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SUPPLEMENTAL FEEDING OF SHEEP GRAZING ON DRY RANGE

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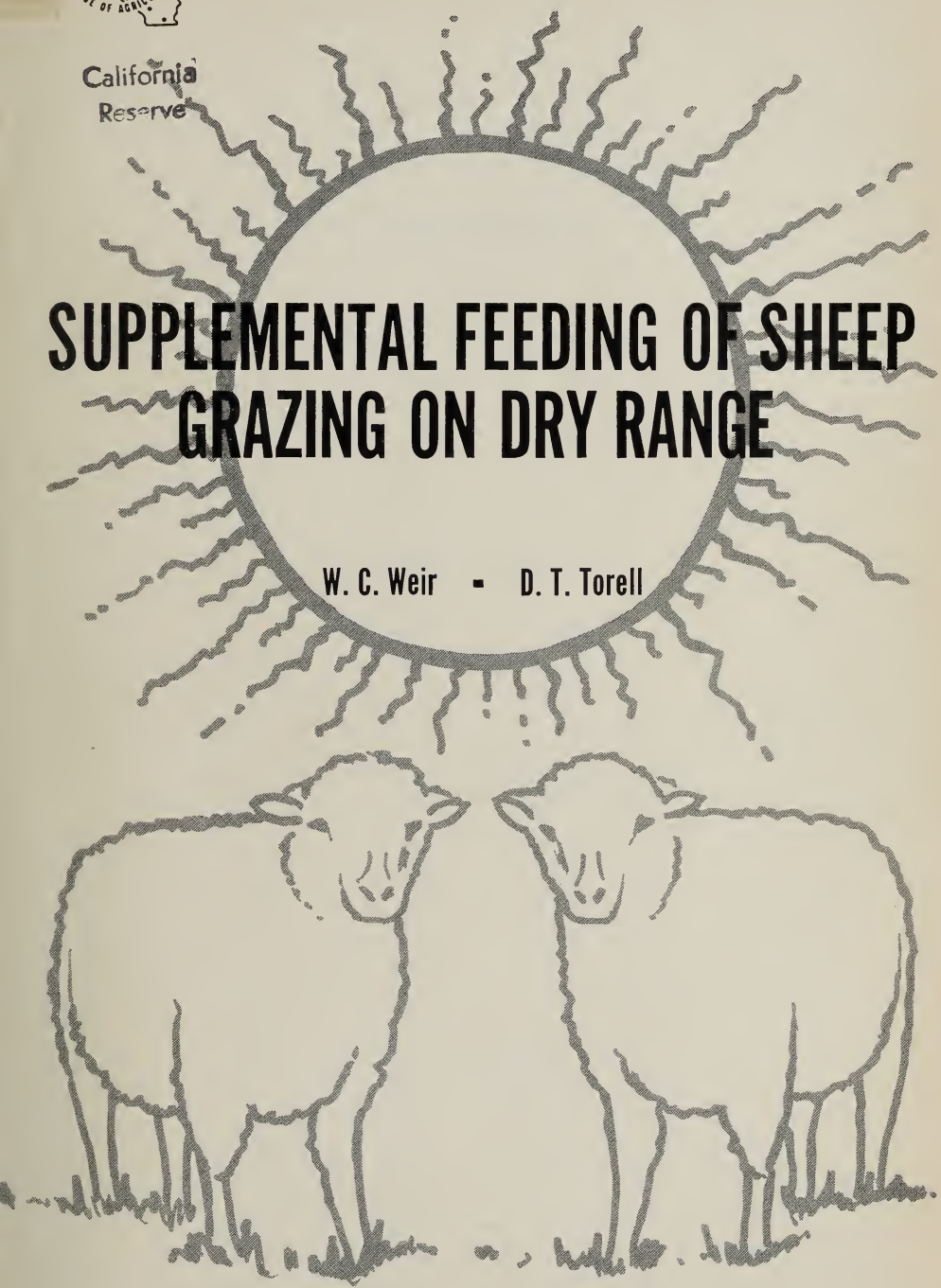

CALIFORNIA AGRICULTURAL
EXPERIMENT STATION

BULLETIN 832

SEASONAL CHANGES in chemical composition of range forages and their effect on the nutrition of grazing animals have been investigated by many workers.

Animals grazing on predominantly grass-range forage are likely to have nutrient deficiencies during the dry-feed season. Producers of weanling ewe lambs are interested in keeping them thrifty, growing, and producing a good clip of wool, but sometimes this presents problems. Development of the esophageal-fistula technique for obtaining samples of what livestock eat has helped with these problems by increasing our knowledge of feed consumed on the range and thus suggesting nutrient supplements for optimum production. This bulletin is a summary of 7 years of investigation to determine the amount and kind of feeds, as well as the frequency of feeding, for proper supplementation of weanling lambs grazing on dry annual-range forage.

MAY, 1967

THE AUTHORS:

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INTRODUCTION

In the winter of 1951–52 trials conducted at the Hopland Field Station, located in the inland northern coastal area of California, indicated that ewes responded to supplementation with a mixture of cottonseed meal and salt. In the summer and fall of 1953 lambs were supplemented with cottonseed meal and salt while others were unsupplemented. The supplemented and unsupplemented animals differed significantly in performance. The two groups grazed the same pastures but on an approximately 28-day change-over rotation; thus it is possible that not all of the observed difference was due to the supplementation alone.

SUPPLEMENTAL FEEDING OF SHEEP GRAZING ON DRY RANGE[1]

PROCEDURE

In the study reported here, sheep were grazed as a common flock, so that all lambs had equal access to annual range feed. The flock was gathered in mid-morning, brought to a barn on the edge of the two pastures being used, and then sorted through a cutting chute into the appropriate treatment groups. At the barn they were group-fed supplements; water and salt were available in feeding pens as well as in pastures. After a few hours all lambs were turned back to pasture as one flock. Initially the lambs were gathered every day, but after 1956 lambs were gathered Mondays through Fridays only.

Lambs were fed from the first of July until the first week of December each year—this will be referred to as the "supplemented period." After the supplemented period all lambs were treated as one flock and grazed on other parts of the Hopland Field Station in accordance with feed availability. This period—referred to as the "recovery period"—terminated at shearing the following spring. At shearing the lambs were again weighed and measured. The period from July until the following May will be referred to as the "combined period."

Range forage at the Hopland Field Station consists of a wide variety of annual grasses, legumes, and broadleaf herbs. Depending upon rainfall and temperature, the plants germinate in the fall, grow little during most winters, and then grow and produce well through the spring months. The feed dries and matures during May and June so that only mature dry forage is available to the grazing animals by July. Adequate dry feed is usually available but is of limited nutritive value.

The chemical composition of the forage actually consumed was measured by the use of esophageal-fistulated sheep as sampling animals. Grazing sheep will select and consume material which is higher in protein and lower in crude fiber than the forage obtained by hand clipping; figure 1 shows the protein content of forage selected by the sheep. (Complete chemical analyses of the samples obtained are presented in appendix table 1.) The forage was sampled at approximately monthly intervals from July through November in various years. Protein content usually ranged from 4½ to 7½ per cent, with only occasional values above 7½ per cent during July, August, and September. In 1959 an early rain followed by good growing weather produced green feed in September, with a marked increase in protein content of forage available through the latter half of that year. Early rains also produced green fall feed in 1956 and in 1957. In 1958, 1960, 1961, and 1962 protein content of the forage was never above 7.7 per cent; most of the time it was below 6 per cent and on some occasions below 5 per cent.

[1] Submitted for publication May 18, 1966.

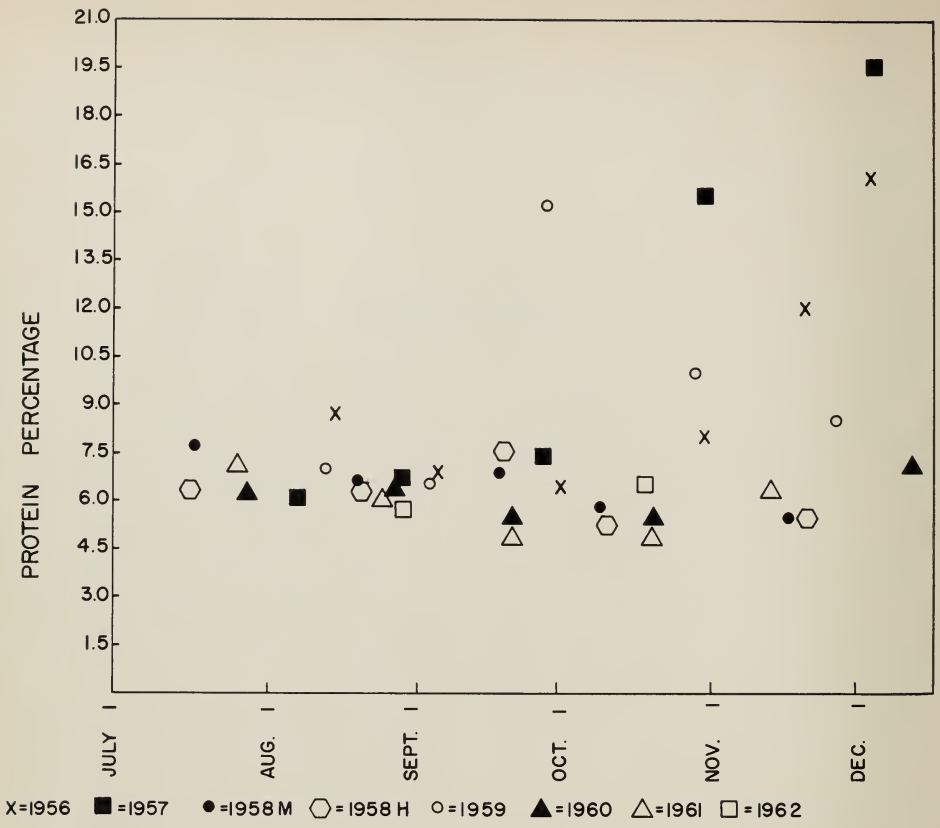

Fig. 1. Protein content of range forage collected from experimental pastures by esophageal-fistulated sheep, 1956 through 1962. M = moderately grazed. H = heavily grazed.

Performance of Unsupplemented Lambs

Body and wool weights of unsupplemented lambs are the best indication of the effect of environment on the animal. In all trials, 17 to 36 control animals were carried as an unsupplemented flock; figure 2 shows the year-to-year body weights of these animals. In 1956, 1957, 1959, and 1962 the control lambs gained from July to December; in 1958, 1960, and 1961 the control lambs lost with varying degrees of severity during the supplemented period. From December to May the lambs gained weight, but their final weights in May reflected the losses or gains during the July to December period. The average grease wool production for the year ending in May also reflected wide seasonal variations. In 1956 and 1957 wool production averaged 8 pounds; in 1959, 6.4 pounds; and in 1962, 7.4 pounds. When there was body-weight loss during the supplemented period there was a correspondingly lower wool production. Wool production averaged 5.4 pounds on heavily grazed pastures in 1958, 6.2 pounds in 1959, 5.6 pounds in 1960 and 5.5 pounds in 1961 on moderately grazed pastures. The relationship of performance during the supplemented period to the protein content of the forage collected is rather striking. In 1959 following the early rain there was an excellent growth of fall feed; in

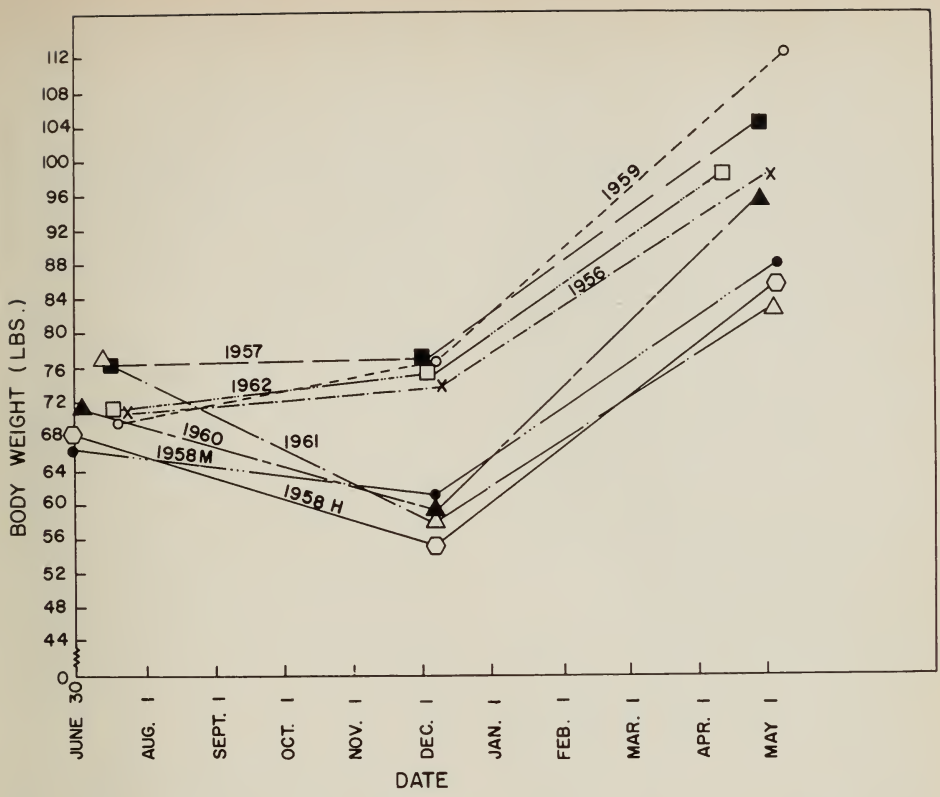

Fig. 2. Body weights of unsupplemented (control) lambs during the supplemented and recovery periods during the trials from 1956 through 1962. M = moderately grazed. H = heavily grazed.

1957 there was green feed in November and early December, and in 1956 green feed was available somewhat later. The average date of the first effective rainfall was October 23, although such rainfalls occurred over a period of 8 weeks.

In 1958, 11 per cent of the control lambs on the heavily grazed pasture died during the supplemented period, and 6 per cent died during the recovery period. In 1961, one lamb died of malnutrition during the supplemented period. Although some minor death losses did occur in other years, they could not be attributed directly to the nutritional regime and therefore have been discounted. Detailed performance of the lambs is shown in appendix tables 2 through 15. Performance of the control lambs will be used as base data and the performance for all groups will be compared with that of the control group by year. These control lambs were subjected to somewhat more stress than lambs which would be grazing similar pastures under normal range conditions. They were gathered, sorted, and held in the barn even though they were not supplemented. They are suitable base animals for comparison with the treated groups, because they received exactly the same treatment except for the supplemental feeding.

