DWARFISM

In Beef Cattle

The Description, Cause, and Control

Agricultural Experiment Station
University of Arizona
Tucson

DECEMBER 1955
SUMMARY

Dwarfs have been reported in all major beef cattle breeds in this country. It has been definitely established that dwarfism is due to inherited factors.

The genetic factors that cause dwarfism are of the recessive type. This means that the sire and dam are equally responsible when a dwarf calf is born. Since dwarfism is inherited as a recessive, animals that transmit the factor appear normal and cannot be distinguished in appearance from dwarf-free animals. The dwarf gene is introduced and maintained in the breeding herd by these normal-appearing carriers, and unless proper precautions are taken the incidence of dwarfism is likely to increase appreciably in many of these herds.

On the basis of information now available, measures which can be used by the breeder to control the frequency of the dwarf gene in his herd includes:

1. Elimination of proven carriers
2. Elimination of progeny of proven carriers
3. Progeny testing of prospective sires
4. Screening bulls prior to progeny test
5. Establishment of a dwarf-free nucleus herd.

The breeder is urged to carefully observe his animals for indications of all dwarf types and also for other undesirable characteristics which may occur in his herd. Prompt remedial measures will go far toward eliminating these undesirable hereditary factors (and may completely eliminate them) before they become widely distributed through the herd.

ACKNOWLEDGMENTS

The authors express gratitude for the data and livestock provided by cooperating breeders, for the records and financial assistance provided by the American Hereford Association, and for the efforts of Mr. Dan W. Clarke of Tucson in obtaining some of the desired breeding stock. The assistance of the Experiment Station Veterinarians (Drs. W. J. Pistor, V. H. Fisher, and R. E. Reed) is gratefully acknowledged. Thanks are extended to Miss Ann Sayre, A. C. Chiles, and T. P. Jardine for the general assistance provided.
DWARFISM IN BEEF CATTLE

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The frequent occurrence of dwarfism in prominent beef cattle breeds of the United States has prompted research investigations from 1948 to the present time. Most of these investigations were centered around one particular form of dwarfism, as it was found to occur in the Hereford breed. That dwarf type is described in the next section of this report. Based upon research findings to date, this publication presents the characteristics, describes the mechanism of inheritance, and outlines the suggested methods of reducing the incidence of this form of dwarfism.

Although application of this information to the Hereford breed is emphasized, it is not inferred that other breeds are free of the dwarfism. Dwarfs similar to those found in the Hereford breed have been produced by Aberdeen-Angus and Shorthorn cattle as well. This has been reported by Gregory and others (6), and both Aberdeen-Angus and Shorthorn dwarfs have been observed by the authors of this publication.

Dwarf Characteristics

Dwarf calves vary in appearance and in development with age just as do normal calves. Some show obvious abnormalities at all ages; others appear almost normal at birth and develop characteristic defects later. Those animals that approach normal at birth may develop width, depth, compactness, thickness of fleshing, and a mature appearance before obvious evidence of dwarfism appears. Such calves are easily mistaken for individuals of preferred type.

Since a sound control program is dependent upon the recognition of the dwarf calves produced, all calves should be examined for evidence of the abnormality. Special care should be given the questionable cases to increase the chances for survival and positive classification. Stillborn calves and those dying within the first two months after birth should be studied closely.

The characteristics most commonly observed in Hereford dwarfs, of the type under consideration, are presented in the succeeding paragraphs.

Visible indications of dwarfism in newborn calves

Five indications, determined by visual inspection, were exhibited in varying degrees by 18 living dwarfs examined at the Arizona Station.

1. A protrusion of the eyes accompanied by a glassy stare.
2. A continuous protrusion of the tip of the tongue.
3. Apparent muscular weakness.
Fig. 1. A three-day-old dwarf in which some general characteristics of the abnormality are very apparent. Weight at birth — 52 pounds.

