QUANTITY AND COMPOSITION OF EWES' MILK: ITS RELATION TO THE GROWTH OF LAMBS

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INTRODUCTION

During the progress of an investigation upon different breeds of sheep at the Idaho Agricultural Experiment Station observations were made upon the rate of growth of lambs from five breeds of ewes that are commonly found in this section of the country. The results indicated that lambs from some of the breeds studied made a decided gain over others in the same period of time. Inasmuch as the sheep industry is of such economic importance to the Nation, the rate of growth of the lambs assumes more than ordinary interest, and an effort is being made to ascertain the relation of the quantity and composition of ewes' milk of each breed to the growth of the lambs.

FACTORS ESSENTIAL IN GROWTH

The chief factors in growth are inherited capacity and a sufficient quantity of nutritious food. The second factor only will be studied, since without sufficient food inherited capacity for growth will be more or less inhibited.

Growth depends upon nutritious foods, and recent investigators have demonstrated that these foods must contain a sufficient quantity of inorganic salts, certain amino acids, lipoids, fats or oils of a peculiar nature, and vitamines. The absence of any of these substances is detrimental to growth. It is obvious that a well-balanced food is essential, and in milk we have the highest type of such food. The fact, however, remains that milk from ewes of different breeds has been found to vary in quantity and composition, and this may account to some extent for differences in growth.

REVIEW OF LITERATURE

As early as 1850 data were collected giving the analysis of ewes' milk. Since that time many investigators [2] have contributed to our knowledge of the composition of ewes' milk. Their results, however, have dealt mainly with the high-milk-producing ewes of foreign countries, where

[1] The authors wish to acknowledge with thanks the careful work of the following men whose assistance made it possible to carry on this work: To Messrs. Grover D. Turnbow, R. R. Groninger, and Ronald Wood credit is due for the chemical analyses; to Messrs. O. W. Johnson, C. H. Ficke, and W. H. Booth (killed in service, France) for the careful determination on yield of milk and growth of lambs.

[2] KÖNIG, J. CHEMIE DER MENSCHLICHEN NAHRUNGS- UND GENUSSMITTEL. Aufl. 4, Bd. 1, p. 265–271. Berlin, 1903.

yield of milk and the butter-fat content was of greatest consequence. These results are of little benefit in the solution of this problem, other than to show the great variation that occurs between different breeds and within the breeds. This problem will include only such breeds as are common to this section of the country. Among the above-mentioned investigations, only two give figures upon breeds that will be included in this work. Filhol and Joly [1] give figures upon the Southdown, and Hucho [2] upon the Hampshire breed. These results serve only to verify the results of other investigators, and show the variation between breeds.

Fuller and Kleinheinz,[3] of the Wisconsin Station, made a study of the yield, fat, and total solids of the milk of five breeds of sheep; the Oxford, Southdown, Dorset, Shropshire, Merino, and the Montana grade. They included two ewes of each breed in their study, and took the average of the two results as the average of the breed. In determining the milk yield, the lamb was weighed before and after sucking the mother ewe. This was repeated at frequent intervals during a 48-hour period, from which the yield of milk for 24 hours was calculated. They observed that, when the ewes were milked by hand, only about one-half the quantity of milk was obtained as when the first method was used. The results on the two ewes of each breed show a wide variation in milk yield and percentage of fat between the breeds.

Ritzman,[4] of the New Hampshire Station, in a recent publication has made a valuable contribution to the present knowledge of ewes' milk. His work dealt especially with the fat content and its relation to growth of lambs. A summary of his results on the fat content of 6 distinct breeds and 11 crossbreeds over a considerable period of years showed a great variation in the percentage of fat. The outstanding feature was that not only did breeds differ in fat content of milk, but individual ewes within the breed differed greatly. Moreover, these individual ewes showed marked differences in fat percentage at different lactation periods. This fact was observed by the writers during a preliminary investigation of ewes' milk carried on a year previous to this present investigation. Ritzman concluded that the growth of the lamb was not dependent upon the percentage of fat, but he was of the opinion that it depended mainly on the quantity of milk. No actual milk yields were obtained by him, but an estimation of the yields made by observation was tabulated as "high-", "good-", "fair-", and "poor-milking" ewes.

From a review of the literature it is evident that an accurate estimation of the quantity and composition of ewes' milk is necessary in order

[1] FILHOL, and JOLY. ANALYSES DU LAIT DE BREBIS APPARTENANT À DIFFÉRENTES RACES. *In* Compt. Rend. Acad. Sci. [Paris] t. 47, no. 25, p. 1013–1014. 1858.

[2] HUCHO, Hermann. UNTERSUCHUNGEN ÜBER SCHAFMILCH MIT BBESONDERER BRÜCKSICHTIGUNG DER OSTFRIESISCHEN MILCHSCHAFE. *In* Landw. Jahrb., Bd. 26, Heft 2/3, p. 496–547. 1897.

[3] FULLER, J. G., and KLEINHEINZ, Frank. ON THE DAILY YIELD AND COMPOSITION OF MILK FROM EWES OF VARIOUS BREEDS. *In* Wis. Agr. Exp. Sta. 21st Ann. Rpt. 1903/04, p. 48–50. 1904.

