VERTICAL FIBER HIDE DEFECT: A BIOPSY STUDY OF HEREFORD AND ANGUS CATTLE OF KNOWN GENEALOGY*

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Abstract

Hide biopsies from 604 Hereford and Angus cattle of known lineage were evaluated to examine statistically the occurrence and distribution of vertical fiber hide defect with respect to breed, sex, and age; the heritability; of the defect; and its relationship to reproductive efficiency. The defect was not found in Angus cattle, but it was found in 15.3 percent of all Herefords evaluated. Its heritability was found to be 81 percent in males and 88 percent in females. Reproductive efficiency was not affected by the defect.

Introduction

Vertical fiber hide defect (VFD), which appears to be an inherent structural weakness limited to Hereford cattlehides, first became obvious when it was described by Amos (1) in Australia. Later Tancous and Schmitt (2, 3) described it in commercial hides in this country. Everett *et al.* (4) presented evidence of VFD in multiple progeny hides from known sires which strongly suggested that it was genetic in origin. Some investigators (5) attributed the defect to excess fat resulting from intensive feeding practices. Hannigan *et al.* (6) reported the results of a hide biopsy study of identical and fraternal Hereford and Holstein twin heifers fed either a high- or low-energy diet. The study established that VFD is not induced environmentally, but strongly supported the hypothesis that it is genetically influenced. The defect was found only in Hereford cattle, not in Holsteins.

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Everett and Hannigan (7) presented evidence from a crossbreeding experiment involving the same twin cattle, that showed a higher rate of calf mortality and conception failures for cows with VFD than for those free of the defect. However, during the course of the present study, Dufty *et al.* (8) from Australia, reported on the effect of VFD on the reproductive performance of Herefords, and found no significant difference in fertility or calving problems between animals with VFD and those without it.

Bitcover *et al.* (9) found the defect in Hereford bulls. Marx (10) reported finding extreme structural weakness from the defect in Hereford hides being prepared for export in Argentina.

This paper presents the results of histological studies of 604 hide biopsies (465 Hereford and 139 Angus cattle) and statistical analyses of the results. Prompted by Everett and Hannigan's (7) preliminary indications that VFD might be related to reproduction problems, the project was implemented in cooperation with the Roman L. Hruska U.S. Meat Animal Research Center (USMARC) to study the occurrence and heritability of VFD and its effect on animal performance traits.

Experimental

Test Design

The test was set up by the author from USMARC to evaluate specific experimental objectives: (1) to study the effects of sex, age, and breed on VFD in cattle; (2) to evaluate the heritability of the defect; and (3) to evaluate its relationship to reproduction and other performance characteristics. Table I shows the number of animals according to age, sex, and breed selected for the histological survey.

TABLE I

NUMBER, BREED, SEX, AND AGE OF TEST ANIMALS

	Hereford		Angus	
Age	Male	Female	Male	Female
years				
1/3	54*	47*		
7/12	50*	50*		
1	28	42	8	19
1½	50	49	20	20
2		24		19
3		23		18
4		23		19
5 to 9		25		16

*Animals resampled approximately 7 months later.

The purebred Hereford and Angus cattle were located at the USMARC. For the first time, 4- and 7-month old calves as well as cows 2 to 9 years old were selected for study in addition to the usual 12- and 18-month old animals.

Biopsy Technique

A biopsy sample 1 cm in diameter was taken from the rump area of each animal 10 in. in from the tail and 10 in. down from the backbone with an automatic biopsy gun (11). The biopsies were taken from the selected animals from December 1980 until March 1981 and from the resampled calves in August and September 1981.

Each biopsy specimen, referred to as a sample, was put into 10 percent neutral formalin* as soon as it was obtained and sent to the Eastern Regional Research Center for the histological evaluation of the orientation of its fiber structure.

