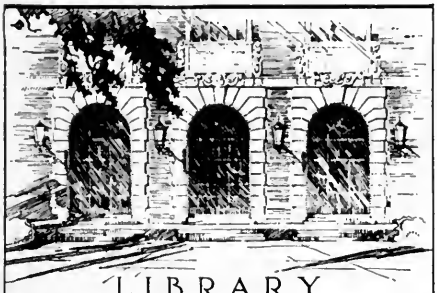

An Analysis of Milking Shorthorn Milk Records

By W. L. GAINES

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CONTENTS

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An Analysis of Milking Shorthorn Milk Records

By W. L. Gaines, Chief in Milk Production

EXTENSIVE STATISTICAL STUDIES have been made of the milk- and fat-production records of the various breeds of dairy cattle. No such studies have been carried out, however, for Milking Shorthorns, a breed bred for both milk and meat production. Official records similar to those kept for strictly dairy breeds are available for this dual-purpose breed, having been published continuously since 1915, except in 1918, in the Milking Shorthorn Year Book. It was therefore the purpose of the study reported here to subject these records to a statistical analysis.

For this study records from Volumes 9 to 23 (1924-1938), which include R.M. (Record of Merit) numbers 1,910 to 8,564, were used (Fig. 1). Only records which included age of cow at calving, length of record, milk-fat yield, and fat percentage in addition to milk yield were studied.

To appear in the Year Book a record must meet certain requirements. "Double letter" (DL) records require that a cow give birth to a living calf within 14 months after freshening; "single letter" (SL) records have no calving requirement. An SL cow 30 months old or younger when her record was started must produce at least 5,250 pounds of milk or 210 pounds of fat before her record is accepted (it is not necessary to satisfy both requirements but only one). An SL cow whose record starts when she is 60 months old or older must produce at least 8,000 pounds of milk or 300 pounds of fat. Requirements for cows in between these ages are graduated uniformly on a day basis. The requirement for DL records is .9 that of SL records, plus the calving requirement already mentioned.

A record is not necessarily confined to a single lactation and may start at any time, but in actual practice most of the records start within a week after calving. If a second lactation is involved, the length of record includes any dry period intervening. Some records were shorter than the maximum (SL-<12 mo.; DL-<10 mo.), either because the cow went dry or because the record-keeping was discontinued.

RECORD OF MERIT COWS, 7890—8564

*Two milkings per day. † Three milkings per day.

Owner of Cow	R. M. Number	Name, Sire and Dam of Cow	Breeder	Class	Birthdate M. D. Y.	Age at Calving Y. M. D.	Age at Starting Y. M. D.	Length of Record M. D.	Pounds Milk	Per Cent Fat	Pounds Fat
Joho Thomas Adkins, Prentice, Ill.	7890	*Blossom m1824692 S. Elk Run Daniel 1714620. D. Black Creek Christie 1582333.	Jesse E. Oakley	CC	8- 8-34	2- 4-24	2- 4-26	8-28	8,209.0	4 63	380 10
	7891	*Dora 2d 1799189 S. Woodlyn Duke 1599134. D. Dora Oxford 880673.	John Thomas Adkins	CC	8-10-34	2- 2-14	2- 2-21	9- 1	10,728.0	5 33	572 14
	7892	*Duchess 50th 1722673 S. Prince of Woodlyn 1529246. D. Duchess 49th 1020997.	John Thomas Adkins	CC	10- 1-32	4- 3-27	4- 4- 1	9-23	8,995.0	4 21	379 03
	7893	*Princess Fairy 1775258 S. Model's Prince 2d 1601816. D Natick Fairy 1478763.	Webster Knight	C	1-21-34	3- 0-13	3- 0-17	8-10	8,193.0	4 62	378 41
	7894	*Queen's Jewel m1713218 S. Jewel's Laddie 1661950. D. Queen Cardiffdale 2d 1327172.	Ralph S. Wilmington	C	1-22-32	4- 8-27	4- 9- 9	8- 0	9,395.5	4 38	411 42
Antonini Bros., Stockton, Calif.	7895	*Hollandale Diamond 1766211 S. Hollandale Pal O'Mine 1676317. D. Hollandale Radiance 1689156.	Hollandale Farm	C	5-13-33	3- 2-29	3- 3- 3	10- 1	6,955.4	3 97	276 11
	7896	*River Bend White Ellen m1873665 S. Northwood Rex 1580836. D. River Bend Portia 1638946.	Antonini Bros.	C	12-28-34	1- 8-23	1- 9- 3	9- 0	6,398.5	4 03	258 16
	7897	*Rockrose Kitty 1813281 S. Rockrose Defence 2d 1615222. D. Rockrose Faith 2d 1725020.	Dwight A. Smith	C	8-22-34	2- 1-10	2- 1-13	8-26	6,284.7	4 06	275 45
	7898	*Rockwood Roan Frances 1788393 S. Northwood Rex 1580836. D. Frances 1064402.	H. L. Kenyon	C	8- 2-33	2-10-29	2-11- 1	11-28	8,568.9	4 03	345 78
J. L. App, Franklin, Ind.	7899	*Imperial Jane m1815433 S. Glenside Imperialist 1542255. D. Florence Jane 1616078.	Archie I. Wentworth	CT	6- 1-33	2- 8- 5	2- 8- 8	11-23	8,558.5	3 70	316 92
	7900	*Tekla 4th m1776620 S. Glenside Imperialist 1542255. D. Tekla 3d 1514889.	Archie I. Wentworth	CT	3- 1-33	3- 1- 1	3- 1- 4	10-24	7,638.0	3 62	276 69
Emmett Arnold, Janesville, Wis.	7901	*Duchess 1885627 S. Innisfail Anderson 4th 1692911. D. Lady Duchess 1673484.	Robert Keenan & Son	CT	3- 4-35	1-11-29	2- 0-27	12- 0	6,850.5	3 97	272 03
	7902	*Goldie's Lass 1894925 S. Prince Rudy 1693317. D. Goldie 1642389.	Wm. Payne	CT	9-29-32	4- 5-18	4- 5-21	12- 0	9,975.7	3 98	396 81
F. H. Arnold & Sons, Janesville, Wisc.	7903	*Christmas Gift 10th m1772957 S. Fair Lad 3d 1598428. D. Christmas Gift 6th 1409431.	Andrew Bergum	CT	12-23-33	2- 8- 0	2- 8- 3	11- 6	6,855.2	4 13	283.23
	7904	*Dorothy Batchelder 1552361 S. Babraham Queenston 1400699. D. Dorothy Clay 798864.	F. H. Arnold & Sons	CT	1- 5-28	8-11-15	8-11-18	12- 0	10,920.0	4 13	451.23

Fig. 1.—A typical page from the Milking Shorthorn Year Book

For the purposes of this study the records were grouped as follows:

Milkings per day	*Letter*	*Length of record*	*Designation of group*	*Number of records*
2	Single	12 months (365 days)	2x-SL-12 mo.	2,585
2	Single	Less than 12 months	2x-SL-<12 mo.	2,130
2	Double	10 months (305 days)	2x-DL-10 mo.	504
2	Double	Less than 10 months	2x-DL-<10 mo.	462
3	Single	12 months (365 days)	3x-SL-12 mo.	345
3	Single	Less than 12 months	3x-SL-<12 mo.	285
	Total records			6,311

There were 48 DL records in the 3x category but because they occurred so infrequently, they are not included in this study. There were 8 records for cows milked four times a day and 6 of these records in a 4x-SL-12 mo. group are considered because they afford some indication of the response of the breed to such extra-pressure methods of management.

TABLE 1.—FREQUENCY DISTRIBUTION OF RECORDS ACCORDING TO FAT PERCENTAGE
(Figures indicate percent of total records in each group)

Fat percentage class[a]	Group						
	All records	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.
2.9	.06	.04	.09	....	....	.29	....
3.0	.11	.08	.14	.20	....	....	.35
3.1	.41	.43	.47	....	.43	.58	.35
3.2	1.01	.97	1.13	1.19	.65	1.16	.70
3.3	1.79	1.62	1.92	1.79	1.30	2.61	2.11
3.4	3.45	2.44	3.80	5.36	4.55	4.64	3.51
3.5	5.13	4.99	5.45	5.56	3.68	6.38	4.21
3.6	7.43	7.35	7.09	7.14	6.49	12.75	6.32
3.7	10.09	9.79	10.23	9.72	8.01	11.88	13.68
3.8	12.12	12.46	11.88	9.72	11.04	13.04	15.79
3.9	12.06	12.34	11.83	14.29	8.44	12.46	12.63
4.0	11.96	11.99	12.86	8.93	10.17	11.59	13.68
4.1	10.19	10.95	9.15	10.91	11.90	7.54	10.18
4.2	8.08	8.01	7.89	8.73	10.39	6.96	6.67
4.3	5.91	6.54	5.73	5.95	5.84	2.61	5.61
4.4	4.47	4.29	4.69	5.56	6.06	3.19	1.40
4.5	2.19	2.05	2.39	1.79	3.90	1.16	1.05
4.6	1.35	1.43	1.03	1.79	2.81	.29	1.05
4.7	.95	1.08	.85	.79	1.95	....	.35
4.8	.49	.43	.56	.60	.87	.29	....
4.9	.35	.35	.42	....	....	.29	.35
5.0	.13	.04	.23	....	.43	....	....
5.1	.08	.12	....	....	.43	.29	....
5.2	.10	.12	.09	....	.22	....	....
5.3	.05	.04	.05	....	.22	....	....
5.4	.02	.04	....	....	....	....	....
5.5	.02	.04	....	....	....	....	....
5.6	.02	....	....	....	.22	....	....

