PHYSICAL CHANGES IN YOUNG DAIRY HEIFERS
AS INDICATED BY TYPE EVALUATION STUDIES

DISSERTATION

Presented in Partial Fulfillment of the Requirements
for the Degree Doctor of Philosophy in the
Graduate School of The Ohio State University

By

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INTRODUCTION

Interest in type is older than many of our modern breeds of livestock. In fact, exhibitions and shows no doubt aided greatly in the establishment of some breeds by helping to keep the ideal of the breed in the minds of the breeders.

The first modern livestock show was held in Sussex, England, in 1798 and within the next few years, the idea spread to many countries and to nearly all kinds of livestock. Showring winnings have played a prominent role in the selection of breeding stock. Indeed, in beef cattle, sheep and some types of horses this is about the only tool available. In contrast is the thoroughbred in which no type standards exist, and pedigrees are judged solely on race track performance. The importance of type in other animals is between these extremes. Only during the past few years have performance tests been applied to swine. This is not surprising since there is a rather high correlation between appearance and utility in meat animals. On the other hand, it seems probable that the correlation between egg laying ability, or milk production, and conformation would be comparatively low, if not altogether lacking, or even negative. This, of course, does not mean that type is of no value in poultry or dairy cows. On the contrary, good type is in great demand. For the breeder of dairy cattle, it has three values: esthetic value, advertising value, and sale value. A few blue ribbons from important shows may increase the sale value of an average producing cow tenfold. Part of this new
value may be transferred to relatives of the winning cow, or even to unrelated animals in the same herd.

The increased use of production records as a guide in the selection of dairy cattle would be expected to result in less interest in body conformation, but this has apparently not been the case. Breeders of purebred dairy cattle, as a whole, are probably more type-conscious today than ever before. Each of the five major dairy breeds initiated a herd classification program between 1929 and 1947. Under this program, any breeder may have a showring type evaluation placed on each cow in his herd. This evaluation has distinct advantages over showring placing in two important respects: (1) the animal is evaluated in terms of a scorecard representing the ideal of the breed, not in terms of other animals at a show; and (2) herd classification provides a more complete analysis of a herd, a sire's daughters, or a cow family. While only a few breeders exhibit a few of their best animals at major shows, herd classification not only reaches more breeders but includes the entire herd. A breeder may compile an impressive record in the showring with a few highly selected individuals which are not truly representative of his herd. Although it is expected that breeders will cull some of their poorest type animals before classification, it is much more difficult to influence the total result.

Up to the present time, classification has been applied only to cows that have freshened and to more or less mature bulls. The present study was designed to determine whether such evaluations have any value when applied to young heifers. If body conformation in heifers can be translated into adult conformation, the time and expense
of raising poor type individuals, which will later be culled, can be saved. It would also be possible to make an earlier evaluation of the type transmitted by a sire.

In addition to these benefits to be gained from more knowledge of type, there is the danger that emphasis on any given aspect of conformation may detract from the utility of the animal. Even though the type features in themselves are not antagonistic to utility, the fact that they are used as criteria for selection detracts from the emphasis which is placed directly upon productivity. Examples of deterioration in utility following selection by other criteria are well known.

The Cocker Spaniel and the Irish Setter were once highly respected hunting dogs, but have lost most of their hunting instincts since they have been used as pets and as decoration for estates. In many breeds of dogs certain families or lines have been highly developed for bench showing. These strains are held in contempt by people interested in hunting or in stock working dogs.

The high correlation between type and utility in beef cattle has been pointed out, yet even here the emphasis on blockiness and short leggedness have resulted in an animal which has so nearly lost its ability to walk that many ranchers are declaring it unsuited to the western range country and are turning to Brahman crosses. A recent report indicates that showing type standards may be antagonistic to egg production in chickens.

With these facts in mind, a more extensive basic knowledge of type seems highly desirable, especially in regard to its association with, or affects upon, production, growth and health.
REVIEW OF LITERATURE

General

Most of the interest in type has centered around the establishment of families and herds of good type by breeding and selection, the association between type and production, and more recently, the repeatability of type classification ratings.

The differences between good beef type and good dairy type are easily recognized. Swett et al (1928) compared the anatomy of an Aberdeen Angus cow and a Jersey cow in great detail. The Angus was Blackbird of Dallas, a winner at major shows and the Jersey was Sophie 19th of Hood Farm which was not a show cow but was known for her production. The results of the comparison were disappointing in that very little difference in the anatomy of the two cows could be found. The greatest external difference was in the extreme fleshiness of "Blackbird" and the lack of flesh in "Sophie." The greatest internal difference was in the amount of secretory tissue in the udder.

Gowen (1925), (1926), (1933) made several studies of the association between body measurements and the production. His general conclusions were that the positive correlations were largely due to size of the cow, size of the udder and to the "wedge shape". The latter is an interesting observation in view of the method by which it was derived and the fact that heart girth and weight have become almost synonymous. By partial correlation Gowen separated the effects of weight and heart girth. This yielded a positive correlation
between weight and production but a negative correlation between heartgirth and production.

Garner (1932), in a study of English Shorthorns and Minnesota Holsteins found a positive correlation between several body measurements which indicate size and production.

The latest and most comprehensive studies dealing with the correlation between body measurements and production are the work of Swett et al. (1953). These studies include some 30 measurements on 185 Holsteins and 194 Jerseys at the Beltsville Station; and 165 Holsteins and 152 Jerseys from the herds of about 20 state experiment stations. The measurement most consistently correlated with production was length of head. In other measurements breed and herd differences were found. Body depth measurements were best in Holsteins, but height and length were better indicators of production in Jerseys. Muzzle circumference was found to be correlated with production in both breeds at the state experiment stations but not at Beltsville. Live weight was only slightly associated with milk yield.

Almost the same measurements were made on 164 Holstein and 169 Jersey heifers at Beltsville (Swett, 1952). High correlations were found between measurements of 3, 6 and 12 months old heifers and measurements taken as cows. Measurements at these young ages were about as closely associated with production as were the cow measurements. In this study 18 of the 30 measurements were found to be significantly correlated with production in Holsteins. However, little correlation with production was found in Jerseys. The breed
difference was not explained.

These works have no direct bearing upon type as such except that size is considered a desirable part of type.

Lush (1945) reports a study by Engeler of 455 Brown Swiss cows which were inspected for registration and scored. The correlation between type score and production was found to be .04.