[4] RITZMAN, E. G. EWES' MILK: ITS FAT CONTENT AND RELATION TO THE GROWTH OF LAMBS. *In* Jour. Agr. Research, v. 8, no. 2, p. 29–36, 1 fig. 1917. Literature cited, p. 35–36.

to ascertain the factors which influence growth, since analyses of the milk of individual ewes differ widely. In the first year's work, which was preliminary in nature, five breeds of ewes were studied, an estimation of the quantity of milk given by each ewe was made every seven days, on two ewes of each breed. Chemical analyses of the samples of milk taken in 10-day periods after lambing were made for a period of 70 days. The gain of the lamb was recorded every seven days. The chief objections showing up in the preliminary work were as follows: It became evident that samples of milk for analysis and total quantities of milk ought to be taken at the same period, or as near thereto as possible. The experiment included only two ewes in each breed, and in some cases one might give an abnormally high or low milk yield, which would show unfair averages in the breed. Still another factor entered into the work. A period of 70 days proved too long, for lambs need access to grain early in their life, and as grain was fed to them this made any correlation of composition of milk and growth futile. All the above difficulties were eliminated by the following procedure adopted in this work:

PLAN OF INVESTIGATION

It was realized that any work on the study of the milk of ewes must include a number of ewes before a fair average of the milk constituents could be obtained. However, in this work the difficulty becomes very evident, for with a great number of ewes the work becomes so laborious that the use of a great number in the experiment is prohibitive. The aim was to choose three ewes which showed characteristics of the average ewe of the particular breed. This was done by starting with four ewes of each breed and continuing with the three that showed the nearest to the normal milk yield for the breed. Six breeds of ewes and three ewes from each breed were used in this experiment. The period of investigation continued for 50 days. Every 10 days after lambing the total quantity of milk was recorded, and samples of milk were taken. The weight of the lamb was taken at birth and every 10 days thereafter, from which the gain was calculated.

METHODS USED IN OBTAINING MILK SAMPLES

In determining the total milk yield of each ewe the lamb was separated from the mother ewe at 6 o'clock in the morning. At 7 it was allowed to suckle the ewe. This was done in order to start all ewes on a uniform basis. At frequent intervals during the 24-hour period, which began after the lamb suckled the ewe at 7 o'clock, the lamb was weighed, allowed to suckle, and reweighed, on a balance weighing accurately to 1 gm. The sum of the differences in the lamb's weight before and after suckling the ewe during the 24-hour period gave the total yield of milk. In this manner all the milk was obtained without causing any nervousness on the part of the ewe, and the results gave a good

representative total yield of milk. The milk samples for the analysis were obtained as follows: After the 24-hour period was concluded for the total yield of milk the lamb was kept away from the ewe until a sufficient quantity of milk was in the udder; then the lamb was allowed to suckle one side, while the other was milked dry. In this manner a uniform sample was obtained without causing undue nervousness on the part of the ewe.

CONSTITUENTS DETERMINED IN THE MILK

The samples of milk were analyzed for the following constituents: Total nitrogen, casein, albumin, fat, lactose, specific gravity, and ash. The ash was then analyzed for the calcium and phosphorus content.

METHODS USED

TOTAL NITROGEN.—A quantity of milk (approximately 5 gm.) was weighed accurately and the nitrogen determined by the Kjeldahl method.

CASEIN.—Casein was precipitated by acetic acid on a weighed quantity of milk according to the official method. The nitrogen determined by the Kjeldahl method and the results multiplied by the factor 6.38.

ALBUMIN.—After neutralizing the filtrate obtained after removing the casein, with sodium hydroxid, and adding acetic acid of the proper strength and quantity, according to the official methods,[1] the nitrogen was determined by the Kjeldahl method and the result multiplied by 6.38.

NONPROTEIN NITROGEN.—The sum of the nitrogen of the casein and albumin was subtracted from the total nitrogen. The result gave the nonprotein nitrogen.

FAT.—The fat was determined by the Babcock method.

LACTOSE.—A portion of milk (approximately 10 gm.) was weighed accurately in a flask and 25 cc. of distilled water were added. The proteins were precipitated with a sufficient quantity of colloidal ferric hydroxid as described by Hill.[2] They were then filtered off and the clear filtrate collected in a volumetric flask. The proteins were washed with distilled water until free from lactose. The combined filtrate and washings were made up to a definite volume and the lactose determined by the volumetric method of Benedict.[3] The colloidal ferric hydroxid proved to be a very efficacious clarifier, as it is very simple to use and insures thorough clarification and a clear solution.

SPECIFIC GRAVITY.—Specific gravity was determined by the Westphal balance.

ASH.—The ash was made upon composite samples of the four samples of milk by the official methods.

CALCIUM AND PHOSPHORUS.—Calcium and phosphorus were determined from the ash residues by the methods described by Richmond.[4]

DISCUSSION OF RESULTS

In Table I is found the percentage composition and total yield of milk of each ewe for the entire series taken every 10 days during a period of 24 hours. In all cases the first results upon the total weight

[1] ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. REPORT OF COMMITTEE ON EDITING METHODS OF ANALYSIS. p. 287–289. Baltimore, Md., 1916. (Jour. Assoc. Off. Agr. Chem., v. 2, no. 3, pt. 2.)

[2] HILL, REUBEN L. NOTE ON THE USE OF COLLOIDAL IRON IN THE DETERMINATION OF LACTOSE IN MILK. *In* Jour. Biol. Chem., v. 20, no. 3, p. 175–176. 1915.

[3] BENEDICT, STANLEY R. THE DETECTION AND ESTIMATION OF GLUCOSE IN URINE. *In* Jour. Amer. Med. Assoc., v. 57, no. 15, p. 1193–1194. 1911.

