Onderstepoort Journal of Veterinary Science and Animal Industry, Volume 4, Number 2, April, 1935.

Rearing Dairy Calves.

By L. L. ROUX, B.Sc., M.Sc.(Illinois), Animal Husbandry Research Officer, Ermelo.

INTRODUCTION.

NORMAL growth of dairy calves is desired whether the object is to rear stud stock, or to produce heifers from grade cows for the purpose of selling or using them as replacement material in a commercial herd.

Herd improvement can be achieved only by systematic breeding and this involves the rearing of normal healthy calves out of the best cows, which have been sired by a well selected, pure bred bull. The full value of this system of herd improvement is not obtained when the progeny of good cows is sold and lost sight of, slaughtered, or not reared to the best advantage. Furthermore, as it is more than likely that restrictions against the selling of dairy products from unclean herds will be extended, it is important that calves out of good milking herds free from disease, such as tubeculosis and contagious abortion, should be well reared.

Breeders of pure bred dairy stock are, generally, well versed in methods of rearing calves, but it may, in certain instances, be found possible to reduce the cost of production by economical methods without inhibiting normal growth.

Dairymen who sell cream and who have skim milk available are in the most favourable position to rear calves, as the supplementary feeds required in conjunction with skim milk can either be grown or be obtained at reasonable prices. It would be of interest to such dairymen to know what supplementary feeds are most suitable and what quantities of milk are required. A surplus of skim milk may mean either the rearing of more calves, or the undertaking of another enterprise such as poultry or pigs.

Dairymen who sell whole milk are in a much less favourable position to rear calves, as the price obtained for whole milk does not warrant it being used for calf rearing; consequently, the calves are disposed of as soon as possible. However, calves may be satisfactorily reared on a surprisingly small quantity of whole milk, provided suitable substitutes are fed.

The buying up of calves from dairymen who are unable to rear them, should attract considerable attention; this should prove a lucrative enterprise when calves out of good healthy herds can be obtained and the art of management and feeding is understood. The larger city markets generally have good supplies of suitable dairy calves, but the difficulty and the cost of transporting calves only a few days old for long distances, are the handicaps in the development of this enterprise.

HISTORICAL SURVEY.

The rearing of calves on whole milk only is too costly an undertaking; consequently, all methods of hand-rearing calves aim at the use of a minimum amount of whole milk, which at first is supplemented and subsequently entirely replaced by skim milk or meals.

In spite of the fact that whole milk is a complete feed for the young calf, it is inadvisable to continue feeding milk alone beyond a certain period. McCandish (1924) found that while whole milk alone was not a good ration for calves, milk and grain was even poorer, as the grains added so much magnesium that the calcium used in the removal of the magnesium had to be drawn from the body stores. However, the addition of lucerne hay to the milk and grain ration led to a positive calcium balance; also, the bulk of the hay affected a normal distension of the rumen and other parts of the digestive tract.

Otis (1905) states that cows that are milked give larger yields than when suckling calves and the higher the yielder, the greater the profits. He gives interesting data in comparing the three forms of rearing dairy calves, the main features of which are presented in the following table:—

Experiment.	Number of calves.	Days fed.	Average gain per head (lb.).	Daily gain per head (lb.).	Cost per 100 lb. gain in dollars.
1. Skim Milk.....	10	154	233	1·51	2·26
2 Whole Milk....	10	154	287	1·86	7·06
3 Running with dams.....	22	140	248	1·77	4·41

Although the smallest gains were made by the skim milk fed calves, a daily gain of 1·51 lb. is satisfactory; moreover, the cost of this gain was half as much as that for the calves running with their dams, and less than a third of the cost of the whole milk fed calves. It is stated that the amounts of grain consumed by the three groups were 439, 470 and 475 lb. respectively.

In connection with the above experiment, the author compares the nutritive values of skim and whole milk by giving the following table:—

Digestive Nutrients, Percentage.

(From Henry's "Feeds and Feeding.")

	Dry matter in 100 lb.	Digestible nutrients in 100 lb.		
		Protein.	Carbohydrates.	Ether extract.
Skim Milk.....	9·4	3·9	5·2	0·3
Whole Milk.....	12·8	3·6	4·9	3·7

It is pointed out that skim milk is rich in protein and therefore a good tissue forming feed; also, that the loss of fat in skim milk may be replaced satisfactorily for calf rearing by supplementing with grain feeding.

Although skim milk is generally the most plentiful form of milk available for calf rearing, it is well to mention here that other forms of milk have been tried. Otis, previously quoted, states that calves may be successfully reared on butter milk, but that calves thus reared are inferior to skim milk reared calves and the former require more grain per 100 lb. gain. Eckles (1919) states that whey contains about one-fourth as much protein as skim milk and the feeding of one-half pound of oil meal in one gallon of whey well mixed and fed as skim milk is advocated. Also, calves to be reared on whey should be fed on whole milk for at least six weeks before being put on to whey. White and Kuelling (1919) found that 5 per cent. milk diluted to 25 per cent. dilution and fed with good grain rations and hay, produced 1 to 1·4 lb. in gain per head per day, but calves thus fed were not equal in appearance to skim milk fed calves.

In connection with the quantities of milk required for rearing dairy calves, Eckles, previously quoted, cites experimental data to indicate that as little as 90 lb. of whole milk can be used when rearing calves on skim milk, although generally 200 lb. or more are fed. He states that usually 2,300 to 3,000 lb. of skim milk are fed and that, while calves thus fed can be reared without grain, it is customary to feed up to 150 lb. per calf during the first six months.

Hunziker and Caldwell (1916) compared a group of whole milk fed calves with a group fed skim milk. A supplementary home-mixed calf meal (containing hominy feed, linseed meal, red dog flour, and dried blood) was fed to the whole milk group, while both groups received ground maize and oats as a dry mash in addition to lucerne hay and a small quantity of silage. The following table of average feed consumptions has been compiled from the data given.

	Whole milk.	Skim milk.	Home-mixed meal.	Dry mash.	Lucerne hay.	Silage.
1. Whole Milk Group.....	214·0	—	244·1	154·0	397·7	40·8
2. Skim Milk Group	131·3	2,022·4	—	178·7	455·7	61·1

In the above experiment, the average daily gains were 0·95 lb. and 1·21 lb. respectively. The authors conclude that, for a ration to be an unqualified success, it should produce an average of at least one pound of gain per day during the first six months of the life of the calf.

More satisfactory results with meals as substitutes for whole milk are mentioned by Eckles, previously quoted, as having been obtained at the Pennsylvania and Massachusetts Experiment Stations

by feeding a limited amount of whole milk which was entirely replaced by a meal in from ten to fourteen days. The most satisfactory substitutes consisted of: 30 lb. wheat flour, 25 lb. cocoanut meal, 20 lb. nutrium, 10 lb. oil meal, and 10 lb. dried blood. The average consumption per calf during eighty-three days was 121 lb. whole milk and 186 lb. meal. During the first six months, an average daily gain of 1·25 lb. may be expected with this meal.

Bender and Bartlett (1929) report 100 per cent. normal height and 101·2 per cent. normal weight in rearing dairy calves to six months of age without the use of skim milk and the feeding of a limited amount of whole milk for a period of 30 days. During the first week, the calves received only whole milk; meal and lucerne hay were available during the second week; whole milk reduction was commenced from the third week; and at the end of the fourth week, whole milk feeding was stopped and the calves were fed meal, lucerne hay and water. The meal mixture consisted of: 25 lb. yellow maize meal, 37·5 lb. ground oats, 12·5 lb. wheat bran, 12·5 lb. linseed oil meal, 12·5 lb. blood flour, and 3 per cent. minerals (1 lb. bone meal, 1 lb. pulverised limestone, and 1 lb. salt). The meal and the lucerne hay were fed *ad lib.* The average daily gain in weight was 1·56 lb. and the feed consumption was 2·92 lb. of meal per 1 lb. gain in weight. Unfortunately the milk consumption is not given in the report of the experiment.

As previously stated, Eckles (1919) recommends that a certain amount of grain should be fed to skim milk reared calves. Also, it is advised that, if maize is the only grain fed to skim milk reared calves, an advantageous change may be made as the calves approach weaning time by introducing oats, bran or oil meal into the ration.

The choice of grains to be fed in conjunction with skim milk depends upon their availability and cost. Mead (1929) states that the grains, barley oats and maize are well suited for the purpose because the milk protein adequately supplements those of the grains which in turn furnish the feed value removed in the butterfat. Henry and Morrison (1923) quote the experience of Fain and Jarnagin and Cottrell, Otis and Honey with grain sorghums, which were considered to be well suited to feed with skim milk to calves. Curtiss (1897) found pure maize meal superior to oil meal when fed with skim milk as oil meal gave lower and more expensive gains. Wande (1928) in feeding maize meal and crushed monkey nuts in conjunction with skim milk, found that, while the ration gave satisfactory growth, the feed costs were 60·4 per cent. of the total costs, and he concluded that crushed monkey nuts at 25s .per 100 lb. made the ration unsatisfactory from an economic point of view.

The form in which grains should be fed to calves is frequently questioned. In the work of Otis, previously referred to, it is stated that, preferably, calf meals should be fed dry as, when mixed with a fluid, the saliva of the mouth is not given a chance to act on the starch of the meals. While shelled maize may be fed after calves are well started on eating grain, kaffir corn is best ground. Otis is also of the opinion that there is no great advantage in giving a large variety of grains to skim milk fed calves.

With regard to the feeding of hays the above writer is of the opinion that, while lucerne and clover hays are splendid for young calves, they are too loosening and that tame hay from mixed grasses is probably best, although the former hays should be introduced as soon as the calves can properly handle them.

Murray (1929) considered the feeding of teff hay satisfactory when the calves were permitted to graze during part of the day.

Hays may be fed in various forms to calves. The results of trials in which the feeding of different forms of lucerne hay was carried out at the Oregon State Agricultural College (1931), are indicated in the following table:—

	Long hay.	Chopped hay.	Hay meal.
	lb.	lb.	lb.
Daily refuse.....	1·0	0·2	0·0
Daily consumption.....	13·4	12·7	16·0
Daily grain consumed.....	4·6	4·6	4·2

In connection with the feeding of long lucerne hay, general observation reveals that, provided hay is fed in suitable racks, the wastage of good quality lucerne hay is small and the wastage decreases as the calves grow older.

It is of interest to know of what value maize silage is in a calf-rearing ration. In the work of Hunziker and Caldwell, previously referred to, silage was included in the rations but the amounts consumed were very small. White and Kuelling (1919) considered that the inclusion of silage in the ration of calves did not cheapen the cost per pound gain and they remarked that, when calves take to silage at three and four months of age, it is necessary to restrict the amounts consumed so as to induce them to eat grain which has more growing power.

The feed schedules followed by investigators are based upon the feed requirements of the calves at various ages. Such minute details as reported by Hunziker and Caldwell (1916) are of immense value in constructing such schedules. From the data of these authors, it is possible to compute the weekly nutritive requirements of dairy calves at various ages. Murray (1929) gives a weekly feed schedule which was adopted with success at the School of Agriculture, Potchefstroom. Variations of this schedule have been utilized at that and other institutions in this country.

PLAN OF THE EXPERIMENT.

A calf rearing experiment was conducted at the Veterinary Research Laboratory, Ermelo, in 1932. The object of the investigation was to determine the suitability of a compound concentrate ration as a substitute for whole milk and to compare the results with those obtained from a skim milk ration in conjunction with which maize was fed.

The details of the feeding schedules of the two groups of calves for the experimental period of twenty-six weeks are given below in terms of per calf per day:—

Group I.—Fed Whole Milk Ration.