The apparent parallel between chickens and dairy cattle in the relationship between type and production has been mentioned. It is often pointed out that the culling of hens on the basis of external appearance is a very useful method of selection. There is no doubt that even a slightly experienced judge is able to select hens that are currently in production but there is little evidence that the hens culled by this method are basically poor producers. Cooper and Maddison (1954) have recently made a preliminary report on a breeding project with Rhode Island Reds in England. In this project 10 cockerels are selected each year and mated with 12 pullets each. From the progeny of each cockerel 40 pullets are placed in the laying batteries for the production test. The first year, two different panels of experienced judges scored the pullets on type just before they started to lay. The correlations between the type score and production for the two panels were -.717 and -.708; both were significant at the 5% level.

The progeny of only one cockerel combined good type and high production to the extent of being above the average in both.
Classification and Production

With growth of herd classification, interest developed in the association between classification rating and production. At the same time more accurate means were developed for eliminating some of the environmental factors, particularly the adjustment of production records for age. Still more recently, more refined statistical methods have assisted in the interpretation of these data.

Copeland (1939) in a study of 4587 Jersey cows found the correlation between classification score and production to be .254 ±.024.

Lush (1945) reports that officially classified Holstein cows produce about 24.6 pounds more butterfat for each grade increase in type classification. (Production records were on the basis of 3 milkings per day, 365 day lactations and adjusted to maturity.) He found a similar regression of fat on type for Jerseys to be 12.3 pounds per grade. In this case the production basis used was twice daily milking for 305 days.

The foregoing studies did not take into account herd differences or sire differences which appear to be quite important in such studies. It can usually be shown that herds on test tend to have higher classification averages than herds not on test, also that classified herds have higher production averages than herds that have not been classified. Herds with good type probably have more favorable environment for high production. Even within herds the "Excellent" cows often get preferred treatment. Furthermore, it would be surprising if herds with the best type and production did not also use
the best sires. In support of these views, Tyler and Hyatt (1948), in a study of 5177 classified Ayrshires cows with production records, found that the coefficients of correlation between type rating and first record, record nearest classification, and average record, to be .53, .42 and .50 respectively, on an inter-herd basis. The same coefficients were .16, .16 and .19, respectively, when computed on an intra-herd basis.

Rennie (1951) found the intra-sire, phenotypic correlation between classification rating and a single butterfat record in 3328 Canadian Jersey cows to be .13.

Touchberry (1951) found the phenotypic correlation between type rating and milk production in the Iowa State College Holstein Herd to be .18.

Heritability

The inheritance of type is undoubtedly very complex due to the fact that each part of the animal must be of the desired shape and size, and all parts must blend together to produce a stylish appearance. Considering this complexity, Petersen (1950) points out the rather surprising fact that three successive generations of animals have won grand championships at the national dairy shows of three different breeds.

The inheritance of type has not been studied intensively. The literature does contain numerous reports of individuals which exhibit abnormalities of conformation such as wry tail, wry face, flexed tendons and many others. The modes of inheritance of some of these
characters are known. In most cases these manifestations would not be considered variations of normal type and so are only mentioned in this report. Gilmore (1950), (1952) has made a very comprehensive review of the literature in this field.

Many observers have suggested a positive correlation between slope of rump and slope of udder. Since both are objectionable it was postulated that selection for levelness of rump would produce level udder floors. Leighton and Graves (1947) studied rump and udder angle from more than 500 photographs of 155 Holstein females in the U. S. Dairy Experiment Station, Woodward, Oklahoma and found no association between rump slope and udder slope ($r$ equals .021 ±.11). These workers found that rump slope generally increased up to about 5 years of age with most of the increase before 3 years. Some individuals, however, showed marked, unexplained variations.

The heritability of a single, final, classification rating has been estimated by several workers. Tyler and Hyatt (1948) estimated heritability in Ayrshires to be .30 with 5% fiducial limits of .19 and .42. Their data consisted of the progeny of 368 bulls which had six or more daughters classified on the same day by the same inspector; and 1601 cows, the dams of which were classified the same day by the same inspector. The same workers (1950) later found that this estimate gave satisfactory results when used together with classification rating of the sire and dam to predict the type ratings of the progeny of various matings.

Harvey and Lush (1952) using data from 245 Jersey herds found
the intra-herd regression of type of daughter on type of dam to be .071 yielding an heritability estimate of .14 ±.04. This is in close agreement with the estimate of .16 obtained by Rennie (1951) using the same method on 858 Canadian Jersey cows and their dams. The apparent disagreement between these latter estimates and that of Tyler and Hyatt may not be real since the errors are comparatively large. It should be noted that variance due to sire, inspector, and time were eliminated from the data of Tyler and Hyatt, whereas only herd differences were removed by the other workers. There may also have been some effect from the fact that the Ayrshire dams were all rated as more or less mature cows, since they were rated the same day as their daughters. Harvey and Lush point out the possible existence of breed differences.

Touchberry (1951) in the Iowa State College Holstein herd found the intra-sire correlation between type of daughter and type of dam to be -.085 which was not significant and yielded an heritability estimate of approximately zero.

**Genetic Correlation**

If selection for one character is practiced with the hope of producing improvement in another, the genetic correlation as well as the phenotypic correlation between the two is of interest. Hazel (1943) developed the methods of calculating genetic correlation by calculating the phenotypic correlation between one character in one animal and the other in a close relative. Thus genetic correlation may be defined as the portion of the association between two characters
that is inherited. Intra-sire genotypic correlations between type rating and butterfat production were investigated in Jerseys by Harvey and Lush (1952) and Rennie (1951) through dam-daughter pairs. Their estimates were .18 and .24, respectively. Touchberry (1951) found no genetic correlation between type and either milk or fat production in Holsteins. Both Touchberry, and Harvey and Lush explain that a difference in emphasis placed on the two traits by different groups of breeders could produce a genetic correlation in the population. There is no doubt that this situation exists, but the magnitude of its effect is not known.

Brakel (1954) found no association between the number of stars awarded a bull under the American Jersey Cattle Club Star Bull Program and the average classification rating of his daughters. Under this program a bull may qualify for one to seven stars on the basis of type and butterfat production of his dam, his paternal half sisters, and the maternal and paternal half sisters of his sire and dam. A maximum of 26 points may be awarded for production and 12 points for type classification.

Repeatability of Classification Ratings

The fact that the conformation of a cow undergoes changes from time to time is unquestioned. However, the magnitude of, and the reasons for, these changes have not been established in great detail. In addition to real changes in type, a certain amount of variation in classification ratings may, no doubt, be attributed to differences
among judges and to the inability of a judge to remain inflexibly constant in his evaluations.

