6-1-1974

TB72: Selection for Type and Milk Production in Dairy Cattle

Howard C. Dickey

Recommended Citation

SELECTION FOR TYPE AND MILK PRODUCTION IN DAIRY CATTLE

Howard C. Dickey

Selection for Type and Milk Production in Dairy Cattle

Howard C. Dickey*

Selection is said to be the keystone in the arch of animal breeding and as such gives direction, purpose and strength to the improvement of animal species. To provide meaningful improvement, selection must be accurate and as intense as possible. Production and type traits in dairy cattle are quantitative, grading from poor through excellent, and are controlled by polygenes. Polygenes have the properties (a) of being additive or cumulative in their effects on each trait, (b) of lacking dominance and recessiveness, and (c) they are affected by the environment in their expression on the traits to which they contribute control.

Accuracy of selection for a trait can be defined as the correlation between the real breeding value of an animal and what it is thought to be by the breeder. This means that accurate records are needed for the traits for which selections are made. Accuracy can vary from −1.0 to +1.0, depending on how well the breeding value of the animals is estimated. For most production traits, based on one lactation, accuracy of selection is about +0.3, while the average of three lactations will improve accuracy to +0.6 in most cases. Since waiting for a third record before selections are made will increase the years between generations, the improved accuracy is nearly offset by increased generation length. Also, high correlations of >0.9 have been found between partial lactations (5 months) and completed lactations. In view of this observation, many alert dairy cattle breeders are culling breeding cows for low production before the end of the first lactation. This practice decreases generation length. The heritability of partial (5 months) lactations is 0.3 which is the same as that of completed lactations.

MILK PRODUCTION IN DAIRY CATTLE

The judicious use of the Predicted Difference (P.D.) as a basis for the selection of dairy sires has increased accuracy of selection. By reducing environmental bias, when daughters were compared with their herdmates for milk production, accuracy has been increased from an average of 0.25 for an ordinary daughter average to 0.75 for the P.D. of a sire. Use of the P.D. for dairy sire selection and use by dairy cattle

* Professor, Department of Animal and Veterinary Sciences, University of Maine at Orono.

breeders should improve milk production when above average P.D. sires are used.

Since Dairy Herd Improvement Association records of production were first reported in 1906, we have much better information about progress attained for this trait.

Table 1.

Production of purebred dairy cattle and other dairy cattle in U.S.A.

Class of	1935			1970		
Cattle	Milk	Test	Fat	Milk	Test	Fat
	pounds	%	pounds	pounds	%	pounds
Ayrshire	8682	4.04	349	11646	3.86	450
Brown Swiss	10108	4.12	416	12606	3.99	503
Guernsey	8050	5.03	405	10129	4.60	466
Holstein	11338	3.45	391	14508	3.60	522
Jersey	6830	5.31	363	9265	4.97	460
All USA cows	4500	4.10	185	9385	3.65	343
All DHIA cows	7977	4.04	322	12659	3.77	477

A comparison of the average production of dairy cattle in this country in 1935 and 1970 is presented in Table 1 (1, 2). Increases are shown in average milk and butterfat production during these 35 years, but butterfat test in the milk produced has decreased. Maximum butterfat tests were recorded for DHIA cows from 1940 through 1943 with an average of 4.07% (2). During the 35-year period, average annual milk production per cow has increased by 140 pounds. This increase can be attributed primarily to improved feeding and management, with selection accounting for not more than 56 pounds of milk annually. During these 35 years our dairy cow numbers have decreased from more than 26 million to less than 12 million head. This has given dairymen a much greater opportunity to select and save the better cows for breeding purposes. Intensity of selection has played a role since intensity is based on the percentage of animals used to produce the next generation as shown in Table 2.

Ordinarily, intensity of selection among cows should average about 0.1 standard deviations, but during the last 25 years the intensity was closer to 0.2 standard deviations. Intensity for cow selection was doubled during this period of shrinkage in total cow numbers. Even though only 20 percent of our cows are production-tested, accuracy has improved, especially on sire provings in A.I. studs.

