SOME FEATURES OF SCORING AS A
TOOL IN BEEF CATTLE SELECTION

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Lawrence L. Kramer
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The undersigned, appointed by the Dean of the Graduate Faculty, have
examined a thesis entitled

SOME FEATURES OF SCORING AS A
TOOL IN BEEF CATTLE SELECTION

presented by Lawrence L. Kramer

a candidate for the degree of Master of Science

and hereby certify that in their opinion it is worthy of acceptance.

John F. Lasley
J. E. Comfort
J. E. Weinman

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TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
II. REVIEW OF LITERATURE	4
III. MATERIALS AND METHODS.	16
IV. RESULTS AND DISCUSSION	20
V. SUMMARY.	38
LITERATURE CITED	40

LIST OF TABLES

TABLE	PAGE
<p>I. Analysis of Variance of the Differences Between Sexes of Beef Calves for Thirteen Traits</p>	21
<p>II. Analysis of Variance of the Differences Between Judges for Fourteen Traits of Beef Cattle</p>	22
<p>III. Analysis of Variance of the Differences of the Scores for the Same Calf for a Group of Sixty-Six Beef Calves.</p>	24
<p>IV. Intra-Class Correlations Within the Scores for Each Calf for Thirteen Traits.</p>	26
<p>V. Correlations Between Judges on the Basis of Total Score.</p>	28
<p>VI. Correlation of Weaning Weights with Individual Judges Total Score for Each Calf</p>	31
<p>VII. Correlation of Total Score with the Component Traits of the Score Card.</p>	33
<p>VIII. Correlation of Weaning Weights with the Component Traits of the Score Card.</p>	35

CHAPTER I

INTRODUCTION

"Like begets like." There are many graphic illustrations today to immediately convince even the most doubtful of the fallacy of this statement. Since such is the case, the truly progressive animal breeder must always be on guard to maintain that margin of improvement in his livestock that he has developed over the average of the population. In this unending war of man against nature, it is evident that one must use all the means available for selecting and improving his seed stock, and in addition must constantly search for newer and better methods to supplant those already available.

Theoretically, three tools for animal improvement exist; selection, inbreeding, and crossbreeding. Of these, one, selection, is used universally by all livestock men, be they animal breeders or merely animal multipliers. When either of the other two means of improvement are used, they are used in association with selection. This, then, entirely justifies further study of this method of animal improvement.

Fundamentally there are three bases for selection; individuality, pedigree and progeny. Each of these has

several advantages that the others lack, but in addition, they also have their respective disadvantages. The scope of this paper is such that it will only deal with the first--individuality.

Individuality can generally be broken down into two sub-divisions; type and performance. Type may be described as a comparison of an animal to the ideal, usually on the basis of conformation. It is rather an abstract measure since it depends upon several variables for its success. First, the ideal for a breed or species is apt to change from time to time. It might even be said that the ideal animal is an abstraction that is in a slow but constant state of change. The second variable encountered is the ability of the judging official to compare the animal in question to the accepted ideal.

If one accepts the hypothesis that type is continually changing, then he must also accept the fact that the judge, in order to do a competent job, must be aware of these changes and abide by them in his decisions.

Performance, the second component part of selection, is somewhat harder to determine. This is so because the performance of an animal is based on records which require time and work to compile; therefore are not used to the degree that type is as a basis for selection.

Since type or conformation plays such an important role in the selection of animals, it is only fitting that

this mode of selection has been, and will continue to be, a subject to which animal breeders will devote time and energy in order to make some degree of improvement in the tool itself.

In line with this effort for improvement, the score card has evolved. This is a listing of those traits of economic importance which are heritable to a practical degree supposedly. Individual animals are evaluated for each of these characteristics on the basis of a proportionate part of the whole, which is considered ideal. A total of these proportionate amounts results in a final figure, the total score, which is considered to be some index of this animal's worth as compared to every other animal as well as to the accepted standard.

It is the purpose of this paper to actually evaluate the effectiveness of such a method as a measure of animal improvement; to determine if these phenotypic comparisons can actually foretell the final value of an animal, and too, offer perhaps some method of improvement in the process.