The first reported study of the repeatability of classification ratings was made by Johnson and Lush (1942). This was a ten-year study of the Iowa Station Holstein Herd in which a nationally known judge or an official classifier rated each female in the herd each year. A station committee, composed of the authors and the herdsman also rated each female during the week nearest her birthdate. The intra-cow correlation for the station committee was .55 and for the "judges" .34. Averaging two ratings almost doubled the repeatability for "judges" but had little effect on the repeatability of the "station committee". Consecutive ratings were found to be no more repeatable than those separated by two or more years, although ratings were found to increase with age up to about 5 years. Ratings on heifers under one year of age were less repeatable but the increase in repeatability with age was small.

Hyatt and Tyler (1948) studied the variation in type ratings in the Reymann Memorial Ayrshire Herd in which all cows were classified three times each year from 1942 through 1946. The intra-cow correlations for three inspectors were found to be .73, .82 and .62 on 52, 42 and 9 cows, respectively. A similar correlation among all inspectors was .55 on 101 cows. Of 80 cows which were rated at least three and an average of five times, 26 (32.5%) varied two or more grades. Like Johnson and Lush, the authors found a tendency for ratings to increase with age. Part of the variation among inspectors
was apparently due to their inability to attach the same importance to
defects, particularly those of udder shape and attachment, and of
feet and legs, especially weak pasterns. Cows scored higher during
the first three and last two months of their lactation period as
compared to the middle months.

With some modifications in 1947, the study of the Reymann
Memorial Herd was continued and further findings were reported by
Benson, Tyler and Hyatt (1951). The basic changes included the use
of breakdown ratings for the ten divisions of the official Ayrshire
score card, and the use of two official inspectors who rated all
females twice each year, independently but at the same time. One
inspector, designated "repeat", returned each time, while the other,
designated "official" was a different person each time. No signifi­
cant differences were found between "repeat" and "official". The
correlations between "repeat" and each "official" varied from .61
to .76 for final rating and from .10 to .77 for different scorecard
divisions. Repeatability of single final rating on 83 cows was .56
for "repeat" and .48 for "official". Repeatabilities for scorecard
breakdowns ranged from .30 to .61 for "repeat" and from .23 to .48
for "official". All repeatabilities were statistically significant
at the 1% level.

In another phase of this same study, heifers, starting at four
months of age, were rated at the same time, and by the same method,
excepting a slight modification of the scorecard for the udder break­
downs. Repeatabilities for heifer ratings were markedly lower than
for cows. Repeatabilities of final rating were .28 for "repeat" and .20 for "official," with range of .0 to .30 for "repeat" and .0 to .28 for "official" on breakdowns. The repeatabilities of "repeat" were not significant for head and neck, middle and loin, rear udder attachment, and overall udder. "Official" had no significant repeatability on shoulders and chest, size of teats, shape of teats and overall udder.

In an earlier study in the same herd by Hyatt, Tyler, and Conklin (1949), 102 females were classified into five grades, fair to excellent, by a single official classifier. Heifers were first classified when 6 to 12 months of age and were reclassified each six months thereafter. No significant difference was found between classification ratings made at different ages. There was no significant correlation between ratings made at six months and those made at any other age, but correlations between all other heifer ages were significant. The regression of average heifer grade on average cow grade was .45.

Harvey, Ross and Fourt (1953) classified heifers in the University of Idaho herd into 18 groups at three ages as follows: 6 to 11 months, 12 to 17 months, and 18 to 23 months. Each heifer was given a rating for mammary system, dairy character, breed character, general appearance and overall. Analysis of the data revealed that: (1) changes in type with age are largely unpredictable; (2) correlation between judges ranged from .09 to .40 with a slight tendency for the same judge to be more repeatable than different judges.
MATERIALS AND METHODS

Data for the present study are a part of the permanent files of the Ohio-Federal Breeding Project. The herds included in this study are all owned by the Ohio Department of Mental Hygiene and Correction, and are composed of purebred Holsteins, although registrations have not been maintained completely. Type evaluation has been a part of this project since July, 1950 when scoring was begun on cows in two herds. In January, 1951 the study was extended to all seven herds in the project at that time, and to heifers. The working plan, as adopted at that time, includes the scoring of each female at the time of the bi-monthly visit nearest the ages selected. These ages are 3 months, 6 months, 12 months, 3 months after first freshening, and 3 months after the first freshening after 5 years of age. Obviously this is a long-time project and only a relatively small part of the ultimate body of data is available at this time. This study is confined to the first three ages.

Each animal is scored independently by two men at each age. Each judge indicates coded reasons for each part which scores less than 80. The field work sheet and coded criticisms are shown in Figure 1 and Table 1, respectively. Averages of the scores of the two judges are computed and entered on the permanent file card of each animal.

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1 A cooperative dairy cattle breeding project with the Dairy Husbandry Branch (U.S. Dept. of Agr.), Ohio Agricultural Experiment Station, and the Ohio Department of Mental Hygiene and Correction cooperating.
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<td>B2 - C1 - H3</td>
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Figure 1 Type evaluation work sheet for field use.
**TABLE 1**

**INDEX OF CRITICISMS FOR TYPE EVALUATIONS**

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<th>D. Rump and Thighs</th>
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<td>1. Wry face</td>
<td>1. High coarse tail setting</td>
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<td>2. Parrot mouth</td>
<td>2. Low pins</td>
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<tr>
<td>3. Roman nose</td>
<td>3. Low thurls</td>
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<tr>
<td>4. Ewe neck</td>
<td>4. Narrow pins</td>
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<td>5. Short neck</td>
<td>5. Thick thighs</td>
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<tr>
<td>7. Narrow muzzle</td>
<td>7. Short rump</td>
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<tr>
<td>8. Short thick head</td>
<td>8. Narrow hooks</td>
</tr>
<tr>
<td>a. Alertness of eye</td>
<td>10. Patchy at tailhead</td>
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<tr>
<td>b. Carriage of head and ear</td>
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<tr>
<td>10. Small sunken eye</td>
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<tr>
<td>11. Staggy head (maleness)</td>
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<td>12. Small nostrils</td>
<td></td>
</tr>
</tbody>
</table>

| B. Shoulders and Chest | |
|------------------------||
| 1. Wing shoulders      | |
| 2. Narrow chest floor  | |
| 3. Shallow chest       | |
| 4. Open coarse shoulders | |
| 5. Flat fore rib       | |
| 6. Coarse thick brisket | |
| 7. Weak crops          | |

| C. Middle and Loin     | |
|------------------------||
| 1. Shallow body        | |
| 2. Weak back           | |
| 3. Weak loin           | |
| 4. Short body          | |
| 5. Narrow loin         | |
| 6. Cut up in rear flank | |
| 7. Close ribbed        | |
| 8. Lacks spring of rib | |

| E. Feet and Legs       | |
|------------------------||
| 1. Cow hooked          | |
| 2. Sickle hooked       | |
| 3. Weak pasterns       | |
| 4. Toe-out in front    | |
| 5. Knock knees         | |
| 6. Shallow heels       | |
| 7. Buck knees          | |
| 8. Legs too straight   | |
| 9. Short legs          | |

| F. Size and Shape of Udder | |
|-----------------------------||
| 1. Small                    | |
| 2. Pendulous                | |
| 3. Tilted                   | |
| 4. Halved                   | |
| 5. Quartered                | |
| 6. Blind quarters           | |
| 7. Lack of fore udder develop-ment | |
| 8. Cut under rear udder     | |
| 9. Unbalanced               | |
| 10. Bulging fore udder      | |
| 11. Bulging rear udder      | |
### TABLE 1 (cont.)

