T H E S I S

T H E D E A T H L O S S O F P E A FED LAMBS IN THE SAN LUIS VALLEY

Submitted by

Sherman S. Wheeler

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Colorado Agricultural College

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THIS THESIS HAS BEEN APPROVED AND RECOMMENDED FOR

THE DEGREE OF MASTER OF SCIENCE

C. P. Gillette
Chairman and Professor of Zoology

E. P. Sandsten
Professor of Horticulture

J. E. Newsom
Professor of Veterinary Pathology

Committee on Advanced Degrees
Colorado Agricultural College
Fort Collins, Colorado

THIS THESIS HAS BEEN READ

APPROVED AND RECOMMENDED

FOR CREDIT

Head of the Department of Fred G. Morton

Colorado Agricultural College

Fort Collins, Colorado

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Part I

INTRODUCTION

The introduction, some twenty years ago, of the field pea, or Canada field pea, into the San Luis Valley, marked the beginning of one of the most important industries of the Valley--that of fattening lambs on field peas. At this time Valley farmers were just beginning to realize the injurious effects of continuous grain farming and to see the need for a livestock system of farming and a leguminous crop in the rotation in order to maintain soil fertility. (1) Field peas was found to be a reliable and adaptable crop that not only provided the nitrogen so essential to soil fertility, but which also proved to be an excellent feed for cattle, hogs, and sheep. As a feed for fattening lambs, however, it became of most importance.

Farmers and stockmen were not slow to see the advantage of field peas for fattening lambs. The nearby ranges supplied thousands of lambs which could be brought to the Valley pea fields at a comparatively low cost. When the lambs were ready to come off the range in early October, the field peas had matured and were ready to utilize as feed for the lambs. Bands of lambs were simply turned into the fields and allowed to forage at will, thus harvesting the pea crop at a great saving of labor, coupled with the further advantage of good distribution of valuable manure. The loss of lambs was, in these days, a negligible factor, rarely reaching over two or three percent at the most, and frequently running as low as one half of one percent or even less. It was an easy method of feeding, required

no great amount of expensive labor or equipment, and returned, as a rule, a good profit. The industry, therefore, grew. Within eight or ten years, so we are told, from the inception of this method of feeding, as many as 260,000 lambs were fattened annually. The number of lambs fed during the peak of production reached a figure close to 500,000. It may be thus seen what importance an industry of such magnitude was to the prosperity and progress of the Valley.

Beginning some nine or ten years ago, however, lamb feeders experienced a more or less heavy death loss of lambs fed on peas in the usual manner. At first this loss was not alarming, but as year by year the losses ran higher, feeders came to the realization that they were confronted with a serious problem. Losses of one and two percent, common five years ago, became losses of four and five percent. Some feeders reported losses as high as six and seven percent. These losses have continued until the present time, when, in recent years, the death loss has been so uniformly high as to compel many feeders to discontinue feeding or to feed fewer lambs. As a consequence, we find that where three or four hundred thousand lambs were fed a dozen years ago, the last few years have seen but sixty or seventy thousand fed. It is estimated that during the season of 1923-24 but forty to fifty thousand lambs were fed, and of this number, five or six thousand at least were shipped out of the Valley before they were fat, simply because feeders felt that

it was better to sell "warmed up" lambs than to finish them out against the chance of losing a high percentage before the lambs were ready for shipment.

Enough has been said of this problem to indicate the importance of its solution, but we have said nothing of that vital question, what is the cause of the mortality? The truth may be stated, that no one has arrived at a satisfactory solution of the problem. It is not our purpose to discuss this point at length in the introduction, since that will be taken up in more detail later, but a few considerations of a general nature regarding the explanation of the death loss by Valley feeders and veterinarians would appear to be of value at this time. It must be understood, in the first place, that the following are but suggestions and personal opinions, and being such, they must not be considered conclusive, although many appear logical.

Valley feeders are not totally discouraged over the death loss. With the continued prevalence of the death loss, we find feeders throughout the feeding districts each adopting some method of management whereby the death loss may be minimized. Generally speaking, these methods are more or less successful, but vary in detail to such an extent that no definite statement as to what method is best under all conditions can be made. Each feeder's idea of the cause of the mortality and the best way to cope with it differs from his neighbor's. This is to be expected in view of the fact that each feeder's experience differs with regard to the lambs he

has fed.

From the experience of feeders, we know that by taking the lambs off peas entirely, the death loss is effectively checked. This, however, does not help the feeder a great deal since his problem is to continue to feed the peas yet accomplish this withouta heavy death loss. All that this knowledge affords us is a method whereby we can cause the loss to cease when we remove the cause, for feeders, for the most part, seem convinced that the death loss may be traced to something harmful in the peas when fed in large quantities to the lambs.

There are some, who, believing that the death loss is due to an excess amount of the heavy concentrated feed, peas, being fed, attempt to limit the amount of peas consumed daily, hoping in this manner to cut down the loss. Those who follow out this plan, usually allow the lambs to run in the pea field a limited time each morning and afternoon. The common practice is to start them on peas gradually, slowly increasing the time the lambs are on peas until they are out several hours each morning and afternoon, being confined to a corral between feeding periods. A mexican is usually employed to herd the lambs according to the method the feeder deems best. A method of herding that is commonly used is to allow the lambs, upon first being turned into the field in the morning or afternoon, to work over the area that has previously been more or less foraged before allowing them access to fresh peas, the idea being to prevent the lambs from getting too much peas during the short time that they are allowed in the field.

We have been told that this method of feeding is in a large measure successful depending upon the regularity with which the herder follows out this procedure. The success met with in following out the limited ration plan is not without it disadvantages. In the first place, it is not always a positive check against a discouraging death loss. We have known of feeders who followed this plan to feel compelled to either sell their lambs before they were fat, or to adopt corral feeding. Secondly, by limiting the ration so that the death loss is cut to a safe minimum, many feeders have experienced difficulty in getting the lambs fat. This is especially true with respect to the so-called light end of the band remaining after the fattest and largest lambs have been topped out and shipped to market. These two factors may be said to affect any method employed by feeders ~~in~~ which the concentrate ration is limited or not full-fed.

Another plan followed by some feeders is to allow the lambs to work over small grain or alfalfa stubble before being turned on the peas, the idea being to prevent the lambs from going into the pea field too hungry and gorging themselves on peas. Many of the small grain and alfalfa stubble fields afford considerable feed, thereby making utilization of feed that might suffer less complete utilization by other classes of stock. This method affords a somewhat uncertain measure of safety against the death loss. In this connection it has been observed that lambs which are allowed to get hungry between feeding periods have a tendency to gorge themselves when turned on the peas,

whereas lambs which have been allowed to remain in the pea fields the greater part of the day eat small amounts of peas at frequent intervals, and apparently are never very hungry for them. We have noticed that where lambs were confined without feed during the interval between feeding periods, upon being turned into the pea field they ate ravenously, consuming, we believe, almost as much during the brief time that they are out as do the lambs which are allowed in the field all morning or afternoon. This observation has brought a number of the feeders to the conclusion that limiting the time that the lambs are allowed on peas to a few hours or less, morning and afternoon, is not a wise practice, yet, believing that the consumption of peas should in some way be controlled, they have adopted a method whereby the lambs, upon return to the corrals in the forenoon and in the late afternoon, have addess to roughage, either a good quality of straw or alfalfa hay, or both. It would appear that such a method has an advantage if for no other reason that it provides the lambs with something to eat between feeding periods instead of allowing them nothing, as is the practice of some lamb feeders. As to the advantage gained by filling the lambs on roughage before turning them into the pea field, we are not so certain, since some feeders who have followed this procedure experience a more or less heavy death loss, sometimes losing more lambs through this method of feeding than do their neighbors who make no attempt to keep the lambs filled.

Believing that the pea ration is too high in prot-

ein for the safe feeding of lambs, and that this fact may be at least partially responsible for the death loss, certain other feeders have tried supplementing the pea ration with barley or a mixture of barley and oats. As a rule, they have not adopted any such practice until the death loss on peas has reached a figure which indicates that some measure must be taken to check the loss. Feeders are adverse toward feeding supplements of this nature until forced to the point of attempting to control the loss because of the high cost of such feeds in comparison with peas. In some cases, the lambs have been taken off the peas entirely and fed grain or a grain mixture, plus alfalfa or alfalfa and straw mixed, then turned back on the peas. For a while there is usually no death loss, only to be followed later by a more or less serious mortality. Other feeders have fed grain and hay and allowed the lambs a limited amount of peas. The same thing may be said regarding this method--it has proved successful in some cases, but not in others, and has the added disadvantage of increased cost of fattening. A few feeders, not having faith in the methods followed by their neighbors, still persist in following the old plan of turning the lambs into the pea fields and in no way preventing them from eating all that they will. Occasionally such a method meets with no disastrous results, but usually, sooner or later in the feeding period, the lambs start dying in large numbers.

As a result of the heavy losses during the past few years many feeders have felt compelled, as mentioned above, to either corral feed or sell. In addition to the extra expense

of corral feeding or pen feeding, another factor tends to prevent its adoption in the San Luis Valley. It is that very little of this type of sheep feeding has ever been done in the Valley, thus tending to prevent feeders from having the assurance of success in this method that feeders in other districts of the state have.

Regarding the time when the death loss generally occurs during the feeding period, there is some disagreement. As a rule, the loss occurs to the greatest extent toward the latter part of the feeding period, but losses may be expected as early as the first three or four weeks following the turning of lambs on peas. From that time on, the losses may be continuous or only occasional, or they may cease only to start again a month or so later. Some bands of lambs show no death loss until they are practically finished. Others show a loss when the band is about two thirds to three fourths fat. It is not safe to assume any definite time when the loss may be expected. It is usually that the fattest and thriftiest lambs die. This has been explained by the fact the thrify lambs naturally consume more peas than the weaker lambs, and that this greater amount of peas may be responsible for the mortality.

A question that has naturally arisen in the reader's mind is, why have the lambs fed within the recent years died whereas lambs fed apparently in an identical manner showed no such heavy losses a dozen or more years ago? Lamb feeders again disagree on this point. We present below the opinions of a number of feeders regarding the answer to this question. First,

lambs fed a dozen years ago were turned on peas which did not yield such a crop of seed as those planted during recent years, and that lacking as large a quantity of peas, the lambs were forced to eat more vines, thus tending to offset the injury attributed to a heavy consumption of peas. Secondly, peas were planted thinner in the early days, the object not being such a heavy crop of seed, and by reason of this fact, the vines cured out better, making them palatable feed for the lambs. The lambs therefore ate more vines which tended to balance the ration better. A third explanation is that in the early days of lamb feeding there were no mouldy or rusty vines, common in recent years, and that this mould or rust is responsible in part for the death loss. It is true that many of the vines have the appearance of being mouldy, having a blackish spot or rust, which doubt less gives rise to this theory. This subject received the attention of the Pathology Section of the Colorado Agricultural Experiment Station, and it was found (5) that when the mould or rust was fed experimentally, no mortality or sickness resulted, indicating that this theory must at the outset be rejected.

We have attempted to summarize briefly the death loss problem in the San Luis Valley as to its history and as to its present status, and we have endeavored to give the reader a clear idea of conditions as they exist so that he will be better able to understand the material that follows. We shall next take up a discussion of the investigational work on the death loss problem that has been carried on in the San Luis Valley during the past three years, such an account of the work,

however, being but a foundation for the discussion following, on the conclusions that may be drawn from the experiments, and also for the discussion of the possible explanations of the death loss of pea-fed lambs.

It is the purpose of this paper to discuss the death loss of pea-fed lambs in the San Luis Valley:

1st From the standpoint of its general aspects--this has been included above in the introduction or Part I of this paper.

2nd From the standpoint of the investigations that have been carried on in an attempt to determine the cause of the trouble; Part II of this thesis.

3rd From the standpoint of the possible explanations of the death loss, which is included in Part III of this thesis.

From the above named discussions, a number of general conclusions will be drawn with regard to the death loss problem.

PART II

LAMB FEEDING EXPERIMENTS

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SAN LUIS VALLEY

Part II

Lamb Feeding Experiments in the San Luis Valley.

With a view toward determining (1) whether peas were responsible for the death loss in the Valley and (2) if peas were responsible to find out a safe method of utilizing them as sheep feed, the Pathology Section of the Colorado Experiment Station carried on a series of experiments during the seasons of 1921-22, and 1922-23 respectively.

The first year of the experiment five lots of one hundred lambs each were fed the following rations:

Lot I allowed to run at will on peas with no attempt at limiting the ration.

Lot II. Herded lambs on peas starting in with five minutes morning and afternoon and increasing five minutes every three days until the lambs were on full feed.

Lot III. Fed the lambs on alfalfa alone for ten days, then followed the same system as with Lot I, except that alfalfa was kept before the lambs at all times when they were in the corrals.

Lot IV. Fed the lambs on wheat straw alone for seven days, then followed the same plan as with Lot II, keeping straw before the lambs at all times when in the corral.

Lot V. Confined the lambs in the corral and fed pea hay through panels. A few days after the lambs were started on the experiment half of each lot was vaccinated

with Hemorrhagic Septicemia vaccine. Within the next two months, out of fourteen lambs that died, ten had been vaccinated and four had not. The last month of the experiment Lots I and II were moved onto new peas. Ten lambs died out of these two lots after the transfer, and of this number five had been vaccinated and five had not. The results of this year's investigation should that

(1) Hemorrhagic Septicemia did not appear to be the cause of the death loss.

(2) Lambs did not appear to die until they had put on a considerable amount of fat, and that the death loss appeared to be heaviest with fat lambs allowed a full ration of peas. Thinner lambs allowed a full ration of peas showed little or no loss. (5)

The following year five lots of one hundred lambs each were fed these rations:

Lot I Pen or corral fed on barley and alfalfa hay.

Lot II Pen or corral fed on pea hay.

Lot III Allowed to run at will on peas.

Lot IV Herded on peas in the manner described above for Lot II for the previous year.

Lot V Pen or corral fed on pea hay and barley.

This year none of the lambs were vaccinated with Hemorrhagic Septicemia vaccine, but were observed as to the effect of the different rations upon the death loss in the respective lots fed. A tabulation of the losses in the various lots shows.

the following results:

Lot No.	I	II	III	IV
Ration Fed	Barley and alfalfa	Pea Hay	Peas in field	Herded on peas
Death Loss	7*	4	2	4

Lot No.	V
Ration Fed	Pea hay and barley.
Death Loss	8

* Of Lot I, three died of bloat and one as a result of castration.

The total loss was 25 head or 5% of the total number fed.

Summarizing these two years of work it may be said that it was proved that Hemorrhagic Septicemia was not the cause of the death loss of the lambs fed field peas. As regards the effect of the various rations fed as a means of checking the death loss, no definite statement could be made. (5).

It was thought wise to carry on the experimental work from a nutritional standpoint, so this phase was undertaken by the Animal Investigations Section of the Colorado Experiment Station. The object of the work carried on by the Animal Investigations Section during the season of 1923-24 was to determine a system of management and feeding whereby the heavy death loss commonly experienced with pea-fed lambs might be eliminated and checked to such an extent that feeders could feel safe in feeding out large bands of lambs on field peas. It was the purpose of this work to definitely isolate a specific cause of the trouble and to evolve a method

of feeding and management that would lend to hold in check the loss and which would prove practical and effective under existing conditions in the Valley. Neither was accomplished in the one year's work.

Lamb Feeding Experiment 1923-1924

Preliminary Work.

Before the actual experimental feeding began, considerable work was necessary. It was the plan to feed five lots of one hundred lambs each, four of which were to have field peas as a part or all of the ration. This necessitated the purchase, in the first place, of sufficient acreage of peas to supply the lambs with an abundance of feed since it seemed advisable to give the lambs every opportunity to die from the effects of peas, rather than by limiting the amount consumed through an insufficient acreage or a light stand, to preclude the possibility of a representative death loss. Although the field pea crop was considered a good one this past fall we found many fields with a rather uneven stand or badly infested with weeds. Sixty two and one-half acres of peas located on the Rupert ranch five miles north and three and one half miles east of Monte Vista were accordingly purchased. This acreage was situated close to an artesian well and was so fenced that it was only necessary to construct several cross fences in order to provide a field for each of the four lots fed on peas. A temporary fence (See diagram) was built so that the lambs allowed to run on the two largest acreages

would clean up part of the feed before being turned on the remainder, thus avoiding undue waste.