Amount of Range Forage

In the first two years' trials there was always adequate dry feed available to the lambs. The third year half of the lambs grazed a pasture with adequate dry feed, and the other half was placed in a pasture which had been previously grazed to

reduce the amount of dry feed available (the latter group has been labeled the "heavily grazed treatment group"). Both control groups lost weight during the supplemented period, with a loss of 11.7 pounds for animals on heavily grazed pasture and 5.6 pounds for those on moderately grazed pasture. Lambs receiving supplements gained 3 pounds more in the moderately grazed pasture than in the heavily grazed when the supplement was cottonseed meal, and 2.8 pounds more when the supplement was alfalfa pellets. Thus, any supplementation program must assume that there is adequate dry feed available for the animals and that supplement is being used only to increase the utilization of the dry range forage. (Appendix tables 5 and 7.)

Supplemental Feeds

Feedstuffs available for use in supplementing low quality range forage are genenerally of four types. (All of the following analyses are on a 100 per cent dry-matter basis.)

High-protein plant materials. Cottonseed meal and soybean meal are high in protein, medium to low in fiber and lignin, and are good sources of energy. The material used varied from 46.2 to 58.2 per cent protein, and from 2.8 to 13.8 per cent crude fiber. (Appendix table 16.)

Grains. Barley was used as a high-energy, low-protein feed. The barley varied from 9.6 to 12 per cent protein, and from 4.3 to 6.9 per cent crude fiber.

Hay. Alfalfa of high quality obtained specifically for these trials was used as a medium-protein, high-fiber feed. The importance of the quality of the alfalfa used was extensively studied through the years. Full-bloom alfalfa contained about 20 per cent protein, whereas most of the other alfalfa analyzed varied from 21.5 to 26 per cent protein. The crude fiber content was low for hay, running from 21.5 to 26.1 per cent. Alfalfa was fed in pellets and in wafers (this will be discussed more fully later).

Synthetic chemical supplements in a carrier. Urea containing 42 per cent nitrogen, and diammonium phosphate containing 21.4 per cent nitrogen and 27 per cent phosphorus, have been tested as supplements to ruminant rations. The use of these inorganic salts as substitutes for natural protein offers considerable promise for reducing the cost of ruminant rations. Molasses-dried beet pulp was selected as a carrier for the urea and the diammonium phosphate in the 1962 trials.

CRUDE PROTEIN CONTENT OF VARIOUS SUPPLEMENTS

Supplement	*Per cent protein*
Soybean meal	50.1 to 58.2
Cottonseed meal	46.2 to 55.2
Alfalfa, dehydrated:	
Bud stage maturity	23.8 to 26.0
Full bloom maturity	19.8 to 20.2
Commercial	21.5 to 23.9
Alfalfa, sun-cured:	
Pelleted	23.1
Wafered	24.2
Barley	9.6 to 12.0
Beet pulp	7.8

Supplemented Period, July to December

Cottonseed meal at the 0.5 pound-per-day level consistently produced increased gains during the supplemented period (table 1). In all cases the difference in response from that of the control animals was highly significant. In 1958 when the controls lost weight, the cottonseed meal response was even greater than in the two previous years. In later years when the cottonseed meal was provided at the 0.25 pound-per-day level, it still produced increased gains over the unsupplemented lambs ($P < 0.01$).

Soybean meal was an excellent supplement at 0.214 of a pound per day—this furnished the same amount of protein as 0.5 of a pound of alfalfa pellets. There was no difference in the gain during the supplemented period between the lambs receiving protein in the form of soybean meal and those receiving equal amounts in the form of alfalfa pellets in 1959. In 1960, when soybean meal was fed once and five times weekly, there was a slight advantage for feeding five times over once weekly, but there was no difference when gains on soybean meal and alfalfa pellets or wafers were compared.

Animals fed alfalfa pellets consistently showed gains over control animals ($P < 0.01$). Increases ranged from 4.6 pounds in 1957 for lambs on moderately grazed pasture supplemented with the full-bloom, lower-protein pellets, to 19.4 pounds in 1958 for lambs on heavily grazed pasture supplemented with the bud-stage, high-protein pellets. In this latter case it is likely that when the dry forage was limited there was also an energy response to the alfalfa pellets: cottonseed meal in that year, fed at the 0.5 pound level, produced even greater gains over the control than did the alfalfa. In 1961, when the level of feeding was reduced to 0.25 pound of alfalfa pellets either once or five times per week, the gain over the controls was similar for both the 0.25 pound and 0.50 pound level as well as for 0.25 of a pound of cottonseed meal. When the alfalfa level was increased to 1.0 pound per head per day the gain was significantly greater. Apparently, the feed value of alfalfa as a range supplement is directly proportional to its protein content.

Lambs supplemented with a mixture of one-half cottonseed meal and one-half barley consistently gained more than did the unsupplemented controls. The level of gain was not as high as that obtained by cottonseed meal alone, but was higher than that produced by barley alone. As expected, the mixture was intermediate in value between the two feeds fed separately.

Although barley produced increased gains over the controls it was the least efficient of the supplements tested. In 1956 and 1957 the half-pound of barley produced gains of the same magnitude as the full-bloom alfalfa pellets. In 1956 the cottonseed meal, cottonseed meal and barley mix, and bud-stage alfalfa all produced significantly higher gains than did barley. In 1957 cottonseed meal alone, and cottonseed meal and barley mixture, both produced significantly higher gains than did barley. In 1959 barley was fed at 0.352 of a pound per day to provide equivalent energy to that available in a half-pound of alfalfa pellets. Although increasing the gains over the unsupplemented controls, barley produced the lowest gains of any of the supplements. In 1960 barley was increased to 0.7 of a pound per lamb per day to furnish approximately twice the energy available in alfalfa meal—at that level it produced gains of the same magnitude as those pro-

TABLE 1

INCREASED BODY AND WOOL WEIGHTS OF SUPPLEMENTED ANIMALS

Supplement (pounds per day)	Year	Weight superiority of supplemented to control animals		
		Body weight		Yearling grease fleece
		End of supplemental period	As yearlings	
		lb.		
Cottonseed meal:				
0.50	1956	11.3**	1.5	1.1
0.50	1957	11.4**	5.7	1.3**
0.50 (moderately grazed)	1958	21.6**	8.8**	2.5**
0.50 (heavily grazed)	1958	24.6**	8.5**	3.0**
0.25 (5 feedings per week)	1961	13.1**	6.8*	1.0**
0.25 (1 feeding per week)	1961	13.9**	7.0*	1.0**
0.24	1962	12.3**	2.6	1.0
Soybean meal:				
0.214	1959	12.8**	5.9**	1.1**
0.214 (5 feedings per week)	1960	13.8**	3.2	1.8**
0.214 (1 feeding per week)	1960	9.9**	0.6	1.5**
Alfalfa pellets, dehydrated: (bud stage maturity)				
0.50	1956	10.1**	5.0	0.82
0.50	1957	6.4**	3.1	1.1**
0.50 (moderately grazed)	1958	15.1**	4.8**	1.50**
0.50 (heavily grazed)	1958	19.4**	8.5**	2.1**
Alfalfa pellets, dehydrated: (full bloom maturity)				
0.50	1956	6.6**	1.8	0.6
0.50	1957	4.6**	2.9	0.9*
(commercial)				
0.50 (5 feedings per week)	1959	14.2**	6.3**	1.2**
0.50 (2 feedings per week)	1959	13.7**	8.3**	1.5**
0.50 (1 feeding per week)	1959	11.1**	4.3*	1.2**
0.453 (salt limited)	1959	9.6**	3.6	1.2**
Alfalfa pellets, dehydrated: (commercial)				
0.25 (5 feedings per week)	1961	10.9**	5.2	0.4
0.25 (1 feeding per week)	1961	10.0**	6.5**	0.4
0.50 (1 feeding per week)	1961	11.8**	4.7	0.8*
1.00 (1 feeding per week)	1961	22.5**	9.5**	2.6**
Alfalfa, sun-cured:				
0.5 pelleted (5 feedings per week)	1960	12.0**	0.2	1.7**
0.5 pelleted (1 feeding per week)	1960	11.9**	3.7	1.1**
0.5 wafered (5 feedings per week)	1960	11.2**	2.6	1.3**
Cottonseed meal and barley:				
0.25 + 0.25	1956	11.1**	2.3	0.85
0.25 + 0.25	1957	8.5**	3.6	0.81*
Barley				
0.50	1956	6.2**	1.7	0.24
0.50	1957	4.8**	1.4	0.1
0.352	1959	5.2**	3.0	0.6
0.7	1960	12.6**	4.3	1.2**
Molasses-dried beet pulp:				
0.24	1962	2.6*	−0.7	0.3
0.19 + 11.1 per cent urea	1962	2.1	0.3	0.1
0.09 + 20.3 per cent diammonium phosphate	1962	1.3	−1.0	0.1
0.25 + 4.1 per cent diammonium phosphate	1962	4.8**	0.3	0.6
0.16 + 3.8 per cent diammonium phosphate and 9.4 per cent urea	1962	3.1**	3.1	0.1

* Significant at 5 per cent level.
** Significant at 1 per cent level.

duced by a half-pound of alfalfa pellets or 0.214 of a pound of soybean meal. Even 0.7 of a pound of barley per day furnished only 4.4 grams of nitrogen per day; this is lower than any level of cottonseed or soybean meal fed in the trials.

Molasses-dried beet pulp was used as a carrier for urea in the 1962 trial. When fed as the only supplement at 0.24 of a pound per day it produced a slight increase in gain over the unsupplemented controls. The difference of 2.6 pounds was significant at the 5 per cent level. Adding either urea or diammonium phosphate to the beet pulp did not increase its effectiveness in producing gains in supplemented animals. None of the additives to beet pulp made it as valuable as cottonseed meal as a dry range supplement. The addition of urea and diammonium phosphate had an adverse effect on palatability, so that only the dried beet pulp which was supplemented with 4.1 per cent diammonium phosphate was consumed at the intended level.

Recovery Period

At the close of the supplemented period in December all lambs were placed in one flock and grazed in various pastures. In all years a marked increase in body weight was found during the period from December to shearing time, usually about May 1. Compensatory growth—the tendency of an animal which has been underfed to increase its rate of growth beyond normal upon realimentation—was evident in the growth rate of the control animals compared with those which had been supplemented. In all years those animals which gained least during the supplemented period made greater gains during the recovery period.

Combined Periods

The weight of most economic significance in the yearling ewe is found at breeding time (approximately 18 to 20 months of age) when ovulation rate is correlated with body weight. The effects of the supplements are shown in table 1 under the column labeled "As yearlings." Supplemented animals were always larger than the unsupplemented controls at shearing time, except when feeding molasses-dried beet pulp and molasses-dried beet pulp plus 20.3 per cent diammonium phosphate. However, variation was often such that differences were not statistically significant. Only under severely adverse conditions (such as in 1958) does it appear that supplementation has a practical effect on body size of yearling ewes at shearing.

EFFECT OF SUPPLEMENTATION ON WOOL PRODUCTION

The feeding of supplements during the 5-month summer and fall period consistently produced a grease wool increase of 1 to 2 pounds per sheep, which seems to be a reflection of both the amount and the protein content of supplement fed. Lower-protein feeds such as full-bloom alfalfa and barley were less effective in producing wool. Increased wool production from barley was significant only when barley was fed at the rather high level of 0.7 of a pound per sheep per day. One-fourth of a pound of alfalfa pellets per day was insufficient to produce statistically increased wool weights. In those years for which data were available on clean fleece weight, the effect of supplementation was further demonstrated by increased pro-

duction of clean wool. In 1960 and 1961 staple length of the wool was affected by supplementation to a significant degree, but in 1959 and 1962 the differences were not statistically significant. Quality of wool was also affected by supplemental feeding: there was a much larger percentage of cotted, broken, and tender fleeces from sheep which had been unsupplemented. This places added economic significance on the effect of supplementation on quality of wool produced.

Wool production of ewes remaining in the flock was measured yearly through 1963. Only in one lot in 1961 was there a demonstrable carry-over effect for wool production in later years—this one lct was the group which had received 1 pound of alfalfa hay per day during the supplemental period. In other words, differences due to supplementation will show up at the first shearing, but ordinarily such differences will have disappeared by the time of later shearings.

EFFECT OF SUPPLEMENTAL FEEDING ON THE BODY MEASUREMENTS OF SHEEP

To further study the effect of supplementation on growth and development of weanling ewe lambs, a series of body measurements developed by Cassard *et al.* was recorded for the lambs. (Results of these measurements are shown in appendix tables 3, 6, 7, 9, 11, 13, and 15.) Body measurements were taken following shearing in May of 1957 and 1958, but gain data are not available on the 1956 and 1957 ewe crop. In December, 1958, measurements were taken at the end of the supplemented period and again following shearing, allowing a computation of gain in measurements between the end of the supplemented period and shearing. Starting in July of 1959, lambs were measured at the beginning of the supplemented period, at the end of the supplemented period, and again after shearing. This allowed computation of the gain in body measurements during the supplemented period, during the recovery period, and during the combined period.

Height at Withers

There was so much variation within treatment groups that no significant differences were demonstrated. This is understandable in view of the fact that measurement depends to some extent on the manner in which the animal is standing at the time the measurement is taken.

Length

This measurement from the point of the shoulder to the pinbone at the tailhead did not produce significant differences for the combined period from July to the following May, but in some years it reinforced the body weight measurement data. For example, in December of 1958 the controls measured significantly shorter than any of the treated groups followed by (1) the alfalfa-supplemented lambs grazing on the heavily grazed pasture, (2) the alfalfa lambs on moderately grazed pasture, (3) cottonseed meal on the heavily grazed pasture and (4) the cottonseed meal lambs on moderately grazed pasture. During the following recovery period compensatory growth was evident, with the controls catching up with those that had grown more during the supplemented period. In the fall of 1959, during the supplemented period, the controls were shorter than any of the other lambs except the barley-fed lambs; the alfalfa and soybean meal lambs were the longest. These differences disappeared

during the recovery period, and there were nonsignificant differences for the combined period. In the 1961 trial, 1 pound per head per day of alfalfa produced greater length than all other feeds. The difference was significant in all groups except those fed cottonseed meal once a week. During the recovery period the lambs which had been fed the high level of alfalfa made significantly less length gain; consequently by the end of the combined period there was no significant difference.

Heart Girth

There was no difference due to supplements in May of 1957 or 1958, or for the combined periods in 1959, 1960 or 1962. During the recovery periods compensatory growth was again manifested, with a tendency to catch up on the part of those lambs which had grown least during the supplemented period. In the 1959 trial, the control group was followed by the barley group during supplementation, and all alfalfa groups were superior to the control and to barley. Again in the recovery period the control and barley lambs caught up, resulting in no significant effects in May. In 1960 the control lambs were smaller, with all the supplemented lambs falling into a class larger than the controls. Again in the recovery period, control lambs overcame their disadvantage with a resulting nonsignificant combined period effect. In 1961 heart-girth measurement showed increased gains resulting from the supplementation with 1 pound of alfalfa per day. All of the other supplements were intermediate between the high level of alfalfa and the control lambs. During the recovery period the gap between the control lambs and the supplemented lambs decreased, but in May the controls were still significantly smaller than the lambs which had received the 1 pound of alfalfa and those which had received 0.25 pound of cottonseed meal five times weekly. In 1962 heart-girth measurements of lambs supplemented with cottonseed meal were significantly superior to the measurements of the controls and lambs supplemented with beet pulp and diammonium phosphate plus urea, and with beet pulp with high levels of diammonium phosphate during the fall period. The differences disappeared during the recovery period, and there was no net effect in May.