Table 2.

Selection differentials attainable with truncation selection when specific fractions of a group of animals are retained for producing the next generation

	Fraction Saved	Selection Intensity*	Fraction Saved	Selection Intensity*	
(cow culling)	0.90	0.20	0.09	1.80	
	0.80	0.35	0.08	1.86	
	0.70	0.50	0.07	1.92	
	0.60	0.64	0.06	1.99	
	0.50	0.80	0.05	2.06	Dams of
	0.40	0.97	0.04	2.15	Bulls
Dams of	0.30	1.16	0.03	2.27	Used in
Bulls	0.25	1.27	0.02	2.42	A.I.
Used in	0.20	1.40	0.01	2.67	
Natural	0.15	1.55	0.005	2.89	
Service	0.10	1.76	0.001	3.37	

* Selection intensity in standard deviation units (17).

In order to improve quantitative traits, the breeder should know the following about the traits for which selections are made:

    a. Whether his breeding animals are above or below average.
    b. The amount of variation for the traits.
    c. The heritability of the traits.
    d. The genetic correlations between the traits.

Table 3 gives the averages of the yields per lactation for milk and its components among Maine dairy herds (18). Average percentage of fat, SNF, T.S. and protein in the milk of each breed as well as the ratios of SNF/fat and protein/fat are listed in Table 3. From a breeder's point of view the most important values found in Table 3 are the standard deviations for each trait. Breeders can substitute into the following equation to obtain the underlined values in Table 4.

$$R_x = i_x h^2_x \sigma P_x$$

where R_x = predicted response in trait X after a generation of selection for trait X

i_x = the intensity of selection for trait X

h^2_x = heritability of trait X

P_x = the phenotypic standard deviation in trait X

For example, using Holstein data, the i_x for selection among the top 90 percent of the cows is 0.20 and for selecting among the top 10 percent of the sires is 1.76. Averaging the values 0.20 and 1.76, we obtain 0.98 or rounding to 1.00 which is the value used for i in Table 4. The heritability $_x$ ⸺ ⸺ ⸺ 0.28 for the production of milk, fat, SNF, T.S. and protein.

Table 3.

Averages and standard deviations of the yields of milk and its components, in pounds, and the percentages of milk components for dairy breeds

Trait	Ayrshire		Brown Swiss		Guernsey		Holstein		Jersey	
	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*	Mean	S.D.*
Yields										
Milk	10920	2340	12200	3130	9560	2410	16430	3140	10470	2490
Fat	463	100	485	140	478	120	626	130	537	140
SNF	967	210	1111	290	874	220	1417	270	975	230
Total solids	1430	300	1596	420	1352	340	2043	390	1512	370
Protein	366	80	410	110	330	90	531	100	385	100
Lactose-Min.	601	165	701	180	535	170	886	280	590	180
Percentages										
% Fat	4.24	.30	3.98	.30	5.00	.40	3.81	.40	5.13	.50
% SNF	8.86	.50	9.11	.30	9.14	.30	8.62	.30	9.31	.40
% T.S.	13.10	.60	13.08	.60	14.14	.60	12.43	.60	14.44	.80
% Protein	3.35	.30	3.36	.30	3.55	.30	3.23	.25	3.68	.30
Ratios										
SNF/FAT	2.09	.20	2.29	.20	1.83	.15	2.26	.20	1.81	.20

* Standard deviation is used by the animal breeder in estimating genetic response to selection.

Table 4.