4. Incoordinated locomotion combined with faulty equilibrium.

5. Proportionally short legs.

The peculiar appearance of the eyes, also noted by Lindley (10), is illustrated by the dwarf calf pictured in Figure 1. The protruding tongue is also obvious. This calf was extremely weak and could not rise or nurse unassisted prior to its death at five days of age. Such weakness was not unusual in other specimens. Those animals that overcame the initial weakness exhibited incoordinated leg movements, a condition also observed by Lindley (10). This incoordination, with lateral staggering that suggested faulty equilibrium, was most apparent when the afflicted animals were induced to move suddenly or rapidly. That the dwarfism reduces leg length was also recognized by Gregory and others (6). Short forecannons were characteristic of the Arizona dwarfs.

Flexed forepasterns (Fig. 1) apparently are not characteristic of all dwarfs. The flexed condition was not generally cited by other research workers as a common manifestation of dwarfism, and cooperating stockmen reported that it did not occur frequently. It was exhibited, to a moderate degree, by some of the normal calves examined at the Arizona station; but it was usually more pronounced in the dwarfs.

In addition to the characteristics previously described, a visual examination of the dwarfs at the Arizona station less frequently revealed the following:

1. The appearance of maturity due to the impression of width, depth, and compactness combined with thickness of fleshing. This is in general agreement with the observations of Johnson and others (8) and Gregory and others (7).

2. Bulging foreheads and heads that were wide in relation to their lengths. Gregory and others (6 and 7) observed these characteristics, although exceptions were noted. Johnson and others (8) could not detect the bulging forehead in every case.

3. Jaws that were unusually undershot (incisor teeth too far forward to mesh with the dental pad). This condition was also observed by Lindley (10) and was found quite common by Gregory and others (7).
Table 1. — A Comparison of Normal and Dwarf Measurements\(^1\,\!^2\)  
(Bull Calves Only)

<table>
<thead>
<tr>
<th>Measurements and Ranges</th>
<th>Normal</th>
<th>Normal</th>
<th>Dwarf</th>
<th>Dwarf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecannon (Length)(^3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.3 - 16.0</td>
<td>18</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>12.2 - 13.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hock to dewclaw (Length)(^4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.1 - 27.5</td>
<td>24</td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>22.5 - 23.0</td>
<td></td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>20.0 - 22.4</td>
<td></td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Lower jaw (protrusion)(^5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2 - 0.5</td>
<td>14</td>
<td></td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>0.6 - 1.1</td>
<td></td>
<td></td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>1.2 - 1.6</td>
<td></td>
<td></td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

\(^1\)Measurements in centimeters. 1 cm. = 0.3937 in. or 1 in. = 2.54 cm.  
\(^2\)When feasible, the measurements were taken within three days after birth.  
\(^3\)From most prominent point of accessory carpal bone to coronary band of dewclaw.  
\(^4\)From point of tuber calcis to coronary band of dewclaw. Leg flexed with metatarsal perpendicular to tibia.  
\(^5\)From anterior margin of dental pad to posterior border of incisor teeth on median line with jaws closed.

Birth measurements and weights

The indicators of dwarfism previously discussed are most obvious in living calves. The first four peculiarities can be detected in the live animals only; the remaining characteristics are often masked to some degree after death, which may occur at any age as a result of the dwarfism.

Because of complications arising from early mortality, the Arizona station obtained a series of body measurements in an effort to differentiate between dwarf and normal animals at birth. The data are not yet conclusive, but three measurements appear to have diagnostic promise. These measurements, obtained on Hereford males of conventional breeding, are shown in Table 1. The number of measurements on females were too few to warrant consideration.

Of the three promising measurements, only the length of the forecannon completely differentiated the dwarf and normal calves. The distance from the hock to the dewclaw was of somewhat less value. These indications that dwarfism affects leg length support the conclusions drawn from visual appraisals and are in agreement with the observations of Gregory and others (6).

Although the undershot jaw was pronounced in some dwarfs, the measurements in Table 1 show that this condition provided no clear differentiation. While there were indications that the undershot condition tended to be more extreme in the dwarfs, it was not uncommon
in normal calves at birth. Of interest, however, was the fact that the jaws of the normal calves adjusted to normal or nearly so at an early age; the undershot condition usually persisted in the dwarfs. Gregory and others (6) also found this to be true.