Chest Width

Commencing in December, 1958, chest-width measurements were taken across the rib cage behind the shoulders. At this time significant differences were found between the controls and all treated groups, with the cottonseed meal lambs on the moderate grazing level showing greatest increase in chest width. In the following period compensatory growth was again shown, with controls catching up. Again in 1959 this measurement showed the difference between the unsupplemented lambs and those receiving barley, as compared with those receiving soybean meal and alfalfa. The barley and control lambs recovered sufficiently so that there was no net effect for the combined periods. In 1960, the chest width was smaller for the control lambs than for all the supplemented groups at the end of the fall period, but the controls caught up during the recovery period with a net nonsignificant effect. In the 1961 trial the 1 pound of alfalfa again demonstrated its superiority over the other treatments; the cottonseed meal and the half-pound of alfalfa meal per day also showed more effect than did the quarter-pound of alfalfa meal. During the recovery period most of the groups increased enough to fall into the same class, except that the 1 pound of alfalfa per day resulted in a wider chest width at the May measurements. In the 1962 trial there was no significant effect.

Chest Depth

The chest-depth measurement, taken from

the top of the backbone to the bottom of the sternum, was also instituted in December, 1958. Controls showed the shallowest chest, followed by alfalfa lambs on the heavy and moderate grazing level. Cottonseed meal on the moderately grazed pasture produced the deepest chest. During the following period the controls made the greatest recovery, followed by alfalfa lambs and cottonseed meal lambs. In 1959, controls and barley lambs were more shallow in the chest than were the hand-fed alfalfa lambs and the soybean meal supplemented lambs. There was no significant effect during the recovery period nor any net effect for the combined periods. In the 1960 trial there was no significant effect during either the supplemented or the combined periods, but during the recovery period the control lambs did make significantly more gain in chest-depth than did lambs which had received alfalfa pellets, barley, or soybean meal five times per week. During the supplemented period in 1961, controls were significantly lower than the lambs fed the 1 pound of alfalfa meal and the quarter pound of cottonseed meal five times per week. Gains during the recovery period were not significant, but in May the controls were significantly smaller in this measurement than were lambs fed cottonseed meal five times per week and those fed the 1 pound of alfalfa. During the 1962 trial there were no significant effects.

Summary of Body Measurements

Body measurements tend to confirm body-weight data, and to further demonstrate the superiority of cottonseed meal and soybean meal as supplements for growing lambs even at low levels of supplementation such as a quarter of a pound per day. They confirm that barley is the poorest supplement investigated except (possibly) some of the synthetic products. They further demonstrate that 1 pound of alfalfa pellets per day has a marked beneficial effect on the growth of weanling ewe lambs.

Yearling Grade

In connection with breeding studies underway at the Hopland Field Station all yearling ewes were graded on a phenotypic grade similar to that used in the California Beef Cattle Improvement Program. For example, a 2+ is 90 per cent, a 2 is 87 per cent, etc. These grades were assigned by experienced sheep judges a few days after shearing. The results were analyzed for 1956 through 1960, but only in the spring of 1959 was a difference due to treatment detected. Following the rather severe winter treatment in the winter of 1958, visual grading corresponded exactly with the weight gain of these ewes the previous winter—that is, the controls which had been on the heavily grazed pasture had the lowest grades. They were followed by the controls from the moderately grazed pasture, then by the alfalfa-supplemented lambs from the heavily grazed pasture, the alfalfa lambs from the moderately grazed pasture, with the cottonseed meal supplemented lambs grading the highest.

Lifetime Production

After shearing as yearlings, all ewes were placed in the station flock and subjected to the standard management for other sheep on the station. They were subjected to culling procedures normally followed in a good livestock operation, and retention was based on individual record of production as well as appearance and thriftiness.

Mature Live Weight

Weight of the ewes at the start of the breeding season in early August was selected as the indicator of normal weight—this weight was least affected by lamb production. (These weights are shown in appendix tables 2, 4, 5, 8, 10, and 12 as gain from one year to the next.) Comparing August body weights

of ewes in the flock and then reporting the change as "gain" or "loss" eliminates the problem of culling effect on the average live weight of the flock. Figures 3 and 4 show the live weight pattern along with wool production of two of the groups of ewes. Figure 3 shows a year in which the controls gained weight during the supplemented period; figure 4 shows a year (1958) when some controls died during the supplemented and recovery periods. Supplementation usually had no permanent effect on lifetime size, and under comparatively favorable conditions in 1956, 1957, and 1959 no differences were detected in gains following cessation of trials. The controls which were unsupplemented on the heavily grazed pasture in the winter of 1958 made the largest gain from August, 1959, to August, 1960, indicating that they had not made their compensatory growth. The same is true for 1960, when there was no difference in gain from shearing to first breeding nor during the first lambing year—but controls made significantly greater gains during 1962–63. In the 1961 group the differences between the cottonseed meal groups in 1962–63 cannot be explained by present data.

Lamb Production

Data have been reported on number of lambs weaned and average pounds of lamb produced per ewe remaining at lambing (lamb production of these ewes is shown in appendix tables 3, 6, 7, 9, 11 and 13). To get a figure for statistical analysis, the 120-day weight of single lambs produced was calculated and analyzed. Examination of the ranking of the lambs produced per ewe does not indicate any consistent treatment effect—the 120-day weights of single lambs were not sig-

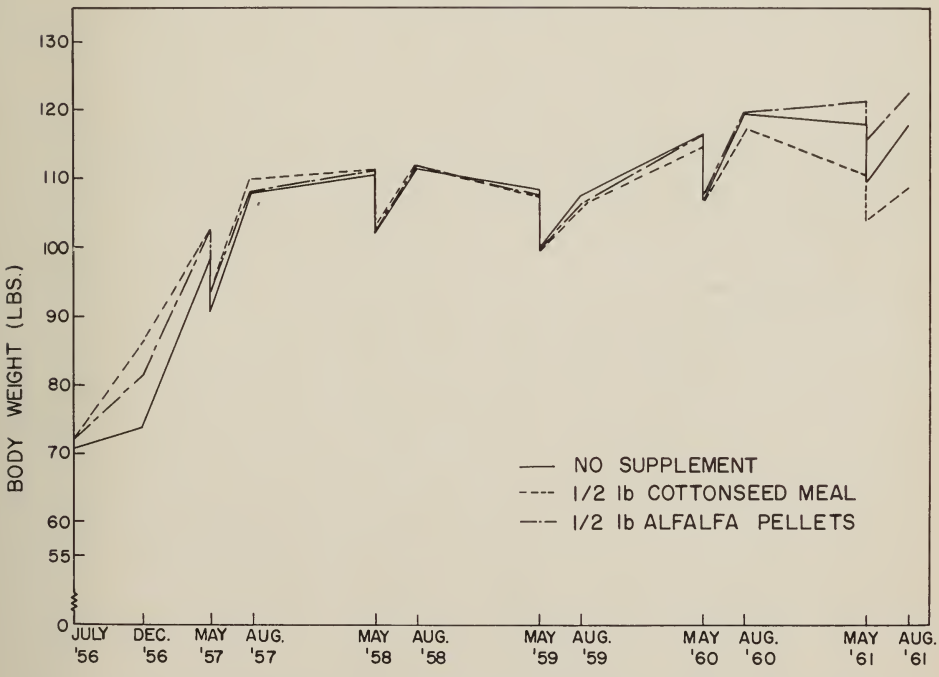

Fig. 3. Body and wool weights of ewes from the 1956 supplementation trial. Supplementation took place from July to December, 1956. After 1956 all groups were treated alike. Wool weights are shown by the drop each May.

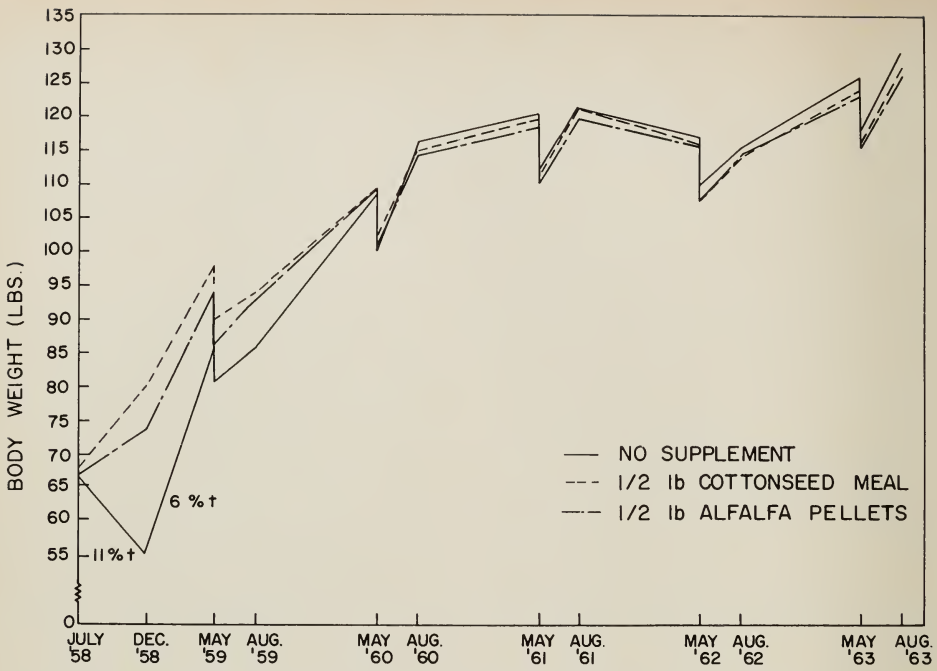

Fig. 4. Body weights of ewes from the 1958 heavily grazed group. Supplementation took place from July to December, 1958. After 1958 all groups were treated alike. Eleven per cent of the unsupplemented flock died during the supplementation period, and 6 per cent during the recovery period. Wool weights are shown by the drop each May.

nificantly different and no pattern could be detected. Apparently the level of supplementation does not have a lifetime effect on lamb production.

Wool Production

No effect of supplementation on wool production could be detected beyond the shearing at yearling age.

Energy Content of the Lamb Carcass and the Wool

To assess body composition changes taking place, representative lambs were slaughtered at the beginning and end of the supplemented period and following the recovery period in 1959, 1960 and 1961. Eight or nine representative lambs were slaughtered initially and then four or five lambs from each of three treatment groups were slaughtered at the end of each of the following periods. Lamb carcasses were weighed in air and in water and the specific gravity calculated. Using procedures and formulae presented by Meyer and by Garrett it was possible to calculate the percentage fat in the carcass and the energy value of the carcass and the wool. (Table 2 shows the per cent fat in the carcasses.) The differences in the fat content of the carcasses in 1959 and in 1960–1961 dramatically demonstrate the differences from year to year. An exceptionally good feed year occurred in 1959, but 1960 and 1961 were poor feed years. In 1959, control lambs managed to retain their fat stores while those fed barley and soybean meal actually increased their fat percentages during the supplemented period. By the following May lambs from all three treat-

TABLE 2

ENERGY AND FAT STATUS OF LAMBS, CALCULATED FROM CARCASSES OF REPRESENTATIVE LAMBS

Supplement (daily)	1959		1960	Supplement (daily)	1960		1961	Supplement (daily)	1961		1962
	July	Dec.	May		July	Dec.	May		July	Dec.	May
	fat in carcass (per cent)										
None	23.8	24.0	29.2	None	25.3	18.6	16.2	None	21.4	19.9	13.6
0.352 lb. barley	23.8	27.3	28.7	0.7 lb. barley	25.3	22.9	20.1	0.25 lb. alfalfa	21.4	21.5	15.2
0.214 lb. soybean meal	23.8	26.3	27.7	0.214 lb. soybean meal	25.3	21.5	17.3	0.25 lb. cottonseed meal	21.4	23.0	13.9
	calculated energy in carcass (megacalories)										
None	45.7	50.5	83.9	None	52.1	36.0	48.4	None	47.9	34.3	39.7
Barley	44.8	60.3	84.9	Barley	51.4	45.9	57.0	Alfalfa	47.7	43.4	39.4
Soybean meal	45.8	65.3	87.3	Soybean meal	56.9	51.8	53.9	Cottonseed meal	47.4	45.9	43.0
	calculated energy in wool (megacalories)										
None	5.6	12.3	19.6	None	3.7	10.2	16.1	None	4.6	10.6	16.8
Barley	5.6	12.9	20.9	Barley	3.7	11.6	18.8	Alfalfa	4.6	11.1	17.7
Soybean meal	5.6	13.5	22.0	Soybean meal	3.7	12.3	20.1	Cottonseed meal	4.6	11.7	19.0
	calculated energy in carcass and wool (megacalories)										
None	51.3	62.8	103.6	None	55.8	46.2	64.5	None	52.5	44.0	56.5
Barley	50.3	73.2	105.9	Barley	55.1	57.5	75.8	Alfalfa	52.3	54.5	57.1
Soybean meal	51.3	78.8	109.3	Soybean meal	60.6	64.1	74.0	Cottonseed meal	52.0	57.6	62.1

ments were fat. All of these lambs were graded "choice" at slaughter time. In 1960 and 1961, however, the controls lost some of their fat stores during the supplemented period, as did even the supplemented lambs in the 1960 supplemented period. The low fat percentages in the carcasses in May of 1960 and 1961 are somewhat surprising, but again the carcass grades tend to confirm the observation in that in 1961 all lambs slaughtered in May graded utility except one graded cull. In 1960 slightly more than half were graded utility, whereas the others were graded good—this despite the fact that all lots had made excellent gains during their recovery period from December to May. Evidently these gains were very low in fat content.

Acting on the assumption that slaughtered lambs were representative of their treatment groups, the percentage of "corrected carcasses" determined on the slaughtered lambs was applied to the live weight of the average lamb in each lot. (A corrected carcass is one containing 20 per cent fat, 15.8 per cent protein and 1250 kilocalories per pound.) Thus it was possible to calculate the megacalories of energy in the carcass of the average lamb in each treatment group.

In 1959 the lambs continued to store energy in the carcass through the trial, and there was a considerable accumulation of fat in the carcass by May. In 1960 all of the lots lost energy during the supplemented period; by May neither the controls nor the soybean-supplemented lambs had recovered the energy in their carcass with which they started the previous July. The barley-supplemented lambs had more than recovered their original carcass energy, but the data do not appear consistent inasmuch as the barley lambs actually had less energy in their carcass at the end of the supplemented period than did the soybean lambs. In 1961 all treatment groups again lost energy in the carcass during the supplemented period, and had not recovered their loss by May despite the fact that they were growing rapidly. Wool contains a considerable fraction of the energy in the living sheep, particularly during the period of the year when it is in full fleece, and so the energy in the wool is also shown in table 2. The assumption was made that all lambs were producing wool at the rate of 8 pounds per year from the date they were shorn as lambs until they were started on trial. In both the supplemented and recovery periods it was assumed that they were producing wool at a daily rate necessary to produce the fleece that was shorn from each lot at the end of the recovery period. By December about 20 per cent of the energy of the carcass and the wool was in the fleece and by May about 30 per cent of the energy was in the wool, particularly in the thinner lambs in 1960 and 1961.