CHAPTER II

REVIEW OF LITERATURE

In his text, Stock Breeding, Miles (1878) begins a chapter on selection with the following statement: "The intelligent breeder will make a vigorous selection of breeding stock in accordance with a well defined and consistent standard of excellence." He in turn quotes Lord Rivers, who when asked how he succeeded in breeding such fine Greyhounds, replied, "I breed many and hang many." Such is both the theoretical and practical aspect of selection as a tool of animal improvement.

That selection is important in animal breeding has been justified previously. In an attempt to improve this important means of animal improvement, the score card has evolved. Rommel (1904) in discussing the value of the score card in animal husbandry states that while its use by the judge in the show ring is obsolete, it does have a very important place in the livestock industry. For teaching in colleges, the use of a card allows the cardinal principles of judging to be impressed upon the student. By this method, important points of form and action are pointed out, as well as a systematic method of judging developed. When the student becomes thoroughly familiar

with the relative value of the points included on the score card, it can be disregarded and replaced with class judging.

The selection index, such as the score card serves in this case, cannot be justified as a tool in practical breeding work as readily as in teaching. Winters (1954) states that the selection index might be an almost fool-proof method of selection if the information used in constructing the index is accurate. However, such is not the case. Average values covering a period of time must be used and this fact in itself defeats its purpose. These values do not permit the amount of selection for different characters to be varied as their importance to the line or herd varies. As a result, exceptional individuals may be overlooked.

Lush (1945) speaks in greater detail on the construction of a selection index. The information used in the construction of the index, referred to by Winters (1954) is listed by Lush as follows. First, as he lists them, is the importance of the characteristic. That is, to what extent variation effects the phenotypic merit of the animal. Secondly, the heritability of each characteristic included in the index. This may be explained as that part of any unit improvement of the selected parents that will exhibit itself in the offspring. Genetic correlations is

the third point listed by Lush. This is a comparison of the interaction between two or more genetic traits affected by the same genes, as opposed to what would happen if they were independent. And finally the fourth point is phenotypic correlations. This point is explained much the same as the previous one except that it deals with characters affected by environment and genes rather than genes alone.

Logically, it would seem to be of value to search the literature to ascertain just how these points have been treated by statistical research, yielded by field work.

With regards to the first point as outlined by Lush (1945), importance of the characteristic, little work is actually available on beef cattle.

Gregory, Blunn and Baker (1950), with a total of 237 observations found no significant difference in weaning weight due to the sex of the calf or due to the difference between sires. However, they did find that calves which were heavier at birth tended to maintain this advantage and thus be heavier at weaning.

Data on 424 steers from 68 bulls fed out during a 13 year period are reported by Durham and Knox (1953). Following this study, these authors found that grade at the beginning of the period tended to be negatively associated or not associated at all with subsequent gains. They

found that gain during the fattening period was associated with the subsequent grade. They found no correlation in the data between weaning grade and carcass grade.

Interest in heritability of traits in beef cattle has been sizeable since the first work was reported in 1946. The published data lends support to Winters' (1954) conclusion that the average heritability values used do not permit for varied selection within a certain herd or line, which is necessary if an index is to be fully effective.

The first work reported on heritabilities in beef cattle appeared in 1946. This work by Knapp and Nordskog (1946a) was the result of a study of 177 steer calves from 23 sires. Heritabilities based on intra-sire correlations were reported as; 23 per cent birth weight, 12 per cent weaning weight, 81 per cent final feed lot weight, 99 per cent gain in feed lot, and 75 per cent efficiency of gain. When the heritabilities were calculated from sire-progeny regressions, the values were; 42 per cent birth weight, 0 per cent weaning weight, 69 per cent final weight, 46 per cent daily gain, and 54 per cent efficiency of gain.

An interesting observation is made by the authors on their work; the first heritabilities on beef cattle. "The estimates of heritability obtained from these data are

higher than seems reasonable and the cause or causes of these high estimates are not known. Meanwhile, these results are interpreted to indicate that the breeder and feeder of beef cattle can take encouragement from this report with respect to selection of cattle for both rate of gain and efficiency of feed utilization."

A further study was made on these same animals at a later date by these workers (1946b). In this work they found the heritability for score at weaning to be 53 per cent, slaughter grade 63 per cent, and carcass grade 84 per cent. They concluded from this later work that though there seems to be less heritability in measures of quality of product than in the measure of growth, there is ample opportunity for selection for these characteristics.