**INDEX OF CRITICISMS FOR TYPE EVALUATIONS**

<table>
<thead>
<tr>
<th>G. Udder Attachments</th>
<th>I. Dairy Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Low rear</td>
<td>1. Thick, beefy</td>
</tr>
<tr>
<td>2. a. Narrow rear</td>
<td>2. Throaty</td>
</tr>
<tr>
<td>b. Weak rear</td>
<td>3. Lacks refinement</td>
</tr>
<tr>
<td>3. Weak median suspensory ligament</td>
<td>4. Overly refined</td>
</tr>
<tr>
<td>4. Weak fore</td>
<td>5. Staggy</td>
</tr>
<tr>
<td>5. Broken fore</td>
<td>6. Thick coarse hide</td>
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<tr>
<td>6. Weak lateral suspensory ligament</td>
<td>7. Lacks angularity</td>
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</table>

<table>
<thead>
<tr>
<th>H. Teats, Veins and Quality</th>
<th>J. Breed Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Large teats</td>
<td>1. Lack of size and scale</td>
</tr>
<tr>
<td>2. Uneven size teats</td>
<td>2. Lack of symmetry and balance</td>
</tr>
<tr>
<td>3. Poor teat placement</td>
<td>3. Lack of style</td>
</tr>
<tr>
<td>4. Not perpendicular</td>
<td>4. Uneven topline</td>
</tr>
<tr>
<td>5. Meaty texture</td>
<td></td>
</tr>
<tr>
<td>6. Small teats</td>
<td></td>
</tr>
<tr>
<td>7. Deficient udder veining</td>
<td></td>
</tr>
<tr>
<td>8. Deficient body veining</td>
<td></td>
</tr>
<tr>
<td>9. Funnel shaped teats</td>
<td></td>
</tr>
</tbody>
</table>
(Figure 2). The coded criticisms are noted on the back of the same card (Figure 3). The divisions of the scorecard, such as head and neck or shoulder and chest, will be referred to as "scorecard divisions" or as "breakdowns". The total, or overall, score for the animal is the sum of these ten breakdown scores. The scorecard was adopted for several reasons. The ten divisions of equal point value allow the recording of considerable detail in a form which is readily handled in analysis. It was also considered easier to use a system in which each division had the same point value rather than some of the other scorecards in use in which the various divisions have different values. Although each scorecard divisions is usually considered to have a basis of 10, no decimal points were recorded in the original data and none were used in the analysis. Whether the breakdowns are valued at 10 or 100, and whether the total score is considered an average or a total of the breakdowns does not affect the statistical computations of their interpretations.

Some modification of the scorecard would, no doubt, make it more applicable to heifers, particularly in regard to the udder. However, since the study will continue to the mature animal stage, it was considered highly desirable to use the same scoring system for all ages. The inconvenience is largely concerned with the udder where obviously many of the features exhibited by the producing cow cannot be seen in the young heifer. Size and shape of udder can be scored as such, lacking only the details of shape. Scoring of udder attachments, however, is based almost entirely on the rear attachment.
<table>
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<th>Date</th>
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<td>82</td>
</tr>
</tbody>
</table>

Figure 2 Type evaluation file card. Numbered columns correspond to score card divisions, head and neck to general appearance respectively.

(1) B 4 - E 2 - I 1,7
(2) B 4 - F 8 - G 1
(3) B 4 - C 3,4 - E 2

Figure 3 Reverse side of type evaluation file card showing coded criticisms. Actual ages are indicated in months and days and numbered consecutively.
The division heading, "teats, veins and quality," could be abbreviated to teat placement, with some weight occasionally given to teat size. The various other breakdown divisions are best defined by reference to the list of criticisms.

The three men who were originally expecting to do the scoring worked together on some 250 cows in an attempt to standardize the level of scoring and the magnitude of the cuts for various defects.

The data used in the main body of the study include the 544 Holstein heifers which were scored between March 1, 1951 and March 1, 1954, at 3, 6, and 12 months of age in five herds. The first two months, January and February, 1951, were considered a training period and the data were omitted. In four herds, Athens, Dayton, London, and Orient, heifers were scored almost exclusively by the same two men, usually working together. Five different judges are involved in the Toledo data, all working in pairs, but in several different combinations. Examination of the data suggests some judge differences in this herd. However, no attempt is made to evaluate this effect. No attempt was made to analyze the obvious differences between herds in this study since the reasons for these differences would be very difficult to establish. These causative factors probably include environmental influences, sires used, and genetic differences between cow herds. In recognition of these differences, the analysis was kept on an intra-herd basis. For this reason data from two smaller herds were not included, since it seemed probable that the numbers of heifers were too small to yield significant results.
All herds in this study are under the general supervision of a state agriculturist who exercises some control over management. Before the beginning of the breeding project he was almost entirely responsible for sire selection in these herds. Related bulls have been used in different herds. One sire at Athens has had several sons that were used in other herds. However, the effects of these common influences on heredity and environment are considered negligible in this study. Management, especially in calf raising, is quite variable between herds. A minimum of culling for type has been done in these herds. With the possible exception of the Athens herd, no females are removed primarily because of poor type, except in extreme cases, such as an udder that is so broken down that its usefulness is seriously impaired. In most cases cows which are classified poor are retained in the herds as grades. The proportion of registered cattle in these herds ranges from about 20 per cent at London to 100 per cent at Athens. The lack of emphasis on type in the management of these herds is considered a valuable asset in its study; however, possibly as a result of this lack of emphasis, exceptionally good type is notably rare. The study is thus limited to some extent by lack of the complete range in type.

Some idea of the differences in environment between herds may be of value in interpreting the results of the study. For this purpose the herds might be ranked from best to poorest as follows: London, Athens, Toledo, Orient, and Dayton. Athens management differs from that of the other herds in that the heifers usually
remain in the calf barn until they are past one year of age. In the
other herds they are usually moved to sheds, open barns, or to
pasture at 6 to 8 months.

Methods outlined by Snedecor (1946) were used in the analysis of
these data.