Expected response per generation in yield of milk and its components in pounds as selections are made in the top 90% of the cows and top 10% of the sires for the yield of one component

Trait selected for	Response found in the yield of milk its component traits				
	Milk	Fat	SNF	TS	Protein
Ayshires					
Milk	655	22	56	79	20
Milk fat	511	28	48	76	19
SNF	629	23	59	82	21
TS	616	25	58	84	21
Protein	583	23	56	80	22
Brown Swiss					
Milk	876	31	78	111	28
Milk fat	684	39	66	107	27
SNF	841	32	81	115	29
TS	824	36	80	118	29
Protein	780	33	77	112	31
Guernsey					
Milk	675	26	59	89	22
Milk fat	526	34	50	87	20
SNF	648	27	62	93	24
TS	634	31	60	95	24
Protein	601	28	59	90	25
Holstein					
Milk	879	28	73	103	25
Milk fat	685	36	61	99	23
SNF	844	29	76	107	27
TS	826	33	74	109	27
Protein	782	30	72	104	28
Jersey					
Milk	697	31	62	97	25
Milk fat	544	39	52	94	23
SNF	669	32	64	102	27
TS	655	36	63	104	27
Protein	620	33	61	98	28

The σP for milk in Holsteins is 3140 pounds as found in Table 3. Therefore, $R_x = 1 \times 0.28 \times 3140 = 879$ pounds of milk. The remaining values appearing in Table 4 are determined by using the formula—

$$CR_y = i_x h_x h_y r A_{xy} \, \sigma py$$

where CR_y = the correlated response in trait Y when selection pressure has been placed on trait X

i_x = intensity of selection for trait X

h_x = square root of the heritability for trait X

h_y = square root of the heritability for trait Y

$r A_{xy}$ = genetic correlation between X and Y

σpy = the standard deviation for trait Y

As an example, assume that in selecting for milk production in Holstein cattle (trait X) and selecting among the top 90 percent of the cows and top 10 percent of the bulls for milk production, the increase in protein production (trait Y) can be determined per lactation each generation. Using the formula substitutions of values can be made.

$$CR_y = 1 \times 0.529 \times 0.529 \times 0.89 \times 100\#$$
$$= 1 \times 0.28 \times 0.89 \times 100\#$$
$$= 0.2492 \times 100\#$$
$$= 24.9\# \text{ or } 25\# \text{ of protein produced}$$

The genetic correlations between milk yield and the yield of each of the milk components are presented in Table 5. These values were obtained in the NE-46 and the S-49 projects (5). The genetic correlations are used to develop the values for CR presented in Tables 4 and 6.

The expected responses to selection in Table 6 show that the production traits improve about 1/6 as fast when selections are made for type alone as opposed to selecting for the production traits alone. The same table shows that type scores improve about ⅓ as fast when selections are made for production alone as compared with the selection for type alone. This agrees with Harvey and Lush (6).

Table 5.

Genetic correlations of milk composition and yield in dairy cattle

Traits	Milk	Fat	SNF	TS	Protein
Fat	0.78				
SNF	0.96	0.81			
TS	0.94	0.91	0.98		
Protein	0.89	0.83	0.95	0.95	
Final type score	0.18	0.16	0.18	0.18	0.18

Table 6.

Expected pounds of response in yield of Holstein milk and its components and final type score as we select in the top 90% of the cows and top 10% of the sires for type or production

Trait selected for	Response found per generation					
	Milk	Fat	SNF	TS	Protein	Type Sore
Milk	879	28	73	103	25	.37
Milk fat	685	36	61	99	23	.32
SNF	844	29	76	107	27	.37
TS	826	33	74	109	27	.37
Protein	782	30	72	104	28	.37
Final type score	158	6	14	20	5	1.11%

TYPE IN DAIRY CATTLE

Type improvement in dairy cattle has been erratic. There is no plan, such as DHIA, which enrolls all dairy cattle in a type evaluation program. The Holstein-Friesian breeders first initiated a Herd Classification program in 1928. The Jersey breeders followed in 1932 while the Ayrshire, Brown Swiss and Guernsey breeders started Herd Classification as late as 1947. The Purebred Dairy Cattle Breeders Association adopted a score card in 1943 which unified the goals and evaluation of the type desired in dairy cattle of all breeds. This score card even gave eight points for feet and legs. Previously, some score cards devoted no points to these traits. A later revision of the P.D.C.B.A. score card now gives 10 points for feet and legs.