[4] RICHMOND, HENRY DROOP. DAIRY CHEMISTRY. p. 81–82. London. 1890.

of milk were secured 10 days after the birth of the lamb. This duration of time was allowed to elapse in order to allow the milk of the ewe to become normal. Analyses of ewes' milk, made by Weiske and Kennepohl[1] at different periods, varying from 1½ hours to several days after the birth of the lamb, show that 10 days is ample time for the milk flow to assume its normal composition.

The results of the table indicate, as would naturally be assumed, that there is a decrease in the milk flow of the ewes in the 50-day period. In only one instance was this not true; that was in the case of Cotswold ewe, No. 753, which maintained not only a constant milk flow throughout the experiment, but actually showed a slight increase at the end of the 50-day period.

TABLE I.—*Quantity and composition of ewes' milk*

Breed and No. of ewes.	Sample No.	Date of sampling.	Weight of ewe.	Total quantity of milk for 24-hour period.	Specific gravity.	Casein.	Albumin.	Nonprotein nitrogen.	Fat.	Lactose.	Ash.	Ash percentage of calcium and phosphorus in ash.	
												Calcium.	Phosphorus pentoxid.
COTSWOLD			*Lbs.*	*Gm.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
2518	1	Feb. 18	190	1,931	1.029	2.44	0.91	0.076	7.2	4.79	0.87	15.15	19.92
	2	Feb. 28	184	1,980	1.033	2.47	.88	.075	8.1	4.83	.....	.....	.....
	3	Mar. 10	189	1,805	1.031	3.60	.64	.087	8.6	4.00	.....	.....	.....
	4	Mar. 20	193	1,122	1.035	3.59	.78	.062	7.4	4.93	.....	.....	.....
	5	Mar. 30	188	1,176	1.033	3.52	.83	.067	5.2	5.12	.....	.....	.....
Average			188	1,585	1.034	3.32	.81	.065	7.3	4.73	.87	15.15	19.92
753	1	Feb. 21	164	1,956	1.033	2.86	.81	.070	10.4	4.81	.77	15.24	28.24
	2	Mar. 3	159	2,141	1.032	3.01	.78	.040	8.0	5.07	.....	.....	.....
	3	Mar. 13	161	2,105	1.033	3.07	.45	.081	7.8	5.16	.....	.....	.....
	4	Mar. 23	157	1,637	1.033	3.10	.83	.051	6.4	4.79	.....	.....	.....
	5	Apr. 2	159	1,986	1.032	3.19	.54	.051	6.0	5.20	.....	.....	.....
Average			159	1,965	1.033	3.04	.68	.058	7.7	5.00	.77	15.24	28.24
2097	1	Feb. 28	159	1,555	1.035	2.82	.72	.088	7.8	4.76	.34	11.33	18.77
	2	Mar. 10	150	1,302	1.028	3.04	.52	.087	9.2	4.93	.....	.....	.....
	3	Mar. 20	147	1,113	1.033	2.94	.64	.062	7.6	4.63	.....	.....	.....
	4	Mar. 30	145	838	1.035	3.04	.85	.067	7.8	4.60	.....	.....	.....
	5	Apr. 9	149	816	1.034	2.98	.88	.059	8.2	4.22	.....	.....	.....
Average			149	1,124.8	1.033	2.96	.72	.072	8.1	4.62	.84	11.33	18.77
HAMPSHIRE													
30	1	Feb. 17	189	2,477	1.029	2.84	.72	.081	10.3	4.58	.76	12.32	22.12
	2	Feb. 27	177	2,487	1.034	2.73	.81	.072	6.2	4.80	.....	.....	.....
	3	Mar. 9	176	2,328	1.032	2.89	.48	.081	6.0	4.50	.....	.....	.....
	4	Mar. 19	165	1,845	1.035	3.62	.48	.062	7.6	4.88	.....	.....	.....
	5	Mar. 29	164	1,328	1.033	3.41	.48	.051	8.2	4.95	.....	.....	.....
Average			174	2,093	1.032	3.09	.59	.069	7.6	4.74	.76	12.32	22.12
50	1	Feb. 20	172	3,439	1.030	2.62	.91	.078	8.25	4.61	.81	14.22	24.65
	2	Mar. 2	152	2,278	1.031	3.77	.43	.059	6.85	4.53	.....	.....	.....
	3	Mar. 12	151	2,534	1.030	2.84	.36	.054	6.2	4.86	.....	.....	.....
	4	Mar. 22	136	2,300	1.031	3.36	1.36	.056	5.0	4.97	.....	.....	.....
	5	Apr. 1	139	1,848	1.035	3.07	.52	.059	3.9	4.73	.....	.....	.....
Average			150	2,479.8	1.031	3.13	.71	.061	6.0	4.74	.81	14.22	24.65

[1] WEISKE, H., AND KENNEPOHL, G. UNTERSUCHUNGEN ÜBER SCHAFMILCH UNTER VERSCHIEDENEN VRHÄLTNISSEN. *In* Jour. Landw., Jahrg. 29, p. 451–472. 1881.