Corrals were built close to the artesian well to facilitate watering of the lambs. Each pen was approximately 48 feet long by 32 feet wide, thus allowing ample room for the one hundred lambs confined therein. Fourteen and sixteen foot length panels wired to posts, were used in the construction of the pens. A space of eight inches between the bottom two boards of each panel afforded room through which the lambs could eat hay. A feeding alley was constructed as shown on the diagram, which facilitated herding the lambs and from their respective pea fields. It was planned to have the hay fed from stacks built adjacent to the pens and fenced in by panels in order to prevent the lambs from eating hay in going to and from the corrals.

Water was carried from the artesian well, a one inch pipe being used for this purpose. A series of wooden troughs was placed, one to each pen, in line with holes bored in the iron pipe, so that there was a continuous flow of water to each trough, thus preventing freezing. The troughs were set at a slight angle so that the water drained into an adjacent ditch. This system of watering proved satisfactory with the exception that occasionally the water spattered more or less as a result of high winds.

For the use of the herder a small portable, wooden shack was rented at a nominal cost and placed close to the pens. It

was necessary that the herder be close to the corral at night since feeders have found that otherwise the lambs may be molested by dogs or coyotes. Most sheepmen in the Valley provided a small tent and stove for the use of their Mexican herders.

Five hundred and twenty five lambs were purchased shortly before the experiment started through a sheep dealer in Monte Vista. The lambs were received at Capulin weighing on an average of 60 pounds and were driven overland to Monte Vista, a distance of some thirty miles. From Monte Vista, after a short rest, the band was driven out to the Rupert ranch. These lambs were a good grade of improved stock, showing a preponderance of black-face blood. There were a few off colored lambs, and three black lambs. Most of the lambs sheared fleeces of medium length, there being but few typical, short-wooled lambs, and relatively few long, coarse-wooled lambs. As regards sex, there considerably more wether lambs than ewe lambs. These lambs were typical of the kind raised in the Valley, especially those raised by Mexicans in that only the ewe lambs had been docked.

Experimental Methods Followed.

During the three days prior to placing the lambs on feed, the band was ear-tagged, sorted, and alloted. The lambs were sorted according to three grades by weight and condition namely, heavy, medium, and light, the sorting and ear-tagging being done at the same time. Having sorted out

the extra twenty five lambs a proportionate number indiscriminately chosen from each of the three grades, was counted out of their pens, to form each lot of onehundred lambs. It will thus be seen that Lot I contained the same number of heavy grade lambs as Lot II and so on with respect to each grade and lot. Below is a table showing the total and average number and average weight of each grade of lambs as they were alloted.

Grade by Weight	Heavy	Medium	Light
Total Number	195	255	50
Average Number in each lot.	39	51	10
Average weight Lbs.	60.23#	53.90#	46.83#

Following allotment lots I, II, III, and IV were branded with black and red sheep paint to assist in identification.

An average of three group weights was considered the average initial weight of the lambs. Individual weights could not be taken due to lack of the necessary equipment and to the impracticability of weighing individually such a large number of lambs. Group weights were taken every thirty days during the course of the experiment and an average of three final group weights was taken for the average final weight. To facilitate weighing a scale pen was constructed on a standard wagon scale platform, the lambs being driven to and from the scales and the corrals. The middle day of the three days on which the lambs were weighed was considered the day that the experiment began and the weight of the lambs as they went

into the experiment was considered to be the average of the weights taken on the three days.

The rations and methods of feeding them for each lot follow:

Lot I, Field A----Turned on peas and allowed free access to them at all times except night when they were corralled.

Lot II, Field B----Herded on peas, beginning with ten minutes in the morning and afternoon, and increasing this time five minutes each day until on full feed. Alfalfa was kept before the lambs while in the corrals.

Lot III, Field C----Herded in the same manner as Lot II, but fed oat hay while in the corrals.

Lot IV. Herded in the same manner as Lot II and Lot III, oat hay before them while in the corrals, and barley fed twice daily, morning and evening.

Lot V. Pen fed on alfalfa and barley. No peas. All lots had access to water and salt at all times while in the corral.

Lots I and V were fed as checked lots. Supplementary feeds fed were as follows:

Lot I potatoes

Lot II

Lot III potatoes, alfalfa

Lot IV potatoes, alfalfa

Lot V

These feeds were added later in the feeding period as described below. Ref. page.

A description of the feeds fed follows:

Peas -- Good quality, uniform stand, and well podded. They were evidently a mixture of the San Luis Valley Stock Pea or Mexican pea, and the White Marrow Fat or Colorado White, the feed being locally grown. Cost $16.25 per acre.

Oat Hay -- Fair quality hay containing a small amount of other grains, afew grasses, and some blackened alfalfa. This hay when cut and shocked was in good condition but was damaged by subsequent rains. There was a small smount of matured grain in this hay. Cost $6 per ton.

Alfalfa Hay -- Excellent quality first cutting hay with a high proportion of leaves and fine stems. It was highly relished by the lambs. Some of it was slightly stack burned but/was apparently no less value as a feed than the bright hay. Cost $14.00 per ton, delivered.

Barley -- Valley raised California Feed Barley of good quality but containing a considerable amount of weed seeds, and some trash. It weighed 45 pounds to the bushel. Cost $32.08 per ton, delivered.

Potatoes -- Cull grade potatoes containing a few rats, but consisting largely of small, shrivelled and frosted potatoes unfit for market. Cost 15¢ per cwt.

The procedure followed in feeding the various feeds named above was as follows:

Lot I. -- The lambs were turned out on the peas at 7 A. M. and were driven in from the field and corralled at 5 P. M.

Lot II. -- Alfalfa was fed about 7 A. M. and the lambs allowed to fill on hay for an hour before turning them into the field. Fresh hay was fed at noon, but in limited quantity. The lambs were turned out into the pea field again at 3 P. M. The evening feed of hay was given about 4:30 P. M. and was the heaviest feed of the day so that the lambs would have plenty for the night.

Lot III. -- Oat hay was fed in the sam manner as alfalfa in Lot II, except when alfalfa was added to the ration, when the oat hay was fed at noon with the potatoes. Alfalfa was fed in the morning and at night, the idea being to preclude any possibility of fermentation occuring from potatoes and alfalfa being fed at the same time.

Lot IV. -- These lambs were fed in the same manner as Lot III but had no fresh hay allowed them before eating their grain, directly after which they were turned out on the peas. In this lot no alfalfa was fed in the morning when this hay was used as a supplementary feed, but a generous amount was given at night. Grain was invariably fed before turning the lambs out on peas.

Lot V. -- These lambs were fed their grain about 8 A. M followed by a limited amount of alfalfa hay. At noon a lit-

tle fresh hay was thrown up but care was taken that the lambs did not get too big a fill of hay before their afternnon feed of barley which was fed about four o'clock. A good fill of hay was given just after the grain was fed.

It was our aim to follow out a regular system of feeding. We found that it seemed to produce the best results when hay was withheld from the grain fed lambs until after the concentrate had been fed. Potatoes appeared to best fit into the schedule at noon as explained above. We believed that hay should be fed most liberally at night and should be limited during the day. In herding the lambs in lots 2, 3 and 4, we made no attempt with the exception of Lot 2 toward the end of the experiment, at controlling the acreage over which the lambs grazed while they were on the peas.

In feeding the barley to Lots IV and V a very light grain allowance was given at the start and was gradually increased. Each lot was started at .05 lb. per head daily and increased so that Lot V was getting a pound per head daily at the end of 37 days and Lot IV a pound per head daily at the end of 42 days. It was our experience that when lambs are allowed peas in addition to grain as was the case in Lot IV, it was difficult to induce the lambs to consume more than a pound per head daily, our observations showing that above a pound per hed daily the appetite for barley was directly dependent upon the length of time the lambs were allowed on peas, regardless of the fact that barley was in-

variably fed before turning the lambs out in the pea field. The grain was spread out into low troughs, the alley gates closed, and the lambs turned into the pen, thus formed. The time required for the lambs to clean up the grain varied with the amount placed before them, the weather, and, as was the case with Lot IV, the length of time the lambs had been running on peas.

Gains Made by the Lambs

In an experiment of this kind the primary object was not one of determining what feed or combination of feeds produced the heaviest and most economical gains. This was not the problem because peas afford the sheep feeder of the San Luis Valley the cheapest feed, and a feed upon which fairly rapid gains may be made. The problem was one of finding a method of feeding or a combination of feed which would effectively control the death loss when fed in addition to peas. For these reasons, a consideration of the gains made by the different lots fed is simply of interest to the feeder as a means of showing him what gains he might expect by feeding such feeds. A tabulation of the gains made by the five lots fed follows.

Gains Made by Lambs -- 100-Day Feeding Period.

Lot & Ration Fed	I Peas	II Peas Alf.	III Peas. Oat Hay (Alf. & Pot)	IV Peas. Oat Hay Barley (Alf.& Pot)	V Barley Alfalfa
Av.Initial Wt.	56.76	56.15	54.58	55.63	56.93
Av. Final Wt.	86.22	79.10	74.12	80.20	81.97
Av.Gain per Lamb	29.46	22.95	19.54	24.57	25.04
Av. Daily Gain per Lamb at Feed Lot	.284	.228	.188	.236	.248
Av. Daily Gain per Lamb at Mkt. 6% Shk.	.232	.180	.142	.187	.198

A glance at the above table shows that the lambs allowed access to peas at all times, Lot I, made considerably the best gains. This substantiates the experience of valley feeders who have found out, as has been mentioned above, that whenever the pea ration is limited, even when a grain supplement is fed, the lambs do not fatten as quickly. It also tends to substantiate the experience of some feeders who have found that an unlimited pea ration produces a higher daily gain than corral feeding on barley or a grain mixture and alfalfa hay, to say nothing of the advantage pea feeding has in producing more economical gains, barring, of course, the death loss.

It is interesting to note in this connection, what the buyers of the lambs at Denver thought of them. The lots were ranked as follows:

Lot I	first
Lot II	third
Lot IV and V	tied for second
Lot III	Poorest lot

It was to be expected that all the lambs would not be considered fat enough to be sold as fat lambs. The commission company accordingly sorted each lot into two lots, a fat and a feeder end, the number of fat and feeder lambs in each lot showing in the following table.

Lot No.	Number Fat	Number Feeder	Av. Wt. Fat End	Av. Wt. Feeder End
I	68	23	84.56	74.78
II	27	69	84.44	76.09
III	11	74	82.73	73.51
IV	44	44	84.09	73.41
V	44	49	82.50	72.45

Both the feeder and fat lambs sold for $13.40 per cwt. It was stated by the commission house which sold the lambs that by sorting out the feeders and selling them separately, a better price could be realized for the fat lambs than could have been expected if the unfinished lambs had been sold along with the fat lambs. In this connection it may be mentioned that Valley feeders usually "top out" their lambs, shipping only those which are fat, and holding the "light end" on feed for a longer period. In this experiment this could not have been done for obvious reasons, but the figures above show what might have been expected had the band been "topped out" at a time when a carload of lambs were fat enough to ship--that is, a similar proportion to the

number of fat lambs actually sorted out at the market would probably have been sorted out at such a time.

Death Loss of the Experimental Lambs

We have spoken briefly above regarding the peculiarities of the death loss problem, but we have not gone into detail with regard to the typical conditions associated with the death of lambs allowed to run on peas. From the experience of Valley veterinarians, the conditions associated with the death loss of lambs vary considerably, cases of death showing a rather wide variation both as regards symptoms before death and post-mortem indications. The symptoms before death may be said to be, as a general rule, diarrhea, weakness and dizziness, a comatose condition, and usually, shortly before death, more or less violent convulsions. Occasionally there are apparently no symptoms whatever, lambs apparently in good health have dropped without warning, and after a few violent convulsions have died. On the other hand lambs have been known to live for several weeks, touching neither food nor water, and gradually wasting away until death comes apparently as the result of starvation. Most feeders' experience has shown that the lambs die within a few hours to a day after the symptoms of sickness are first noticed. We have observed a few lambs apparently affected by acute cerebral symptoms shortly before death. These lambs often run around in circles, bleating and grinding their teeth.

Post mortem examination usually shows one or more of the following conditions to be present,--pulpy kidney, pin-point or patechial hemorrhages on the diaphragm pericardium, pleura and skin, hemorrhagic lymph glands, pneumonia tracheitis; enteritis; a par-boiled appearance of the liver; and occasionally a large quantity of a watery fluid in the abdominal cavity. Cases in which the death has occurred quickly usually show, upon examination of the contents of the rumen, a mass of partly digested food consisting largely of peas, pods, and stems of straw or hay, which have a characteristic fermenting odor. Upon removal of the pelt we have observed a watery consistency between the flesh and the pelt. It has been observed that frequently but one of the conditions named above is evident upon post mortem examination, for example pneumonia or tracheitis, accompanied by none of the conditions which would suggest digestive disturbance, such as enteritis, abnormal kidney or liver has been found.

It is an interesting fact that it has been difficult to take a pea fed lamb when it is first noticed to be sick and by special treatment, to cure it. We have heard of feeders who have saved lambs by various methods, but it is as a rule a waste of time to attempt to cure them. Lambs which have been sick, and apparently recovered, feeders have told us, rarely fatten off well the same season, making it necessary to carry them over on grass until the following

fall. For this reason the lambs when first noticed sick or off feed, are simply allowed to die. In the experimental band there was one lamb in Lot II, which apparently recovered after sickness lasting ten days. When first noticed sick, this lamb was taken out of the lot, given a dose of epsom salts, then confined to a pen by himself. For four or five days he touched neither food nor water, but about the sixth day he was seen attempting to eat a little alfalfa hay. However, it was fully a week before he could have been said to be normal, and ready to be put back into the lot. Another lamb, treated much the same way, from our observation never touched feed for the five weeks he remained alive, and drank very little water. Upon post mortem examination, this lamb showed none of the characteristic symptoms of disease described above, but the body tissues had wasted to such an extent that the pelt, in some places, adhered to the bones. The rumen showed a compact, almost dry mass of ingesta, indicating that no digestion had taken place for a considerable length of time. His weight at the time of death was less than half of his normal weight when he first was taken sick.

This experiment being chiefly concerned with the effect of various rations and methods of management upon the death of pea fed lambs, it was essential that accurate records be kept of the death loss of lambs during the course of the experiment. A record of the deaths was kept, showing the date of death, the lot in which the death occurred, the dead lamb's number and his weight at time of death, the

symptoms before death and the post mortem indications, and the grade of lamb, whether heavy, medium or light. If a lamb were replaced by another lamb from the twenty-five extra lambs, the latter lamb's number was recorded, together with his weight at the time of replacement. Whenever a replacement was necessary, a lamb weighing approximately the same as the lamb that died was used, and the difference between his weight and that of the dead lamb was added or subtracted from the total weight of that lot. In this connection it may be stated that replacements were discontinued after the first month. This made it necessary to calculate all final data with regard to gains and feed consumed, on a basis of total lamb days. The total number of lamb days was found by multiplying separately the number of days by the number of lambs remaining in the lot after each death, then adding these results to find the total number of lamb days for the entire lot.

We have prepared two charts (see plates I & II) to which we shall refer in the following discussion of the actual death loss of the experimental lambs. These charts will serve to make clearer the distribution of the death loss in the various lots as well as aid in a comprehensive discussion of the death loss. In the graphical chart we have not shown any of the losses except those apparently caused by the pea field disease. (We refer for convenience sake, to all deaths associated with the lambs running on peas or the pea field disease, admitting however that this

term may be an erroneous one). Lot V is omitted from the charts because it was considered a check lot, and, altho deaths also occurred in this lot, they were not significant in an experiment of this kind, since this lot received no peas.

Referring to plates I and II it will be noticed that the death loss began simultaneously in Lots III and IV respectively the twenty third day the lambs had been on feed. The loss increased to six and seven lambs in Lots III and IV respectively within the eight days following; or expressed on a percentage basis, six and seven per cent respectively in eight days. At this point it may be stated that Valley lamb feeders as a rule do not experience a death loss as early in the feeding period as was the case with the experimental lambs this year, nor, generally speaking, does the death loss percentage reach such a high figure within such a short period of time. Both of these statements may perhaps be explained by the fact that lambs fed in the usual manner during recent years, that is, allowed to run on peas a limited time each day with a limited access to fresh peas daily, do not get as heavy a daily ration of peas as did Lots III and IV at the time the death loss began. Altho the lambs in these two lots were allowed on peas but forty five minutes morning and afternoon, we believe that they nevertheless consumed a larger amount of peas in this short period of time than did lambs herded in the manner described above. We have, however, no means of proving this point other than by our observations.