Type can have a good effect on the general appearance of a herd of dairy cows. Also the selection for wearability and freedom from certain difficulties encountered with weak pasterns, loose udder attachments, poor teat size and shape, pinched heartgirth, lack of body capacity, crooked legs, spread toes and shallow heels improves the usefulness of the cows. Type cannot be measured objectively like production. This creates problems of analysis and interpretation which are not present with objectively measured traits. However, studies by Cassell *et al.* (3, 4) using 30,715 daughter-dam pairs reported in Table 7 show that all score card traits are medium in heritability for Holsteins. Furthermore, LaSalle *et al.* (7) estimated heritabilities for descriptive type traits in 86,095 daughter-dam pairs of Holstein cows as shown in Table 8.

Research shows that final classification scores are influenced by differences in age and stage of lactation (8, 9). There is little variation due to differences among experienced classifiers. Herd and year effects on type rating are generally smaller than such effects for milk produc-

Table 7.

Heritability values for final classification scores and score card traits for registered Holstein-Friesian cows

Traits	Heritability (%)
Final classification score	31
Score card traits	
General appearance	29
Dairy character	19
Body capacity	27
Mammary system	22

tion. Van Vleck (10) and Carter *et al.* (11) suggest that herdmates need not be considered when reporting type ratings for daughters of sires. Herdmate comparisons might become more important as size of herds gets larger.

Cassell *et al.* (12) confirmed the need for age adjustment factors and published (13) factors for adjusting final classification scores to maturity. These data are based upon 223,372 Holstein cows classified in 1971 and 1972. Their factors are shown in Table 9. Mature score was 80.7 for these data.

It still appears that there should be a correction made for the stage of lactation when the cow is classified. Benson *et al.* (14) showed significant differences in type ratings with the first to fourth month of lactation giving higher type scores and the tenth month through the dry period giving lower type scores than the fifth through ninth months of lactation.

In order to improve accuracy in determining a bull's ability to transmit type, the Holstein-Friesian breeders (15) have developed an index named Predicted Difference for Type.

$$PDT = b [(\bar{P}-\bar{B}) - 0.5 h^2 (\bar{D}-\bar{B})]$$

where $b = Nh^2/4 + (N-1) h^2 + 4 \text{ sum } n (n-1) /N (C^2)$

$\bar{D}$ = mature average of daughters $\overset{i\ \ i}{=}$ 80.7 in 1974

$\bar{B}$ = mature breed average

0.5 = relationship between daughter and dam

$\bar{P}$ = mature average of dams

Final classification score is the trait being used at the present time. With time, general appearance, dairy character, body capacity and mammary system should be added to the PDT.

Thirteen descriptive traits for cows have also been added to herd classification of Holsteins. Each trait has three to five coded divisions. For instance, udder quality is coded 1 (30%) soft and pliable, 2 (63%)

Table 8.

Heritability values for descriptively coded traits in registered Holstein-Friesian cows

Traits	Codes (%)		Description	Heritability (%)
Stature	1	(41)	Upstanding	47
	2	(47)	Intermediate	12
	3	(12)	Low set	51
Head	1	(3)	Ideal	17
	2	(10)	Short	44
	3	(35)	Plain and/or coarse	18
	4	(4)	Weak	23
Front end	1	(20)	Chest strong width	17
	2	(4)	Coarse shoulder	18
	3	(9)	Narrow and weak	18
Back	1	(37)	Strong, wide loin	18
	2	(6)	Low front end	34
	3	(13)	Weak loin	28
Rump	1	(8)	Long, wide and level	14
	2	(15)	High pins	28
	3	(18)	Narrow pins	26
	4	(10)	Sloping	46
Hind legs	1	(2)	Strong, squarely placed	28
	2	(38)	Acceptable	13
	3	(43)	Sickled	18
	4	(10)	Too light bone	27
	5	(7)	Too straight (posty)	39
Feet	1	(5)	Strong, good shape	16
	2	(7)	Spread toes	11
	3	(27)	Shallow heel	10
Fore udder	1	(8)	Firmly attached	37
	2	(52)	Slightly bulgy	12
	3	(13)	Short	18
	4	(2)	Broken	33
Rear udder	1	(10)	High and wide	28
	2	(11)	Narrow and pinched	26
	3	(2)	Loose, broken	36
Udder support	1	(68)	Strong ligaments	21
	2	(6)	Floor too low	24
	3	(9)	Tilted	33
	4	(1)	Broken ligaments	35
Teat size and placement	1	(22)	Desirable size & placement	22
	2	(1)	Rear teats far back	83
	3	(20)	Wide front teats	30
	4	(9)	Poor shape	33
Miscellaneous	1	(2)	Winged shoulders	20
	2	(8)	Toeing out	13
	3	(9)	Weak pasterns	11
	4	(1)	Crampy	43
	5	(4)	Small size	25