[a]Lower class limit. The published records report fat percentage to the closest second decimal; hence the 2.9 class includes actual values from 2.895 up to but not including 2.995.

FAT PERCENTAGE AND YIELDS OF MILK, FAT, AND FCM

The percentage frequency distribution with regard to fat percentage for each of the six groups and all the groups together is given in Table 1. Similar data with respect to milk yield are given in Table 2.

Fat percentage and milk yield. For fat percentage the groups did not differ greatly in means, standard deviations, and coefficients of variation (CV), but for milk yield there were decided differences in means and standard deviations, altho differences in CV were not large

TABLE 2.—FREQUENCY DISTRIBUTION OF RECORDS ACCORDING TO MILK YIELD
(Figures indicate percent of total records in each group)

Milk yield class[a]	Group						
	All records	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.
lb.							
3 500	.02	.04	....	....	....	....	....
4 000	.13	.12	.05	.60	.22	....	....
4 500	1.03	.66	.70	2.39	4.55	....	....
5 000	4.20	3.91	3.52	9.94	8.01	....	.70
5 500	6.70	6.50	7.37	9.74	9.52	.58	1.05
6 000	8.34	8.51	9.58	9.15	9.96	1.16	2.11
6 500	8.89	9.90	8.87	10.93	9.31	2.03	3.86
7 000	9.87	9.44	10.19	12.33	16.23	2.61	5.61
7 500	9.00	8.63	9.86	10.14	10.39	3.19	8.77
8 000	11.74	11.76	14.37	8.35	9.74	4.35	10.18
8 500	8.29	7.89	9.81	7.95	6.71	4.06	8.77
9 000	7.13	7.35	7.32	7.36	4.55	5.80	9.12
9 500	5.21	5.69	4.93	3.18	4.11	4.93	8.77
10 000	4.66	4.68	4.93	1.79	2.81	5.51	9.47
10 500	3.52	4.06	2.58	1.39	.65	9.28	7.02
11 000	2.81	3.02	1.97	2.39	1.08	7.25	5.26
11 500	2.09	2.36	1.36	.80	.43	7.25	3.86
12 000	1.66	1.35	.75	.99	.65	8.99	5.26
12 500	1.39	1.16	.70	.20	.43	8.41	3.86
13 000	.92	1.12	.38	.20	....	4.06	2.11
13 500	.71	.74	.19	....	.65	4.64	1.05
14 000	.38	.19	.28	....	....	2.90	1.05
14 500	.29	.23	.14	....	....	2.03	.70
15 000	.27	.31	.05	.20	....	2.03	....
15 500	.10	.04	.05	....	....	.58	.70
16 000	.22	.08	....	....	....	3.19	.35
16 500	.13	....	.05	....	....	2.03	....
17 000	.08	.12	....	....	....	.58	....
17 500	.06	.04	....	....	....	.87	....
18 000	.05	.04	....	....	....	.29	.35
18 500	.03	.08	....	....	....	....	....
19 000	.02	....	....	....	....	.29	....
19 500	....	....	....	....	....	....	....
20 000	.02	....	....	....	....	.29	....
20 500	.02	....	....	....	....	.29	....
21 000	.02	....	....	....	....	.29	....
21 500	.02	....	....	....	....	.29	....

[a]Lower class limit. The 3,500 class includes values from 3,500 up to but not including 4,000.

(Table 3 and Fig. 2). This corresponds with what is true generally, since in every breed of milk cows fat percentage is distinctly less variable than milk yield. This is to be expected since fat percentage merely expresses the *ratio* of milk fat to milk (which might be about the same for either high- or low-producing cows), while milk yield can vary greatly because it is influenced by environmental factors such as feed. Conditions that tend to increase milk yield tend to increase fat yield at the same time, so that the ratio between the two is not appreciably changed.

Mean milk yield was 8,337 pounds and mean fat percentage was 3.97. The figure for fat percentage may be said to represent a definite characteristic of the Milking Shorthorn breed, but because milk yield depends so much on environmental factors, a yield of 8,337 pounds should not be assumed to be characteristic.

The coefficient of correlation between fat percentage and milk yield for all the groups was −.217 (Table 4). This means that as fat percentage increases there is a tendency for milk yield to decrease (this is assuming that fat percentage affects yield of milk).

TABLE 3.—MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION IN FAT PERCENTAGE, MILK YIELD, MILK-FAT YIELD, AND MILK-ENERGY YIELD

Group	Fat percentage	Milk	Fat	FCM
		Means		
		lb.	*lb.*	*lb.*
2x-SL-12 mo.	3.99	8 334	331	8 299
2x-SL-<12 mo.	3.97	8 044	318	7 988
2x-DL-10 mo.	3.97	7 481	296	7 432
2x-DL-<10 mo.	4.05	7 383	298	7 423
3x-SL-12 mo.	3.88	11 576	448	11 350
3x-SL-<12 mo.	3.93	9 695	380	9 578
All six	3.97	8 337	330	8 285
		Standard deviations		
2x-SL-12 mo.	.327	2 079	81.1	2 019
2x-SL-<12 mo.	.334	1 758	69.1	1 706
2x-DL-10 mo.	.326	1 745	68.6	1 699
2x-DL-<10 mo.	.373	1 674	70.7	1 695
3x-SL-12 mo.	.304	2 779	108.6	2 704
3x-SL-<12 mo.	.288	2 113	83.5	2 064
All six	.332	2 167	84.3	2 102
		Coefficients of variation		
2x-SL-12 mo.	8.2	25.0	24.5	24.3
2x-SL-<12 mo.	8.4	21.9	21.7	21.4
2x-DL-10 mo.	8.2	23.3	23.2	22.9
2x-DL-<10 mo.	9.2	22.7	23.7	22.8
3x-SL-12 mo.	7.8	24.0	24.2	23.8
3x-SL-<12 mo.	7.3	21.8	22.0	21.5
All six	8.4	26.0	25.5	25.4

TABLE 4.—COEFFICIENTS OF CORRELATION BETWEEN FAT PERCENTAGE AND MILK YIELD, FAT YIELD, AND FCM YIELD

Group	Coefficient of correlation between fat percentage and:		
	Milk yield	Fat yield	FCM yield
2x-SL-12 mo.	−.224 ± .012	+.107 ± .013	−.027 ± .013
2x-SL-<12 mo.	−.219 ± .014	+.169 ± .015	+.012 ± .015
2x-DL-10 mo.	−.196 ± .029	+.159 ± .029	+.016 ± .030
2x-DL-<10 mo.	−.138 ± .030	+.259 ± .029	+.107 ± .031
3x-SL-12 mo.	−.152 ± .035	+.174 ± .035	+.042 ± .036
3x-SL-<12 mo.	−.161 ± .039	+.189 ± .039	+.048 ± .040
All six	−.217 ± .008	+.106 ± .008	−.026 ± .009

In Figs. 3 and 4 this trend is shown for two groups—2x-SL-12 mo. and 3x-SL-12 mo.—by the slanting lines passing thru the crosses.

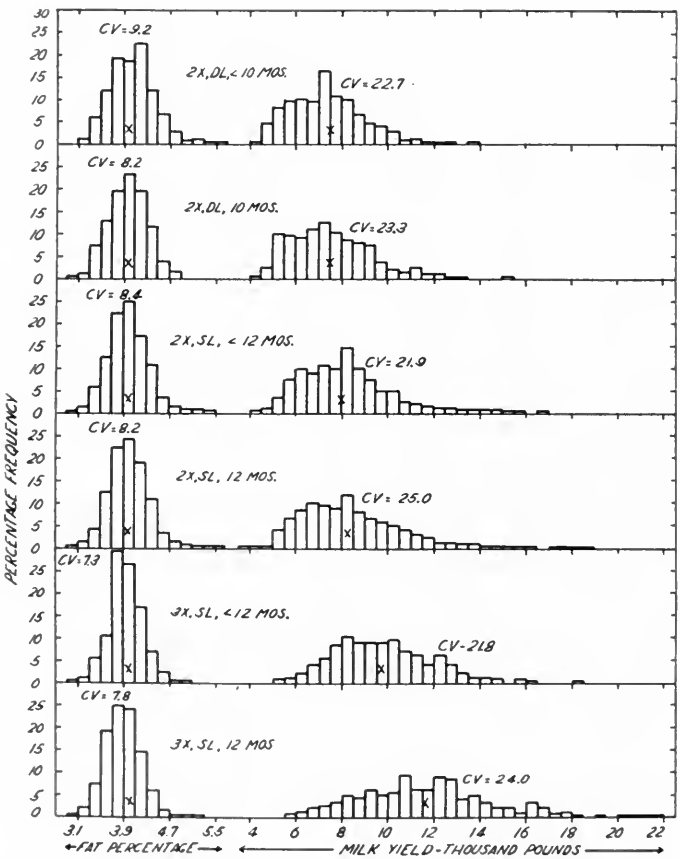

Fig. 2.—Percentage frequency distribution curves for fat percentage and milk yield. Crosses indicate means. CV is the coefficient of variation.