The death loss in Lots III and IV continued until November 20th, when the two lots were taken off the peas. Alfalfa hay and potatoes were fed in addition to the original ration, minus peas (3) for a period of fourteen days. During this time, as will be noted upon reference to the charts, but one death occurred. This lamb had been sick two weeks so its death may be attributed to the effect of previous treatment. The cessation in death loss was to have been expected in view of the fact that the death loss has been definitely associated with field peas. The purpose, however, of this change of ration was not to stop the death loss while the lambs were off peas--that was logically to be expected as has been brought out above--but to determine whether the feeding of alfalfa and potatoes had any effect upon checking the death loss when the lambs were turned back on peas again and the supplementary feed discontinued. The addition of alfalfa and potatoes was made upon the suggestion of Valley veterinarians, whose experience had indicated that hogs become "sick" from being allowed to run on peas with no supplementary feeds. When hogs affected by such sickness were taken off the peas and fed alfalfa and potatoes for about ten days, then allowed again to run on peas with no additional feed, the peas apparently had no bad effect and the hogs fattened off with no further trouble. It was our desire to find out whether this method successfully applied to fattening hogs would likewise check the death loss of lambs.

Accordingly the change described above was made.

Referring to the charts again, it will be noticed that shortly after the lambs in Lots III and IV were put back on the peas, with the original ration, deaths again occurred in these two lots. The losses were five and six lambs in Lots III and IV respectively during the fourteen day period following the change back to the original ration. It appeared evident from these losses, following so soon after the change back to the original ration, that alfalfa and potatoes had little value as a check upon the death loss when these feeds were fed to lambs taken off the peas, then allowed peas after the feeding of alfalfa and potatoes was discontinued. Apparently what was beneficial to pea-fed hogs, had little value for pea-fed lambs. The death loss following the return to the original ration also tended to substantiate the argument that the death loss in these two lots was to be directly associated with peas. However, in order to convince ourselves upon this point, oat hay was fed to the check lot, number five, in order to determine whether there were a possibility that a toxic principle was present in the oat hay, which could in any way be responsible for the loss. The oat hay, as has been mentioned above, was was of damaged quality. No results which could point toward the oat hay as being the cause of the trouble were obtained, so we came to the conclusion that the peas, and they alone were to be associated with the death losses in Lots III and IV.

Believing that potatoes and alfalfa might possibly prove of value as a death loss checking supplement to the original rations of Lots III and IV, it was decided to turn the lambs in these two lots on peas as before but to feed in addition, alfalfa and potatoes for fourteen days. By such a method of feeding, the value of the combination of supplementary feeds as a check against the death loss might be established. By referring to the charts, it will be noticed that the only losses which occurred during this period were those which occurred during the two days following the change in ration, one death being in Lot IV and two in Lot III. We attribute these three deaths to the result of the previous method of feeding, which conclusion we regard logical in view of the fact that no deaths occurred during the remaining twelve days of this period. The fact that there were no further losses during the remainder of the period tended to show that the combination of alfalfa and potatoes had the effect of counteracting, so to speak, the effect of the peas.

Just what alfalfa and potatoes supplied that would counteract the effect of peas in the rations of Lots III and IV, we are not certain. With the idea that the succulence supplied by the potatoes was the important factor, the ration was again changed in these two lots. For the next twenty days potatoes only was added to the original ration of Lots III and IV, no alfalfa being fed. From a glance at

the chart, it will be noticed that during this twenty day period there were four deaths in Lot III and three in Lot IV. Of these deaths only one in Lot III was typical of the death loss previously experienced. The other three lambs that died in this lot were sick from three days to a week before death. In Lot IV two of the lambs that died during this period were typical, and the other lamb was sick three days before death. The fact that four out of seven of the lambs that died in these two lots exhibited a tendency toward less acute symptoms before and after death than had been the case during the two periods in which the death loss ran so high, tended to show that potatoes alone were not as efficient in checking the death loss as was a combination of alfalfa and potatoes. On the other hand, however, the fact that for twenty days the death loss in the two lots combined was but seven lambs as against fourteen for the last period of fourteen days when no supplementary ration was fed, tends to show that potatoes had a definite effect in checking the loss.

With ten days left until the end of the experiment it was decided to feed alfalfa and potatoes again to Lots III and IV to further substantiate, if possible, our tentative conclusion that a combination of these two feeds, when fed in conjunction with the oritinal rations fed to these two lots of lambs, had a definite effect in checking the death

loss. Referring to the charts it will be seen that during these last ten days two lambs in Lot III died. These deaths, however, could not be classed as typical of the so-called pea field disease, nor could they be attributed to the ration fed at the time of death, since one lamb had been sick a month, and the other, ten days.

Summarizing the results of the experimental methods followed in handling these two lots, we may come to these tentative conclusions:

(1) That in Lots III and IV peas were evidently to be associated with the death loss.

(2) That taking the lambs off the peas and feeding alfalfa and potatoes had no effect in checking the loss once the lambs were put back on the original ration again.

(3) That alfalfa and potatoes fed in addition to the original rations appeared to have a definite effect in checking the death loss of lambs fed peas and oat hay, and peas, oat hay and barley.

(4) That potatoes alone fed in addition to the original rations not to have as beneficial value in checking the death loss in these two lots as did alfalfa and potatoes.

Having discussed the experimental methods employed in feeding Lots III and IV, we turn now to Lot II. This lot,

as has been mentioned, was simply fed alfalfa hay in addition to the daily allowance of peas. The first death in that lot occurred the same day as did the first deaths in Lots III and IV, namely November 13th. A post mortem examination of the lamb that died in this lot showed symptoms of death from bloat, presumably from the alfalfa hay that was fed, therefore this death could hardly be considered to be associated with the pea ration. It may be well to state here that other than this one case, no trouble was experienced with bloat among the experimental lambs, although we know of one feeder who, some four or five years ago, experienced a loss of some three per cent from bloat in a band of lambs fed barley and alfalfa hay, the latter being fed in self-feeders.

The next death in Lot II occurred the last day of November, this lamb having been sick a week previous to his death, but nevertheless showing the typical post-mortem indications of the pea field disease. Another typical death occurred three days later, making the total loss from the pea field disease up to this point two lambs. The following day, December 4th, the lambs were allowed to run on the field of peas, Field IV, that Lot IV had run on up until the first change in ration. This change for Lot II onto a different field was made to determine whether the heavier stand of peas in Field IV than in Field II(where Lot II had previously run) would show as heavy a death loss in Lot II as it did in Lot IV. If such proved to be the

case, it would lead to the conclusion that the death loss could be associated with the relative denseness of stand of peas in the various fields. A glance at the charts, however, shows that if Field IV had a denser stand than Field II this fact apparently had little effect on the death loss in Lot II, since there were but two deaths in this lot after they had been turned in on the peas of Field IV, so they were allowed to remain in this field until the last ten days of the experiment, when, due to a greater abundance of peas in the untouched portion of Field II, they were allowed to run there, with no further death loss. Reference to the charts again brings out this fact--that upon being turned on peas again, Lot IV showed a heavy loss when allowed to run on the less dense stand of peas in Field II, thus proving conclusively that the relative denseness of stand in the two field had nothing to do with the comparatively high and low death losses in Lots IV and II respectively. We felt, as a result of this experiment, that either of the two fields mentioned had a heavy enough stand of peas to kill lambs; for that matter, the same could have been said in regard to all four fields, since the stands in Fields I and III were as good, if not better, than the stand in Field II.

This point having been conclusively settled, it was decided after the two deaths in Lot II had occurred since the change onto field IV, to limit the consumption of peas in this lot, by allowing them to run on only a limited area in Field IV at each feeding period. Heretofore, in all lots "herded," so to speak, on the peas, the lambs

had been simply turned onto their respective fields for a certain length of time, then herded back to the corrals at the end of a half hour, for example. No attempt had been made to confine the lambs on a certain area in their respective fields, however. The herder, therefore, remained out in the field with the lambs in Lot II until time to bring them back to the corrals, and herded them so that they foraged over only a certain limited area of the field. As soon as this area was well cleaned up, the lambs were allowed to forage over a fresh area. At the same time, observations were made to find out whether, in herding in such a manner, the lambs ate any of the vines of the pea plant. In this regard we found this to be true--that only a small amount of stems or vines of the peas were eaten by the lambs in this lot, or, in fact, any of the lots herded on peas. In Lot I, allowed unlimited access to peas during the day, we observed lambs eating considerably more of the vines. This difference perhaps may be explained by the fact that Lots II, III and IV were fed roughage when in the corrals, and consequently found no need of eating the coarse pea vines, whereas Lot I received no such roughage, and was forced to eat what roughage they could find in the field.

Whether holding the lambs in Lot II on a limited area each day was responsible for no further deaths during the remainder of the time they were on Field IV, we were

not certain. If there had been a heavy death loss in this lot previous to the inauguration of this method of herding, followed by a complete cessation of death loss, then we would have felt that this method of herding was effective in checking the death loss. But such were not the conditions of the experiment, so without further experimentation on this point, we feel unqualified to make a conclusive, definite statement on this phase of death loss control.

During the last ten days of the experiment, Lot II was transferred, as mentioned above, to the untouched peas in Field II. The lambs were not herded on a limited area, but were allowed access to the whole 13 acres for the period of time they were allowed on peas--one hour.

No death loss occurred during this 10-day period on a heavy, fresh stand of peas.

Before beginning a discussion of the experimental methods followed with regard to Lot I, it may be well to mention here that at no time were Lots II, III and IV allowed to run on peas over an hour at a time or a total of two hours per day. This was done for the reason that these lambs were to be fed a limited ration of peas, supplemented by other feeds, and to allow these supplementary feeds their beneficial effect, if any, the lambs should not be allowed to be so full of peas that but little of the supplementary feeds would be consumed. This fact was emphasized in feeding Lot IV barley in addition to peas. It was found

difficult to make this lot consume over one pound per head daily when the lambs were allowed on peas one hour, morning and evening, regardless of the fact that grain was always fed before turning the lambs on peas. Another reason that the lambs were not allowed on peas more than an hour was that apparently their appetite for peas was satisfied in that length of time, as was evidence repeatedly by the lambs coming in from the pea field at the end of approximately an hour's time and waiting around, feeding listlessly, until time to be herded into the corrals.

Lot I was allowed free access to peas at all times during the day being corraled only at night, to prevent losses by dogs or coyotes. They were allowed to run on one third of Field I until this portion was well cleaned up, when they were turned on the reamining two-thirds of the field, the 29th of November. At all times this lot received an unlimited ration of peas. No death loss from pea field disease occurred until December 22nd, after the lambs had been on feed two months, during which time good gains had been made. In fact, at this time--the end of December--many of the lambs in this lot were fat enough for the market, a statement which could not have been made with regard to any of the other four lots. The first death from peas was typical of the heavy losses experienced in Lots III and IV--sudden death with the typical post-mortem indications.

This death was followed fifteen days later by another, and ten days later by another. Four more lambs died during the last ten days of the experiment, bringing the death loss percentage in that lot up to seven during the course of the experiment. Another lamb died the day following the close of the experiment. All of these lambs showed the typical post-mortem indications of the pea-field disease, and all died suddenly. During the last eight days of the experiment potatoes was fed in order to find out whether this supplementary feed would check the death loss. Unaccustomed as they were to the potatoes, it was impossible to bring the lambs in this lot up to a heavy consumption of potatoes in this short length of time, so that the effect of potatoes in checking the loss in this lot was not given a fair trial.

Summarizing the deaths in the four pea-fed lots, we have the following table.

Lot No.	No. Lambs Death Due to P. F. D.	No. Lambs Death Due to Doubtful Cause.-No Marked Symptom	No. Lambs Death Due to Bloat	Accidental	Dogs Coyotes	Total
I	7	--			3	10
II	4	--	1			5
III	14	4		1		19
IV	17	2		1		20
Totals from each cause	(42)	(6)	(1)	(2)	(3)	(54)

% Death Loss	All Causes	10.8%
" "	Typical P. F. D.	8.4%
" "	No m'k'd Symptoms	1.3%
" "	Bloat	.02%
" "	Accidental	.04%
" "	Dogs & Coyotes	.06%

Total During Exp.	Typical P. F. D.	42
" " "	No M'k'd Symptoms	6
" " "	Bloat	1
" " "	Accidental	2
" " "	Coyotes	3

The death loss in Lots III and IV was unusually high compared with the average loss of pea-fed lambs in the Valley during the past season, which loss, we believe, was not as an average over three and one-half per cent. A few individual bands showed a loss of as high as five and six per cent, but this was considered unusually high. It is a question whether, if, in Lots III and IV, one method of management had been followed thruout the experiment, the death loss would have been less than it actually was when for the sake of experimental inquiry, a constantly changing method of management was followed. We can not justly assume that had the lambs in Lots III and IV been allowed to continue on peas a limited time each day, with the original rations, the death loss would have continued at the rate it began because it has been the experience of Valley feeders that the death loss often continues over a period of several weeks or longer, then cease altogether, or to intermittently cease and began again. Whether the heavy death losses immediately following a change

back to the original ration in Lots III and IV, was to a certain degree influenced by the sudden change of the ration, it is difficult to say with any degree of certainty. The fact is clear, however, that the death loss in both Lots III and IV can be associated with peas and that the supplementary ration of alfalfa and potatoes proved a definite means of checking the loss.

A death loss of seven per cent, as was experienced in Lot I, is not surprising nor is it so unusually high in view of the method in which this lot of lambs was fed. We believe that during the past feeding season, no feeders in the Valley made a practice of turning their lambs in the pea fields without any attempt at herding them or in some way limiting the amount of peas consumed. Therefore, no comparison from this past season can be made. In the past, however, it has been reported that losses of six and seven per cent in lambs allowed to run at will on peas were not unusual. It is an interesting fact that in Lot I the death loss did not assume serious proportions until comparatively late in the feeding period which substantiates the point brought out earlier in this paper, that often the heaviest losses occur toward the end of the feeding period.

Lot II showed a death loss percentage which would be considered over a period of years, to be slightly above the average. Whether this comparatively low death loss was

due to the effect of the addition of alfalfa hay to the ration or to the fact that a more regular method of feeding was followed in this lot we can not say.

In the light of but one year's experimental work on this problem definite conclusions from the experimental results can not be drawn. A few tentative conclusions, however, may be drawn, which follow:

(1) The feeding of field peas seems to be definitely associated with the death loss of pea-fed lambs.

(2) An unlimited ration of peas, the lambs being allowed to run at will in the field, apparently is certain of causing a more or less heavy death loss during the latter part of the feeding period.

(3) Limiting the pea ration by cutting down the length of time the lambs are allowed on peas, and feeding oat hay, or oat hay and barley when the lambs are in the corrals, apparently has no effect in controlling the death loss.

(4) Limiting the pea ration in the manner described above, and feeding alfalfa hay when the lambs are in the carrols may have some effect on controlling the death loss.

(5) Taking the lambs off peas entirely and feeding alfalfa and potatoes in addition to the original rations, then turning the lambs back on peas again apparently has no effect in controlling the loss once the lambs are back on the peas again.

(6) A supplementary ration of alfalfa and potatoes fed to lambs receiving a limited amount of peas daily, and oat hay, or oat hay and barley, apparently exerts a definite affect in controlling the death loss.

(7) A supplementary ration of potatoes alone when fed to lambs receiving a limited amount of peas daily and oat hay or oat hay and barley, apparently is not as efficient in controlling the death loss as is the combination of alfalfa and potatoes.