When the energy in the carcass and in the wool is combined a clearer picture of the energy storage evolves. In 1959 all groups increased greatly in energy, with twice as much energy stored by May as was present in the lambs at the beginning of the trial in July, 1959. In 1960 and 1961 there was some net storage in both years by the end of the recovery period, but it was of much smaller magnitude than that in 1959. Table 2 shows the actual values; table 3 shows the percentage increase over the initial weight and energy.

Table 3 also compares weight and energy change with initial weight or energy composition. At the end of the recovery period in 1959, when the lambs were gaining and were fat, data indicate that body weight markedly underestimated the gain in actual energy. In 1960, when the controls lost weight during the supplemented period, the same relationship was demonstrated by the energy calculations. Data for 1960 indicate that the weight at the end of the recovery period in May overestimated the energy storage at that time. In 1961, when all lots were showing losses of weight, energy data in-

TABLE 3

ENERGY AND WEIGHT CHANGES COMPARED TO INITIAL WEIGHT OR BODY COMPOSITION*

Supplement (daily)	July to December			July to May		
	Energy	Weight	Energy/ weight ratio	Energy	Weight	Energy/ weight ratio
	per cent			*per cent*		
1959:						
None	22.5	9.5	2.4	102	61.3	1.7
0.352 lb. barley	45.5	17.2	2.7	110	67.8	1.6
0.214 lb. soybean meal	53.5	27.8	1.9	113	71.2	1.6
1960:						
None	−17.1	−16.9	1.0	15.6	33.4	0.4
0.70 lb. barley	4.6	0.7	6.5	37.7	41.7	0.9
0.214 lb. soybean meal	6.0	2.2	2.7	22.3	37.1	0.6
1961:						
None	−14.4	−22.7	0.6	7.7	9.1	0.8
0.25 lb. alfalfa	4.3	− 8.5	−0.5	9.2	16.5	0.6
0.25 lb. cottonseed meal	10.8	− 5.7	−1.9	19.3	19.5	1.0

* Percentages shown are increases over initial weight or energy composition. Minus signs indicate decreases from initial weight or energy.

TABLE 4

EFFECT OF SUPPLEMENTS WITH VARYING NITROGEN CONTENTS ON BODY AND FLEECE-WEIGHT GAINS

Supplement	Amount fed per day	Average nitrogen supplemented per day	Average body weight gain over controls	Average grease fleece increase over controls
	lb.	*gm.*	*lb.*	*lb.*
Soybean meal	0.214	7.7	12.2	1.5
Cottonseed meal	0.25	7.3	11.5	1.0
	0.50	15.8	17.2	2.0
Alfalfa	0.25	3.9	10.4	0.4
	0.50	7.4	11.4	1.2
	1.00	15.7	22.5	2.6
Cottonseed meal and barley	0.50	10.0	9.8	0.83
Barley	0.352	2.5	5.2	0.6
	0.50	3.6	5.5	0.2
	0.70	4.4	12.6	1.2
Beet pulp	0.24	1.2	2.6	0.3
+ 11.1 per cent urea	0.19	4.6	2.1	0.1
+ 20.3 per cent diammonium phosphate	0.09	2.0	1.3	0.1
+ 4.1 per cent diammonium phosphate	0.25	2.1	4.8	0.6
+ 43.8 per cent diammonium phosphate and 9.4 per cent urea	0.16	3.8	3.1	0.1

dicate that the alfalfa and cottonseed meal supplemented lambs were actually making slight gains in energy storage. The data for May, 1961, also show that live weight overestimated slightly the storage of energy in the carcass and the wool.

Nitrogen Need per Day

Table 4 shows approximate levels of gain over the controls, and average increase in fleece weight with varying levels of supplement and varying intakes of nitrogen per day. Responses obtained per unit of nitrogen with the beet pulp and its synthetic supplements seemed quite different from those obtained with the natural feeds.

Labor Saving and Supplementation

In most of the trials discussed here the sheep were gathered 5 days a week and hand-fed supplement—the cost of labor for such feeding would obviously be a deterrent to supplementation under most range operations. The use of salt as an appetite inhibitor in alfalfa pellets, and less frequent feedings, were both investigated as economy measures (salt-meal mixtures had been used routinely for several years at Hopland). From July 21 through October 18, 1959, when salt in alfalfa pellets was used as an inhibitor, the average daily intake of feed ranged from 0.302 pound daily the first 2-week period to 0.595 during the third 2-week period. From October 19 to 29, salt was increased to 20 per cent with a resulting feed intake of 0.270; from October 30 through December 8, with green feed available, salt was reduced to 10 per cent, with a resulting feed intake of 0.513. Thus, it is possible to limit the intake of self-fed alfalfa pellets by the use of salt but the variable intake (depending upon feed available and season) creates problems. The most practical solution would appear to be to set a salt percentage of 15 to 20 per cent and let the intake vary.

As to the increased interval between feedings of alfalfa pellets, in 1959 there was no difference in gains between groups fed once, twice or five times per week. In 1960 there was no difference between the groups fed once and those fed five times per week. However, with 0.214 pound of soybean meal per day the lambs gained a little more when fed five times a week rather than once a week. In 1961 when sheep were fed a quarter of a pound of cottonseed meal per day five times per week, and one time per week, there was no difference in response; this was also true when alfalfa pellets were used at the same rates. When feeding the full supplemental ration 1 day per week, all of the feed was consumed within 3 days regardless of supplement used. Accordingly, it is believed that supplementation of ewe lambs may be safely done by feeding the supplement only once per week.

Palatability of Supplements

All of the supplements of natural feedstuff variety were palatable to the lambs, although the barley, cottonsed, and soybean meals were somewhat dusty and caused some discomfort. Pelleted feeds were palatable to most lambs as soon as they became accustomed to them, although there was an occasional problem with choking (no fatalities resulted from this, however).

The real palatability problems appeared in 1962 when molasses-dried beet pulp was supplemented with urea or diammonium phosphate. The intended level of supplementation was a quarter pound per head per day but only those lambs receiving pelleted molasses-dried beet pulp, or beet pulp plus 4.1 per cent diammonium phosphate, consumed the intended amount of supplement. When 11.1 per cent urea was added to the supplement, only 0.19 of a pound was consumed on the average. When 3.8 per cent diammonium phosphate and 9.4 per cent urea were added, only 0.16 of a pound per day was consumed. When 20.3 per

cent diammonium phosphate was added, less than one-tenth of a pound was consumed per day. In these trials consumption was based on group feeding; since 1963, facilities have been available for individual feeding, and wide variations in intake have been noted. From a practical standpoint, however, the group averages are still meaningful.

Efficiency of Supplements

Because of difference in amounts of protein in various supplemental feeds a comparison of efficiency is useful in determining which feed is most economical, and this may be obtained by dividing pounds gained by pounds of crude protein consumed.

Lambs receiving 0.5 of a pound per day of cottonseed meal (CSM) gained more weight than those receiving 0.5 of a pound per day of alfalfa. This is explained by the fact that CSM may contain as much as twice the crude protein present in alfalfa. By dividing gain by amount of crude protein this variable was eliminated and alfalfa was shown to be more efficient per unit of protein than CSM. However, when equal amounts of protein were fed in the form of alfalfa, CSM, or soybean meal (SBOM), alfalfa was superior only one year in three. It would appear then that efficiency is greater when smaller amounts of protein are fed. This was also found to be true when alfalfa pellets were fed at various levels during 1961: efficiency was 1.38 with 0.25 pound per day of alfalfa pellets, 0.671 with 0.50 pound per day, and 0.640 with 1 pound per day. Moir has suggested that a small amount of supplemental feed stimulates microorganisms in the rumen, and these then stimulate the animal to eat more range forage. However, as the amount of supplement is increased, a point is reached where it is not only supplementing but replacing range forage.

Efficiency of a supplement is also affected by the condition of pasture available. During 1958, when one pasture was heavily grazed and the other moderately grazed, efficiency of both alfalfa pellets and CSM was greater in the heavily grazed pasture. It is likely that the additional feed furnished the animals in the moderately grazed pasture was actually replacing some of the range forage.

EFFECT OF GRAZING PRESSURE ON EFFICIENCY*

Grazing pressure	*Alfalfa (0.5 lb.)*	*Cottonseed meal (0.5 lb.)*
	Efficiency	
Moderate	0.778	0.578
Heavy	1.000	0.659

* Pounds gain per pounds crude protein consumed.

Alfalfa pellets were tested for three years (see text table which follows). The first year (1959) the pellets were fed once a week to one group, twice a week to a second group, and five times a week to the third group. Alfalfa appeared to be more efficient when fed five times a week during all three years, but the differences were slight in 1960 and 1961. SBOM and CSM were tested only one year, therefore the results of these two supplements are not considered conclusive. In 1960 soybean meal appeared to be more efficient when fed five times a week, whereas in 1961 cottonseed meal was slightly more efficient when fed once a week.

EFFECT OF FEED INTERVAL ON EFFICIENCY*

Feedings per week	*Alfalfa*			*Soybean meal*	*Cottonseed meal*
	Efficiency				
	1959	*1960*	*1961*	*1960*	*1961*
1	0.738	0.660	1.138	0.510	0.818
2	0.910	...	...	...	...
5	0.943	0.666	1.241	0.710	0.771

* Pounds gain per pounds crude protein consumed.

The protein content of alfalfa pellets varies considerably with stage of maturity at time of harvest (see next text

table). In both years the bud-stage alfalfa was slightly more efficient than the full-bloom alfalfa. Since sheep can consume only so much feed, a bulkier supplement such as the full-bloom alfalfa may be replacing range forage.

EFFECT OF ALFALFA MATURITY ON EFFICIENCY*

	Efficiency	
Stage of maturity	*1956*	*1957*
Bud	0.515	0.461
Full bloom	0.466	0.419

* Pounds gain per pounds crude protein consumed.

In an attempt to study the relationship between supplemental nitrogen intake per day and gain during the supplemented period, an analysis of covariance was run between grams supplemental nitrogen per day and pounds gain over the controls. The reduction due to regression was highly significant ($P < 0.01$), the value of $b = 0.783$ with standard error of estimate of 4 per cent. The regression formula for estimating increased gain over unsupplemented controls is $Y = 0.783\ X + 4.69$, where X = grams of nitrogen intake per day in the supplement, and Y = increased gain over unsupplemented controls during the season in pounds.

ECONOMICS OF SUPPLEMENTATION

Results of 7 years of supplementally feeding ewe lambs on the range indicate that major benefits are reduction of death loss in poor feed years, avoidance of weight loss during the supplemented period, and increased quantity and improved quality of wool. As there appears to be no carry-over effect in body size or in lamb or wool production in subsequent years, the cost of the supplement must be justified in the production of improved wool and improved thriftiness of the ewe lambs during the weanling year. If a producer can obtain alfalfa pellets for 50 dollars per ton or 2½ cents per pound, and if he wishes to supplement at a quarter-pound per day, his feed cost would be about six-tenths of a cent per day. If it is necessary to supplement for 150 days, his total feed cost per sheep would be about 90 cents. If he increases wool production by 1 pound and sells the wool for 60 cents per pound he has therefore paid for about two-thirds of the feed cost of the supplement. In general it appears that the increased wool production will probably pay for about half of the feed cost of the supplement. The shorter the dry-feed season during which supplementation is necessary, the less will be the feeding costs. No allowance has been made in these calculations for the cost of labor in handling the feed.

These studies were conducted with ewe lambs, but the same principles would apply to "growing out" feeder wethers. If the cost per pound of crude protein in a supplement when divided by the estimated efficiency of the supplement is less than the selling price per pound of lamb, it might be economical to hold the feeder lambs for the extra gain. Lamb price fluctuations, value of dry range feed, and labor costs should also be considered.

SUMMARY

Weanling ewe lambs grazing on low-protein, dry annual range responded to a wide variety of supplemental feeds. Most effective as supplements were high-protein

meals—cottonseed meal and soybean meal. Alfalfa pellets made from high-quality dehydrated forage were also effective in preventing weight losses and increasing wool production. A mixture of half cottonseed meal and half barley was less effective than cottonseed meal alone. Barley and molasses-dried beet pulp were the least effective supplements used. The addition of urea and diammonium phosphate to molasses-dried beet pulp introduced palatability problems which need further clarification. One-quarter pound per sheep per day of alfalfa, cottonseed meal, or soybean meal appears to be the practical minimum level at which to supplement. Through compensatory growth unsupplemented lambs tended to overcome their handicap and become as large at maturity as those which were supplemented during their weanling year. There was no lifetime effect on either lamb or wool production following the year of supplementation. Response to supplementation of both body-weight gain and increased wool production was related to the nitrogen provided by the supplement. The intake of supplement can be successfully limited by the addition of salt to the supplement. Another labor-saving practice is the feeding of the supplement once, rather than five or seven times, per week.

Carcass composition studies show that body- plus wool-weight changes tend to underestimate the changes in energy storage and loss taking place in yearling sheep. Data indicate that the increased wool clip resulting from supplementation will pay approximately half of the feed cost of the supplement used in these trials.

ACKNOWLEDGMENTS

Appreciation is extended to the American Dehydrators Association for their generous support of this work. Credit is also given to Mr. S. L. Stovall of Spreckels Sugar Company for making the molasses-dried beet pulp available for the 1962 trial. The authors also express deep appreciation to the staff of the Hopland Field Station for their help in conducting these trials; to Mr. Luther Jones and Mr. John Dobie of the Agronomy and Agricultural Engineering Departments, respectively, who were most helpful in obtaining, processing, and describing the alfalfa used in these trials; to Dean J. H. Meyer and Professor G. E. Bradford for their advice and help in various aspects of the work; and to Dr. D. L. Palmquist for his assistance while Mr. Torell was on sabbatical leave. The authors particularly wish to thank Mr. J. Fielder and his personnel at the Dixon Dryer Company for their help and patience in obtaining appropriate alfalfa samples for these studies.