Although some dwarfs at birth appeared to possess short, deep, wide bodies and heads that were wide in relation to length, measurement data indicated that they did not differ materially from many normal calves in these respects. Furthermore, weight was not sufficiently indicative of dwarfism. At an average age of 38 hours; dwarf weights in excess of 60 pounds were common. A maximum weight of 76 pounds was recorded.

**Hydrocephalus**

An internal hydrocephalus (the accumulation of fluid in the lateral ventricles of the brain) was noted by Johnson and others (8) upon the post mortem examination of a 10-day-old dwarf. Gregory and others (6) considered the probable influence of this condition on the
head form of the dwarf. A limited study of this fluid accumulation was made at the Arizona Station, and the findings are illustrated in Figure 2. The skull specimens taken from calves not more than 5 days of age, were frozen and then sectioned on the median line.

Hydrocephalus was not apparent in all of the dwarf specimens and it was observed in one specimen from a calf believed to be normal. The hydrocephalic condition is clearly visible in dwarf section 11A of Figure 2. This was the most extreme condition found in the four dwarfs examined. Dwarf section 7B is representative of the other three. Of four supposedly normal specimens examined, evidence of hydrocephalus was found only in 168A. In this case the condition was moderate, but it is clearly visible in Figure 2.

The sire of calf 168A was progeny tested on 20 carrier cows by a cooperating breeder. It was reported that all calves were normal and that no stillbirths or early calfhood losses were suffered. Since this sire was tested at better than the one percent probability level, there is reasonable assurance that calf 168A was not a dwarf. The possibility that it may have been a carrier of one dwarf gene (see appendix for definitions) was not eliminated however.

These limited observations indicate that hydrocephalus need not accompany dwarfism in newborn calves, and the evidence suggests that the condition may occur, to at least a moderate degree, in calves that are not dwarfs. A report of extreme internal hydrocephalus in Holstein-Fresian cattle by Cole and Moore (4), and their review of the literature pertaining to hydrocephalus in cattle and other species, suggest that certain aspects of the condition illustrated herein should receive further study.

Postnatal development of dwarf characteristics

The postnatal development of dwarf characteristics, as observed at the Arizona Station, are depicted in Figures 3 and 4. The observations are in general agreement with those of previous authors. In each figure, the photographs marked D-15 and D-90 illustrate the characteristics of a representative dwarf male at 15 and 90 days of age respectively. A growthy male calf of normal phenotype is pictured in photographs N-15 and N-90.

The side view of the dwarf calf at 15 days of age (Fig. 3) shows no striking evidence of abnormalities. In the experience of the authors, this was not unusual, and it is in agreement with the report of Gregory and others (7) that the dwarflike appearance may not be very apparent until six weeks or more of age.

At 90 days of age, the side views of the dwarf and normal animals shown in Figure 3 reveal some rather striking differences. The photographs are on approximately the same scale, and the contrast in the size of the animals is very apparent. The rather short muzzle, the dished face, and the pronounced forehead region above the eye-level are apparent in the dwarf. The short cannon bone, the tendency toward paunchiness, the lack of condition, and the general appearance of maturity are also evident in the dwarf animal at 90 days of age.

Additional contrasts may be seen in the front views of the same
dwarf and normal animals (Fig. 4). Here it may be seen that the protruding tongue and the prominent, glassy eyes, found quite characteristic of young dwarfs are still apparent in this dwarf at 15 days of age. The rather peculiar stance exhibited by the dwarf was not unusual. This apparently was due to the lack of proper muscular coordination and faulty equilibrium.

A comparison of the front views of the dwarf and normal males at 90 days of age (Fig. 4) depict common differences that are not always pronounced at birth. The dwarf head appears wide in proportion to its length, and the "undershot" jaw is more apparent than formerly. The tongue no longer protrudes; the eyes are no longer prominent. The narrow back and loin shown by the dwarf were common in dwarfs of this age or older, and the paunchiness was typical. This paunchiness does not necessarily imply a bloated condition, although the development of a bloat tendency was not uncommon. If the bloat tendency developed, it was accompanied by a loss of condition.
Fig. 4. Dwarf calf "D" and normal calf "N" at 15 and 90 days of age.
TABLE 2 — NORMAL AND DWARF CALVES PRODUCED WHEN CARRIER COWS WERE BRED TO CARRIER BULLS

