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The Inheritance of Body Weight in Relation to Milk Secretion

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The Inheritance of Body Weight in Relation to Milk Secretion

C. W. Turner

Abstract.—By converting fat production and body weight to their "mature equivalent" it is possible to study the progeny performance of Jersey sires in which both the yearly fat production and body weight of the daughters and their dams are considered. Comparison of the changes in body weight and yearly fat production between dams and daughters indicate that Jersey sires can cause significant changes in yearly fat production of their daughters as compared with their dams without causing a material increase or decrease in body weight. On the average, an increase of 100 pounds in body weight of the dams results in an increase of about 16 pounds in the body weight of the daughters. It was also determined that there was an increase of approximately 20 pounds in yearly fat production for each 100 pounds increase in body weight above 342 pounds body weight. Based on these observations, evidence was presented which indicates that the greater production of large cows at best only slightly exceeds the cost of obtaining the additional product. It is concluded that the sires whose daughters are above the average for the breed in fat production without exceeding the average in body weight are especially desirable because their daughters are increasing the economy of fat production of the breed.

I. The Inheritance of Body Weight in Jersey Register of Merit Cattle in Relation to Yearly Fat Production

The importance of yearly milk and fat production records in the selection and improvement of dairy cattle has long been recognized. The history of the Advanced Registry and Herd Improvement Associations is ample evidence that some type of testing system will have a permanent place in the progress of the dairy industry. One of the greatest faults of the testing of the past has been the limited number of cows which have been included. This fault is gradually becoming less with the adoption of cheaper methods of testing.

Records of production have several important uses. The immediate value is that it serves as a measure of the cow in culling out low producers. Many studies have been reported showing the relation between the average yearly production of cows and the profit over feed cost, which indicate that the low producer is always a liability. The elimination of low producing cows from the herd may be considered a *passive method* of herd improvement.

Records of production serve also as a *dynamic method* of herd improvement. Instead of passively eliminating low producing cows after they have been grown to a productive age, the records of production should serve as a guide in the selection of sires which have demonstrated their ability to produce daughters above the average for the breed. The continued use of the sire which has proved his ability to transmit high production to his daughters has no equal in herd improvement.

The earliest systematic study of the progeny performance of dairy cattle was begun by Pearl (1917-19) of the Maine Station and continued by Gowen and Covell (1921). Unfortunately they selected as a measure of the transmitting ability of the sire the difference in milk production of the dams and daughters. In many cases they even failed to report the actual mature equivalent production of the sire's daughters.

At the time two objections were raised by the writer to this method of indicating the transmitting ability of dairy sires. The first objection was the possibility of there being differences in the dam and daughter comparison depending on whether the sire was mated with high or low producing dams. It was believed that the measure of the transmitting ability of sires should be the same irrespective of the quality of dams to which they were mated. The second objection was the failure to present the actual average mature equivalent production of the daughters and the dams so that each sire's progeny performance could be compared with the average performance of all sires. Clearly, the sire's producing progeny above the average of the breed should be recognized.

In order to make available for breeders the progeny performance of dairy sires free of these objections Turner and Ragsdale (1923-24) at this Station began a series of studies of the official records of the various dairy breeds, and these studies have been continued up to the present time. (Turner 1925-1927, Gifford and Turner 1928, and Gifford 1930.)

The ultimate goal in this work was the determination of an index of the sires which would represent their potential transmitting ability. To do this it became necessary to determine the average influence of the dams upon the daughters' production. As a result of extensive comparisons of the production of dams and daughters it was found that the relationship as measured by correlation, partial correlation (the sires held constant), or regression equations was very low. So low in fact that considering the effect of environmental factors and other causes of variation in production records, *for all practical purposes the most satisfactory measure of the sire's transmitting ability was shown to be the average mature equivalent production of the progeny.*

To confirm these findings by other methods, the progeny of various sires were separated into two groups based on the production of the dams. Into one group the daughters of high producing dams were placed. Into the other group the daughters of the low producing dams were placed. The various indexes of sires which have been advanced were then applied to the two groups of dams and daughters of each sire. As the sire was the same for both groups, the best index of the sires would be the one which showed the smallest difference between the two groups. Thus if the two groups gave the same sire index, the evaluation of the influence of the dam would be perfect. The deviation between the two indexes would measure the relative value of the methods employed.

The deviation was found to be lowest when the following equation suggested by the writer was used:

Sire = Daughter's average — .15 Dam's average (Jersey breed). A slightly greater deviation was found when no index was used. The other indexes were shown to be decidedly inferior by this method of comparison.

Gowen (1930) has recently reported quite similar results in a study of Jersey sires. He compared the progeny performance of the sires entering the Register of Merit prior to 1923 with the daughters entering since that date. It was found that the correlation coefficient was 0.433 for milk yield when no sire index was used. The difference between the dams and daughters proposed by Pearl and extensively used by Gowen was shown to be practically worthless as the correlation was only 0.176 for milk yield. The other indexes were found to be less valuable than the actual mature equivalent production of the daughters.

These observations greatly simplify the proving of sires as it eliminates the necessity of excluding dams without production records, and thus not only hastens the proving of sires, but in the case of many sires which are mated with untested dams furnishes a test of progeny performance where dam and daughter comparisons were not possible.

The use of the term "proved sire" by McDowell and Parker (1926) to include only sires having five or more daughters whose yearly milk and butterfat records have been compared with the production records of their dams in studies of cow testing association records explains the reason why the number of proved sires in the entire country up to January 1, 1929 totaled only 700 (McDowell 1930). The number of proved sires would be much greater and they would become proved earlier if progeny performance alone was used as an index of future transmitting ability.

THE BODY WEIGHT OF DAIRY CATTLE

It is interesting to note that in all of the studies of the progeny performance of dairy cattle, nothing was said of the body weight of the cows considered. The reason for the lack of study in most breeds of dairy cattle may be explained by the lack of data on the body weight of the cows in the Advanced Registry. However, in the case of the Jersey Register of Merit either the actual or estimated body weight of all cows completing test were reported prior to 1921. These data are unique in furnishing a large number or records of yearly fat production and body weight.

It was believed that a study of these data would furnish interesting information on the mode of inheritance of body weight and its relation to yearly fat production.

The object of the present paper is to report the results of a study of the progeny performance of Jersey sires where both the yearly fat production and body weight of the daughters and their dams are considered.

As in previous studies, the fat production records made at various ages were converted to their mature equivalent by means of age conversion factors. It became necessary to convert the body weight of the cows to their mature body weight also. For this purpose the relation between the age and body weight of Jersey Register of Merit cows was used as a basis in computing the conversion factors. The reader is referred to section III where the weight conversion factors employed are presented.

COMPARISON OF JERSEY SIRES ON BASIS OF DAUGHTERS' BODY WEIGHT AND FAT PRODUCTION

All sires having 10 or more Register of Merit daughters were included in this study. However, only those sires having one or more dam and daughter pairs for both live weight and fat production are reported. As the report of the weight record was discontinued in 1921 only the older sires are included. Thus in many cases the number of dams and daughters compared will be less than the number of yearly record daughters. The more nearly the number of pairs of dams and daughters compares with the total number of daughters, the more satisfactory are the values for the given sire. Unfortunately, the number of pairs is far too small to be representative of the sire's progeny performance in many cases.

The results of this study are presented in Table I. It will be noted that the average body weight and yearly fat production of the daughters of each sire are included. The percentage frequency distribution of the average body weight of the progeny of the sires is presented in the form of a histogram in Figure 1. To compare with these data are presented the average body weight and yearly fat production of their dams. In the last two columns are found the increase or decrease in fat production and body weight of the daughters as compared with their dams.

The purpose of reporting the difference between the body weight and fat production of the dams and daughters was not to indicate the sires which had caused improvement in the daughters over their dams, but rather to determine if the increases and decreases in body weight and yearly fat production moved together. In other words, when the daughters of a sire increase in yearly fat production as compared with their dams, does the average body weight of the daughters also increase?

TABLE 1.—COMPARISON OF THE MATURE EQUIVALENT LIVE WEIGHT AND FAT PRODUCTION OF THE DAUGHTERS OF JERSEY SIRES AND THEIR DAMS

Name and Number of Sire	Year of Birth	Number of Yearly Record Daughters	Number of Dams and Daughters Compared	Daughters		Dams		Daughters exceed dams in	
				Average Mature Equivalent Fat Production (lbs.)	Average Mature Equivalent Live Weight (lbs.)	Average Mature Equivalent Fat Production (lbs.)	Average Mature Equivalent Live Weight (lbs.)	Average Fat Production(lbs.)	Average Live Weight (lbs.)
Adelaide's Sultan 123005	1912	14	10	627	1067	632	1035	—5	+32
Aldan's Noble 89581	1909	10	6	459	882	574	887	—115	—5
Altama Interest 98466	1910	20	14	501	975	524	951	—23	+24
Astor's Fairy Boy 113679	1913	15	1	550	987	563	950	—13	+37
Baronette's Golden Lad 67908	1904	13	2	524	921	444	928	+80	—7
Belvedere's Gamboge Majesty 97440	1909	13	2	443	999	459	990	—16	+9
Benedictine King 86100	1909	23	10	547	1075	469	978	+77	+98
Benedictine's Plymouth Lad 91106	1910	10	1	607	967	662	870	—55	+97
Bermuda's Eminent 93798	1910	14	5	431	787	398	862	+33	—75
Biltmore's Torment 60761	1900	12	4	440	856	473	906	—33	—50
Blossom's Foxhall 82038	1908	10	3	506	1045	477	832	+28	+214
Bluebell's Owl 79641	1906	14	5	436	830	444	912	—8	—82
Bonnetta's King 108980	1912	18	14	588	1075	587	1033	+2	+42
Brown Lassie's Compass 71626	1905	16	3	488	890	484	921	+4	—31
Buttercup's Golden Lad 124256	1913	10	6	540	947	558	905	—18	+43
Captain Hugo 22410	1905	11	2	506	909	440	972	+66	—63
Champion Torono's Son 104471	1910	16	10	623	833	653	852	—31	—19
Champion Torono's Son 11th 136233	1914	12	4	499	965	461	1005	+38	—40
Chief Engineer 47148	1898	11	5	598	972	532	929	+66	+43
Cicero of S. B. 97904	1911	19	10	535	1012	689	1023	—155	—11

TABLE 1.—COMPARISON OF THE MATURE EQUIVALENT LIVE WEIGHT AND FAT PRODUCTION OF THE DAUGHTERS OF JERSEY SIRES AND THEIR DAMS (continued)

Name and Number of Sire	Year of Birth	Number of Yearly Record Daughters	Number of Dams and Daughters Compared	Daughters: Average Mature Equivalent Fat Production (lbs.)	Daughters: Average Mature Equivalent Live Weight (lbs.)	Dams: Average Mature Equivalent Fat Production (lbs.)	Dams: Average Mature Equivalent Live Weight (lbs.)	Daughters exceed dams in: Average Fat Production (lbs.)	Daughters exceed dams in: Average Live Weight (lbs.)
Combination of St. Savior's 88245	1904	16	2	535	770	556	896	—20	—126
Count's Foxy Lad of Waikiki 142808	1915	14	1	386	1010	517	819	—132	+191
Derry's Golden Jolly 82807	1902	13	1	386	1129	376	1000	+11	+129
Diploma's Bijou Boy 86292	1908	10	3	481	922	463	877	+18	+45
Dolly's Champion Knight 119967	1913	28	15	582	889	527	913	+55	—25
Dulcet's Majesty 98230	1911	27	3	500	941	441	923	+60	+18
Ella's Majesty Oxford 99911	1911	13	1	789	1103	389	1013	+340	+91
Eminent 69631	1897	33	1	448	894	429	1013	+19	—119
Eminent 6th 75752	1906	16	3	484	927	457	943	+27	—17
Eminent 10th 75753	1906	13	12	397	900	451	897	—54	+3
Eminent 19th 78620	1907	26	5	642	790	409	872	+234	—82
Eminent's Pilot 75364	1905	22	8	595	962	491	934	+104	+28
Eminent of St. Martin 73207	1906	18	4	558	855	420	895	+137	—40
Eminent's Raleigh 69011	1901	27	2	555	949	509	901	+46	+48
Eminent's Sensational King 107123	1911	11	1	502	683	835	1004	—333	—321
Eurybia's Son 68790	1904	14	2	380	1069	455	999	—75	+70
Ev-Ken of Dover 112708	1913	12	6	500	762	509	873	—10	—110
Fairy Glen's Raleigh 79438	1906	35	17	569	963	504	935	+65	+28
Fairy's Noble Boy 93378	1910	10	1	508	950	558	800	—50	+150