Histology

The formalin-fixed samples were cut in half in the plane of the hair follicles and then cut on a freezing microtome into cross sections 40 to 60 microns thick. Sections were stained with hematoxylin and eosin (Lillie-Mayer variant 12), and the fiber bundles were examined microscopically. Their architectural structures were designated as normal (N), vertical (V), or intermediate (I). *The normal fiber bundle orientation* is compact with bundles interweaving at an angle of approximately 50° to 60°. *Vertical fiber bundle orientation* is mostly vertical with little or no interweaving and usually has a very loose appearance. *Intermediate fiber bundle orientation* is loosely interwoven with a variably upright angle of weave; it appears vertical in localized areas. The terms intermediate and vertical are thought to represent two degrees of the same defect.

In addition to fiber orientation, four other characteristics were evaluated from the cross sections. Grain depth (thickness of corium minor layer) was measured from the epidermis to the base of the average hair roots using a rule graduated in units of 0.1 mm. Total hide thickness was measured from the epidermis to the junction of corium major and subcutaneous layers. Depth of sweat glands was measured from the epidermis to the base of the deepest sweat glands found. Corium fat was evaluated subjectively on a scale of 0 to 4, with the higher values indicating more fat.

Statistical Analyses

Results of the histological evaluations showing the presence and degree of VFD were collated with data on the genetic background, reproduction, and other traits in each animal's history on file at the USMARC.

Appropriate computer programs were available for investigation of the data submitted. A fixed model program for least-squares analyses was used to investigate the effect of sex, age group, and breed on the occurrence of VFD and on

*1-10 dilution of 37 percent formaldehyde saturated with calcium carbonate. Formaldehyde irritates mucous membranes and has been under study as a possible carcinogen for them, so skin contact with the chemical or its vapors should be avoided. For the latest information, a Material Safety Data Sheet should be obtained from the manufacturer and the recommended precautions should be followed.

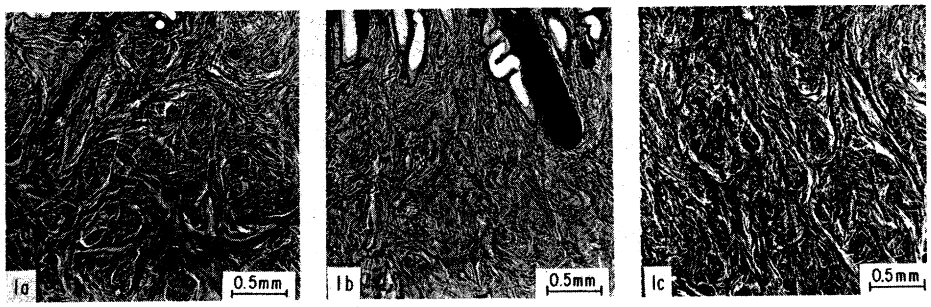

FIGURE 1. – Cross sections of upper corium of three Hereford biopsy samples illustrating the three types of fiber structure a) normal; b) vertical; c) intermediate.

physical characteristics such as hide thickness, grain depth, and corium fat. Similar types of analyses using a mixed model were performed to estimate heritability and the genetic relationship to other traits. The lifetime reproduction performance of cows with and without VFD was evaluated using data available on pregnancy and weaning of animals sampled in the study.

Results and Discussion

Evaluation of Fiber Structure

All biopsy samples were examined microscopically and their fiber structures were designated as either normal, vertical, or intermediate. Photomicrographs representing each are shown in Figure 1. (The defect was not found in the Angus breed.) From the least-square analysis, the average occurrence of the defect designated as either intermediate or vertical in all Herefords examined is estimated to be 15.3 percent (62 of the 465 animals evaluated had the defect), as shown in Table II. Also shown in Table II is the distribution of VFD in male and female animals in each age group. For the first time, 4- and 7-month old animals were examined for the defect and it was found at both ages. In the year-old cattle, more females than males showed the defect, while in the 18-month age group, more males than females showed it. The 2- to 9-year-old animals, all of which were females, had higher percentages of the defect than the younger animals. The greater percentages found in females may be partially due to experimental sampling differences. Of 65 sires used in the test, 31 had one or more defective offspring. Biopsies from the sires were not available. Figure 2 shows the distribution of normal and defective progeny among 16 of these sires; 15 others had only one defective progeny each. Wide variation in the frequency of the defect is apparent. One sire had an incidence of 7 out of 16, two others had 4 out of 5, and still another had 2 out of 23. These data, as will be confirmed later, indicate a high degree of heritability of the defect.