<table>
<thead>
<tr>
<th>Experiment Station</th>
<th>Observed</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Normal</td>
</tr>
<tr>
<td>Arizona¹</td>
<td>90</td>
<td>66</td>
</tr>
<tr>
<td>California²</td>
<td>61</td>
<td>46</td>
</tr>
<tr>
<td>Iowa³</td>
<td>266</td>
<td>197</td>
</tr>
</tbody>
</table>

¹Pahnish and others (13)
²Gregory and others (7)
³Lush and Hazel (12)

In addition to the characteristics previously discussed, all of the dwarf animals developed respiratory difficulties within the first three months of life. Forced respiration was, in most cases, very pronounced. The lack of coordination, apparent at early ages, persisted throughout life.

**Inheritance of Dwarfism**

When the study of Hereford dwarfism was first undertaken by the various experiment stations, the existing evidence suggested that the condition was inherited. Such evidence was first presented by Johnson and others (8).

**Evidence of Inheritance**

Genetic studies designed to test the probable mechanism of inheritance were reported by the Iowa, California, and Arizona Stations. A summary of these results is presented in Table 2. Evidence obtained at each of the stations indicates that a simple recessive gene is responsible for the dwarfism. (A glossary of terms commonly associated with the subject of dwarfism is presented at the end of this bulletin).

To obtain the data shown in Table 2, cows that had previously dropped dwarf calves were bred to bulls that had sired such calves. Assuming that a simple recessive gene was responsible, it was expected that 75 percent of the progeny would be normal and 25 percent would be dwarfs. At each station, the expected results and the actual results of the tests were in close agreement. The dwarfism appears with about equal frequency in both sexes.

Additional breeding tests were conducted by Pahnish and others (13). When dwarf sires were used on carrier cows, dwarf and normal calves were produced in nearly equal numbers. When dwarf sires were bred to dwarf females, all of the offspring were dwarfs. These results conform to expectations based on the assumption that a simple recessive gene is responsible for the abnormality.

In view of the evidence presented, dwarfism must be considered a breeding problem. It is not the result of faulty nutrition; it cannot be eliminated by changing basic rations or introducing feed supplements.

**The action of the recessive dwarf gene**

Since existing evidence indicates
Fig. 5. The introduction of dwarfism into a dwarf-free herd by a carrier bull. On the average, 50% of the calves from such matings will be carriers.
that the specific Hereford dwarfism under consideration is caused by a simple recessive gene, the action of such a gene is explained in the following paragraphs. The terms used in this explanation are defined in the appendix.

Figure 5 illustrates the manner in which dwarfism may be introduced into a herd. Either a male or female may be responsible for the introduction of the dwarf gene. Figure 5 illustrates the introduction of the gene by the male. The following points are apparent:

1. A carrier (Heterozygous) bull appears normal in size and conformation. Therefore a breeder may use such a bull unknowingly. The dwarf gene is recessive and has no obvious effect on the animal when paired with the dominant normal gene.

2. The genes exist in pairs. The pair possessed by a given animal may consist of two genes for normal growth, a normal and a dwarf gene as in the case of the bull shown in Figure 5, or two dwarf genes.

3. Each parent contributes one member of the gene pair to the offspring.

4. The carrier bull should be expected to contribute the dwarf gene to its offspring just as frequently as the normal gene is contributed.

5. Even though a carrier bull is used on cows that are dwarf free (homozygous normal) an average of about 50 percent of the offspring should be expected to carry one dwarf gene.

6. The calves that receive one dwarf gene appear normal in size and conformation. At the present time, there appears to be nothing unusual in the visual appearance of these animals that can serve as a means of identifying them.

A breeder may first introduce the dwarf gene into his herd in the manner illustrated in Figure 5; however, the presence of the dwarf gene in the herd will escape recognition until matings of the kind illustrated in Figure 6 are accomplished. Matings of this kind are then the ones that continue to be troublesome.

1. Just as the carrier bull contributes normal and dwarf genes to the offspring in equal numbers, so will carrier females contribute to their calves.