Fancy's Red Flag 87222	1909	15	2	437	837	425	874	+12	—37
Fanny's Oxford Majesty 91781	1909	19	1	789	1108	551	1000	+238	+108
Favic's Prince 107961	1912	42	9	813	996	580	931	+232	+65
Fern's Lad of St. Martin 80126	1906	10	5	535	888	497	984	+38	—97
Fillmore's Foxglove 78878	1906	11	2	406	813	436	768	—29	+45
Financial Beauty's King 132904	1915	24	3	669	1030	680	968	—11	+62
Financial Countess Lad 86252	1908	27	3	587	1020	506	1001	+81	+19
Financial Fern Noble 113644	1912	21	3	614	896	559	1004	+55	—107
Financial King's Eminent 94592	1910	27	1	399	658	396	861	+3	—203
Financial King's Stockwell 106574	1911	20	9	617	906	602	943	+16	—37
Financial Raleigh 86298	1907	12	7	548	936	576	946	—28	—10
Financial Remus 104413	1910	13	3	489	963	514	1019	—25	—56
Flying Fox's Eminent 78568	1907	12	10	574	861	452	898	+123	—37
Flying Fox's Victor 64768	1902	21	4	524	920	552	921	—28	—1
Fontaine's Caiest 81118	1907	18	8	492	911	511	1012	—19	—101
Fontaine's Chieftain 97158	1907	32	13	610	956	468	922	+143	+34
Fontaine's Duke 61709	1901	11	6	555	1003	661	962	—107	+41
Fontaine's Gamboge Knight 96186	1910	15	4	506	880	471	865	+35	+15
Fontaine's King 65641	1903	11	1	557	1042	634	967	—76	+76
Fontaine's Lodestar 77305	1907	10	8	479	998	468	963	+11	+35
Fontaine's Raleigh 105374	1912	15	8	540	959	519	948	+21	+12
Forfarshire's King Dalton 95339	1908	13	6	604	822	533	1073	+71	—251
Foxhall's Champion 124108	1912	15	6	626	969	584	997	+42	—28
Foxhall's Fern Lad 99378	1910	10	2	573	906	451	939	+122	—33
Foxhall's Jubilee 76944	1905	25	14	557	982	519	987	+37	—6
Fox's Johnnie O'Dreamwold 68143	1903	13	2	409	850	423	823	—14	+28
Foxy's Brown Poet 82982	1907	16	9	473	904	467	950	+6	—46
Fussy's Fern Noble 129041	1913	10	3	488	893	530	777	—42	+116
Galway Fern Rioter 98284	1911	13	4	671	932	452	952	+219	—19
Gamboge Knight 95698	1903	52	4	552	960	506	922	+46	+38
Gamboge Knight's Fox 106160	1912	11	2	801	891	651	998	+151	—107
Gamboge Oxford Lad 62784	1903	25	6	536	947	497	914	+39	+32
Gamboge's Prince 105565	1911	27	1	393	999	474	1103	—81	—104
Gamboge's Vellum's Majesty 123063	1913	15	2	617	980	523	961	+94	+19
Gedney's Farm Girl's Oxford 75998	1907	39	25	599	955	587	972	+11	—17
Gedney Farm Napoleon Oxford 93795	1908	13	10	591	857	660	939	—68	—82
Gedney Farm Oxford Lad 71238	1900	24	1	528	891	608	905	—80	—14
Gertie's Son's Boy 71825	1905	12	2	545	881	585	956	—40	—75
Gertie's Son's Victor 123159	1912	23	4	504	835	471	989	+34	—155
Gertie's Stoke Pogis 56492	1899	15	4	602	871	569	909	+33	—38
Gertrude's Jap 93947	1908	16	9	567	993	556	913	+11	+80
G. G. Chief of Ashburn 86044	1909	17	8	560	956	459	815	+101	+140
Glory's Noble 90655	1909	22	3	483	904	487	922	—4	—18
Golden Cicero 80272	1907	15	3	495	882	606	987	—111	—105

TABLE 1.—COMPARISON OF THE MATURE EQUIVALENT LIVE WEIGHT AND FAT PRODUCTION OF THE DAUGHTERS OF JERSEY SIRES AND THEIR DAMS (continued)

Name and Number of Sire	Year of Birth	Number of Yearly Record Daughters	Number of Dams and Daughters Compared	Daughters: Average Mature Equivalent Fat Production (lbs.)	Daughters: Average Mature Equivalent Live Weight (lbs.)	Dams: Average Mature Equivalent Fat Production (lbs.)	Dams: Average Mature Equivalent Live Weight (lbs.)	Daughters exceed dams in: Average Fat Production (lbs.)	Daughters exceed dams in: Average Live Weight (lbs.)
Golden Fern of Alden 114321	1911	11	1	534	950	392	789	+142	+162
Golden Fern of Linden 84011	1907	14	4	562	886	432	994	+131	—108
Golden Fern's Noble Jr. 103786	1912	11	8	670	962	612	1010	+58	—48
Golden Fern's Son 78687	1906	25	15	554	955	523	899	+31	+57
Golden Fern's Militiaman 147510	1915	14	1	497	1069	577	1218	—80	—149
Golden Glow's Chief 61460	1901	40	16	615	1001	564	1001	+51	—1
Golden Jolly's Masterpiece 86295	1905	18	1	599	832	461	881	+139	—50
Golden Lad of Summit 85396	1909	15	13	554	953	514	980	+40	—27
Golden Lily's Majesty 119596	1912	12	3	485	893	548	926	—63	—33
Golden Lucy's Eminent Lad 85639	1909	11	10	582	1023	537	973	+45	+50
Golden Maid's Prince 94944	1910	10	3	626	948	488	921	+137	+27
Golden Maid's Viscount 113344	1911	11	1	404	933	396	911	+9	+22
Golden Spark of Montpelier 84576	1908	11	3	551	998	435	1006	+116	—9
Golden Shylock 81862	1907	13	6	511	1089	476	888	+35	+201
Golden Tycoon 104240	1911	30	4	582	839	501	901	+81	—62
Hawthorne's Prince 104887	1912	11	4	534	880	512	998	+22	—118
Hazel Fern Golden King 77872	1907	10	8	499	987	494	1073	+6	—86
Hebron Victor 80100	1905	17	2	506	813	448	878	+58	—66
Hector Marigold 59121	1900	34	5	473	980	534	1025	—61	—45
Hillside Torono 101729	1911	29	3	686	835	499	807	+187	+28
Holger 109744	1910	27	16	746	1008	548	987	+198	+21

Hood Farm Figgis Toronto 90517	1909	23	12	535	1072	485	942	+50	+130
Hood Farm Pogis 9th 55552	1898	79	39	560	864	482	877	+78	—13
Hood Farm's Golden Fern's Lad 80437	1907	16	10	527	793	565	862	—38	—70
Hood Farm Torono 60326	1900	72	40	691	852	544	897	+147	—45
Hood Farm Torono 11th 78757	1907	14	1	687	853	522	962	+165	—109
Hood Farm Torono 20th 82854	1906	21	20	589	815	611	824	—22	—10
Hood Farm Torono 21st 83413	1908	14	7	474	874	425	911	+49	—37
Ibsen's Glory 92986	1910	11	3	498	938	457	917	+41	+21
Idle Hour Blue Belle Prince 72292	1905	42	4	526	945	429	982	+97	—38
Illahee Stoke Pogis 97031	1910	10	4	495	1054	469	1004	+26	+50
Imported Combination's Premier 150715	1910	31	2	562	890	595	928	—33	—38
Imported Cowslip's Golden Noble 120789	1909	26	5	459	894	517	866	—57	+28
Imported Gamboge's Royal Majesty 149864	1909	17	5	533	920	611	896	—78	+25
Imported Golden Fern's Noble 145762	1909	65	6	508	981	561	872	—53	+11
Imported Golden Maid's Prince 93538	1900	42	1	408	911	380	840	+28	+71
Imported Hauteville Fairy Boy 90952	1909	27	6	466	911	476	933	—10	—22
Imp. King of Hambie 65298	1901	19	4	507	969	487	945	+20	+24
Imported Oxford Majesty 134090	1906	48	3	564	929	483	749	+80	+180
Imported Oxford You'll Do 111860	1906	83	69	552	974	449	927	+103	+47
Imported Ramsgate Champion 93534	1908	16	1	493	857	423	1002	+70	—145
Imported Stockwell 75264	1903	11	1	375	972	585	1000	—210	—28
Interested Prince 58224	1899	46	29	563	972	529	940	+34	+32
Interested Prince 2nd 95708	1910	31	20	583	1023	613	998	—30	+25
Interested Prince's Owl 98117	1911	30	6	496	922	479	958	+17	—36
Interested Veda s Prince 122951	1913	24	13	547	937	427	1039	+120	—102
Irene's King Pogis 73182	1905	62	30	510	1079	567	1050	—58	+29
Island Lodestar 67638	1904	11	7	455	851	538	917	—82	—66
Ixia's Noble Ra eigh 102596	1911	13	8	504	943	474	1000	+29	—57
Jacoba's Emanan 84177	1908	11	9	573	1071	623	1087	—50	—16
Jacoba's Premier 89296	1909	14	9	560	993	672	1051	—113	—59
Jap's Sayda's Baron 142559	1915	11	4	610	1072	473	905	+138	+167
Jessie's Fairy Lad 112740	1912	15	8	470	897	463	829	+7	+68
Jubilee Foxhall 82299	1908	10	1	395	1069	404	1013	—9	+57
Jubilee of Bois D'Arc 29041	1891	13	4	478	1014	527	964	—49	+51
Karnak's Jap 84363	1908	11	1	557	967	490	1075	+67	—108
Karnak's Noble 87952	1908	28	20	524	944	545	951	—21	—7
Keepsake's Golden Lad 71325	1904	14	12	547	1030	464	1061	+82	—31
King Melia Ann of Albany 96033	1909	17	8	501	916	504	991	—2	—75
King Sappho King 65262	1902	25	2	454	991	421	1079	+33	—89
Lad's Pogis of Hickory Lawn 108050	1912	14	1	430	1038	452	1007	—23	+31
Lady Letty's Eminent 82309	1908	40	17	490	956	451	974	+39	—18
Lady Letty's Victor 65020	1902	41	20	595	977	543	940	+51	+37
Latoma's Golden Topper 84170	1908	10	1	571	1040	426	819	+146	+221
Le Cotil's Raleigh 120688	1912	14	5	439	986	513	1015	—75	—29
Leda's King 96707	1911	17	9	515	955	523	944	—8	+11
Le Gros 102789	1911	21	4	489	881	539	799	—50	+82
Leo of Smith Farm 80490	1907	11	1	616	882	486	972	+130	—90
Lime Ridge Lass 30th's Pogis 107192	1912	17	8	552	1061	525	924	+27	+137
Lookout Prince 115074	1913	27	3	424	812	433	918	—10	—106

TABLE 1—COMPARISON OF THE MATURE EQUIVALENT LIVE WEIGHT AND FAT PRODUCTION OF THE DAUGHTERS OF JERSEY SIRES AND THEIR DAMS (continued)

Name and Number of Sire	Year of Birth	Number of Yearly Record Daughters	Number of Dams and Daughters Compared	Daughters		Dams		Daughters exceed dams in	
				Average Mature Equivalent Fat Production (lbs.)	Average Mature Equivalent Live Weight (lbs.)	Average Mature Equivalent Fat Production (lbs.)	Average Mature Equivalent Live Weight (lbs.)	Average Fat Production (lbs.)	Average Live Weight (lbs.)
Lookout Torono 78593	1906	31	22	457	944	448	988	+9	—44
Loretta's King 65050	1902	59	19	544	1004	472	981	+72	+23
Loretta's D's Champion's Son 77002	1906	16	8	425	969	445	1014	—20	—45
Loretta's King of Friendship 76500	1906	10	2	507	908	510	1005	—3	—97
Lorna's Altana's Interest 108420	1912	14	5	613	1026	452	1015	+161	+11
Lou's Torono 106614	1912	15	6	631	938	613	956	+18	—18
Lucy's Prince P. S. 3939 H. C.		10	1	426	972	415	1000	+11	—28
Lucky Fern 126758	1914	13	1	457	910	492	1050	+35	—140
Mabel's Poet 65780	1899	15	5	542	936	464	901	+78	+35
Mabel's Poet's Sultan 77854	1907	10	1	666	832	510	907	+156	—75
Mabel's Raleigh 77913	1907	14	5	535	912	529	940	+6	—28
Mabel's Raleigh P. S. 3722 H. C.		17	3	571	966	474	922	+97	+43
Majestic Fern 84428	1908	27	9	541	906	530	1025	+11	—119
Majesty's Gamboge Lad 119409	1913	12	3	616	1005	492	976	+124	+29
Majesty's Intense 127191	1914	10	2	509	1040	408	995	+101	+45
Majesty's Oxford Fox 134214	1915	18	9	589	977	496	992	+93	—16