1st to 3rd day: Nursed by dams.
4th to 7th day: 7·5 lb. dam's whole milk.
2nd and 3rd weeks: 7·5 lb. whole milk.
4th to 6th week: 10 lb. whole milk plus ½ lb. to 1 lb. grain mixture.
7th to 8th week: 7·5 lb. whole milk plus 1 to 1¼ lb. grain mixture.
9th to 10th week: 5 lb. whole milk plus 1½ lb. grain mixture.
11th week: 2·5 lb. whole milk plus 1½ lb. grain mixture.
12th to 26th week: No milk. 2 to 4½ lb. grain mixture.

The grain mixture fed to Group I consisted of:—
32 lb. finely crushed yellow maize.
6 lb. wheat bran.
4 lb. peanut meal.
2 lb. blood meal.
5 per cent. of 2 parts bone meal and 1 part salt.

Hay ration: Good quality lucerne hay was offered from the third week.

Group II.—Fed Skim Milk Ration.

1st to 3rd day: Nursed by dams.
4th to 7th day: 7·5 lb. dam's whole milk.
2nd week: 7·5 lb. whole milk.
3rd week: 10 lb. whole milk.
4th week: 10 lb. whole milk plus 2·5 lb. skim milk.
5th week: 7·5 lb. whole milk plus 5 lb. skim milk.
6th week: 5 lb. whole milk plus 7·5 lb. skim milk.
7th week: 2·5 lb. whole milk plus 10 lb. skim milk.
8th week: 15 lb. skim milk plus 1 lb. grain mixture.
9th to 20th week: 15 lb. skim milk plus 1 to 3½ lb. grain mixture.
21st week: 10 lb. skim milk plus 4 to 4½ lb. grain mixture.
22nd week: 7·5 lb. skim milk plus 4 to 4½ lb. grain mixture.
23rd week: 5 lb. skim milk plus 4 to 4½ lb. grain mixture.
24th week: 2·5 lb. skim milk plus 4 to 4½ lb. grain mixture.
25th week: 1·25 lb. skim milk plus 4 to 4½ lb. grain mixture.
26th week: 1·25 lb. skim milk plus 4 to 4½ lb. grain mixture.

The grain mixture fed to Group II consisted of:—
Very finely crushed yellow maize and 5 per cent. of 2 parts bone meal and 1 part salt up to the 22nd week.

Thereafter the mixture was altered to:—

85 lb. very finely crushed yellow maize.

15 lb. peanut meal.

5 per cent. of 2 parts bone meal and 1 part salt.

Hay ration: Good quality lucerne hay was offered from the third week.

The experimental period of each calf terminated at twenty-six weeks of age, when the calves were put out on pasture with no supplementary feeding with the exception of a bone meal and salt lick. The period on pasture from the twenty-seventh to the fifty-second week is referred to in the text as the post-experimental period.

Experimental Animals.

The twenty calves used in the two groups were born on the Experiment Station; they were the first calves out of good grade Friesland cows by a pure-bred Friesland bull. The great majority of the calves were born during April, 1932.

Alternate calves, in order of birth, were placed in Group I, or the whole milk group, and the remainder in Group II, or the skim milk group.

Management, Housing and Exercise.

All calves were removed from their dams when three days old, after which they were continued on their dam's milk for four days.

As the date of birth of each calf was known, the alterations to rations of individual calves were made according to the details of the feeding schedules. When the birth date of calves varied only by a few days, the alterations to their rations were made on the same date after such calves were about two months old. This was done to concentrate all ration changes on a particular day, the weekly day of weighing the calves. Milk rations were fed thrice daily until the calves were four weeks old, thereafter milk was fed twice daily until milk rations fell below five pounds, when milk was fed once daily. All milk was fed sweet and at approximately blood heat.

The calves were housed in a semi-open shed which was well ventilated yet warm during cold nights. The pen of each group of calves was fitted with stanchions for the feeding of individual calves, while a hay rack in each pen made it possible to have hay available at night to minimise the tendency of calves eating bedding. The milk and meal rations were fed in buckets to individual calves locked in the stanchions.

Water was available to the young calves in the pens. When calves became three weeks old they were let out daily to an exercise camp. Clean trough water was available in passing to and from the camp, which was situated about three hundred yards from the calf-shed. The camp supplied plenty of shade, no grazing was available.

Hay rations were fed in the camp at 8.30 a.m. and 2 p.m. daily. The accompanying photograph indicates the type of rack used. It will be noticed that a wide trough was constructed under the rack for the purpose of collecting the finer portions of the hay which generally fall through the sections of a rack; the wide trough permitted the calves to clean up the finer portions of the hay from both sides.

Groups I and II.—Calves 4 to 5 months old in exercise camp.

All calves were dehorned when approximately two months old, and male calves were castrated with a Burdizzo at about three months of age. All calves were tested for tuberculosis when about five months old; there were no reactors. No serious illnesses occurred during the course of the experiment. A few of the calves of both groups scoured slightly during the earlier part of the experiment, but little difficulty was experienced in overcoming this by reducing the rations for a few days and administering lime water.

As each calf completed the twenty-six week experimental period, it was passed out of the experiment to enter what has been called the post-experimental period. During this latter period, which terminated when calves were one year old, the calves were turned on to pasture and given what was considered good farm management under conditions obtaining at the Experiment Station and similar country during December, 1932, to May, 1933. The introduction to pasture was gradual in that the calves were fed a small quantity of hay in the morning for the first few days before being put out to graze. The grazing was considered to be good and consisted largely of " rooigras " (*Themeda triandra*). No supplementary feed was given during the post-experimental period, but a 3 oz. dose of two parts bone meal and one part salt was given daily.

Recording of Data.

As previously stated, alterations to the rations of individual calves were made to conform to the schedule of feeding according to age in weeks. Feed-room directions were put out constantly to indicate the necessary ration alterations. Any refuse of milk, meal or hay was recorded and no refuse was refed.

All calves were weighed as soon as possible after birth. During the course of the experiment, calves were weighed individually at weekly intervals and on three successive days at twenty-eight day intervals. Weighing was carried out between 6 and 7 a.m., that is before feeding and watering.

Owing to the measuring and photographic apparatus not being available at the commencement of the experiment, wither measurements and photographic records were not taken during the earlier part of the experiment. However, subsequently wither measurements were taken at monthly intervals with a measuring stick graduated in centimetres. Photographs were taken at the ages of twelve and twenty-six weeks. These photographs are presented with the text. The wither measurements given in connection with the photographs have been converted to inches to correspond with the scale on the photographic frame.

During the post-experimental period, weights of calves and wither measurements were taken at twenty-eight day intervals.

EXPERIMENTAL RECORDS.

Feed Consumption.

Details of weekly feed consumption by individual calves have been compiled from the daily records; such data are presented in Appendix I and II from which Tables I and II of the text have been constructed.

It will be seen from Table I that the whole milk fed calves consumed a total of 5,270 lb. of whole milk which, for the seventy-four days during which the milk was fed, was a daily average of 7·12 lb. per calf. As the colostrum obtained from the dams during the first three days was an unknown quantity, the three days have not been taken into account in the above and subsequent similar calculations.

The meal consumption of Group I from the fourth to the seventh week was low, being a daily average of 0·5 lb. per calf. Some of the calves took to their meal reluctantly, although methods of inducing them to eat the meal were adopted. From the twelfth week the meal was consumed eagerly and, while the average consumption of meal per calf per day was 4·10 lb. during the latter part of the experimental period, the equivalent average for the entire period of 161 days, during which meal was fed, was 2·41 lb.

Because the calves of Groups I and II were fed hay together and as there were some differences in the ages of the calves, an analysis of the hay consumption similar to that made for other feeds would be misleading. Group I consumed an average of 3·15 lb. of lucerne hay per calf per day during a period of 168 days.

The feed consumption of Group II is given in Table II.

TABLE I.

Group I.—Feed Consumption in Pounds.

Experimental Periods.	Whole milk.		G. maize.	Wheat bran.	Peanut meal.	Blood meal.	Bone meal.	Salt.	Meal.		Lucerne hay.	
	Total.	Average per head per day.							Total.	Average per head per day.	Total.	Average per head per day.
1st to 3rd week.....	1302·5	6·20	—	—	—	—	—	—	—	—	—	—
4th to 7th week.....	2595·0	9·27	97·6	18·3	12·2	6·1	4·4	2·2	140·8	0·50	—	—
8th to 11th week.....	1372·5	4·90	264·0	49·6	33·0	16·5	12·6	6·2	381·9	1·36	—	—
12th to 22nd week.....	—	—	1528·0	286·5	191·0	95·5	69·9	34·9	2205·8	2·86	—	—
23rd to 26th week.....	—	—	796·8	149·3	99·6	49·8	36·0	18·0	1149·5	4·10	—	—
	5270·0	7·12*	2686·4	503·7	335·8	167·9	122·9	61·3	3878·0	2·41†	5286·5	3·15‡

NOTE.—* Average per head per day for 74 days.
† Average per head per day for 161 days.
‡ Average per head per day for 168 days.

TABLE II.

Group II.—Feed Consumption in Pounds.

Experimental period.	Whole milk.		Skim milk.		G. maize.	Peanut meal.	Bone meal.	Salt.	Meal.		Lucerne hay.	
	Total.	Average per head per day.	Total.	Average per head per day.					Total.	Average per head per day.	Total.	Average per head per day.
1st to 3rd week.....	1543·5	7·35	—	—	—	—	—	—	—	—	—	—
4th to 7th week.....	1791·0	6·40	1752·5	6·26	—	—	—	—	—	—	—	—
8th to 11th week.....	—	—	4120·0	14·71	292·0	—	10·2	5·1	307·3	1·10	—	—
12th to 22nd week.....	—	—	10740·0	13·95	2054·3	—	72·0	36·0	2162·3	2·81	—	—
23rd to 26th week.....	—	—	769·9	2·75	946·9	167·1	39·0	19·5	1172·5	4·19	—	—
	3334·5	7·25*	17382·4	10·80†	3293·2	167·1	121·2	60·6	3642·1	2·74‡	5286·5	3·15§

NOTE.—* Average per head per day for 46 days.
† Average per head per day for 161 days.
‡ Average per head per day for 133 days.
§ Average per head per day for 168 days.

The average daily whole milk consumption of 7·25 lb. per calf is high due to the short feeding period of forty-six days. The corresponding average consumption of skim milk was 10·8 lb. over a period of 161 days.

The skim milk fed calves readily took to the meal which was offered from the eighth week. The table indicates that the average daily consumption of meal over a period of 133 days was 2·74 lb. per calf.

The consumption of lucerne hay was the same as that of Group I, namely a daily average of 3·15 lb. per calf over a period of 168 days.

Weight Data.

The weekly weights of individual calves of Groups I and II from birth to twenty-six weeks of age are given in Appendix III.

The accompanying Graph I has been constructed from the average weights given in the tables of the appendix. The " normal " growth of Holstein calves according to the data of Eckles (1920) has been plotted in order to permit a comparison; the " normal " weights of Eckles are contained in Table V of the text.

It was considered of interest to present also the weight curves during the post-experimental period and to continue the comparison with the " normal " of Eckles. The data recorded during this period are given in the subsequent Tables IX and X in the text.

Chart 1.—Average Weight Curves.