PART III

A STUDY OF THE POSSIBLE CAUSES of the DEATH LOSS OF PEA-FED LAMBS

A. Unbalanced Ratio of Nutrients.

Although the death loss problem has been discussed somewhat at length, generally, and from an experimental angle, we have not attempted to bring out any explanation of the specific cause of the death loss other than to mention briefly the opinions of Valley lamb feeders advanced on this point. Even though theories advanced by veterinarians and feeders appear logical, such opinions lack conclusive proof. Although the majority of persons interested in this problem concede that peas are in some way responsible for the death loss, the problem is still unsettled, for, if peas are the cause, what is it in the peas or in the pea forage that is capable of producing the death loss? If, on the other hand, peas are not the cause of the death loss, but that the mortality is due to an infectious organism, as some claim, then what is there to prove or disprove the presence of such an organism? The fact remains that as yet the specific cause, if one actually exists, of the death loss is still unknown. Be that as it may, however, we feel that a discussion of this kind is incomplete without further study on the subject of the possible explanations of the death loss. We would emphasize this point, however, before taking up this discussion, that the experimental work outlined above was undertaken with a view toward finding some practical method of controlling the death loss. The re-

sults obtained from such experimental work, would, of course, suggest possible specific causes of the death loss, and should lead to further study from the angle of the specific cause. Conversely, such a study might lead to valuable suggestions in further experimentation in controlling the death loss. It becomes evident, therefore, that the two problems are closely associated with one another.

In the discussion that follows, we have endeavored to bring out from an impartial viewpoint the main points which we believe should determine the acceptance or rejection of each of a number of theories suggested as the explanation of the death loss of pea-fed lambs. The theories which have suggested themselves as a possible explanation of the specific cause of the loss are as follows:

A. Unbalanced Ratio of Nutrients
B. Vitamin Deficiency
C. Mineral Deficiency
D. Protein Sensitization or Anaphylaxis
E. Specific Infection

Unbalanced Ratio of Nutrients

Field peas, analyses show us, are about twice as high in protein as any of the common cereal grains such as corn, barley, or oats. The following table taken from Henry

and Morrison (2) shows the comparative amounts of digestible nutrients in field peas, corn, barley, and oats.

Digestible Nutrients in 100 Lbs.

	Dry Matter lbs.	Crude Protein lbs.	Carbo-hydrates lbs.	Fat lbs.	Total lbs.	N.R.
Field Peas	90.8	19.0	55.8	o.6	76.2	1:3.0
Corn	88.0	7.4	66.6	4.5	84.2	1:10.4
Barley	90.7	9.0	66.8	1.6	79.4	1:7.8
Oats	90.8	9.7	52.1	3.8	77.5	1:6.3

The above table shows us that we have in the seed of the field pea a feed very high in protein and comparatively low in fat, with a nutritive ratio very much narrower than that of the common cereal grains. We cannot assume, however, that lambs turned into the pea fields and allowed an unlimited amount of peas consume peas alone. It has been our observation, as has been mentioned above, that lambs consume a considerable amount of dry roughage in the fields, chiefly the finer stems of the pea vines. The amount of digestible nutrients in the pea vines, therefore, becomes a factor to be considered. Henry and Morrison (2) give the analysis of field pea hay as follows:

Digestible Nutrients in 100 Lbs.

	D.M. lbs.	Cr. Pr. lbs.	C.-H. lbs.	Fat lbs.	T.D.N. lbs.	N.R.
Field Pea Hay	90.6	7.7	47.0	0.9	56.7	1:6.4

We realize that an analysis of pea hay can not

be considered comparable, exactly, with an analysis of the dried stems and vines as found in the field and eaten by the lambs. The carbohydrate content of the dried vines doubtless would be slightly higher and the protein content lower than in field pea hay, but the vines might never-the-less be classed as a protein roughage. It is at best somewhat an uncertainty to assume that the vines consist of the largest part of the roughage consumed, since a certain amount of sunflower heads and fine stems are eaten together with various weeds and the straw from volunteer oats and other grains. Never-the-less, it seems certain that lambs allowed an unlimited, unsupplemented ration of peas are compelled to consume a ration higher in protein than lambs fed a variety of feeds.

The Morrison Feeding Standard for fattening lambs provides for a nutritive ratio of 1:6 to 1:6.7 at the beginning of the feeding period. With an increase in weight, the standard allows for a wider ratio, 1:6.7 to 1;7.2 at 70 to 90 lbs. live weight, and 1:7.0 to 1:8.0 at 90-110 lbs. live weight. Thus we see that lambs fed an unlimited, unsupplemented ration of peas are forced to a greater protein intake than is considered by authorities necessary for fattening. While it is difficult to accurately determine the amount of peas and roughage eaten under such conditions, we may assume that lambs fed in this manner eat on the average 1.25 lbs. peas and 1.0 lb. of roughage per head per day. Admitting the lack of accurate data on the amount of these feeds consumed, and the exact analysis of the pea vines, we never-the-less believe that the following

data is of interest in the consideration of the protein requirements of fattening lambs.

Ration	Digestible Nutrients: Dry Matter lbs.	Cr. Prot. lbs.	Carbo-hydrates lbs.	Fat lbs.	T.D.N. lbs.	N.R. of ration
peas, 1.25 lbs.	1.14	.24	.69	.008	.94	
Vines, 1.00 lbs.	.90	.08	.47	.009	.57	
Total	2.04	.32	1.16	.017	1.51	1:3.7

By reference to the requirements of the Morrison Standard, mentioned above, we see that at all times during the feeding period, lambs fed an unlimited, unsupplemented ration of peas are receiving approximately one third again as much protein as the Morrison Standard considers necessary. The total digestible nutrients in such a ration, however, is comparable with the requirements of the standard for the first part of the feeding period, while the total dry matter is a little low. We may come to the conclusion, therefore, that an unlimited, unsupplemented ration of field peas is unbalanced, that is, it contains a greater amount and proportion of protein than is necessary for fattening lambs.

Lambs fed a limited amount of peas, that is, allowed on peas but a short length of time each day, and receiving no supplementary feed such as oat hay or alfalfa hay, we believe, as we have pointed out previously, eat almost as much peas during the length of time they are allowed on peas as do lambs allowed free access to peas in the field. This fact, to-

gether with the fact that lambs eat less roughage in the field when fed in this manner than when allowed to run at will, would seem to indicate that a limited, unsupplemented ration of peas has also the same disadvantage, that is, it is too high in the amount and proportion of protein.

With a view toward supplying more roughage to the lambs allowed a limited amount of peas, Valley feeders have fed straw and alfalfa hay to the lambs while corraled. This was likewise the object in feeding alfalfa hay and oat hay to Lots II and III respectively. It may be of interest to show here what effect the addition of alfalfa or oat hay has upon the balance of nutrients.

Comparative Analyses, Alfalfa and Oat Hay

DIGESTIBLE NUTRIENTS IN 100 LBS.

	Total Dry Matter	Crude Protein	Carbo-hydrates	Fat	Total Digestible Nutrients	Nutritive Ratio
	lbs.	lbs.	lbs.	lbs.	lbs.	
Oat Hay	88.0	4.5	38.1	1.7	46.4	1:9.3
Alfalfa	92.1	10.3	39.6	0.6	51.4	1:4.0

By referring to the table on the analysis of field pea hay, we see that alfalfa hay supplies more protein than does the field pea hay, thus having a tendency, when added to a ration of peas, to widen the nutritive ratio very little. Below is a table showing approximately the amount of the various nutrients consumed per head per day when alfalfa is added to a limited ration of peas. We must admit again that the

amount of peas consumed here is at best an approximation, but the amount of hay consumed in the experimental feeding trials is a fair representation of the amount that would ordinarily be fed in the Valley under the same conditions of management.

Lot II Peas, limited amount, 2 hours daily, plus alfalfa hay, full-fed when lambs in corral.

Digestible Nutrients

Av. Daily feed per head.	T. D.M. lbs.	Cr. Prot. lbs.	C-H. lbs.	Fat lbs.	T. D. N. lbs.	N.R.
peas. 1 lb.	.91	.19	.56	.006	.76	
alfalfa 1.84 lb.	1.69	.19	.73	.012	.94	
Total	2.60	.38	1.29	.018	1.70	1:3.5

Referring to the Morrison Standard again, it will be seen that a ration of peas, fed in limited amount, plus alfalfa, is, in reality, slightly narrower than an unlimited ration of peas, unsupplemented other than by what roughage is picked up in the pea field, although the total carbohydrate and total digestible nutrient contents of such a ration are somewhat higher. A ration such as alfalfa and peas, fed in the manner the experimental Lot II was fed, undoubtedly supplied more roughage, since the lambs had access to hay at all times when in the corral, but as has been pointed out, this greater amount of available roughage did not widen the nutritive ratio, since the hay itself was high in protein. This ration, with the exception of being unnecessarily high in protein,

is comparable with the requirements of the Morrison Standard in total dry matter and in total digestible nutrients, being better in these two items than is the Lot I ration.

With the oat hay as a roughage in addition to a limited quantity of peas, as was fed to the lambs in Lot III, we have a carbonaceous roughage supplementing the peas. Disregarding for the present the supplementary feeds of alfalfa and potatoes fed to this lot later in the feeding period, we have a ration as follows.

Lot III Ration: Peas, limited quantity, 2 hours daily. Oat hay fed while lambs corralled.

Digestible Nutrients

Average Daily Feed per Lamb	Total Dry Matter	Crude Protein	Carbohydrates	Fat	Total Digestible Nutrients	Nutritive Ratio
	lbs.	lbs.	lbs.	lbs.	lbs.	
Peas. 1 lb.	.91	.19	.56	.006	.76	
Oat Hay, 1.19 lb.	1.04	.054	.45	.020	.55	
Total	1.95	.244	1.01	.026	1.31	1:4.4

We notice that the ration of peas and oat hay comes the nearest of any thus far discussed to the requirements of the Morrison Standard, both as to the amount and as to the proportion of the various nutrients. The nutritive ratio of this ration is considerably wider than those previously discussed. Yet, as reference to to the charts, Plates I

and II, will show, this lot had, together with Lot IV, the highest death loss among the experimental lots. The possible relationship between the death loss and the characteristics of the different rations fed will be discussed later, however.

Turning now to an example of lambs fed a limited amount of peas plus a carbonaceous roughage plus a cereal grain, as was the case with Lot IV, we have the following amounts and proportion of the various nutrients.

Lot IV Ration: Peas, limited, 2 hours daily.
Oat hay fed when lambs were in the corral.
Barley fed twice daily.

Digestible Nutrients.

Average Daily Feed per Lamb	Total Dry Matter lbs.	Crude Protein lbs.	Carbo-hydrates lbs.	Fat lbs.	Total Digestible Nutrients lbs.	Nutritive Ratio
Peas, .75 lb.	.68	.14	.42	.005	.57	
Barley, .71 lb.	.64	.064	.47	.011	.56	
Oat Hay, 1.05lb.	.92	.047	.40	.018	.49	
Total	2.24	.251	1.29	.034	1.62	1:5.5

The ration fed to Lot Iv is, according to the Morrison Standard, a more nearly balanced ration than any of the rations previously considered. The effect of adding barley is to widen the nutritive ratio. The amount of protein, however, is, according to the Morrison Standard,

still a little high.

Since the rations discussed above are very nearly representative of the rations fed in the Valley, we may safely draw a few general conclusions regarding such rations from the angle of lack of balance of nutrients.

(1) A ration composed of peas alone, supplemented only by what roughage is picked up in the pea field, is unnecessarily high in the proportion and amount of protein, the nutritive ratio of such a ration being very narrow.

(2) Limiting the time that the lambs are on peas and feeding no supplementary feed while the lambs are in the corrals is a practice which only tends to reduce the amount of peas eaten, and in no way counteracts the effect of the high protein of the peas.

(3) Feeding alfalfa hay supplies more bulk to the ration, and may contribute toward reducing the loss, but inso-far as balancing the ration from a protein standpoint is concerned, it has little value.

(4) The addition of barley or a similar low protein grain such as corn or oats, widens the nutritive ratio to a point comparable with feeding standard requirements, and provides, as far as nutrients are concerned, the best balanced ration of those most commonly fed in the Valley.

From the viewpoint of the balance of nutrients, it is interesting to note the effect of the addition of the supplementary feeds, alfalfa and potatoes, to a ration of peas in limited quantity plus oat hay and oat hay and barley respectively, as fed to Lots III and IV.

Digestible Nutrients

Lot III.

Av. Daily Ration		Total Dry Matter	Crude Protein	Carbo-hydrates	Fat	Total Digestible Nutrients	Nutritive Ratio
Peas	.8#	.73	.15	.45	.005	.61	
Oat Hay	1.19#	1.04	.054	.45	.020	.55	
Alfalfa	1.68#	1.55	.17	.67	.011	.86	
Potatoes	.6 #	.13	.007	.09	.0007	.10	
Total		3.45	.381	1.66	.0367	2.12	1:4.6

Digestible Nutrients

Lot IV.

Av. Daily Ration		Total Dry Matter	Crude Protein	Carbo-hydrates	Fat	Total Digestible Nutrients	Nutritive Ratio
Peas	.6 #	.54	.11	.33	.004	.46	
Oat Hay	1.05#	.92	.047	.40	.018	.49	
Alfalfa	1.41#	1.30	.15	.56	.0092	.72	
Barley	.71#	.64	.064	.47	.011	.56	
Potatoes	.6 #	.13	.007	.09	.0007	.10	
Total		3.53	.378	1.85	.0429	2.33	1:5.2

It is evident from what the above tables show, that the addition of alfalfa and potatoes to the rations of peas and oat hay, and of peas, oat hay, and barley did not widen the ration perceptibly. Of course, the total nutrients were increased to a point above the total amount required in the Morrison Standard, but the proportion of protein was also increased due to the addition of alfalfa hay to the ration. It becomes evident, therefore, that the balance of nutrients alone was not the factor that determined the value of this

combination of feeds as a check against the death loss. There are other factors, however, which perhaps might have the effect of checking the loss either singly or acting in combination, such as the succulence of such a ration as provided by the addition of potatoes, and the greater variety of feeds. The matter of succulence appeals to us as one factor that may have some effect in checking the loss, since the experience of feeders and the work of experiment stations has shown that the addition of succulent feeds to fattening rations has had the effect of increasing the palatability of the ration and tends to keep the animals on feed and in better thrift. We also recognize the value of a variety of feeds such as the rations in Lots III and IV show upon addition of alfalfa and potatoes. The theory, that the combination of succulence and greater variety in the ration may be of value in checking the death loss appears to us a logical one from the standpoint of a balanced ration and of the general requirements of a good ration.

Recent investigations have shown that simply because a ration provides what is considered to be an optimum amount of the three nutrients, protein, carbohydrate, and fat for the purpose the animal is being fed, it may never the less be inadequate with respect to several factors which have been found to have a definite place in the adequate and complete nutrition of animals. These factors are in brief, (1) the quality of the proteins fed, (2) the mineral content of the ration, and (3) the vitamin content. Following a discussion of the quality

of proteins, the last two factors will be taken up in more detail.

A discussion of the question of balance of nutrients as a possible specific cause of the death loss is incomplete without brief mention of a comparatively new angle of animal nutrition, that of the quality of proteins in a ration, and its bearing upon the death loss problem from the aspect of balance of nutrients. As has been stated, a ration may be adequate in every way from the standpoint of the proportion and amount of each of the various nutrients, yet the protein of such a ration may be quite inadequate. It was once believed that all proteins were of equal nutritional or dietary value, and, having supplied the necessary amount of protein, properly supplemented with carbohydrates and fats, the ration or diet was complete and would produce the optimum result. In the light of comparatively recent investigations, however, it has been found that certain proteins are incomplete - that is, they do not, upon being broken down chemically, yield all of the animo acids, (the end products of protein digestion used by the body to build up its own proteins) necessary for complete nitrogen metabolism. Gelatin is the foremost example of an incomplete protein. It shows a complete lack of the amino acids, tyrosin, trytophan and cystin. In experiments with gelatin, Orum and Munk (3) found that part of the protein required in a ration could be substituted by gelatin, but when it formed the sole source of nitrogen, there was always a deficit. Many experiments have since been conducted with

other proteins from other sources, notably by Osborne and Mendel, (3) to show the effect of rations of purified proteins from various sources, supplemented by carbohydrates and fats. The results of these experiments, as well as of those by other investigators, as McCollum (3) points out, are of questionable value because of the use, in such experimental rations, of protein-free milk, which contains enough residual nitrogen to supplement certain of the incomplete proteins.