Majesty's Star 104594	1911	17	7	571	938	466	936	+105	+2
Majesty's Western King 113111	1909	16	3	543	894	479	870	+64	+24
Majesty's Wonder 90717	1909	15	4	468	1012	453	1015	+16	—4
Marigold's Exile King 63232	1901	14	10	513	963	524	914	—11	+50
Marigold's Jap 100085	1910	12	3	504	1021	385	1031	+119	—10
Marston's Interested Prince 71855	1905	11	10	574	986	506	952	+68	+34
Martha Bluebell's Odelio 102298	1910	17	7	524	1041	454	1010	+71	+32
Matilda's Interested Owl 121648	1913	13	1	733	910	538	1024	+196	—114
Maud's Melia Rioter 75751	1906	18	7	550	990	445	981	+105	+10
McKay's Lad 104234	1911	12	4	668	965	565	968	+103	—3
Meridale's Interested Duke 111310	1911	13	8	507	1027	442	922	+64	+106
Meridale Oxford Owl 118444	1913	13	6	654	969	740	959	—87	+10
Meridale Prince Darling 135643	1914	27	3	589	950	482	939	+107	+11
Meridale Sayda's Baron 132139	1914	11	1	738	1010	404	929	+334	+81
Merry Maiden Prince 71597	1905	17	4	440	951	487	1004	—47	—53
Minaret Exile 56933	1898	11	9	454	994	518	968	—65	+26
Mistletoe Pogis 75371	1906	10	3	510	1025	508	986	+1	+39
Model's Oxford Lad 66518	1903	11	6	465	924	540	960	—75	—36
Mona Rose's Glory 92531	1909	14	9	584	992	585	932	—1	+60
Mona's Eminent 84618	1908	13	1	413	814	378	937	+35	—122
Mona's Handsome Stockwell 90390	1909	14	7	494	869	604	969	—110	—100
Mon Plaisir's Majesty of F. 126484	1913	14	2	503	917	613	903	—110	+14
Morny Cannon's Bright Prince 107441	1910	12	7	431	942	472	1013	—41	—71
Morocco's Pioneer 105679	1911	31	8	746	986	624	1026	+121	—40
Mr. Inez Marigold Pedro 79701	1907	16	7	427	957	386	907	+41	+50
Naiad's Golden Lad 674775	1903	11	3	451	845	450	998	+1	—152
Nettina's Meridale Prince 114174	1912	19	7	510	848	484	816	+26	+31
Nobleman of St. Cloud 76091	1907	17	3	490	866	448	826	+42	+40
Noble of Oaklands 95700	1905	44	5	433	943	518	889	—85	+54
Noble Peer 90653	1909	10	4	660	1008	630	1004	+31	+4
Noble's Aristocratic Boy 101939	1911	21	3	543	900	573	932	—30	—32
Noble's Sensational Lad 118536	1913	20	4	623	1020	541	959	+82	+61
Noble's Fawn Prince 95705	1910	13	1	568	916	506	964	+61	—49
Noble's Jolly Sultan 97181	1907	27	2	395	846	521	907	—126	—61
Noble Oxford Sultan 106403	1911	17	3	448	809	446	859	+2	—50
Noble's Raleigh 82757	1908	15	4	601	1096	628	1108	—27	—12
Noble Sultan 106673	1911	13	2	427	956	415	1029	+12	—74
Oakwood D's Fox 126834	1913	24	6	522	815	422	910	+100	—95
Octavia's Duke 102270	1910	13	11	557	989	519	995	+39	—5
Oonan Count 57470	1899	19	8	467	973	442	974	+25	—1
Oonan's 23rd Grandson 74887	1906	14	6	528	937	633	1049	—105	—112
Ophelia's Challenger 120468	1913	15	9	623	935	516	971	+107	—36
Owl's Oxford Interest 121457	1913	18	1	477	950	500	950	—23	0
Owl of Belleview 106305	1911	17	7	490	1092	528	962	—38	+130
Oxford Daisy's Flying Fox 83284	1908	41	23	597	1005	626	985	—28	+20
Oxford Duke O'Dreamwold 126888	1913	13	5	506	956	439	1007	+66	—51
Oxford Handsome Prince 83338	1908	12	4	499	928	564	950	—65	—22
Oxford Lad's Progress 92916	1909	16	5	593	986	610	951	—17	+35
Oxford's Fairy Boy 92821	1910	11	5	615	996	658	1010	—43	—14
Oxford Victory 83122	1908	10	3	505	903	527	1040	—22	—137
Oxford You'll Do Junior 102269	1910	15	9	611	884	582	947	+29	—63

TABLE 1.—COMPARISON OF THE MATURE EQUIVALENT LIVE WEIGHT AND FAT PRODUCTION OF THE DAUGHTERS OF JERSEY SIRES AND THEIR DAMS (continued)

Name and Number of Sire	Year of Birth	Number of Yearly Record Daughters	Number of Dams and Daughters Compared	Daughters		Dams		Daughters exceed dams in	
				Average Mature Equivalent Fat Production (lbs.)	Average Mature Equivalent Live Weight (lbs.)	Average Mature Equivalent Fat Production (lbs.)	Average Mature Equivalent Live Weight (lbs.)	Average Fat Production (lbs.)	Average Live Weight (lbs.)
Plymouth's Hallowee'n Fox 102320	1911	16	7	489	969	513	1029	—24	—60
Pogis 75th of Hood Farm 94501	1909	20	10	621	866	576	875	+44	—9
Pogis 94th of Hood Farm 90492	1910	16	9	538	945	466	882	+72	+64
Pogis 95th of Hood Farm 92620	1909	26	10	656	965	637	956	+20	+8
Pogis 99th of Hood Farm 94502	1909	104	65	722	898	652	658	+71	+40
Pogis 99th of Hood Farm 7th 118462	1913	17	6	586	888	593	905	—8	—17
Pogis 99th of Hood Farm 21st 133582	1914	16	3	824	970	479	883	+346	+87
Pogis of Galiad 84397	1908	11	8	511	951	506	879	+5	+72
Poppy's St. Mawes 115434	1911	24	12	675	950	713	953	—38	—3
Premier of Fairview 116508	1912	14	3	484	980	478	821	+6	+159
Pretty Maid's Figgis Fox O'D 89351	1909	16	3	553	990	432	893	+122	+97
Pride's Olga 3d's King 83683	1908	17	6	608	1034	500	923	+108	+111
Pride's Olga Rosaire's Son 84768	1907	17	6	468	1020	444	915	+24	+105
Prince Jonquil 85334	1908	11	4	521	1047	512	983	+9	+64
Queen's Raleigh 88322	1909	34	17	603	959	490	935	+112	+24
Queen's Fairy Boy 108321	1912	13	2	602	971	524	979	+78	—8
Queen's St. L. Rioter Boy 138159	1914	12	3	461	792	544	975	—83	—183
Raleigh's Fairy Boy 83767	1905	54	19	573	960	542	912	+31	+47
Raleigh's Fairy Boy 4th 101482	1911	21	8	528	965	482	997	+46	—32
Raleigh's Fairy Boy 9th 113825	1913	15	3	726	909	795	1009	—69	—100

Raleigh's Noble 90478	1910	13	2	611	969	447	954	+164	+16
Raleigh's Plymouth Noble 104107	1911	11	1	537	891	527	786	+10	+105
Raleigh's Poet 102464	1911	10	4	599	1012	477	880	+122	+132
Raleigh's Torono 108456	1901	31	12	603	867	698	814	—96	+53
Rinda Lad of S. B. 89518	1909	48	19	685	949	580	950	+105	—1
Roiter Jersey Lad 58001	1898	24	9	549	953	477	1030	+71	—77
Robert You'll Do 120790	1911	13	3	592	935	492	947	+100	—13
Rockwood Laddie 82915	1908	13	4	540	861	574	957	—34	—96
Rosaire's Fern Lad 98590	1910	15	5	652	1041	479	1018	+173	+23
Rosaire's Olga Lad 87498	1909	51	30	679	953	659	963	+20	—10
Rose's King Banner 75839	1906	10	5	577	974	445	828	+132	+146
Royal Majesty 79313	1903	45	7	635	929	495	915	+140	+13
Royal Majesty of St. Cloud 89541	1909	83	24	584	912	479	864	+105	+48
Roycraft Eminent 103231	1911	24	3	598	742	479	849	+119	—108
Sayda's Heir 45360	1896	14	2	465	942	493	947	—29	—5
Sayda's Heir 3rd 74817	1902	62	32	579	967	519	936	+60	+30
Sayda's Oxford Owl 121234	1913	12	8	577	911	556	985	+21	—74
Sayda's King of Meridale 121724	1914	22	7	784	979	549	942	+235	+36
Sampson Exile 72702	1902	10	6	508	878	578	967	—69	—90
Sans Aloi 81012	1907	18	5	661	988	452	882	+209	—106
Scott's Champion 105387	1911	11	2	403	799	594	861	—191	—62
Sea Lad P. S. 4720 H. C.		10	3	533	939	541	840	—8	+99
Sensational Fern 75024	1906	24	5	560	933	569	919	—10	+14
Shannon Raleigh 105825	1911	16	3	712	937	696	898	+16	+39
Sibley's Choice 83040	1907	23	10	686	1012	574	980	+113	+33
Sibley's Interested Prince 108578	1911	16	9	641	1046	495	957	+146	+89
Silver Chimes of S. B. 96021	1910	41	14	685	968	591	945	+93	+24
Sir Oxford's Majesty 105869	1912	13	7	517	759	477	888	+41	—129
Sultan of Oaklands 78475	1904	22	3	511	892	435	845	+76	+47
Sultan of Rockland 121150	1913	19	10	618	948	645	1031	—27	—83
Susy's St. Mawes 135577	1915	10	4	790	940	783	896	+7	+44
The Imported Jap 75265	1904	49	37	609	1037	533	959	+76	+79
The Jap's Owl 138146	1914	11	4	665	1046	575	1038	+91	+8
The King of Cloverland 115137	1912	12	5	689	1109	726	1119	—37	—10
The Owl of Meridale 85853	1907	14	13	484	1021	554	975	—70	+46
The Owl's Double Grandson 80314	1907	10	6	630	962	629	937	+1	+25
The Owl's Oxford Prince 85699	1905	15	7	537	995	512	960	+25	+35
The Plymouth Lad 89792	1905	16	3	569	1021	495	941	+74	+80
The Warden 77015	1907	35	16	465	885	404	833	+61	+53
Toga's Noble Lord 96421	1910	13	7	480	942	522	956	—42	—14
Tom You'll Do 113062	1913	20	8	498	802	488	902	+10	—100
Torono Pogis 78657	1907	28	26	561	951	559	970	+2	—19
Topsy's Fontaine Prince 95704	1910	10	1	510	816	501	829	+9	—14
Tormentor of KawKawlin 42880	1894	16	3	503	971	504	989	—1	—18
Valentine's Ashburn Baronet 100044	1911	23	12	704	1014	485	912	+220	+103
Valentine's Count 69878	1904	17	14	424	916	431	983	—7	—67
Valentine's Oonan 58076	1899	20	10	478	990	490	900	—12	+90
Viola's Foxy Eminent 90972	1909	13	2	602	1010	522	901	+80	+109
Viola's Golden Jolly 79314	1904	16	5	498	950	511	939	—13	+11

TABLE 1.—COMPARISON OF THE MATURE EQUIVALENT LIVE WEIGHT AND FAT PRODUCTION OF THE DAUGHTERS OF JERSEY SIRES AND THEIR DAMS (continued)

Name and Number of Sire	Year of Birth	Number of Yearly Record Daughters	Number of Dams and Daughters Compared	Daughters		Dams		Daughters exceed dams in	
				Average Mature Equivalent Fat Production (lbs.)	Average Mature Equivalent Live Weight (lbs.)	Average Mature Equivalent Fat Production (lbs.)	Average Mature Equivalent Live Weight (lbs.)	Average Fat Production (lbs.)	Average Live Weight (lbs.)
Viola's Oxford Lad 89600	1910	14	6	587	968	473	918	+115	+50
Violet's Oakland Count 80974	1908	12	8	445	883	489	876	—43	+7
Village Knight 120791	1911	17	7	544	867	543	904	+1	—37
Sophie's 19th's Tormentor 113302	1913	76	24	734	884	642	858	+92	+26
Sophie's 19th's Tormentor 5th 144980	1916	20	1	700	1010	393	842	+307	+168
Sophie's Climax 139809	1915	16	1	694	1051	738	1129	—44	—77
Sophie's Emblem 135038	1915	19	7	627	1030	684	1083	—57	—53
Sophie's Gilsland Tormentor 123534	1914	14	1	572	987	550	950	+22	+37
Sophie's Premier 111613	1912	29	13	565	967	579	1037	—14	—70
Sophie's Torono 110518	1911	16	7	609	868	661	809	—51	+59
Spermfield Owl 57088	1899	48	27	592	980	534	948	+58	+32
Spermfield Owl 2d 93634	1909	27	20	648	1036	498	963	+150	+74
Spermfield's Prince Interest 95697	1910	49	17	696	997	536	907	+161	+91
Springvale Stoke Pogis 54779	1898	11	2	492	977	614	1020	—122	—43
St. Mawes 72053	1904	21	3	513	965	568	981	—54	—16
St. Mawes Golden Poppy 125510	1913	23	2	729	980	484	808	+245	+172
St. Mawes Lad 130501	1914	21	3	624	950	606	1039	+18	—88
St. Mawes Noble 132488	1914	15	3	667	980	504	897	+163	+84
St. Mawes of Ashburn 115996	1913	22	10	767	988	596	921	+171	+67
St. Lambert of Winona 79567	1907	12	3	504	842	516	904	—13	—62
St. Omers Torono 81219	1906	41	3	549	877	510	955	+39	—78
Stockwell's Fern Laddie 104236	1911	11	5	602	903	555	1047	+47	—144
Stockwell's Trinity Prince 79317	1906	17	2	498	822	478	791	+20	+31
Sultana's Golden Jolly 86180	1908	21	3	502	939	511	998	—9	—59
Sultana's Jersey Lad 55391	1899	16	4	551	948	510	1077	+41	—129
Sultana's Oxford Lad 76506	1907	10	4	480	899	484	915	—3	—16
Sultana's Virginia Lad 82703	1907	25	7	664	928	546	980	+118	—52
Winnie Pedro's King 72947	1905	12	7	571	1019	549	1066	+21	—48
Xenia's Sultan 224118	1918	12	1	596	1024	568	891	+27	+133
You'll Do Oxford 98772	1910	19	3	540	944	671	843	—131	+102

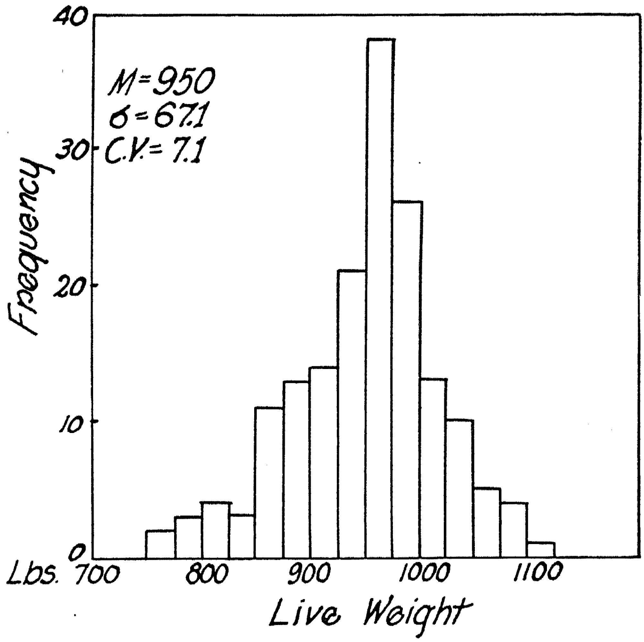

Fig. 1.—The frequency distribution of the average body weight of the progeny of Jersey sires.