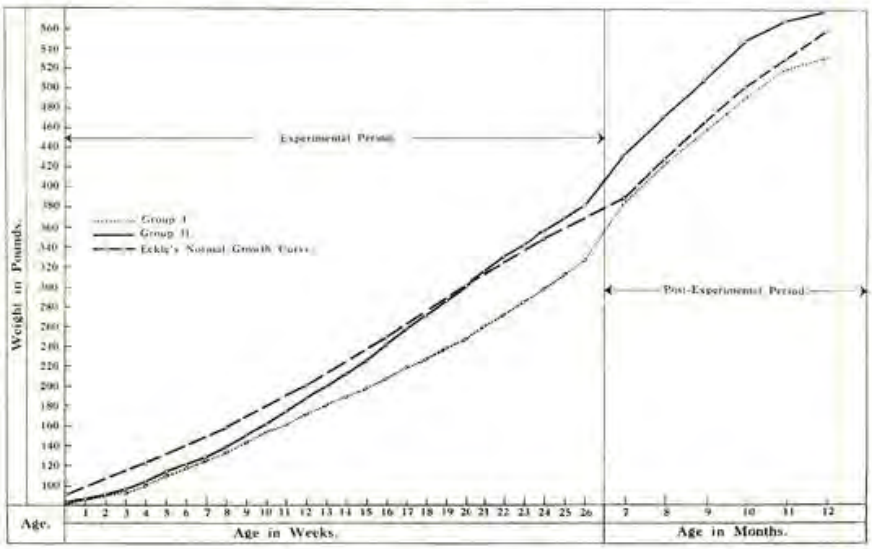

TABLE III.

Group I.—Initial and Final Weights.

Calf No.	Sex.	Period in experiment.	Birth weight.	Weight at 26 weeks.	Gain in weight.	Average daily gain.
		Days.	lb.	lb.	lb.	lb.
5147	F.	184	68·0	324	256·0	1·39
5149	F.	179	79·5	281	201·5	1·12
5152	M.	183	87·5	352	264·5	1·44
5153	F.	182	85·0	338	253·0	1·39
5155	F.	179	86·0	304	218·0	1·21
5157	F.	183	75·0	328	253·0	1·38
5159	F	178	83·0	327	244·0	1·37
5161	F.	181	87·5	344	256·5	1·42
5162	M.	180	90·5	358	267·5	1·49
5165	M.	179	82·0	300	218·0	1·22
TOTALS...		1,808	824·0	3,256	2,432·0	13·43
Averages...		180·8	82·4	325·6	243·2	1·34

TABLE IV.

Group II.—Initial and Final Weights.

Calf No.	Sex.	Period in experiment.	Birth weight.	Weight at 26 weeks.	Gain in weight.	Average daily gain.
		Days.	lb.	lb.	lb.	lb.
5148	M.	184	75·0	384	309·0	1·68
5150	F.	177	96·0	415	319·0	1·80
5151	M.	176	77·0	399	322·0	1·83
5154	F.	181	82·5	359	276·5	1·53
5156	F.	184	100·0	427	327·0	1·78
5158	F.	180	76·0	353	277·0	1·54
5160	F.	182	78·0	369	291·0	1·59
5163	F.	180	70·5	367	296·5	1·65
5164	M.	180	84·5	395	310·5	1·72
5166	M.	179	72·5	354	281·5	1·57
TOTALS...		1,803	812·0	3,822	3,010·0	16·69
Averages...		180·3	81·2	382·2	301·0	1·67

BIRTH WEIGHTS.

It is obvious from Tables III and IV that there was no significant difference between the average birth weights of Groups I and II, which were 82·4 lb. and 81·2 lb. respectively. However with a standard deviation of 7·717 lb. in the birth weights of the two groups of ten calves each, the above mean weights are both significantly below the value of 90 lb. given by Eckles (1920) as the " normal " birth weight of Holstein calves. The probability of obtaining the above discrepancies from 90 lb. is in the case of Group I less than 2 per cent. and in the case of Group II less than 1 per cent. Nevertheless, the birth weights of the two groups were reasonably similar, the coefficient of variability being only 9·4 per cent.

The sexes are not equally distributed in the groups; in Group I there were three males and seven females, and in Group II four males and six females. An analysis of the birth weights of the sexes would indicate that sex did not influence birth weight.

Average Growth Rates.

Sex had no effect upon the average growth rates. It has been computed from Tables III and IV that the average daily gains in weight for the males and females gave mean values of 1·56 and 1·74 lb. respectively. Since the two sexes were not represented in equal proportions, weighted differences were taken and the comparison with the appropriate standard error, calculated from perfectly equalised animals as to sex and group, showed no significant response to sex.

In the case of group differences, with mean average daily gains of 1·34 lb. and 1·67 lb. in Groups I and II respecively (Tables III and IV), and a standard deviation, from perfectly equalised animals as regards sexes and groups, of 0·1181 lb., there is a highly significant difference of 0·33 lb. per day between the two mean values in favour of Group II, or the skim milk fed calves.

Gains in Weight compared with Normal Growth.

Table V has been constructed from Appendix III and Tables VIII and IX (the latter are subsequently presented in the text) with the object of illustrating the monthly averages and weight ranges. The "normal" weight data of Eckles (1920) have been included to permit a further comparison. In Table VI the average weights of Groups I and II have been expressed as percentages of the normal.

TABLE V.

Calf Weights.

Age.	Grade Frieslands, Ermelo.						Holsteins.		
	Group I (whole milk).			Group II (skim milk).					
	Average	Highest.	Lowest.	Average.	Highest.	Lowest.	Normal.	Highest.	Lowest.
Months.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Birth.....	82	90	68	81	100	70	90	112	55
1.....	99	112	90	103	127	87	121	137	114
2.....	134	147	126	138	163	125	157	164	142
3.....	171	189	156	188	215	171	200	221	173
4.....	208	225	185	242	273	219	249	269	203
5.....	248	271	220	301	339	280	302	330	233
6.....	298	329	261	356	395	325	349	392	263
7.....	383	411	335	433	465	388	389	454	285
8.....	423	455	370	472	512	428	425	503	286
9.....	457	479	399	507	551	447	466	554	303
10.....	491	519	437	548	598	480	501	600	332
11.....	518	546	464	566	635	512	529	659	368
12.....	530	564	469	579	654	532	558	675	399

TABLE VI.

Average Weights. A Comparison with the "Normal".

Age.	Normal. Eckles (1920).	Group I. Percentage Normal.	Group II. Percentage Normal.
Months.	lb.	lb.	lb.
Birth.....	90	91·1	90·0
1.....	121	81·8	85·1
2.....	157	85·4	87·9
3.....	200	85·5	94·0
4.....	249	83·5	97·2
5.....	302	82·1	99·7
6.....	349	85·4	113·2
7.....	389	98·5	111·6
8.....	425	99·5	111·1
9.....	466	98·1	108·8
10.....	501	98·0	109·4
11.....	529	97·9	107·0
12.....	558	95·0	103·8

In order to compare the total weight and gains in weight during the experimental period with the "normal" conditions as given by Eckles, the first twenty-four weeks are being considered because the exact "normal" increase for twenty-six weeks is not tabulated.

The mean increases in weight for twenty-four weeks were 215·5 lb. and 274·5 lb. for Groups I and II respectively The standard deviation for these increases is 18·3 lb. and there is again the highly significant difference between Groups I and II in favour of the latter. The differences between the "normal" increase of twenty-four weeks and the above mean values are highly significant in favour of the "normal" in the case of Group I, and significant in favour of Group II. (See Table VII.)

Similar results are obtained when the mean weight, instead of the mean increases, at the end of the twenty-four weeks are considered. However, the "normal" birth weight was higher than those of the two experimental groups which fact causes the difference between the "normal" weight at twenty-four weeks and the mean weight of Group II at that age to be insignificant. The mean values are 298 lb., 356 lb., and 349 lb. for Group I, Group II and the "normal" respectively. The standard deviation within the two experimental groups is 22·95 lb. (See Table VII.)

Detailed Analysis of Various Growth Stages.

Interesting features are revealed by an analysis of intermediate periods; this analysis is presented in Table VII.

TABLE VII.

A Further Analysis of Body Weight.

Mean.	Group I.	Group II.	"Normal."	S.D.
	lb.	lb.	lb.	lb.
Birth weight.....	82·4 (10)	81·2 (10)	90	7·717
Daily gain during experimental period.....	1·34 (10)	1·67 (10)	—	0·118
Increase up to third week...	9·9 (10)	13·2 (10)	23	5·77
Increase from third week to fourth week.....	32·6 (10)	32·7 (10)	34	2·63
Increase up to seventh week.	42·5 (10)	45·9 (10)	—	6·06
Increase from seventh to twenty-sixth week.....	200·5 (10)	254·8 (10)	221	19·84
Weight at twenty-four weeks	298·0 (10)	356·0 (10)	349	22·95
Gain up to twenty-fourth week	215·5 (10)	274·5 (10)	259	18·30
Increase during post-experimental period.....	201·6 (9)	193·7 (9)	206	25·00
Increase during tenth to twelfth months of post-experimental period.....	38·0 (9)	42·3 (9)	57	13·38

NOTE.—(*a*) In the above table, the numbers in brackets indicate the number of animals of which the values are means.

(*b*) In the accompanying discussion the terms "significant" and "highly significant" mean that probabilities of obtaining as great or greater values, or differences in values, are less than 5 percent., and 1 percent. respectively.

During the first week, both groups were fed their dams' milk and no important difference was found between the mean increases, 2·2 lb. and 3·5 lb. in Groups I and II respectively. This close agreement remained throughout the second and third weeks although the rations were altered during the third week in that Group II received 2·5 lb. more whole milk per calf per day than Group I. Probably because of this increase of feed, there was a slight increase in difference between the mean increases for that week in favour of Group II, although the difference was still quite insignificant. The similarity of rate of growth was maintained until the end of the 7th week, for the mean increases at the end of this period were 42·5 lb. and 45·9 lb. in Groups I and II respectively, while the standard deviation was 6·06 lb.

Compared with the "normal" there was a definite break in the growths at the end of the third week, at which stage mean increases in weight were 9·9 lb., 13·2 lb., and 23·0 lb. in the cases of Groups I, II and the "normal" respectively. The increases during this period vary with a standard deviation of 5·77 lb. and the difference between the means of the two experimental groups remained within the limits of reasonable expectation, which was the case throughout the seven week period. However, at the end of the third week, the differences between the "normal" increase and the mean increase of both groups is highly significant in favour of the "normal".

Considering the remaining four weeks of the seven week period, the differences are all insignificant. The mean increases in weight during these four weeks were 32·6 lb., 32·7 lb., and 34·0 lb. for Groups I, II and the " normal " respectively, while the standard deviation was 2·627 lb. This standard deviation is exceedingly small as the coefficient of variability is only 8 per cent. as compared with 46 per cent. during the previous period of three weeks. This latter feature will be discussed in a subsequent paragraph.

Before the analysis of the weight increases during the experimental period is concluded, it remains to be shown that the differences in the results obtained for the whole period were brought about during the remaining part of the experiment. During this period, or subsequent to the seventh week, the mean gains in weight of Groups I and II were 200·5 lb. and 254·8 lb. respectively, while the standard deviation was 19·835 lb. The difference is highly significant in favour of Group II. Furthermore, the mean value of Group I was below, and that of Group II was above the " normal " value of 221 lb.; both these differences are significant.

The Relationship between Growth Rate and Birth Date.

The following discussion deals with the difference between the coefficients of variability of the two periods mentioned in previous paragraphs.