While experimental inquiry into the subject of the nutritive value of proteins is still imperfect, certain facts have been brought out that apparently are conclusive. The work of McCollum and Davis (3) with regard to the dietary deficiencies of cereal grains brings out this conclusion - that all the amino acids necessary for the nutrition of an animal are contained in the proteins found in the seeds of wheat, corn, oats, rice, peas, beans, flax, millet and kaffir corn. Certain of these proteins, however, are found in such limited amounts that the extent to which the remaining and more abundant proteins may be utilized is restricted. It is for this reason, McCollum (3) states, that these proteins are of low biological value unless supplemented by proteins from other sources which make up for their deficiencies. Thus we see that a ration may be balanced with respect to the amount of the three nutrients, protein, carbohydrate, and fat, yet in reality may show an actual lack of balance upon looking into the quality of the proteins supplied.

McCollum's (3) experimental work on this phase of nutrition establishes the fact that the nutritive value of proteins is determined by their yields of the amino acids which are formed in digestion. The more nearly the proportions of amino acids found in the proteins used as food correspond to the content of the amino acids in the body tissues, the more effectively can the food protein be transformed into body proteins. Here we have another ideal toward which to work in making up rations for farm animals.

Having briefly discussed this phase of protein nutrition from its most significant general aspects, it may be of interest to speak of its bearing upon the rations fed to the experimental lots. While it is difficult to find much information of any significant bearing upon this subject, since experiments with regard to the quality of proteins have been confined to laboratory animals, it is never the less of interest to note what investigators have done along this line. It is the opinion of McCollum (3), as a result of the work carried on by him and his associates with rats, that (1) cereal grains enhance each other's proteins better in all cases than do combinations of proteins of two legume seeds, such as the pea and bean, (2) neither of the above combinations are as equal in quality of their proteins as certain combinations of a legume seed with a cereal in which the cereal furnishes two thirds and the legume seed one third of the total protein diet. Of the cereals best suited to complete the proteins supplied in peas,

wheat is superior to corn. The chief protein in corn, zein, is incomplete being deficient in lysin and tryptophan, both important amino acids.

In the same series of experiments from which McCollum drew the above conclusions, he found that the combination of the proteins from barley and a legume seed were not as good in the results obtained as those from feeding a combination of wheat and peas. These observations were made upon the growth, fertility and infant mortality of rats. Whether we can safely establish any correlation between such results and the problem of the inadequacy of proteins as a possible factor in causing the death loss of lambs, we rather doubt, since in the first place, the class of animal is very different, and secondly, the experimental observations were made with entirely different ends in view.

The general conclusions regarding the value of certain combinations of grains and legume seeds in supplementing each other from the standpoint of the quality of their proteins may be of some significance, if such conclusions can safely be applied to the nutrition of farm animals. These conclusions appear to bring this fact out - that a ration of peas alone not only supplies an excess amount of protein, but also supplies an inadequate balance in quality of protein. To make up for the deficiency in protein quality, a cereal grain, preferably wheat, appears to have the greatest value, with barley a second choice. Thus we have in the combination of peas plus a cereal grain a

ration that not only is better balanced from the standpoint of the quality the proteins, but is also better balanced with respect to the amount and proportion of the protein.

Summarizing our discussion of a lack of balance of nutrients as a possible cause of the death loss, we may say that:-

1. There is, to our knowledge, not conclusive evidence to show that a lack of balance of nutrients or the inadequacy in the quality of the proteins of a ration may produce as acute symptons in farm animals as the death of lambs.

2. An unbalanced ration however, and one inadequate in the quality of its proteins, has shown, from the experience of stockmen, more or less unsatisfactory results with growing stock and to a lesser degree, with fattening stock. This fact may be a contributing factor toward the death loss, even though an unbalanced ration, both as to quantity and quality of its proteins, may not be the sole factor in the explanation of the death loss.

B. Vitamin Deficiency

Of the more recent angles of human and animal nutrition to be studied, that of the vitamines has attracted wide interest and has provoked a large amount of research and investigation. Vitamines, or accessory food substances, are, according to Smith (4), chemical substances contained in various fresh foods in extremely minute proportions. Their chemical nature is not known. The function of vitamines appears to be to direct metabolism, but in what way this is accomplished is not clearly known. Vitamines have been found to be absolutely essential to the diet of man. Their importance however, in the diet of farm animals has, as yet, not definitely been proved. Without the vitamins in the diet, man and laboratory animals have been found to be subject to certain diseases known as dietary deficiency diseases.

The vitamins thus far definitely isolated are:

1. Fat soluble A, or vitamin A
2. Water soluble B, or vitamin B
3. Water soluble C, or vitamin C

A fourth, vitamin D, some authorities claim to have isolated, but this is as yet uncertain.

Fat soluble A or vitamin A is contained in greatest abundance in certain green leaves, such as alfalfa, clover, and spinach, and also in yellow corn, carrots, and in yellow sweet potatoes. Most seeds of plants, tubers, and fleshy roots are deficient in this vitamin, with certain exceptions such as those mentioned above. Vitamin A has been proved to be intimately

associated with yellow pigmentation (3). Leaves containing much yellow pigment, even the latter is masked by green pigment, are richer in this vitamin than leaves containing little yellow pigment. However, it has been definitely proven that carotin and xanthophyl, yellow pigments in plants, are not identical with vitamin A (3). Results of work by Drummond and his associates (3) have shown that there is no relation between vitamin content and color.

As regards the relation of this vitamin to the dietary deficiency diseases, McCollum and Durmmonds (3) have proved that xeropthalmia of man and experimental animals is a deficiency disease in the same sense as beri-beri, and is due specifically to a lack of the fat soluble vitamin. Vitamin A has also been associated with the prevention of rickets, Mellanby (3) believing that this vitamin is a specific anti-scorbutic substance, altho other investigators, notably Hess and Unger (3), hold the belief that rickets is not due to a dietary deficiency but to hygienic factors especially sunlight. McCollum (3) is of the opinion that rickets is not a deficiency disease in the same sense as are beri-beri, scurvy, and xeropthalmia of dietary origin, but it is to be associated with a phosphorus and calcium deficiency in the diet, and with an organic anti-rachitic substance found to a marked degree in cod-liver oil, and to a lesser and more doubtful extent in butter-fat. This author tentatively suggests that the organic anti-rachitic factor is distinct from fat soluble A. This anti-rachitic factor is the vitamin D referred to above.

Water soluble B, or vitamin B, is found in all natural food-stuffs, but its principle source is the seeds of plants and the yolk of eggs. In the cereal grains this vitamin is contained in the endosperm and in the germ, the vitamin being lost when these portions of the seed are removed in milling. Yeast is also a source of vitamin B. The dietary deficiency disease of man, beri-beri, and its homologue in experimental animals, poly neuritis, is caused by a lack of this vitamin in the ration. These deficiency diseases have been cured by including in the diet, food-stuffs rich in vitamin B, such as extract of rice polishings or the use of un-milled cereals.

Water soluble C is contained in all fresh vegetables, particularly in cabbage, tomatoes, lettuce, carrots, potatoes and turnips. This vitamin is destroyed by heat or drying and is therefore absent in all dried vegetables subject to high temperatures. Tomatoes appear to retain their anti-scorbutic properties after being cooked. A lack or deficiency of this vitamin in the diet of man or of experimental animals produces a condition known as scurvy.

With this brief introduction it may be well to consider the relationships of vitamins to the problem of the death loss of pea-fed lambs. As was brought out earlier in this paper, it is our aim to discuss each of the suggested causes of the death loss from an impartial viewpoint, bringing out as much

evidence as possible that has any important bearing upon the subject. A consideration of the relation of vitamins to the problem of death loss of pea fed lambs seems to suggest the possibility of a discussion of the subject from two angles:-

1. Vitamin deficiency and its relation to the rations fed to pea fed lambs.

2. The correlation between the deficiency diseases and the typical death losses in pea fed lambs or pea field disease.

From the table on the next page, we notice that of the rations fed to the experimental lambs, none were totaly deficient in the fat soluble vitamin, except, possibly, the ration of peas unsupplemented. Peas, as it will be seen in the table have an uncertain amount of the fat soluble vitamin, some investigations showing its prewence and others vice-versa. When a ration of peas, however, is supplemented with alfalfa hay, well cured, bright, and green, as was the hay fed to the experimental lots, the latter supplies an abundance of this vitamin, making up for any deficiency of fat soluble A in the peas. Barley and oat hay do not contain this vitamin and are therefore of no value in making up for deficiency of this vitamin in peas. Potatoes also have an uncertain value as a source of vitamin A.

With respect to the anti-neuritic vitamin, or water soluble B, it is plainly seen that all the rations fed were amply supplied with this accessory food substance. Potatoes, according to the table given in Henry and Monison (2), are a good source of this vitamin, but McCollum gives potatoes a negative

Amounts of the Various Vitamins in Rations Fed to Experimental Lambs, Monte Vista, 1923-24

Data obtained from (McCollum's "Newer Knowledge of Nutrition" and "Feeds & Feeding" by Henry & Morrison

Lot	Rations Fed	Fat soluble A or Vitamin A	Water soluble A or Vitamin B	Water soluble C or Vitamin C	Water soluble D or Vitamin D
I.	Peas	- to ~~+~~	~~++~~	-	?
II.	Peas	- to ~~++~~	~~++~~	-	?
	Alfalfa	~~+++~~	~~++~~	-	?
(Original ration	(Peas	- to ~~++~~	~~++~~	-	?
	(Oat hay	-	?	-	?
(III. Supplementary ration	(Alfalfa	~~+++~~	~~++~~	-	?
	(Potatoes	- to ~~+~~	~~++~~ (?)	~~++~~	?
(Original ration	(peas	- to ~~++~~	~~++~~	-	?
	(Oat hay	-	?	-	?
	(Barley	-	~~++~~	-	?
(IV. Supplementary ration	(Alfalfa	~~+++~~	~~++~~	-	?
	(Potatoes	- to ~~+~~	~~++~~ (?)	~~++~~	?

Note:- The number of plus signs indicates the relative quantity of the various vitamins in the feeds. "?" indicates that there is no data available or that the quantity of vitamin is doubtful.

value as a preventive of beri-beri. The addition of barley, oat hay, alfalfa and potatoes would apparently be of no particular value in supplementing a ration of peas other then to add somewhat to the total amount of the vitamin B present, since peas alone are considered a good source of the vitamin.

It is in the anti-scorbutic vitamin that we find the most interesting relationship. Upon reference to the table, we find that none of the rations contain food stuffs that are sources of vitamin C except those rations in which potatoes were used as a supplement. Potatoes are considered a good source of vitamin C and are of relatively high value as a preventive of scurvy. The most significant fact, however, is that in the rations where the anti-scorbutic vitamin was supplied the death loss was effectively checked. The inference, however, is not that the death loss previous to the addition of potatoes to the ration was due to a lack of vitamin C in the ration, nor that the anti-scorbutic vitamin was the sole factor in checking the death loss when it was supplied in the form of a supplementary ration of potatoes. The possibility exists that the water-soluble C vitamin may be the deciding factor in controlling the death loss, but this must be proved or disproven by further investigation on this subject. We must not overlook also the possibility that the presence of vitamin C may play a partial role in checking the loss in combination with the benefit derived from the succulence and variety afforded in feeding the supplementary ration of alfalfa and potatoes.

Apparently no correlation can be established between the dietary deficiency diseases xerophthalmia and poly neuritis, due to deficiencies of vitamins A and B respectively, and the typical pea feed disease of lambs, because in the first place, there exists in the pea ration, unsupplemented as well as supplemented, enough of these vitamins to prevent such diseases, with the possible exception of a ration of peas alone, were lambs susceptible to them, and, secondly, these two dietary deficiency diseases are in no way similar to the so called pea field disease. Furthermore, we have no evidence to show that xeropthalmia or poly neuritis affect sheep. The Rowett Research Institute (5) of Aberdeen, Scotland, however has reported that lambs have responded with a marked increase in growth with the addition of cod-liver oil, a substance rich in vitamin A, as well as in the anti rachitic factor, to a ration relatively poor in vitamin A. Doctor Arnold Thieler of South Africa (5) attempted to induce deficiency diseases in farm animals by feeding rations as nearly devoid of vitamin B as possible, but in no case was he able to induce symptoms that could be interpreted as being due to vitamin deficiency.

It is difficult to attempt to establish a relationship between the lack of or doubtful amount of vitamin A in the rations not supplemented by alfalfa hay, to the death loss, as being caused by rickets. There are several reasons why such a relationship must be regarded as highly skeptical. Rickets in the first place, bears no close resemblance to the pea field disease, and, secondly, indications point toward the fact that

rickets may be associated with the absence or deficiency in amount of calcium and phosphorus, and a deficiency in the ration of the so called anti-rachitic vitamin, which may or may not be the same as vitamin A. Rickets, however, will be more fully discussed under mineral deficiency and its relationship to the pea field disease.

There would appear, however, to be somewhat more ground for establishing a possible relationship between the lack of vitamin C and the death loss, the cessation of these losses when potatoes, rich in vitamin C were fed, and the similarities between animal scurvy and the typical pea field disease. Experimental scurvy as produced in guinea pigs by Cohen and Mendel (3), showed upon autopsy, congestion, hemorrhage or ulceration of the stomach and intestines, together with swollen joints and fragility of the bones. Paralysis of the animals afflicted with scurvy was often typical. The post mortem indications referred to above, together with the paralysis of the lambs are similar to the symptoms and post mortem indications of the pea field disease, viz., weakness and paralysis of the lambs internal hemorrhages, and congestion of the intestines. There are, however, some rather pronounced dissimilarities of the two diseases which tend to substantiate our belief that the pea field disease is in no way related to scurvy. In the first place, scurvy is a disease characterized by swollen and tender joints, while the animals are in good health and growing normally. This has not been observed in lambs that have died of the pea field disease. The advanced symptoms of scurvy in guinea pigs, rats being

immune to this disease, we have mentioned, differ from the pea field disease in that they apparently are of purely a digestive and skeletal nature, while those of the pea field disease vary widely from intestinal congestion, internal hemorrhages, and broken down kidney to tracheitis, pneumionia and cerebral symptoms, with apparently no indication of fragility of the bones. Diarrhea is also not characteristic of scurvy, and it is usually one of the symptoms of the pea field disease. Scurvy does not show the acute symptoms as soon as the pea field disease, the latter often, as mentioned above, being characterized by a very sudden appearance of sickness followed shortly by death. These differences appear to indicate that the two diseases are different, even though certain similarities exist. Furthermore, we have been unable to find any literature describing a disease of sheep analogous to scurvy,

From the meagre information available regarding the vitamin requirements of farm animals it appears that their requirements are very low and that the dietary deficiency diseases common to experimental animals such as rats and guinea pigs and to man, if they exist in farm animals, are not of such serious a nature as to cause appreciable economic loss. We realize, however, that further investigation into the subject of vitamins may reveal contrary results.

Summarizing the discussion on the relationship of vitamin deficiency to the death loss of pea fed lambs, we would bring out the following points:-

1. That the common rations fed to pea fattened lambs in the Valley are:

a. Deficient in vitamin C unless supplemented by a succulent feed such as potatoes.

b. Deficient in vitamin A unless supplemented by a bright, green colored hay such as alfalfa.

c. Sufficiently rich in vitamin B that no supplementary feeds rich in this vitamin are necessary.

2. That vitamin C may be a determining factor in the control of the death loss, but indications tend to show that the disease for which this vitamin is a preventive is not common to sheep nor does it bear close enough resemblance to the pea field disease to consider the two diseases similar.

3. That experiments have thus far shown farm animals to have low vitamin requirements and apparently no susceptibility to the dietary deficiency diseases against which vitamins are specific preventives.

4. That vitamin deficiency appears to have a somewhat doubtful bearing upon the specific cause of the death loss of pea fed lambs, although the deficiency of vitamin C may be a partially contributing factor toward the cause of the death loss of pea fed lambs.