In considering this problem only sires having not less than five dam and daughter pairs were included in the study. The sires which increased the production of their daughters over that of their dams were divided into groups depending on the amount of increase in fat production. Then the average change in body weight between dams and daughters was determined. For example, of the 24 sires whose daughters exceeded the fat production of their dams by 25 pounds or less, there were 9 whose daughters exceeded their dams in body weight and 15 whose daughters were less than their dams. The average body weight of the daughters of the 24 sires showed an actual decrease of 11.3 pounds as compared with their dams. The next group (from 25-50 pounds fat) also showed a slight decrease in body weight on the average. However, as the increase in fat production of the daughters over their dams becomes greater, there appears to be a tendncy for the body weight of daughters to exceed slightly the body weight of the dams. Of a total of 109 sires whose daughters' fat production averaged 72.1 pounds greater than that of their dams there was an average increase in body weight of the daughters of only 6.8 pounds compared to their dams. (See Table 2.) It would appear from these data that the Jersey sires whose daughters exceed the fat production of their dams have increased in yearly fat production for reasons other than a material increase in body weight.

TABLE 2.—RELATION OF INCREASE IN FAT PRODUCTION OF DAUGHTERS OVER DAMS TO CHANGE IN BODY WEIGHT
(Based on sires having 5 or more Dam and Daughter pairs)

Increase of Daughters in Fat Class Center	Change in Body Weight of Daughters Compared to Dams					
	Weight Increase		Weight Decrease		Net Change in Weight	
	Number of Sires	Average Weight Change	Number of Sires	Average Weight Change	Total Number of Sires	Average Weight Change
lbs.		*lbs.*		*lbs.*		*lbs.*
12.5	9	49.6	15	47.9	24	—11.3
37.5	10	67.2	15	48.5	25	—2.2
62.5	13	50.1	6	75.5	19	+10.4
87.5	5	52.4	3	20.0	8	+25.2
112.5	10	49.3	7	51.8	17	+7.6
137.5	4	70.5	1	45.0	5	+47.4
162.5	5	53.2	0	----	5	+53.2
187.5	1	21.0	0	----	1	+21.0
212.5	1	103.0	1	106.0	2	—1.5
237.5	2	50.5	1	82.0	3	+6.3
Total	60		49		109	
Average		+54.9		—52.2		+6.8

Average fat increase for weight increase =85 pounds.
Average fat increase for weight decrease =56.4 pounds.
Average fat increase for both =72.1 pounds.

A similar study was made of the sires whose daughters decreased in fat production when compared with their dams. Of a total of 60 sires, the daughters of 26 showed an average increase in body weight of 36 pounds, while 34 showed an average decrease of 48.9 pounds in body weight. The daughters of the entire group of sires decreased an average of 47.3 pounds in yearly fat production and a decrease of 12.1 pounds in body weight. Here again the change in body weight does not appear to have been a significant factor in causing the decrease in yearly fat production. (See Table 3.)

TABLE 3.—RELATION OF DECREASE IN FAT PRODUCTION OF DAUGHTERS OVER DAMS TO CHANGE IN BODY WEIGHT
(Based on sires having 5 or more Dam and Daughter pairs)

Increase of Daughters in Fat Class Center	Change in Body Weight of Daughters Compared to Dams					
	Weight Increase		Weight Decrease		Net Change in Weight	
	Number of Sires	Average Weight Change	Number of Sires	Average Weight Change	Total Number of Sires	Average Weight Change
lbs.		*lbs.*		*lbs.*		*lbs.*
12.5	10	37.0	12	55.5	22	—13.4
37.5	4	45.5	9	32.6	13	—8.6
62.5	7	28.8	5	57.2	12	—7.0
87.5	4	35.5	3	43.6	7	+1.5
112.5	1	41.0	4	69.0	5	—47.0
137.5						
162.5			1	11.0	1	—11.0
Total	26		34		60	
Average		36.0		48.9		—12.1

Average fat decrease for weight increase =44.8 pounds.
Average fat decrease for weight decrease =49.2 pounds.
Average fat decrease for both =47.3 pounds.

From these observations, the writer is believed to be justified in concluding that Jersey sires can cause significant changes in yearly fat production (either upward or downward) of their daughters as compared with their dams without causing a material increase or decrease in body weight. The importance of this observation will be further considered in a discussion of the efficiency of fat production in relation to body weight.

COMPARISON OF THE BODY WEIGHT OF DAMS AND DAUGHTERS

As indicated in the introductory review, extensive comparisons of the fat production of the dams and daughters of dairy sires have invariably shown a very low relationship. As a result of these findings, it was concluded that for all practical purposes the average mature equivalent fat production of the daughters is entirely satisfactory as a measure of the sire's transmitting ability.

Similarly, in a study of the inheritance of body weight, the relation of the dams' body weight to the daughters' body weight is of interest. Therefore, a study was planned with the object of obtaining data which would throw light on the relation between the body weight of the dams and daughters and indirectly the influence of the dams upon the average progeny performance of the sires.

As pointed out previously (Turner 1927), if a sire was bred to a large number of dams of varying productive abilities, the dam and daughter comparison would indicate the influence of the dams, as the sire would be the same in each case. Unfortunately such sires are not available. It is necessary, therefore, to study the entire population of dams and daughters. There are two alternatives in such an analysis.

First, it is possible to determine the relation between the body weight of the dams and daughters irrespective of the sire's influence. Second, the relation between the dams and daughters of sires whose progeny performance is similar. The latter plan would tend to hold constant the influence of the sires (as far as such is possible) and the relationship indicated by the comparison would more nearly represent the relation between the dam's body weight and their transmitting ability to their daughters. Both methods are presented in Tables 4 to 8, inclusive.

In Table 4 is presented a dam and daughter comparison which includes the daughters of all Jersey sires studied. The mean or average body weight of the daughters by dams of increasing body weight is shown. The regression slope determined by the method of least squares was found to be 0.276. (It is interesting to note that the regression slope for fat production was found to be 0.351).

TABLE 4.—RELATION BETWEEN THE DAMS' BODY WEIGHT AND THEIR DAUGHTERS' BODY WEIGHT

All Jersey Sires

Dam's Weight Mid-class Value	Number of Cows Included	Body Weight Calculated from Equation*	Daughter's Mean Body Weight	Standard Deviation	Coefficient of Variation
lbs.		*lbs.*	*lbs.* ±	*lbs.*	
675	7	877.7	896.5 ±14.96	58.70 ±10.58	6.55 ±1.18
725	46	891.5	895.7 ±10.85	109.05 ± 7.67	12.18 ± .87
775	103	905.3	909.5 ± 6.70	100.85 ± 4.74	11.09 ± .52
825	220	919.1	903.2 ± 4.86	106.75 ± 3.43	11.82 ± .38
875	299	932.9	939.1 ± 4.17	106.85 ± 2.95	11.38 ± .31
925	442	946.7	947.8 ± 3.24	100.85 ± 2.29	10.64 ± .24
975	473	960.5	955.9 ± 2.94	94.75 ± 2.08	9.91 ± .22
1025	355	974.3	969.8 ± 3.55	99.10 ± 2.51	10.22 ± .26
1075	159	988.1	997.0 ± 5.40	101.00 ± 3.82	10.13 ± .38
1125	75	1001.9	1015.0 ± 8.21	105.50 ± 5.81	10.39 ± .57
1175	35	1015.7	1003.6 ±10.82	95.00 ± 7.66	9.47 ± .76
1225	16	1029.5	996.9 ±23.27	138.00 ±16.45	13.84 ±1.68
1275	3	1043.3	975		
1325	4	1057.1	1237.5		
Total	2237				

*Equation fitted by the method of least squares $Wt._{dau.} = 691.4 + 0.276\ Wt._{dm.}$ where $Wt._{dau.}$ is the body weight of the daughters and $Wt._{dm.}$ is the body weight of the dams.

The criticisms of this method have been discussed in a previous publication (Turner 1927) to which the reader is referred. To meet these criticisms, the data were separated as shown in Tables 5 to 8 inclusive. The sires were grouped according to their progeny performance by 100-pound body weight classes beginning at 750 pounds. This grouping has the advantage of holding the influence of the sires fairly constant.

TABLE 5.—RELATION BETWEEN THE DAMS' BODY WEIGHT AND THEIR DAUGHTERS' BODY WEIGHT

Jersey sires whose daughters average over 1050 pounds in body weight

Dam's Weight Mid-class Value	Number of Cows Included	Body Weight Calculated from Equation*	Daughter's Mean Body Weight	Standard Deviation	Coefficient of Variation
lbs.		*lbs.*	*lbs.*	*lbs.*	
725	3	956.0	1025		
775	4	974.8	1050		
825	5	993.6	1075		
875	5	1012.4	1075		
925	21	1031.2	1048.85 ±14.82	100.70 ±10.48	9.60 ±.99
975	27	1050.0	1028.70 ±10.62	81.70 ± 7.49	7.94 ±.73
1025	22	1068.8	1077.25 ±14.12	98.20 ± 9.98	9.11 ±.93
1075	19	1087.6	1064.5 ±14.35	92.60 ±10.35	8.69 ±.95
1125	12	1106.4	1125.0 ±11.24	57.65 ± 7.95	5.12 ±.71
1175	6	1125.2	1083.3		
1225	3	1144.0	1141.6		
1275	1	1162.8	1125		
1325	3	1181.6	1258.3		
Total	131				

*Equation fitted by the method of least squares $Wt._{dau.} = 683.4 + 0.376\ Wt._{dm.}$ where $Wt._{dau.}$ is the body weight of the daughters and $Wt._{dm.}$ is the body weight of the dams.

TABLE 6.—RELATION BETWEEN THE DAMS' BODY WEIGHT AND THEIR DAUGHTERS' BODY WEIGHT

Jersey sires whose daughters average between 950 and 1049 pounds in body weight

Dam's Weight Mid-class Value	Number of Cows Included	Body Weight Calculated from Equation*	Daughter's Mean Body Weight	Standard Deviation	Coefficient of Variation
lbs.		*lbs.*	*lbs.*	*lbs.*	
725	9	964.8	991.65 ± 21.82	97.05 ± 15.43	9.78 ± 1.55
775	21	970.3	975.00 ± 14.53	98.70 ± 10.28	10.12 ± 1.05
825	77	975.8	963.30 ± 7.05	91.75 ± 4.98	9.52 ± .52
875	138	981.3	995.65 ± 4.85	84.40 ± 3.43	8.47 ± .34
925	240	986.8	983.95 ± 3.51	80.70 ± 2.48	8.20 ± .25
975	269	992.3	985.20 ± 3.30	80.30 ± 2.34	8.15 ± .24
1025	202	997.8	994.30 ± 3.87	81.50 ± 2.74	8.19 ± .27
1075	97	1003.3	1014.70 ± 5.88	85.85 ± 4.16	8.46 ± .41
1125	47	1008.8	1005.80 ± 10.28	104.40 ± 7.27	10.38 ± .72
1175	22	1014.3	1013.6 ± 10.83	75.30 ± 7.65	7.43 ± .76
1225	9	1019.8	1002.7		
Total	1131				

*Equation fitted by the method of least squares $Wt._{dau.} = 885.1 + 0.110\ Wt._{dm.}$ where $Wt._{dau.}$ is he body weight of the daughters and $Wt._{dm.}$ is the body weight of the dams.

TABLE 7.—RELATION BETWEEN THE DAMS' BODY WEIGHT AND THEIR DAUGHTERS' BODY WEIGHT

Jersey sires whose daughters average between 850 and 949 pounds in body weight

Dam's Weight Mid-class Value	Number of Cows Included	Body Weight Calculated from Equation*	Daughter's Mean Body Weight	Standard Deviation	Coefficient of Variation
lbs.		*lbs.*	*lbs.*	*lbs.*	
725	29	869.94	869.85 ± 11.45	91.3 ± 8.09	10.50 ± .93
775	69	879.58	888.05 ± 7.31	90.0 ± 5.17	10.13 ± .58
825	100	889.23	885.00 ± 6.01	89.1 ± 4.25	10.07 ± .48
875	127	898.88	904.55 ± 5.33	89.0 ± 3.77	9.84 ± .42
925	155	908.53	906.95 ± 4.50	83.05 ± 3.18	9.16 ± .35
975	160	918.18	909.10 ± 4.48	83.95 ± 3.17	9.23 ± .35
1025	123	927.83	923.35 ± 5.33	87.60 ± 3.77	9.49 ± .41
1075	39	937.48	926.30 ± 10.33	95.60 ± 7.31	10.33 ± .79
1125	17	947.13	966.20 ± 12.94	79.05 ± 9.15	8.18 ± .95
1175	7	956.78	903.60 ± 21.41	83.8 ± 15.13	9.27 ± 1.67
1225	4	966.43	975.00 ± 31.53	93.5 ± 22.29	9.59 ± 2.29
Total	830				

*Equation fitted by the method of least squares $Wt._{dau.} = 729.4 + 0.194\ Wt._{dm.}$ where $Wt._{dau.}$ is the body weight of the daughters and $Wt._{dm.}$ is the body weight of the dams.