2. When carrier bulls are mated to carrier females, an average of only 25 percent of the calves obtain the normal gene from both parents and thus are dwarf-free.

3. Fifty percent of the calves from carrier X carrier matings, on the average, obtain a dwarf gene from one parent or the other. These animals are not visibly different from the dwarf-free calves.

4. An average of 25 percent of the calves from carrier X carrier matings receive the dwarf gene from both parents and are dwarfs (homozygous recessives) (Table 2 and Fig. 6).

5. One dwarf calf provides ample evidence that both the dam and sire carry the gene for dwarfism.

6. Dwarfism can result when any two animals possessing the dwarf gene are mated. The dwarfism is not created by inbreeding.
Fig. 6. An illustration of the results obtained by mating a carrier bull with carrier females. On the average, 25% of the calves will be dwarf free, 50% will be carriers, and 25% will be dwarfs.
Control of Dwarfism

The manner in which dwarfism appears to be inherited has been discussed in the previous section of this publication. On the basis of this information, it is possible to outline control measures. Some of these measures are now in use. The extent to which such practices can be applied by each breeder are best determined after an evaluation of the individual situation. The practices, all or part of which should prove helpful where a dwarf problem is encountered, are discussed in the succeeding paragraphs.

Eliminate proven carriers

The elimination of proven carriers, whether male or female, is an obvious step. As illustrated in Figure 6, one dwarf calf provides evidence that both the dam and sire carry the dwarf gene. Carrier bulls should be sold for slaughter. The carrier females, although they should be eliminated from the main herd, may be retained as a special herd for conducting progeny tests to be explained later.

Eliminate the progeny of proven carriers

The progeny of proven carriers are poor breeding risks. As shown in Figure 5, one half of the progeny of a carrier parent will, on the average, carry one dwarf gene even though they appear normal. If both parents are carriers, an average of 75 percent of the progeny will appear normal; but two-thirds of these can be expected to carry the gene for dwarfism (Fig. 6). Where pedigrees are available, one might go even further and consider the elimination of prospective breeding animals when known carrier ancestry is prevalent behind the parent stock. The farther the known carrier ancestors are removed from the animal under consideration, the less will be the chances that the animal has received the dwarf gene.

Progeny test prospective sires

The progeny test is the most generally accepted method of determining whether a bull carries the dwarf gene. Although this is a rather expensive and time consuming test, complicated in some cases by the production of questionable calves, it can be used advantageously by some breeders. It is also a tool, used experimentally, to evaluate techniques that may eventually provide more suitable and economical methods of detecting carrier animals. The principle types of progeny tests are shown in Table 3.

The most satisfactory test herd is made up of cows that are known carriers by virtue of the fact that they have each produced at least one dwarf calf in the past. The greater the number of matings accomplished, the greater is the accuracy of the test. The number of matings required is dependent upon the accuracy desired by the breeder or the number of matings that he is in a position to make within his required time limits. As shown in Table 3, there should be only one chance out of 100 that a carrier bull would escape detection if 16 matings with carrier cows produced normal calves only. Eleven to 16 matings are generally recommended. To allow for breeding failures, a few cows in excess of the number desired might be used. If the number of cows is
**Table 3. — Methods of Testing a Bull for the Presence of a Recessive Dwarf Gene**

<table>
<thead>
<tr>
<th>Number matings (&quot;N&quot;)</th>
<th>Test bull X Carrier Cows</th>
<th>Test bull X Cows from Carrier Sire and dam</th>
<th>Test bull X Cows from Carrier Sire or dam</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>56.3</td>
<td>69.5</td>
<td>76.6</td>
</tr>
<tr>
<td>4</td>
<td>31.6</td>
<td>48.2</td>
<td>58.6</td>
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<tr>
<td>6</td>
<td>17.8</td>
<td>33.5</td>
<td>44.9</td>
</tr>
<tr>
<td>8</td>
<td>10.0</td>
<td>23.3</td>
<td>34.4</td>
</tr>
<tr>
<td>10</td>
<td>5.6</td>
<td>16.2</td>
<td>26.3</td>
</tr>
<tr>
<td>12</td>
<td>3.2</td>
<td>11.2</td>
<td>20.1</td>
</tr>
<tr>
<td>14</td>
<td>1.8</td>
<td>7.8</td>
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<td>9.0</td>
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<td></td>
<td>2.6</td>
<td>6.9</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>1.8</td>
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<tr>
<td>24</td>
<td></td>
<td>1.3</td>
<td>4.1</td>
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<tr>
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<td></td>
<td>0.9</td>
<td>3.1</td>
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<td>28</td>
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<td>2.4</td>
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<td>30</td>
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<td>1.8</td>
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<tr>
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<tr>
<td>36</td>
<td></td>
<td></td>
<td>0.8</td>
</tr>
</tbody>
</table>