The close agreement between the birth weights and the growth rates of the calves over the greater part of the experiment was not evident during the first period of three weeks. During this period the individual variations were exceptionally high. These variations are found to be due to the smaller gains in weight made by the calves born at a later date; this is evident in both groups. Correlating the gains in weight during the first period of three weeks with the number of days individual calves were born after the date of birth of the first calf, the remarkable correlation coefficient of $-0·95$ was obtained for eighteen calves. This value is highly significant. By considering only the first week, a highly significant value of $-0·786$ was found. Furthermore, in order to ascertain to what extent the two groups agree in the decline in gain of weight of the later born calves, the correlation between the two groups for pairs of calves in their birth order was calculated. A highly significant correlation coefficient of $+0·77$ was obtained. Again, for the first week the same agreement between the two groups is reflected by a correlation coefficient of $+0·74$. No biological explanation can be suggested for this peculiar feature. However, it must be clear that the highly significant correlations account for the large coefficient of variability.

Wither Heights.

The wither measurements taken during the course of the experiment are given in Appendix IV. The means of wither measurements at the three stadia indicated are given in Table VIII.

TABLE VIII.

Age.	Group I.	Group II.	"Normal."	S.D.
	cms.	cms.	cms.	cms.
3 months.....	84·6 (10)	84·5 (10)	86·8	1·683
6 months.....	100·0 (10)	100·8 (10)	100·9	3·786
12 months.....	114·3 (10)	116·3 (9)	114·0	2·302

NOTE.—In the above table, the numbers in brackets indicate the numbers of calves of which the values are means.

There is no significant difference between the wither measurements of the two experimental groups at the stages for which the measurements are given. At three months the "normal" value was higher than the means of both groups, the differences being highly significant. However, during the next three months the experimental groups caught up with the "normal" and they maintained this relationship up to the end of the twelve month period, when Group I was 100·3 per cent. normal and Group II 102·1 per cent. normal.

GAINS IN WEIGHT DURING THE POST-EXPERIMENTAL PERIOD.

At the end of the experimental period of twenty-six weeks, the calves of both groups were put on to veld and observations were continued until the calves were twelve months old. The weight data for the post-experimental period are given in Tables IX and X.

TABLE IX.

Group I.—Monthly Weights in Pounds during the Post-experimental Period.

Calf No.	Weight at 26 weeks.	Age in months.						Total gains from 6 to 12 months.
		7.	8.	9.	10.	11.	12.	
5147	324	406	451	479	507	535	544	220
5149	281	335	370	329	437	464	469	188
5152	352	406	444	479	513	541	558	206
5153	338	385	436	468	519	546	564	226
5155	304	359	402	440	482	509	528	224
5157	328	367	411	445	484	520	550	222
5159	327	370	395	433	470	482	503	176
5161	344	408	445	486	500	525	523	179
5162	358	411	455	481	514	537	529	171
TOTALS.	2,956	3,447	3,809	4,110	4,426	4,659	4,768	1,812
Averages.	328·4	383·0	423·2	456·7	490·7	517·7	529·8	201·4

TABLE X.

Group II.—Monthly Weights in Pounds during the Post-experimental Period.

Calf No.	Weight at 26 weeks.	Age in months.						Total gains from 6 to 12 months
		7.	8.	9.	10.	11.	12.	
5148	384	450	493	517	552	582	599	215
5150	415	458	502	543	583	611	629	214
5151	399	462	490	537	563	597	615	216
5154	359	409	442	479	510	519	546	187
5156	427	465	512	551	598	635	654	227
5158	353	388	428	447	480	512	532	179
5160	369	437	470	512	517	563	547	178
5163	367	417	457	498	519	536	539	172
5164	395	415	451	476	508	542	550	155
TOTALS.	3,469	3,901	4,245	4,559	4,930	5,097	5,211	1,743
Averages.	385·4	433·4	471·7	506·6	547·8	566·3	579·0	193·7

During the post-experimental period, there were no important differences between the mean gains in weight which were 201·4 lb., and 193·7 lb. in Groups I and II respectively. Also, there is no significant difference between these values and the corresponding figure, 206 lb., of the " normal ". However, it must be pointed out that during the eleventh and twelfth months smaller increases were made in the mean values of both groups as compared to the " normal "; these values were Group I, 38 lb.; Group II, 42·3 lb. and the " normal " 57 lb. It is seen that the mean values of the two groups are not significantly different.

In the post-experimental period, the same tendency of the later born calves to increase less in weight is observed. This agrees to such an extent with the findings during the first period of three weeks that the correlation coefficient between the increases for the same animals is +0·5, which is quite significant for the 18 animals considered. The two youngest animals have been excluded in this comparison. Whether the above agreement was a coincident or whether the one is dependent upon the other is not revealed by the statistical analysis.

DISCUSSION.

Otis (1905) demonstrated the high cost of rearing dairy calves when a large amount of whole milk was fed, and he indicated that very satisfactory results can be obtained at nearly one quarter the cost by rearing calves on a skim milk ration.

Experiments have been reported in which meals have been used as milk substitutes necessitating the feeding of only small quantities of whole milk and eliminating the use of skim milk. (Hunziker and Caldwell, 1916; Eckles, 1919; Bender and Bartlett, 1929).

In the experiments reported here, one group of calves was fed whole milk and a milk substitute meal, another group received skim milk and a supplementary meal.

Feed Consumption.

The feed consumption data of the two groups of calves were given in Tables I and II of the text. The feed consumptions per calf have been extracted from these tables and they are reflected in the following table.

TABLE XI.

Average Feed Consumption in Pounds.

Group.	Whole milk.	Skim milk.	Ground maize.	Wheat bran.	Peanut meal.	Blood meal.	Bone meal.	Salt.	Lucerne hay.
I.....	527·0	—	268·6	50·4	33·6	16·8	12·3	6·1	528·6
II.....	333·4	1,738·2	329·3	—	16·7	—	12·1	6·1	528·6

It is seen from Table XI that Group I consumed 193·6 lb. more whole milk per calf than Group II, however, the latter group obtained in addition to whole milk 1738·2 lb. of skim milk. While Group II was fed an average of 60·7 lb. more maize than Group I, the latter group consumed 16·9 lb. more peanut meal and in addition 50·4 lb. of bran and 16·8 lb. of blood meal.

Group I consumed rather more whole milk, 527·0 lb. than is generally recommended for calves receiving an efficient meal as a milk substitute. Hunziker and Caldwell (1916) fed 213·95 lb. of whole milk but obtained an average daily gain of only 0·95 lb. Eckles (1919) refers to experiments in which 121 lb. of whole milk had been fed and a daily gain of 1·25 lb. was obtained. It is important to note that the relatively small amount of whole milk, 121 lb., was fed over a long period, eighty-three days. This would appear to be an important consideration when reduced quantities are fed. On the other hand, Bender and Bartlett (1929) reported remarkable success and a daily gain of 1·56 lb. by feeding whole milk for only one month, but the amount of whole milk fed was not given. The Group I calves consumed an appreciable amount of meal which, including bone meal and salt, totalled 387·8 lb. It is diffcult to see how this amount can be reduced, especially if the feeding of smaller amounts of whole milk is contemplated.

Group II consumed somewhat more whole milk, 333·4 lb., than calves thus reared usually receive. Eckles (1919) states that generally about 200 lb. are fed. However, the skim milk consumption of this group was 1738·2 lb. which is considerably less than the amount, 2,000-3,000 lb., recommended (Hunziker and Caldwell, 1916; Eckles, 1919). This group consumed an average of 346·0 lb. of meal; this amount is considerably larger than the amounts fed in similar experiments. It is possible that a reduction of whole milk and meal consumption may be made, if the skim milk ration is increased.

Body Weight.

The weight data given in Tables III. IV, and V and analysed in the discussions accompanying these tables indicate a satisfactory stage of growth attained by the experimental calves in both groups at twenty-six weeks of age. The calves of Group I, or the whole milk fed calves, experienced less rapid growth than those of Group II, or the skim milk fed calves. The mean weights at twenty-six weeks of age were 298 lb. and 356 lb. for Groups I and II respectively, and the standard deviation was 22·95 lb. The mean daily gains during the period were Group I, 1·34 lb., and Group II, 1·67 lb., indicating a highly significant difference of 0·33 lb. in favour of Group II.

It has been indicated that an analysis of the intermediate stages of the experimental period, such as is given in Table VII, reveals some interesting results. No significant difference existed in the birth weights of the two groups, neither were there any significant differences reflected during the first and second weeks while the calves received only whole milk and identical amounts of whole milk were fed to the groups. There was a slight yet insignificant advantage reflected in Group II during the third week when that group received 2·5 lb. more whole milk per calf than did Group I. However, compared with the " normal ", there was a definite break in the growth of the two experimental groups at the end of the third week. During the subsequent four weeks, which completed the seven weeks period, the mean increases in weight were 32·6 lb., 32·7 lb. and 34·0 lb. for Groups I, II, and the " normal " respectively; the differences are insignificant. During this period of four weeks, Group I consumed 9·27 lb. of whole milk and 0·5 lb. of meal per calf per day (Table I) and Group II consumed 6·4 lb. of whole milk, 6·26 lb. of skim milk, and no meal (Table II). It was seen that the difference in the mean increases of weight took place subsequent to the seventh week, the values for Groups I and II being 200·5 lb. and 254·8 lb. respectively and the standard deviation was 19·835 lb.

Wither Heights.

There was no significant difference between the wither heights of the two experimental groups at three and six months of age, and at the latter age the measurements of Groups I and II were 99·1 per cent. and 99·9 per cent. " normal ".

Nutritive Value of Feeds Consumed.

The following tables have been constructed with the assistance of the tables of feed values of Henry and Morrison (1923).

TABLE XII.

Group I.

Consumption per calf.	Total dry matter.	Digestible nutrients.		
		Crude protein.	Carbo-hydrates.	Fat.
	lb.	lb.	lb.	lb.
Whole milk—527·0 lb.	71·67	17·39	25·30	18·97
Ground maize—268·6 lb.	235·86	20·68	177·57	12·36
Wheat bran—50·4 lb.	45·31	6·30	20·97	1·50
Peanut meal—33·6 lb.	31·38	13·54	7·56	3·09
Blood meal—16·8 lb.	15·17	11·61	—	0·15
Lucerne hay—528·6 lb.	483·19	56·04	206·17	4·76
Totals	882·58	125·56	437·57	40·73

TABLE XIII.

Group II.

Consumption per calf.	Total dry matter.	Digestible nutrients.		
		Crude protein.	Carbo-hydrates.	Fat.
	lb.	lb.	lb.	lb.
Whole milk—333·4 lb.	45·33	11·00	16·00	12·00
Skim milk—1,738·2 lb.	171·08	62·46	88·65	3·48
Ground maize—329·3 lb.	291·14	25·36	217·67	15·15
Peanut meal—16·7 lb.	15·60	6·73	3·76	1·54
Lucerne hay—528·6 lb.	483·19	56·04	206·17	4·76
Totals	1,005·34	161·59	532·25	36·93

It is obvious from the preceeding tables that the skim milk fed calves of Group II consumed feeds the total nutritive value of which was higher than that of the feed consumed by the calves of Group I by 36·03 lb. crude protein and 94·68 lb. carbohydrates, but which was 3·80 lb. lower in fat. Also, on an average, the skim milk fed calves consumed 122·76 lb. total dry matter more than did the whole milk fed calves.

It is of interest to compare the nutritive requirements per hundred pounds gain of the two groups. For this purpose Table XIV has been constructed from data in Tables III, IV, XII and XIII.

TABLE XIV.

Requirements per hundred pounds Gain in Weight.

Group.	Total dry matter.	Digestible nutrients in pounds.		
		Crude protein.	Carbohydrates	Fat.
	lb.	lb.	lb.	lb.
I.....	362·87	51·63	179·92	16·75
II.....	334·00	53·68	176·83	12·27

It is seen from the above table that Group I calves required more total dry matter, carbohydrates, and fat per hundred pounds gain in weight than did the calves of Group II.

Feed Costs.

