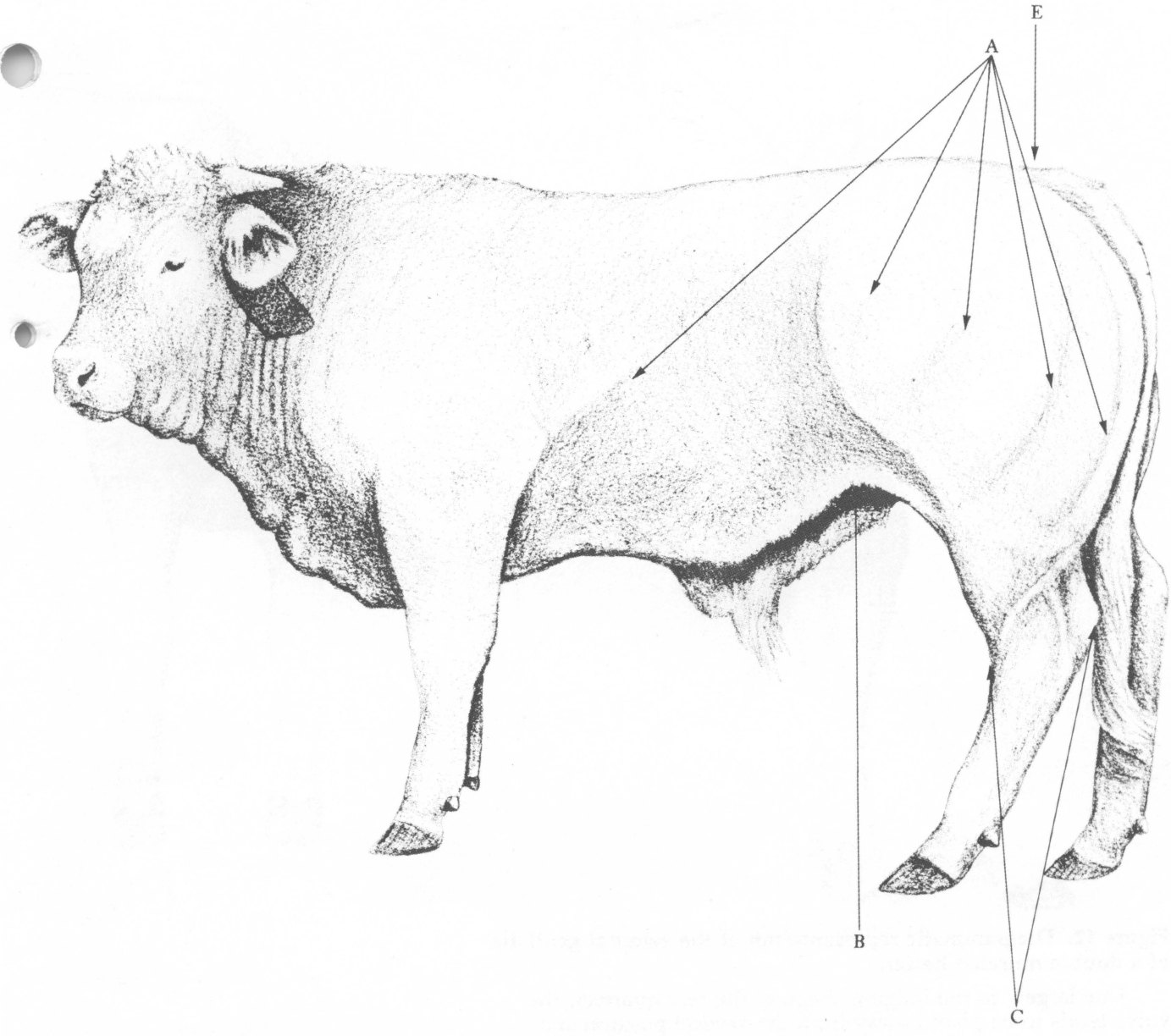

Figure 11. Actual double-muscled bull.

Sickle hocks (C), the opposite of the post-legged condition, is evident in this bull. The post-legged condition occurs more frequently. Other commonly occurring features of double-muscling such as (A) muscle creases and (E) forward tail setting are also evident.