C. Mineral Deficiency

In discussing the possible relationship of mineral deficiency to the specific or partial cause of the death loss of pea fed lambs in the San Luis Valley, it may be well to speak briefly of the importance and role of the mineral salts in animal nutrition. It has become a well known fact that as a rule an animal will die sooner from mineral starvation than from food starvation (4). Just why this should be is not definitely known, but Forbes (6) suggests that the mineral components of the body directs its various vital processes in some mysterious manner, possible by carrying electric charges which stimulate the body cells. To quote Smith (4) "The salts of the body direct its metabolism; they are connected with assimilation, secretion, excretion and the building up of the skeleton; moreover, they maintain the body fluids at their normal reactions -- i.e. the blood and lymph at neutrality, the saliva alkaline, the gastric juice, acid, the intentinal fluide alkaline, and the urine acid or alkaline depending upon the species of animal." It is one of the functions of the kidney to protect the animal against an unbalanced mineral content in the blood by promptly excreting any excess of the various salts which may be present. When the food, however, furnishes the blood with an unbalanced salt mixture, the kidneys may not be able

to keep the blood composition normal with the resultant injury to the animal (2). Certain minerals, for example, may be antagonistic in their action in the animal body. In voiding an excess of magnesium the body loses calcium to such an extent that there may actually be a deficiency. Such diseases as "millers horse rickets" or "bran disease" have been attributed to the feeding of feeds containing a high proportion of magnesium to calcium, such as wheat bran and wheat middlings.

The mineral or ash requirements of animals are quite largely determined by the rate at which the various mineral constituents are excreted from the body. This statement also may be applied to growing animals which use mineral matter to build up the skeleton as well as for the body functions mentioned above. There are several factors which enter into the loss of ash from the body; viz.:

(1) As mentioned above, the body may in an effort to maintain the osmotic pressure by removing a surplus of one mineral salt impoverish itself with respect to another salt, thereby creating a need for increased supply of the constituent in the feed.

(2) Excess body acids may be disposed of by combination with fixed bases of the carbonates and phosphates present in the blood. The neutralization of acids produced

in the body does not involve the excretion of any equivalent amount of a base, as the acid urine of some species shows.(6). In such cases, according to Armsby (6) the kidneys are able to separate more or less of the phosphoric acid from the bases of the blood, excreting it as acid phosphate in the urine and retaining a corresponding amount of the bases in the blood.

(4) The larger part of the ash of the animal body is contained in the skeleton, which serves as a reserve to be drawn upon to supply the blood with the mineral constituents necessary. This reserve may be drawn upon to such an extent through feeding over long periods of time feeds deficient in calcium that the skeleton becomes weakened by the constant drain of this element upon it.

The ask requirements for maintenance, it will thus be seen, depend on two factors: (6)

(1) The amounts of the various mineral substances which are thrown into the circulation above the body's needs and therefore removed by the excretory organs.

(2) The nature of the feed consumed with respect particularly to the relative proportions of its ash elements.

Some common feeding stuffs are relatively low in total ash, as well as especially deficient in certain mineral elements. Corn, for example, according to Henry and Morrison (2), is particularly low in total ash, the per-

centage composition of this feed showing but 1.5% ash. The legume roughages, on the other hand, are especially valuable as sources of mineral constituents, the average of all analyses of alfalfa showing an ash content of 8.6%.

The following table serves to show the wide variance in mineral content of some of the commonly used feeding stuffs.

MINERAL COMPOSITION OF SOME COMMON FEEDS

(From Henry & Morrison)

Feed	Mineral Matter in 1000 lbs.									
	Potash K_2O	Soda Na_2O	Lime CaO*	Magnesia MgO	Iron Oxide Fe_2O_3	Sulphuric Acid SO_3	Phosphoric Acid * P_2O_5	Silica SO_2	Chlorin Cl	Total
	lb.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Corn	4.0	0.4	0.2	1.8	0.11	3.8	6.9	0.3	0.65	18.16
Oats	5.6	2.3	1.4	2.0	0.38	4.9	8.1	12.5	0.70	37.88
Cottonseed Meal	18.1	3.5	3.6	8.6	0.84	12.4	26.7	5.5	0.39	79.63
Corn Stover	12.9	6.5	6.6	1.4	0.71	4.3	4.5	9.1	2.87	48.88
Wheat Straw	7.4	3.0	2.9	1.0	0.26	3.8	1.3	28.4	1.98	50.04
Alfalfa Hay	22.3	5.6	19.5	5.9	1.68	7.8	5.4	8.1	4.74	81.02

From a study of the above table, the marked difference in ash content of some of the common feeding stuffs will be apparent. There are, however, several considerations which affect the value of various feeds as sources of mineral matter. The total mineral content of a feed is not so important as its composition

with respect to the most important mineral constituents, namely, potassium, sodium, calcium, phosphorus, and chlorin, and the relative proportion of these constituents. Another consideration we must take into account is the difference in feeds with respect to the acid or basic character of their ash constituents. Feeds containing in digestible form, much phosphorus or sulfur tend to produce in the body corresponding amounts of sulfuric and phosphoric acids which must be neutralized by the basic constituents of the body. Conversely feeds containing large proportions of bases tend to have the opposite effect.

Feeds differ widely as regards their suitability for ash maintenance. The concentrates, generally speaking, are relatively high in phosphorus and sulfur, low in calcium, and moderately rich in potassium. Roughages, on the other hand, especially the legume hays, are rich in calcium and alkalies, and low in sulfur and phosphorus. The relation of acid to basic elements has, as the above discussion would indicate, an important bearing upon the suitability of a feed for ash maintenance but, as Armsby (6) points out, the assumption that all excess of acid over basic elements in the diet should be avoided seems unwarranted in view of the fact that the body, by means of ammonia, is able to neutralize excess amounts of acid and by means of the kidneys to separate the acids from the bases, thereby preventing an

abnormal condition of the body fluids and tissues. It is only when the excess is so large, Armsby (6) continues, as to exceed the capacity of these regulative arrangements, and therefore begins to draw on the fixed bases of the body such as the skeleton, that an excess of acid becomes a source of danger.

Although the question the ash balance in animal nutrition may still be regarded as somewhat indefinitely solved, due to the lack of experimental evidence, what experiments that have been performed tend to show that with herbivora, rations composed of a large proportion of legume roughage there need be no fear of ash deficiency when such roughages are produced on land not deficient in lime and phosphorus. Hart Steenback, and Humphrey (6) have clearly shown the beneficial effects of leguminous roughages from the standpoint of mineral content, when cows fed alfalfa or clover hay produced strong, vigorous calves as against weak or dead calves when cows were fed oat or wheat straw, with grain and grain by-products to maintain a balanced ration according to feeding standards. With brood sows the same investigators (7) found that the addition of from 15 to 25 per cent of alfalfa hay to a ration of grain and common salt, produced normal, live litters, whereas sows allowed nothing but grain and salt farrowed a high percentage of weak and dead pigs. The above brief discussion should

be sufficient to bring out the important part that the inorganic constituents of feeds play in animal nutrition.

The points brought out in the above discussion would suggest a discussion of the relationship of mineral deficiency to the death loss problem from the following viewpoints:

(1) Do rations fed in the San Luis Valley to fattening lambs supply a sufficient amount and the right proportion of the various mineral constituents to satisfy the ash requirements of fattening lambs.

(2) If such rations show a deficiency in mineral content, can the pea-field disease be associated, through its similarity in symptoms and post-mortem indications, with a mineral deficiency disease?

The first question stated above implies that the mineral requirements of fattening lambs have been determined, and that the question may be answered specifically in terms of such requirements. Although the specific amount of each mineral constituent and their relative proportion necessary for farm animals is still an open question, enough experimental work has been done to show the detrimental results of deficiencies of certain minerals, especially calcium, phosphorus, sodium and chlorin.

Some work has been done on the mineral requirements of sheep, (7) the results obtained do not throw much light upon the actual mineral requirements of sheep, but instead

show the relative digestibility of the various mineral constituents fed at different planes of intake. Experimental results tend to show that when legumes grown on soil which is not deficient in calcium are supplied in abundance in the ration, detrimental results from a lack of calcium are usually eliminated. Yet, lacking sufficient experimental evidence to prove this point, we can not assume that an abundance of leguminous roughage in the ration is all that is necessary in order to make a ration adequate with respect to minerals. It is therefore impossible to answer at present the first question stated, in specific terms. The inquiry into the subject of the mineral requirements of fattening lambs must therefore be limited to a study of the ration from the standpoint of their ash content deficiencies in order to determine which rations of such type are considered an adequate source of minerals.

From the somewhat uncertain information that is available since a state soil survey of the San Luis Valley has not been made, we have every reason to believe that Valley soils are not markedly deficient in any of the most important mineral elements. At any rate indications are that if Valley soils are deficient in this respect, they are not enough so to result in the production of crops markedly deficient in mineral content. We may therefore consider Valley-raised crops as having the average mineral content.

It may also be said at this point that the practice of supplying salt to fattening lambs is quite general among feeders. Possible deficiencies in sodium and chlorin in the rations fed, therefore, are taken care of, and need no further discussion. The phosphorus and calcium content of the rations are of the most importance with respect to possible mineral deficiencies and will therefore receive the most emphasis in the discussion below.

Lambs allowed an unlimited, unsupplemented ration of field peas consume, as has been mentioned earlier in this paper, in addition to the seed of the pea a considerable amount of the pea vines and other roughage in the field in order to satisfy their natural need for bulk. From a mineral standpoint the seed of the pea is similar to other leguminous seeds such as the cowpea, soybean, and navy bean, which are, according to Forbes (9), a better source of calcium as well as of other basic elements than are the cereal grains. The more recent work of McCollum and his associates, (10) however, indicates that peas are deficient in calcium, sodium, and chlorin. When a ration of 45 percent peas was adequate with respect to all factors except minerals, the addition of calcium, sodium and chlorin, was all that was needed to make the ration complete and adequate for all the needs of the animal (the rat). Whether fattening lambs are as dependent upon the supply of these constituents for normal development as are rats, it is difficult to say. If

lambs allowed to run on peas ate the seed of the pea only, with no roughage, there might be reason to suspect a mineral deficiency factor in the death loss, but the leguminous roughage that the lambs eat while in the fields should make up for the deficiency in calcium. There would be a tendency, therefore, for lambs allowed unlimited access to peas in the field to balance their own ration with respect to minerals. With lambs allowed a limited amount of peas daily, and fed no roughage while confined to the corrals, there is a tendency to eat less of the pea vines during the short time the lambs are in the field, therefore allowing for a possible deficiency in calcium. We may draw the conclusion from the points brought out above that lacking information regarding the specific mineral requirements of fattening lambs, the practice of allowing the lambs free access to peas at all times, is not in the light of present knowledge, conducive toward mineral inadequacy. A limited amount of peas daily with no additional roughage fed would appear to possibly have a deficiency in calcium.

When peas are supplemented by a liberal quantity of a good quality of alfalfa hay, such as was fed to Lot II, we have even more reason to assume that the ration is adequate with respect to mineral content, although experimental results may be obtained which may disprove this assumption. Oat hay, on the other hand, would appear to be open to some criticism from a mineral standpoint as a supplementary roughage

for pea fed lambs. Oat hay according to Fraps (8) is considerably inferior to alfalfa hay as a source of lime, magnesia, and potassium, as the following comparative figures show:

	Silica	Lime	Magnesia	P_2O_5	Potash
	pct.	pct.	pct.	pct.	pct.
Alfalfa, Average 4 analyses	1.02	1.65	.42	.51	2.61
Oat Hay, 1 analysis	6.68	.42	.28	.41	1.60

The limited pea ration would appear to be improved from a mineral standpoint by the addition of a leguminous roughage such as alfalfa hay, but the addition of oat hay would appear to have doubtful value in this respect.

From a mineral standpoint, the addition of barley to a ration of peas, limited amount, and oat hay adds appreciably to the phosphorus content of the ration, but does not correct the calcium deficiency. Although we have been unable to find data showing the mineral composition of barley, it may be considered very similar to corn and the other commonly used carbonaceous concentrates. Lambs fed barley, oat hay, and peas would perhaps be benefitted by the addition of alfalfa hay from the standpoint of the addition of calcium to the ration.

We have above, in each case, suggested the use of

alfalfa hay as a supplementary roughage where there is a possibility that a calcium deficiency exists. Realizing, however, that this suggestion assumes that alfalfa possesses a sufficient amount of this mineral to correct any deficiency in the pea field ration, we would suggest that a phosphorus and calcium mineral mixture might possibly be of value in the pea ration. Very little experimental work with supplementary mineral mixtures for sheep, none to our knowledge, having been done with fattening lambs. Bray of the Colorado Station has been experimenting with minerals for pregnant ewes, but as yet has arrived at no conclusions regarding their value. Whether a mineral mixture would be of value for pea-fed lambs depends on the following factors:

(1) The actual mineral requirements of fattening lambs-whether the mineral requirements of fattening lambs actually demand an additional source of ash above what is supplied in the feed.

(2) The proven value of alfalfa or other good legume hay as a source of calcium.

These factors are as yet indetermined, so no conclusions can be drawn with regard to the value of a mineral mixture with pea-fed lambs.

In conclusion we may say that rations fed to pea fed lambs in the San Luis Valley may be deficient in minerals if (2) the lambs are allowed no time to consume a liberal quantity of the pea-forage when turned into the fields a limited time daily, and (3) if the lambs when

fed in such a manner are not supplied with a mineral-rich roughage such as alfalfa hay. Otherwise, with plenty of alfalfa hay, or with free access to peas at all times and consequent greater consumption of the pea vines, it would appear that the mineral factor is adequate for fattening lambs.

In attempting to associate the pea-field disease with a mineral deficiency disease, we are forced to make the somewhat unwarranted assumption that certain rations fed to lambs in the Valley are deficient in minerals, particularly calcium. The fact that it is not a certainty that some of the rations fed to lambs are inadequate with respect to their mineral content, must needs make the following discussion somewhat hypothetical. Certain interesting facts may nevertheless tend to substantiate a possible relationship, making it not altogether without ground for a somewhat superficial inquiry.

In the first place, we would call attention to an interesting fact--that the experimental Lots III and IV, in which it will be remembered, the highest death loss occurred, received rations which alone among the four pea-fed lots, might be criticised for being deficient in minerals, chiefly calcium. The death loss apparently was checked by the addition of alfalfa and potatoes. The roughage in the combination of supplementary feeds is of fairly well established mineral value, while potatoes have comparatively little mineral value.

Furthermore, Lot II, which received a ration presumably the richest in minerals, alfalfa hay and peas, showed the lowest death loss. Lot I on the other hand, which had free access to peas and pea-vines, showed the second lowest death loss. Is there a correlation between the death losses and the mineral content of the rations, or was it simply a coincidence? This question can not be answered in the light of but one year's experimental work, nor can the answer be found in investigating the records of Valley feeders, since there is such a mass of conflicting information available that no definite conclusion can be safely drawn. If such a correlation exists, an answer to the second question stated above is necessary to arrive at a conclusion as to whether the death loss of pea-fed lambs is in any way caused by mineral deficiency or inadequacy.

There are a number of diseases in animals which have been attributed, wholly or in part, to mineral deficiency. A lack of sufficient minerals, particularly calcium, in the ration of pregnant cows has been found to be conducive to the production of weak and prematurely born calves (7). Thus we see the importance of minerals in pre-natal animal nutrition. After the animal is born, a great drain is placed upon the female through the milk to provide adequate mineral nourishment for the young. If the female at this period is not fed adequately with respect to minerals, especially calcium and phosphorus, in order to

keep the ash content of the milk constant, the mineral matter may be withdrawn from the skeleton to supply the deficiency, with the resultant injury to the mother. During the growing period the young animal may suffer from a disease called rickets, a disease characterized by weakness and consequent malformation of the bones, general debility, and in the case of young pigs, posterior paralysis. This disease has been associated with a lack of sufficient calcium in the ration, although other factors may enter into its eteology. From South Africa come reports of a disease of cattle which apparently is due to a lack of sufficient minerals in the forage. (5) We have been unable to learn the symptoms or pathological conditions associated with this disease.