TABLE 8.—RELATION BETWEEN THE DAMS' BODY WEIGHT AND THEIR DAUGHTERS BODY WEIGHT

Jersey sires whose daughters average between 750 and 849 pounds in body weight

Dam's Weight Mid-class Value	Number of Cows Included	Body Weight Calculated from Equation*	Daughter's Mean Body Weight	Standard Deviation	Coeefficient of Variation
lbs.		*lbs.*	*lbs.*	*lbs.*	
675	3	775.2	891.66		
725	5	782.5	795.00		
775	9	789.7	858.30		
825	38	796.9	806.60 ± 8.26	75.50 ± 5.85	9.36 ± .72
875	29	804.2	797.40 ± 7.83	62.45 ± 5.54	7.83 ± .69
925	28	811.5	796.40 ± 12.55	98.45 ± 8.88	12.36 ± 1.11
975	16	818.7	831.25 ± 12.58	74.65 ± 8.90	8.98 ± 1.07
1025	8	825.9	825.00		
1075	3	833.2	875.00		
1125	1	840.5	1025.00		
1175	0	847.7			
1225	1	854.9	725.00		
Total	141				

*Equation fitted by the method of least squares $Wt._{dau.} = 677.3 + 0.145\ Wt._{dm.}$ where $Wt._{dau.}$ is the body weight of the daughters and $Wt._{dm.}$ is the body weight of the dams.

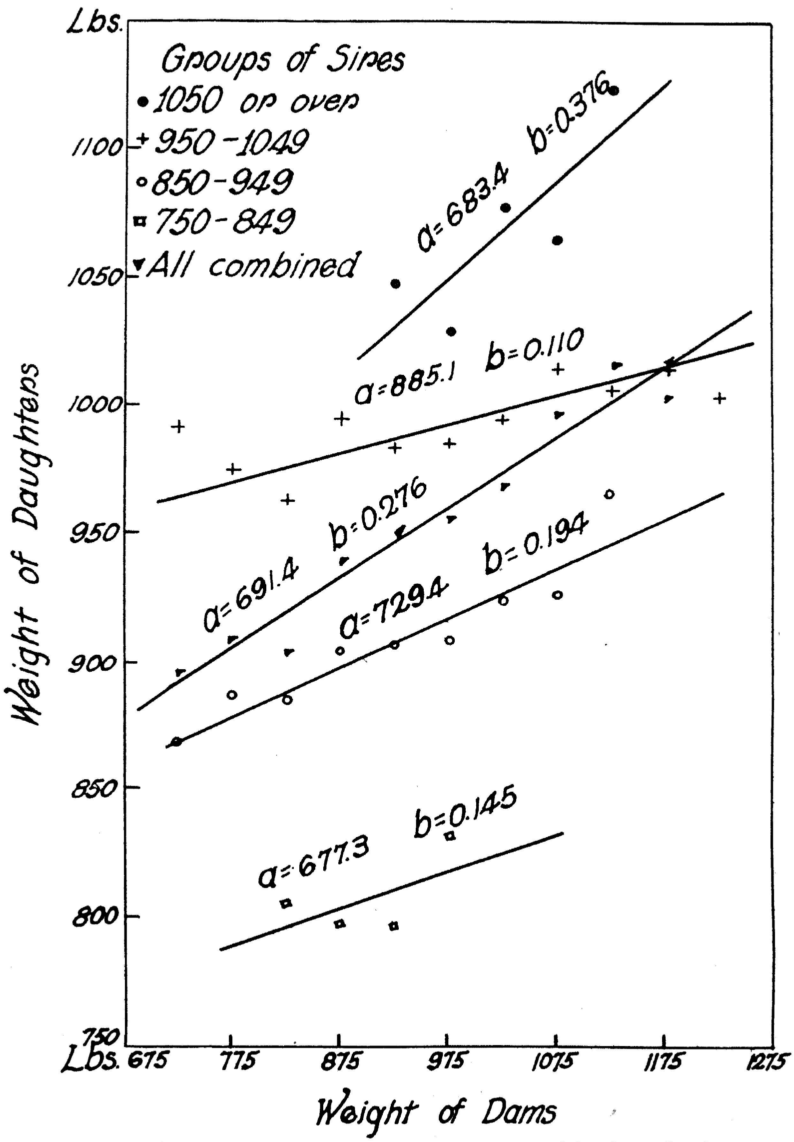

Fig. 2.—The relation between the body weight of the dams and daughters of various groups of sires is presented. The smooth lines passing through the observed values were fitted by the method of least squares to the equation $Wt._{dau.} = a + bWt._{dam}$ in which $Wt._{dau.}$ is the body weight of the daughters, $Wt._{dam}$ the body weight of the dams, a the sire's potential transmitting ability for body weight, and b the rate of increase in the body weight of the daughters. The values for a and b are placed on the figure. While there is some variability in the values of b, the weighted average is 0.159. In round numbers there is an increase of 15 to 20 pounds of body weight of the daughters for an increase of 100 pounds of body weight of the dams above the potential transmitting ability of the sire.

The data in Tables 4 to 8 are plotted in Figure 2. The smooth lines passing through the observed values were fitted by the method of least squares to the equation Wt. dau. = a + b wt. dam in which Wt. dau. is the body weight of the daughters, Wt. dam the body weight of the dams, *a* the sire's potential transmitting ability for body weight, and *b* the rate of increase in the body weight of the daughters. The values for a and b are placed on the figure.

TABLE 9.—REGRESSION EQUATIONS OF DAUGHTERS' BODY WEIGHT ON THE DAMS' BODY WEIGHT

Sire's Progeny Ave. Live Weight	Regression Equation		Dam and Daughter Pairs Included
	a	b	
1050 or over	683.4	0.376	131
950-1049	885.1	0.110	1131
850- 949	729.4	0.194	830
750- 849	677.3	0.145	141
All combined	691.4	0.276	2237

The equations for each group of sires are presented in Table 9. With the exception of the first group of sires, the values of b are quite similar. The weighted average of the b's was found to be 0.159. This means that there is an increase of about 16 pounds of body weight of the daughters for an increase of 100 pounds of body weight of the dams above the potential transmitting ability of the sires. (The corresponding weighted average of the b's for fat production for Jerseys was 0.135.)

From a consideration of these data, it appears that the inheritance of body weight of Jersey cattle follows much the same plan as the inheritance of yearly fat production. Because the relationship of the body weight of the dams and daughters as measured by regression equations is low, the conclusion is reached that the most satisfactory measure of the sire's potential transmitting ability for body weight is the average mature equivalent body weight of the daughters.

II. The Relation Between Body Weight and Fat Production

The earliest study of the relation between body weight and milk and fat production appears to be the work of Woll (1900) who compared the weight and production records of 183 cows reported by the Agricultural Experiment Stations of the United States. The entire group was divided into three weight classes, light, medium, and heavy. The results of this tabulation are shown below:

Weight Class	Average Weight	Yearly Production Milk	Yearly Production Fat	Fat
		lbs.	lbs.	%
Light	858	5860	270.2	4.61
Medium	985	6570	287.1	4.37
Heavy	1096	6449	279.0	4.32

These data were also classified by breeds with approximately the same trend; namely, the light cows produced less milk and fat than the medium or heavy cows. Between the medium-sized and heavy cows there appeared little difference. In the light of more recent work it might be noted that the factor of age appears to be entirely neglected. It would be expected that the younger cows would be lighter and lower producers.

Woll (1912) again made a study of the relation between body weight and production in connection with the analysis of the records of the Wisconsin Dairy Cow Competition 1909-1911. In this study the cows were placed in groups of 30 cows each in order of decreasing production of butterfat. The average weight of cows in each group was then determined. In general the body weight declined in the same order as the butterfat. However, this method of determining the effect of body weight is not very satisfactory. This is especially true due to the fact that the age effect again was not considered.

Nevens (1919) reclassified the records published by Woll (1912) on a weight basis. Each breed was studied separately. It was found that as the weight increased the yearly milk and butterfat production increased also. He concluded that the maintenance requirements of cows is directly proportionate to body surface and not to weight. The larger cows thus have a slight advantage in amount of feed required per 100 pounds of live weight. Large cows eat and produce more than small cows and are more efficient producers. The age of the cows was not considered. As both weight and fat production increase with age, the tabulation does not show the effect of weight alone on production.

Recently Gowen (1925) made a study of 339 Holstein 7-day fat records where certain body measurements and live weights of the cows were also available. Due to the fact that body dimensions, body weight, and fat production increase with age, and the age factor was not considered, the study does not indicate the true relation between body weight and fat production.

Turner, Ragsdale, and Brody (1924) made a study of the Register of Merit records where the weight records were available comparing the body weight and yearly fat production of these cows. It was found when all records were grouped together that after the Jersey cow reached the body weight of 470 pounds, there was an increase of 104 pounds in fat production per year for an increase of 100 pounds of body weight with age.

However, when the age was made constant instead of an increase of 104 pounds of fat for an increase of 100 pounds of body weight, there was an increase of about 20 pounds of fat for each 100 pounds of body weight. It was concluded that an increase of body weight contributes about 20 per cent to the total increased fat yield with age, while the other 80 per cent of increased fat yield with age is due to other factors accompanying increased maturity.

In a study of Guernsey Advanced Register records where body weight was available (2700 records), Turner (1929) confirmed the above conclusions. It was found in the case of the Guernseys under consideration that for an increase of 100 pounds in live weight accompanying age there was an increase of 77 pounds of fat per year. However, when age was held constant there was an increase of only 20 pounds of fat for an increase of 100 pounds in weight. It was concluded that about 25 per cent of the total increase of fat secretion with age was due to the live weight of the animals concerned, whereas the other 75 per cent of the increase in fat secretion with age would be ascribed to the development of the udder by recurring pregnancies.

From a study of cow testing association records McDowell (1929) concluded that the big cows win on the average in production of milk and butterfat and in income over cost of feed per cow. From the data presented by McDowell, the writer has computed the average increase in yearly fat production to be 14 pounds for each 100 pounds increase in body weight. While McDowell does not mention the factor of age in this paper, he has informed the writer that only mature cows were included, thus eliminating the factor of age.

Considering the lower average fat production of cows in cow testing associations as compared with officially tested cattle, the difference between 14 and 20 pounds of fat for each 100 pounds increase in body weight is as close as could be expected.

Table 1.—Relation Between Weight and Fat Production of Jersey Register of Merit Cows
(Mature Equivalent)

Yearly Fat Production	Body Weight (pounds)																	
	Under 600	600 649	650 699	700 749	750 799	800 849	850 899	900 949	950 999	1000 1049	1050 1099	1100 1149	1150 1199	1200 1249	1250 1299	1300 1349	1350 1399	1400 up	Total
lbs.																			
Under 400	1	2	8	23	31	96	110	101	110	79	24	10	6	1			1		603
400- 424	2		5	18	50	85	123	120	126	91	28	11	3		2				664
425- 449	1		6	27	49	94	120	131	133	88	35	29	16	3					732
450- 474	2		6	17	46	80	113	170	179	111	49	29	4	5					811
475- 499			5	34	51	94	133	113	154	91	56	16	6	5					758
500- 524			2	15	49	90	110	141	170	88	71	8	6	4	1	1			756
525- 549		1	1	11	22	71	111	136	177	93	43	13	10	3					692
550- 574			5	10	33	48	71	99	141	102	51	10	5	5	1		1	1	583
575- 599	1		1	18	20	51	74	66	96	80	42	13	9	4	2			1	478
600- 624			3	11	19	38	48	70	99	66	43	12	4	1	3			3	420
625- 649				4	28	32	20	61	74	57	35	13	11	4			1		340
650- 674				6	18	23	45	28	79	52	37	15	13	1					317
675- 699				5	3	19	30	31	49	37	30	17	12	4					237
700- 724			1	1	10	17	22	27	55	47	46	14	1	2		1			244
725- 749					2	5	27	24	43	33	25	7	4						170
750- 774					2	8	19	14	31	18	19	7	1	1	2				122
775- 799				2	5	8	10	13	27	29	12	15	4		1				126
800- 824				1	1	9	14	7	18	24	7	8	3	1		1			94
825- 849				1		2	10	3	13	11	7	8	2	2	1				60
850- 874					1	3	9	9	8	12	4	3	4	1					51
876- 899				2	1	3	4	5	10	8	17	10	1						61
900- 924						4		2	2	8	2		1	1	1				21
925- 949				1		2	2	1	7	4	13	2			1				33
950- 974								8	6	5	6	2	2	1					30
975- 999							1	1	2	4	5	1	1						15
1000-1024								1	2	1		2							6
1025-1049									2	2	2				1				7
1050-1074									2										2
1075-1099												1							1
1100-up						1		1			2		1		1				6
Total	7	3	43	207	441	883	1226	1383	1815	1241	711	276	130	49	17	3	3	5	8443

r = 0.1137 ± .006

BODY WEIGHT AND FAT PRODUCTION

In the previous studies of the relation between body weight and yearly fat production, it was pointed out that the effect of age on these two variables was either entirely ignored or was eliminated by determining the relation between the two variables, holding the age constant.