TABLE I.—*Quantity and composition of ewes' milk*—Continued

Breed and No. of ewes.	Sample No.	Date of sampling.	Weight of ewe.	Total quantity of milk for 24-hour period.	Specific gravity.	Casein.	Albumin.	Nonprotein nitrogen.	Fat.	Lactose.	Ash.	Ash percentage of calcium and phosphorus in ash.	
												Calcium.	Phosphorus pentoxid.
HAMPSHIRE—con.			*Lbs.*	*Gm.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
33	1	Feb. 23	189	3,103	1.030	2.83	1.27	0.11	11.2	4.59	0.78	15.19	27.68
	2	Mar. 5	169	2,159	1.033	3.04	1.11	.09	6.0	4.83	.....	.....	.....
	3	Mar. 15	176	1,352	1.030	3.33	.59	.06	6.8	4.93	.....	.....	.....
	4	Mar. 25	168	1,505	1.032	2.88	.81	.09	6.8	4.86	.....	.....	.....
	5	Apr. 4	169	1,573	1.033	2.81	.82	.08	7.4	4.42	.....	.....	.....
Average			176	1,938.4	1.032	2.97	.92	.08	7.6	4.72	.78	15.19	27.68
SOUTHDOWN													
89	1	Feb. 23	129	1,747	1.031	3.11	1.14	.094	11.35	4.94	.76	15.39	23.78
	2	Mar. 8	127	1,383	1.027	3.24	1.04	.070	8.0	4.98	.....	.....	.....
	3	Mar. 15	128	988	1.034	4.03	.62	.067	5.6	4.97	.....	.....	.....
	4	Mar. 25	124	863	1.030	3.18	.86	.090	8.8	4.98	.....	.....	.....
	5	Apr. 4	126	753	1.034	3.60	.66	.030	7.4	4.73	.....	.....	.....
Average			127	1,146.8	1.031	3.43	.86	.070	8.2	4.92	.76	15.39	23.78
128	1	Feb. 26	110	1,754	1.040	2.51	.80	.064	5.2	5.02	.78	14.43	28.68
	2	Mar. 5	111	1,521	1.030	3.52	.88	.014	5.3	4.86	.....	.....	.....
	3	Mar. 18	111	1,368	1.033	3.73	.48	.064	8.0	4.97	.....	.....	.....
	4	Mar. 28	108	1,393	1.035	2.54	.67	.056	5.6	4.96	.....	.....	.....
	5	Apr. 7	104	1,317	1.034	4.01	.64	.078	7.0	4.59	.....	.....	.....
Average			109	1,470.6	1.034	3.26	.69	.060	6.2	4.88	.78	14.43	28.68
207	1	Mar. 10	136	1,551	1.035	3.25	.83	.120	7.6	4.01	1.19	12.22	20.96
	2	Mar. 20	133	1,262	1.035	3.72	.84	.070	8.0	4.72	.....	.....	.....
	3	Mar. 30	132	1,051	1.035	3.84	.77	.070	9.0	4.82	.....	.....	.....
	4	Apr. 9	134	895	1.037	3.76	.74	.030	7.9	3.94	.....	.....	.....
	5	Apr. 19	130	743	1.035	3.74	.91	.050	7.9	4.07	.....	.....	.....
Average			133	1,100.4	1.035	3.66	.82	.068	8.0	4.31	1.19	12.22	20.96
SHROPSHIRE													
752	1	Mar. 12	153	1,417	1.035	3.97	.65	.07	8.0	4.73	.95	17.03	27.31
	2	Mar. 22	156	1,596	1.035	2.83	.48	.08	8.4	4.83	.....	.....	.....
	3	Apr. 1	147	1,468	1.035	3.64	.65	.07	7.6	4.97	.....	.....	.....
	4	Apr. 11	142	1,037	1.035	3.66	.47	.06	7.8	4.07	.....	.....	.....
	5	Apr. 21	146	1,018	1.035	3.77	.56	.02	8.8	3.84	.....	.....	.....
Average			149	1,307.2	1.035	3.57	.56	.06	8.1	4.48	.95	17.03	27.31
366346	1	Mar. 15	167	2,602	1.034	3.98	.67	.09	6.4	4.88	.84	21,78	34.73
	2	Mar. 25	156	2,144	1.033	3.97	.72	.07	8.0	4.89	.....	.....	.....
	3	Apr. 4	156	2,148	1.034	3.95	.78	.09	6.4	4.73	.....	.....	.....
	4	Apr. 14	151	1,836	1.033	3.36	.88	.09	7.2	4.12	.....	.....	.....
	5	Apr. 24	150	1,524	1.039	3.34	.89	.07	8.0	3.82	.....	.....	.....
Average			156	2,050.8	1.034	3.72	.79	.08	7.2	4.48	.84	21.78	34.73
49	1	Mar. 14	159	1,499	1.030	3.37	.67	.066	7.2	5.10	.87	19.04	30.57
	2	Mar. 24	156	1,701	1.037	3.06	.88	.042	10.4	4.90	.....	.....	.....
	3	Apr. 3	153	1,088	1.030	3.11	.89	.092	9.6	4.73	.....	.....	.....
	4	Apr. 13	149	996	1.032	3.08	.92	.09	8.8	4.22	.....	.....	.....
	5	Apr. 23	149	924	1.034	2.98	.96	.09	9.6	3.91	.....	.....	.....
Average			153	1,241.8	1.032	3.12	.86	.076	9.1	4.57	.87	19.04	30.57
LINCOLN													
1940	1	Feb. 21	192	1,528	1.013	2.98	.81	.06	10.8	4.72	.82	16.95	28.62
	2	Mar. 3	191	1,456	1.036	2.88	.89	.043	9.0	4.71	.....	.....	.....
	3	Mar. 13	191	1,193	1.027	3.28	.56	.076	7.2	4.89	.....	.....	.....
	4	Mar. 23	186	1,191	1.025	2.98	.83	.087	8.0	4.82	.....	.....	.....
	5	Apr. 2	188	1,180	1.026	2.83	.52	.073	8.8	4.73	.....	.....	.....
Average			189	1,309.6	1.023	2.97	.72	.067	8.8	4.77	.82	16.95	28.62