Gregory et. al. (1950) calculating heritabilities at two different stations in Nebraska, found values of 45 per cent and 100 per cent for birth weight, 0 per cent and 45 per cent for gain from birth to weaning, and 26 per cent and 52 per cent for weaning weight at the two stations. These estimates were obtained from paternal half-sib correlations.

Revised estimates of heritability of traits in beef cattle were presented by Knapp and Clark (1950). These revised estimates were based on the progeny of 64 to 110 Hereford sires in studies conducted at the U.S. Range

Livestock Experiment Station, Miles City, Montana. These estimates, obtained by half-sib correlations were; 53 per cent birth weight, 28 per cent weaning weight, 28 per cent weaning score, and 33 per cent carcass grade. Lower fiducial limits of heritability (PL .01), based on half-sib correlations, were; 26 per cent birth weight, 7 per cent weaning weight, 4 per cent weaning score, and 10 per cent carcass grade. Following this work, this group concluded, "These figures indicate the relatively high influence of heredity in determination of growth after weaning. Growth measures were more highly influenced by heredity than were measures of quality and conformation."

A report by Dawson et. al. (1954) deals with the six-month weights of 446 calves produced during the years 1945-50 at the U.S. Iberia Livestock Experiment Farm, Jeanette, Louisiana, in a strain of cattle derived from a Brahman-Angus crossbred foundation. Heritability of six-month weight was estimated as zero from sire-offspring regressions and paternal half-sib correlations of immediate offspring, and from 5 per cent to 15 per cent based on dam-offspring regression. The authors pointed out the importance of maternal abilities in determining six-month calf weights and suggested they are heritable traits.

Data from 4553 calves raised at the U.S. Range Livestock Experiment Station, Miles City, Montana, were analyzed by Koch and Clark (1953a). Heritability estimates

calculated were: 35 per cent birth weight, 24 per cent weaning weight, 21 per cent gain from birth to weaning, 18 per cent weaning score, and 27 per cent yearling score. These analyses indicated that maternal environment is important for birth weight, gain from birth to weaning and weaning score. All calculations were made using maternal and paternal half-sibs.

In a continuation of the above work, using dam-offspring and sire-offspring calculations, Koch and Clark (1955b) arrived at the following values as heritability estimates: (first value is offspring on dam and second is progeny average on sire) 44 per cent and 35 per cent for birth weight, 11 per cent and 25 per cent weaning weight, 7 per cent and 17 per cent for gain from birth to weaning, and 16 per cent and 15 per cent for weaning score.

The work of Rollins and Wagnon (1956) estimated the heritability of weaning grade in two experimental range herds, A and B, of similar breeding that were managed alike except that Herd A cows were supplemented during the fall and winter when the range was nutritively deficient. On the basis of paternal half-sib relationships, heritability estimates were made within each of three generations for each herd. The estimates for Herd A were consistently higher than those for Herd B, but were not significant. The average heritability estimate for the two herds was

36 per cent. On the basis of selection experiments extending over two generations, heritability of weaning grade in Herd A was estimated at 42 per cent while in Herd B it was 29 per cent. Within years there was a correlation of .42 between weaning grade and weaning weight.

Shelby et. al. (1955) summarized the data collected during ten years (1942-51) of Record of Performance testing at the U.S. Range Livestock Experiment Station at Miles City, Montana. The data consisted of records of 635 steers from grade cows mated to 88 sires from nine lines. Some of the characteristics studied were; birth weight, weaning weight, final weight at the completion of the feed lot period, gain in the feed lot, and slaughter grade. The results indicated the effects of differences between years were highly significant for all characteristics. Differences between sires within lines were not significant for carcass grade, but were significant for weaning weight, and were highly significant for the other characteristics.

Heritability estimates were obtained as follows; 72 per cent birth weight, 23 per cent weaning weight, 60 per cent gain in feed lot, 84 per cent final weight at the end of feed lot period, and 42 per cent slaughter grade.

The authors of this work concluded; "Selection for most growth characteristics should be based on the indivi-

dual's own record, while selection for carcass characteristics must be based on sib or progeny test."