intermediate, 3 (3%) could not determine, 4 (4%) meaty. With this information paternal sisters can be compared with their breedmates and their dams to determine if differences in these traits are real. The statistical procedure for comparing the descriptive trait of paternal sisters with their breedmates is as follows:

Let P = % of the paternal sisters (daughters of a sire) within a
      specific code (1-5) and category (1-13).

Let Q = % of the daughters of a sire in all other codes within a
      specific category.

Let s = standard deviation of the above so that s = $\sqrt{PQ/N}$

where N = the number of scored daughters of a sire

Let T = (P − BA) ÷ s

where BA is the weighted breed average for the code (1-5) and
category (1-13).

The 10% level of probability in the table of T (students) (16)
is considered significant.

Example: If 25% of 20 daughters (N) of a sire are coded (1) firmly
attached, high and wide in rear udder, then P = 25% and Q =
75%.

Then s = $\sqrt{(25 \times 75)}$ ÷ 20 = 9.68.

If the appropriate BA is 10%, then the T-value is:
      (25 − 10) ÷ 9.68 = 1.5496

Table 9.

Factors for age adjusting final classification scores to maturity

Age in months	Adjustment factor
Less than 24	1.06
24-25	1.05
26-28	1.04
29-33	1.03
34-37	1.02
38-47	1.01
48-73	1.00
74-101	.99
102-106	.98
107-136	.97
137-142	.96
143-168	.95
More than 168	.95

This calculated T does not exceed the tabled T (1.725). There-
fore, the conclusion is that there is no significant difference between the
percentages of daughters of this sire that are coded 1 for rear udder
and their breedmates that are coded 1 for rear udder. This sire would
not be expected to sire a significantly higher percentage of daughters
coded 1 for this trait than the percentage already found among cows in
the breed as a whole.

Daughters can also be compared with their dams for all the descrip-
tive codes. The procedure follows:

      P = % of a sire's daughters which are found within a specific
            code (1-5) and category (1-13).

Q = % of the sire's daughters which are in all other codes in that category.

P_1 & Q_1 = % of the dams in the same category as their daughters.

BA & BA_1 = % of all Holsteins in the same categories as daughters and dams.

s & s_1 = same standard deviation for daughters and dams, respectively.

$$s = \sqrt{PQ/N} \qquad\qquad s_1 = \sqrt{P_1Q_1/N_1}$$

where N = No. of daughters and N_1 = No. of dams.

$$T = (P - P_1) - (BA - BA_1) \div \sqrt{PQ \div N + P_1Q_1 \div N}$$

The 10% level of probability in the table of T (students) is considered significant.

Example: There are 40 daughters of a sire with their dams that are descriptively classified. Seventy percent of the daughters are coded 2 (moderate length-slightly bulgy) in fore udder at an average age of 3 years and 7 months. Forty percent of the dams are coded 2 in fore udder at an average age of 7 years and 9 months. The calculations follow: $T = (70 - 40) - (30 - 36) \div \sqrt{70 \times 30 \div 40 +}$

$40 \times 60 \div 40 = 3.3962**$

This value exceeds the value of 1.684 in the T table. The conclusion is that there is a significantly higher percentage of daughters coded 2 in fore udder than their dams. These two tests can be useful in determining the "transmitting patterns" of Holstein sires. This helps in making selective matings to improve specific type traits. No bull improves every trait, so choices have to be made to select for the most important traits.