With detailed information lacking with regard to the mineral deficiency disease reported from South Africa, and the fact that it apparently affects only cattle, the only mineral deficiency disease which can possibly be associated with the pea-field disease is rickets. Rickets in farm animals is most common in growing pigs, especially in the winter, colts, calves, and lambs apparently not being so susceptible to this condition, altho a lack of sufficient minerals doubtless prevents their maximum growth and development after they are weaned. Typical rickets is primarily a disease of growing, young animals, and apparently

does not affect mature stock. The disease manifests itself by weakness of the bones, debility, often paralysis, and stinted growth, although the disease in man according to McCollum,(2) is a disease of the entire organism. Here is the first and a very important dissimilarity between this disease and the pea-field disease since the latter affects animals approaching maturity. Furthermore, the symptoms and post-mortem indications of the pea-field disease bear very little resemblance to the typical symptoms and post-mortem indications of the pea-field disease. It would appear, therefore, that the two diseases are in no way related. Whether the pea-field disease is a form of unknown mineral deficiency disease seems doubtful. It in no way resembles a disease in which the lack of calcium or phosphorus has manifested itself--usually a weakness of the skeleton and body muscles which comes on gradually, as against the acute symptoms of the pea-field disease. It may be possible that the excess of acid over basic mineral constituents in a ration composed largely of a concentrate such as the limited, unsupplementary ration of peas provides, has a bearing upon the death loss, but again we know of no literature to show that an acute disease such as the pea-field disease may be considered, may be caused by such a condition of the mineral constituents of a ration.

In conclusion we may say that although there may be

evidence to support the view that some of the rations fed to fattening lambs in the San Luis Valley may be deficient in minerals, especially calcium, there apparently is no evidence to show that the pea-field disease is in any way associated with any known mineral deficiency disease. It would appear, therefore, that we are justified in coming to the general conclusion that mineral deficiency is a doubtful explanation of the death loss of lambs in the San Luis Valley although perhaps mineral deficiency may be a contributing factor in the explanation of the mortality.

D. Protein Sensitization or Anaphylaxis

Protein sensitization or anaphylaxis has been defined by Biedl and Krans (11) as "that state of specific hyper-sensitiveness induced in animals by protein injections and in which symptoms of poisoning follow subsequent injections of the same protein in doses which would have no affect on untreated animals." This definition at once suggests further discussion as to the explanation of anaphylaxis, a point upon which there is considerable difference of opinion. The theory of Vaughan and Wheeler according to Buchanan (11) appears to fit conditions best, although it does not explain adequately all of the phenomena connected with anaphylaxis. This theory is as follows. "The proteins are the normal stimulants to cell secretion. When a foreign protein is introduced into the blood or into the tissues it stimulates certain body cells to elaborate that specific ferment which will digest that apecific protein. When such a protein first comes in contact with the body cells the latter are unprepared to digest the former, but this function is gradually acquired. The protein contained in the first injection is slowly digested, and so ill effects are observable. When subsequent injections of the same protein are made the cells prepared by the first injection, pour out the specific ferment more promptly and the effects are determined by the rapidity with which the digestion takes place. The poisonous group in the protein molecule may be set free so rapidly and in sufficient amount to kill the animal." The above

theory is based on Vaughan's (10) conclusion that all proteins can be split chemically into a non-toxic fraction which can sensitize animals against the protein from which it is derived and secondly into a toxic fraction which produces anaphylactic symptoms when injected, but which does not sensitize against the protein from which it is derived. As has been mentioned above, this theory is not wholly satisfactory, but the nature of this paper would seem to preclude the necessity of going into this point in greater detail. There are, however, certain well established facts with regard to the anaphylactic phenomenon which we believe, should be mentioned. These have been clearly summarized by Buckanan (12) as follows:-

1. It is possible to sensitize suitable animals by means of a great variety of proteins such as blood-serum, egg white, milk, plant proteins, bacterial proteins, and yeast proteins. A very minute amount of protein is necessary for sensitization in many cases.

2. It is possible to secure an anaphylactic shock in an animal that has previously been sensitized only after a lapse of a definite period following the first injection.

3. Sensitization of an animal can in general, be best affected by the parenteral introduction of the protein, although sensitization has in some cases, been produced as a result of ingestion or rectal injection.

4. The type of anaphylactic reaction differs with the species of animals and to a less degree, with the site and method of making the second injection, and the amount of protein used.

5. The reaction is highly specific. An animal sensitized against a particular protein will react only when the same protein is re-injected.

As mentioned above, the anaphylactic shock manifests itself differently with different species of animals. In guinea pigs the symptoms develop in three stages, the first characterized by excitement during which the animal itches intensely and attempts to scratch every part of its body that it can reach with its feet. The second stage is one of partial paralysis, accompanied by shallow, difficult breathing. This is usually followed by a third convulsive stage during which the animal throws back its head, expelling urine and feces at the same time. In the dog, the first stage is one of excitement and restlessness often accompanied by vomiting. This stage is followed by one of great muscular weakness, and, in some cases, labored breathing and expulsion of feces. This state may last for many hours, the animal either slowly dying or making a complete recovery. Other animals have not received the experimental observation that has been given the animals mentioned above. Friedemann and Isaac (10) have sensitized goats and sheep, and Doerr (10) sensitized horses and birds. Bang (10) in attempting to immunize cattle against contageous abortion, used horse serum broth cultures of the aborteon bacillus and found that the second injection was followed by grave anaphylactic symptoms.

"Up to the present time," says Vaughan (10), "No animal thoroughly tested has failed to respond to protein sensitization".

Having spoken briefly of the symptoms of anaphylactic shock it is of interest to note what authorities have to say regarding the mechanism of anaphylaxis and the conditions usually found in animals which have died from analhylactic shock. In guinea pigs, according to Auer and Lewis (11) the death is caused by the tetanic contraction of the smooth muscles of the bronchioles of the lung. Upon post-mortem examination the lungs have been found to be inflated and minute hemorrhages have been found on the pleura. On account of the difference in the action of anaphylactic poison on guinea pigs and dogs, the mechanism of protein sensitization is different. The work of Biedl and Kraus (10) has shown that with dogs, fall of blood pressure is a characteristic and constant result of the second injection. The decreased blood pressure has been attributed to lessened peripheral resistance, and has been given as the cause of the brain anemia, the disturbances of respiration, vomiting, and expulsion of the urine and feces typical of the anaphylactized dog. We have been unable to find any information other than that mentioned above regarding the mechanism of the anaphylactic shock with farm animals.

Thus far our discussion has dealt largely with anaphylaxis as produced by parenteral injection. This is the most common means of injection and the one which produces the most marked anaphylactic results. Whether or not sensitization is possible through the alimentary canal is a question that has been much discussed, especially, as Zinsser (13) points, out in an attempt to explain food sensitization in the human. In a definite

proportion of human patients subject to food sensitization, states Zinsser (12) there is reasonable evidence for a complete analogy of this condition with anaphylaxis, as sensitization is developed a certain length of time after the first contact with the responsible food stuff, the first ingestion causing no symptoms of anaphylaxis whatever. The remaining cases of food sensitization are those in which sensitization is produced with absolutely no traceable previous contact, with the harmful food. It is believed that such cases are inherited.

Proteins ordinarily will not pass through the intestinal mucosa. Roseman and Anderson (13) however, have shown that guinea pigs can be sensitized in this manner and Wells (12) made similar observations. Schloss (13) accomplished the same thing by feeding guinea pigs on egg white. The theory has been advanced that the absorption of the protein that produces food sensitization takes place at a time when the intestinal mucosa has been injured by the intestinal disease accompanying various forms of malnutrition or diarrhea. The fact that a very minute quantity of protein is necessary to produce sensitization supports the above theory. Furthermore it has been found that when animals are liberally fed on proteins the same proteins may be found unchanged in the blood, and occasionally in the urine. The above evidence tends to leave little doubt but that the protein antigen may enter the circulation unchanged through the alimentary tract, though possibly under abnormal local conditions of the intestine.

In establishing a correlation between anaphylaxis and the pea-field disease, a number of questions suggest themselves, the answers to which should lead to some general conclusions with

regard to the plausibility of the theory as an explanation of the death loss of pea-fed lambs. The first question that comes logically to one's mind is whether we may regard sheep susceptible to protein sensitization. Although as has been pointed out above, the farm animals have not been generally used as subjects of experimental inquiry into anaphylaxis, we believe that Vaughan's statement quoted above, together with the fact that Friedemann succeed in sensitizing sheep should satisfactorly answer this question, leaving little doubt in the readers mind that protein sensitization is possible in sheep.

Can anaphylasis be induced by the ingestion of large amounts of foreign protein? We would refer the reader to the brief discussion above on food sensitization and the possibility of protein sensitization by way of the alimentary tract as a partial answer to the question. While the cases reported are confined to man and laboratory animals, is there not ground for the belief that anaphylaxis can be produced in a like manner in farm animals, granting this susceptibility to protein sensitization? We believe that there is. But the question can not be left at this point without suggesting a possible explanation of protein sensitization by feeding lambs on field peas.

Vaughan (11) points out that all proteins foreign to the animal body may produce the anaphylactic reaction. Wells and Osborn (11) in this work with the anaphylactic effect of various vegetable proteins, found that the legumins from peas produced typical anaphylactic reactions in animals sensitized to this protein. Peas, therefore, may be considered capable of producing

anaphylactic shock. Granting that field peas, comparable in composition with the edible peas of man, can produce anaphylaxis, how, then, may the typical sensitization and the resultant shock be explained? It has been suggested as was brought out above, that at times the intestinal mucosa may be injured coincident with digestive disorders to such an extent that a normal absorption of proteins does not take place, that is, not all of the protein is absorbed through the intestinal mucosa into the circulation as amino acids. Instead a small amount of protein may be absorbed which has not undergone the process of being broken down into the end products by the proteolytic digestive enzymes, and thus pass into the circulation producing protein sensitization. Following such sensitization it may be possible that at another period, the intestinal tract may again be sufficiently abnormal, coincident with digestive disorder as to permit the absorption into the blood stream of a second minute quantity of native protein, which, following upon previous sensitization produces an anaphylactic reaction. This theory could be applied to the common methods of feeding field peas in which it is reasonable to suppose that the lambs may suffer from digestive trouble, coming as they do from the range which provides feed of an entirely different nature than field peas, a succulent forage as against a high protein concentrate, and being in a half-starved condition when turned into the pea-field as they often are. It is a well known fact among sheep feeders that a rapid change in the type of feed fed may result in sheep going "off feed." Lambs, perhaps more than any other class of stock are susceptible to feed irregularities, and it has been our observation that early in the feeding period there

may be more or less scouring when the lambs are first turned into the pea fields, evidence of digestive disorder. It would seem plausible that the lambs may become sensitized against one or more of the proteins of the field pea at this time. As they become more used to the peas , scouring ceases, and the lambs give every evidence of thrift and well being. This period may last some time, depending upon factors of which we are unceratin. Following the application of this theory, however, we assume that at some time following sensitization, the peas, or possibly some other feed, cause a second digestive disorder and in the manner described above, the sensitizing protein is once again absorbed, but this time to produce the active anaphylactic shock. Such in brief, is the theory that has been suggested as a possible explanation of the pea-field disease through anaphylaxis. We would endeavor to emphasize, however, this point that we have no direct evidence to support this theory.

The application of such a theory to the comparative death losses in the experimental lots is interesting. In Lot I. it will be noted by reference to the charts that no deaths which could be attributed to peas occured until comparatively late in the feeding period. We would assume in such a case where the lambs after first being turned on the peas were not disturbed, but allowed constant access to the peas all day, that after the first few days the steady unchanged diet of peas tended to produce a condition of digestive well-being. It is possible that sensitization toward the pea proteins did not occur early in the feeding period in this lot, if we are to apply the

theory to this particular lot, but the experience of other feeders has shown that death may occur early in the feeding period with this method of feeding, in which case sensitization must have taken place early in the period. So far as that is concerned the time of sensitization and what corresponds to the second injection of the protein is, at best, a matter of conjecture in any of the methods of feeding lambs, but the difference in method appears to induce a possible correlation between the time, at least, and possibly, the rate of death, and sensitization and anaphylactic shock. To continue with the unlimited, unsupplemented pea ration, we again assume that the anaphylactic shock, if death may be said to be caused by such, follows upon some condition of the feed which renders the already sensitized lamb susceptibly to the anaphylactic reaction. Just what condition of the feed should cause a digestive disorder is impossible for us to say.

In the experimental Lots III. and IV. it would appear that sensitization occured early in the feeding period, possible through the practice of allowing the lambs but a very limited amount of peas for the first few days. The feeding of oat hay, and oat hay and barley to Lots III. amd IV. respectively, would, we believe, tend to offset the chance of digestive disorder following the turning of lambs on peas since it was assumed that feeding these feeds tended to precent the lambs from gorging themselves on peas to the extent that they would if no roughage had been supplied during the time they were in the corrals. Assuming that sensitization

in these two lots took place early in the feeding period, it would seem that within less than a month the lambs became susceptible to the anaphylactic reaction through some irregularity or abnormality in the feed, this susceptibility than in the other experimental lots. On this assumption, the feeding of alfalfa hay and potatoes had a beneficial effect upon the digestive system, thus possibly preventing further absorption of the protein poison. The fact that the supplementary feeds, alfalfa and potatoes, provide for greater variety and succulence in the ration tends to substantiate our assumption that these feeds tended to produce a better digestive condition and, therefore, less tendency for native protein absorption.

The death loss in Lot II. to which alfalfa hay was fed from the beginning in addition to a limited pea ration, can be explained from the anaphylactic theory only by the fact that the alfalfa fed to these lambs added variety to the ration or possibly, that there is in this feed some unknown principle which would tend to produce digestive well-being. On this point we have no evidence other than the fact that alfalfa hay provides an abundance of calcium and vitamin A as against considerably less of these constituents in oat hay. Whether this may be a contributing factor toward protection against protein sensitization, we have no positive evidence to submit, but the possibility may exist in view of the ever increasing knowledge with regard to the role of vitamins and minerals in regulating the body processes.

An analogy between the pea-field disease and anaphylasis is not complete without a comparison of the typical symptoms and post-mortem conditions peculiar to both diseases. By reference to the typical symptoms of anaphylaxis in guinea pigs and in dogs, it will be noted that the most comparable symptoms are the convulsions and labored breathing, a condition often noticed in lambs just previous to death. On the other hand, the symptoms sometimes observed in dogs, of continued depression lasting until death, has also been observed in lambs dying of the pea-field disease. We have observed the symptoms of excitement common to both dogs and guinea pigs in lambs, but there is, to our knowledge, no record of lambs showing the typical itching sensation and scratching effect. Another symptom commonly observed in lambs comparable with the symptoms in experimental animals is the expulsion of urine and feces just prior to death, although we do not consider this point particularly significant in view of the fact that many diseases characterized by convulsions immediately prior to death, show this symptom: Post-mortem examination has shown guinea pigs to have pin-point hemorrhages on the pleura, a condition some times found in lambs which have died from the pea-field disease. In lambs, however, we have not observed the typically inflated lungs of the anaphylactized guinea pig. The condition of lambs is often, on the other hand, one of congestion of the lungs, with evidence of pneumonia. Outside of the statement made above that grave anaphylactic reactions had been observed in cattle, we

have been unable to find information regarding the typical anaphylactic symptoms and post-mortem conditions of farm animals. The fact that we are forced to compare the symptoms observed in guinea pigs and dogs, animals in no way related to the sheep, with the symptoms of the pea-field disease in lambs, makes an attempted correlation on this point of somewhat doubtful value at its best.

We have, to summarize, the following points in favor of anaphylasis as an explanation of the death loss of pea-fed lambs:

1. Sheep have been sensitized to proteins and may be considered susceptible to anaphylasis.

2. It is possible to sensitize animals through the feed eaten, especially when a high proportion of protein is fed.

3. The field pea may be considered a source of a protein or proteins capable of producing anaphylaxis.

4. A plausible theory has been advanced to explain anayphylasis in pea-fed lambs.

On the other hand we have given evidence to show:

1. That sensitization through the alimentary tract is rare and that no information has come to our attention to show that farm animals may be sensitized in this manner.

2. That the symptoms and post-mortem indications typical of the pea-field disease bear, but a few similarities to the symptoms and post-mortem indications of anaphylaxis, and the latter having been observed only in experimental animals. Animals of a different class than sheep.

3. That plausible as the theory presented above may be, there is no direct evidence to show that such an explanation of anaphylaxis and the consequent death loss of lambs acutally takes place or even that it is possible in view of what little is definitely known regarding anaphylaxis through the alimentary tract.

With the above points in mind, we believe that the reader will agree that but one conclusion can be drawn from this discussion - that although anaphylasis has much to support it as an explanation of the death loss of pea-fed lambs in the San Luis Valley, there is sufficient contrary evidence to prevent us from accepting this theory as an explanation of the mortality. Further work may, in time, substantiate the anaphylasis theory, but at present we must regard it with doubt.