Very little work is available, as such, on either phenotypic or genotypic correlations as defined by Lush (1945). However, Knapp and Clark (1951), in an analysis based on 613 steers from 83 Hereford sires in work conducted at Miles City, Montana, reported the following results. Calculations revealed a gross correlation of .0001 between score at weaning and gains in the feed lot. A genetic correlation of .300 and an environmental correlation of $-.304$ was obtained. These workers concluded that there is little value in selecting feeders for rapid gain if sole dependence is placed on visual methods of selection.

A major part of this present work deals with testing the reliability of scores given a group of calves by several judges. In line with this objective, the literature was searched for previous work along this line on beef cattle. Surprisingly, little was available. That which was located is reviewed herein.

Based on a total of 187 different animals scored over a ten year period, Gifford et. al. (1951) presented some interesting statistics. Within-season correlations on this group indicated that the judges were in agreement on the points of conformation scored. They seemed to agree more closely for items on which they considered the entire

animal. Judges were least able to recognize differences in the fore quarters. The correlations between repeated scores of a cow by the same judge were generally between .4 and .5. The judges were able to agree more closely with one another on a particular classification date than they were able to agree with their previous scores. Significant differences in judges scores existed, and were of minor importance in determining the total variance in conformation scores.

Brown et. al. (1953) reporting on 8048 classifications over a ten year period report the following results. Judges with a basic knowledge of desirable conformation of beef cattle gave similar ratings to a particular animal at a particular time. The ratings of the judges appeared to be in closer agreement on items of conformation for which they considered the whole animal than for items of conformation for which they considered only part of the animal. The repeatability of ratings by the same judge on the same cows in different seasons was usually between .4 and .6 except when the calculations were made using a small number of animals. It appeared that the major reason for variation of scores in the study was due to differences between cows, thus indicating that the score card was an effective guide for recording differences in conformation.

Brown et. al. (1956) studied conformation scores given to 383 calves and 342 older beef cattle of Angus and Hereford breeding at four experiment stations. Simple correlations varied significantly between groups of cattle in several instances. Average correlations between scores and weight, chest depth, body width and fullness of round were positive, but of limited predictive value. Correlations between chest height and score were negative while wither height and body length were not consistently related to scores. Multiple correlations between all the measurements studied and conformation scores varied from .38 to .76 for the various groups.

Green (1957) reported on two groups of Angus calves scored by three men at the beginning and end of a feeding trial. A total of 45 calves were used in the study.

Coefficients of correlations between scores recorded by different scorers on the same group of calves ranged from .2 to .8. A similar range was found for the scores on individual judges scoring the same group of calves, but on different dates. Averages of the scores of the different judges indicated that the different scores were not in too great a degree of agreement concerning the relative merit of different parts of the body of the calves. Two scorers tended to give the calves too high a score when actual scores were compared to estimated scores. This was

CHAPTER III

MATERIALS AND METHODS

The Agricultural Experiment Station of the University of Missouri maintains a herd of approximately 300 Hereford cattle at Weldon Springs, Missouri. This herd consists of both purebreds and grades, with the purebreds divided into two breeding groups. One group, "the open group," is mated to outbred bulls, while the other, "the closed group," is mated to bulls produced within the group itself.

In the spring of 1957, sixty-six calves were scored in the Weldon Spring herd. Forty-eight of these were heifers, eighteen were bulls. This group of calves was scored individually by five competent members of the Animal Husbandry Department and the Agricultural Experiment Station of the University of Missouri.

The score card (A. H. Form 522: see following page) consists of eleven traits; "scale," "thickness of flesh," "Smoothness of body," "head," "chest," "rear flank," "back," "loin," "rump," "round," and "body." The highest possible score on each was ten, with the exception of "head" and "rear flank," in which case the figure was five. Conversely, the lowest possible score in the case of the first group was three, while "head" and "rear flank" was

particularly true in the case of one of the scorers. Correlations between the scores given and the rate of gain were low in the first group of calves. Initial age and weight apparently had an effect on the scores given the second group of calves.