As the cost of rearing calves varies considerably according to the number and the value of calves, labour employed, facilities available, prices of feeds, etc., it is necessary for individuals interested to compute what may be expected to be their expenses in the calf rearing enterprise.

The following tables have been constructed to indicate what the feed costs of rearing the experimental groups of calves were, when feeds were obtained at the prices indicated.

TABLE XV.

Group I.

Feeds.	Total amount consumed by group.	Cost of Feeds.	Total Cost.	Cost per Calf.
	lb.		£ s. d.	£ s. d.
Whole milk.....	5,270·0	5·31d. per gal...	11 13 2½	1 3 3½
Ground maize.....	2,686·4	4s. 7d. per 100 lb.	6 3 1½	0 12 3½
Wheat bran.....	503·7	5s. 5d. ,, ,,	1 7 3	0 2 8½
Peanut meal.....	335·8	7s. 4d. ,, ,,	1 4 7½	0 2 5½
Blood meal.....	167·9	8s. 4d. ,, ,,	0 14 0	0 1 4½
Bone meal.....	122·9	7s. 9d. ,, ,,	0 9 6	0 0 11½
Salt.....	61·3	3s. 1d. ,, ,,	0 1 10½	0 0 2½
Lucerne hay.....	5,286·5	4s. 0d. ,, ,,	10 11 6	1 1 1½
		Totals.....	£32 5 1	£3 4 5

TABLE XVI.

Group II.

Feeds.	Total amount consumed by group.	Cost of Feeds.	Total Cost.	Cost per Calf.
	lb.		£ s. d.	£ s. d.
Whole milk.....	3,334·5	5·31d. per gal....	7 7 7	0 14 9
Skim milk.....	17,283·4	1½d. per gal.....	10 17 3	1 1 8¾
Ground maize.....	3,293·2	4s. 7d. per 100 lb.	7 10 11	0 15 1
Peanut meal.....	167·1	7s. 4d. ,, ,,	0 12 3	0 1 2¾
Bone meal.....	121·2	7s. 9d. ,, ,,	0 9 5	0 0 11¼
Salt.....	60·6	3s. 1d. ,, ,,	0 1 10½	0 0 2¼
Lucerne hay.....	5,286·5	4s. 0d. ,, ,,	10 11 6	1 1 1½
		TOTALS.....	£37 10 9½	£3 15 0½

The prices of feeds in the above tables were determined as follows: Average monthly prices of milk during the period of the experiment were obtained from the local creamery and from these averages a general average was computed. The prices of feedstuffs are average prices during the period of the experiment of a Johannesburg firm, plus the transport charges to Ermelo, a railage distance of 173 miles.

It is seen from Tables XV and XVI that the feed costs per calf in Group I, or the whole milk reared calves, were £3. 4s. 5d., while the same costs in Group II, or the skim milk reared calves, amounted to £3. 15s. 0½d. The whole milk costs in Group I were £1. 3s. 3¾d., while whole and skim milk costs in Group II were £1. 16s. 5¾d. The total meal costs, including minerals, in Group I were £1. 0s. 0½d. and those in Group II 17s. 5¼d.

It has been computed that the feed costs per hundred pounds gain in weight in Groups I and II were £1. 6s. 6d. and £1. 4s. 11d. respectively. Hence, while the total feed costs of Group I are somewhat less than that of Group II, the cost per hundred pound gain in the former group is higher than that in Group II.

SUMMARY AND CONCLUSIONS.

1. Two rations for rearing dairy calves up to six months of age were tested.

2. Ten grade Friesland calves reared on a small quantity of whole milk and a compound meal as a milk substitute which was supplemented by lucerne hay, attained 85 per cent. normal weight and 99·1 per cent. normal height.

(*a*) The average birth and final weights were 82·4 lb. and 325·6 lb. respectively, and the average daily gain was 1·34 lb.

(*b*) The feed costs per calf were £3. 4s. 5d. and the feed costs per hundred pounds gain in weight were £1. 6s. 6d.

When on pasture from six to twelve months of age, these calves attained 95 per cent. normal weight and 100·3 per cent. normal height at one year of age.

It is deducted that, while maximum weight was not attained on the experimental ration, growth was, nevertheless, satisfactory, as the calves were 99·1 per cent. normal height at six months of age, and they were able to show rapid advancement when put on pasture.

3. Ten grade Friesland calves reared on a skim milk ration supplemented by maize and lucerne hay, attained 113·2 per cent. normal weight and 99·9 per cent. normal height.

(*a*) The average birth and final weights were 81·2 lb. and 382·2 lb. respectively, and the average daily gain was 1·67 lb.

(*b*) The feed costs per calf were £3. 15s. 0½d. and the feed costs per hundred pounds gain in weight were £1. 4s. 11d.

When on pasture from six to twelve months of age, these calves attained 103·8 per cent. normal weight and 102·1 per cent. normal height at one year of age.

It may be deducted that maximum growth was attained on this experimental ration.

4. The milk substitute ration did not prove to be as efficient as the skim milk ration. However, the two rations tested serve two distinct purposes and they are both considered suitable and economical for rearing desirable types of dairy calves.

ACKNOWLEDGMENTS.

The author is indebted to Dr. D. J. Schutte for the construction of the feed schedules adopted in the experiment, and to Mr. A. P. Malan, Statistician, Onderstepoort, for assistance in connection with the analysis of the data.

REFERENCES.

BENDER, C. B., AND BARTLETT, J. W. (1929). A Study of the Factors affecting the Growth of Dairy Heifers. *Jnl of Dairy Sc.*, Vol. 12, pp. 37-50.

CURTISS, C. F. (1897). Feeding Separator Milk to Calves. *Iowa Agric. College, Bul. No.* 35, pp. 759-768.

ECKLES, C. H. (1919). Dairy Cattle and Milk Production. *Calf Raising.* The Macmillan Company, pp. 174-202.

ECKLES, C. H. (1920). The Normal Growth of Dairy Cattle. *Agric. Expt. Station, University of Missouri, Research Bul.* No. 36.

HENRY, W. A., AND MORRISON, F. B. (1923). Feeds and Feeding. *Raising Dairy Cattle.* The Henry-Morrison Co.

HUNZIKER, O. F., AND CALDWELL, R. E. (1916). Skim milk and milk Substitutes for Calf Feeding. *Agric. Expt. Station, Purdue University, Bul. No.* 193.

McCANDISH, A. C. (1924). Studies in the Growth and Nutrition of Dairy Calves. *Jnl. of Dairy Sc.* , Vol. 7.

MEAD, S. W. (1929). Feeding and Management of Dairy Calves in California. *College of Agric., University of California, Berkley. Bul.* No. 478.

MURRAY, C. A. (1929). Raising Dairy Calves on Skim Milk. Animal Husbandry Expt. No. 47. *Potchefstroom School of Agric.* (Unpublished.)

MURRAY, C. A. (1929). Raising Dairy Calves on Skim Milk. *Farming in South Africa*, Vol. IV, No. 37.

OREGON STATE AGRICULTURAL COLLEGE. (1931). Bul. No. 276.

OTIS, D. H. (1905). Experiments with hand-fed Calves. *Kansas State Agric. College, Bul.* No. 126.

WANDE, A. F. (1928). Hand-rearing of Dairy Calves. *Dept. of Agric., Union of South Africa, Bul.* No. 39.

WHITE, G. C., AND KUELLING, J. A. (1919). Experiments in Calf Feeding: Corn Silage: Whole Milk Dilutions. *Agric. Expt. Station Storrs, Connecticut, Bul.* No. 102.

APPENDIX I.

Group 1.—Weekly Whole Milk and Meal Consumption in Pounds.

Calf Nos.	5147		5149		5152		5153		5155		5157		5159		5161		5162		5165	
Feed	W.M.	G.	W.M.	G.	W.M.	G.	W.M.	G.	W.M.	G.	W.M.	G.	W.M.	G.	W.M.	G.	W.M.	G.	W.M.	G.
1 week	45·0	—	15·0	—	12·5	—	12·5	—	52·5	—	15·0	—	30·0	—	15·0	—	17·5	—	15·0	—
2 ,,	52·5	—	52·5	—	52·5	—	52·5	—	52·5	—	52·5	—	52·5	—	52·5	—	52·5	—	52·5	—
3 ,,	52·5	—	52·5	—	57·5	—	57·5	—	65·0	—	55·0	—	60·0	—	52·5	—	52·5	—	52·5	—
4 ,,	62·5	1·8	65·0	—	70·0	1·0	70·0	1·1	70·0	2·5	70·0	1·2	70·0	2·9	67·5	0·5	65·0	0·3	65·0	1·4
5 ,,	70·0	3·5	70·0	1·5	70·0	3·0	70·0	3·1	70·0	3·6	70·0	3·3	70·0	3·8	70·0	1·0	70·0	0·5	70·0	2·5
6 ,,	70·0	3·5	70·0	2·8	67·5	6·5	67·5	3·9	57·5	5·6	70·0	3·5	62·5	6·4	70·0	2·6	70·0	1·4	70·0	5·8
7 ,,	55·0	7·9	57·5	6·2	52·5	7·6	52·5	6·0	52·5	6·1	52·5	6·2	52·5	7·6	55·0	4·2	57·5	1·8	57·5	6·7
8 ,,	52·5	9·2	52·5	7·7	50·0	8·7	50·0	7·6	40·0	9·0	50·0	9·6	42·5	9·1	52·5	8·0	52·5	3·7	52·5	7·0
9 ,,	37·5	8·7	37·5	7·9	35·0	10·5	35·0	10·1	35·0	10·5	35·0	9·7	35·0	10·5	37·5	8·5	40·0	8·2	50·0	10·1
10 ,,	35·0	10·5	35·0	6·6	32·5	10·5	32·5	10·1	22·5	10·5	32·0	10·5	25·0	10·5	35·0	9·5	35·0	9·7	25·0	10·5
11 ,,	20·0	10·5	20·0	8·7	15·0	11·0	15·0	10·5	5·0	13·9	15·0	11·0	7·5	12·5	20·0	10·5	22·5	10·5	22·5	10·5
12 ,,	2·5	13·5	2·5	10·9	—	14·0	—	14·0	—	14·0	—	14·0	—	14·0	2·5	14·0	5·0	13·0	5·0	14·0
13 ,,	—	17·5	—	11·7	—	16·0	—	14·0	—	14·0	—	14·0	—	14·0	—	15·9	—	14·0	—	14·0
14 ,,	—	17·5	—	14·6	—	17·5	—	14·0	—	17·5	—	14·0	—	17·5	—	16·1	—	16·0	—	17·5
15 ,,	—	17·5	—	13·0	—	19·3	—	17·5	—	21·0	—	17·5	—	17·5	—	17·5	—	17·0	—	17·5
16 ,,	—	21·0	—	19·2	—	20·9	—	20·4	—	21·0	—	19·5	—	21·0	—	21·0	—	17·5	—	17·5
17 ,,	—	21·0	—	20·2	—	20·5	—	21·0	—	21·0	—	21·0	—	21·0	—	21·0	—	20·9	—	21·0
18 ,,	—	21·0	—	19·9	—	21·0	—	20·8	—	21·0	—	21·0	—	21·0	—	21·0	—	21·0	—	20·8
19 ,,	—	21·0	—	20·6	—	21·0	—	21·0	—	21·0	—	21·0	—	24·5	—	21·0	—	21·0	—	21·0
20 ,,	—	21·0	—	20·9	—	24·5	—	24·5	—	24·5	—	24·5	—	24·5	—	21·0	—	21·0	—	24·5
21 ,,	—	24·5	—	24·5	—	28·0	—	28·0	—	24·5	—	24·5	—	28·0	—	24·5	—	24·5	—	24·5
22 ,,	—	28·0	—	28·0	—	28·0	—	28·0	—	28·0	—	28·0	—	28·0	—	24·5	—	23·7	—	28·0
23 ,,	—	28·0	—	28·0	—	28·0	—	28·0	—	28·0	—	28·0	—	31·5	—	28·0	—	28·0	—	28·0
24 ,,	—	28·0	—	28·0	—	31·5	—	31·5	—	31·5	—	31·5	—	31·5	—	28·0	—	28·0	—	31·5
25 ,,	—	31·5	—	31·5	—	31·5	—	31·5	—	31·5	—	31·5	—	31·5	—	31·5	—	31·5	—	31·5
26 ,,	—	31·5	—	31·5	—	31·5	—	31·5	—	—	—	31·5	—	—	—	31·5	—	31·5	—	29·5
Totals	555·0	398·1	530·0	363·9	515·0	412·0	515·0	398·1	522·5	379·3	517·5	396·5	507·5	388·8	530·0	381·3	530·0	364·7	547·5	395·3

APPENDIX II.