TABLE I.—*Quantity and composition of ewes' milk*—Continued

Breed and No. of ewes.	Sample No.	Date of sampling.	Weight of ewe.	Total quantity of milk for 24-hour period.	Specific gravity.	Casein.	Albumin.	Nonprotein nitrogen.	Fat.	Lactose.	Ash.	Ash percentage of calcium and phosphorus in ash, Calcium.	Ash percentage of calcium and phosphorus in ash, Phosphorus pentoxid.
LINCOLN—contd.			*Lbs.*	*Gm.*		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1913	1	Feb. 27	187	1,955	1.033	2.92	1.12	.101	7.6	4.74	0.67	15.20	27.56
	2	Mar. 9	179	1,569	1.033	3.22	.84	.062	6.0	4.72	.....	.....	.....
	3	Mar. 19	176	1,441	1.033	2.98	.58	.059	6.9	4.87	.....	.....	.....
	4	Mar. 29	176	1,274	1.035	3.39	.95	.077	6.4	4.60	.....	.....	.....
	5	Apr. 8	176	1,482	1.035	3.38	.91	.078	7.4	4.70	.....	.....	.....
Average			179	1,544.2	1.033	3.17	.88	.075	6.8	4.72	.67	15.20	27.56
1996	1	Feb. 24	193	1,574	1.032	2.60	1.19	.100	9.6	4.75	.80	14.73	29.13
	2	Mar. 6	180	1,313	1.032	2.67	1.26	.084	7.2	4.85	.....	.....	.....
	3	Mar. 16	182	735	1.029	3.66	.45	.037	11.4	4.93	.....	.....	.....
	4	Mar. 26	185	481	1.030	3.25	.40	.011	8.2	5.12	.....	.....	.....
	5	Apr. 5	175	506	1.032	3.35	.39	.032	8.2	4.30	.....	.....	.....
Average			183	921.8	1.031	3.10	.73	.053	8.9	4.79	.80	14.73	29.13
RAMBOUILLET													
36	1	Feb. 12	136	1,918	1.033	3.63	.86	.062	10.05	4.82	.91	18.49	29.38
	2	Feb. 22	131	1,391	1.037	3.62	.75	.029	11.9	4.78	.....	.....	.....
	3	Mar. 4	130	1,347	1.032	4.75	.52	.048	9.6	5.00	.....	.....	.....
	4	Mar. 14	130	1,131	1.034	4.22	1.23	.037	9.6	4.60	.....	.....	.....
	5	Mar. 24	131	1,112	1.033	4.58	.84	.070	8.2	4.68	.....	.....	.....
Average			132	1,379.8	1.034	4.16	.84	.059	9.8	4.77	.91	18.49	29.38
59	1	Feb. 26	156	2,582	1.039	3.42	.98	.110	7.4	5.00	.80	16.64	31.08
	2	Mar. 8	151	2,113	1.032	3.05	.95	.019	6.8	4.97	.....	.....	.....
	3	Mar. 18	149	1,766	1.040	3.40	.48	.064	6.4	5.08	.....	.....	.....
	4	Mar. 28	147	1,706	1.034	3.17	.74	.062	5.9	5.07	.....	.....	.....
	5	Apr. 7	144	1,758	1.033	3.59	.51	.029	7.0	4.56	.....	.....	.....
Average			149	1,985	1.035	3.32	.73	.056	6.7	4.93	.80	16.64	31.08
74	1	Feb. 28	169	1,525	1.042	3.64	.94	.067	3.4	4.71	.86	19.64	32.47
	2	Mar. 10	167	1,262	1.030	3.45	1.27	.054	9.6	4.76	.....	.....	.....
	3	Mar. 20	160	1,140	1.034	3.25	.72	.091	6.4	4.79	.....	.....	.....
	4	Mar. 30	164	880	1.037	2.96	.58	.057	8.0	4.75	.....	.....	.....
	5	Apr. 9	165	802	1.034	3.45	.86	.062	8.2	4.00	.....	.....	.....
Average			165	1,121.8	1.035	3.34	.87	.066	7.1	4.60	.86	19.64	32.47

A study of Table I brings out the fact that there is a great variability in the percentages of the constituents of ewes' milk. Not only is this true among the different breeds, but also during the lactation period of the individual. The most constant constituent in the milk of all breeds examined appears to be lactose, while fat seems to be the most variable. The difference in the percentages of fat is very marked, not only between the breeds, but during the lactation period of the individual. These observations are in harmony with the results secured by Ritzman,[1] who also found that the fat varied at different lactation periods of individual ewes and who concluded that—

No great reliance can be placed on single tests of an individual, and that a test must either cover a larger number of periods during one lactation of an individual or that

[1] RITZMAN, E. G., 1917. OP. CIT., p. 31.

it must cover an average of a large number of individuals at one period, in order to be representative.

When the average percentages of fat for the five lactation periods of each ewe are determined and compared, the variation of fat content is not so marked, which indicates clearly the value of a number of tests rather than one single test on an individual.