BEEF-CATTLE SCORING FORM

Animal No. Class Age Date

Weight Condition Station

Breed Sire Dam

Scorer

POINTS	NUMBER 1			NUMBER 2			NUMBER 3			NUMBER 4			NUMBER 5		
Scale.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0
Thickness of flesh.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0
Smoothness of body.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0
Head.....	5	4.75	4.5	4.25	4.0	3.75	3.5	3.25	3.0	2.75	2.5	2.25	2.0	1.75	1.5
Chest.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0
Rear flank.....	5	4.75	4.5	4.25	4.0	3.75	3.5	3.25	3.0	2.75	2.5	2.25	2.0	1.75	1.5
Back.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0
Loin.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0
Rump.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0
Round.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0
Body.....	10	9.5	9.0	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0	4.5	4.0	3.5	3.0

Total score

one and five-tenths. A total of the scores for each of the eleven traits resulted in a "total score" for each animal. It is on the basis of the "total score" that selection or rejection of the animal is based. In addition to the above traits, a score for condition was obtained on all animals, ranging in value up to fifteen. A value for temperment was obtained on the heifer calves, with a perfect temperment being equal to ten.

With regard to methods used in the analysis of these data, standard procedures were followed throughout. A single score for each animal for each trait was arrived at by deriving the mean value of the scores of the five scorers.

The analysis of variance was arrived at by first computing a correction factor (C):

$$C = \frac{(\sum X)^2}{N}$$

This factor was then subtracted from a total sum of squares:

$$(\sum x^2) - C$$

A sum of squares between classes was calculated:

$$\left[\frac{(\sum X)^2}{N} \right] \quad / \quad \left[\frac{(\sum X)^2}{N} \right]$$

from which the correction factor (C) was also subtracted.

These values were then used to determine an F ratio, according to Fisher.

Correlations (r) were arrived at by use of the following formulae:

$$r = \frac{\sum(XY) - \left[\frac{(\sum X)(\sum Y)}{N} \right]}{\sqrt{\left[X^2 - \frac{(\sum X)^2}{N} \right] \times \left[Y^2 - \frac{(\sum Y)^2}{N} \right]}}$$

Multiple correlations were computed on the Burroughs Type E-102 Electronic Computer.

CHAPTER IV

RESULTS AND DISCUSSION

Since both heifer and bull calves were included in these data, it was necessary to calculate a variance ratio to determine if the sex of the calf would have a decisive effect on future results. If so, it would be necessary to correct for this influence so as not to bias any conclusions in this respect. These variance ratios (F ratios) are shown in Table I.

Examination of this table shows the largest ratio value to be 3.02. This value was not significant since the F Table (Snedecor 1956) lists a value of 4.00 for the 5 per cent level of probability and 7.08 for the 1 per cent level. Therefore, it was not necessary to consider the sex of the calves in future calculations nor to make corrections for them.

An investigation to determine how well a number of judges could agree on scores for a group of calves has been stated to be one of the purposes of this work. In line with this goal, an analysis of variance was computed to test the variation between the judges scores for each trait for the total group of calves. The results of this analysis are shown in Table II.

TABLE I
ANALYSIS OF VARIANCE OF THE DIFFERENCES
BETWEEN SEXES OF BEEF CALVES
FOR THIRTEEN TRAITS

Characteristic	F Ratio
Scale	3.02*
Thickness of Flesh	1.65*
Smoothness of Body	.69*
Head	.18*
Chest	.49*
Flank	1.05*
Back	.07*
Loin	1.35*
Rump	.33*
Round	2.42*
Body	.22*
Total Score	1.77*
Condition	1.71*

* Not significant

TABLE II
ANALYSIS OF VARIANCE OF THE DIFFERENCES
BETWEEN JUDGES FOR FOURTEEN TRAITS
OF BEEF CATTLE

Characteristic Scored	F ratio
Scale	13.54***
Thickness of Flesh	4.17***
Smoothness of Body	7.70***
Head	30.69***
Chest	12.15***
Flank	6.83***
Back	6.03***
Loin	26.49***
Rump	9.43***
Round	12.81***
Body	11.11***
Total Score	11.95***
Condition	24.48***
Temperament (Females only)	6.86***

*** Highly significant

The F ratio values in Table II range from a high of 30.69 for the trait "head" to a low of 4.17 for the trait "thickness of flesh." All of these values were highly significant.

From a practical point of view, these results indicated that for any one trait there was a greater amount of variation between the range of scores of each of the judges than there was between the scores of the calves they judged. More simply put, one could say that there was more variation among the judges than the judges could see among the calves.