TYPE AND PRODUCTION IN DAIRY CATTLE

In selecting for both type and production it is informative to use a chart as shown in Figure 1. The herd average can be calculated for type and for production as shown in Table 10 and plotted on the chart. Then a breeder should set his goals such as Goal A or Goal B on the chart. If a line is then drawn from the Goal to the herd average and a perpendicular line struck from the Goal-herd average line, a cow index can be developed which will best serve the breeder in reaching his goal.

The Cow Index for Goal A is:

Cow Index = Cwt. of milk + 7.5 (Final Type Score)

This index will cull the cows in such a manner that the herd will be pushed toward Goal A. The use of sires which transmit good type and

---

**Highly significant statistically. $P = < .01$ which means that the value of T 3.3962 would occur less than 1 time in 100.
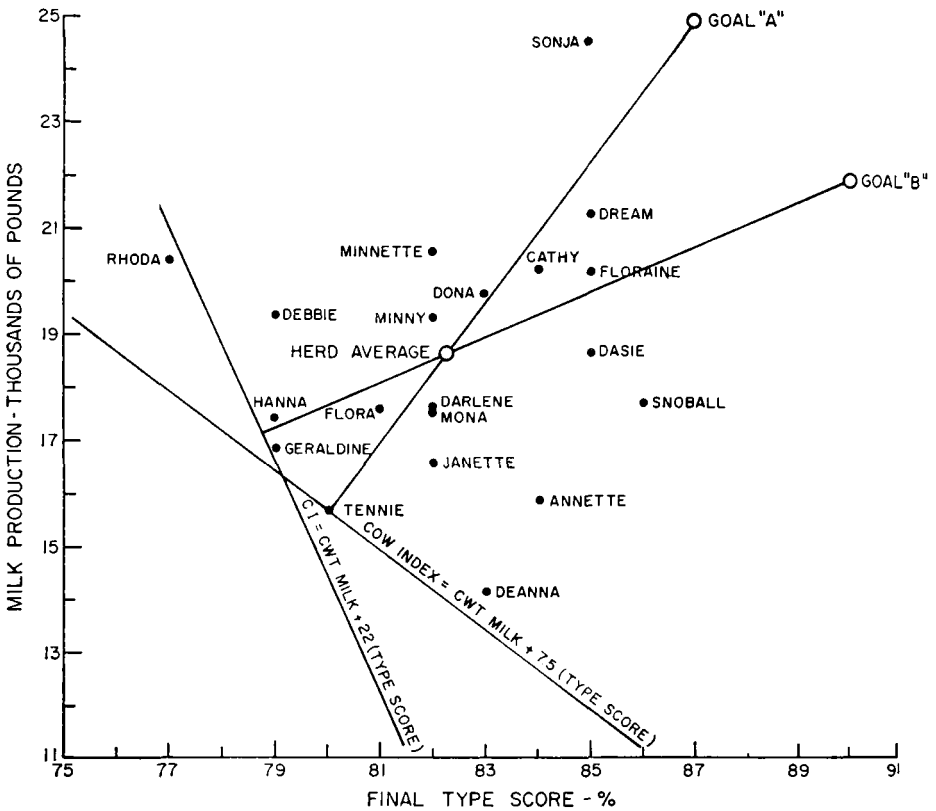
Figure 1.
Cow Indexes for Use with Goal "A" or Goal "B" for Production and Final Type Score.

production will help materially. Each cow index should be "home-made" and fit the desires of each breeder. The relative values in the Cow Index can be changed to give greater or lesser emphasis to type and production as improvements are made. The selection index should yield about 1.4 times more progress per generation than using type and milk production truncation selection individually for each cow.