In connection with the present study, a large number of records were available in which both body weight and yearly fat production had been converted to their mature equivalent. As the conversion to maturity eliminated the age factor, the entire population could now be grouped together to determine the relation between body weight and yearly fat production.

The correlation surface is presented in Table 1. It will be noted that the minimum entrance requirements severely limits the population of the lower producing cows. For this reason the coefficient of correlation is not entirely satisfactory. The coefficient of correlation between mature body weight and yearly fat production was found to equal + 0.1137± 0.006. This is a rather low but distinctly significant value.

These data may also be studied by determining the increase in yearly fat production for each increment in average body weight. These results are shown in Table 2 and Figure 1. For each 100 pounds increase in body weight above 342.3 pounds it was found there was an increase of approximately 22 pounds in yearly fat production. These results are in complete agreement with the preceding study.

TABLE 2.—RELATION BETWEEN WEIGHT AND FAT PRODUCTION OF JERSEY COWS (Both body weight and fat production converted to the mature equivalent)

Body Weight Mid-class Values	Number of Cows Included	Yearly Fat Production Calculated from Equation*	Mean Fat Production	Standard Deviation	Coefficient of Variation
lbs.		*lbs.*	*lbs.*	*lbs.*	
675	43	490.8	477.0± 7.99	77.75± 5.65	16.30±1.216
725	207	501.8	510.8± 4.82	102.75± 3.41	20.11± .693
775	441	512.8	516.0± 3.09	96.17± 2.18	18.64± .438
825	883	523.8	519.2± 2.50	110.10± 1.77	21.20± .355
875	1226	534.8	527.6± 2.19	113.72± 1.55	21.55± .306
925	1383	545.8	529.9± 2.03	112.07± 1.44	21.15± .283
975	1815	556.8	552.0± 1.91	120.87± 1.35	21.89± .256
1025	1241	567.8	565.6± 2.53	131.92± 1.79	23.32± .332
1075	711	578.8	600.5± 3.58	141.62± 2.53	23.58± .444
1125	276	589.8	636.5± 6.59	162.25± 4.66	25.49± .777
1175	130	600.8	608.8± 8.68	146.82± 6.14	24.11±1.064
1225	49	611.8	597.2±12.90	133.92± 9.12	22.42±1.602
1275	17	622.8	583.1±32.41	197.95±22.91	33.95±4.357
Total	8422				

*Equation fitted by the method of least squares F=342.3+0.216W, where F is the yearly fat production (pounds) and W is body weight at the close of the lactation.
Mean fat =547.087 ±.0367
S. D. =124.873 ±.0259
C. V. =22.825

To compare with these data, the cows were grouped into classes according to fat production and the body weight determined. It will be recalled that this was the method used by Woll. The results are

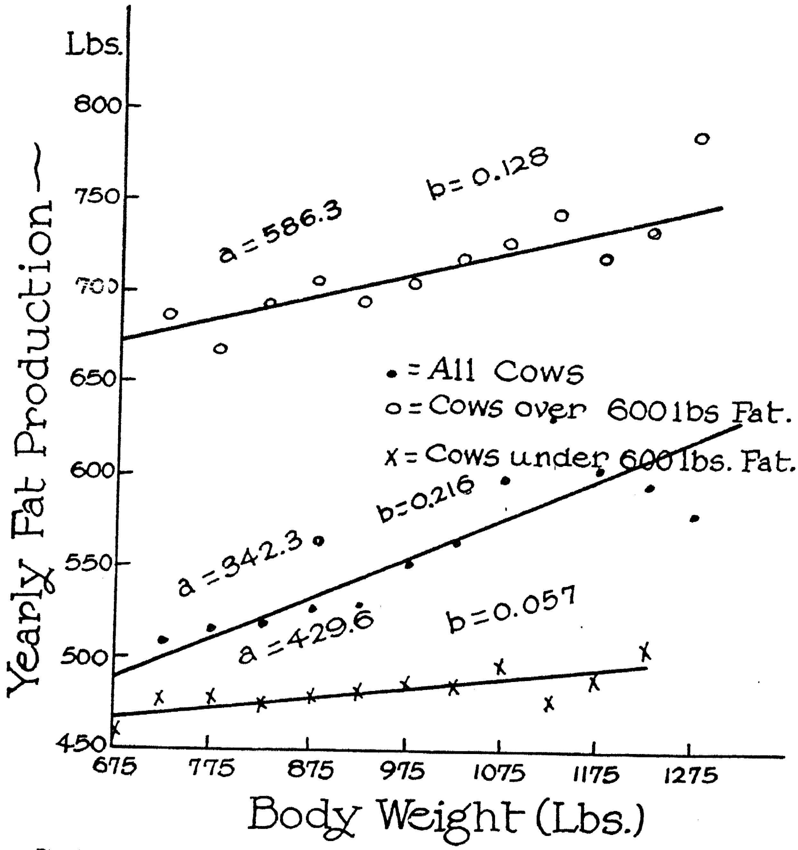

Fig. 1.—The relation between increasing body weight and yearly fat production is presented graphically. The smooth lines passing through the observed values were fitted by the method of least squares to the equation $F = a + b\,W$, where F is the yearly fat production (pounds) and W is body weight at the close of the lactation. The values for a and b are placed on the figure. For each 100 pounds increase in body weight above 342.3 pounds it was found there was an increase of approximately 22 pounds in yearly fat production for the entire group of Jersey cows.

shown in Table 3. For each 100 pounds increase in fat production above 845.3 pounds body weight, there was found an increase of 18 pounds in body weight.

A second reason for making an additional study was the hope that these data would furnish the answer to the following question: Does the same relation between body weight and fat production hold true for high producing and low producing cows? In other words, will cows capable of producing 600-700, or 800 pounds of fat per year show a greater response to increasing body weight than do cows capable of producing 400 or 500 pounds of fat.

TABLE 3.—RELATION BETWEEN YEARLY FAT PRODUCTION AND BODY WEIGHT JERSEY REGISTER OF MERIT CATTLE

Yearly Fat Production Mid-class Value	Number of Cows Included	Body Weight Calculated from Equation*	Mean Body Weight	Standard Deviation	Coefficient of Variation
lbs.		*lbs.*	*lbs.*	*lbs.*	
387.5	603	915.0	915.0± 2.80	101.9± 1.98	11.14± .22
412.5	664	919.5	918.3± 2.55	97.1± 1.80	10.57± .20
437.5	732	924.0	926.[illegible]± 2.67	106.8± 1.88	11.52± .20
426.5	811	928.5	936.8± 2.17	91.6± 1.53	9.78± .16
487.5	758	933.0	924.6± 2.48	101.4± 1.76	11.18± .19
512.5	756	937.5	935.2± 2.39	97.3± 1.69	10.40± .18
537.5	692	942.0	942.2± 2.31	90.1± 1.63	9.56± .17
562.5	58[illegible]	946.5	949.5± 2.81	100.5± 1.98	10.58± .21
587.5	478	951.0	946.6± 3.37	109.2± 2.38	11.53± .25
612.5	420	955.5	953.9± 3.55	107.9± 2.51	11.31± .26
637.5	340	960.0	961.7± 3.53	96.6± 2.50	10.05± .26
662.5	317	964.5	965.4± 3.99	105.4± 2.82	10.92± .29
687.5	237	969.0	981.6± 4.71	107.4± 3.33	10.94± .34
712.5	244	973.5	981.0± 4.27	98.9± 3.02	10.09± .31
737.5	170	978.0	980.6± 3.17	61.3± 2.24	6.25± .23
762.5	122	982.5	980.8± 5.94	97.3± 4.20	9.92± .43
787.5	126	987.0	988.1± 6.33	105.3± 4.47	10.65± .45
8 2.5	94	991.5	983.0± 7.43	106.8± 5.25	10.86± .53
837.5	60	996.0	1007.5± 9.57	109.8± 6.76	10.90± .67
862.5	54	1 00.5	984.3± 9.48	103.2± 6.69	10.48± .68
887.5	61	1005.0	1007.8± 9.08	105.1± 6.42	10.[illegible]3± .64
912.5	21	100[illegible].5	1005.9±17.82	121.0±12.59	12.03±1.25
937.5	33	1014.0	1014.4±12.15	103.4± 8.58	10.19± .85
962.5	30	1018.5	1021.7±10.44	84.7± 7.37	8.29± .72
987.5	15	1023.0	1035.0±12.81	73.5± 9.05	7.10± .87
Total	8421				

*Equation fitted by the method of least squares $W = 845.3 + 0.18\,F$, where W is the body weight at the close of the lactation, and F is the yearly fat.
Mean body weight = 944.095 ±.0152
S. D. = 103.577 ±.0108
C. V. = 10.971

From a priori reasoning it might be expected that animals with a large mammary gland capable of large secretion would be handicapped by a lack of body weight and might, therefore, produce 30 or 40 pounds of fat per year for each additional 100 pounds of body weight. Conversely, the low producing cow with limited glandular capacity having a body far in excess of the requirements of the udder would show little or no response, as far as fat production is concerned, to increased body weight.

To test out this theory, it was first proposed to separate the population in Table 1 into groups based on yearly fat production. Thus take the 400 to 500 pound producers and determine the relation between the increase in body weight and fat production. Then study the 500 to 600 pound producers in a similar way. When the records were grouped according to this plan, it was found that there was practically no change in fat production for 100 pounds increase in body weight. The same result was obtained throughout the entire range of fat production.

As an alternative the entire population was divided into two groups. The cows producing under 600 pounds are grouped in Table 4 on the basis of their body weight and corresponding fat production. In Table 5 are grouped all cows producing 600 pounds of fat or more per year.

TABLE 4.—RELATION BETWEEN WEIGHT AND YEARLY FAT PRODUCTION IN JERSEY CATTLE PRODUCING UNDER 600 POUNDS OF FAT

Body Weight Mid-class Value	Number of Cows Included	Yearly Fat Production Calculated from Equation*	Mean Fat Production	Standard Deviation	Coefficient of Variation
lbs.		*lbs.*	*lbs.*	*lbs.*	
675	39	468.04	460.6±6.49	60.05±4.59	13.03±1.01
725	173	470.88	476.2±3.17	61.77±2.24	12.97± .48
775	351	473.74	477.1±2.08	57.87±1.47	12.12± .31
825	709	476.59	475.9±1.55	61.02±1.09	12.82± .23
875	965	479.44	479.2±1.32	60.92± .94	12.71± .20
925	1077	482.29	482.3±1.21	58.87± .86	12.20± .18
975	1286	485.14	488.8±1.12	59.47± .79	12.16± .16
1025	823	487.99	488.2±1.48	62.85±1.04	12.87± .22
1075	399	490.84	498.7±1.95	57.75±1.38	11.57± .28
1125	139	493.69	479.6±3.32	58.00±2.35	12.09± .49
1175	65	496.54	490.5±5.35	63.92±3.78	13.03± .78
1225	30	499.39	509.1±6.55	53.15±4.63	9.85± .86
Total	6056				

*Equation fitted by the method of least squares, F = 429.6 ± 0.057 W, where F is the yearly fat production (pounds) and W is body weight at the close of the lactation.

TABLE 5.—RELATION BETWEEN WEIGHT AND YEARLY FAT PRODUCTION IN JERSEY CATTLE PRODUCING OVER 600 POUNDS OF FAT

Body Weight Mid-class Values	Number of Cows Included	Yearly Fat Production Calculated from Equation*	Mean Fat Production	Standard Deviation	Coefficient of Variation
lbs.		*lbs.*	*lbs.*	*lbs.*	
725	34	678.77	686.7± 10.44	90.25± 7.21	13.14±1.14
775	90	685.15	667.8± 4.19	58.90± 2.96	8.82± .43
825	173	691.52	693.3± 4.23	82.50± 2.99	11.89± .44
875	261	697.90	706.78± 3.30	79.05± 2.33	11.18± .33
925	305	704.27	696.20± 3.45	89.42± 2.44	12.84± .36
975	529	710.65	705.65± 2.65	90.47± 1.88	12.82± .27
1025	417	717.02	717.13± 3.07	92.87± 2.17	12.95± .31
1075	310	723.40	728.48± 3.94	102.77± 2.78	14.11± .39
1125	137	729.77	745.35± 5.83	101.15± 4.12	13.57± .56
1175	64	736.15	721.48± 8.06	95.62± 5.70	13.25± .80
1225	19	742.52	736.20±15.71	101.50±11.10	13.79±1.54
1275	10	748.90	787.50±29.89	140.10±21.13	17.79±2.76
Total	2349				

*Equation fitted by the method of least squares F = 586.3 + 0.128 W, where F is the yearly fat production (pounds) and W is body weight at the close of the lactation.

The regression equations in both cases are very low, due it is believed, to the restriction of the population. From these data the writer reluctantly arrived at the conclusion that the question could not be solved by this method of grouping the records.