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Appendix Table 1

CHEMICAL COMPOSITION OF RANGE FORAGE COLLECTED BY ESOPHAGEAL FISTULATED SHEEP

(Expressed on dry-matter basis)

Date	Pasture	Number of collections	Protein	Ether extract	Crude fiber	Lignin	Ash
			per cent				
1956							
August 14	1	4	8.8	1.04	28.3	10.6	9.3
September 5	2	4	6.7	1.78	26.9	10.8	10.8
October 2	1	3	6.5	.96	29.0	9.6	7.8
October 31	2	3	8.0	1.96	32.0	16.3	6.8
November 20	2	3	12.1	2.02	26.6	15.9	10.2
December 5	1	3	16.1	1.55	26.1	14.9	8.3
1957							
August 6	1	2	6.0	1.50	30.5	10.7	20.2
August 28	2	2	6.7	1.88	30.0	12.2	10.7
September 25–30	1	4	7.4	1.17	33.9	12.3	8.7
October 31	2	2	15.5	3.47	22.8	7.6	9.2
December 5	1	3	19.5	3.49	20.6	5.9	10.0
1958							
Moderately grazed:							
July 17–18	1	7	7.7	....	....	11.9	....
August 20	1	5	6.6	....	....	11.7	....
September 18	1	5	6.9	....	....	11.1	....
October 10	1	6	5.8	....	....	10.2	....
November 19	1	7	5.5	....	....	11.1	....
Heavily grazed:							
July 17–18	2	7	7.2	....	....	12.3	....
August 20	2	7	6.4	....	....	10.8	....
September 18	2	5	7.5	....	....	12.5	....
October 10	2	6	5.6	....	....	9.5	....
November 19	2	7	5.5	....	....	12.6	....
1959							
August 13–14	1	6	7.1	1.5	....	8.6	8.0
September 4	1	3	6.6	1.7	....	8.9	7.8
September 29	1	4	15.2	2.4	....	9.8	9.6
October 30	1	2	10.0	1.9	....	10.6	7.8
November 25 and 30	1	4	8.5	1.8	....	10.2	8.1
1960							
July 27	1	3	6.1	1.5	30.8	9.9	7.9
August 25	1	3	6.4	1.9	28.8	9.6	8.4
September 21	1	2	5.5	0.9	31.3	9.4	8.9
October 21	1	3	5.5	1.7	35.1	10.8	6.7
December 13	1	3	7.1	1.3	34.7	12.2	4.8
1961							
July 25	1	3	7.2	1.3	27.5	9.6	11.8
August 25	1	3	6.1	1.5	29.0	9.8	11.3
September 21	1	2	4.9	1.2	31.1	9.9	11.4
October 21	1	3	4.9	1.6	35.9	11.5	12.2
November 14	1	2	6.3	1.3	34.9	11.6	11.4
1962							
August 28–29	1	2	5.9	1.3	27.0	....	5.2
October 18, 19, 22*	1	3	6.4	6.8	8.7	....	3.6

* Includes acorns.

Appendix Table 2

AVERAGE BODY-WEIGHT GAINS DURING 1956 SUPPLEMENTATION AND SUBSEQUENT GAINS THROUGH 1961

(All supplements fed at 0.5 pound per day)

Type of supplement	Number of lambs	Average initial weight of lambs	Average gains July 1956 to May 1957			Average gains May 1957 to August 1961†				
			Supplemented period (7/56 to 12/56)	Recovery period (12/56 to 5/57)	Combined period (7/56 to 5/57)*	5/57 to 8/57*	8/57 to 8/58*	8/58 to 8/59*	8/59 to 8/60*	8/60 to 8/61*
		lbs.								
Control (no supplement)	24	70.8	3.1[a]	16.8[c]	19.8	17.4 (18)	3.6 (18)	−4.1 (15)	11.7 (11)	−1.6 (8)
Barley	24	72.3	9.3[b]	11.8[b]	21.5	14.6 (19)	3.9 (19)	−5.6 (16)	12.9 (12)	3.0 (7)
Cottonseed meal and barley	28	71.2	14.2[c]	8.0[a]	22.1	14.9 (22)	1.2 (20)	−3.0 (16)	9.2 (13)	−3.5 (2)
Cottonseed meal	20	72.0	14.4[c]	7.0[a]	21.3	16.7 (11)	2.0 (9)	−5.6 (7)	11.2 (4)	−8.7 (3)
Alfalfa (bud stage)	23	68.0	13.2[c]	11.6[b]	24.8	14.6 (19)	2.9 (17)	−5.4 (13)	9.3 (9)	−2.3 (7)
Alfalfa (full bloom)	28	71.9	9.7[b]	11.4[b]	21.6	16.1 (24)	1.1 (24)	2.9 (17)	6.8 (14)	−3.0 (9)

* All weight figures for this period are N.S. (not significantly different).

† Figures in parentheses in columns below indicate number of ewes remaining.

[a,b,c] Gain is significantly ($P < .05$) different if superscript is different.

Appendix Table 3

LAMB AND WOOL PRODUCTION AND YEARLING GRADE AND MEASUREMENTS OF EWES SUPPLEMENTED IN THE 1956 TRIAL

(All supplements fed at one-half pound per day)

Item	Control (no supplement)	Barley	Increase by supplement†	Cottonseed meal and barley	Increase by supplement†	Cottonseed meal	Increase by supplement†	Alfalfa bud	Increase by supplement†	Full alfalfa	Increase by supplement†
					lamb production 1958						
Number of ewes remaining at lambing...	17	16	....	20	....	9	....	17	....	22	....
Number of lambs weaned.....	11	10	....	15	....	7	....	16	....	16	....
Average weight of lamb per ewe (lb.)....	44.8	41.9	− 2.9	47.8	3.0	53.4	8.6	66.3	21.5	47.1	2.3
Average 120-day weight of single lambs (lb.)*.....	69.2	67.0	− 2.2	63.8	− 5.4	68.7	− 0.5	70.6	1.4	67.3	− 1.9
					lamb production 1959						
Number of ewes remaining at lambing...	17	19	....	18	....	9	....	17	....	23	....
Number of lambs weaned.....	16	17	....	16	....	8	....	17	....	23	....
Average weight of lamb per ewe (lb.)....	68.2	61.0	− 7.2	62.5	− 5.7	65.9	− 2.3	76.9	8.7	75.8	7.6
Average 120-day weight of single lambs (lb.)*.....	75.4	74.5	− 1.1	74.2	− 1.2	83.2	7.8	80.7	5.3	78.2	2.8
					lamb production 1960						
Number of ewes remaining at lambing...	14	16	....	16	....	6	....	13	....	17	....
Number of lambs weaned.....	13	19	....	16	....	5	....	15	....	19	....
Average weight of lamb per ewe (lb.)....	70.7	82.6	11.9	73.9	3.2	67.6	− 3.1	82.6	11.9	77.3	6.6
Average 120-day weight of single lambs (lb.)*.....	76.2	77.6	1.4	75.1	− 1.1	81.1	4.9	75.2	− 1.0	80.5	4.3
					lamb production 1961						
Number of ewes remaining at lambing...	11	12	....	12	....	4	....	8	....	13	....
Number of lambs weaned.....	14	16	....	15	....	6	....	11	....	16	....
Average weight of lamb per ewe (lb.)....	91.1	90.2	− 0.9	92.3	1.2	110.0	9.9	99.7	8.6	87.0	− 4.1
Average 120-day weight of single lambs (lb.)*.....	79.6	76.2	− 3.4	77.1	− 2.5	85.3	5.7	78.5	− 1.1	77.8	− 1.8

Number of ewes available at lambing	5	5	....	2	....	2	....	1	....	4	....
Number of lambs weaned	6	6	....	0	....	2	....	1	....	4	....
Average weight of lamb per ewe; (120-day weights)	79.4	78.2	− 1.2	....	....	78.0	− 1.4	62.4	−17.0	73.1	− 6.3
Average 120-day weight of single lambs (lb.)*	72.4	70.4	− 2.0	....	....	78.0	5.6	62.4	−10.0	73.1	0.7
					average wool production (lb. grease weight)						
Date shorn:											
5/5/57*	8.31	8.55	0.24	9.16	0.85	9.39	1.08	9.13	0.82	8.90	0.59
4/29/58*	9.15	8.63	− 0.52	8.32	− 0.83	8.13	− 1.02	8.28	− 0.87	8.45	− 0.70
4/23/59*	8.40	7.91	− 0.49	8.16	− 0.24	8.10	− 0.30	7.85	− 0.55	8.28	− 0.12
5/6/60*	9.39	8.59	− 0.80	8.82	− 0.57	8.08	− 1.31	8.72	− 0.67	9.08	− 0.31
4/28/61*	8.1	7.5	− 0.60	7.8	− 0.30	6.9	− 1.20	8.1	0.00	7.5	− 0.60
5/4/62*	7.4	6.6	− 0.80	8.6	1.20	7.6	0.20	6.9	− 0.50	7.2	− 0.20
Number of animals remaining	6	6	....	2	....	2	....	7	....	7	....
					yearling measurements (May 5, 1957)‡						
Heart girth (cm.)*	81.4	81.5	0.1	82.2	0.8	81.7	0.3	82.4	1.0	82.0	0.6
Length (cm.)*	70.7	72.3	1.6	71.4	0.7	72.6	1.9	71.9	1.2	72.6	1.9
Height at withers (cm.)*	62.1	63.1	1.0	63.8	1.7	63.4	1.3	63.6	1.5	63.4	1.3
					yearling grade §						
Graded 5/5/57	84.9	84.9	0.0	85.2	0.3	84.2	− 0.7	84.8	− 0.1	84.8	− 0.1

* Differences between groups are nonsignificant.
† Increase refers to comparison with the control group.
‡ Based on 20 ewes per lot.
§ Yearling grade is a visual grade (2+ = 90, 2 = 87, etc.).

Appendix Table 4

AVERAGE BODY-WEIGHT GAINS DURING 1957 SUPPLEMENTATION AND SUBSEQUENT GAINS THROUGH 1963

(All supplements fed at 0.5 pound per day)

Type of supplement	Number of lambs	Average initial weight of lambs	Average gains July 1957 to April 1958*			Average gains April 1958 to August 1963†					
			Supplemental period (7/57 to 12/57)	Recovery period (12/57 to 4/58)	Combined period (7/57 to 4/58)	4/58 to 8/58	8/58 to 8/59	8/59 to 8/60	8/60 to 8/61	8/61 to 8/62	8/62 to 8/63
		lb.									
Control (no supplement)	33	76.4	0.3[a]	20.8[b]	20.0	16.0 (31)	− 5.0 (25)	11.4 (20)	2.2 (16)	− 5.9 (9)	13.8 (6)
Barley	34	73.6	5.0[b]	17.4[ab]	21.4	16.6 (27)	−12.6 (25)	15.4 (20)	2.8 (16)	− 4.4 (9)	18.6 (8)
Cottonseed meal and barley	31	75.3	8.8[c]	15.9[a]	23.6	17.5 (27)	− 8.7 (23)	13.5 (20)	0.2 (14)	− 3.6 (9)	20.0 (8)
Cottonseed meal	34	73.0	11.7[d]	15.1[a]	25.8	18.0 (30)	− 7.5 (25)	11.6 (17)	8.0 (11)	− 3.7 (7)	11.1 (7)
Alfalfa (bud stage)	33	76.8	6.7[bc]	17.5[ab]	23.2	16.3 (31)	− 9.0 (27)	10.6 (26)	0.6 (20)	− 2.2 (14)	11.1 (13)
Alfalfa (full bloom)	32	75.5	4.9[b]	18.3[ab]	23.0	14.4 (27)	− 9.2 (23)	11.8 (18)	4.9 (14)	− 7.2 (6)	7.3 (3)

* Based on 28 lambs (9 summer shorn and 19 unshorn) in each lot. Wool weight of summer shorn lambs included as gain.

† Figures in parentheses in columns below indicate number of ewes remaining. All weight figures in the columns below are N.S. (not significantly different). Minus signs indicate weight loss.

[a,b,c,d] Gain is significantly ($P < 0.05$) different if superscript is different).

Appendix Table 5

AVERAGE BODY-WEIGHT GAINS DURING 1958 SUPPLEMENTATION AND SUBSEQUENT GAINS THROUGH 1963

(All supplements fed at 0.5 pound per day)

Type of supplement	Number of lambs	Average initial weight of lambs	Average gains June 1958 to May 1959 *			Average gains May 1959 to August 1963‡				
			Supplemented period: 6/58 to 12/58	Recovery period: 12/58 to 5/59	Combined periods: 6/58 to 5/59	5/59 to 8/59	8/59 to 8/60	8/60 to 8/61	8/61 to 8/62*	8/62 to 8/63
		lb.								
Moderately grazed pasture:										
Control (no supplement)	35	66.7	-5.6^{b}	20.5^{c}	14.9^{a}	4.8 (29)	23.3 (24) $^{a'}$	8.4 (20)	0.0 (17)	13.4 (16)
Cottonseed meal	35	67.5	16.0^{d}	7.7^{a}	23.7^{c}	5.8 (25)	20.4 (19) $^{a'}$	4.1 (15)	0.5 (15)	14.6 (18)
Alfalfa pellets	35	67.9	9.5^{c}	$10.2^{a,b}$	19.7^{b}	2.9 (28)	23.2 (26) $^{a'}$	5.4 (22)	−1.8 (20)	14.6 (18)
Heavily grazed pasture:										
Control (no supplement)	36	67.2	-11.7^{a}	25.1^{d}	13.4^{a}	5.2 (18)	30.7 (17) $^{b'}$	4.9 (14)	−6.0 (13)	13.8 (12)
Cottonseed meal	36	67.5	12.9^{d}	$9.0^{a,b}$	$21.9^{b,c}$	3.7 (26)	21.9 (24) $^{a'}$	6.4 (16)	−7.5 (13)	13.6 (12)
Alfalfa pellets	35	66.4	7.7^{c}	12.1^{b}	19.8^{b}	5.8 (27)†	22.6 (22) $^{a'}$†	5.2 (16)	−5.3 (11)§	11.7 (11)

* Minus signs indicate weight loss.

† Significant ($P < 0.05$) interaction between previous level of grazing and previous supplement.

‡ Figures in parentheses in columns below indicate number of ewes remaining. All figures in these columns (except column "8/59 to 8/60") are not significantly different.

§ Ewes from originally heavy-grazed pastures lost more than from moderately grazed ($P < 0.01$).

^{a,b,c,d} Gains very significantly ($P < 0.01$) different if superscript is different.

$^{a'\ b'}$ Gain is significantly ($P < 0.05$) different if superscript is different.