If a breeder adopts Goal "A" or 25,000 pounds of milk with an 87% final type score, he proceeds as follows: (a) He locates this goal on a chart as is shown in Figure 1; (b) Then he would draw a line be-tween Goal A and the Herd Average located at 18,593 pounds of milk and 82.25% final type score; (c) A line perpendicular to the Goal A – Herd Average line is drawn; (d) Two values for production and two values for the corresponding final type score are taken from this perpen-

Table 10.

Milk production and type scores for University of Maine Holstein cows

Barn Name	Mature, 305-day lactation average	No. of lactations	Mature type score average	No. of classifications
	pounds		%	
Dasie	18,666	6	85	5
Cathy	20,287	5	84	4
Geraldine	16,840	3	79	3
Flora	17,588	4	81	3
Deanna	14,175	3	83	2
Dream	21,386	2	85	2
Hanna	17,466	2	79	2
Mona	17,518	2	82	2
Floraine	20,242	2	85	1
Debbie	19,416	2	79	1
Dona	19,828	2	83	1
Darlene	17,552	2	82	1
Sonja	24,636	1	85	1
Rhoda	20,471	1	77	1
Snoball	17,740	1	86	1
Annette	15,917	1	84	1
Minny	19,414	1	82	1
Minnette	20,538	1	82	1
Tennie	15,678	1	80	1
Janette	16,512	1	82	1
Average	18,593		82.25	

dicular line, i.e., 19,450 pounds of milk and 75% final type score and 11,900 pounds of milk and 85% final type score; (e) The differences in production and final type scores for these two points are found, i.e., 19,450-11,900 = 7,550 pounds of milk, i.e., 85%-75% = 10%. Then 75.50 cwt. of milk is divided by 10 to give 7.55 to use for the multiplier of final type score in the Cow Index to move the Herd Average toward Goal A. Each cow in the herd would receive a Cow Index value using the formula Cow Index = Cwt. Milk ÷ 7.55 (Final Type Score). These values are found in Table 11.

Perhaps a breeder decides that Goal "B" or 22,000 pounds of milk with a 90% final type score is his aim. He wants more type and less production in his cattle than for Goal "A" He proceeds as follows: (a) He locates this goal on a chart as is shown in Figure 1; (b) Then he draws a line between Goal "B" and the Herd Average located at 18,593 pounds of milk and 82.25% final type score; (c) A line perpendicular to the Goal B—Herd Average line is drawn; (d) Two values for production and two values for the corresponding final type score are taken from this perpendicular line as 21,000 pounds of milk with 77% final type score and 12,200 pounds of milk with an 81% final type score· (e) The differences in production final type score for these

Table 11.

Cow index values for the cows in the herd using Goal A and Goal B

| Barn Name | Cow index value with | | | |
	Goal A	Rank	Goal B	Rank
Dasie	828.51	5	2,056.66	5
Cathy	837.07	4	2,050.87	6
Geraldine	764.85	19	1,906.40	19
Flora	787.43	14	1,957.88	15
Deanna	768.40	18	1,967.75	14
Dream	855.61	2	2,083.86	2
Hanna	771.11	17	1,912.66	18
Mona	794.28	11	1,979.18	12
Floraine	844.17	3	2,072.42	3
Debbie	790.61	13	1,932.16	16
Dona	824.93	7	2,024.28	7
Darlene	794.62	10	1,979.52	11
Sonja	888.11	1	2,116.36	1
Rhoda	786.06	15	1,898.71	20
Snoball	826.70	6	2,069.40	4
Annette	794.37	12	2,007.17	9
Minny	813.24	9	1,998.14	10
Minnette	824.48	8	2,009.38	8
Tennie	760.78	20	1,916.78	17
Janette	784.22	16	1,969.12	13
Average	806.92		1,995.44	

two points on the Cow Index line are found, i.e., 21,000-12,200 = 8,800 pounds of milk, i.e., 81%-77% = 4%. Then 88.00 Cwt. of milk is divided by 4 to give 22 to use for the multiplier of final type score in the Cow Index to move the Herd Average toward Goal B. Each cow in the herd would receive a Cow Index value using the formula Cow Index = Cwt. Milk + 22 (Final Type Score). These values are found in Table 11.

