sidered, creep-feeding for the entire season was more profitable than stopping creep-feeding of the concentrate mixture in the spring, but about equal to creep-feeding alfalfa hay until spring.

Present Research

Additional data concerning methods of creep-feeding and kinds of creep-feeds will be furnished by a test now in progress in which six lots of calves are being fed as follows:

Lot 1—Creep-fed concentrate mixture until weaning
Lot 2—Creep-fed concentrate mixture until spring
Lot 3—Creep-fed pelleted mixture until spring
Lot 4—Creep-fed alfalfa hay until spring
Lot 5—Creep-fed pelleted alfalfa hay until spring
Lot 6—Not creep-fed

An Evaluation of the X-Ray Method for Identifying Carriers of the Snorter Dwarf Gene in Beef Cattle

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The present attitude of the beef cattle industry towards dwarfism is in sharp contrast to that of a few years ago. The fear, doubt and confusion accompanying the onset and early history of this hereditary defect has been replaced by one of optimism that dwarfism is under control. Such optimism has been encouraged by the marked reduction in the occurrence of snorter dwarf calves in recent years.

The control measures, practiced by breeders, that are responsible for this decline are pedigree selection and progeny testing. Pedigree selection, or more correctly pedigree discrimination against lines of breeding known to include dwarf carriers, has been the most widely used of these methods. Progeny testing, although the most effective, has been limited mainly to the larger purebred herds because of the expense and time involved.

Pedigree selection can be effective as a means of controlling dwarfism if it is based on accurate pedigree information. In too many cases such information is lacking, and discrimination is based on rumor and hearsay. Under such conditions pedigree selection is useless as a method for controlling dwarfism. Even though reliable pedigree information is available as a basis for selection, wholesale discrimination against certain lines of breeding undoubtedly results in a serious loss to the breed of many superior animals that are in reality free of dwarfism.

It should be emphasized that the presence of known dwarf producers in an animal's pedigree merely indicates that animal could be a carrier.

"A" Classification, Snorter Dwarf

"C" Classification, Predicted Dwarf Free

Figure 1.—Radiographs of the lumbar vertebrae, lateral view, of calves that are (A) a snorter dwarf, and (C) predic-ed free of the dwarf gene.

If an animal has not produced dwarf calves after an adequate progeny test, his dwarf carrier ancestry means nothing. Such progeny tested animals are actually as safe and often safer to use than many animals from pedigree clean lines.

There is no doubt that the number of dwarf calves has been reduced, and that the frequency of dwarf carriers in beef herds has decreased. This is evidence that many of the pedigree clean lines have proven themselves. However, the possibility remains that some lines considered clean may actually include dwarf carriers that have never been detected. The increased use of progeny tested bulls reduces the chance that such carriers will be detected. They, and their descendants, will keep the dwarf gene in the cattle population and thus constitute a threat to the industry if breeders relax their efforts to control dwarfism. For this reason research is being continued in an effort to develop an accurate diagnostic test, which would be immediately available for use if dwarfism should ever again threaten to become an important problem.

At the present time no accurate means of identifying dwarf carrier animals has been developed. Several experiment stations have been engaged in research programs directed towards developing such a diagnostic technique. One method that was proposed was based on differences observed in X-rays of the lumbar vertebrae of very young calves. Examples of these characteristic vertebral differences are presented in Figure 1.

The most noticeable differences are seen in the lateral profile of the body of the vertebrae. The vertebrae of animals believed to be free of the dwarf gene (C classification) appear rectangular in outline and have a smooth ventral surface, which is arched dorsally. The other extreme is the dwarf (A classification) which shows marked undulations of the ventral profile, so that the ventral surface of the vertebrae protrudes downward. In addition the ventral edge of the vertebrae of the dwarf is usually shortened, resulting in a somewhat triangular, rather than rectangular, outline. The degree of abnormality observed in the vertebrae of calves predicted to be carrier (B classification) varies considerably. X-rays of the B type range from those only slightly abnormal, and almost like the C type, to those very definitely abnormal and almost as severely deformed as the A type.

The accuracy of the X-ray method has been extensively tested at the Oklahoma Station, as well as at several other state experiment stations. The purpose of this report is to summarize the results to date and evaluate this method.

Procedure

Calves produced in three projects at the Ft. Reno Station in 1955, 1956, and 1958, and in two projects in 1957 and 1959, were X-rayed before they were one week of age. Included were Hereford and Angus calves as well as a few Hereford x Angus crossbred calves. On the basis of the radiographs of their lumbar vertebrae the calves were classified as A (dwarf), B (predicted to be carrier) and C (predicted to be clean). Calves with B X-rays were further classified as to degree of abnormality as MB (mild B, only slightly abnormal), IB (intermediate B, definitely abnormal), or XB (extreme B, extremely abnormal). However, calves with any of these three classifications of B X-rays were predicted to be carriers.