TABLE II

DISTRIBUTION OF VFD IN HEREFORDS ACCORDING TO SEX AND AGE

Sex	Age (years)	No. of Animals	Inter-mediate	Defects			Mean VFD*
				Vertical	Total	%	
M	1/3	54	1	0	1	1.85	
F	1/3	47	4	2	6	12.77	7.3
M	7/12	50	2	2	4	8.0	
F	7/12	50	5	1	6	12.0	10.0
M	1	28	1	0	1	3.6	
F	1	42	5	5	10	23.8	13.7
M	1½	50	6	0	6	12.0	
F	1½	49	5	0	5	10.2	11.1
F	2	24	3	3	6	25.0	20.8
F	3	23	4	2	6	26.1	21.9
F	4	23	3	2	5	21.7	17.6
F	5+	25	4	2	6	24.0	19.8
M	all	182	10	2	12		11.1
F	all	283	33	17	50		19.4
M&F	all	465	43	19	62		15.3

*Means are from a least squares analyses of variance fitting fixed effects for the mean, sex, age group, and sex-age group. Only the effect of sex was significant ($P < .05$).

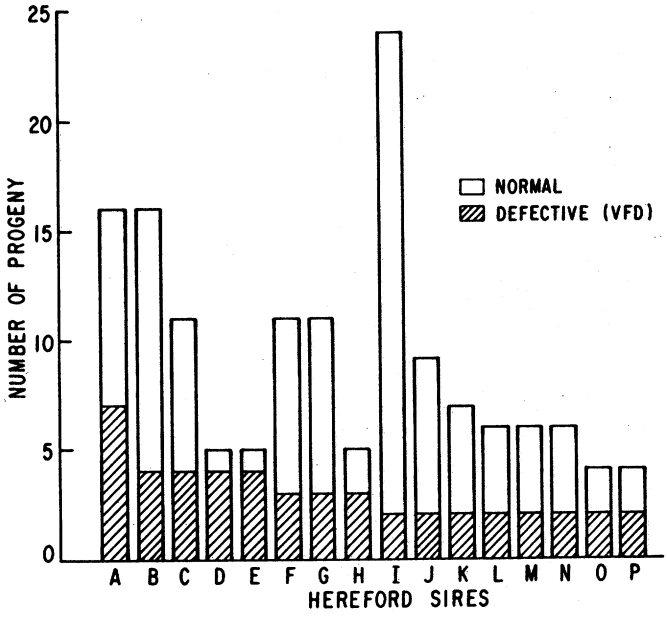

FIGURE 2. — Bar graph showing the number of normal and defective progeny from Hereford sires with more than one defective offspring.

Other Properties Evaluated

Other hide characteristics measured were hide thickness, grain depth, and fat in the corium layer. These traits differed slightly with breed and age as shown in

TABLE III

AVERAGE* HIDE THICKNESS, GRAIN DEPTH, AND FAT SCORE

Age (years)	Sex	Hide thickness (mm)		Grain depth (mm)		Fat score**	
		Hereford	Angus	Hereford	Angus	Hereford	Angus
1/3	M	3.92	–	1.52	–	0.2	–
1/3	F	4.16	–	1.53	–	0.5	–
7/12	M	5.43	–	1.66	–	1.0	–
7/12	F	5.47	–	1.68	–	1.4	–
1	M	6.61	5.88	1.77	1.60	0.5	0.0
1	F	6.52	6.05	1.70	1.57	1.0	1.2
1½	M	6.88	5.75	1.79	1.61	0.6	0.1
1½	F	6.96	5.63	1.77	1.57	1.1	1.2
2	F	6.48	5.42	1.74	1.56	1.3	0.5
3	F	6.68	5.56	1.76	1.60	0.7	0.6
4	F	6.46	6.00	1.76	1.62	1.5	1.5
5+	F	6.46	5.95	1.75	1.60	1.4	1.3

*Means are from a least-squares analyses of variance, fitting fixed effects for the sex, age, breed, sex-age, sex-breed, age-breed, and sex-age-breed. Only the effect of age and breed were significant ($P<.01$).