A close examination of Table 11 reveals that the cows with the lowest Cow Index using Goal A are Tennie, Geraldine and Deanna. If a breeder is using Goal B, the cows with the lowest Cow Index are Rhoda, Geraldine and Hanna. If a breeder decides that he would not desire to cull Rhoda because she produced 20,471 pounds of milk, then he could decide to keep her as a milk producer and not keep any calves from her. If he decides that Rhoda is not a cull cow in his breeding program, then he should reexamine his goals and change them so they would more nearly approach Goal A, since Rhoda is not a cull cow for a breeder who is aiming toward Goal A.

After four years, a breeder should again calculate his Herd Average for mature milk production and mature final type score to determine his herd's progress. If satisfactory progress has been made toward his

goal, then he should continue to use the same Cow Index in selecting his cows for breeding purposes. If unsatisfactory progress has been made, then he should examine his sire selection program, mating program and revalue his Cow Index.

LITERATURE CITED

(1) Olson, T. M. 1938. Elements of Dairying. The Macmillan Company, New York, New York.

(2) Agricultural Research Service, United States Department of Agriculture. Dairy Herd Improvement Newsletters.

(3) Cassell, B. G., J. M. White, W. E. Vinson and R. H. Kliewer. 1973. Genetic and phenotypic relationships among type traits in Holstein-Friesian cattle. J. Dairy Sci., 56:1171-1177.

(4) Cassell, B. G., J. M. White, W. E. Vinson and R. H. Kliewer. 1973. Sire-son relationships for type in Holstein-Friesian cattle. J. Dairy Sci., 56:1164-1170.

(5) Wilcox, C. J., S. N. Gaunt and B. R. Farthing. 1971. Genetic interrelationships of milk composition and yield. Southern Coop. Ser. Bull. 155.

(6) Harvey, W. R. and J. L. Lush. 1952. Genetic correlation between type and production in Jersey cattle. J. Dairy Sci., 35:199-213.

(7) LaSalle, T. J., J. W. Jamison and J. M. White. 1973. Heritability of descriptive type traits in Holstein cattle. J. Dairy Sci., 56:676.

(8) McGilliard, L. D. and J. L. Lush. 1956. Changes in type classification of dairy cattle. J. Dairy Sci., 39:1015.

(9) Hansen, L. R., G. R. Barr and D. A. Wieckert. 1969. Effects of age and stage of lactation on type classification. J. Dairy Sci., 52:646.

(10) Van Vleck, L. D. 1964. Variation in type appraisal scores due to sire and herd effects. J. Dairy Sci., 47:1249.

(11) Carter, H. W., J. C. Rennie and E. B. Burnside. 1965. Cause of variation in type classification scores. J. Dairy Sci., 48:710.

(12) Cassell, B. G., J. M. White and W. E. Vinson. 1972. Heritability of type traits in Holsteins. J. Anim. Sci., 35:173.

(13) Cassell, B. G., W. E. Vinson, J. M. White and R. H. Kliewer. 1973. Age correction factors for type traits in Holsteins. J. Dairy Sci., 56:1178.

(14) Benson, R. H., W. J. Tyler and G. Hyatt. 1951. Some causes of variation in type ratings of Ayrshire cows. J. Dairy Sci., 34:502.

(15) Kliewer, R. H. 1971. Advances in the use of type data for evaluation of registered Holstein sires. Proc. 25th Con. N.A.A.B., pp. 54-66.

(16) Snedecor, G. W. 1956. Statistical Methods. 5th Ed. Iowa State University Press. Ames, Iowa.

(17) Rice, V. A., F. N. Andrews, E. J. Warwick and J. E. Legates. 1967. Breeding and improvement of farm animals. 6th Ed. McGraw-Hill Book Company, New York, New York.

(18) Dickey, H. C. 1970. Breeding dairy cows for milk composition traits. Re-
        ... ... Life ... ... Maine. pp. 24-30.