These lines are valid descriptions of the relation between fat percentage and milk yield, in so far as that relation can be expressed by a straight line. The coefficient of correlation for the 2x-SL-12 mo. group is —.224. The decrease in yield with increasing fat percentage of this group can be determined by dividing the standard deviation of milk yield, 2,079 pounds, by the standard deviation of fat percentage, .327, and multiplying the quotient by the coefficient of correlation. Thus .224 × 2079/.327 equals 1,424 pounds, which represents the decrease in milk yield for each increase of 1 in fat percentage in this group. For the 3x-SL-12 mo. group, which has a correlation of —.152, the decrease is 1,388 pounds.

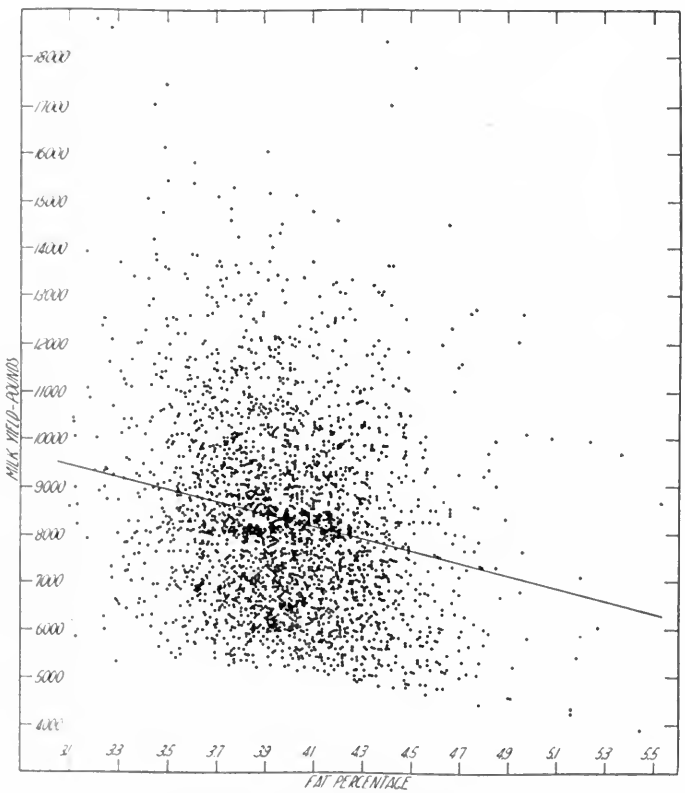

Fig. 3.—Each of the 2,585 pairs of records in the 2x-SL-12 mo. groups for fat percentage and milk yield is represented by a dot. The cross indicates the mean fat percentage and mean milk yield, and the straight line passing thru the center of the cross shows the regression of milk yield on fat percentage (coefficient of correlation, —.224).

So far as numerical values alone are concerned, it is equally valid to say that as milk yield increases, fat percentage tends to decrease. The extent of this tendency for the 2x-SL-12 mo. group is .224 × .327/2079, or a reduction of .035 in fat percentage for each 1,000 pounds increase in milk yield.

A point of interest in connection with Fig. 3 is the way in which the distribution of the dots is cut off at a more or less straight line near the bottom of the graph. This is due to the entrance requirement which keeps out any record showing less than 5,250 pounds of milk containing up to 4 percent fat or less than 210 pounds of fat in milk containing more than 4 percent fat. If all records were included, a

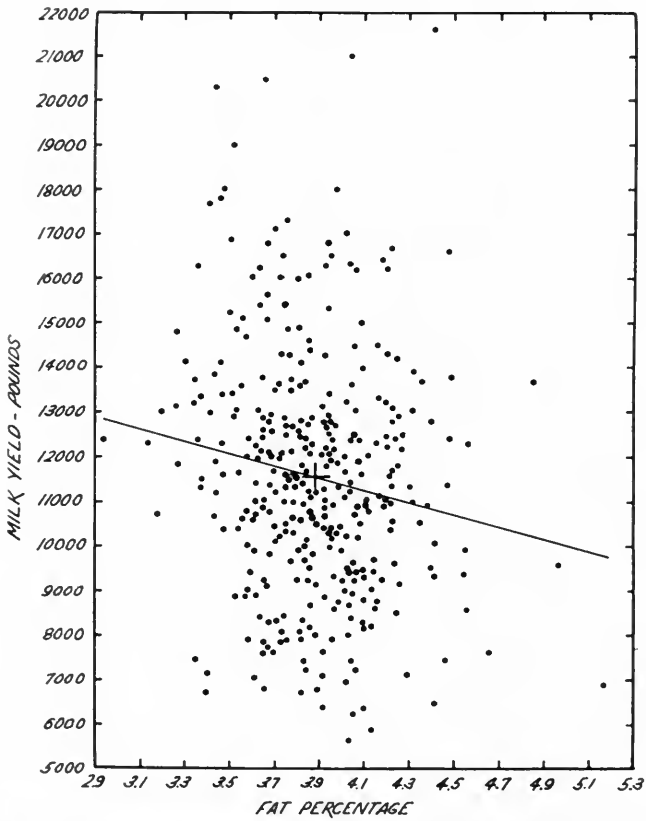

Fig. 4.—Fat percentage and milk yield for the 3x-SL-12 mo. group are shown here in the same way as those for the 2x-SL-12 mo. group are shown in Fig. 3. Coefficient of correlation is —.152.

symmetrical distribution of milk yield about its mean would probably result, with occasional records running down to 2,000 pounds or even less. In Fig. 4, on the other hand, the dots do not form a straight line across the bottom, indicating that the entrance requirement did not exclude any considerable number of records, probably either because of inherently higher-producing cows in the 3x group, or of more favorable environmental factors (such as feed supply), or of a combination of inherent and environmental factors.

Fat percentage and milk-energy yield. Milk-energy yield (FCM) can be estimated very accurately by the formula $FCM = .4M + 15F$, in which M is the actual milk yield in pounds, F is the actual milk-fat yield in pounds, and FCM is the estimated milk-energy yield in pounds of 4-percent milk. One hundred pounds of FCM is equal to about 34 therms (34,000 large calories) and contains about 3.4 pounds of protein regardless of the percent of fat in the original milk.

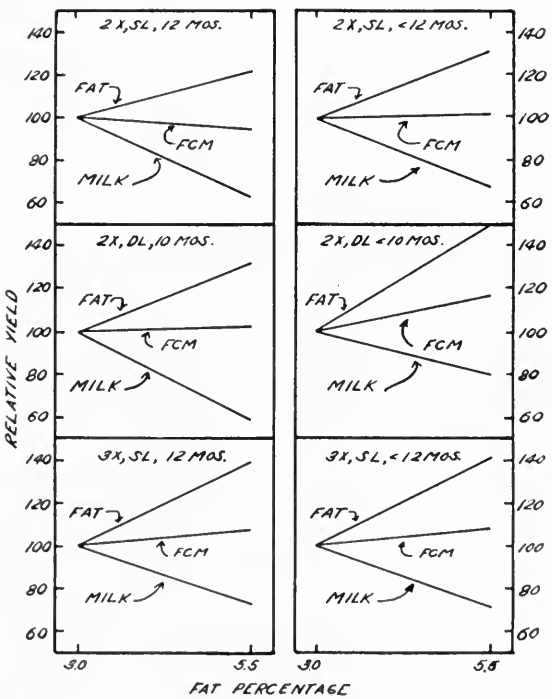

Fig. 5.—Regressions of milk yield, milk-fat yield, and FCM yield on fat percentage were about the same for all six groups. In each case the yield shown by the regression line at 3-percent fat is taken as 100.