Results and Discussion

Data were taken from a total of over 1500 calves during the five-year period. Of these, 85 calves had a known genotype for the dwarf gene. Table 1 shows the X-ray classifications of all animals of known genotype.

In the dwarf carrier group, 13 animals that were X-rayed as young calves later proved to be carriers by producing dwarf offspring. Four of these had been predicted to be clean on X-ray, and nine were predicted carriers (one mild B, three intermediate B's, and four extreme B's). From a total of 36 known carriers, eight were predicted clean and 28 were called carriers on the basis of their X-rays. Converting these numbers to percentages, 77.8 percent of the known carriers were accurately predicted carriers (classified B) and 22.2 percent were erroneously predicted clean (classified C).

Table 1 also shows the X-ray classifications of a group of 49 dwarf calves (homozygous for the recessive dwarf gene). Included in this group

Table 1.—Summary of X-ray Classifications of All Animals of Known Genotype for the Dwarf Gene.

Genotype	No. Animals	No. animals in each X-ray classification				
		C	MB	IB	XB	A
Heterozygous (Carriers)						
By Progeny Test	13	4	1	3	5	—
One Dwarf Parent	23	4	6	9	4	—
Total Carriers	36	8	7	12	9	
Homozygous Recessive (Dwarf)	49	—	—	—	3	46

are Hereford, Angus and Hereford x Angus crossbred dwarfs. Ninety-four percent of the 49 calves X-rayed had lumbar vertebral abnormalities characteristic of the dwarf. The three dwarf calves that were not classified A had very extreme B type X-rays. Very few non-dwarf calves have had X-rays this extreme, and no non-dwarf calf has been classified as A.

These data indicate that the X-ray method is very accurate in distinquishing dwarf calves from non-dwarfs. Usually, dwarfs can be identified by their appearance; however, in some cases the external characteristics do not become noticeable for several weeks. For this reason, the X-ray method has considerable value in the identification of dwarfs at an early age and in diagnosing calves that are born dead.

In order to further test the accuracy of the X-ray method, calves were X-rayed in a herd of cows that is believed to be free of the dwarf gene (Project 650). A summary of the X-ray classifications is presented in Table 2. Most of the bulls used in this herd are considered to be dwarf free; however, three of the bulls were later proven to be carriers by progeny test in the tester herd, and four of them are considered as possible carriers from pedigree information. Therefore, the calves are grouped according to the dwarfism status of their sires.

If the X-ray predictions were completely accurate, all calves from clean cows and sired by clean bulls should have a C X-ray. As shown in

Table 2.—Summary of X-ray Classifications of Calves Produced in a Herd Believed to Be Free of the Dwarf Gene (Project 650).

No. Bulls	Dwarfism Status of Bulls	No. Calves	X-ray Classification (% of Total)			
			C	MB	IB	XB
12	Probably Clean	144	79.2	8.3	9.7	2.8
4	Possible Carrier	75	81.3	13.3	5.3	0
3	Known Carrier	62	59.7	14.5	21.0	4.8

Table 2, of 144 calves of presumably clean breeding, 79.2 percent were classified C (predicted clean) and 20.8 percent were classified B (predicted carriers). These results indicate that either there are some undetected carriers in the cow herd or that the X-ray method is only about 80 percent accurate in classifying dwarf free calves. This estimate of accuracy is in agreement with the results reported from other experiment stations doing similar work.

The three known carrier bulls sired 62 calves, of which 59.7 percent were predicted clean and 40.3 percent were predicted carriers. It would be expected that on the average, one-half of these calves should be carriers and one-half clean. These results suggest that a few carrier calves in the group were predicted clean, but they also definitely illustrate that the dwarf gene is very closely associated with the abnormal vertebrae.

The four bulls that are considered as possible carriers from their pedigrees sired a high percentage of C calves (81.3 percent). From this evidence alone, it appears that the bulls are clean; however, it would be necessary to test them by several matings to dwarf carrier cows before one could have much confidence that they do not carry the dwarf gene.

In order to evaluate various methods used for identifying dwarf carriers, a herd of proven dwarf carrier cows was established at the Fort Reno Agricultural Experiment Station in 1956. This herd consists of about 80 Hereford and 40 Angus cows, all having produced dwarf calves. If a bull is mated to six of these cows without producing a dwarf, the chances are less than 20 out of 100 that he is a carrier. If he is mated to 11 cows without siring a dwarf, the chances are less than 5 out of 100 that he is a carrier. If he sires 16 normal calves out of carrier cows without a dwarf, the chance that he is a carrier is less than one out of 100. Of course, if a bull sires one dwarf calf, he is definitely proven a carrier, no matter how many normal calves he has sired. This is a very accurate means of determining the dwarfism status of bulls, but it is a very expensive and time consuming process.