The repeatabilities of scores given the same heifer at different
ages were estimated by coefficients of correlation. Coefficients were
computed, by herds, for each scorecard division. An overall estimate
was obtained by combining the data from all five herds, and a second
such estimate was obtained from the mean of the weighted z values.

Age differences were tested for significance by analysis of
variance computed from the combined data of all herds.

The t-test and analysis of variance were used to test for sire
differences within each herd which had two or more sires with at least
twenty daughters each.
RESULTS AND DISCUSSION

Before proceeding with the analysis of the data it seemed desirable to make some study of the effect of time upon the scoring level. Monthly averages were computed for each scorecard division, for each age in two herds which are considered to represent the extremes of environment. These monthly averages were plotted on graph paper and examined for seasonal and other time trends, and herd difference. Finally, monthly averages were computed by breakdown and age for the combined data from the Athens, Dayton, London, and Orient herds (see Appendix, Tables 6, 7, and 8). Examination of these averages reveal them to be quite uniform over the three-year period. There is some indication of a very slight increase in scores for head and neck, and for feet and legs during the first year. There is an even less perceptible lowering of udder scores during the first few months. It seems highly unlikely that any time trend exists which could influence other studies.

Repeatability

Repeatability, as used here, is a measure of the association between scores given the same heifer at different ages.

The repeatability of type scores from one age to another was estimated by simple correlation within each herd. Coefficients were computed for each of the ten scorecard divisions and the total score between each two ages, that is, between 3 months and 6 months,
6 months and 12 months, and 3 months and 12 months. The results are presented in Tables 2, 3, and 4, respectively. These coefficients varied widely between herds and between scorecard divisions. In only two divisions were the coefficients significant at the 1% level in all herds. These two were feet and legs between 3 and 6 months, and rump and thighs between 6 and 12 months. The only division in which scores were not repeatable in any herd was head and neck, between 3 and 12 months of age. Although several coefficients were quite small, only two were negative and these were quite low.

Since no information was available that indicated the existence of herd differences in repeatability all herds were combined into one estimate. Comparison of these coefficients with those of the individual herds raised serious question as to whether the herds could be appropriately combined. One of the more extreme cases is found in udder size and shape between 6 and 12 months. In this instance the largest coefficient for an individual herd is .309 at Dayton, yet the combined estimate is .466. The apparent explanation for this increase is that the herds are at different levels with trends in the same direction. By combining such data the distribution is lengthened without being widened appreciably. At the opposite extreme are the correlations between 3 and 6 months for udder size and shape. In this case the coefficient for the combined data (.143) is smaller than the least herd coefficient (.174). The explanation in this case is that the changes which heifers undergo between 3 and 6 months are not the same in all herds, but are at about the same
### TABLE 2

**REPEATABILITY OF TYPE EVALUATIONS FROM 3 MONTHS TO 6 MONTHS OF AGE**

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</table>

*Difference between herds significant at the 5% level.

**London omitted from average. Difference significant at 1% level.**
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*Difference between herds significant at 5% level.
**Difference between herds significant at 1% level.
TABLE 4

REPEATABILITY OF TYPE EVALUATIONS
FROM 3 MONTHS TO 12 MONTHS OF AGE

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<td>.196</td>
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*Difference between herds significant at 5% level.
**Difference between herds significant at 1% level.
level. When these data are combined the distribution is concentrated rather than lengthened and the apparent correlation is lessened. In view of this development it seemed desirable to use a different approach in establishing one combined estimate of repeatability. This was done by converting each $r$ to a weighted $z$ (Snedecor 1946). Chi-square was used to test for differences among the $z$ values before averages were computed and converted to $r$. Significant differences between herds (1% level) were found in each age comparison. The correlation for total score between 3 and 6 months shows such a difference, which is readily attributed to the London herd by inspection. After omission of this herd the average $r$ is .399 which is very close to the $r$ for the combined data. Actually this variation between herds in total score is not regarded as very important since the total score merely reflects the breakdown scores of which it is composed. The differences in the other two age comparisons are regarded more seriously, particularly since both occur in the same division: teats, veins and quality. Considering all three age combinations, it appears that at least two, and probably three populations have been sampled. In this division the Toledo herd exhibits no significant repeatability between any ages; the London and Orient herds show good repeatabilities between all ages (.307 to .484); and in the other three herds the estimates vary from about .0 to about .3 for the three age comparisons. No explanation of these herd differences is apparent, but since they do exist, the possibility of different groups within the herd is suggested. Perhaps the daughters of different sires exhibit different patterns of the development.
With some exceptions, a few of which have been pointed out, there is fairly good agreement between the correlations obtained by combining all herds and those computed from the average $z$. Although each may be more appropriate in certain cases, the averages are considered generally the more reliable estimate of repeatability. These averages are remarkably uniform for the different scorecard divisions and totals. On the whole, the repeatabilities are slightly higher between 3 and 6 months than between 6 and 12. The coefficients for the 3 to 12 months comparisons are notably lower, as would be expected. The ranges for the average $r$'s are .223 to .325, .174 to .372, and .157 to .228 for the three to six, six to twelve, and three to twelve age comparisons, respectively.

These results do not agree well with the findings of Benson, Tyler and Hyatt (1951) who obtained repeatabilities ranging from .0 to .30 for breakdowns on 90 heifers in one herd. The lack of agreement may be due to the difference in numbers, the use of several herds in the present study, and the closely approximated ages in this study compared to the twice yearly appraisal in the West Virginia work.

**Age Differences**

The same data used in the previous section was tested for differences between ages by analysis of variance. The results, which are presented in Table 5, indicate age differences in each division and in total score, which are all far beyond the 1% level of probability. Very little data on this subject is available, hence these find-
TABLE 5
THE EFFECT OF AGE ON TYPE RATINGS OF HEIFERS

<table>
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<th>Age</th>
<th>Shoulders</th>
<th>Head</th>
<th>Middle</th>
<th>Rump</th>
<th>Feet</th>
<th>Shape</th>
<th>Attach-</th>
<th>Dairy</th>
<th>Gen.</th>
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<td>Chest</td>
<td>Loin</td>
<td>Thighs</td>
<td>Legs</td>
<td>Size</td>
<td>ment</td>
<td>Char.</td>
<td>App.</td>
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<td>.41</td>
<td>.40</td>
<td>.36</td>
<td>.31</td>
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a \( F_{.01} = 4.65 \) (degrees of freedom = 2 and 543)

b Minimal significant difference = \( \frac{\text{Mean square within ages}}{\text{number of heifers}} \) \( \cdot t_{.01} \)
findings seem to merit somewhat detailed discussion.