TABLE 5.—MILK YIELD, FAT YIELD, AND MILK-ENERGY YIELD FOR DIFFERENT FAT-PERCENTAGE CLASSES

Fat percentage class[a]	Average milk yield for groups indicated						Average fat yield for groups indicated						Average FCM yield for groups indicated					
	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.
	lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
2.9	7 294	10 680	.....	.....	12 421	.....	214	318	...	...	364	...	6 128	9 042	.....	.....	10 428	.....
3.0	12 664	8 251	9 174	.....	.....	12 037	386	253	278	...	...	363	10 856	7 095	7 840	...	...	10 260
3.1	9 589	10 623	.....	7 429	11 495	15 650	301	337	...	233	364	500	8 351	9 304	.....	6 467	10 058	13 760
3.2	9 713	9 277	7 816	8 153	13 168	12 673	316	302	253	265	428	410	8 625	8 241	6 921	7 236	11 687	11 219
3.3	9 083	8 844	8 680	8 165	12 568	10 025	304	296	291	275	422	335	8 193	7 978	7 837	7 391	11 357	9 035
3.4	9 907	8 842	8 232	7 698	13 132	10 382	342	305	285	265	453	359	9 093	8 112	7 568	7 054	12 048	9 538
3.5	8 972	8 533	7 818	7 769	12 301	10 050	318	303	278	276	436	357	8 359	7 958	7 297	7 248	11 460	9 375
3.6	8 746	8 245	7 707	7 945	11 928	9 756	319	301	281	290	436	355	8 283	7 813	7 298	7 528	11 311	9 227
3.7	8 726	8 110	7 712	7 545	11 597	9 969	327	304	289	283	436	374	8 395	7 804	7 420	7 263	11 179	9 598
3.8	8 425	8 134	7 589	7 300	11 023	9 751	324	313	292	281	424	376	8 230	7 949	7 416	7 135	10 769	9 540
3.9	8 402	8 137	7 546	7 580	11 618	9 625	331	321	298	299	457	380	8 326	8 070	7 488	7 517	11 502	9 550
4.0	8 038	8 017	7 127	7 383	10 949	9 611	325	324	289	299	443	389	8 090	8 067	7 186	7 438	11 025	9 679
4.1	8 078	7 818	7 650	7 024	10 433	9 888	335	323	317	291	431	410	8 256	7 972	7 815	7 175	10 638	10 105
4.2	7 953	7 778	6 817	7 564	12 157	8 199	337	330	288	321	514	348	8 236	8 061	7 047	7 841	12 573	8 500
4.3	7 839	7 355	7 034	7 279	11 692	8 654	340	319	306	317	507	375	8 236	7 727	7 404	7 667	12 282	9 087
4.4	8 143	7 454	7 054	6 757	11 940	7 762	362	331	313	300	531	345	8 687	7 947	7 517	7 203	12 741	8 280
4.5	7 125	7 522	7 097	7 520	10 075	10 744	324	341	322	342	458	486	7 710	8 124	7 669	8 138	10 900	11 588
4.6	7 344	7 907	7 312	6 991	7 555	10 138	341	367	339	325	353	471	8 053	8 668	8 010	7 671	8 817	11 120
4.7	7 389	7 481	5 242	6 430	.....	16 120	350	355	248	305	...	770	8 206	8 317	5 817	7 147	...	17 998
4.8	7 936	7 668	7 072	7 462	13 677	.....	382	370	343	361	665	...	8 904	8 617	7 974	8 400	15 446	.....
4.9	7 717	6 687	.....	.....	9 559	9 998	382	330	...	...	474	492	8 817	7 625	.....	.....	10 934	11 379
5.0	10 010	6 674	.....	4 637	.....	.....	508	336	...	233	...	...	11 624	7 710	.....	5 350	.....	.....
5.1	4 644	.....	.....	6 478	6 874	.....	240	...	...	334	355	...	5 458	.....	.....	7 601	8 075	.....
5.2	7 697	5 574	.....	5 282	.....	.....	403	289	...	276	...	...	9 124	6 565	.....	6 253	.....	.....
5.3	9 670	10 969	.....	10 728	.....	.....	520	588	...	572	...	...	11 668	13 208	.....	12 871	.....	.....
5.4	3 891	.....	.....	.....	.....	.....	212	...	...	...	...	...	4 736	.....	.....	.....	.....	.....
5.5	8 661	.....	.....	.....	.....	.....	479	...	...	...	...	...	10 649	.....	.....	.....	.....	.....
5.6	.....	.....	.....	9 265	.....	.....	...	...	...	525	...	...	.....	.....	.....	11 581	.....	.....

[a]Lower class limit. The published records report fat percentages to the closest second decimal; hence the 2.9 class includes actual values from 2.895 up to but not including 2.995.

The correlation between fat percentage and FCM is negative for all the records considered together and for the 2x-SL-12 mo. group, while in all other groups it is positive (Table 4). In all cases the correlation is small, so that for all practical purposes fat percentage and FCM may be considered independent variables in these records.

Fat percentage and milk-fat yield. Coefficients of correlation between fat percentage and fat yield are positive for each group of records (Table 4), indicating that as fat percentage increases there is a tendency for milk-fat yield to increase.

Summary of fat-percentage correlations. A graphical summary of the relation between fat percentage and milk yield, fat yield, and FCM yield is given in Fig. 5. These regression lines, derived from the data of Tables 3 and 4, are plotted on a percentage basis for simplicity of comparison. In each case the yield at 3 percent fat is taken as 100, with the lines covering the range from 3 to 5.5 percent fat. These lines show the tendency of yield to change as fat percentage changes.

Each of the six groups presents about the same picture. When the 3-percent yield is taken as base, the 5.5-percent yield shows that milk yield decreased about 30 percent, milk-fat yield increased about 30 percent, and FCM yield stayed about the same.

These figures are quite consistent with those found in the records of other breeds. The general conclusion is well established that:

As fat percentage increases { milk yield decreases / fat yield increases / FCM yield is unaffected

Milk yield, fat yield, and FCM yield for the various fat-percentage classes and groups of records are given in Table 5.

AGE AT CALVING AND MILK YIELD

Revision of Age-Correction Factors for Milking Shorthorns

The "correction" of milk yield for age of cow is a practice of long standing and wide use. One of the purposes of this study was to determine the accuracy of the age-correction factors for Milking Shorthorns. To do this it was necessary to study the method by which the factors were arrived at and then to see whether that method would give the same answer when applied to the records reported here.

The average FCM yield by age groups for 4,216 records of Red Danish cows in Denmark is presented in Fig. 6 (these records are comparable to the records of Dairy Herd Improvement Associations).

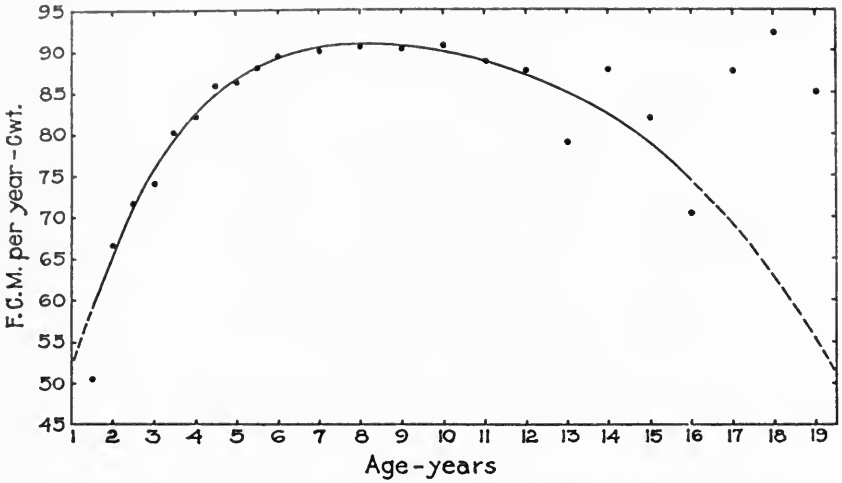

Fig. 6.—This curve shows the origin of the age-yield curve on which the correction factors on page 576 are based. The curve shown above is derived from 4,216 annual records of cows of the Red Danish breed in Denmark. The three points at the right represent a single cow and are omitted in fitting the equation.

They show the well-known tendency for milk yield to increase as a cow becomes older until it reaches a maximum when the cow is about 8 years old, and then to decrease. The records clearly indicate the increasing phase. That yield declines after a cow is 8 years old is not so well proved but is assumed to be true. The smooth curve of Fig. 6 represents an equation fitted to the observations and assumes that milk production does decline after a certain age. The highest point in this curve is at 9,056 pounds, which is termed the smoothed maximum yield with age for this population of cows and records. In Fig. 7 this smooth curve is reproduced on a percentage basis,[1] with the point of maximum FCM yield at 100. Records of six other breeds, including the first 1,014 R.M. records of the Milking Shorthorns, are superimposed on the graph to bring them together for easy comparison. In each case the smoothed maximum is taken as 100.

It is apparent from Fig. 7 that there are considerable differences

[1]The equation of this curve is $\log y = 2.02057 - .487e^{-.505t} - .00149e^{.263t}$. This means that there are two components to the age-yield relation: one of growth or increase, which decreases at the rate of 50.5 percent (the exponent .505) a year; the other of senescence or decrease, which increases at the rate of 26.3 percent (exponent .263) a year. This equation permits computation of the age-correction factors given on page 576.