*Procedure described by Kidwell (9).*

too few to complete a test in one year, they may be rebred the following year.

A test herd may be made up of females, both parents of which are known dwarf producers. The test females may or may not have produced dwarfs. This test is not as good as the one previously described for several reasons. In the first place, a greater number of cows is required. Twenty-six cows of this type will provide a test with about the same degree of accuracy as 16 known carrier females (Table 3). Secondly, extreme care must be exercised in assembling a test herd of this kind. When there are known carrier females among the test cows, under no circumstances should they be removed. If the test females are to be divided into two or more groups, the division should be entirely at random. It should not be on the basis of pedigree, appearance, or other criteria. Furthermore, rebreeding a bull to the same cows to obtain sufficient matings is hazardous in this case. When the number of females is small, the percentage of carriers in the population may be considerably less than the average number expected.

Females of still a third category may be assembled as a progeny
test group. These are females, one parent of which is known to carry the dwarf gene. A greater number of cows must be used in a test of this kind than in the other two described. Thirty-six of these cows are about equal to 16 known carriers or 26 cows, both parents of which are known carriers (Table 3). Here again, any divisions must be made entirely at random and known carriers must remain in the test group or groups. As in the test previously described, repeated use of the same cows to obtain the desired number of matings may not result in an accurate test.

Two variations of the third test may be applied if the breeder so desires. First, a bull may be tested by mating him with his own unselected daughters; secondly a bull may be used on the unselected daughters of a known carrier bull. If the bull being tested is a carrier, one or more dwarfs should be obtained from these matings. It is important that the daughters used in these tests be unselected.

The accuracy of either of these tests may be read from the last column of Table 3. If 35 cows all produce normal calves, there is about one chance out of 100 that the tested bull carries the dwarf gene.

Screen the bulls prior to the final breeding test

Although the use of known carrier females offers the most satisfactory breeding test, obviously few breeders can assemble enough females of this kind to test all bulls that he requires. It is often difficult to assemble enough females of known carrier parentage to further fulfill these needs. To make the best use of the available test females, it may be advisable to screen the sire prospects and then test those that appear most favorable. It may be necessary to use some bulls as a result of the screening only. The following screening procedures may be used in selecting young bulls for test purposes:

1. Eliminate bulls of known carrier parentage.

2. Look for bull prospects sired by progeny tested bulls or bulls on which a partial progeny test is available. In addition to this, favor those that were produced by cows that may have been bred repeatedly to known carrier sires in the past without undesirable results. Those produced by cows within well-defined lines that have given little or no trouble may be good prospects. The latter would be particularly true if known carrier sires had been used in the line without producing dwarfs. Calves by these known carriers should, of course, be discarded.

3. Consider using the known carrier females for the final test. If females of carrier parentage are not available for this purpose, consider using each sire prospect on five or six of these unselected females to extend the screening process prior to the final test. The accuracy of these partial tests may be read from Table 3.

4. Conduct complete breeding tests, insofar as possible, on those bulls that successfully withstand the screening.

Select females for a nucleus herd around which to build

A complete breeding test on female stock is usually not feasible.
Table 4. — The Chances That a Cow Carries the Dwarf Gene When Normal Calves Are Sired by Dwarf Bulls.

<table>
<thead>
<tr>
<th>Normal calves dropped by same cow</th>
<th>Chances in 100 that dam carries the dwarf gene¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50.0</td>
</tr>
<tr>
<td>2</td>
<td>25.0</td>
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<tr>
<td>3</td>
<td>12.5</td>
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<td>6</td>
<td>1.6</td>
</tr>
<tr>
<td>7</td>
<td>.8</td>
</tr>
</tbody>
</table>

¹Adapted from calculations of Warwick (16).