In head and neck, the scores are notably lower at 12 months than at the other two ages. The most frequent criticisms appear to be lack of style and long narrow heads. The fact that the hair is often quite long and rough on yearlings but comparatively short and sleek on younger heifers may be a contributing factor in this difference. In support of this suggestion is the fact that the Athens yearlings which were usually still in the calf barn, averaged exactly the same as at 3 months and only slightly less than at 6 months.

The averages for shoulders and chest show progressive improvement with age. The improvement is considerably greater between 3 and 6 months, but the change from 6 to 12 months is also highly significant. Each of the five herds uniformly exhibits the same trend except Toledo, in which the 6 and 12 months scores are about the same. It seems probable that the difference in this herd is due to the disproportionate numbers of heifers of the various ages scored by different judges. A possible explanation for this improvement in score is suggested in unpublished data (Clifton and Rickard, 1954), which shows that the spinal processes usually grow above the top of the shoulder blades during this age period. Of 144 heifers examined in the Toledo herd only three had spinal processes above the shoulder blades at 3 months of age; they protruded between 3 and 6 months on 75 heifers; between 6 and 12 months on 51; and had not protruded at 12 months on the remaining 15. These processes no doubt make the withers appear sharper and the shoulders more neatly laid in.
Middle and loin ratings improved greatly from 3 months to 6 months then dropped almost halfway between at 12 months. The improvement in the 3 to 6 months interval was the same in all herds and may be the normal development of body as the heifer begins to consume appreciable amounts of roughage. The later drop does not seem to have a logical explanation. In the Dayton herd the scores dropped considerably more than in the other herds, actually falling slightly below the 3 months scores, suggesting an environmental difference. This is not borne out, however, by the other herds since the size of their drops were almost identical, and variations would have been expected.

The average scores for rump and thighs remained about the same from 3 to 6 months but dropped markedly between 6 and 12 months. This is in apparent agreement with the work of Leighton and Graves (1947) who found that rump slope increased with age. Sloping rump is the most common reason for low scores in this division.

Feet and legs improve between 3 and 6 months, then show no significant change in the combined data between 6 and 12 months. Inspection of the herd averages reveals that scores in the Toledo herd were lower at 12 months than at 6. All other herd averages were slightly higher at 12 months, and the Dayton herd average was markedly higher.

The combined data for udder size and shape shows a substantial improvement from 3 to 6 months, about half of which has been lost at 12 months of age. However, this information is of little value in predicting the averages of the herds. Athens heifers tended to improve slightly with age, while London heifers showed exactly the opposite trend. Scores in the Dayton herd declined with age especially
between 6 and 12 months. In the Orient herd, scores were slightly higher at 6 months. Only the Toledo herd exhibited exactly the trends of the combined data.

The age changes in udder attachments and teats can be described in about the same terms as size and shape. Although significant trends are noted in the combined data, herd variations occur.

Dairy character was generally rated somewhat higher at 6 months, but some herd difference is suggested at 12 months, possibly due to high condition of some heifers at this age.

General appearance followed a similar trend except in the Dayton herd, where the yearling scores were markedly lower, and the 3 and 6 months averages about equal.

The total scores were higher at 6 months than at the other two ages. Herd differences at 12 months appear to vary with herd environment; the heifers at Athens show up comparatively well at this age, while the Dayton heifers score quite low in comparison with the other ages.

These findings are not in agreement with those of Harvey, Ross and Fourt (1953) who found that, "changes in type from time to time are largely unpredictable." However, the heifers studied by these workers were older (6 to 23 months of age) and were not scored at specific ages but were divided into three age groups of 6 months each. The scorecard used by these workers had only four divisions: general appearance, dairy character, body capacity and mammary system. These two differences could easily have obscured the age changes found in the present study.
In general, it appears that heifers, under the conditions of this study, are scored somewhat higher at 6 months than at the other two ages. This may be due in part to their physical condition which is often best at this age. The possible detrimental effect of long, rough hair coats on yearlings has already been mentioned, and it is well known that clipping, especially around the head and tailhead, greatly improves the appearance. Even so, the evidence that this is an important factor is not strong. This shaggy appearance is much more pronounced during the winter months, yet no seasonal variation is noted. Another possible explanation for differences between yearlings and younger heifers is that certain changes are associated with maturity. The evidence that skeletal changes occur at certain ages, or stages of development, have been presented in the cases of withers, and rump. It seems probable that other such skeletal changes may occur in head, chest, and back, which have not as yet been detected. Some further division of the scorecard may be necessary to study some such changes. For example, the recorded score for middle and loin may be a compromise between an excellent body capacity and a very weak back. These details are not necessarily important in a determination of type for practical use but they are of considerable academic interest.

Differences due to Sires

It is common knowledge that the progeny of a sire can sometimes be distinguished by their appearance, even at very young ages. This does not necessarily mean that these animals are unusually good or poor in any particular feature of type. No reference is found in the
literature to any formal study in which such sire differences were evaluated. The data in this study includes 20 or more daughters of 14 different sires. Another sire (number 22 at Toledo) had 13 daughters, then died, and was followed by his son. Since the daughters of this sire-son combination seemed homogeneous they were also included. These sires were all in service over the entire period of the study and the group includes all sires that played any important role in the breeding program during this time. Because of herd differences and since no sire was used in more than one herd it seemed necessary to conduct studies of sire differences in each herd independently. Since Orient had only one sire with a sufficient number of daughters this herd was omitted. Remaining are the Athens and Dayton herds with two sire groups each, the London herd with four, and the Toledo herd with six.

Some of the sires had only 20 daughters or slightly more so this number was arbitrarily selected as the sample size. The greatest number of daughters of one sire which had been scored at all three ages was the 51 daughters of sire number 24 at London. Since it is more convenient to analyze data in groups of equal size, various methods of sample selection were considered. It proved impossible to select groups which were evenly distributed over the same time interval, so the first 20 daughters of each sire were used. Actually, this method resulted in as little time variation as any and also eliminated some judge changes. The evaluations used in this analysis were made from February, 1951 to May, 1953, inclusive. The daughters of sire number 21 in the London herd were spread over a somewhat longer period, and those of sire
number 27 at Toledo are more concentrated than those of the other sires in these respective herds. No importance is attributed to this difference.

Differences between the means of sire groups were tested for significance by the t-test and analysis of variance. Differences in variance were tested by F and by Bartlett’s test for homogeneity. These tests for homogeneity have special significance in this study since uniformity, or lack of it, among the daughters of a sire may be just as important as their level. Minimal significant differences were computed for each comparison. For two groups this value is the product of the standard error of the difference times t at the 5 percent level. The comparable value for more than two groups is equal to

\[ \sqrt{\frac{\text{mean square within groups}}{\text{size of subsample}}} \cdot t_{.05}. \]

These latter values cannot properly be used to show a difference between any two means unless statistically significant differences were found.