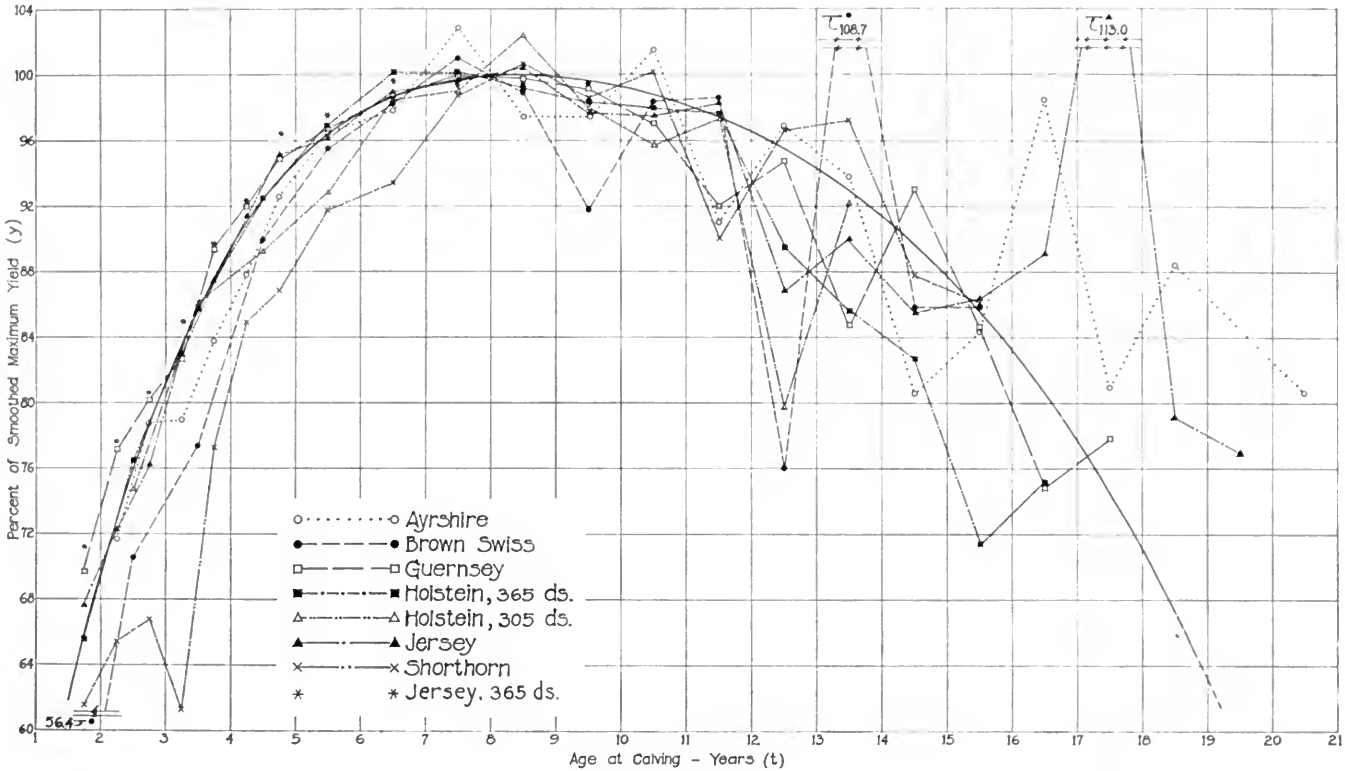

Fig. 7.—Relation of age at calving to yield in seven breeds (smoothed maximum yield equals 100). The smooth curve is reproduced from Fig. 6 after being adapted to the setup of Fig. 7. Note that the smooth curve needs to be shifted twelve months to the right to fit the data for the Milking Shorthorns, which are the first 1,014 R.M. records of the breed, or up to June 1, 1920. As shown in Fig. 8 the present records (1924-1938) indicate the shift should be only six months.

between the records for the various breeds, particularly with reference to the ascending part of the curve, but it is also apparent that the smooth curve will be fairly well adjusted for any one of the breeds when it is shifted either to left or to right, as the case requires. For the Guernsey breed it will fit the data when it is shifted two months to

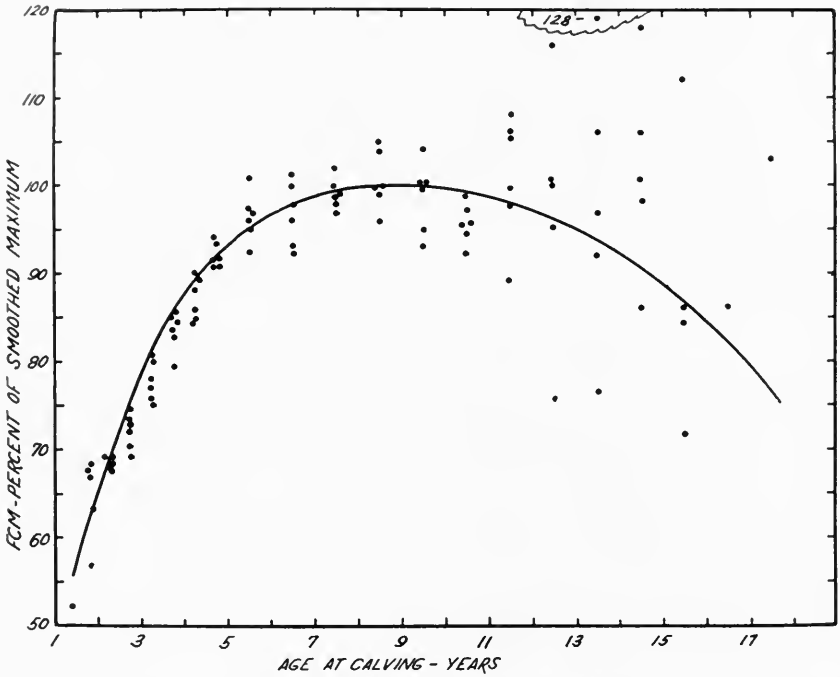

Fig. 8.—Relation of FCM yield to age at calving in Milking Shorthorn cows. Each of the six groups of records is plotted separately according to age at calving. The smooth curve is the same as that of Fig. 7, but is shifted six months to the right. As thus adjusted it forms the basis for the age-correction factors for Milking Shorthorns given on page 576.

the left; for the Jersey breed recent and trustworthy data indicate that the line needs to be shifted three months to the left. For the Milking Shorthorn breed, on the other hand, it needs to be shifted twelve months to the right.

This comparison says in effect that the Milking Shorthorn breed matures 15 months later in the function of lactation than the Jersey breed. That Milking Shorthorns should mature later than Jerseys seems consistent with general observation, but that the difference

should be 15 months seems extreme. The data in Fig. 8 show clearly that the first 1,014 R.M. records of the breed (up to June 1, 1920), which were used to make up Fig. 7, do not represent the present status of the breed as shown by the records from 1924 to 1938.

In making up Fig. 8 the first step was to arrive at the smoothed maximum FCM yield for each of the six groups. This was done by fitting the equation $FCM = a + b \times age + c \times age^2$ to the age classes and FCM yields at 5 years and up. The smoothed maximum FCM yield for each was as follows:

Group	*Age when maximum was reached* *years*	*Smoothed maximum FCM* *lb.*
2x-SL-12 mo.	10.62	10,228
2x-SL-<12 mo.	9.11	9,447
2x-DL-10 mo.	8.16	8,910
2x-DL-<10 mo.	7.06	8,708
3x-SL-12 mo.	9.86	13,161
3x-SL-<12 mo.	10.89	10,832

The exact age at which the maximum is attained by this method is of no particular importance, except for application in its equation to ascertain the smoothed maximum yield. The smoothed maximum yield determined by this method amounts to an age-corrected average.

The smooth curve in Fig. 8, which seems to fit the dots well, is that of Fig. 7 shifted six months to the right. This indicates that in recent years the breed has matured six months earlier in the milking function than formerly, since according to the earlier records this curve would need to have been shifted twelve months to the right. It seems unlikely that this earlier maturity represents a change in the inherent qualities of the breed; it is more likely that it is a result of change in management of the cows making R.M. records.

For a table of age-correction factors for Milking Shorthorns, as revised, see page 576.

Other Data on the Relation of Age to Yield

Various data in connection with the relation between age and yield are given in Table 6. Records for cows less than six years old at calving in the 2x-SL-12 mo. group are plotted in Fig. 9 according to age at calving and milk yield. The correlation was .610 (this correlation is higher than is usually found). For cows up to six years old milk yield was evidently more closely associated with age than with fat percentage, where the correlation was $-.224$.