**Density and distribution of fat was observed in the corium major layer and arbitrarily scored from 0 to 4.

Table III. The Hereford cattlehides were approximately 1 mm thicker than those of the Angus breed at 12 months of age and did not change much beyond this age. The grain depth of Herefords was about 0.14 to 0.20 mm greater than that of Angus cattle. Fat in the corium was approximately the same for both breeds and increased only slightly with age.

Differences due to breed, sex, and age influence these properties and are of significance to tanners in their selection of hides suitable for specific products. Previous work by Everett and Hannigan (13) reported the prevailing differences between Hereford and Holstein hides, and the present work contributes information about Angus hides. The depth of grain layer is especially important because at equivalent angles of fiber weave it directly affects the strength of thin-split grain leathers. Excess fat in the corium is also of concern because it may require some modification of processing systems.

Sweat glands of cattle normally are as deep as the hair roots, but as we have

TABLE IV

DEEP* SWEAT GLANDS (DSG) IN HEREFORDS

Group	Age (years)	Sex	No. of animals		Depth of DSG, mm	
			Total	DSG	Ave.	Range
1	1/3	M	54	4	3.0	—
	1/3	F	47	6	2.8	2.5-3.0
2	7/12	M	50	0	—	—
	7/12	F	50	7	3.1	2.5-4.0
3	1	M	28	2	3.5	3.0-4.0
	1	F	42	1	4.0	—
4	1½	M	50	3	4.0	3.5-4.5
	1½	F	49	1	3.5	—
5	2 to 5	F	95	0	—	—

*Normally the sweat glands arise at the base of hair roots; see corresponding data for depth of grain layer.

found in previous work with a pair of identical twin Hereford heifers (6), they sometimes penetrate into the corium, as shown in Figure 3. Table IV shows that deep sweat glands were found in 24 of the heifers up to 1½ years in age. The depths ranged from 2.5 mm in the younger heifers to 4.5 mm in the older ones. The significance of this condition is not clear, but to the best of our knowledge deep sweat glands have not been reported elsewhere. Our earlier work led us to believe that deep sweat glands might be heritable, but the evaluation of these data showed that they are not.

Resampling of Younger Animals

The 4- and 7-month old calves were resampled approximately 7 months later at ages 11 to 14 months because it was previously thought that VFD did not become manifest until the animals reached approximately 1 year of age. In addition to the 17 calves found with defective fiber structure at 4 and 7 months of age, five more animals showed evidence of the defect on re-examination, raising the total number of defectives from 62 to 67. Two of these cases were males and the other three were females.

In the resampled calves the total thickness of hides increased from approximately 4 to 6.6 mm and in grain depth from 1.5 to 1.75 mm. The deep sweat glands of the resampled calves ranged in depth from 2.5 to 4.5 mm.

Statistical Analyses

The fixed model programs showed that the breed difference was highly significant and that the defect was expressed to a higher degree in females than in males. The effects of age were not significant.