Appendix Table 6

LAMB AND WOOL PRODUCTION, YEARLING GRADE, AND MEASUREMENTS OF EWES SUPPLEMENTED IN THE 1957 TRIAL

(All supplements fed at one-half pound per day)

Item	Control (no supplement)	Barley	Increase by supplement†	Cottonseed meal 50 per cent and barley 50 per cent	Increase by supplement†	Cottonseed meal	Increase by supplement†	Bud-stage alfalfa pellets	Increase by supplement†	Full bloom alfalfa pellets	Increase by supplement†
					lamb production 1959						
Number of ewes remaining at lambing	30	28	....	26	....	29	....	30	....	27	....
Number of lambs weaned	21	23	....	17	....	21	....	21	....	14	....
Average 120-day weight of lamb per ewe (lb.)	48.3	58.2	9.9	44.9	3.4	49.4	1.1	46.8	− 1.5	35.0	−13.3
Average 120-day weight of single lambs (lb.)*	71.9	70.8	− 1.1	68.7	− 3.2	68.2	− 3.7	67.6	− 4.3	69.2	− 2.7
					lamb production 1960						
Number of ewes remaining at lambing	25	25	....	23	....	26	....	26	....	22	....
Number of lambs weaned	23	22	....	23	....	22	....	28	....	22	....
Average 120-day weight of lambs per ewe (lb.)	67.3	68.7	1.4	70.8	3.5	58.1	− 9.2	76.4	9.1	72.0	4.7
Average 120-day weight of single lambs (lb.)*	75.0	79.5	4.5	73.3	− 1.7	69.9	− 5.1	74.7	− 0.3	74.7	− 0.3
					lamb production 1961						
Number of ewes remaining at lambing	20	20	....	19	....	17	....	24	....	16	....
Number of lambs weaned	21	21	....	20	....	17	....	30	....	16	....
Average 120-day weight of lamb per ewe (lb.)	79.5	79.7	0.2	78.8	− 0.7	69.8	− 9.7	86.2	6.7	75.8	− 3.7
Average 120-day weight of single lambs (lb.)*	77.1	82.9	5.8	79.7	2.6	74.0	− 3.1	80.5	3.4	78.4	1.3

lamb production 1962											
Number of ewes remaining at lambing...	15	15	....	12	....	11	....	19	....	14	....
Number of lambs weaned.....	14	15	....	11	....	9	....	20	....	10	....
Average 120-day weight of lambs per ewe (lb.).....	62.7	63.3	0.6	59.7	− 3.0	54.1	− 8.6	67.7	5.0	43.5	−19.2
Average 120-day weight of single lambs (lb.)*.....	69.6	66.8	− 2.8	69.0	− 0.6	68.1	− 1.5	68.8	− 0.8	63.8	− 5.8
lamb production 1963											
Number of ewes with records available...	6	8	....	8	....	5	....	11	....	6	....
Number of lambs weaned.....	6	8	....	5	....	4	....	16	....	7	....
Average 120-day weight of lambs per ewe (lb.).....	68.4	70.6	2.2	41.8	−26.6	59.3	− 9.1	99.2	30.8	79.8	11.4
Average 120-day weight of single lambs (lb.)*.....	70.4	69.3	− 1.1	77.4	7.0	74.1	3.7	79.6	9.2	71.9	1.5
average wool production											
1957–58 clean wool (lb.).....	5.90[a]	5.97[ab]	0.07	6.53[bc]	0.63‡	6.88[c]	0.98¶	6.72[c]	0.82¶	6.59[c]	0.69‡
1959 grease weight (lb.)*.....	7.82	7.88	0.06	8.30	0.48	8.12	0.30	8.21	0.39	7.9	0.08
1960 grease weight (lb.)*.....	8.78	8.53	− 0.25	8.80	0.02	8.85	0.07	8.74	− 0.04	8.80	0.02
1961 grease weight (lb.)*.....	7.7	7.8	0.10	8.2	0.50	8.3	0.60	8.0	0.30	8.4	0.70
1962 grease weight (lb.)*.....	7.3	7.5	0.20	8.0	0.70	8.2	0.90	7.9	0.60	8.2	0.90
1963 grease weight (lb.)*.....	6.8	7.5	0.70	8.0	1.20	8.0	1.20	7.2	0.40	8.1	1.30
yearling measurements											
Heart girth (cm.)*.....	80.4	80.3	− 0.1	81.3	0.9	82.6	2.2	82.5	2.1	80.7	0.3
Length (cm.)*.....	72.0	71.9	− 0.1	71.5	− 0.5	72.3	0.3	72.1	0.1	71.0	− 1.0
Height at withers (cm.)*.....	62.4	62.8	0.4	62.6	0.2	62.5	0.1	62.6	0.2	62.1	− 0.3
yearling grade, per cent§											
Date graded 4/30/58*.....	84.3	84.9	0.6	86.0	1.7	86.0	1.7	85.9	1.6	85.3	1.0

* Differences between groups are nonsignificant. Minus signs indicate loss or decrease.
† Increase refers to comparison with the control group.
‡ Increase significant ($P < 0.05$).
§ Based on 8 summer shorn and 19 unshorn lambs in each lot. Yearling grade is a visual grade (2+ = 90, etc.).
¶ Increase highly significant ($P < 0.01$).
[a,b,c] Wool production significantly ($P < 0.05$) different if superscript is different.

Appendix Table 7

LAMB AND WOOL PRODUCTION, YEARLING GRADE, AND MEASUREMENTS OF EWES SUPPLEMENTED IN THE 1958 TRIAL

Item	Moderately grazed pasture			Heavily grazed pasture		
	Control (no supplement)	Cottonseed meal (0.5 lb. per day)	Alfalfa pellets (0.5 lb. per day)	Control (no supplement)	Cottonseed meal (0.5 lb. per day)	Alfalfa pellets (0.5 lb. per day)
			lamb production 1960			
Number of ewes remaining at lambing	29	25	31	18	27	28
Number of lambs weaned	22	22	22	13	20	19
Average lb. of lamb per ewe (120-day wts.)	55.7	73.2	69.4	52.8	54.7	45.1
Average 120-day weight of single lambs (lb.)*	73.5	73.6	69.4	73.2	74.2	71.6
			lamb production 1961			
Number of ewes remaining at lambing	24	18	26	16	23	22
Number of lambs weaned	31	23	26	16	25	20
Average lb. of lamb per ewe (120-day wts.)	92.6	87.5	71.4	75.6	75.3	67.2
Average 120-day weight of single lambs (lb.)*	79.5	76.1	76.8	77.1	77.0	77.6
			lamb production 1962			
Number of ewes remaining at lambing	10	7	9	6	7	6
Number of lambs weaned	8	9	10	6	9	8
Average lb. of lamb per ewe (120-day wts.)	53.6	81.5	60.6	72.1	87.3	82.5
Average 120-day weight of single lambs (lb.)*	70.0	64.5	69.0	72.1	73.6	63.7
			lamb production 1963			
Number of ewes remaining at lambing	17	14	20	12	12	12
Number of lambs weaned	19	18	21	11	15	14
Average lb. of lamb per ewe (weaning wt.)	88.1	96.5	78.4	77.7	100	92.1
Average 120-day weight of single lambs (lb.)*	73.9	79.2	76.3	75.0	83.3	76.8
			average wool production (lb.)			
1959 clean wool (lb.)	3.4^{b}	5.0^{e}	4.5^{cd}	2.9^{a}	4.8^{de}	4.2^{c}
1959 grease wool (lb.)	6.2	8.7	7.7	5.4	8.4	7.5
1960 grease weight (lb.)*	8.2	8.4	8.2	8.4	8.3	8.9
1961 grease weight (lb.)*	7.8	8.3	7.9	8.0	7.9	8.5
1962 grease weight (lb.)*	7.6	8.2	8.0	7.8	8.1	8.4
1963 grease weight (lb.)*	7.3	8.4	7.5	7.9	8.1	8.4
			body measurements (cm.)			
Heart-girth gain†	71.2^{b}	80.7^{e}	77.5^{cd}	68.0^{a}	79.1^{de}	75.3^{c}
	3.7^{c}	-2.1^{a}	-0.6^{ab}	6.4^{d}	-1.2^{a}	0.8^{b}
Length-gain†	65.2^{a}	70.8^{c}	68.9^{bc}	64.3^{a}	70.1^{bc}	68.1^{b}
	4.1^{bc}	1.2^{a}	2.2^{a}	5.2^{c}	1.4^{a}	3.0^{ab}
Chest-width gain†	15.7^{a}	18.9^{d}	17.7^{bc}	15.1^{a}	18.5^{cd}	17.3^{c}
	3.5^{b}	1.7^{a}	2.1^{a}	4.0^{b}	1.7^{ab}	2.4^{a}
Chest-depth gain†	$22.7^{a'}$	$25.5^{d'}$	$24.2^{b'c'}$	$22.1^{a'}$	$24.9^{e'd'}$	$23.8^{b'}$
	4.7^{b}	2.9^{a}	3.7^{ab}	4.6^{b}	3.0^{a}	3.6^{ab}
Height at withers gain†	58.2	59.1	59.5	57.2	60.3	58.6
	3.8	3.1	3.0	4.1	2.8	4.1
			yearling grade (per cent)‡			
Grade on 5/8/59	82.4^{ab}	84.6^{c}	83.9^{bc}	82.1^{a}	84.5^{c}	83.5^{abc}

* Differences between groups are nonsignificant.
† Initial measurement 12/8/58. Gain from 12/8/58 to 5/8/59. Minus signs indicate loss or decrease.
‡ Yearling grade is visual grade (2+ = 90, 2 = 87, etc.).
^{a,b,c,d,e} Wool production, body measurement, or grade very significantly different ($P < 0.01$) if superscript is different.
$^{a',b',c',d'}$ Body measurement significantly different ($P < 0.05$) if superscript is different.

Appendix Table 8

AVERAGE BODY-WEIGHT GAINS DURING 1959 SUPPLEMENTATION AND SUBSEQUENT GAINS THROUGH 1963

Type of supplement	Number of lambs	Average initial weight of lambs (lb.)	Average gains July 1959 to May 1960 (lb.)			Average gains May 1960 to August 1963 (lb.)†			
			Supplemented period: 7/59 to 12/59	Recovery period: 12/59 to 5/60	Combined periods: 7/59 to 12/60	5/60 to 8/60	8/60 to 8/61	8/61 to 8/62	8/62 to 8/63
Control (no supplement)	20	69.8	6.6^{a}	29.8^{b}	36.4^{a}	−3.7 (16)	1.6 (14)	8.6 (12)	9.7 (11)
Alfalfa pellets:									
5 feedings per week (0.5 lb. per day)	19	66.1	20.8^{d}	21.9^{a}	42.7^{bc}	−6.4 (14)	2.6 (13)	10.2 (13)	9.2 (13)
2 feedings per week (0.5 lb. per day)	19*	65.8	20.3^{d}	23.9^{a}	44.7^{c}	−4.7 (17)	1.2 (16)	5.2 (14)	18.2 (11)
1 feeding per week (0.5 lb. per day)	19	68.5	17.7^{cd}	23.0^{a}	40.7^{bc}	−6.4 (16)	5.1 (13)	8.0 (11)	12.6 (9)
with salt (0.453 lb. per day)	19	71.0	16.2^{c}	23.7^{a}	40.0^{ab}	−4.8 (19)	4.1 (17)	9.8 (17)	14.5 (15)
Barley (0.352 lb. per day)	20	68.4	11.8^{b}	27.7^{b}	39.4^{ab}	−4.9 (15)	6.4 (12)	8.0 (12)	9.1 (9)
Soybean oil meal (0.214 lb. per day)	20	69.9	19.4^{d}	22.9^{a}	42.3^{bc}	−5.4 (18)	1.0 (17)	9.6 (16)	3.1 (14)

* One lamb removed during recovery period.

† Figures in parentheses in columns below indicate number of ewes remaining. All weight figures in columns below are N.S. (not significantly different). Minus signs indicate weight loss.

^{a,b,c,d} Gains significantly ($P < 0.05$) different if superscript is different.

Appendix Table 9

LAMB AND WOOL PRODUCTION, YEARLING GRADE, AND MEASUREMENTS OF EWES SUPPLEMENTED IN THE 1959 TRIAL

Item	Control (no supplements)	Alfalfa pellets					Other supplements			
		Five feedings per week (0.5 lb. per day)	Two feedings per week (0.5 lb. per day)	One feeding per week (0.5 lb. per day)	With salt (0.453 lb. per day)	Increase by supplement‡	Barley (0.352 lb. per day)	Increase by supplement‡	Soybean oil meal (0.214 lb. per day)	Increase by supplement‡
lamb production 1961										
Number of ewes remaining at lambing	15	14	14	13	16	....	15	....	18	....
Number of lambs weaned	16	15	11	13	12	....	9	....	18	....
Average pounds of lamb per ewe	74.5	73.7	58.8	67.4	55.9	....	45.3	....	71.9	....
Average 120-day weight of single lambs (lb.)*	72.2	71.8	76.5	68.4	79.1	....	70.5	....	76.2	....
lamb production 1962										
Number of ewes remaining at lambing	14	15	16	12	17	....	12	....	17	....
Number of lambs weaned	16	12	16	11	14	....	10	....	12	....
Average pounds of lamb per ewe	71.8	50.6	66.8	55.7	53.8	....	57.0	....	47.5	....
Average 120-day weight of single lambs (lb.)*	63.7	62.6	68.2	62.6	67.3	....	63.2	....	67.5	....
lamb production 1963										
Number of ewes remaining at lambing	11	13	12	10	17	....	10	....	15	....
Number of lambs weaned	17	17	10	10	19	....	11	....	17	....
Average pounds of lamb per ewe	102.5	87.8	68.9	71.4	79.3	....	77.6	....	76.1	....
Average 120-day weight of single lambs (lb.)*	70.8	69.9	72.5	77.2	75.2	....	75.5	....	69.6	....

average wool production

Grease weight, 5/5/60 (lb.)	6.4[a']	7.6[bc']	7.9[c']	7.6[bc']	7.6[bc']	1.2 to 1.5§	7.0[ab']	0.6	7.5[bc']	1.1§
Estimated clean weight, 5/5/60 (lb.)	3.5[a']	4.0[bc']	4.3[c']	4.2[c']	4.2[c']	0.5¶ to 0.8§	3.8[ab']	0.3	4.3[c']	0.8§
Staple length (cm.)*	8.8	9.6	9.8	9.5	9.2	0.4 to 1.0	9.4	0.6	9.0	0.2
Grease weight, 4/28/61 (lb.)*	6.7	6.8	7.4	7.0	6.9	....	7.3	....	6.6	....
Grease weight, 5/4/62 (lb.)*	7.1	7.2	7.6	7.4	7.8	....	7.7	....	6.9	....
Grease weight, 4/15/63 (lb.)*	6.8	8.1	8.5	7.8	7.8	....	8.2	....	7.3	....
average heart girth (cm.)†										
Initial measurement	70.8	69.1	68.8	70.2	71.2	....	69.8	....	71.4	....
average gain heart girth (cm.)†										
Supplemental period	4.6[a']	9.0[cd']	9.5[d']	8.4[cd']	7.9[c']	3.3 to 4.9§	6.4[b']	1.8¶	8.8[cd']	4.2§
Recovery period	8.3[bc']	6.2[a']	6.6[ab']	6.2[a']	6.3[a']	−1.7 to −2.1¶	8.6[c']	0.3	5.9[a']	−2.4§
Combined period*	13.0	15.3	16.1	14.5	14.7	1.5 to 2.1	15.0	2.0	14.6	1.6
average length (cm.)†										
Initial measurement	65.5	65.3	64.5	65.5	66.0	....	66.0	....	65.4	....
average gain length (cm.)†										
Supplemental period	2.8[a']	5.8[bc']	6.7[c']	4.9[bc']	6.3[c']	2.1¶ to 3.9§	4.2[ab']	1.4	6.0[c']	3.2§
Recovery period*	4.2	2.7	1.9	2.3	1.6	−1.5 to −2.6	2.9	−1.3	3.0	−1.2
Combined period*	7.1	8.5	8.6	7.2	7.8	0.1 to 1.5	7.0	−0.1	9.0	2.0
average chest-width (cm.)†										
Initial measurement	17.2	16.9	16.4	17.0	17.4	....	17.0	....	17.3	....