Group II.—Weekly Whole Milk, Skim Milk, and Meal Consumption in Pounds.

Calf No.	5148			5150			5151			5154			5156		
Feed	W.M.	S.M.	G.	W.M.	S.M.	G.	W.M.	S.M.	G.	W.M.	S.M.	G.	W.M.	S.M.	G.
1 week	45·0	—	—	42·5	—	—	37·5	—	—	30·0	—	—	45·0	—	—
2 ,,	52·5	—	—	57·5	—	—	55·0	—	—	52·5	—	—	55·0	—	—
3 ,,	62·5	—	—	70·0	5·0	—	70·0	2·5	—	67·5	—	—	70·0	5·0	—
4 ,,	70·0	12·5	—	65·0	22·5	—	67·5	20·0	—	70·0	15·0	—	65·0	27·5	—
5 ,,	50·0	37·5	—	47·5	40·0	—	50·0	37·5	—	55·0	32·5	—	47·5	40·0	—
6 ,,	32·5	55·0	—	30·5	57·5	—	32·5	55·0	—	37·5	50·0	—	30·0	57·5	—
7 ,,	17·5	70·0	—	12·5	80·0	1·0	15·5	75·0	0·5	20·0	67·5	—	12·5	80·0	0·7
8 ,,	5·0	95·0	4·7	—	105·0	6·3	—	105·0	4·5	2·5	100·0	2·4	—	105·0	4·5
9 ,,	—	105·0	5·4	—	105·0	9·5	—	105·0	9·5	—	105·0	7·0	—	105·0	9·0
10 ,,	—	105·0	9·4	—	105·0	12·5	—	105·0	12·0	—	105·0	10·3	—	105·0	10·5
11 ,,	—	105·0	13·5	—	105·0	14·0	—	105·0	14·0	—	105·0	14·0	—	105·0	14·0
12 ,,	—	105·0	14·0	—	105·0	17·5	—	105·0	17·5	—	105·0	17·5	—	105·0	14·0
13 ,,	—	105·0	17·5	—	105·0	17·5	—	105·0	17·5	—	105·0	17·3	—	105·0	14·0
14 ,,	—	105·0	17·5	—	105·0	14·0	—	105·0	17·2	—	105·0	17·5	—	105·0	17·5
15 ,,	—	105·0	13·5	—	105·0	20·7	—	105·0	20·5	—	105·0	17·5	—	105·0	17·5
16 ,,	—	105·0	19·8	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	105·0	17·5
17 ,,	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0
18 ,,	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0
19 ,,	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0
20 ,,	—	105·0	21·0	—	105·0	24·5	—	105·0	24·5	—	105·0	24·5	—	105·0	24·5
21 ,,	—	105·0	24·5	—	70·0	28·0	—	70·0	28·0	—	70·0	28·0	—	70·0	28·0
22 ,,	—	70·0	28·0	—	52·5	28·0	—	52·5	28·0	—	52·5	28·0	—	52·5	28·0
23 ,,	—	52·5	28·0	—	35·0	28·0	—	35·0	28·0	—	35·0	28·0	—	35·0	28·0
24 ,,	—	35·0	28·0	—	17·5	31·5	—	17·5	31·5	—	17·5	31·5	—	17·5	31·5
25 ,,	—	17·5	31·5	—	9·1	31·5	—	9·1	31·5	—	9·1	31·5	—	9·1	31·5
26 ,,	—	9·1	31·5	—	9·1	31·5	—	9·1	31·5	—	9·1	31·5	—	9·1	31·5
TOTALS	335·0	1,819·1	379·8	325·0	1,763·2	400·0	328·0	1,748·2	400·2	335·0	1,718·2	390·5	325·0	1,768·2	381·7
Calf Meal No. 3*	—	—	119·0	—	—	122·5	—	—	122·5	—	—	122·5	—	—	122·5
Calf Meal No. 2*	—	—	251·8	—	—	277·5	—	—	277·7	—	—	268·0	—	—	259·2

* NOTE.—Up to the 22nd week the meal of Group II consisted of finely ground maize and 5 per cent. of 2 parts bone meal and 1 part salt.
From the 23rd week the meal of Group II consisted of finely ground maize, 15 per cent. peanut meal, and 5 per cent. of 2 parts bonemeal and 1 part salt.

APPENDIX II. (*continued*).

Group II.—Weekly Whole Milk, Skim Milk, and Meal Consumption in Pounds.

Calf No.	5158			5160			5163			5164			5166		
Feed	W.M.	S.M.	G.	W.M.	S.M.	G.	W.M.	S.M.	G.	W.M.	S.M.	G.	W.M.	S.M.	G.
1 week	15·0	—	—	30·0	—	—	7·5	—	—	22·5	—	—	52·5	—	—
2 ,,	52·5	—	—	52·5	—	—	52·5	—	—	54·5	—	—	66·5	—	—
3 ,,	67·5	—	—	55·0	—	—	65·0	—	—	67·5	—	—	70·0	10·0	—
4 ,,	70·0	12·5	—	70·0	2·5	—	70·0	—	—	70·0	15·0	—	60·0	27·5	—
5 ,,	55·0	32·5	—	67·5	20·0	—	65·0	22·5	—	55·0	32·5	—	42·5	35·0	—
6 ,,	37·5	50·0	—	40·0	47·5	—	37·5	40·0	—	37·5	50·0	—	25·0	62·5	—
7 ,,	20·0	67·5	—	32·5	55·0	—	30·0	57·5	—	20·0	67·5	—	7·5	90·0	—
8 ,,	2·5	100·0	2·5	15·0	75·0	0·5	12·5	80·0	1·0	2·5	100·0	2·5	—	105·0	3·5
9 ,,	—	105·0	6·7	—	105·0	4·0	—	105·0	4·0	—	105·0	3·0	—	105·0	3·5
10 ,,	—	105·0	9·0	—	105·0	7·5	—	105·0	7·0	—	105·0	6·6	—	105·0	7·0
11 ,,	—	105·0	13·8	—	105·0	12·5	—	105·0	6·0	—	105·0	7·0	—	105·0	10·5
12 ,,	—	105·0	14·0	—	105·0	12·7	—	105·0	10·5	—	105·0	9·0	—	105·0	10·5
13 ,,	—	105·0	18·3	—	105·0	14·0	—	105·0	10·5	—	105·0	10·5	—	105·0	14·0
14 ,,	—	105·0	16·8	—	105·0	14·0	—	105·0	12·5	—	105·0	14·0	—	105·0	14·0
15 ,,	—	105·0	17·5	—	105·0	16·0	—	105·0	14·0	—	105·0	14·0	—	105·0	17·5
16 ,,	—	105·0	17·5	—	105·0	17·5	—	105·0	17·5	—	105·0	14·0	—	105·0	7·5
17 ,,	—	105·0	21·0	—	105·0	21·0	—	105·0	17·5	—	105·0	14·0	—	105·0	21·0
18 ,,	—	105·0	21·0	—	105·0	21·0	—	105·0	17·5	—	105·0	17·5	—	105·0	21·0
19 ,,	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	105·0	17·5	—	105·0	21·0
20 ,,	—	105·0	24·0	—	105·0	21·0	—	105·0	21·0	—	105·0	21·0	—	85·0	24·5
21 ,,	—	70·0	24·5	—	70·0	28·0	—	70·0	24·5	—	105·0	24·5	—	60·0	24·5
22 ,,	—	52·5	28·0	—	52·5	28·0	—	52·5	24·5	—	70·0	24·5	—	42·5	28·0
23 ,,	—	35·0	28·0	—	35·0	28·0	—	35·0	28·0	—	52·5	28·0	—	24·0	28·0
24 ,,	—	17·5	28·0	—	17·5	28·0	—	17·5	28·0	—	35·0	28·0	—	13·7	28·0
25 ,,	—	9·1	31·5	—	9·1	31·5	—	9·1	31·5	—	17·5	31·5	—	9·1	31·5
26 ,,	—	9·1	31·5	—	9·1	31·5	—	9·1	31·5	—	9·1	31·5	—	—	—
Totals	320·0	1,715·7	389·1	362·5	1,653·0	357·7	350·0	1,653·2	328·0	329·5	1,814·1	318·6	324·0	1,729·3	325·5
Calf Meal No. 3*	—	—	119·0	—	—	119·0	—	—	119·0	—	—	119·0	—	—	87·5
Calf Meal No. 2*	—	—	250·1	—	—	238·7	—	—	209·0	—	—	199·6	—	—	238·0

* NOTE.—Up to the 22nd week the meal of Group II consisted of finely ground maize and 5 per cent. of 2 parts bone meal and 1 part salt.
From the 23rd week the meal of Group II consisted of finely ground maize, 15 per cent. peanut meal, and 5 per cent. of 2 parts bonemeal and 1 part salt.

APPENDIX III.

Group I.—Weekly Weights in Pounds.

Calf No.	Sex.	Birth Weight.	Age in weeks.											
			1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
5147	F.	68·0	80	80	87	90	100	116	120	128	134	149	152	162	173
5149	F.	79·5	84	84	91	95	102	114	120	126	130	142	142	156	166
5152	M.	87·5	95	101	105	112	125	132	140	147	158	165	172	189	196
5153	F.	85·0	87	91	95	100	112	119	127	136	150	158	165	181	190
5155	F.	86·0	88	94	96	100	113	119	125	136	144	152	157	168	177
5157	F.	75·0	88	88	90	104	108	113	123	134	143	148	161	171	182
5159	F.	83·0	82	87	89	100	106	113	122	131	136	147	158	166	175
5161	F.	87·5	85	88	89	92	101	110	118	127	139	150	157	165	175
5162	M.	90·5	88	93	94	102	114	122	131	139	153	163	174	181	195
5165	M.	82·0	85	87	89	97	104	114	125	131	139	153	164	170	175
Totals.....	.....	824·0	862	893	925	992	1,085	1,172	1,251	1,335	1,426	1,527	1,602	1,709	1,804
Averages....		82·4	86·2	89·3	92·5	99·2	108·5	117·2	125·1	133·5	142·6	152·7	160·2	170·9	180·4

Calf No.	Sex.	Birth Weight.	Age in weeks.											
			14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.
5147	F.	68·0	185	191	199	214	221	235	251	261	271	283	296	308	324
5149	F.	79·5	169	178	185	196	204	214	229	233	239	255	261	272	281
5152	M.	87·5	206	214	225	238	250	261	270	280	299	304	322	335	352
5153	F.	85·0	197	204	222	229	236	245	257	272	282	291	306	324	338
5155	F.	86·0	187	191	207	214	217	226	234	242	261	269	283	297	304
5157	F.	75·0	188	201	211	222	232	243	253	269	274	294	302	320	328
5159	F.	83·0	182	196	204	211	222	235	238	254	265	284	295	313	327
5161	F.	87·5	185	198	210	224	230	247	257	274	284	301	316	326	344
5162	M.	90·5	206	213	221	235	246	259	271	286	295	315	329	343	358
5165	M.	82·0	183	188	199	205	211	222	230	241	252	253	271	288	310
Totals.....	.....	824·0	1,888	1,974	2,083	2,188	2,269	2,387	2,481	2,612	2,722	2,849	2,981	3,126	3,256
Averages....		82·4	188·8	197·4	208·3	218·8	226·9	238·7	248·1	261·2	272·2	284·9	298·1	312·6	325·6

APPENDIX III. (*continued*).