The difference between cows with VFD and those without it for lifetime preg-

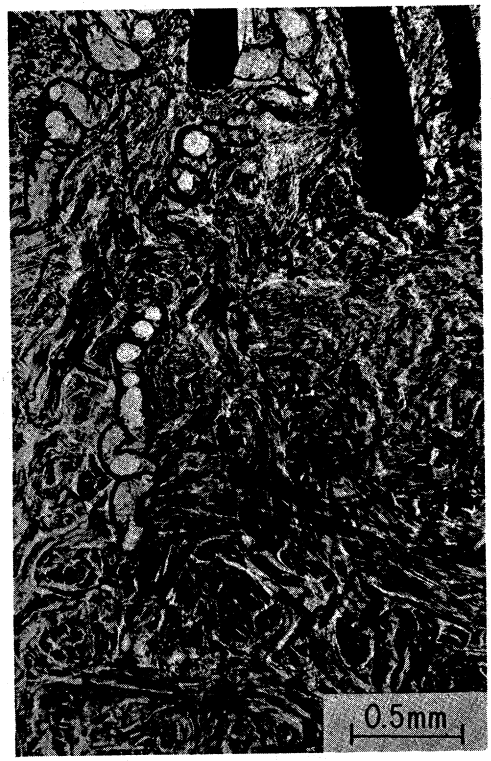

FIGURE 3. — Cross section of biopsy sample demonstrating deep sweat glands found in 24 of the Hereford cattle investigated.

nancy rate was not significant for females 18 months of age and older. The frequency of VFD in older cows tended to be greater than in the younger ones, indicating that it was not strongly associated with conception failures and low reproduction rates, as assumed by Everett and Hannigan (7). Animals failing to conceive would have been culled from the herd at an earlier age. The effects of VFD on lifetime pregnancy rate, lifetime birthrate, lifetime calf crop born alive, and lifetime calf crop weaned were not significant. The pregnancy rate was 94 percent for cows with the defect and 93 percent for those without it.

The mixed model analysis showed the significant effect of the sire indicating that the vertical fiber hide defect has a heritable basis. The estimates of heritability (± standard error) for VFD were very high, 88 (±25) percent in females and 81 (±31) percent in males, and the variations due to environmental effects or nonadditive gene effects were small. Selection to reduce the frequency of the defect and the frequency of the gene or genes causing it should be very effective and should have great economic potential for the leather industry.

The heritability estimates for grain thickness and hide thickness were 40 (±22)

percent and 34(±21) percent in heifers, respectively, and 52 (±30) percent and 58 (±30) percent in males, respectively. VFD is not strongly associated genetically with hide thickness, corium fat, or growth.

Heritability is the proportion of the differences between animals—measured or observed—that are transmitted to the offspring. Thus it is the proportion of the total variation caused by additive gene effects. The higher the heritability for any trait, the greater the rate of genetic improvement or effective selection for that trait (14).

Conclusions

In the herds studied: (1) VFD was found in 15.3 percent of the Hereford cattle examined; (2) it was not found in Angus cattle; (3) it was estimated to be 88 percent heritable in Hereford females and 81 percent heritable in Hereford males; (4) reproduction efficiency and growth rates were not affected by it; (5) it was found for the first time in 4- and 7-month old animals; (6) since sires have significant genetic input for VFD, evaluation of them for its presence should be effective in eliminating it in several generations by selective breeding. Therefore, it is recommended that biopsies should be taken on sires obtained for breeding and that only those found free of VFD should be employed.

Acknowledgments

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Discussion

JEAN J. TANCOUS (Tanners' Council Laboratory, Discussion Leader): I noticed the Abbey took the cow and the calf away from the front yard. When our association came here, I think they were afraid that we would take a biopsy or maybe a hide. We thank Mary for this statistical evaluation and we appreciate that it represents a tremendous amount of work. Making the cross sections for 604 biopsies is very time consuming. Actually, we are grateful to the U.S. Department of Agriculture for their valuable continued research on causes of inherent and parasitic defects in the hides and skins at the farm level. The studies on several parasitic damages, less damaging brands, and veininess in calfskins, as well as the studies on the vertical fiber defect, have contributed much needed information about rawstock problems. I personally am very grateful because their papers in the journal are helping us in the revision of our book, *Skin, Hide, and Leather Defects.* Mary's paper in 1973, which was co-authored by Al Everett and Joe Naghski, was concerned with a biopsy study of the vertical fiber defect in hides from twin calves that were fed high-and low-energy diets. This study gave conclusive evidence that the defect is genetic, and the thought that force feeding was the cause, really was not so. This more extensive study on 604 hide biopsies has given statistically sound information that heredity factors are very important. Mary, do you know how our 1965 study, which was sponsored by the USDA, compared with your present study on 604 hides?