Table III provides more information on this subject about the group of calves. This table gives an analysis of the variations of the scores for the same calf. The values for the traits in this case ranged from a high figure of 5.68 for "thickness of flesh" to a low of 1.72 for "condition." ("Temperment," with a value of 5.80 was the highest of any trait considered, but the data were available on only the heifer calves.) All of the values in this table were highly significant (at the 1 per cent level of probability).

Once again, more simply, this statistic applied to these data revealed that for any one calf, the judges saw less disagreement in the features of the calf than they had among themselves.

TABLE III
ANALYSIS OF VARIANCE OF THE DIFFERENCES
OF THE SCORES FOR THE SAME CALF FOR
A GROUP OF SIXTY-SIX BEEF CALVES

Characteristic Scored	F ratio
Scale	3.64***
Thickness of Flesh	5.68***
Smoothness of Body	3.31***
Head	2.28***
Chest	3.54***
Flank	3.39***
Back	2.53***
Loin	2.39***
Rump	2.62***
Round	4.02***
Body	4.58***
Total Score	6.03***
Condition	1.72***
Temperament (Females only)	5.80***

*** Highly significant

These results in Tables II and III indicate that individually these judges failed to score a particular characteristic or calf the same numerically. That is, a particular degree of acceptability may be rated consistently the same by one scorer, while another may rate the same degree of desirability either uniformly lower or higher. It must be remembered, however, that these figures deal with absolute scores and give no indication as to the degree of correlation between judges. The correlation between judges is discussed in connection with Table V.

The data in these tables brings to light one of the greatest faults of any scoring system, and is the reason that selection indices are not used to a greater extent. By use of any such method, it is necessary that the same individual score all the animals affected if any value is to be placed on absolute values. Unfortunately, in most cases, these absolute values are the ones that are given consideration by the practical beef cattleman, due to the fact that he can understand them. Of course, some value could be derived from scores made by several individuals, but the results would be relative and be expressed in abstract terms which are not readily understood by the average cattleman.

A further disadvantage to scores, even if they are all made by the same individual, is that there is no

TABLE IV
 INTRA-CLASS CORRELATIONS WITHIN THE
 SCORES FOR EACH CALF FOR THIRTEEN TRAITS

Characteristic Scored	"r ₁ " Value
Scale	.715 ***
Thickness of Flesh	.388 ***
Smoothness of Body	.573 ***
Head	.856 ***
Chest	.690 ***
Flank	.538 ***
Back	.501 ***
Loin	.836 ***
Rump	.628 ***
Round	.706 ***
Body	.669 ***
Total Score	.687 ***
Condition	.824 ***

*** Highly significant

guarantee that over a period of time an individual's opinion will not vary. Several factors contribute to this. First, as pointed out earlier, the ideal animal as defined by the breed associations is in a constant state of change. Since this is the case, it is necessary for all who judge (or score) to change their mental picture of what is desired. However, this fluid situation must always move at a certain rate as prescribed by the powers that be. Herein lies one of the major difficulties; while everyone is aware that a certain amount of change is necessary, no one can guarantee that all who judge will alter their opinion to the correct degree or even in the proper direction.

Secondly, as with all cases wherein the human element is involved, experience is an influencing factor. Were a man to re-judge the same group of animals scored years earlier, undoubtedly there would be variation; more variation than could be accounted for by changes in condition, maturity or other environmental factors that affect an animal.

Table IV provides information on the intra-class correlations within the scores for each calf for thirteen traits. Since five judges scored each calf for each trait, this statistic relates to what degree the five scores were associated for any one trait for any calf. Each of these values is highly significant, but would be expected to be

TABLE V

CORRELATIONS BETWEEN JUDGES ON THE
BASIS OF TOTAL SCORE

Judge	II	III	IV	V
I	.58 ***	.54 ***	.63 ***	.59 ***
II		.60 ***	.72 ***	.67 ***
III			.64 ***	.58 ***
IV				.64 ***

*** Highly significant

so since the data from which they were calculated were also highly significant (Table II). However, it is interesting to note that those traits that have a " r_1 " of .7 or above; "scale," "head," "loin," "round," and "condition," are in most cases traits that are relatively easy to see even by those of limited judging experience. Those traits with an " r_1 " value of .6 or less; "thickness of flesh," "smoothness of body," "flank," and "back," seem to be characterized as a group by being relatively abstract. That is, they are not well defined in the eyes of many who judge and as a result, a lower intra-class correlation was evident; i.e., there was a great deal of variation in the judges scores for these traits. (Large intra-class correlation indicates relatively small variation among the individuals of the sub-samples--Snedecor, 1956.)