The two sires which are compared in Athens herd (see Figures 4, 5, and 6) are quite different in breeding. Number 26 was bred in the herd and he is somewhat related to a very high percentage of the females in the herd through both grandsires, several half brothers of his sire, and other related sires. Sire number 18 is a complete outcross, and is about 28 percent inbred. Regardless of these differences, these two sires seem to transmit about the same type characteristics. Significant differences were found at 3 months of age in rump and thighs, and in udder attachment; at 6 months, in middle and loin; and at 12 months in feet and legs. Not only are these differences few in number, but they also seem to be characteris-
Figure 4. Sire differences in type evaluation of 3 months old heifers. Athens Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level). Solid bar indicates significance at 5% level or less.

Legend:  
\[\text{-----} \text{sire no. 18}\]  
\[\text{------} \text{sire no. 26}\]
Figure 5  Sire differences in the type evaluation of 6 months old heifers. Athens Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend:  sire no. 18
        sire no. 26
Figure 6 Sire differences in the type evaluation of 12 months old heifers. Athens Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend: ——— sire no. 18
—–—– sire no. 26
tic of a particular age. Only the difference in feet and legs holds any particular interest. In this division the daughters of number 26 were scored at about the same level at all ages, while the daughters of number 18 show a rather pronounced tendency to improve with age. This sire himself has exceptionally straight legs, having been criticized by an official classifier for being "post-legged."

The two sires compared in the Dayton herd (Figures 7, 8, and 9) are of somewhat the same general line of breeding although they have no recent common ancestors. Both represent a mild form of line breeding in this herd. This similarity in breeding did not prevent the demonstration of rather marked differences in their progeny.

A difference in shoulders and chest at 3 months of age was significant at the 1 per cent level. This difference was still apparent at 6 months but was not so pronounced, and at 12 months it had disappeared. In fact, the difference at 12 months was actually in favor of the other sire indicating a notable change between 6 and 12 months. The only other difference at 3 months was in general appearance. This difference was only significant at the 5 per cent level and was not apparent in the later ages. A tendency for daughters of sire 34 to score higher on feet and legs was noted at all ages; however, the difference was not significant until 12 months, and then only at the 5 per cent level. Most interesting in this herd are the very striking differences between sires in all three udder divisions. The daughters of sire 34 had the higher average in all udder divisions at each age; however, none of the differences at 3 months were significant. Differences in all three udder divisions at 12 months were
Figure 7  Sire differences in the type evaluation of 3 months old heifers. Dayton Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend: — sire no. 28
-------- sire no. 34
Figure 8  Sire differences in the type evaluation of 6 months old heifers. Dayton Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend:  ——— sire no. 28
        ———— sire no. 34
* Significant difference between variances
Figure 9  Sire differences in the type evaluation of 12 months old heifers. Dayton Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend:__________ sire no. 28
          sire no. 34
* Significant difference between variances
significant well beyond the 1 per cent level. Variances were unevenly larger in this herd particularly for sire 34, but significant differences in variance between the two sires were demonstrated only twice: at 6 months in teats, and at 12 months in rump and thighs. Daughters of sire 34 also were significantly higher in total score at 12 months. This appears to be due to a decided drop in score for daughters of sire 28 between 6 and 12 months. The fact that the combined herd score dropped during this period was pointed out in the discussion of repeatability. It now seems pertinent to note that all 43 daughters of sire 28 plus 12 daughters of another sire exhibited this marked drop in total score. The 38 daughters of sire 34 plus 14 daughters of three other sires did not change, as a group, during this period.

In the London herd, sire number 10 represents mild line breeding, while the other three sires are strictly outcrosses. The latter, however, are closely related. Sires 11, 21 and 24 are inbred 18.75, 7.8 and 7.8 per cent, respectively, to the same ancestor. In addition, the dam of 24 is a maternal half-sister of sire 11; sires 21 and 24 are by the same sire; and there are other minor relationships. It would not seem surprising if no differences could be demonstrated between daughters of these related sires; however, this is not the case. These differences, at the three ages, are shown in Figures 10, 11, and 12. At the 3 months age variances were found to differ significantly in three divisions. These were head and neck, udder size and shape, and attachment. The most notable feature of these differences seems to
Figure 10  Sire differences in the type evaluation of 3 months old heifers. London Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend: ——— sire no. 10  ——— sire no. 21
        ———— sire no. 11  ———— sire no. 24

* Significant difference between variances
Figure 11  Sire differences in the type evaluation of 6 months old heifers. London Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level). Solid bar indicates significance at 5% level.

Legend:  --- sire no. 10  --- sire no. 21  
----------sire no. 11  --- sire no. 24
Figure 12  Sire differences in the type evaluation of 12 months old heifers. London Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level)
Solid bar indicates significance at 5% level.

Legend:  
- - - sire no. 10  -- - sire no. 21
----- sire no. 11  ---- sire no. 24
* Significant difference between variances
be that the daughters of sire 21 were the least variable in head and neck but the most variable in the two udder divisions. Actually, in the udder divisions the daughters of this sire were not highly variable, but the daughters of the other sires exhibited very low variance. The only difference between sire means at this age was in feet and legs. Here the daughters of sire 11 were scored lower than those of the other sires. These differences at 3 months do not seem to be projected to the later ages. The difference between sire means in head and neck at 6 months is due to the low average of the daughters of sire 10. His daughters also tended to be more variable, but this difference was not quite significant. The daughters of this sire were also rated significantly lower in general appearance and total score. The difference in rump and thighs was due in part to the low average for the daughters of sire 10 and in part to the superiority of sire 21. This latter observation is also apparent at 12 months. Other differences at 12 months were due to significantly lower total scores for daughters of sire 10, and lower variance among daughters of sire 21 in general appearance. Significant differences in all three udder divisions at both 6 and 12 months are due to higher average scores given to daughters of sire 11. This appears to be the most outstanding difference found in this study, although the similar difference in the Dayton herd was only slightly less marked.