TABLE II.—*Average quantity and composition of milk for each ewe and for each breed*

Breed and No. of ewe.	Average total quantity of milk for 24-hour periods.	Specific gravity.	Composition of milk.					
			Casein.	Albumin.	Nonprotein.	Fat.	Lactose.	Ash.
COTSWOLD								
	Gm.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2518	1,585	1.034	3.32	0.81	0.065	7.3	4.73	0.87
753	1,965	1.032	3.04	.68	.058	7.7	5.00	.77
2097	1,124.8	1.033	2.96	.72	.072	8.1	4.62	.84
Average	1,558	1.033	3.10	.74	.065	7.7	4.78	.82
HAMPSHIRE								
50	2,479	1.031	3.13	.71	.061	6.0	4.74	.81
33	1,938.4	1.032	2.97	.92	.080	7.6	4.72	.78
30	2,093	1.032	3.09	.59	.069	7.6	4.74	.76
Average	2,170	1.032	3.06	.74	.070	7.1	4.73	.78
LINCOLN								
1940	1,309.6	1.023	2.97	.72	.067	8.8	4.77	.82
1996	921.8	1.033	3.17	.88	.077	6.8	4.72	.67
1913	1,544.2	1.025	3.10	.73	.053	8.9	4.79	.80
Average	1,258	1.027	3.08	.77	.065	8.1	4.76	.76
RAMBOUILLET								
36	1,379.8	1.039	4.16	.84	.059	9.8	4.77	.91
59	1,985	1.035	3.32	.73	.056	6.7	4.93	.80
74	1,121.8	1.035	3.34	.87	.066	7.1	4.60	.86
Average	1,495	1.036	3.60	.81	.078	7.8	4.77	.85
SOUTHDOWN								
89	1,146.8	1.031	3.43	.86	.070	8.2	4.92	.76
128	1,470.6	1.034	3.26	.69	.060	6.2	4.88	.78
207	1,100.4	1.035	3.66	.82	.068	8.0	4.31	1.19
Average	1,238	1.033	3.45	.79	.066	7.5	4.70	.91
SHROPSHIRE								
752	1,307.2	1.035	3.57	.56	.06	8.1	4.48	.95
366346	2,050.8	1.034	3.72	.79	.08	7.2	4.48	.84
49	1,241.8	1.032	3.12	.86	.07	9.1	4.57	.87
Average	1,532	1.033	3.47	.77	.07	8.1	4.50	.88

Tables II and III are given for convenience of comparison of the average yield and the average analysis of the milk for the 50-day period. Table II gives the averages for the three individual ewes of each breed, and the average of these averages is represented in Table III as the average for the breed.

TABLE III.—*Average quantity and composition of milk for each breed*

Name of breed.	Average total quantity of milk for 24-hour periods.	Specific gravity.	Composition of milk.					
			Casein.	Albumin.	Nonprotein.	Fat.	Lactose.	Ash.
	Gm.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Hampshire	2,170	1.032	3.06	0.74	0.070	7.1	4.72	0.78
Cotswold	1,558	1.033	3.10	.74	.065	7.7	4.45	.82
Shropshire	1,532	1.033	3.47	.77	.007	8.1	4.50	.88
Rambouillet	1,495	1.036	3.60	.81	.078	7.8	4.77	.85
Lincoln	1,258	1.027	3.08	.77	.065	8.1	4.76	.76
Southdown	1,238	1.033	3.45	.79	.066	7.5	4.70	.91

Table III brings out clearly the differences in milk yields for the different breeds. The Hampshire ewes in this experiment easily ranked first in quantity of milk produced, while the differences in the other five breeds were not so great.

TABLE IV.—*Initial weight of lambs and their gain during each 10-day period*

Breed and No. of ewe.	Number of lambs.	Initial weight of lambs.		Amount of weight gained by lambs each 10-day period.		
		First.	Second.	First.	Second.	Total.
SHROPSHIRE		*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
752	1	4,294	.....	2,392	.....	2,392
				2,468	.....	2,468
				2,902	.....	2,902
				2,032	.....	2,032
				1,957	.....	1,957
Total gain 50 days	.....	.....	.....	11,751	.....	11,751
366346	2	3,955	4,407	2,535	2,518	5,053
				2,110	2,304	4,414
				1,372	1,452	2,824
				1,644	1,637	3,281
				1,522	1,374	2,896
Total gain 50 days	.....	.....	.....	.....	.....	18,468
49	2	3,503	3,277	1,682	1,888	3,570
				1,139	1,085	2,224
				1,395	1,023	2,418
				1,360	977	2,337
				751	761	1,511
Total gain 50 days	.....	.....	.....	.....	.....	12,060
LINCOLN						
1940	1	5,311	.....	2,507	.....	2,507
				2,269	.....	2,269
				2,296	.....	2,296
				2,089	.....	2,089
				2,111	.....	2,111
Total gain 50 days	.....	.....	.....	11,272	.....	11,272

TABLE IV.—*Initial weight of lambs and their gain during each 10-day period*—Contd.