APPENDIX TABLE 9 (*Continued*)

Item	Control (no supplements)	Alfalfa pellets					Other supplements			
		Five feedings per week (0.5 lb. per day)	Two feedings per week (0.5 lb. per day)	One feeding per week (0.5 lb. per day)	With salt (0.453 lb. per day)	Increase by supplement‡	Barley (0.352 lb. per day)	Increase by supplement‡	Soybean oil meal (0.214 lb. per day)	Increase by supplement‡
					average gain, chest-width (cm.)†					
Supplemental period	2.6[a]	4.0[bc]	4.2[c]	3.7[bc]	3.6[bc]	1.0¶ to 1.6§	3.0[ab]	0.4	4.4[c]	1.8§
Recovery period	0.92[b]	0.08[ab]	0.58[ab]	0.47[ab]	0.0[ab]	−0.34 to −0.92	0.95[b]	0.03	−0.22[a]	−1.14¶
Combined period*	3.5	4.1	4.7	4.1	3.7	0.2 to 1.2	3.9	0.4	4.0	0.5
					average chest-depth (cm.)†					
Initial measurement	25.3	24.8	25.0	24.0	25.6	....	24.9	....	26.5	....
					average gain, chest-depth (cm.)†					
Supplemental period	0.6[a]	1.9[bc]	2.0[bc]	1.8[bc]	1.0[ab]	0.4 to 1.4§	0.7[a]	0.1	2.1[c]	1.5¶
Recovery period*	1.5	0.6	0.9	1.1	1.4	−0.1 to −0.9	1.8	0.3	0.8	−0.7
Combined period*	2.1	2.5	2.9	2.9	2.4	0.3 to 0.8	2.5	0.4	2.9	0.8
					average height at withers (cm.)†					
Initial measurement	55.9	56.3	56.5	56.3	57.2	....	56.7	....	56.5	....
					average gain, height at withers (cm.)†					
Supplemental period*	2.4	2.4	2.6	2.7	1.6	−0.8 to +0.3	1.1	−1.3	2.4	0
Recovery period*	4.3	3.7	3.5	2.9	3.8	−1.4 to −0.5	4.6	+0.3	4.2	−0.1
Combined period*	6.6	6.2	6.1	5.6	5.6	−1.0 to −0.4	5.7	−0.9	6.7	+0.1

					yearling grade (per cent)					
Date graded 5/9/60*	85.5	84.8	86.2	85.4	86.1	−0.7 to +0.7	85.4	−0.1	85.8	+0.3

* Differences between groups nonsignificant. Minus signs indicate loss or decrease.
† Initial measurement 7/21/59, at the end of the supplemental period 12/9/59 and at the end of the recovery period 5/9/60.
‡ Increase refers to comparison with the control group.
§ Increase very significantly more than the controls.
¶ Increase significantly more than the controls.
[a,b,c] Body measurement very significantly ($P < 0.01$) different if the superscript is different.
[a′,b′,c′,d′] Wool production or body measurement significantly ($P < 0.05$) different if superscript is different.

Appendix Table 10

AVERAGE BODY-WEIGHT GAINS DURING 1960 SUPPLEMENTATION AND SUBSEQUENT GAINS THROUGH 1963

Type of supplement	Number of lambs	Average initial weight of lambs (lb.)	Average gains July 1960 to May 1961 (lb.)			Average gains May 1961 to August 1963 (lb.)§		
			Supplemented period: 7/60 to 12/60	Recovery period: 12/60 to 5/61	Combined period: 7/60 to 5/61‡	5/61 to 8/61‡	8/61 to 8/62‡	8/62 to 8/63
Control (no supplement)	17	71.2	−12.1[a]	30.3[a]	18.2	0.5 (17)	13.1 (10)	25.0 (9)[a′]
Alfalfa pellets:								
5 feedings per week (0.5 lb. per day)	18	76.4	−0.1[bc′]	18.4[b]	18.4	0.4 (17)	10.1 (14)	16.2 (11)[ab′]
1 feeding per week (0.5 lb. per day)	17	74.6	−0.2[bc′]	22.2[b]	21.9	1.4 (17)	11.0 (11)	12.5 (10)[b′]
Alfalfa wafers:								
5 feedings per week (0.5 lb. per day)	17*	76.5	−0.9[bc′]	21.6[b]	20.8	−0.1 (16)	17.2 (8)	21.5 (8)[ab′]
Soybean meal:								
5 feedings per week (0.214 lb. per day)	18†	77.7	1.7[c′]	19.5[b]	21.4	0.6 (17)	14.4 (11)	25.1 (11)[a′]
1 feeding per week (0.214 lb. per day)	17†	75.1	−2.2[b′]	21.0[b]	18.8	−1.9 (16)	21.7 (9)	13.0 (8)[b′]
Barley (0.7 lb. per day)	17	70.2	0.5[bc′]	22.0[b]	22.5	1.6 (17)	11.1 (12)	17.8 (12)[ab′]

* One removed due to incoordination. Minus signs indicate loss.
† One died, cause unknown.
‡ All weight figures in these periods are N.S. (not significantly different).
§ Figures in parentheses in columns below indicate number of ewes remaining.
[a,b,c] Values differ significantly ($P < 0.01$).
[a′,b′ c′] Values differ significantly ($P < 0.05$).

Appendix Table 11

LAMB AND WOOL PRODUCTION AND BODY MEASUREMENTS OF EWES SUPPLEMENTED IN THE 1960 TRIAL

Item	Control (no supplement)	Alfalfa pellets		Alfalfa wafers	Increase by supplement†	Soybean meal		Increase by supplement†	Barley (0.7 lb. per day)	Increase by supplement†
		Five feedings per week (0.5 lb. per day)	One feeding per week (0.5 lb. per day)	Five feedings per week (0.5 lb. per day)		Five feedings per week (0.214 lb. per day)	One feeding per week (0.214 lb. per day)			
amb production 1962										
Number of ewes remaining at lambing	13	15	14	11	....	15	12	....	13	....
Number of lambs weaned	10	13	8	8	....	9	8	....	12	....
Average pounds of lamb per ewe	48.2	56.0	34.2	44.7	....	37.1	40.0	....	55.6	....
Average 120-day weight of single lambs (lb.)*	63.6	64.6	59.9	61.2	....	65.1	59.5	....	62.1	....
lamb production 1963										
Number of ewes remaining at lambing	10	13	10	8	....	11	9	....	12	....
Number of lambs weaned	9	9	9	5	....	9	10	....	15	....
Average pounds of lamb per ewe	64.9	51.3	69.0	46.5	....	59.5	75.3	....	84.7	....
Average 120-day weight of single lambs (lb.)*	74.7	75.3	79.9	74.5	....	76.9	73.3	....	75.2	....
average wool production										
Grease weight 4/27/61 (lb.)	5.6[a]	7.3[b]	6.7[b]	6.9[b]	1.1 to 1.7‡	7.4[b]	7.1[b]	1.5 to 1.8‡	6.8[b]	1.2‡
Wool length 4/27/61 (cm.)	7.6[a′]	8.9[b′]	8.5[b′]	9.0[b′]	0.9 to 1.4§	8.4[b′]	8.7[b′]	0.8 to 1.1§	8.4[b′]	0.8‡
Grease weight 5/4/62 (lb.)*	7.4	7.6	7.2	7.4	....	7.6	7.8	....	7.8	....
Grease weight 4/15/63 (lb.)*	7.4	7.7	8.1	8.4	....	8.4	6.8	....	7.1	....
average heart-girth (cm)¶										
Initial measurement	72.5	74.2	73.6	73.7	....	73.6	72.8	....	71.4	....

					average gain, heart-girth (cm)¶					
Supplemental period	−2.1[a]	2.0[b]	2.3[b]	2.8[b]	4.1 to 4.9‡	3.9[b]	2.4[b]	4.5 to 6.0‡	2.7[b]	4.8‡
Recovery period	6.1[a]	1.8[b]	2.4[b]	2.7[b]	−3.4 to −4.3‡	1.9[b]	3.0[b]	−3.1 to −4.2‡	3.6[b]	−2.5‡
Combined period*	4.1	4.0	4.6	5.5	−0.1 to 1.4	5.9	5.0	0.9 to 1.8	6.3	2.2
					average length (cm)¶					
Initial measurement	66.8	68.3	69.1	68.6	....	68.7	68.1	....	67.7	....
					average gain, length (cm)¶					
Supplemental period*	0.3	2.3	2.1	2.3	1.8 to 2.0	3.1	2.2	1.9 to 2.8	1.8	1.5
Recovery period*	2.3	0.8	0.3	−0.2	−1.5 to −2.5	0.9	1.1	−1.2 to −1.4	1.6	−0.7
Combined period*	2.6	3.1	2.4	1.8	−0.8 to 0.5	4.3	3.4	0.8 to 1.7	3.6	1.0
					average chest-width (cm)¶					
Initial measurement	17.6	18.2	17.4	17.7	....	17.8	17.5	....	16.9	....
					average gain, chest-width (cm)¶					
Supplemental period	−1.7[a]	−0.1[b]	0.3[b]	0.6[b]	1.6 to 2.3‡	0.8[b]	0.1[b]	1.8 to 2.5‡	0.4[b]	2.1‡
Recovery period	3.2[a]	1.6[b]	2.2[ab]	1.9[b]	−1.0§ to −1.6‡	1.3[b]	1.9[b]	−1.3 to −1.9‡	2.4[ab]	−0.8
Combined period*	1.5	1.5	2.4	2.5	0 to 1.0	2.4	2.0	0.5 to 0.9	2.7	1.2
					average chest-depth¶					
Initial measurement	24.3	24.5	24.5	24.5	....	24.7	23.9	....	23.9	....
					average gain, chest-depth (cm)¶					
Supplemental period*	−1.2	0.1	−0.1	−0.1	+1.1 to 1.3	0.1	−0.4	0.8 to 1.3	−0.3	0.9
Recovery period	3.9[a′]	2.4[b′]	2.8[ab′]	2.9[ab′]	−1.0 to −1.5§	2.2[b′]	3.2[ab′]	−0.7 to −1.7§	2.4[b′]	−1.5§
Combined period*	2.6	2.5	2.7	2.8	−0.1 to +0.2	2.6	2.6	....	2.2	−0.4

APPENDIX TABLE 11 (*Continued*)

Item	Control (no supplement)	Alfalfa pellets		Alfalfa wafers	Increase by supplement†	Soybean meal		Increase by supplement†	Barley (0.7 lb. per day)	Increase by supplement†
		Five feedings per week (0.5 lb. per day)	One feeding per week (0.5 lb. per day)	Five feedings per week (0.5 lb. per day)		Five feedings per week (0.214 lb. per day)	One feeding per week (0.214 lb. per day)			
					average height at withers (cm)¶					
Initial measurement.....	57.2	58.2	59.5	58.5	....	57.9	58.7	....	56.7	....
					average gain, height at withers (cm)¶					
Supplemental period*.....	−0.8	0.7	−1.6	−0.8	−0.8 to +1.5	−0.5	−0.9	−0.1 to +0.3	0.3	1.1
Recovery period*.....	2.9	1.9	3.0	2.4	−1.0 to 0.1	2.2	2.8	−0.7 to −0.1	3.2	0.3
Combined period*.....	2.4	2.2	1.4	1.6	−0.2 to −1.0	2.3	1.6	−0.1 to −0.8	3.4	1.0

* Difference between groups are nonsignificant. Minus signs indicate loss or decrease.
† Increase refers to comparison with the control group.
‡ Very significantly different from control ($P < 0.01$).
§ Significantly different from the control ($P < 0.05$).
¶ Initial measurement 7/6/60, at the end of the supplemented period 12/9/60 and at end of recovery period 5/1/61.
^{a,b} Wool production or body measurement very significantly different ($P < 0.01$).
$^{a',b'}$ Wool length or body measurement significantly different ($P < 0.05$) if superscript different.

Appendix Table 12

AVERAGE BODY-WEIGHT GAINS DURING 1961 SUPPLEMENTATION AND SUBSEQUENT GAINS THROUGH 1963

Type of supplement	Number of lambs	Average initial weight of lambs	Average gains July 1961 to May 1962			Average gains May 1961 to August 1963‡	
			Supplemented period: 7/61 to 12/61	Recovery period: 12/61 to 5/62	Combined period: 7/61 to 5/62	5/62 to 8/62†	8/62 to 8/63
		lb.				*lb.*	
Control (no supplement)	17*	76.6	−17.4[a]	18.9[c]	1.5[a′]	17.4 (11)	24.9 (10)[abc′]
Alfalfa pellets:							
5 feedings per week (0.25 lb. per day)	17*	76.2	− 6.5[b]	13.2[b]	6.7[ab′]	15.6 (14)	24.8 (13)[abc′]
1 feeding per week (0.25 lb. per day)	16*	74.9	− 7.4[b]	15.4[bc]	8.0[b′]	13.2 (13)	28.0 (12)[bc′]
1 feeding per week (0.5 lb. per day)	17	77.3	− 5.6[b]	12.1[b]	6.2[ab′]	16.4 (13)	28.5 (13)[bc′]
1 feeding per week (1.0 lb. per day)	16*	76.4	5.1[c]	5.9[a]	11.6[b′]	15.7 (15)	20.4 (16)[ab′]
Cottonseed meal:							
5 feedings per week (0.25 lb. per day)	18	75.8	− 4.3[b]	12.6[b]	8.3[b′]	16.1 (17)	16.4 (17)[a′]
1 feeding per week (0.25 lb. per day)	18	75.8	− 3.5[b]	12.0[b]	8.5[b′]	15.6 (16)	32.1 (16)[c′]

* One lamb died.
† Weight gain values in this column are not significantly different.
‡ Figures in parentheses in columns below indicate number of ewes remaining.
[a,b,c] Values are significantly ($P < 0.01$) different if superscripts are different.
[a′,b′,c′] Values are significantly ($P < 0.05$) different if superscripts are different.