The ability of the judges to agree on the relative merits of this group of calves is shown in Table V. This table is a summary of simple correlation (r) values wherein each judge's total score for each calf is correlated with every other judge's total score for each calf. The " r " values ranged from a low of .54 for Judges I x III to a high of .72 for Judges II x IV. All of the values in this table were highly significant.

This statistic, then, is what was referred to earlier in this chapter. By the use of this procedure it was

possible to avoid using absolute values, but to test associations and trends. These values indicated that the judges as a group agreed to a great extent on the differences between the calves though their absolute values or scores may not have been identical. That is, the judges each could reflect a sizeable amount of the actual differences between the calves in his own standard, but the judges lacked a common standard of absolute values (Table II).

When the individual judge's total score was correlated with a trait of economical importance, rather than with his colleague's figures, the results were somewhat different. Table VI is such a summary. In this table the total score given each calf by each scorer was correlated with "weaning weight", which has been selected as the economic characteristic with which to compare the effectiveness of scores.

In this case, the lack of a significant correlation was evident in two instances, (Judges I and IV). Even though there is a positive trend, these data indicated that the total score failed to reflect, or change in association with, the variation in weaning weight to the desired degree. In one case (Judge II), the correlation was significant at the 5 per cent level, and in the remaining instances the values were significant at the 1

TABLE VI

CORRELATION OF WEANING WEIGHTS WITH
INDIVIDUAL JUDGES TOTAL SCORE
FOR EACH CALF

Judge	"r" Value
I	.219 *
II	.298 **
III	.374 ***
IV	.202 *
V	.357 ***

* Not significant

** Significant

*** Highly significant

per cent level. While in every case the judges could agree with each other at a level that was highly significant, only in two out of the five cases could this be repeated when correlated with an economically important trait.

Several facets of the usefulness and limitations of the score card or scoring index have been discussed. It would be well, then, to examine the mechanism of the tool itself and attempt to determine just how useful this particular group of traits was, both singularly and collectively, for predicting characteristics that can only become absolutely known at some future date.

The first step in attempting to gain this end was to correlate each of the component traits of the card with the "total score"; the addition of all the component parts. This summary is present as Table VII. As one might expect, all "r" values were highly significant. ("Condition" and "temperment" were included although they did not appear on the score card.) These values extended from a low of .440 for "scale" to a high value of .945 for "thickness of flesh." ("Temperment," which included data on only the females failed to show any association with "total score.") The high correlation of total score with condition ($r = .739$) shows that the fatter calves were scored the highest indicating again that "fat is a pretty color."

While this table contributes little from a practical standpoint, it is rather interesting to note that "scale"

TABLE VII
CORRELATION OF TOTAL SCORE WITH THE
COMPONENT TRAITS OF THE SCORE CARD

Characteristic Scored	"r" Value
Scale	.440 ***
Thickness of Flesh	.945 ***
Smoothness of Body	.870 ***
Head	.730 ***
Chest	.897 ***
Flank	.813 ***
Back	.852 ***
Loin	.916 ***
Rump	.898 ***
Round	.922 ***
Body	.943 ***
Condition /	.739 ***
Temperament / (Females only)	.020 *

/ Not a component part of actual score card

* Not significant

*** Highly significant

differed markedly from any of the other values. This point will be discussed in greater detail.

A much more revealing analysis was the result of the correlations summarized in Table VIII. This was the correlation of each of the traits of the score card (plus "condition" and "temperament") with "weaning weight." This yielded information on the degree of association between traits that are supposed to be indicators of the performance records of the individuals, in so far as weight at weaning was concerned.

These "r" values ranged from .679 for "scale" to a low of .127 for "back." "Scale," "thickness of flesh," "round," and "total score" were highly significant; "head," "chest," "loin," and "body" were significant; but "smoothness of body," "flank," "back," and "rump" were not significant. "Condition" was significant, but "temperament" was not according to these data.

This indicates that while some of the characters on which selection was based were highly associated, or at least associated, others had a low degree of association. In other words, considering just one economic factor, "weaning weight," some of these traits led toward selecting calves that had a heavier weight at weaning whereas others did not.