Breed and No. of ewe.	Number of lambs.	Initial weight of lambs.		Amount of weight gained by lambs each 10-day period.		
		First.	Second.	First.	Second.	Total.
LINCOLN—continued		*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
1913	1	5,650	.....	3,003	.....	3,003
				2,754	.....	2,754
				2,256	.....	2,256
				2,286	.....	2,286
				1,782	.....	1,782
Total gain 50 days	.....	.....	.....	12,081	.....	12,081
1996	1	5,424	.....	2,463	.....	2,463
				2,078	.....	2,078
				[a] 844	.....	[a] 844
				696	.....	696
				702	.....	702
Total gain 50 days	.....	.....	.....	6,783	.....	6,783
RAMBOUILLET						
36	1	5,085	.....	2,189	.....	2,189
				3,114	.....	3,114
				2,117	.....	2,117
				2,395	.....	2,395
				1,681	.....	1,681
Total gain 50 days	.....	.....	.....	11,496	.....	11,496
59	2	4,181	4,181	2,526	2,230	4,756
				249	1,969	2,218
				1,140	1,722	2,862
				770	1,681	2,451
				1,612	1,423	3,035
Total gain 50 days	.....	.....	.....	.....	.....	16,092
74	2	3,616	3,390	1,427	937	2,364
				542	598	1,140
				992	780	1,772
				755	795	1,550
				1,012	1,227	2,239
Total gain 50 days	.....	.....	.....	.....	.....	9,065
COTSWOLD						
2518	2	4,633	4,520	2,431	2,318	4,749
				1,527	1,587	3,114
				1,305	1,566	2,871
				1,260	1,363	2,623
				1,222	1,152	2,374
Total gain 50 days	.....	.....	.....	.....	.....	15,731
753	1	4,068	.....	3,696	.....	3,696
				3,549	.....	3,549
				2,976	.....	2,976
				2,995	.....	2,995
				2,191	.....	2,191
Total gain 50 days	.....	.....	.....	15,407	.....	15,407

[a] Lamb sick, did not thrive.

TABLE IV.—*Initial weight of lambs and their gain during each 10-day period*—Contd.

Breed and No. of ewe.	Number of lambs.	Initial weight of lambs.		Amount of weight gained by lambs each 10-day period.		
		First.	Second.	First.	Second.	Total.
COTSWOLD—continued		*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*
2097	1	5,650	.....	2,945	.....	2,945
				1,861	.....	1,861
				1,561	.....	1,561
				1,646	.....	1,646
				1,796	.....	1,796
Total gain 50 days				9,809	.....	9,809
HAMPSHIRE						
30	2	5,424	3,503	1,932	1,679	3,611
				2,919	2,479	5,398
				1,937	1,149	3,086
				2,308	1,527	3,835
				1,934	822	2,756
Total gain 50 days						18,686
50	2	4,407	4,859	3,735	3,338	7,073
				2,213	2,202	4,415
				1,598	2,073	3,681
				2,061	2,275	4,336
				1,416	2,315	3,731
Total gain 50 days						23,236
33	1	4,294	.....	6,349	.....	6,349
				3,814	.....	3,814
				2,769	.....	2,769
				2,835	.....	2,835
				2,317	.....	2,317
Total gain 50 days				18,084	.....	18,084
SOUTHDOWN						
89	1	4,294	.....	2,764	.....	2,764
				2,752	.....	2,752
				2,239	.....	2,239
				1,864	.....	1,864
				982	.....	982
Total gain 50 days				10,601	.....	10,601
128	1	4,068	.....	2,995	.....	2,995
				2,443	.....	2,443
				2,592	.....	2,592
				1,950	.....	1,950
				1,789	.....	1,789
Total gain 50 days				11,769	.....	11,769
207	2	3,616	3,503	1,503	1,555	3,058
				983	1,280	2,263
				815	1,207	2,022
				886	1,524	2,410
				1,247	1,483	2,730
Total gain 50 days						12,483

In Table IV data are given on the initial weight of the lamb or lambs and the gain in weight every 10 days during the period of the experiment. The total gain is also included.

Table V is a combination of the results on total milk yield and the total constituents of the milk, expressed in grams, calculated from the average percentages secured on the 50-day period, and also data on the total gain in weight of the lambs.

Table VI gives the averages of the above constituents for each breed.

TABLE V.—*Relation of Milk Constituents of Individual Ewes to Growth of Lambs*

Breed and No. of ewe.	Total quantity of milk.	Total casein.	Total albumin.	Total non-proteids.	Total fat.	Total lactose.	Total ash.	Weight at birth.		Number of lambs to ewe.	Total growth.
								Lamb No. 1.	Lamb No. 2.		
HAMPSHIRE	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*		*Gm.*
30	104,650	3,237	617	72	7,953	4,960	795	5,424	3,505	[a] 2	21,764
50	123,950	3,897	880	76	7,437	5,974	1,004	4,407	4,859	2	23,236
33	96,920	2,878	891	77	7,375	4,574	756	4,294	.....	1	18,084
Average	108,506.6	3,331	796	75	7,585	5,126	852	.....	.....	.....	21,028
COTSWOLD											
753	98,250	2,987	668	57	7,565	4,912	756	4,068	.....	1	15,407
2518	79,250	2,631	642	52	5,785	3,748	689	4,633	4,520	2	17,731
2097	56,240	1,664	405	40	4,555	2,588	472	5,650	.....	1	9,809
Average	77,913.3	2,427	572	50	5,968	3,749	639	.....	.....	.....	14,318
RAMBOUILLET											
36	68,990	2,870	579	41	6,761	3,280	627	5,085	3,842	[b] 1	13,078
59	99,250	3,295	705	56	6,650	4,913	794	4,181	4,181	2	15,322
74	56,090	1,873	487	37	3,982	2,680	482	3,616	3,390	2	9,065
Average	75,110	2,677	590	45	5,797	3,624	634	.....	.....	.....	12,488
LINCOLN											
1940	65,450	1,944	471	44	5,650	3,122	537	5,311	.....	1	11,272
1913	77,210	2,393	564	41	6,871	3,698	618	5,424	.....	1	12,081
1996	46,090	1,461	406	35	3,135	2,176	309	5,650	.....	1	6,783
Average	63,250	1,933	480	40	5,219	2,999	388	.....	.....	.....	10,045
SOUTHDOWN											
89	57,340	1,967	493	40	4,702	2,821	435	4,294	.....	1	10,601
128	73,530	2,397	507	51	5,559	3,588	573	4,068	.....	1	11,769
207	55,020	2,013	451	37	4,401	2,371	654	3,616	3,503	2	12,483
Average	61,963.3	2,136	484	43	4,554	2,926	554	.....	.....	.....	11,618
SHROPSHIRE											
753	65,360	2,333	366	39	5,294	2,928	621	4,294	.....	1	11,751
366346	102,540	3,814	810	82	7,382	4,594	861	3,955	4,407	2	18,468
49	62,090	1,937	534	43	5,650	2,837	540	3,503	3,277	2	12,060
Average	76,663.3	2,695	570	55	6,109	3,452	675	.....	.....	.....	14,093