Influence of age on yield is shown in greater detail in Fig. 10, where data for cows in the 2x-SL-12 mo. group five years old or younger at calving are classified by monthly age intervals. The 3x-SL-12 mo. records also shown in Fig. 10 are not numerous enough to be split into monthly age groups. Both of these curves show that in-

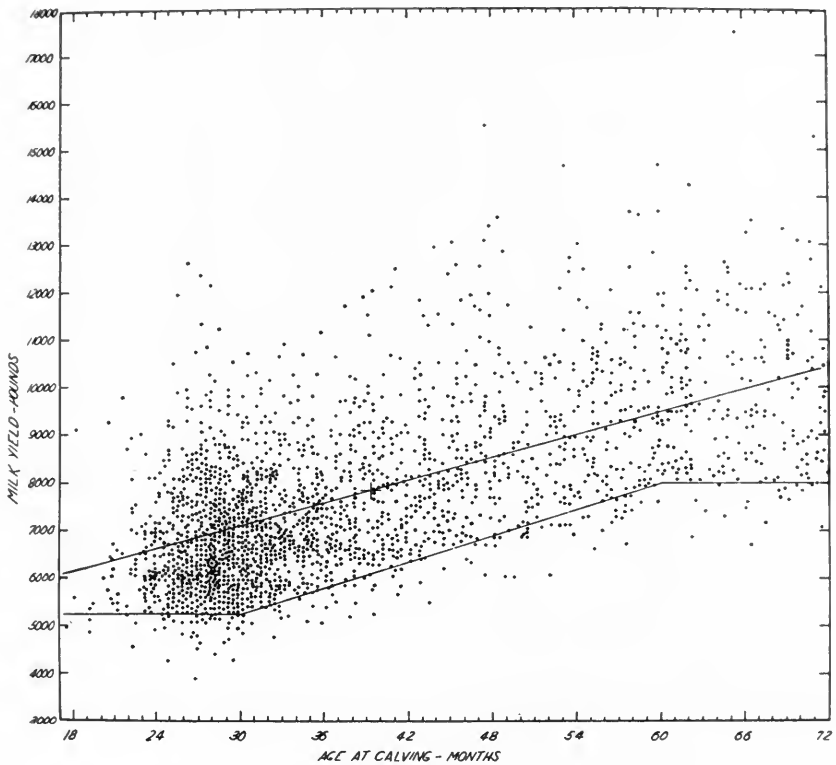

Fig. 9.—Age at calving and milk yield for each of the 2,039 cows under 6 years old in the 2x-SL-12 mo. group are indicated by a dot. The cross indicates the means, and the straight line passing thru it shows the regression of milk yield on age at calving. The coefficient of correlation is +.610. The lower line shows the entrance requirement for milk yield. Any dot below this line represents a record qualifying because of its milk-fat record.

TABLE 6.—EFFECT OF AGE OF COW ON FAT PERCENTAGE, MILK YIELD, FAT YIELD, AND FCM YIELD

Age	Group					
	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.
Frequency distribution by percent						
Jr. 1	.04	.....	.....	.....	.....	.....
Sr. 1	3.56	1.97	3.77	1.08	.29	.....
Jr. 2	21.24	17.18	20.83	15.15	13.33	9.47
Sr. 2	16.87	14.74	18.65	11.90	12.17	8.42
Jr. 3	9.83	8.92	10.12	13.42	6.38	8.42
Sr. 3	7.54	9.30	6.15	7.58	8.12	7.72
Jr. 4	5.38	6.06	5.16	8.01	6.09	6.67
Sr. 4	5.61	6.76	5.16	7.36	4.64	8.07
5	8.82	9.72	8.73	9.96	9.57	16.14
6	7.23	8.22	7.74	8.66	10.43	13.68
7	5.42	6.67	6.15	5.63	7.83	8.07
8	2.79	4.37	1.98	6.28	8.70	5.26
9	2.40	2.58	1.79	2.16	5.22	3.86
10	1.55	1.55	1.79	1.08	2.90	1.75
11	.66	.99	1.39	1.08	2.61	1.75
12	.54	.66	.40	.22	.58	.....
13	.19	.14	.20	.22	.58	.....
14	.15	.14	.....	.22	.29	.35
15	.08	.05	.....	.....	.29	.35
16	.08	.....	.....	.....	.....	.....
17	.04	.....	.....	.....	.....	.....
Average fat percentage						
Jr. 1	4.47	.....	.....	.....	.....	.....
Sr. 1	4.05	3.94	3.86	4.00	3.89	.....
Jr. 2	4.02	4.03	3.97	4.12	3.85	3.98
Sr. 2	3.98	3.97	4.00	4.06	3.87	3.98
Jr. 3	4.02	3.97	3.88	4.03	3.98	4.04
Sr. 3	3.97	3.96	3.91	4.01	3.90	3.91
Jr. 4	3.97	3.93	4.00	4.04	3.91	3.89
Sr. 4	3.94	3.93	3.92	4.07	3.97	4.00
5	3.95	3.95	3.96	4.04	3.87	3.91
6	3.94	3.91	3.99	4.00	3.87	3.91
7	3.88	3.94	3.79	4.02	3.81	3.90
8	3.95	3.93	4.06	3.97	3.85	3.85
9	3.88	3.93	4.15	3.96	3.88	3.78
10	3.87	3.90	4.01	4.17	3.84	3.89
11	3.87	3.85	4.00	3.81	3.73	3.91
12	3.81	3.82	3.98	3.40	4.59	.....
13	3.66	3.88	3.47	3.47	3.61	.....
14	3.76	3.32	.....	4.16	3.47	3.56
15	3.66	3.71	.....	.....	3.36	3.50
16	4.10	.....	.....	.....	.....	.....
17	4.17	.....	.....	.....	.....	.....

(*Table is continued on next page.*)

TABLE 6.—EFFECT OF AGE OF COW ON FAT PERCENTAGE, MILK YIELD, FAT YIELD, AND FCM YIELD (*Continued*)

Age	Group					
	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.
	Average pounds of milk					
Jr. 1	4 963	.....	.....	.....	.....	.....
Sr. 1	6 419	6 515	6 090	5 874	7 605	.....
Jr. 2	6 883	6 480	6 144	5 893	9 058	7 546
Sr. 2	7 154	6 858	6 492	5 966	9 995	7 983
Jr. 3	7 671	7 177	7 289	6 723	10 227	8 636
Sr. 3	8 586	8 036	7 462	7 424	10 549	9 264
Jr. 4	8 756	8 370	7 997	7 766	11 190	9 428
Sr. 4	9 391	8 963	8 438	7 868	12 073	9 937
5	9 927	9 216	9 039	8 407	12 391	10 472
6	10 094	9 202	8 906	8 816	12 482	10 133
7	10 207	9 720	8 935	8 667	13 322	10 980
8	10 153	9 545	9 288	8 721	14 015	10 683
9	10 437	9 515	8 090	8 831	12 760	11 648
10	10 295	9 147	8 651	8 049	12 845	10 146
11	11 085	9 466	9 644	7 983	13 680	11 644
12	10 575	9 703	10 373	7 244	11 454	.....
13	10 447	8 859	12 402	7 230	14 810	.....
14	10 662	10 352	.....	9 032	12 260	13 694
15	9 256	8 349	.....	.....	16 270	8 401
16	8 653	.....	.....	.....	.....	.....
17	10 273	.....	.....	.....	.....	.....
	Average pounds of fat					
Jr. 1	222	...	...	...	...	...
Sr. 1	260	257	235	235	296	...
Jr. 2	277	261	244	243	348	300
Sr. 2	285	272	260	242	387	318
Jr. 3	308	285	283	271	407	349
Sr. 3	341	318	292	298	411	362
Jr. 4	348	329	320	314	437	367
Sr. 4	370	352	331	320	479	397
5	392	364	358	340	479	409
6	398	360	355	353	483	396
7	396	383	339	348	508	428
8	401	375	377	346	540	411
9	405	374	336	350	495	440
10	398	357	347	336	493	395
11	429	364	386	304	510	455
12	403	371	413	246	526	...
13	382	344	430	251	535	...
14	401	344	...	376	426	488
15	339	310	...	...	546	294
16	355	...	...	...	...	...
17	428	...	...	...	...	...