Of the sires studied in the Toledo herd number 35 is a son of number 2, and the other four sires are half-brothers. Less line breeding has been practiced in this herd than in the others covered in this study, and none of the sires are significantly related to the cows in
the herd. In the analysis of the sire differences in this herd (see Figures 13, 14, 15) it was found that a few unusual heifers had caused a noticeable disturbance in variance. Significant differences in variance were found at the age of 3 months in rump and thighs, all three udder divisions, dairy character, general appearance and total score. Of these, only the differences in rump and thighs and dairy character seem to be entirely legitimate. In these two instances the differences were due to the unusual uniformity of the daughters of sire number 27. The differences in udder size and shape, and attachment are due to two unusually poor daughters of sire number 2 and two of sire 22. It was noted that two of these heifers showed symptoms of recent illness and all were below normal weight. All of these heifers had recovered by 6 months of age, to the extent that their scores were not abnormal. However, the differences in variance at 12 months in head and neck, and total score were due to one of these same daughters of sire 22. She died about two months later, apparently from traumatic pericarditis. The other differences at 3 months are due to combinations of these reasons. Lack of homogeneity at 6 months in general appearance, and total score are due to a high degree of uniformity among the daughters of sires 23 and 27. These differences in variance overshadow possible differences between sire means at 3 months in udder attachment, and at 12 months in head and neck. The difference in middle and loin at 3 months appears to be real, but it is not apparent at later ages although the mean for sire 19 remains low. The daughters of sires 2 and 35 were notably below average in feet and legs especially at 12 months. The actual difference appears to be
Figure 13  Sire differences in the type evaluation of 3 months old heifers. Toledo Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend:  sire no. 2  sire no. 22  sire no. 27  sire no. 19  sire no. 23  sire no. 35

* Significant difference between variances
Figure 14  Sire differences in the type evaluation of 6 months old heifers. Toledo Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend:  

--- sire no. 2  
——— sire no. 22  
*—*— sire no. 27  
——— sire no. 19  
——— sire no. 23  
*—*— sire no. 35  

* Significant difference between variances
Figure 15 Sire differences in the type evaluation of 12 months old heifers. Toledo Herd. Height of bar indicates minimal values required for significant difference between sires. (5% level) Solid bar indicates significance at 5% level.

Legend: — sire no. 2 — sire no. 22 — sire no. 27
—— sire no. 19 — sire no. 23 — sire no. 35

* Significant difference between variances
that the daughters for these two sires failed to improve with age while the others did. The daughters of sire 27 were notably superior in udder size and shape, and attachments. Differences were significant only at 12 months although this sire had the highest average at all ages.

Considering all four herds in which sire comparisons have been made, observations may be made concerning each scorecard division, which possibly have wider application than those based on any single herd. It should be borne in mind that while the sire differences demonstrated are real, within the recognized statistical probability of error, the absence of statistically significant differences has no clear interpretation. The failure to demonstrate a difference may be due to the fact that the sires being compared simply transmit about the same type. On the other hand, the inherited type differences may not develop in some instances until the heifers are older than those used in this study. A third possible explanation is that the variations exhibited are environmental rather than hereditary. Differences were found in each scorecard division and in total score in at least one herd at some age. Head and neck differences were found in the London and Toledo herds; however, the Toledo herd difference, both in mean and variance, was partly due to two heifers which were just recovering from severe illness. Shoulders and chest scores differed only in the Dayton herd, and while this difference was rather conclusively demonstrated, it seems to characterize a stage of development which may not have any real significance. Middle and loin differences were demonstrated in the Athens and Toledo herds but no signifi-
cance is indicated. Some indication of sire differences in rump and
thighs was found in all herds with the London herd differences being
particularly impressive. Differences in feet and legs were also
found in all herds, but only at the 3 months age in two herds. Very
strong evidence of udder differences was found in all herds except
Athens. The only evidence of a difference in dairy character was
the exceptional uniformity among the 3 months old daughters of one
sire in the Toledo herd. General appearance differences were found
in all herds except Athens. The differences in variance were more
impressive than those between means. Differences in total score
were found between means in the London and Dayton herds, and among
variances at Toledo.
SUMMARY

From the data on 544 Holstein heifers in five herds, which were rated for type at 3, 6, and 12 months of age, on a ten-division scorecard, the repeatabilities of the various components of type were estimated, by intra-heifer correlations. These correlations between 3 and 6 months scores ranged from .2 to .3 for the different scorecard divisions. The correlations between 6 and 12 months differed only in showing a slightly wider range. Repeatabilities between 3 and 12 months were somewhat lower, ranging from .16 to .2. From this information it may be concluded that the true repeatability of type ratings in heifers of these ages is not far from .2. Variation among the different scorecard divisions is surprisingly small. Variation among herds, and among scorecard divisions within herds, is a serious limitation upon the usefulness of this information in small groups of heifers.

Certain characteristic age changes were noted in all scorecard divisions. The most notable of these were progressive improvement in shoulders and chest with age, lower scores for rump and thighs at 12 months, and improvement in feet and legs, particularly after 3 months of age.

Sire differences were found among heifers at each age. The most outstanding of these differences were in udder, rump and thighs, and feet and legs. Although these differences in 3 months old heifers do not appear to have much permanence, this information does indicate that the body conformation exhibited at this age is at least partly
controlled by heredity, and that certain characteristics at each age, or stage of development, may be attributed to sire differences.

Considering the overall implications of these findings, the variations in type scores among, and within, heifers of these ages may be attributed to several factors: (1) a tendency for a heifer to be rated the same at different ages (repeatability), (2) a tendency for heifers in general to exhibit predictable changes from one age to another, (3) differences among heifers due to heredity, (4) differences between ages in the same heifer due to genetic causes, (5) modification of body conformation due to environmental influences, and (6) the interaction of any two or more of these factors.

The possibility that the results of this study may not be applicable to heifers of breeds other than Holstein should be recognized.

Studies with identical twins would be useful in determining the influences of environment on type ratings. However, great difficulty might be encountered in finding a sufficient number of twin pairs to adequately represent the type range of any breed.

The ultimate test of the worth of these findings can only be determined after the evaluations have been extended to include the more mature ages. At the present time it is not known whether the change with age are permanent, and sire differences among these young heifers may or may not be apparent in older animals.


TABLE 6
AVERAGE TYPE EVALUATION SCORES FOR
3 MONTHS OLD HEIFERS BY MONTHS

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I, Carl Moore Clifton, was born in Greenup County, Kentucky, September 18, 1914, and received my primary and secondary education in the public schools of that county. My undergraduate training was received at Eastern Kentucky State College, Richmond, Kentucky, from which I received the degree Bachelor of Science in 1936. In 1939 I received the degree Master of Science in Agriculture from The University of Kentucky. My professional experience in the field of dairy science includes two years as a supervisor of Dairy Herd Improvement and official testing, a year in milk plant field work, a year as superintendent of the Kentucky Agricultural Experiment Station Dairy, and four years in Agricultural Extension as a dairy specialist. In 1950 I received an appointment with the Agricultural Research Service of the United States Department of Agriculture to do research in dairy cattle breeding in a project sponsored cooperatively by the Bureau of Dairy Industry and the Ohio Agricultural Experiment Station. At the same time I entered The Ohio State University, where I specialized in the Department of Dairy Science, and completed the requirements for the degree Doctor of Philosophy.