Even if carrier bulls were used repeatedly on the females to be tested, it would be necessary that each cow produce 11 to 16 normal calves (no dwarfs) before she could be considered dwarf-free with a reasonable degree of accuracy. Since dwarf bulls can be used for breeding purposes (Pahnish and others 14), this offers an alternative that would reduce the number of required matings by a little more than 50 percent (Warwick, 16).

Table 4 shows the accuracy of a test on females, with various numbers of matings, when a dwarf bull is used. Unfortunately (for this purpose) the mortality rate of dwarf bulls is high at all ages; some do not develop into animals that are capable of natural service, and a breeding pit is necessary when dwarf bulls are used on large females. The breeder may therefore find it advisable to select cows for a nucleus herd on the basis of partial progeny tests and other screening procedures. Where suitable records are available, the following procedures may prove advantageous.

1. Look for a well-defined line in the herd, that has not produced dwarfs even though carrier bulls have been used in the line. This provides some indication that the line is dwarf-free or that the frequency of the dwarf gene is low.

2. Examine the breeding records of individual females, and select those that have been bred repeatedly to known carrier bulls without undesirable results. These animals are partially tested. This necessarily means that one must select older females that still have a few reproductive years left. The dependability of young females, even though they may be from favorable lines, is limited. Because of the few calves produced, the probability that the presence of the dwarf gene in those young females may escape detection is quite high.

3. If the breeder so desires, he might use dwarf bulls to test for the presence of the dwarf gene in a line around which he would like to build or in a line of which he is suspicious. While, as previously explained, there are limitations on the use of dwarf sires, they offer one advantage in that fewer matings are required than would be true if carrier bulls were used.

The search for simplified control methods

Since progeny tests are expensive and time consuming, research workers are searching for more suitable methods of identifying carrier ani-
mals. Gregory and others (5, 6, and 7) found indications that the midforehead prominence, observed in dwarfs, was present to a lesser degree in carriers. This was determined by the use of a precision instrument known as the profilometer. These studies are continuing. Glandular studies are in progress. Carroll and others (3) have reported differences in the functions of dwarf and normal pituitary glands. Other investigations include blood and urine tests, skeletal X-rays, body measurements, and measurements of cerebrospinal fluid pressure.

Dwarf Modifications or Other Dwarflike Types

Dwarflike conditions, differing in certain respects from the recessive type commonly observed, have been found in the Hereford, Shorthorn, and Angus breeds. In some cases, evidence of the mode of inheritance has been reported; in others, little information is yet available. It seems possible that a breeder may be confronted with more than one form of dwarfism at the same time. On the other hand, the possibility that the common recessive type of dwarfism can be modified so the usual characteristics are materially changed has not been eliminated.

Since the dwarf problem may be complicated by modifications or by the presence of more than one form of dwarfism, it is advisable that the breeder examine all dwarfs closely and keep a written record of unusual occurrences. Photographs are extremely valuable. Unusual occurrences should be reported to experiment station personnel, as a special approach to the problem may be necessary.

Compresst dwarfs

That dwarfs may appear when cows of comprest type are mated to bulls of the same type was indicated by Stonaker3. Compresst dwarfs appear similar, in most respects, to the recessive dwarfs usually encountered. Bowed forelegs are common, however. While the forelegs may be a distinguishing feature, there is no assurance that all compresst dwarfs exhibit this defect. It is reported that these dwarfs die early in life. Stonaker's observations indicate that the compresst dwarfism is inherited, but dominance is lacking. In this case, the carrier animals show the compresst type. Gregory (7) received reports of herds in which it appeared that both types of dwarfism were prevalent, because of the high percentage of dwarfs obtained.

"Duck-legged" cattle

Cattle with unusually short legs, although normal in other respects, were observed by Lush (11). These cattle were grade Herefords, but the "duck-legged" condition traced to other than the Hereford breeding. The short legs were due to a dominant gene. The "duck-legged" cattle lived and were capable of reproduction.