(*Table is concluded on next page.*)

TABLE 6.—EFFECT OF AGE OF COW ON FAT PERCENTAGE, MILK YIELD, FAT YIELD, AND FCM YIELD (*Concluded*)

Age	Group					
	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.
	Average pounds of FCM					
Jr. 1	5 315	.....	.....	.....	.....	.....
Sr. 1	6 468	6 461	5 961	5 875	7 482	.....
Jr. 2	6 908	6 507	6 118	6 002	8 858	7 518
Sr. 2	7 137	6 833	6 497	6 016	9 803	7 963
Jr. 3	7 688	7 146	7 161	6 754	10 196	8 689
Sr. 3	8 549	7 984	7 365	7 440	10 385	9 136
Jr. 4	8 722	8 283	7 999	7 816	11 031	9 276
Sr. 4	9 306	8 865	8 340	7 947	12 014	9 930
5	9 851	9 146	8 986	8 463	12 141	10 324
6	10 008	9 081	8 887	8 821	12 238	9 993
7	10 023	9 633	8 659	8 687	12 949	10 812
8	10 076	9 443	9 370	8 678	13 706	10 438
9	10 250	9 416	8 276	8 782	12 529	11 259
10	10 088	9 014	8 665	8 260	12 533	9 983
11	10 869	9 246	9 648	7 753	13 122	11 483
12	10 275	9 446	10 344	6 588	12 472	.....
13	9 909	8 704	11 411	6 657	13 949	.....
14	10 280	9 301	.....	9 253	11 294	12 798
15	8 787	7 990	.....	.....	14 698	7 770
16	8 786	.....	.....	.....	.....	.....
17	10 529	.....	.....	.....	.....	.....
	Average FCM yield as percent of smoothed maximum					
Jr. 1	52.0	.....	.....	.....	.....	.....
Sr. 1	63.2	68.4	66.9	67.5	56.9	.....
Jr. 2	67.5	68.9	68.7	68.9	67.3	69.4
Sr. 2	69.8	72.2	72.9	69.1	74.5	73.5
Jr. 3	75.2	75.6	80.4	77.6	77.5	80.2
Sr. 3	83.6	84.5	82.7	85.4	78.9	84.8
Jr. 4	85.3	87.7	89.8	89.8	83.8	85.6
Sr. 4	91.0	93.8	93.6	91.3	91.3	91.7
5	96.3	96.8	100.9	97.2	92.3	95.3
6	97.9	96.1	99.7	101.3	93.0	92.3
7	98.0	102.0	97.2	99.8	98.4	99.8
8	98.5	100.0	105.2	99.7	104.1	96.4
9	100.2	99.7	92.9	100.9	95.2	103.9
10	98.6	95.4	97.3	94.9	95.2	92.2
11	106.3	97.9	108.3	89.0	99.7	106.0
12	100.5	100.0	116.1	75.7	94.8	.....
13	96.9	92.1	128.1	76.5	106.0	.....
14	100.5	98.5	.....	106.3	85.8	118.2
15	85.9	84.6	.....	.....	111.7	71.7
16	85.9	.....	.....	.....	.....	.....
17	102.9	.....	.....	.....	.....	.....

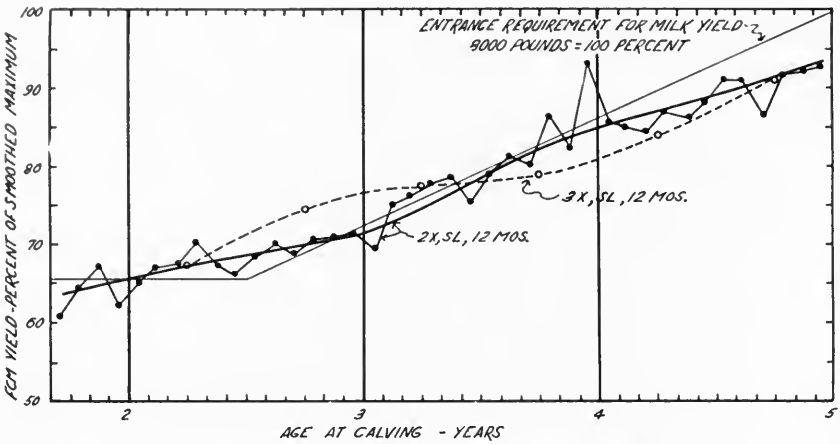

Fig. 10.—A detailed picture of the relation between age at calving and FCM yield shows that there are cycles in the age-yield curve. The smooth curves are freehand curves interpolated to show the trend.

crease in FCM yield occurs in cycles, altho the cycles in the 2x and 3x records do not coincide. For the 2x-SL-12 mo. group the age-yield curve is much steeper from three to four years than it is from two to three years.

Milk Yield Influenced More by Weight Than by Age

Altho the requirements for entry in the Record of Merit are based on yield as related to age and altho the use of age-correction factors is very common, it has been fairly well established that it is not the age but the size of the cow that affects her yield. Unfortunately in the records presented here and in many others like them, age is recorded but live weight is not, so that an age-correction system must be used.

Within certain limits size increases with age, so there is the problem of finding out how much of the cow's increasing yield is due to increased age and how much to increased weight. From records in which both age at calving and live weight within the first 31 days after calving are known, it has been found that age has no appreciable influence on yield independent of live weight, at least for cows up to 13 years old, but that live weight has substantially the same very marked effect on yield whether acting with age or independent of age. It seems evident that increased yield with age is due to the increase in live weight with age. It appears then that a system of milk-yield correction based on live weight of the cow as determined within 31

days after calving is biologically much sounder than the age-correction system.

According to the age-correction table, if a Milking Shorthorn calves at 2 years 4 months, the age-correction factor is 1.50. But it is obvious that a well-grown cow at that age will tend to have a better production record than is assumed by this age-correction factor, and an animal not so well grown will tend to have a lower record.

MONTH OF CALVING AND MILK-ENERGY YIELD

FCM yields classified according to month of calving show that in general August calvers have the lowest FCM yield and November calvers the highest (Table 7 and Fig. 11). Other data relating to month of year in which cows calved are also given in Table 7.

Figure 11 also brings out conspicuously the difference between

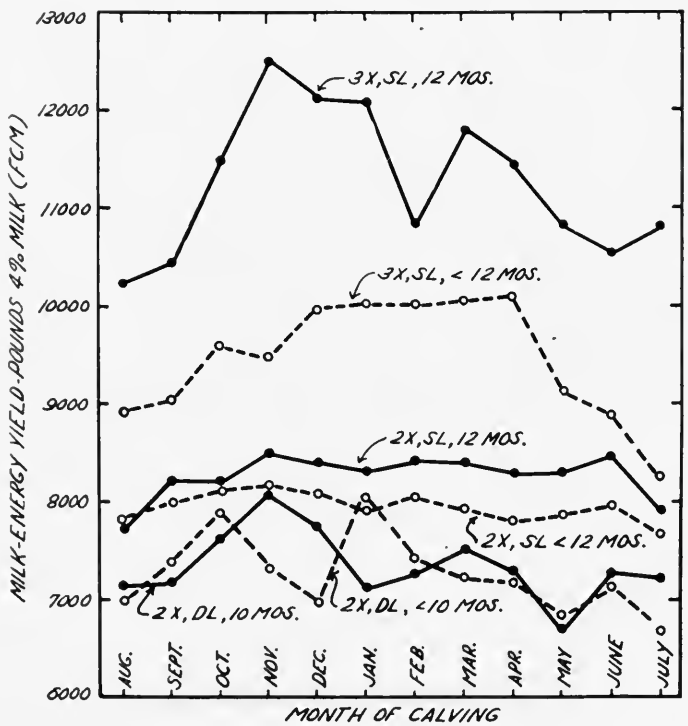

Fig. 11.—November calvers had the highest FCM yield and August calvers the lowest. Note also the superiority of the 3x records over 2x records.

TABLE 7.—EFFECT OF MONTH OF CALVING ON MILK YIELD, FAT YIELD, FCM YIELD, AND FAT PERCENTAGE

Month of calving	Group					
	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.
Frequency distribution by percent						
January	9.48	9.58	11.11	14.50	11.01	11.93
February	8.70	8.40	13.89	12.99	6.96	9.82
March	10.14	9.86	5.95	12.77	10.14	7.37
April	9.05	8.50	5.16	9.96	9.57	6.32
May	7.31	6.85	2.78	2.81	7.54	3.86
June	5.42	5.16	2.56	2.60	6.67	3.86
July	6.15	5.40	3.97	1.52	5.80	3.86
August	7.31	7.56	8.93	4.33	5.22	7.72
September	7.97	8.50	11.90	6.28	9.28	9.82
October	9.25	11.08	12.30	12.12	11.59	12.28
November	9.28	8.36	10.52	9.96	5.22	11.93
December	9.94	10.75	10.91	10.17	11.01	11.23
Average pounds of milk						
January	8 306	8 020	7 128	7 946	12 260	10 202
February	8 509	8 101	7 372	7 442	10 962	10 194
March	8 468	8 097	7 717	7 222	12 061	10 285
April	8 379	7 931	7 465	7 212	11 622	10 447
May	8 427	8 022	6 763	7 035	11 055	9 326
June	8 500	8 024	7 426	7 187	10 629	9 119
July	7 998	7 697	7 390	6 836	11 186	8 343
August	7 806	7 839	7 104	6 844	10 212	8 951
September	8 210	8 006	7 219	7 267	10 747	9 064
October	8 237	8 175	7 614	7 786	11 730	9 655
November	8 509	8 219	8 148	7 307	12 950	9 418
December	8 489	8 168	7 838	6 999	12 449	10 097
Average pounds of fat						
January	334	317	285	326	478	397
February	336	321	289	297	432	397
March	335	313	296	291	466	396
April	331	310	289	288	452	396
May	331	312	267	268	428	360
June	338	317	287	283	420	349
July	313	307	284	262	423	328
August	308	312	286	284	410	356
September	329	321	286	300	410	360
October	329	327	306	320	454	382
November	340	329	325	293	489	381
December	335	321	308	279	476	395
Average pounds of FCM						
January	8 332	7 963	7 126	8 068	12 074	10 036
February	8 444	8 055	7 284	7 432	10 865	10 033
March	8 412	7 934	7 527	7 254	11 814	10 054
April	8 317	7 822	7 321	7 205	11 429	10 119
May	8 336	7 889	6 710	6 834	10 842	9 130
June	8 470	7 965	7 275	7 120	10 552	8 883
July	7 894	7 684	7 216	6 664	10 819	8 257
August	7 742	7 816	7 132	6 998	10 235	8 920
September	8 219	8 017	7 178	7 407	10 449	9 026
October	8 230	8 175	7 636	7 914	11 502	9 592
November	8 504	8 223	8 134	7 318	12 515	9 482
December	8 421	8 082	7 755	6 985	12 120	9 964