Group II.—Weekly Weights in Pounds.

Calf No.	Sex.	Birth Weight.	Age in weeks.											
			1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
5148	M.	75·0	86	90	97	102	113	118	121	129	145	156	171	182	197
5150	F.	96·0	101	108	113	123	131	135	146	160	171	187	198	215	231
5151	M.	77·0	85	91	96	103	119	125	131	144	157	172	183	201	214
5154	F.	82·5	86	89	93	102	116	116	124	132	144	153	166	181	197
5156	F.	100·0	107	109	116	127	133	144	149	163	176	186	198	215	223
5158	F.	76·0	77	77	86	93	102	108	117	125	135	147	160	175	183
5160	F.	78·5	86	89	96	101	109	120	129	138	148	159	174	182	188
5163	F.	70·5	72	79	82	87	99	107	116	125	138	153	162	171	186
5164	M.	84·5	81	85	90	99	105	113	121	130	140	155	168	180	191
5166	M.	72·5	78	80	83	93	102	110	120	132	144	152	162	179	190
Totals.....		812·0	859	887	952	1,030	1,129	1,196	1,274	1,378	1,498	1,620	1,742	1,881	2,000
Averages....		81·2	85·9	88·7	95·2	103·0	112·9	119·6	127·4	137·8	149·8	162·0	174·2	188·1	200·0

Calf No.	Sex.	Birth Weight.	Age in weeks.											
			14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.
5148	M.	75·0	215	218	232	252	265	283	293	312	326	344	351	370	384
5150	F.	96·0	237	252	268	287	303	319	339	345	369	380	395	401	415
5151	M.	77·0	224	238	259	276	290	300	314	333	347	359	369	388	390
5154	F.	82·5	205	218	236	250	266	277	294	301	322	323	337	348	359
5156	F.	100·0	237	256	273	290	302	320	336	353	364	375	395	415	427
5158	F.	76·0	194	207	219	236	248	263	280	294	303	315	325	337	353
5160	F.	78·5	208	218	233	247	259	274	287	299	311	323	340	353	369
5163	F.	70·5	198	212	225	241	256	272	283	302	313	331	346	353	367
5164	M.	84·5	209	224	239	250	279	279	298	312	336	342	362	381	395
5166	M.	72·5	203	218	235	242	254	272	286	297	314	330	340	347	354
Totals.....		812·0	2,130	2,261	2,419	2,571	2,713	2,859	3,010	3,148	3,305	3,422	3,560	3,693	3,822
Averages....		81·2	213·0	226·1	241·9	257·1	271·3	285·9	301·0	314·8	330·5	342·2	356·0	369·3	382·2

APPENDIX IV.

Group I.—Wither Heights in Centimetres.

Calf No.	Sex.	Date born.	At 12 weeks.	23/7/32.	20/8/32.	17/9/32.	At 26 weeks.	15/10/32.	12/11/32.	10/12/32.	9/1/32.	10/2/32.	10/3/32.	At 1 year.	11/4/32.	At 1 year.
5147	F.	31/3/32	82 (23/6/32)	87	92	94	99 (1/10/32)	100	105	107	108	110	113	114 (6/4/33)	—	—
5149	F.	4/4/32	83 (27/6/32)	86	90	93	96 (1/10/32)	100	103	105	107	107	108	112 (6/4/33)	—	—
5152	M.	7/4/32	84 (30/6/32)	87	90	94	98 (7/10/32)	100	102	107	110	111	114	114 (6/4/33)	—	—
5153	F.	8/4/32	85 (1/7/32)	89	91	98	98 (7/10/32)	101	103	107	109	112	114	114 (6/4/33)	—	—
5155	F.	11/4/32	86 (4/7/32)	88	92	97	100 (7/10/32)	101	102	106	111	112	115	—	115	115 (14/4/33)
5157	F.	14/4/32	86 (7/7/32)	89	92	99	101 (15/10/32)	101	104	107	111	112	115	—	114	115 (14/4/33)
5159	F.	19/4/32	84 (12/7/32)	86	91	95	102 (15/10/32)	102	105	106	110	111	114	—	114	114 (20/4/33)
5161	F.	1/5/32	84 (24/7/32)	84	89	93	102 (29/10/32)	100	104	105	110	112	114	—	114	116 (20/4/33)
5162	M.	2/5/32	86 (25/7/32)	86	90	97	103 (29/10/32)	102	103	108	112	113	116	—	117	118 (20/4/33)
5165	M.	23/5/32	86 (15/8/32)	82	86	92	101 (19/11/32)	95	99	102	104	106	109	—	109	111 (16/5/33)

Group II.

5148	M.	31/3/32	84 (23/6/32)	87	92	101	100 (1/10/32)	104	108	111	115	114	116	117 (6/4/33)	—	—
5150	F.	6/4/32	86 (29/6/32)	91	97	102	96 (1/10/32)	106	108	112	112	114	117	117 (6/4/33)	—	—
5151	M.	7/4/32	86 (30/6/32)	91	98	104	93 (7/10/32)	108	110	114	117	118	121	121 (6/4/33)	—	—
5154	F.	9/4/32	86 (2/7/32)	90	98	102	97 (7/10/32)	104	106	107	109	113	114	113 (6/4/33)	—	—
5156	F.	13/4/32	88 (6/7/32)	90	94	105	110 (15/10/32)	110	110	113	113	118	120	—	—	121 (14/4/33)
5158	F.	17/4/32	84 (10/7/32)	86	91	100	105 (15/10/32)	105	105	105	109	111	114	—	—	115 (14/4/33)
5160	F.	22/4/32	82 (15/7/32)	86	91	97	101 (22/10/32)	100	104	106	109	110	112	—	113	114 (20/4/33)
5163	F.	2/5/32	82 (25/7/32)	82	88	95	102 (29/10/32)	100	103	107	110	111	112	—	111	114 (20/4/33)
5164	M.	22/5/32	85 (14/8/32)	82	87	94	104 (19/11/32)	99·5	104	106	109	110	113	—	115	116 (16/5/33)
5166	M.	5/7/32	83 (27/9/32)	72	76	81	100 (31/12/32)	87	93	99	100	101	106	—	105	—

NOTE.—The above measurements are averages of three readings.

GROUP I. CALVES: WHOLE MILK AND MEAL RATION. FIGS. 1-20.

Fig. 1.—No. 5147 at 12 weeks.
Wither Height: 32·8 in. Weight: 162 lb.

Fig. 2.—No. 5147 at 26 weeks.
Wither Height: 39·6 in. Weight: 324 lb.

Fig. 3.—No. 5149 at 12 weeks.
Wither Height: 33·2 in. Wtight: 156 lb.

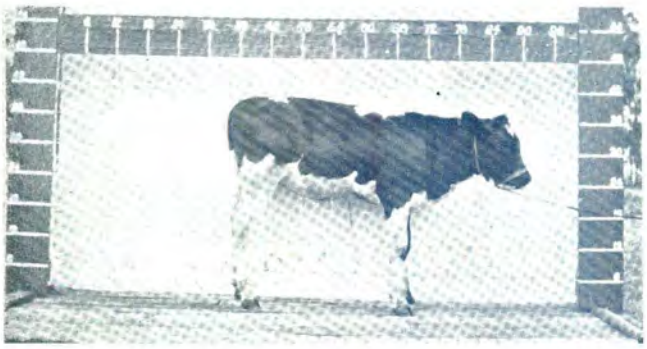

Fig. 4.—No. 5149 at 26 weeks.
Wither Height: 38·4 in. Weight: 281 lb.

Fig. 5.—No. 5152 at 12 weeks.
Wither Height: 33·6 in. Weight: 189 lb.

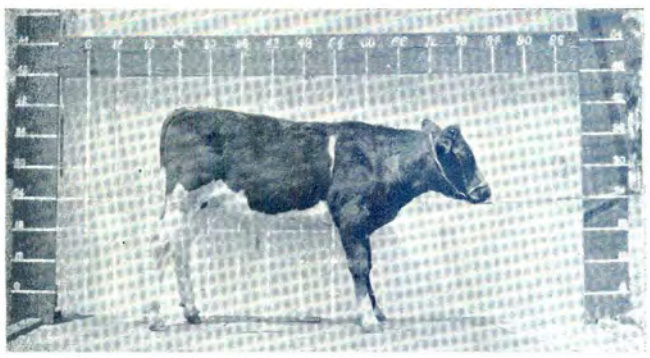

Fig. 6.—No. 5152 at 26 weeks.
Wither Height: 39·2 in. Weight: 352 lb.

Fig. 7.—No. 5153 at 12 weeks.
Wither Height: 34·0 in. Weight: 181 lb.

Fig. 8.—No. 5153 at 26 weeks.
Wither Height: 39·2 in. Weight: 338 lb.

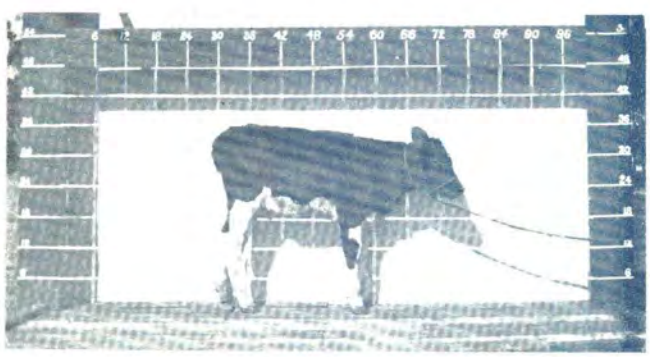

Fig. 9.—No. 5155 at 12 weeks.
Wither Height: 34·4 in. Weight: 168 lb.

Fig. 10.—No. 5155 at 26 weeks.
Wither Height: 40·0 in. Weight: 304 lb.

Fig. 11.—No. 5157 at 12 weeks.
Wither Height: 34·4 in. Weight: 171 lb.

Fig. 12.—No. 5157 at 26 weeks.
Wither Height: 40·4 in. Weight: 328 lb.

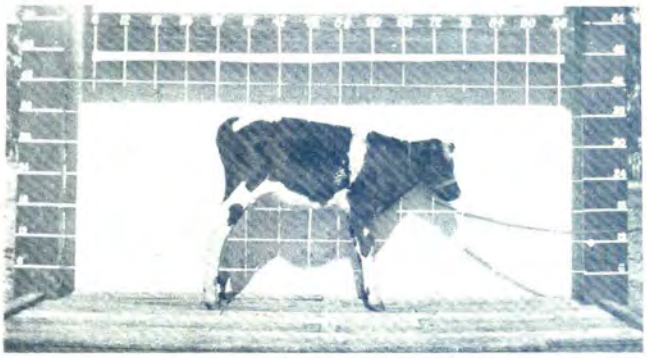

Fig. 13.—No. 5159 at 12 weeks.
Wither Height: 33·6 in. Weight: 166 lb.