E. Specific Infection

and

General Conclusions

One more possible explanation of the death loss of pea fed lambs will now be discussed, namely specific infection. By this term it is meant that the disease, if such it may be termed, iscaused by a mico-organism or bacterium which is pathogenic to pea-fed lambs. Since detailed and thorough comprehensive discussion of this subject belongs to the field of pathological inquiry and investigation, it is not our purpose to attempt to deal with it from a technical viewpoint, but to briefly discuss the subject in the light of what work has already been done on this phase of the problem, and to draw such conclusions as seem warranted therefrom.

As has been mentioned above the Pathology Section of the Colorado Agricultural Experiment Station conducted a series of experiments with lambs in the San Luis Valley in 1921-22 and 1922-23 with a view toward determining the cause of the death losses. The first year, as reference to the account of this work (p 16-20) will show, a number of the lambs were vaccinated with hemorrhagie septicienia vaccine in order to determine whether the death loss was in any way associated with hemorrhagic septicenica. The conclusion arrived at from this phase of the experimental work was that this disease could in no way be associated with the

typical pea-field disease. From time to time, the Pathology Section has examined tissues from lambs which have died of the pea-field disease in order to determine whether any organism could be isolated from such organs as were apparently abnormal upon post-mortem examination, and which could be suspected of being associated with the disease.

Two criteria must be satisfied before an organism may be held responsible for a given disease. (1) The same organism must have been isolated from a large number of typical cases of the disease, (2) if it can be isolated it must be able, upon injection into healthy animals of the same species, to produce the disease in all its typical symptoms, and post-mortem indications. Following these criteria, the investigations of the Pathology Section have not resulted in the isolation of any one organism which could be associated with the disease of pea-fed lambs in the San Luis Valley.

A government pathologist, Dr. G. W. Stiles, Jr., of Denver, Colorado, as a result of investigations into the cause of death losses of pea-fed lambs in the San Luis Valley, and death losses among lambs in Northern Colorado feed lots, has come to the conclusion that these losses are due to a specific organism found in the soil, which he claims to have isolated from dead lambs from the pea-fields of the San Luis Valley and from lambs dead in Northern Colorado feed-lots. This organism has been identified as the malegnant edema bacillus, from which this investigator

has been able to prepare a vaccine which he claims is capable of immunizing lambs against the disease. It is interesting to note that this authority compares the disease of lambs common to both sections of Colorado, to braxy, an old country disease of sheep which has baffled investigators for many years. With the above statements in mind, a few questions naturally suggest themselves, the answers to which may serve to establish a satisfactory answer to the question - are the pea-field and feed-lot diseases of Colorado the same as braxy?

In the first place, what is braxy? Braxy, according to the definition of B. Harvey Mellon (14) "is an acute infections disease of the ovine species due to specific bacillus, and characterized by a very short period of visible illness, a marked regional and seasonal distribution, and by being almost invariably fatal". This disease is found in the British Isles, Norway, Sweden, Denmark and Iceland, and is usually associated with old grazing pastures in hilly districts. Lambs are much more susceptible than older sheep, and the fatter sheep are more susceptible to the disease then the thinner sheep. The above authority is of the opinion that infection comes from the sheep swallowing the organism with their food when grazing on foul pastures, and is not infectious from animal to animal. The usual symptoms are loss of appetite, dullness, and weariness in movement, followed by a dazed condition and difficult breathing. Diarrhea is usually

usually present. Death usually ensues thirty-six to forty-eight hours after appearance of symptoms. Post-mortem examination reveals an extremely rapid onset of putrefaction, although the typical odor of the braxy carcass is not putrefactive. There is usually present a quantity of opaque fluid in the abdominal cavity, a more or less congested lining membrane of the peritoneal cavity, slightly enlarged spleen, a light colored and friable lever, inflamed fourth stomach, and a broken down kidney. (14).

What is the cause of braxy? From the above definition we note that old country authorities seem of the opinion that braxy is caused by a specific organism. Just what organism however, is the cause of the disease is a matter of different opinion. Gaiger (15) in recent report, states that the causal organism of this disease is indistinguishable from the vibrion spetique or malignant edema bacillus, but B. Harvey Mellon (14) is of the opinion that malignant edema does not occur in sheep. Jensen (15) of Iceland attributes the disease to the bradsot bacillus, but maintained that this organism differs from the vibrion septique, a point which Gaiger disagrees. German pathologists have come to the conclusion that the bradsot bacillus of Jensen can be found in the dead bodies of many animals in other words, the invasion is of a post-mortem nature, therefore braxy can not be considered as being caused by this organism, thus discrediting of Jensen's theory. From this brief discussion it is apparent that as yet authorities disagree as to the specific causal organism of the disease braxy.

Having discussed briefly the nature and cause of the disease, a comparison of the pea-fed disease of the San Luis Valley appears logically to be the next step in arriving at a conclusion on this subject.

From the discussion above it will be noted that braxy is a disease of the hilly pastures, especially those presumably pastured one year after another. Here we have little ground for comparison of braxy with the pea-field disease, since the latter is not associated with pastures, although there could be a possibility that lambs allowed to run on land on which the trouble occured before may become infected, thus being in accord with the theory that the organism is found in the soil and the sheep become infected by eating forage grown on previously infected land. In this connection it would be of great interest to know whether, in cases where a fence separated the bands of lambs, one of which showed a heavy loss and the other practically none, the field on which occured the heavy loss was previously sowed to peas and fed off with lambs. Infection, through the soil could be cited as explanation of this mysterious angle of the disease in the lamb fattening district of the Valley. Both in braxy and in the pea-field disease lambs are apparently most susceptible, although we know of cases where losses occured with old ewes on peas, but this is not the rule. Whether this may be attributed to the fact that older sheep rarely are allowed the quantity of peas that is allowed lambs, but, on the other hand, usually

used to clean up the fields after the lambs have been taken off, we are not certain. The symptoms of the disease, as reference to an earlier account of the pea-field sickness and comparison with Mellon's description of braxy above will show, are very similar. We do not in the literature on braxy see any reference to cerebral symptoms just previous to death, a condition often noted in the pea-field disease. The latter disease, although usually followed by quick death, may last a week or more, thus differing from the typical course of braxy. Again, in the pea-field disease, it is not always, though usually, that the disease affects the fatter lambs. Gaiger (15) observed that sheep affected by braxy were restless and uneasy and ground the teeth. This symptom we have often observed in pea-fed lambs previous to the more acute symptoms just prior to death.

We note in a comparison of the post-mortem findings of the two diseases, considerable similarity, such as the fluid in the abdominal cavity (not uncommonly found in the pea-fed lambs), broken down kidney, and abnormally colored liver. On the other hand, the record of braxy post-mortem examinations show a typically congested fourth stomach, and a gaseous condition of much of the bad tissue shortly after death, which is not, from our observations, typical of the post-mortem findings of the pea-field disease, although a characteristic odor is found in nearly all dead lambs. The symptoms of lung congestion and tracheitis and the patachial or pui-ponit hemorrhages usually found associated with pea-

field losses do not appear to be typical of braxy. Whether this is significant we are uncertain.

In the above discussion we have attempted to show wherein we might have cause to believe braxy and the pea-field disease comparable and the same disease, and also wherein this theory finds contrary evidence. The above depends for its acceptance upon first, that braxy is caused by the malignant edema bacillus, and secondly, that the pea-field disease is caused by this same organism, and finally, the resemblance or similarity of the two diseases. Even though braxy were definitely known to be caused by the malignant edema organism which, as we have pointed out, is still an open question, we must question the statement that the pea-field disease as well as the losses in Northern Colorado feed lots are to be associated with the same organism for several reasons. First, the organism has not to the best of our knowledge, been isolated from a large number of cases. Secondly, it has not reproduced the disease in healthy lambs, nor has the vaccine been used with convincing success. Granting, further, certain similarities between the pea-field disease and braxy, there are never the less differencies which would apparently indicate that the two diseases are notidentical with regard to symptoms or post-mortem conditions. We are doubtful, therefore, that the pea-field disease and braxy are identical altho we concede that there are points which substantiate the identical nature of the two diseases.

Returning again to the subject of specific infection from its more general aspect and its relation to the pea-field disease, there are several questions which suggest themselves. It has been brought out above that the infectious organism may be ingested by the lambs through feeding on peas grown on land which was previously infected, thereby accounting for lambs in one band dying heavily, where as lambs in another band runing on peas in an adjoining field (which presumably was not previously infected by the organism) show no such heavy death loss. This theory bears closer inquiry before it may be considered in substantiation of the specific infection theory. It os course, in the first place, depends upon the theory that the infectious organism is carried over in the soil and in some way finds its way into the alimentary tract while the lambs are feeding. If such is the case, is it not reasonable to suppose that lambs could develop the pea-field disease while being run on small grain stubble, potato land, or any other crop which has followed a crop of peas on which there was a heavy death loss of lambs the previous year? Or is it not possible that lambs corraled on such land could become infected even though never fed a ration of peas? We present this argument realizing that we have no evidence to disprove the factthat lambs allowed to run on such crops as small grain stubble as a part of the system of feeding peas may actually pick up the infection while runing on the small grain stubble or other land. The majority of cases,

however, would indicate that lambs managed in such a manner do not show a heavy death loss until they are fed heavier on peas, and do not have access to the other feeds. There is not enough corral feeding of any sort in the Valley to prove or disprove the possibility of infection from the land on which the corrals are built.

The above discussion assumes that the infection can not be communicated from animal to animal, thus disregarding the possibility that the disease may be caused by an infectious organism, which may be transmitted from animal to animal through the feed or water, as well as through the body excretions. If such is the nature of the disease, how can the fact that of two bands of lambs, separately corraled, but run over the same area of peas and to the same source of water, one band shows a high death loss and the other a comparatively low mortality percentage. Such cases have actually occured in the Valley, and would tend to discredit a theory of specific infection based upon animal to animal transmission.

One of the strongest arguments against the theory of specific infection as an explanation of the death loss remains for discussion. This argument may be stated thus. If specific infection is the cause of the death loss, whether infection may be transmitted through the soil or from animal to animal or both, or in fact, any manner, why should the death loss be invariably associated with the feeding of peas - the greater the amount of peas the greater the amount of peas being fed, the higher the mortality as a rule? We have the argument presented

above that the disease braxy is usually associated with the fattest sheep, and that the causal organisms of braxy and the pea-field disease being the same, explains the fact that the disease is always associated with the amount of peas fed. But as we have shown above there is insufficient evidence to convince us that, (1) the causal organism of the pea-field disease has actually been isolated, and (2) that the disease is the same as braxy, hence we believe that the question suggested above remains as yet, unsatisfactorily answered from the standpoint of specific infection.

With the points that have been brought out above in mind we believe that we are justified in coming to the conclusion that the explanation of the death loss of pea-fed lambs on the ground of specific infection may as yet be considered doubtful, although, as we have brought out above, further investigation may tend to substantiate the opposite conclusion.

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Having discussed more or less at length a number of explanations of the death loss of pea-fed lambs, it may be well to summarize these discussions and come to some general conclusions with regard to the theories advanced above.

1. Although an unbalanced ratio of nutrients and one inadequate in protein quality may be detrimental to the well being of farm animals producing more or less unsatisfactory results in growth, and in fattening, there is no

evidence to show that a ration os such nature us capable of producing such acute digestive disturbances as to lead to the death of lambs. We should in the light of this conclusion regard an unbalanced ratio of nutrients and lack of protein quality in a ration as contributing factors in the death loss, but hardly possible as the sole factor in the cause of the mortality.

2. Rations fed to pea-fattened lambs in the San Luis Valley are deficient in vitamins A and C but due to the fact that there is insufficient similarity between the pea-field disease, and the diseases associated with deficiencies in these vitamins, and to the fact that to date, farm animals appear to have very low vitamin requirements, it appears that vitamin deficiency is not specifically associated with the death loss. Like an unbalanced ratio of nutrients, having v vitamin deficiency may be a contributing factor in the cause of the death loss.

3. Rations unsupplemented by alfalfa hay maybe deficient in minerals, particularly calcium, but mineral deficiency hardly seems a possible explanation of the death loss in view of the fact that the pea-field disease in no way resembles a mineral deficiency disease, and that we have no evidence to prove that the pea rations are sufficiently low in minerals to prove detremental to fattening lambs.

4. Due to the fact that sheep may be sensitized to proteins, that is is possible to sensitize animals through the feed eaten, and that the proteins of peas may be con-

siderated capable of producing anaphylasis, the theory of protein sensitization gains support. Contrary evidence to the effect that alimentary protein sensitization is rare, and that the typical anaphylactic reation has been observed shiefly in experimental animals and differs considerably from the characteristic symptoms and post-mortem indications of the pea-field disease leads to the conclusion that anaphylasis is a doubtful explanation of the cause of the death loss.

5. Specific infection as an explanation of the death loss of pea-fed lambs is supported by its similarity to braxy, and the claim of one investigator that he has isolated the organism associated with the pea-field disease, this organism being identical with the braxy bacillus. Since however, the exact cause of braxy is still undicided and since it is questionable whether an organism that is the cause of the pea-field disease has actually been isolated, the question os specific infection still remains an open one, in fact, it may be considered doubtful in view of evidence presented above that tends to show that the disease may not even be of bacterial origin.

From a review of the above summarizing statement it becomes evident that none of the theories advanced may be considered a satisfactory explanation of the death loss. Although it would be gratifying to be able to find some exokanation that would satisfy all the conditions, it is not our purpose to imply that such an explanation, in the

light of what comparatively little work has already been done on the problem, actually is forthcoming. In fact, it may be that no one theory will ever be presented that can satisfactorily explain the loss. In this connection we would re-emphasize that there is nothing to indicate , but that there may be several factors involving one or more of the theories advanced above, which acting together may be the explanation of the mortality. For example, a possibility exists that the unfavorable effect of an unbalanced ration may contribute toward greater susceptibility to infection from an organism gaining entrance to the body through the digestive tract. At any rate, whether those theories as have been suggested are of any value in themselves or not, we believe that their careful consideration should result in suggestions valuable in future experimentation on the death loss problem as well as in correlation with the results obtained in the past seasons work.

Summarizing the results obtained from the experimental lamb feeding at Monte Vista during the season 1923-24 we have the following:

1. Limiting the pea ration by limiting the time the lambs are on peas, and feeding oat hay or oat hay and barley w en the lambs are in the corrals apparently has not effect in controlling the death loss.

2. Limiting the pea ration by limiting the time the lambs are on peas and feeding alfalfa hay in the corrals may

have a beneficial effect in controlling the death loss.

3. Taking the lambs off peas and feeding in addition to oat hay and oat hay and barley, alfalfa hay and potatoes, then turning the lambs on peas again without these supplementary feeds - apparently has no effect in controlling the death loss.

4. A supplementary ration of alfalfa and potatoes fed to lambs receiving a limited ration of peas plus oat hay and peas plus oat hay and barley, apparently exerts a definite effect in controlling the death loss.

5. Potatoes alone when fed to lambs receiving a limited ration of peas plus oat hay and peas plus oat hay and barley, apparently is not as efficient as potatoes and alfalfa in controlling the death loss.

6. Turning the lambs out in the pea-field and allowing them unlimited access to the peas at all times may be considered to usually result in a heavy death loss.

From the results of the experimental work carried on last year, and from the study of the explanations of the death loss of pea-fed lambs, we may draw the following general conclusions:

First. The feeding of field peas to fattening lambs appears to be definitely associated with the death loss - peas are in other words, in some way responsible for the death loss.

Second. Although there is no satisfactory specific explanation of the death loss at present, it apparently is a feed problem - that is, the control of the death loss rests upon a system of feeding and management that will enable the feeder to fatten out a band of lambs without a heavy loss.

Third. The original method of turning lambs out on peas and allowing them all they can eat appears unsafe from a death loss stand point.

Fourth. Limiting the amount of peas in an endeavor to control the loss is of somewhat doubtful value in controlling the loss and has the further disadvantage of taking longer to fatten the lambs.

Fifth. Certain supplementary feeds, particularly alfalfa and potatoes, apparently are of value in checking the death loss when fed to lambs receiving a limited amount of peas.

Sixth. Further investigation is absolutely necessary before conclusive results may be obtained.

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