EQUALIZING FAT RECORDS OF COWS VARYING IN BODY WEIGHT

In comparing records of official production of dairy cattle, little or no attention is given to a consideration of the body weight of the animals. Total milk and fat is the measure adopted by the breed associations in comparing the outstanding cows of the breed. It matters not that one cow may produce 1000 pounds of butterfat weighing only

900 pounds while another may produce 1001 pounds of butterfat weighing 1100 pounds, the second cow becomes the champion for her class.

The data presented in this paper furnishes the necessary information to equalize the fat records of cows of various body weights. The rule for converting the records of cows to a uniform 1000-pound body weight basis is as follows:

Add to or subtract from the actual record of fat production 20 pounds of fat for each 100 pounds of body weight below or above 1000 pounds body weight.

This method of equalization may be applied to records made at the same age without further conversion. To cows of varying ages it is necessary to first convert both body weight and fat production to a uniform basis.

In addition to Jersey records, the rule may also be used to equalize Guernsey records as the same relation has been found between body weight and yearly fat production. Whether it can be applied to the records of other breeds is not known at the present time.

As noted in the preceding discussion, the question whether the relation between body weight and yearly fat production is the same at all production levels is still unanswered.

ECONOMIC CONSIDERATIONS

Since the study of Woll (1900) calling the attention of breeders of dairy cattle to the importance of large body weight in connection with the economic production of milk and butterfat, there has been an effort on the part of many breeders to select the animals of large size in order to increase the average size of their cattle. This tendency has been further increased especially among breeders conducting official tests as the larger cows usually have a better chance to make satisfactory records and no effort has been made to equalize the records of production of cows of varying body weight.

From an economic standpoint, these factors may have led to a false evaluation of the importance of increasing further the body weight of dairy cattle. The data presented in this paper indicates the quantitative relation between body weight and yearly fat production. For each 100 pounds increase in the body weight of mature cows (the same relation has been demonstrated previously for various ages) there is an average increase of about 20 pounds (21.6) in yearly fat production.

From an economic standpoint the question is: How does the feed cost of maintenance of 100 pounds of body weight and the feed cost of 20 pounds of butterfat compare in value with the 20 pounds of butterfat so obtained?

The Morrison feeding standard for dairy cattle will furnish information on the feed cost. The maintenance of a 1000 pound cow for 365 days requires 2893 pounds of total digestible nutrients. Each additional 100 pounds of body weight would require 289.3 pounds of digestible nutrients.

In 400 pounds of 5 per cent milk there are 20 pounds of butterfat. The feed cost of 400 pounds of 5 per cent milk varies between 144.8 pounds and 160.8 pounds of total digestible nutrients. The total feed cost for the maintenance of 100 pounds of live weight and the production of 20 pounds of fat would vary between 434.8 and 450.1 pounds of total digestible nutrients. The feed cost and value of the fat produced is presented below.

Feed Cost		Value of Fat	
per lb.T.D.N.	Cost of T. D. N. required for maintenance and production of 20 pounds of fat	Butterfat at	Value of 20 lbs. of fat
cents			
1.0	$4.35 to $4.50	$.30	$6.00
		.40	8.00
1.5	6.52 to 6.75	.50	10.00
		.60	12.00
2.0	8.70 to 9.00	.70	14.00
		.80	16.00

When total digestible nutrients are relatively cheap and the price of butterfat is relatively high there is a fair spread between the two figures. However, when it is considered that the feed cost makes up about 50 per cent of the total cost of milk production, it is apparent that the greater production of large cows at best only slightly exceeds the cost of obtaining the additional product. It is possible that the investment in fewer animals with the resulting reduction in the investment in buildings and equipment would reduce the cost of items other than feed much below 50 per cent. This being true the advantage of the larger cow would increase correspondingly.

From a consideration of these data it is concluded that there may be some conditions where it is desirable to select animals for greater size but from an economic standpoint the small return for the greater cost of maintenance causes one to question this practice. It seems far more desirable to select sires which will increase the yearly fat production of their daughters above the breed average without increasing materially their average body weight. Increasing the production of dairy cattle without increasing their body weight will lead to greater economy of production.

III. Conversion Factors for Body Weight of Dairy Cattle

It was observed at an early date that milk and fat production, on the average, gradually increases as the dairy cow becomes mature. The change in production with age was fairly well predicted when the graduated minimum entrance requirements to the Advanced Registry and Register of Merit were established. Since that time many studies have been reported indicating the change in fat production with age.

These data show that milk and fat production gradually increase as the dairy cow becomes mature and then gradually decrease with the onset of old age; thus under similar conditions of feeding and management a heifer is expected to increase her yearly production at each succeeding lactation period until she reaches maturity.

From these data it is possible to calculate conversion factors by which records made at any age may be converted to their mature equivalent production. The first conversion factors to be published for this purpose were computed by Turner and Ragsdale (1923) to convert Jersey Register of Merit records to a mature equivalent basis. The method of calculation is very simple. It consists in determining the ratio of the average production at maturity (about 8 years) to the average production at various age intervals.

Conversion factors for each of the dairy breeds have since been reported in connection with studies of the progeny performance of dairy sires. (Turner and Ragsdale 1924, Turner 1925 and 1927, and Gifford and Turner 1928.)

CONVERSION FACTORS FOR BODY WEIGHT

Just as the yearly milk or fat production records made at any age may be converted to their "mature equivalent", so the body weights of dairy cattle may be converted to their mature equivalent. Thus conversion factors may be determined from the ratio of the average live weight at maturity to the average live weight at various age intervals.

In connection with the study of the inheritance of body weight of Jersey Register of Merit cattle it became necessary to compare the yearly fat production and body weights of these animals on a uniform basis. Conversion factors for body weight were therefore required. After computing the conversion factors for body weight of Jersey cattle, it seemed desirable to make a compilation of all available growth records of lactating cattle and determine the body weight conversion factors for each breed.

The object of the present paper is to present a tabulation of the growth of lactating cattle from the age of first calving until growth ceases. From these growth data, conversion factors for body weight have been computed.

GROWTH OF LACTATING CATTLE

Studies of the growth of dairy cattle from birth until two years of age have been reported by Eckles (1920) and Ragsdale et al (1926). Eckles also presented limited data on the growth of cattle during the first five calving periods. To further determine the rate of growth of lactating cattle a study was made by Turner, Ragsdale, and Brody (1923) of the body weights of over 15,000 Register of Merit Jersey cows. It was found that these animals continue to increase in live weight at a constantly decreasing rate until approximately eight years old.

Recently Turner (1928) reported a similar study of about 2,700 Guernsey Advanced Registry cows in which the general course of growth was found to be quite similar to that of the Jersey Breed.

Davidson (1928) has separated the Jersey Register of Merit original entry cows from the re-entry cows. He found that the re-entry cows differ significantly from the original entry cows not only in the weight at a given age but in the time required to reach maturity.

Johansson (1928) gives the rate of growth of Swedish Ayrshire cattle from 2½ to 10 years of age.

The growth of the Russian Gorbatowka breed of cattle has been studied by Kapazinsky (1928). He found that growth in body weight increased until the fifth or sixth calving period.

These growth data are presented in Tables 1 and 2. It will be noted that both the observed body weights and the calculated body weights are included. These calculated values were obtained in most cases by drawing a smooth curve through the observed values so that minor fluctuations were eliminated. The calculated values presented by Davidson (1928), however, were obtained from equations which were fitted to the observed weights.

CONVERSION FACTORS

Using the calculated weight, except in the case of the Swedish Ayrshire, of the cows given in Table 1, age conversion factors for body weight of Jersey Register of Merit, Guernsey Advanced Registry, Holstein-Friesian and Swedish Ayrshire cattle were determined and are presented in Table 3.

It will be noted in Table 1 that maximum body weight is usually reached at about 9 years, so 9 years has been used as the time of maturity. As body weight does not decline significantly after this period, conversion factors for the body weight after 9 years are not needed. The conversion factors for body weight of Jersey cattle used in the study presented in Section 1 are found in column 1 of Table 3.

TABLE 1.—GROWTH OF LACTATING CATTLE

Age	Number of Cows	Turner et al (1923) Jersey Register of Merit Average Weight		Davidson (1928)					
				Number of Cows	Jersey R. of M. Original Entry Average Weight		Number of Cows	Jersey R. of M. Re-entry Average Weight	
		Observed	Calculated		Observed	Calculated		Observed	Calculated
		lbs.	*lbs.*		*lbs.*	*lbs.*		*lbs.*	*lbs.*
Under 1.5	26	710	710	---	---	---	---	---	---
1.5	1001	767	767	831	766	763	---	---	---
2.0	3155	808	810	2565	808	805	---	---	---
2.5	1449	836	843	1086	836	839	35	870	867
3.0	1523	872	872	905	867	865	245	911	896
3.5	1122	888	893	636	881	886	238	907	918
4.0	1171	916	915	585	906	902	285	940	935
4.5	916	930	925	456	922	914	247	942	947
5.0	1692	938	938	419	925	923	260	949	957
5.5	----	---	---	413	931	930	242	964	964
6.0	1235	945	947	335	937	936	194	973	969
6.5	----	---	---	264	933	940	169	973	973
7.0	965	952	955	253	934	943	158	982	976
7.5	----	---	---	206	940	946	133	983	978
8.0	621	957	959	164	944	948	101	982	979
8.5	----	---	---	146	944	949	78	996	981
9.0	364	962	960	191	961	951	118	966	982
10.0	208	957	---	116	964	952	49	949	983
11.0	108	968	---	50	943	952	38	1007	983
12	64	956	---	39	960	953	19	954	984
13	32	961	---	---	---	---	---	---	---
14	14	1036	---	---	---	---	---	---	---
15	9	975	---	34	950	953	19	1012	984
16	4	963	---	---	---	---	---	---	---
Total	15680	---	---	---	---	---	---	---	---

Age	Number of Cows	Turner (1928) Guernsey Average Weight		Johansson (1928)			Turner et al (1924)		
				Number of Cows	Swedish Ayrshire Average Weight		Number of Cows	Holstein Average Weight	
		Observed	Calculated		Observed	Calculated		Observed	Calculated
		lbs.	*lbs.*		*lbs.*	*lbs.*		*lbs.*	*lbs.*
Under 1.5	---	---	---	---	---	---	---	---	---
1.5	63	968	967	---	---	---	20	1094	1094
2.0	775	1005	1006	---	---	---	165	1184	1147
2.5	415	1030	1036	52	1038	---	85	1182	1197
3.0	282	1065	1058	72	1074	---	81	1249	1253
3.5	228	1072	1076	32	1166	---	86	1285	1295
4.0	197	1099	1089	94	1212	---	56	1352	1339
4.5	156	1098	1099	---	---	---	87	1408	1378
5.0	127	1112	1106	67	1265	---	122	1408	1402
5.5	116	1119	1112	---	---	---	---	---	1416
6.0	81	1139	1116	70	1276	---	67	1428	1425
6.5	71	1125	1120	---	---	---	---	---	1430
7.0	46	1103	1122	105	1291	---	56	1437	1434
7.5	51	1113	1124	---	---	---	---	---	1436
8.0	24	1121	1125	---	---	---	36	1434	1440
8.5	31	1121	1127	---	---	---	---	---	---
9.0	21	1132	1127	---	---	---	30	1443	1442
9.5	15	1088	---	---	---	---	---	---	---
10.0	11	1121	1128	50	1267	---	25	1523	---
10.5	7	1101	---	---	---	---	---	---	---
11.0	9	1181	1129	---	---	---	13	1366	---
11.5	7	1132	---	---	---	---	---	---	---
12.0	4	1063	1129	---	---	---	9	1375	---
12.5	3	1242	---	---	---	---	---	---	---
13.0	---	---	---	---	---	---	8	1418	---
Total	2740	---	---	542	---	---	946	---	---

TABLE 2.—GROWTH OF LACTATING CATTLE

	Eckles (1920)						Kapazinsky (1928)	
	Holstein		Jersey		Ayrshire		Gorbatowka (Russian)	
Calving	No. of Cows	Average Weight	No. of Cows	Average Weight	No. of Cows	Average Weight	No. of Cows	Average Weight
		lbs.		*lbs.*		*lbs.*		*lbs.*
1	26	965	12	764	5	868	54	634
2	22	1040		827		874	123	693
3	17	1143		872		960	126	724
4	8	1219		887		1022	122	744
5	4	1247		919		1045	90	759
6							77	768
7							51	788
8							34	794
9-10							37	785
Total	77						714	

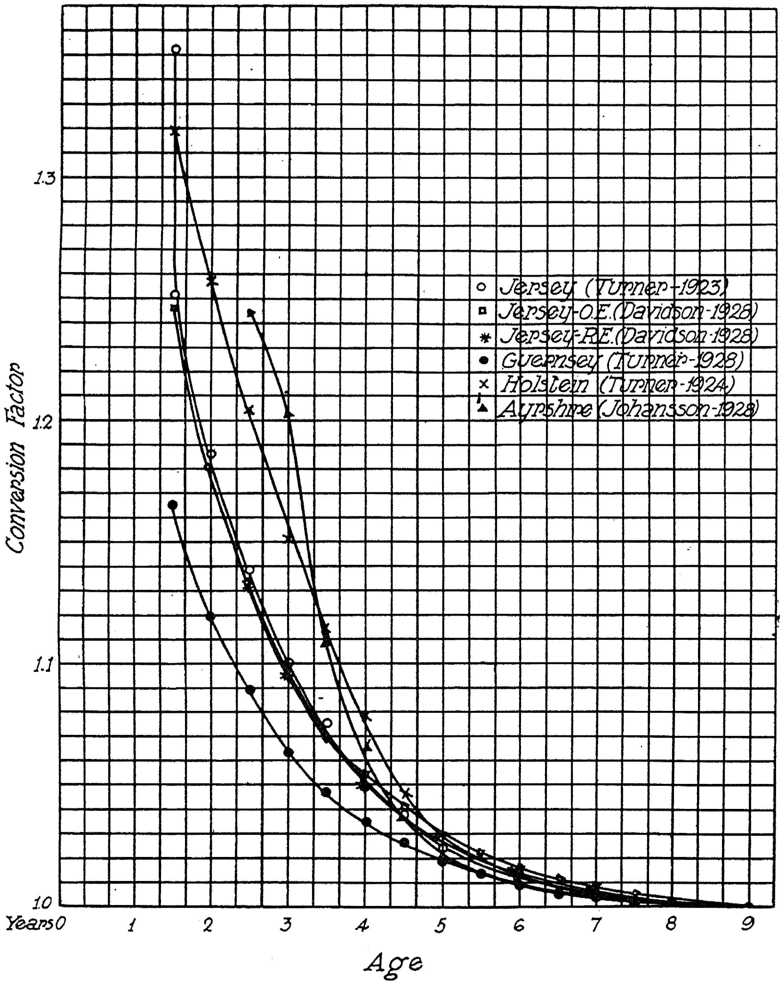

Fig. 1.—A comparison of the body weight conversion factors for various breeds of dairy cattle. It will be noted that the various conversion factors for the Jersey breed are quite similar. It will be noted also that the Guernsey conversion factors are less at a given age than are the Jersey while the Holstein and Ayrshire are higher.