An example of this situation was the trait "scale."

TABLE VIII
CORRELATION OF WEANING WEIGHTS WITH THE
COMPONENT TRAITS OF THE SCORE CARD f

<u>Characteristic Scored</u>	<u>"r" Value</u>
Scale	.679 ***
Thickness of Flesh	.337 ***
Smoothness of Body	.224 *
Head	.248 **
Chest	.281 **
Flank	.127 *
Back	.129 *
Loin	.270 **
Rump	.182 *
Round	.339 ***
Body	.262 **
Total Score	.344 ***
Condition f	.241 **
Temperament f (Females only)	-.042 *

f Not a component part of actual score card

ff Average of scores of five judges

* Not significant

** Significant

*** Highly significant

In Table VII, the correlation with "total score," this trait was lowest of any of the eleven (.440), while in Table VIII, the correlation with "weaning weight," it was by far the greatest (.679). This trait was a poor indication of "total score," but a very good index of "weaning weight." This can be pointed out further by noting that the association between "scale" and "weaning weight" was almost double the value for the association between "total score" and "weaning weight." There is an indication from these figures that for the trait "scale," the judges were grading on the basis of size which is very highly associated with the individual's weight and thereby highly associated with his weight at weaning.

One should not complain against, or degrade a current idea unless he is prepared to offer something better to replace it. Applying this axiom in the present situation is relatively easy if everyone is willing to accept weight at weaning as the ultimate goal of selection and require that a selection index do no more than indicate which animals will be heaviest at weaning. If such is the case, much improvement can be made.

Presently, "total score" and "weaning weight" are associated with an "r" value of .344 (Table VIII). One component of this index alone, "scale," is a much better indicator of "weaning weight" (.679) than "total score"

(Table VIII). Great strides could be made in selection of heavier weights at weaning by merely selecting on the basis of this trait alone and pay no attention to the ten other components of the score card.

However, perhaps even greater improvement can be made by utilizing several of the significant and highly significant correlations with "weaning weight" and incorporating them into a multiple correlation. In line with this objective, "scale," "thickness of flesh," "chest," "loin," "round," "body," and "condition" were correlated with the dependent factor, "weaning weight." This multiple correlation resulted in a value of .724, which is considerably greater than the value for "scale" alone. This, then, provides for a method of selecting calves that will be of heavier weight at weaning with a great deal more accuracy, and in addition provides for fewer traits being scored on each calf.

CHAPTER V

SUMMARY

A statistical analysis was made of scores by five judges for a group of 66 Hereford calves.

An analysis of variance revealed that there was no significant difference in scores between the sexes of the calves. There was, however, a highly significant difference between the scores of the judges as well as differences of scores for the same calf for each of the components of the score card.

Intra-class correlations revealed highly significant values for each trait of the score card; however, this was to be expected since these correlations were calculated from highly significant data (Table II). While all were highly significant, the " r_1 " values in some cases ("scale," "head," "loin," and "condition") were much higher than in others ("thickness of flesh," "smoothness of body," "flank," and "back"). This indicates that there was a small degree of variation in the former group and a larger degree in the latter.

The correlation between any two judges on the basis of total score ranged from .54 to .72 and were all highly significant. When the total score for each judge was

correlated with weaning weight, values for only two judges were highly significant, one was significant, and two were not significant.

In an attempt to improve the scoring index so as to give a greater indication of weaning weight, a multiple correlation value of .724 resulted from combining six traits of the present score card plus "condition." It is the opinion of the author that these traits, with a multiple correlation of this magnitude would be a better index of weight at weaning than the form presently in use. Several of the factors in the present form actually hinder the degree of relationship between the "total score" and "weaning weight."

In conclusion, it can be stated that the judges' scores agreed remarkably well with each other as evidenced by the simple "r" values and the " r_1 " values (Tables IV and V). Superficially, the data in Table VI may appear discouraging, but when one considers the fact that the correlation with "weaning weight" was made on the basis of "total score," and that "total score" itself was not correlated very highly with "weaning weight" (Table VIII), one must readjust his reasoning. Had this correlation with weight at weaning been made on the basis of the revised scoring system outlined above, the author feels a much higher relationship would be evidenced in this table.

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