(*Table is concluded on next page.*)

TABLE 7.—EFFECT OF MONTH OF CALVING ON MILK YIELD, FAT YIELD, FCM YIELD, AND FAT PERCENTAGE (*Concluded*)

Month of calving	Group					
	2x-SL-12 mo.	2x-SL-<12 mo.	2x-DL-10 mo.	2x-DL-<10 mo.	3x-SL-12 mo.	3x-SL-<12 mo.
	Average fat percentage					
January	4.02	3.95	4.00	4.10	3.90	3.89
February	3.95	3.96	3.93	4.00	3.94	3.90
March	3.96	3.87	3.84	4.03	3.86	3.85
April	3.95	3.91	3.86	4.00	3.89	3.79
May	3.93	3.89	3.95	3.81	3.87	3.86
June	3.98	3.95	3.86	3.94	3.95	3.83
July	3.92	3.98	3.85	3.84	3.79	3.92
August	3.95	3.98	4.02	4.14	4.01	3.97
September	4.00	4.01	3.96	4.13	3.82	3.97
October	4.00	4.00	4.02	4.11	3.87	3.96
November	4.00	4.00	3.99	4.01	3.78	4.04
December	3.94	3.93	3.93	3.99	3.82	3.91

2x and 3x records, showing to what an extent 3x records exceed 2x records. The difference between 12-mo. records and <12-mo. records is also quite evident.

FREQUENCY OF MILKING AND MILK-ENERGY YIELD

To see how Milking Shorthorn cows respond to the favorable conditions accompanying three and four milkings daily, the SL-12 mo. records were divided into groups of 2, 3, or 4 milkings and average actual FCM yield and smoothed maximum FCM yield determined. There were only six records in the 4x group (R.M. Nos. 4181, 4182, 5465, 8160, 8162, and 8164) and for these six records age-corrected FCM yield is used as the smoothed maximum. The average records were:

Group	*Actual FCM yield*	*Smoothed maximum FCM*
	lb.	*lb.*
2x-SL-12 mo.	8,334	10,228
3x-SL-12 mo.	11,576	13,161
4x-SL-12 mo.	15,834	17,815

Taking 100 as the base for the 2x group, the Milking Shorthorn records compare as follows with the standards of the Bureau of Dairy Industry and Holstein-Friesian Association of America:

Daily milkings	*Standard of Bureau of Dairy Industry*	*Standard of Holstein-Friesian Association*	*Milking Shorthorns*	
			Actual average	*Smoothed maximum*
2	100	100	100	100
3	124	125	139	129
4	154	150	190	174

These figures indicate that Milking Shorthorns respond to the more favorable conditions accompanying three and four milkings daily with greater yields than would be expected from the standards given. This is especially true for four milkings daily, but the number of such records is, of course, too small to prove this point.

SUMMARY

Because milk records for Milking Shorthorn cows had never been analyzed in the same way as those for other breeds, data from Volumes 9 to 23 (1924-1938) of the Milking Shorthorn Year Book were collected and studied. The records were studied as a whole and in groups according to number of milkings daily, length of calving interval, and length of record. Only records which included age of cow at calving, length of record, milk-fat yield, and fat percentage in addition to milk yield were studied. Milk-energy yield was computed by the formula FCM = .4 × pounds of milk + 15 × pounds of fat.

For the 6,311 records the average yield was 8,337 pounds of milk, 330 pounds of fat, and 8,285 pounds of FCM, and the average fat percentage was 3.97. The subgroups differed greatly in average milk yield, milk-fat yield, and FCM yield, but differed very little in average fat percentage. For the records as a whole, the correlation between fat percentage and milk yield was − .217; between fat percentage and fat yield, + .106; and between fat percentage and FCM yield, − .026 (not significant). Similar correlations were found in each of the subgroups. When the change in yield between 3.0 percent fat and 5.5 percent fat was expressed by a straight line, milk yield showed a decrease of about 30 percent, fat yield increased about 30 percent, and FCM showed very little change.

These records afforded an opportunity to check the age-correction factors previously used for Milking Shorthorns, which were based on records of the breed up to June 1, 1920. The records reported here show a distinct shift toward earlier maturity, amounting to 6 months; and the age-correction factors need to be adjusted accordingly. There is no way of knowing whether this earlier maturity represents a change in the dairy qualities of the breed or a change in management of the cows. Actually age correction is probably simply an indirect allowance for live weight since weight increases with age. A system

of milk-yield correction based on live weight would be biologically more sound than an age-correction system, at least for cows less than 13 years old.

The season in which a cow calved had an appreciable effect on FCM yield. In general August calvers had the lowest yield and November calvers had the highest.

Certain of the records were studied to discover the difference between FCM yields of cows milked three times a day and of cows milked twice a day. The records of a typical group showed that cows milked three times a day exceeded in yield those milked twice a day by 39 percent. The standard for dairy cows of the Bureau of Dairy Industry is that cows milked three times a day should outyield those milked twice a day by 24 percent, so it appears that Milking Shorthorns respond well to the more favorable conditions associated with three milkings daily.

TABLE OF AGE-CORRECTION FACTORS FOR MILKING SHORTHORNS

Find in the table the greatest age which is not greater than the age of the cow at calving. Opposite to this is the multiplier factor which can be used to determine the age-corrected yield of the animal.

Age	*Correction factor*	*Age*	*Correction factor*	*Age*	*Correction factor*
yr.mo.d.		*yr. mo. d.*		*yr. mo. d.*	
2-0- 6	1.61	2-10- 4	1.35	4- 9-26	1.09
2-0-15	1.60	2-10-19	1.34	4-11-19	1.08
2-0-24	1.59	2-11- 4	1.33	5- 1-21	1.07
2-1- 3	1.58	2-11-21	1.32	5- 4- 2	1.06
2-1-13	1.57	3- 0- 7	1.31	5- 6-18	1.05
2-1-23	1.56	3- 0-27	1.30	5- 9-18	1.04
2-2- 3	1.55	3- 1-16	1.29	6- 1- 2	1.03
2-2-13	1.54	3- 2- 5	1.28	6- 5-12	1.02
2-2-23	1.53	3- 2-25	1.27	6-11- 9	1.01
2-3- 3	1.52	3- 3-16	1.26	7- 9-15	1.00
2-3-13	1.51	3- 4- 7	1.25	10- 1-28	1.01
2-3-23	1.50	3- 4-28	1.24	11- 2- 8	1.02
2-4- 3	1.49	3- 5-20	1.23	11-10-17	1.03
2-4-13	1.48	3- 6-12	1.22	12- 5- 5	1.04
2-4-24	1.47	3- 7- 8	1.21	12-10-21	1.05
2-5- 5	1.46	3- 8- 6	1.20	13- 3-11	1.06
2-5-16	1.45	3- 9- 5	1.19	13- 7-21	1.07
2-5-28	1.44	3-10- 4	1.18	13-11-19	1.08
2-6-10	1.43	3-11- 3	1.17	14- 3- 0	1.09
2-6-24	1.42	4- 0- 2	1.16	14- 6-11	1.10
2-7- 8	1.41	4- 1- 5	1.15	14- 9- 7	1.11
2-7-22	1.40	4- 2-14	1.14	15- 0- 0	1.12
2-8- 6	1.39	4- 3-23	1.13	15- 2-16	1.13
2-8-21	1.38	4- 5- 3	1.12	15- 4-28	1.14
2-9- 5	1.37	4- 6-15	1.11	15- 7- 6	1.15
2-9-20	1.36	4- 8- 5	1.10		

This table may be used as it is for Brown Swiss cows. For Ayrshires it is necessary to increase the actual age at calving by 2 months, for Holsteins 6 months, for Guernseys 8 months, and for Jerseys 9 months. Thus a Milking Shorthorn or a Brown Swiss calving when 2 years, 2 months, and 3 days old would have an age-correction factor of 1.55. For an Ayrshire the factor would be 1.49, for a Holstein it would be 1.40, for a Guernsey 1.36, and for a Jersey 1.34.

The average of a large number of age-corrected yields, selected at random, may be expected to equal the average of a large number of actual yields of eight-year-old cows selected at random. The age-corrected yield of an individual cow, however, is not usually the expected yield of that cow when eight years old.

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