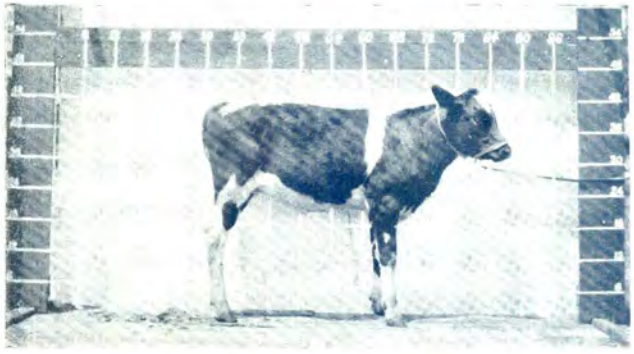

Fig. 14.—No. 5159 at 26 weeks.
Wither Height: 40·8 in. Weight: 327 lb.

Fig. 15.—No. 5161 at 12 weeks.
Wither Height: 33·6 in. Weight: 168 lb.

Fig. 16.—No. 5161 at 26 weeks.
Wither Height: 40·8 in. Weight: 344 lb.

Fig. 17.—No. 5162 at 12 weeks.
Wither Height: 34·4 in. Weight: 183 lb.

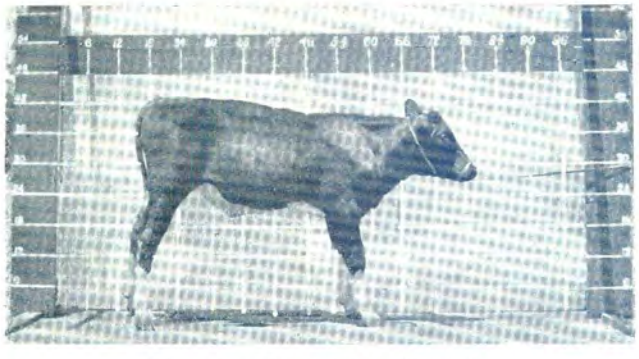

Fig. 18.—No. 5162 at 26 weeks.
Wither Height: 41·2 in. Weight: 358 lb.

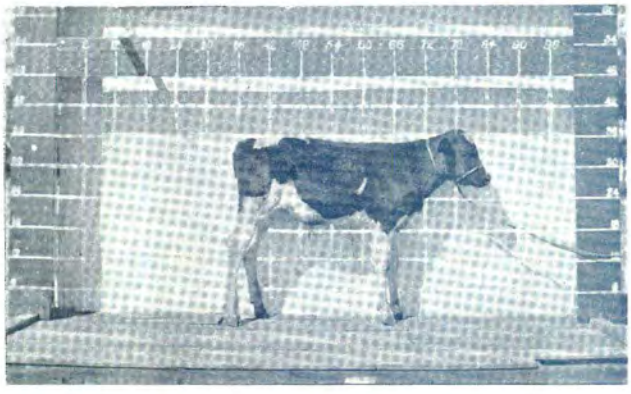

Fig. 19.—No. 5165 at 12 weeks.
Wither Height: 34·4 in. Weight: 170 lb.

Fig. 20.—No. 5165 at 26 weeks.
Wither Height: 40·4 in. Weight: 300 lb.

GROUP II. CALVES: SKIM MILK RATION. FIGS. 21-40.

Fig. 21.—No. 5148 at 12 weeks.
Wither Height: 33·6 in. Weight: 182 lb.

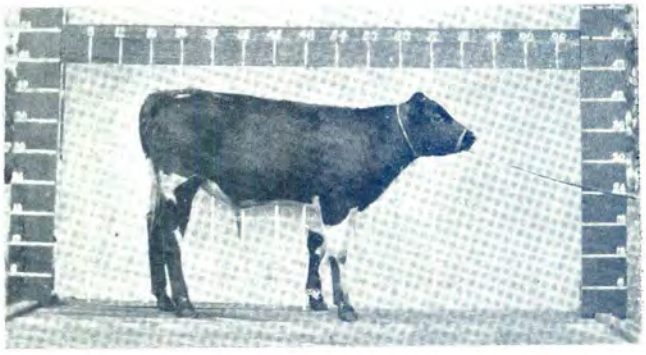

Fig. 22.—No. 5148 at 26 weeks.
Wither Height: 40·0 in. Weight: 384 lb.

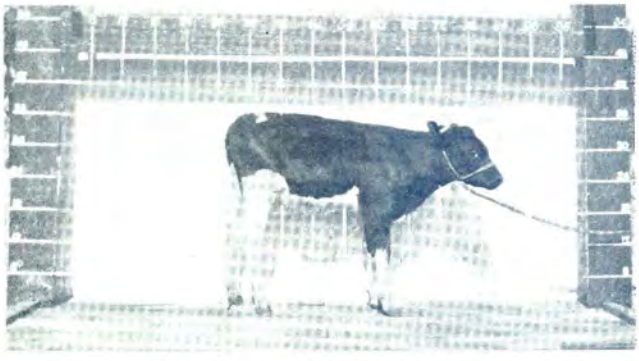

Fig. 23.—No. 5150 at 12 weeks.
Wither Height: 34·4 in. Weight: 215 lb.

Fig. 24.—No. 5150 at 26 weeks.
Wither Height: 38·4 in. Weight: 415 lb.

Fig. 25.—No. 5151 at 12 weeks.
Wither Height: 34·4 in. Weight: 201 lb.

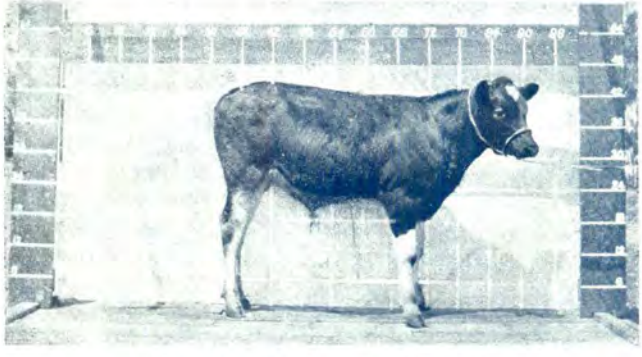

Fig. 26.—No. 5151 at 26 weeks.
Wither Height: 37·2 in. Weight: 399 lb.

Fig. 27.—No. 5154 at 12 weeks.
Wither Height: 34·4 in. Weight: 181 lb.

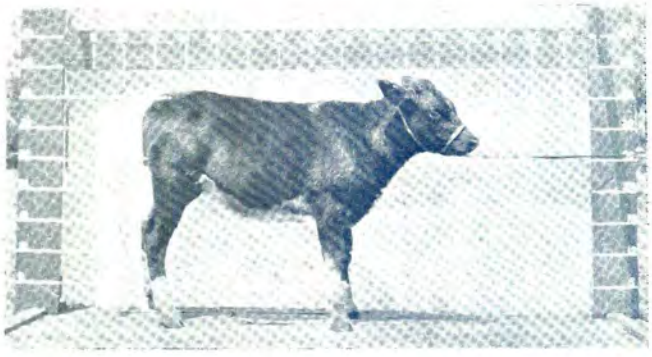

Fig. 28.—No. 5154 at 26 weeks.
Wither Height: 38·8 in. Weight: 359 lb.

Fig. 29.—5156 at 12 weeks.
Wither Weight: 35·2 in. Weieght: 215 lb.

Fig. 30.—No. 5156 at 26 weeks.
Wither Height: 44·0 in. Weight: 427 lb.

Fig. 31.—No. 5158 at 12 weeks.
Wither Height: 33·6 in. Weight: 175 lb.

Fig. 32.—No. 5158 at 26 weeks.
Wither Height: 42·0 in. Weight: 353 lb.

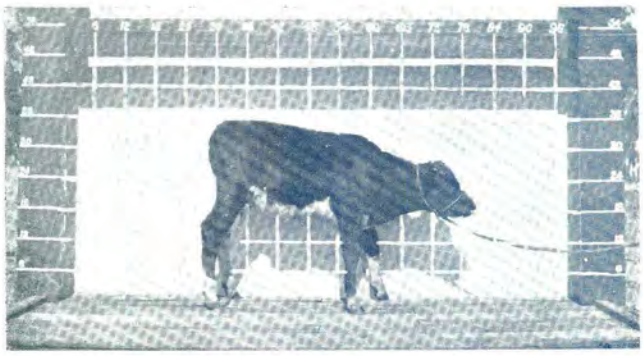

Fig. 33.—No. 5160 at 12 weeks.
Wither Height: 32·8 in. Weight: 182 lb.

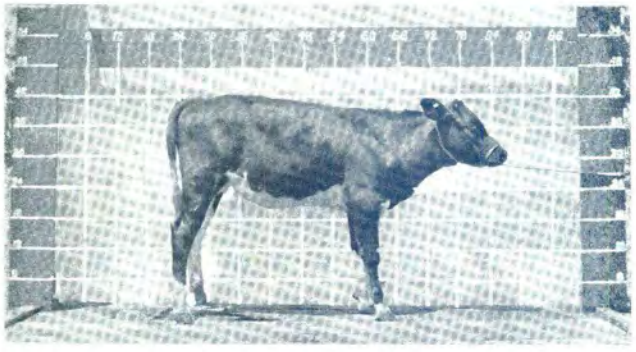

Fig. 34.—No. 5160 at 26 weeks.
WitherHeight: 40·4 in. Weight: 369 lb.

Fig. 35.—No. 5163 at 12 we.eks.
Wither Height: 32·8 in. Weight: 173 lb.

Fig. 36.—No. 5163 at 26 weeks.
Wither Height: 40·8 in. Weight: 367 lb.

Fig. 37.—No. 5164 at 12 weeks.
Wither Height: 34·0 in. Weight: 180 lb.

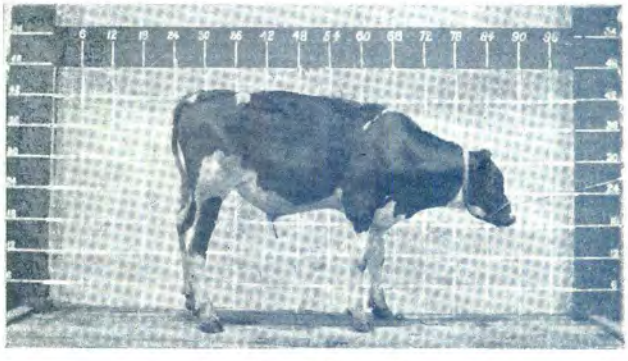

Fig. 38.—No. 5164 at 26 weeks.
Wither Height: 41·6 in. Weight: 395 lb.

Fig. 39.—No. 5166 at 12 weeks.
Wither Height: 33·2 in. Weight: 179 lb.

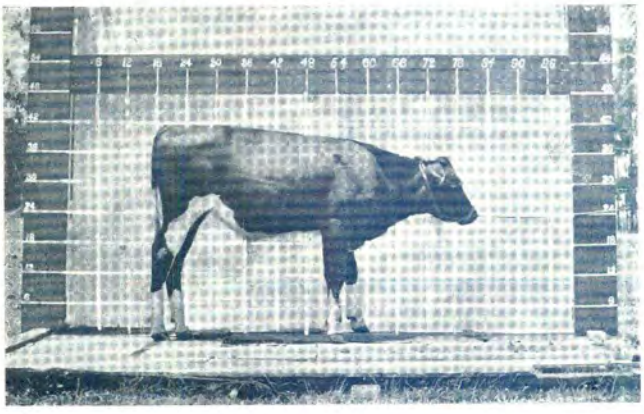

Fig. 40.—No. 5166 at 26 weeks.
Wither Height: 40·0 in. Weight: 354 lb.