During the four years since the tester herd was established, 53 bulls that were X-rayed as calves have been progeny tested. Of the six bulls that have sired dwarfs, five had B X-rays and one had a C X-ray. Table 3 shows the X-ray classifications of 28 bulls that sired six or more

Table 3.—Summary of X-ray Classifications of Bulls That Have Been Progeny Tested by Matings with Carrier Cows.

No. of Test Matings	Chances out of 100 that the bull is a dwarf carrier	No. of Bulls	No. of Bulls in Each X-ray Class			
			C	MB	IB	XB
8-9	7 - 10	9	8	–	–	1
7	13	9	7	1	–	1
6	18	10	6	2	1	1

normal calves and no dwarf calves in the tester herd. The second column indicates the amount of confidence one could have in predicting that the bulls are clean (i.e., the number of times out of 100 that the prediction would be wrong). It is interesting to note that out of the group of nine bulls that sired eight or nine calves each, only one has a B X-ray, and the mathematical odds indicate that about one out of 10 could be a carrier. Likewise, in the other two groups, which are not as well-tested, there are more bulls with B X-rays. Theoretically, we would expect that further matings would reveal one carrier in the first group, one or two carriers in the second group, and two carriers in the last group of bulls. This table illustrates the way in which progeny test results are used. By making a very large number of test matings, one can almost, but never completely, eliminate the possibility that a bull is a carrier.

It is slower and much more difficult to get progeny test information on females. By breeding heifers to a dwarf bull, four normal calves will make the odds about 6 chances out of 100 that the heifer is a carrier. However, such a test would mean keeping the cow until she is six or seven years old. Another problem here is the difficulty usually encountered in attempting to breed to a dwarf bull. It seems that progeny testing of females for dwarfism has too many limitations to be of much value.

Upon examination of the X-rays of 1388 normal calves, it was found that abnormal X-rays occur much more frequently among the males than the females. Table 4 shows the numbers of males and females that were found in the C and B X-ray classifications. The expected numbers (shown in the fourth and fifth columns) are based on the assumption that males and females are equally susceptible to vertebral abnormalities. Out of 694 male calves, 371 were classified B, and out of

Table 4.—The Distributions of Sexes Within X-ray Classifications.

Classification	Observed		Expected		Prob.
	Male	Female	Male	Female	
C	323	420	371.5	371.5	P<.005
B	371	274	322.5	322.5	P<.005
Total	694	694	694.0	694.0	
MB	142	115	128.5	128.5	P<.10
IB-XB	229	159	194	194	P<.005
Total B's	371	274	322.5	322.5	

694 females calves only 274 had B X-rays. This much difference in the sexes would be expected less than five times out of 1000. Since the B classification covers a considerable range of abnormalities, the mild B's were separated from the more extreme B's in order to pinpoint the sex

difference more closely. It was found that there was very little difference between the sexes in the mild B's (MB) and that most of the sex differences was in the IB and XB group, in which males were much more numerous than females. These results indicate that the vertebral abnormality thought to be associated with the dwarf gene shows up more severely in male calves than in female calves. There is no ready explanation for these findings.

The X-ray technique is only one of several methods that have been proposed for distinguishing clean animals from dwarf carriers. The data shown in this report and those from other stations indicate that the X-ray method alone is not accurate enough to use in merchandising breeding cattle. The progeny test is highly accurate, but due to limitations of time and expense, it is impractical to use on large numbers of animals. However, for those breeders who wish to conduct the progeny test, the X-ray method could be a good way to screen bulls before breeding them to the tester females. The X-ray method should eliminate about 80 percent of the dwarf carriers and considerably reduce the expense of a progeny testing program.

Summary

The X-ray method for the identifying carrier of the snorter dwarf gene has been tested extensively for the past five years. This method is based on vertebrae abnormalities as shown on lateral lumbar radiographs of young calves. Results from over 1500 X-rays made at the Fort Reno Station indicate that the X-ray method is approximately 77.8 percent accurate in identifying dwarf carriers, 79.2 percent accurate in identifying dwarf-free calves, and 94 percent accurate in identifying dwarf calves. Sex differences were found in the degree of abnormality of the vertebrae. More males had abnormal X-rays than females, and the abnormalities were more extreme in the males. These sex differences cannot be explained at the present time.

The X-ray method is considered to be highly accurate in identifying dwarf calves and might be of use when the identification by visible characteristics is doubtful. Although the method is not highly accurate in detecting dwarf carriers, it could be a valuable means of screening prospective bulls before progeny testing them for dwarfism.

The Influence of Excessive Fatness On the Performance of Beef Females

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Many purebred cattlemen, who often fatten heifers to a high degree while fitting for show and striving for maximum development, feel that excessive body fat adversely affects the subsequent produc-