MARY HANNIGAN: Recently, I found data showing that 13.4 percent of approximately 3500 to 5000 Hereford and Hereford-like hides, had defective fiber orientation. They were of both known and assumed backgrounds and they were examined 12 to 15 years ago.

TANCOUS: That is pretty close. Are there hopes that this condition can be improved in the future?

HANNIGAN: There is some hope. According to geneticists, because of the high heritability of the defect, it could be readily eliminated in several generations by selective breeding.

TANCOUS: That's encouraging. Are there any questions from the floor? Mary tied this up so tightly that it is very difficult to ask her questions.

DAVID SMALL (William Greiner Co.): Does your no-growth effect mean that the meat and nothing else is affected adversely?

HANNIGAN: Only the hide is affected.

SMALL: There is no other effect?

HANNIGAN: No, not that we know of.

TANCOUS: Are there any other questions?

GUY MOBERG (Seidel Tanning Co.): I was at Loewengart and Co. some years ago when Braunschweig made a similar test. But since then, I've been wondering, is it possible that these were Angus? Were they just strictly Angus or were they white faced? Because the white-faced Angus, I believe, is a cross between the Hereford and the Angus. Are we going to be picking up this situation in the white-faced Angus?

HANNIGAN: Purebred Angus cattle with known genetic background were used in this experiment. In answer to your question, I can only say that in a previous crossbreeding test using defective Hereford dams and normal Holstein sires, no evidence of the defect was found in the examined progeny.

DR. ROBERT LOLLAR (Tanners' Council Laboratory): There have been some questions raised by Jean, in particular, about the possibility of further work to develop the possible means for eliminating or minimizing this defect. I think there is one thing that should be called to the attention of the people in this room. I have been at the Eastern Regional Laboratory a couple of times recently, and have been involved in discussions about the fact that some animals might be available for this study. It's my understanding that these animals have now been rescued from being sent to the slaughter. However, there are some problems developing with reference to the funding of the program at the Eastern Regional Laboratory which would be necessary to follow up on this work. Those of you within the industry who would be concerned about this are urged to get in touch with Steve Feairheller and myself to try to figure out what might need to be done to see that this next step is completed. It would be, I think, a sad situation not to be able to do the work that is contemplated at this time.

TANCOUS: The industry should be urged to cooperate because the USDA needs the support of the industry. Another question?

ROBERT DOGGETT (A. R. Clarke and Co.): Would it be fair to say that those of us who are running side upper leather and using a majority of Hereford-type hides could be looking at about 10 to 15 percent of tender leather in our production based primarily on this cause?

HANNIGAN: I would say, yes. The Hereford hide appears to be weaker than other hides. They seem to have a weakness, that may not be considered intermediate or even vertical. There are many weak hides and 10 to 15 percent is apparently not a bad guess.

LOLLAR: There is one question that has been coming up privately. Would one

of you at the podium care to comment? Is this essentially what is often known in the industry as pulpy butt?

TANCOUS: Yes.

DOGGETT: Are there any steps that the tanner can take to avoid this condition or to lessen its effect?

HANNIGAN: Sorting is probably the only thing that he can really do. If he had some quick nondestructive test, it would be very helpful.

TANOUS: Is there another question?

MICHAEL GILES (Gunnison Brothers, Inc.): I understand that when the animals are young, this defect begins in the butt area. If it does, does it spread with age to the other areas of the hide?

HANNIGAN: I am not sure that it spreads with age. I do not think so. If present, it is found in the butt, and we test for it in the butt. In extreme cases, it can be found over the entire side.

TANCOUS: I am sorry, but this is all the time that we have. Thank you, Mary, for a most interesting and provocative paper.