Long-headed Hereford dwarfs

Little information is available on long-headed Hereford dwarfs. The authors know of two herds in which they have appeared. One of these dwarfs is under observation at the Arizona station. Although the head is long and narrow rather than

3 Animal Husbandman, Colorado Agricultural and Mechanical College, Fort Collins, Colorado. Personal communication.
short and broad, this animal possesses some of the characteristics of the more common Hereford dwarfs. The legs are moderately short; paunchiness is evident, but not extreme; the jaw is undershot; breathing is forced. The growth rate has been slow. The narrow head, short legs, undershot jaw, and small size directed attention to the animal in early calfhood. While this may be a distinct type of dwarfism, there is a possibility that it is a modified form of the dwarf type usually encountered. The dam of the long-headed Arizona dwarf also produced a typical, recessive dwarf.

Compact Shorthorns
These are small-type Shorthorns reported by Stonaker and Tom (15). The head, neck, body, and legs were shorter than those of the “standard” type of Shorthorns. These characteristics were present at birth and throughout life. The “compact” type was apparently due to a dominant gene. The compact Shorthorns survived and reproduced, just as do the “standard” Shorthorns.

“Stumpy” Shorthorns
Baker and others (1) described “stumpy” Shorthorns found in a Nebraska herd. Curly-haired coats, small tail switches, enlarged knees and twisted cannon bones resulting in a bowlegged appearance, and enlarged hoofheads were characteristic of these animals. Body length appeared normal and the heads were not deformed. The “stumpy” calves were recognized at birth by the curly-haired coats. A simple recessive gene was believed to be responsible for this dwarflike condition. Whether this gene is in any way associated with the recessive dwarfism considered throughout this bulletin has not been determined. The “stumpy” animals lived and could reproduce.

Long-headed Angus dwarfs
Long-headed Angus dwarfs were reported by Baker and others (2). From birth to two or three months of age, these dwarfs exhibited compact, low-set, thick bodies and short, wide heads. The heads became longer and narrower at more advanced ages. A simple recessive gene was considered the most likely cause of the abnormality. Whether this is a modification of the recessive dwarfism that appears common to the Hereford, Shorthorn, and Angus breeds has not been reported.

A portion of the study on which this bulletin is based is a contribution from the Western Regional Beef Cattle Research Project W-1, which is a cooperative research program of the agricultural experiment stations of all the eleven western states and Hawaii, (Washington, Oregon, California, Idaho, Montana, Wyoming, Colorado, Utah, Nevada, New Mexico, Arizona and the Territory of Hawaii) and the United States Department of Agriculture.
DEFINITIONS OF TERMS

Gene — The basic unit of inheritance. Only two genes need be considered in the discussion of the inheritance of dwarfism. These are the gene for normal growth “N” and the gene for dwarfism “d.” These genes occur in pairs, and a given animal may carry either the NN, Nd, or dd combination.

Dominant gene — A gene that masks the outward expression of the other gene with which it may be paired. N is dominant over d.

Recessive gene — A gene that has no apparent effect on the animal if paired with a dominant gene. The gene, d, is recessive.

Homozygote — An animal possessing a pair of genes, both members of which are alike. An animal possessing either the NN or dd combination is a homozygote.

Dwarf-free or Clean — An animal possessing the NN combination is a “homozygous dominant” or “homozygous normal” animal and is commonly called a “dwarf-free” or “clean” animal.

Dwarf — An animal possessing the dd combination is a “homozygous recessive” animal or, in this case, a dwarf.

Heterozygote or Carrier — An animal possessing a pair of genes, the members of which are not alike. An animal possessing the Nd combination is a “heterozygous” animal and is commonly called a “dwarf carrier.”

Genotype — Refers to the gene combination possessed by an individual. For the purpose of this study three genotypes (NN, Nd, and dd) must be considered.

Phenotype — The outward expression of the gene combination possessed by the animal. An animal of the NN type appears normal and is said to be “phenotypically normal” or of normal phenotype. Since animals with the Nd combination show no visible abnormalities, they are said to be “phenotypically normal.” Animals with the dd combination appear abnormal and thus show the “dwarf phenotype.”
LITERATURE CITED


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