[a] Ewe had triplets, one was taken away on ninth day.
[b] Lamb had leg broken on ninth day and was removed.

In a comparison of the total quantity of milk constituents and the total growth of the lambs there is one disturbing factor. In all breeds, with the exception of the Lincoln, twins were born to one or more ewes in each breed, and in one case triplets. The three Lincoln ewes all gave birth to single lambs. It is obvious that in comparison of quantity

of milk and growth of lambs the best experimental results in this investigation would have been obtained if all ewes were allowed to raise only one lamb. In future work it is hoped that this condition may be fulfilled. However, many factors prevented such an arrangement. At the time of this investigation, which is an outgrowth of a more extended investigation on sheep, it was desired to make the work correspond as closely as possible to the actual conditions found in sheep husbandry, and other data were collected besides those included in this paper.

TABLE VI.—*Relation of Milk Constituents of Breeds to Growth of Lambs*

Breed.	Total quantity of milk.	Total casein	Total albumin.	Total non-proteids.	Total fat.	Total lactose.	Total ash.	Number of lambs to ewes.	Total growth.
	Gm.	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*	*Gm.*		*Gm.*
Hampshire	108,506.6	3,331	796	75	7,585	5,126	852	5	21,028
Cotswold	77,913.3	2,427	572	50	5,968	3,749	639	4	14,318
Shropshire	76,636.3	2,695	570	55	6,107	3,452	674	5	14,093
Rambouillet	75,110	2,677	590	45	5,797	3,624	634	5	12,488
Lincoln	63,250	1,933	480	40	5,219	2,999	388	3	10,045
Southdown	61,963.3	2,136	484	46	4,554	2,926	554	4	11,618

It is quite evident that twin lambs, given a sufficient quantity of milk, will make a greater total gain than a single lamb, provided their initial weights correspond and they are equally strong at birth. A certain amount of milk is essential for the growth of a lamb, but on the other hand there is a limit to the amount of milk that an animal can assimilate. Therefore, two lambs, given a sufficient quantity of milk, will have an advantage in total gain over a single lamb. The single lamb, however, is generally larger than either of the twin lambs at birth, but from an economical standpoint it is obvious that twins are more desirable in the flock than singles.

A compilation of the data on the Hampshire breed shows the single lamb of ewe No. 33 gained nearly as much in the same period of time as the twin lambs of ewe No. 30. A comparison of the total yield of milk shows ewe No. 33 produced slightly less than ewe No. 30.

In the Cotswold breed we have ewe No. 753 giving more than either of the other two ewes, and the single lamb has made a gain almost equal to the gain of the twin lambs of ewe No. 2518. Ewe No. 2518 has twin lambs, and their total gain is only slightly greater than the single lamb of ewe No. 753. The third ewe, No. 2097, shows a smaller milk yield than ewe No. 2518 with the twin lambs, and the gain of her single lamb is a little more than one-half as much as the total gain of the twin lambs. In the Rambouillet and Southdown breeds we find the total gain in weight of the lambs is proportional to the amount of milk consumed. In the Lincoln breed, the only breed where there are three single lambs, their gain in weight is also proportional to the quantity of milk consumed. However, the lamb belonging to the Lincoln ewe, No. 1996, became sick at the end of 20 days and did not thrive thereafter.

It appears from this experiment that the greatest factor in growth is quantity of milk; hence, a high-milk-producing ewe is more valuable than a low one. The inherited capacity for growth, however, must not be overlooked. As to the relative merits of the breeds, it is not the purpose of this investigation to enter upon a discussion. To draw conclusions upon such a small number of ewes in each breed would be unfair. It was the aim of this experiment to make the investigation as fair as possible to all breeds studied, and the authors desire to emphasize clearly the fact that results upon the different breeds are given wholly as an attempt to correlate milk yields, their composition, and their relation to growth. The results are not given with an idea of comparing the desirability or undesirability of the breeds included in this experiment, but rather for the purpose of presenting to the farmer and student information in regard to features of certain well-known breeds that have to do with utility and adaptation to certain specific purposes. For example, the man interested in the growth of lambs for early marketing would be interested in a breed that by its yield of milk, and possibly certain other factors, made the greatest average growth of lambs. Another purpose of the experiment is to stimulate the interest of investigators and students of animal breeding in the field for the improvement of certain breeds with reference to factors having to do with profit for the grower. There might even be room for a new breed that would possess all the desirable and highly useful factors of some of the breeds included in this experiment.