Table 3.—Conversion Factors for Body Weight of Dairy Cattle

Age Years	Jersey Register of Merit Records						Guernsey A. R. records		Holstein		Swedish Ayrshire	
	Turner et al (1923) All records Conversion factors		Davidson (1928)				Turner (1928)		Turner et al (1924)		Johansson (1928)	
			Original entry Conversion factors		Re-entry records Conversion factors		Conversion factors		Conversion factors		Conversion factors	
	Maturity	To 2 years	Maturity	To 2 years	Maturity	To 2½ years	Maturity	To 2 years	Maturity	To 2 years	Maturity	To 2½ years
Under 1.5	1.3521	1.1408	------	------	------	------	------	------	------	------	------	------
1.5	1.2516	1.0561	1.2463	1.0550	------	------	1.1655	1.0403	1.3181	1.0484	------	------
2.0	1.1852	1.0000	1.1814	1.0000	------	------	1.1203	1.0000	1.2572	1.0000	------	------
2.5	1.1388	.9609	1.1335	.9595	1.1326	1.0000	1.0889	.9710	1.2047	.9582	1.2437	1.0000
3.0	1.1009	.9289	1.0994	.9306	1.0960	.9676	1.0642	.9500	1.1508	.9154	1.2020	.9665
3.5	1.0750	.9071	1.0734	.9086	1.0697	.9444	1.0474	.9349	1.1135	.8857	1.1072	.8902
4.0	1.0492	.8852	1.0543	.8925	1.0503	.9273	1.3049	.9238	1.0769	.8566	1.0652	.8564
4.5	1.0378	.8757	1.0405	.8807	1.0370	.9155	1.0255	.9154	1.0464	.8324	------	------
5.0	1.0235	.8635	1.0303	.8722	1.0261	.9060	1.0190	.9096	1.0285	.8181	1.0206	.8206
5.5	------	------	1.0226	.8656	1.0187	.8994	1.0135	.9047	1.0184	.8100	------	------
6.0	1.0137	.8553	1.0160	.8600	1.0134	.8947	1.0099	.9014	1.0119	.8049	1.0118	.8135
6.5	------	------	1.0117	.8564	1.0092	.8911	1.0063	.8982	1.0084	.8021	------	------
7.0	1.0052	.8482	1.0085	.8537	1.0061	.8883	1.0045	.8966	1.0056	.7998	------	------
7.5	------	------	1.0053	.8510	1.0041	.8865	1.0027	.8950	1.0042	.7987	------	------
8.0	1.0010	.8446	1.0032	.8492	1.0030	.8856	1.0018	.8942	1.0014	.7965	------	------
9.0	1.0000	.8438	1.0000	.8465	1.0000	.8829	1.0000	.8926	1.0000	.7954	1.0000	.8040

The various conversion factors are compared in Figure 1. It will be noted that the various conversion factors for the Jersey breed are quite similar. The figure also shows that the Guernsey conversion factors are less at a given age than are the Jersey, while the Holstein and Ayrshire are higher.

In addition to the usual conversion factors for converting body weight to the mature equivalent or the average weight that may be reached by cows at maturity, conversion factors are also presented which make possible the comparison of the weight of cows at two years to the body weight at various age intervals.

While the "mature equivalent" conversion factors will probably be used more frequently than the "2-year-old equivalent" factors there are certain advantages in the use of the latter. Very frequently in considering a group of animals for which conversion factors are to be used a majority of the animals will be two-year-olds with a few older animals. If the "mature equivalent" factors are used every record will require conversion, while if the "2-year-old equivalent" factors are used most of the original records will stand with only a few records requiring conversion. All will agree that the less change made in the original records the more stisfactory they will be found. The "2-year-old equivalent" will reduce the number of changes and the magnitude of the change to a minimum in most cases.

In Table 4 are presented the conversion factors based on number of calvings rather than age. The data presented by Eckles covers the first five calving periods. The conversion factors have been determined using the fifth calving period as maturity and the first calving period as the "2-year-old equivalent".

TABLE 4.—CONVERSION FACTORS FOR BODY WEIGHT OF DAIRY CATTLE

Number of Calvings	Holstein		Ayrshire		Jersey		Gorbatowka	
	Eckles (1920)		Eckles (1920)		Eckles (1920)		Kapazinsky (1928)	
	Conversion factor to		Conversion factor to		Conversion factor to		Conversion factor to	
	Maturity	1st calving	Maturity	1st calving	Maturity	1st calving	Maturity	1st calving
1	1.2922	1.0000	1.2039	1.0000	1.2029	1.0000	1.2524	1.0000
2	1.1990	.9279	1.1957	.9931	1.1112	.9238	1.1457	.9149
3	1.0910	.8443	1.0885	.9042	1.0539	.8761	1.0967	.8757
4	1.0230	.7916	1.0225	.8493	1.0361	.8613	1.0672	.8522
5	1.0000	.7739	1.0000	.8306	1.0000	.8313	1.0461	.8353
6	------	------	------	------	------	------	1.0339	.8255
7	------	------	------	------	------	------	1.0076	.8046
8	------	------	------	------	------	------	1.0000	.7985

Summary and Conclusions

I. A study is reported of the progeny performance of Jersey sires in which both the yearly fat production and body weight of the daughters and their dams are considered. The body weights of all cows were converted to their "mature equivalent" by means of weight conversion factors.

Comparison of the changes in body weight and yearly fat production between dams and daughters indicates that Jersey sires can cause significant changes in yearly fat production (either upward or downward) of their daughters as compared with their dams without causing a material increase or decrease in body weight.

To determine the effect of the dams on the daughters' weight, the relation between the dams and daughters was determined. It was found that for each increase of 100 pounds in body weight of the dams there was an increase of about 16 pounds in the body weight of the daughters.

From a consideration of these data, it appears that the inheritance of body weight of Jersey cattle follows much the same plan as the inheritance of yearly fat production.

II. The above data were also used in determining the relation between body weight and yearly fat production. When the records of fat production and body weight were converted to their mature equivalent the factor of age was eliminated. Thus all records could be grouped together. From this study it was found that there was an increase of approximately 20 pounds in yearly fat production for each 100 pounds increase in body weight above 342.3 pounds.

Based on these data a rule for converting the records of cows to a uniform 1000-pound body weight was formulated as follows: Add to or subtract from the actual record of fat production 20 pounds of fat for each 100 pounds below or above 1000 pounds body weight.

In answer to the question: "How does the feed cost of maintenance of 100 pounds of body weight and the feed cost of 20 pounds of fat compare in value with the 20 pounds of fat so obtained?" evidence was presented which indicates that the greater production of large cows at best only slightly exceeds the cost of obtaining the additional product. It is concluded that the sires whose daughters are above the average for the breed in fat production without exceeding the average in body weight are especially desirable because their daughters are increasing the economy of fat production of the breed.

III. In order to compare the body weight of cows at different ages, weight conversion factors were computed from the growth curves of lactating cattle.

Two sets of conversion factors have been formulated. The first will convert the body weight to the "mature equivalent" while the second will convert the body weight to the "2-year-old equivalent". Certain advantages of the latter plan are pointed out.

REFERENCES

Davidson, F. A. 1928 *Growth and senescence in pure bred Jersey cows.* Ill. Agr. Exp. Sta. Bul. 202.

Eckles, C. H. 1920 *Normal growth of dairy cattle.* Mo. Agr. Exp. Sta. Res. Bul. 36.

Gifford, W. 1930 *The mode of inheritance of yearly butterfat production. An analysis of the progeny performance of Holstein-Friesian sires and dams.* Mo. Agr. Exp. Sta. Res. Bul. 144.

Gifford, W., and Turner, C. W. 1928 *The mode of inheritance of yearly butterfat production. Analysis of the progeny performance of Ayrshire sires and dams.* Mo. Agr. Exp. Sta. Res. Bul. 120.

Gowen, J. W. 1925 *Studies on conformation in relation to milk producing capacity in cattle. IV. The size of the cow in relation to the size of her milk production.* Jour. Agr. Research Vol 30, p. 865.

Gowen, J. W. 1930 *On criteria for breeding capacity in dairy cattle.* Proc. Amer. Soc. of Animal Production. Pub. by the Society.

Gowen, J. W., and Covell, M. R. 1921 *Studies in milk secertion. IX. On the performance of the progeny of Holstein-Friesian sires.* Maine Agr. Exp. Sta. Bul. 300.

Gowen, J. W., and Covell, M. R. 1921 *Studies in milk secretion. XII. Transmitting qualities of Holstein-Friesian sires for milk yield, butterfat-percentage and butterfat.* Maine Agr. Exp. Sta. Bul. 301.

Johansson, Ivar 1928 *De svenska notkreatursrasernas kroppsutveckling och produktion* Uppsala, Sweden.

Kapazinsky, W. W. 1928 *The production of the "Gorbatowka" according to date of controlling communities.* (English Summary). The State Breeding Register of the Gorbatoff Red Cattle. Vol. 1.

McDowell, J. C. 1929 *Dairy studies show that within breeds the bigger cows win.* Year Book of Agriculture 1928, U. S. D. A.

McDowell, J. C. 1930 *What has happened in Dairy Herd Improvement Associations.* Hoard's Dairyman, April 10, 1930.

McDowell, J. C., and Parker, J. B. 1926 *Better cows from better sires.* U. S. D. A. Dept. Cir. 368.

Nevens, W. B. 1919 *Breed and size of cows as factors affecting the economy of milk production.* Jour. Dairy Sci., Vol. 2, p. 99.

Pearl, Raymond 1917 *Report of progress on animal husbandry investigations in* 1916. *IV. The analysis of milk records.* Maine Agr. Exp. Sta. Bul. 261.

Pearl, R., Gowen, J. W., and Miner, J. R. 1919 *Studies in milk secretion. VII. Transmitting qualities of Jersey sires for milk yield, butter-fat percentage and butter-fat.* Maine Agr. Exp. Sta. Bul. 281.

Ragsdale, A. C., Elting, E. C., and Brody, S. 1926 *Growth and development. Growth and development of dairy cattle.* Mo. Agr. Exp. Sta. Res. Bul. 96.

Turner, C. W. 1925 *A comparison of Guernsey sires based on the average mature equivalent fat production of the daughters and their dams.* Mo. Agr. Exp. Sta. Res. Bul. 79.

Turner, C. W. 1927 *The mode of inheritance of yearly butterfat production. An analysis of the progeny performance of Jersey sires and dams.* Mo. Agr. Exp. Sta. Res. Bul. 112.

Turner, C. W. 1928 *Growth in weight of Guernsey cows after the age of two years.* Jour. Dairy Sci. Vol 11, p. 265.

Turner, C. W. 1929 *The relation between weight and fat production of Guernsey cattle.* Jour. Dairy Sci., Vol 12, p. 60.

Turner, C. W., and Ragsdale, A. C. 1923 *A comparison of Jersey sires based on the average mature equivalent fat production of the daughters.* Mo. Agr. Exp. Sta. Bul. 206.

Turner, C. W., and Ragsdale, A. C. 1924 *A comparison of Holstein-Friesian sires based on the average mature equivalent fat production of the daughters.* Mo. Agr. Exp. Sta. Bul. 217.

Turner, C. W., Ragsdale, A. C., and Brody, S. 1923 *Normal growth of the Jersey cow.* Jour. Dairy Sci. Vol. 6, p. 461.

Turner, C. W., Ragsdale, A. C., and Brody, S. 1924 *The relation between age, weight and fat production in dairy cows.* Mo. Agr. Exp. Sta. Bul. 221.

Woll, F. W. 1900 *Production of milk and butterfat. IV.* Breeders' Gazette, Vol. 38, pp. 379-380.

Woll, F. W. 1912 *Studies in dairy production.* Wis. Agr. Exp. Sta. Res. Bul. 26.