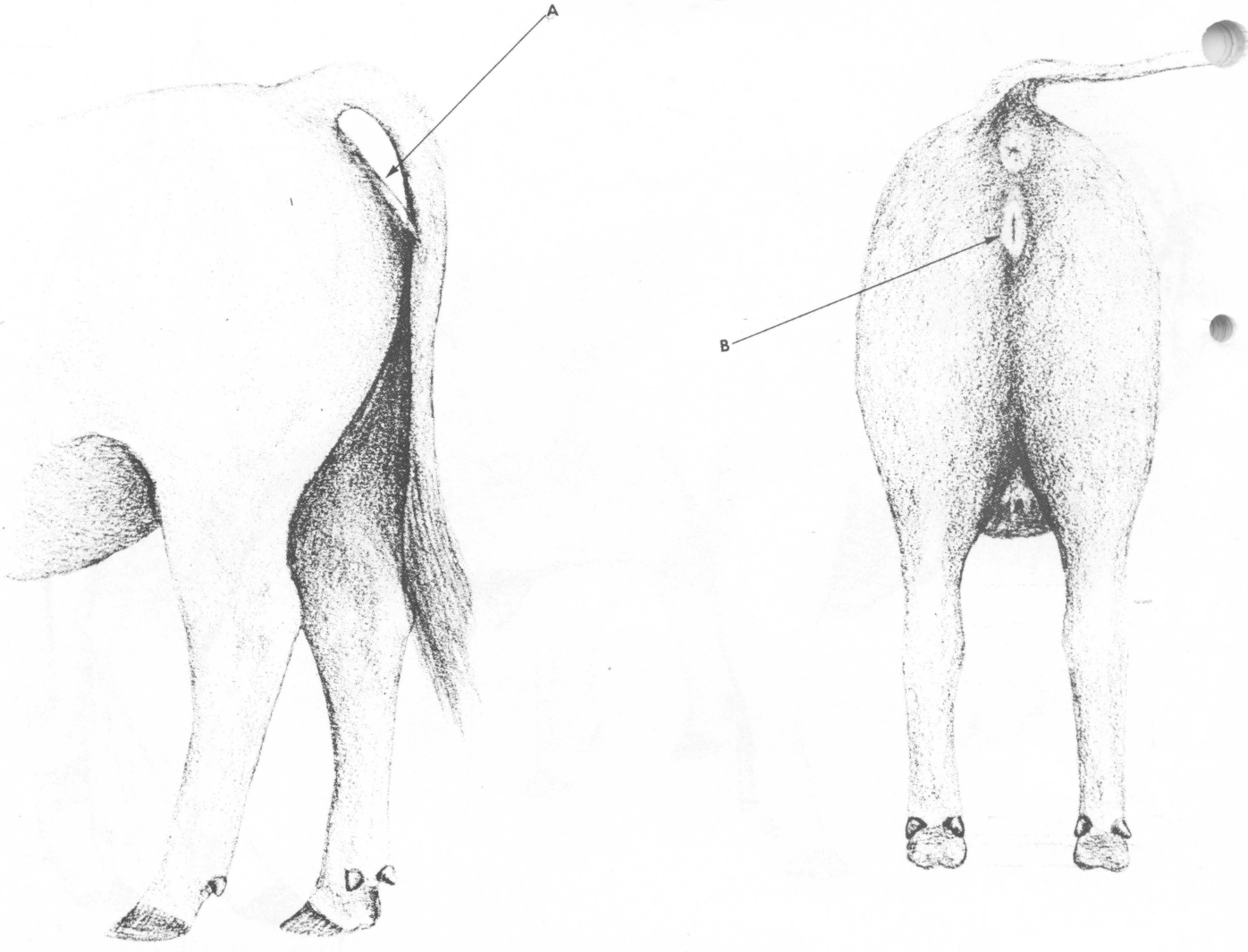

Figure 12. Diagrammatic representation of the external genitalia of a double-muscled heifer.

Due largely to the bulging shape of the rear quarters, the vulva tends to be placed away from the vertical position and more towards the horizontal (A). Because of abnormal position of the vulva, natural breeding may be difficult. The vulva is juvenile in development at all ages (B).

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