Appendix Table 13

LAMB AND WOOL PRODUCTION AND BODY MEASUREMENTS OF EWES SUPPLEMENTED IN THE 1961 TRIAL

Item	Control (no supplement)	Alfalfa pellets							Cottonseed meal		
		Five feedings per week (0.25 lb. per day)	One feeding per week (0.25 lb. per day)	Increase by supplement†	One feeding per week (0.5 lb. per day)	Increase by supplement†	One feeding per week (1.0 lb. per day)	Increase by supplement†	Five feedings per week (0.25 lb. per day)	One feeding per week (0.25 lb. per day)	Increase by supplement†
					lamb production 1963						
Number of ewes remaining at lambing...	8	14	12	....	12	....	16	....	17	16	....
Number of lambs weaned.....	8	10	10	....	6	....	14	....	16	9	....
Average lb. of lamb per ewe.....	73.0	54.9	58.0	....	37.0	....	62.4	....	71.7	43.2	....
Average 120-day weight of single lambs (lb.)*.....	72.9	73.5	70.7	....	74.0	....	73.1	....	76.6	76.8	....
					average wool production						
Grease weight 5/4/62 (lb.).....	5.5[a]	5.9[ab]	5.9[ab]	0.4	6.3[ab]	0.8‡	8.1[c]	2.6§	6.5[b]	6.5[b]	1.0§
Wool length 5/4/62 (cm.).....	7.9[a′]	8.8[b′]	8.6[ab′]	0.7 to 0.9‡	8.5[ab′]	0.6	9.2[b′]	1.3‡	9.0[b′]	9.0[b′]	1.1‡
Grease weight 4/15/63 (lb.).....	8.1[a′]	8.1[a′]	7.9[a′]	− 0.2 to 0	8.2[a′]	0.1	9.9[b′]	1.8‡	8.4[a′]	8.3[a′]	0.2 to 0.3
Wool length 4/15/63 (cm.)*.....	8.5	9.5	9.4	0.9 to 1.0	9.5	1.0	9.9	1.4	9.0	9.5	0.5 to 1.0
					average height at withers (cm)¶						
Initial measurement.....	56.6	56.7	56.3	....	57.2	....	57.0	....	56.4	56.7	....
					average gain, height at withers (cm)¶						
Supplemental period*.....	− 0.1	0.9	0.3	0.4 to 1.0	0.4	0.5	0.8	0.9	0.8	1.1	0.9 to 1.2
Recovery period*.....	3.5	2.6	3.2	− 0.3 to 0.9	3.0	− 0.5	3.0	− 0.5	2.5	2.9	− 0.6 to − 1.0
Combined period*.....	3.1	3.5	3.5	0.4	3.4	0.3	3.9	0.8	3.3	4.0	0.2 to 0.9
					average chest-width (cm.) ¶						
Initial measurement.....	18.7	18.3	18.5	....	18.8	....	18.6	....	18.3	18.4	....

average gain, chest-width (cm)¶											
Supplemental period	− 0.1[a]	1.1[abc]	0.5[ab]	0.6 to 1.2‡	1.3[bcd]	1.4§	2.6[d]	2.7§	2.0[cd]	1.5[bcd]	1.6 to 2.1§
Recovery period	− 0.1[b′]	− 0.4[ab′]	− 0.6[ab′]	− 0.3 to − 0.5	− 1.5[a′]	− 1.4‡	− 1.5[a′]	− 1.4‡	− 1.4[a′]	− 0.7[ab′]	− 0.6 to − 1.3‡
Combined period	− 0.2[a′]	0.7[ab′]	− 0.1[a′]	0.1 to 0.9	− 0.2[a′]	0	1.1[b′]	1.3‡	0.6[ab′]	0.8[ab′]	0.8 to 1.0
average chest-depth (cm)¶											
Initial measurement	24.7	25.0	24.8	....	26.6	....	25.0	....	24.5	24.9	....
average gain, chest-depth (cm)¶											
Supplemental period	− 0.2[a]	0.7[ab]	0.9[ab]	0.9 to 1.1‡	0.6[ab]	0.8	1.8[b]	2.0§	1.3[b]	0.9[ab]	1.1‡ to 1.5§
Recovery period*	1.3	0.4	0.6	− 0.7 to − 0.9	1.1	− 0.2	0.3	− 1.0	0.7	0.9	− 0.4 to − 0.6
Combined period	1.0[a′]	1.2[ab′]	1.5[abc′]	0.2 to 0.5	1.7[abc′]	0.7	2.2[c′]	1.2§	1.9[bc′]	1.9[abc′]	0.9‡
average heart-girth (cm)¶											
Initial measurement	73.3	72.6	71.7	....	72.6	....	72.0	....	71.6	72.8	....
average gain, heart-girth (cm)¶											
Supplemental period	− 1.6[a]	1.9[b]	1.7[b]	3.3§ to 3.5§	2.8[b]	4.4§	7.4[c]	9.0§	3.8[b]	3.2[b]	4.8 to 5.4§
Recovery period	5.0[b]	3.4[b]	3.3[b]	− 1.6 to − 1.7	2.8[ab]	− 2.2‡	− 0.1[a]	− 5.1§	2.4[ab]	2.3[ab]	− 2.6 to − 2.7§
Combined period	3.4[a]	5.1[ab]	5.0[ab]	1.6 to 1.7	5.6[ab]	2.2‡	7.5[b]	4.1§	6.2[b]	5.6[ab]	2.2‡ to 2.8§

APPENDIX TABLE 13 (*Continued*)

Item	Control (no supplement)	Alfalfa pellets							Cottonseed meal		
		Five feedings per week (0.25 lb. per day)	One feeding per week (0.25 lb. per day)	Increase by supplement†	One feeding per week (0.5 lb. per day)	Increase by supplement†	One feeding per week (1.0 lb. per day)	Increase by supplement†	Five feedings per week (0.25 lb. per day)	One feeding per week (0.25 lb. per day)	Increase by supplement†
	average length (cm)¶										
Initial measurement	68.1	69.1	68.6	....	69.5	....	69.5	....	67.7	68.1	....
	average gain, length (cm)¶										
Supplemental period	-0.6^{ab}	-1.2^{a}	0.2^{abc}	0.8 to −0.6	-1.2^{a}	−0.6	2.2^{c}	2.8§	0.4^{abc}	1.3^{bc}	1.0 to 1.9‡
Recovery period	$2.5^{b'}$	$2.6^{b'}$	$3.0^{b'}$	0.1 to 0.5	$2.2^{ab'}$	−0.3	$0.4^{a'}$	−2.1‡	$2.5^{b'}$	$1.3^{ab'}$	−1.2 to 0
Combined period*	1.6	1.6	1.8	0 to 0.2	1.4	−0.2	2.7	1.1	2.9	2.6	1.3 to 1.6

* Differences between groups are nonsignificant.
† Increase refers to comparison with the control group.
‡ Increase significant ($P < 0.05$).
§ Increase very significant ($P < 0.01$).
¶ Initial measurement 7/13/61, and at the end of supplemental period 12/7/61 and at end of recovery period 5/6/62.
^{a,b,c} Wool production or body measurement very significantly different ($P < 0.01$) if superscript different.
$^{a',b',c'}$ Wool production or body measurement significantly different ($P < 0.05$) if superscript different.

Appendix Table 14

AVERAGE BODY-WEIGHT GAIN DURING 1962 SUPPLEMENTATION TRIAL

Type of supplement	Amount consumed (lb. per day)	Number of lambs	Average initial weight of lambs	Average gains July 1962 to May 1963		
				Supplemented period 7/62 to 12/62	Recovery period 12/62 to 5/63	Combined period 7/62 to 5/63†
			lb.			
Control (no supplement)	0.0	18*	71.3	4.9[a]	15.4[c]	20.3
Cottonseed meal	0.24	20	70.4	12.3[d]	10.4[a]	22.9
Molasses-dried beet pulp (MDBP)	0.24	19*	69.6	7.5[bc]	12.1[ab]	19.6
MDBP and 11.1 per cent urea	0.19	19	70.4	7.0[ab]	13.6[bc]	20.6
MDBP and 20.3 per cent diammonium phosphate	0.09	18	69.1	6.2[ab]	13.2[abc]	19.3
MDBP and 4.1 per cent diammonium phosphate	0.25	19	70.1	9.4[c]	10.7[a]	20.6
MDBP and 3.8 per cent diammonium phosphate and 9.4 per cent urea	0.16	19	67.6	8.0[bc]	15.3[c]	23.4

* One lamb missing on 4/12/63.

† Values in this column are N.S. (not significantly different).

[a,b,c,d] Values differ significantly ($P < 0.05$) if superscripts are different.

Appendix Table 15

WOOL PRODUCTION AND BODY MEASUREMENTS OF EWES SUPPLEMENTED IN THE 1962 TRIAL

Item	Control (no supplement)	Cottonseed meal		Molasses-dried beet pulp									
		Cottonseed meal only (0.24 lb. per day)	Increase by supplement†	Molasses-dried beet pulp only (0.24 lb. per day)	Increase by supplement†	Molasses-dried beet pulp plus 11.1% urea (0.19 lb. per day)	Increase by supplement†	Molasses-dried beet pulp plus 20.3% DA-phosphate (0.09 lb. per day)	Increase by supplement†	Molasses-dried beet pulp plus 4.1% DA-phosphate (0.25 lb. per day)	Increase by supplement†	Molasses-dried beet pulp plus 3.8% DA-phosphate and 9.4% urea (0.16 lb. per day)	Increase by supplement†
						average wool production (4/15/63)							
Grease weight (lb.)*	7.4	8.4	1.0	7.7	0.3	7.5	0.1	7.5	0.1	8.0	0.6	7.5	0.1
Wool length (cm.)*	9.5	9.6	0.1	9.6	0.1	9.0	− 0.5	9.4	− 0.1	9.5	....	9.5	....
						average height at withers (cm)¶							
Initial measurement	56.9	56.3	....	56.5	....	56.1	....	55.92	....	56.9	....	56.5	....
						average gain, height at withers (cm)¶							
Supplemental period*	− 0.6	1.1	1.7	0.5	1.1	1.2	1.8	0.6	1.2	0.3	0.9	0.1	0.7
Recovery period	2.6	0.9	− 1.7	1.9	− 0.7	1.4	− 1.2	1.5	− 1.1	1.3	− 1.3	1.6	− 1.0
Combined period*	4.3	4.3	....	4.5	0.2	4.5	0.2	4.2	− 0.1	4.2	− 0.1	4.3	....
						average chest-width (cm)¶							
Initial measurement	17.6	17.4	....	17.2	....	17.2	....	17.3	....	17.2	....	16.6	....
						average gain, chest-width (cm)¶							
Supplemental period*	2.5	3.4	0.9	2.9	0.4	2.8	0.3	2.7	0.2	3.6	1.1	3.2	0.7
Recovery period*	0.5	− 0.1	− 0.6	0.1	− 0.4	0.4	− 0.1	0.1	− 0.4	− 0.9	− 1.4	− 0.1	− 0.6
Combined period*	3.0	3.1	0.1	3.0	....	3.0	....	2.6	− 0.3	2.7	− 0.2	3.2	0.2

						average chest-depth (cm)¶							
Initial measurement.....	23.1	23.6	....	23.5	....	23.5	....	23.2	....	23.5	....	23.2	....
						average gain, chest-depth (cm)¶							
Supplemental period*.....	3.6	4.1	0.5	3.7	0.1	3.7	0.1	3.7	0.1	3.7	0.1	3.6	....
Recovery period*.....	0.7	− 0.3	− 1.0	− 0.2	− 0.9	0.0	− 0.7	0.1	− 0.6	0.3	− 0.4	0.5	− 0.2
Combined period*.....	4.3	3.9	− 0.4	3.5	− 0.8	3.6	− 0.7	3.7	− 0.6	3.9	− 0.4	4.2	− 0.1
						average heart-girth (cm)¶							
Initial measurement.....	70.3	71.0	....	69.7	....	70.4	....	70.6	....	70.7	....	69.6	....
						average gain, heart girth¶							
Supplemental period*.....	4.1$^{a'}$	6.4$^{b'}$	2.3‡	5.0$^{a'b'}$	0.9	5.0$^{a'b'}$	0.9	3.9$^{a'}$	− 0.2	4.9$^{a'b'}$	0.8	4.7$^{a'}$	0.6
Recovery period*.....	5.4	3.3	− 2.1	4.3	− 1.1	4.1	− 1.3	3.7	− 1.7	3.5	− 1.9	4.5	− 0.9
Combined period*.....	9.4	9.7	0.3	9.3	− 0.1	9.0	− 0.4	7.4	− 2.0	8.9	− 0.4	9.4	....
						average length (cm)¶							
Initial measurement.....	65.6	66.1	....	65.7	....	65.9	....	66.8	....	65.8	....	65.5	....
						average gain, length (cm)¶							
Supplemental period*.....	3.4	4.7	1.3	3.9	0.5	3.0	− 0.4	3.1	− 0.3	4.8	− 1.4	4.5	1.1
Recovery period*.....	1.9	1.4	− 0.5	1.8	− 0.1	2.7	0.8	1.4	− 0.5	0.9	− 1.0	1.3	− 0.6
Combined period*.....	5.2	5.8	0.5	5.7	0.5	5.7	0.5	4.6	− 0.6	5.8	0.6	5.8	0.6

* Differences between groups are nonsignificant. Minus signs indicate loss or decrease.
† Increase refers to comparison with the control group.
‡ Increase significant ($P < 0.05$).
§ Increase very significant ($P < 0.01$).
¶ Initial body measurements made 7/17/62, at the close of the supplemental period 12/5/62 and at the close of the recovery period 4/12/63.
$^{a'}$,$^{b'}$ Values differ significantly ($P < 0.05$) if superscript is different.

Appendix Table 16
COMPOSITION OF SUPPLEMENTS
(Dry basis)

Feed	Year	Protein	Crude fiber	Lignin	Ether extract	Ash
		per cent				
Soybean meal (without hulls)	1959	50.1	3.4	1.1	2.0	7.0
	1960	58.2	2.8	0.3	1.0	6.8
Cottonseed meal	1956	46.4	10.3	6.4	3.8	6.7
	1957	55.2	....	...	...	7.6
	1958	46.4	10.3	6.4	3.8	6.7
	1961	46.2	13.8	7.6	1.6	7.3
	1962	46.2	13.8	7.6	1.6	7.3
Alfalfa (dehydrated):						
Bud stage maturity	1956	26.0	21.5	6.4	2.5	11.9
	1957	23.1	27.7	7.3	2.4	12.8
	1958	24.1	23.4	6.7	...	13.4
Full-bloom maturity	1956	20.2	25.0	7.6	2.0	11.4
	1957	18.5	31.0	8.5	2.1	9.8
Commercial	1959	21.5	26.1	8.4	3.8	12.0
	1961	23.9	24.4	7.7	3.6	14.5
Alfalfa (sun-cured):						
Pelleted	1960	23.1	23.1	6.1	4.0	11.7
Wafered	1960	24.2	24.3	6.2	3.7	10.9
Barley	1956	12.0	6.9	1.5	0.9	4.4
	1957	10.1	....	...	...	3.7
	1959	10.8	4.3	1.5	2.4	2.5
	1960	9.6	5.4	1.0	1.2	2.9
		protein (per cent)	*phosphorus (per cent)*			
Beet pulp only	1962	7.8	0.09	...	...	...
+ 11.1 per cent urea	1962	37.4	0.08	...	...	...
+ 20.3 per cent diammonium phosphate	1962	33.4	4.92	...	...	...
+ 4.1 per cent diammonium phosphate	1962	12.7	1.07	...	...	...
+ 3.8 per cent diammonium phosphate and 9.4 per cent urea	1962	36.6	0.97	...	...	...

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