STATION BULLETIN 402 FEBRUARY 1942

Studies of Parasites in Oregon Sheep on Irrigated Pastures

By

J. N. SHAW
O. H. MUTH

Oregon State System of Higher Education
Agricultural Experiment Station
Oregon State College
Corvallis

FOREWORD

THE necessity for maximum production per unit of land or livestock, always important, is of paramount importance now and probably will continue to be so for some time to come, because of the emergencies of war.

The Department of Veterinary Medicine of the Oregon Experiment Station is carrying on studies on many phases of the problems bearing upon livestock management. In this bulletin, members of this investigational staff relate incomplete but significant results of one of these studies—the effect of parasites upon lambs as encountered under one of the newer management practices of western Oregon. It is hoped that these results may aid farmers to avoid losses by suggesting steps toward solution of some of their management problems.

WM. A. SCHOENFELD
Dean and Director

Illustration on Cover—

Ewes and lambs on fescue before going on irrigated pastures.

Studies of Parasites in Oregon Sheep on Irrigated Pastures

By

J. N. Shaw
O. H. Muth
Department of Veterinary Medicine

INTRODUCTION

THESE studies were made as a part of a departmental project on diseases of range animals. The project was begun as a voluntary study before special funds were made available, but because of the demands of regularly authorized projects little progress was made until 1937, when funds were provided.

During the past several years the summers have been unusually dry in the Willamette Valley and many irrigated pastures have been established. In recent years land-use specialists have encouraged irrigation, and the livestock owners immediately thought of sheep to utilize these pastures. There has always been a demand for some improvement in the marketing of left-over Willamette Valley lambs—a way to market lambs that were not fattened on ewe's milk. Because of the success that California sheepmen have had in fattening range lambs on irrigated ladino clover pastures, sheepmen in Oregon, especially in the Willamette Valley, have become interested in similar methods. There has also been some encouragement to develop the use of logged-off land for sheep-raising. To obtain the maximum benefit from such hill pastures, sheepmen have sometimes provided supplementary irrigated pastures in the small valleys.

Realizing that the supplying of moisture for grass would provide ideal conditions for parasites as well as sheep, the Department of Veterinary Medicine realized also that much information would be necessary as to the importance of parasites in animals on such pastures. The department realized further that if ladino clover pastures could be provided in the Willamette Valley and parasites controlled, such pastures could be used to fatten range lambs produced on the ranges of eastern Oregon. Now such lambs either go east as feeders or to California to be fattened on irrigated pastures there. Early observations on irrigated pastures in Oregon indicated that plenty of trouble could be experienced with parasites, and for this reason the following studies were made.

METHODS

Pastures. The first pastures used were plots belonging to the Soils Department of the Experiment Station. These plots had been used by the Animal Husbandry Department sheep for several seasons and the grasses present consisted of a common mixture containing some clover. Little information was gained from these pastures, as the sheep were mostly destroyed by dogs a short time after they were placed on the plots. These trials were made in 1930, but were discontinued until 1940 because of lack of facilities.

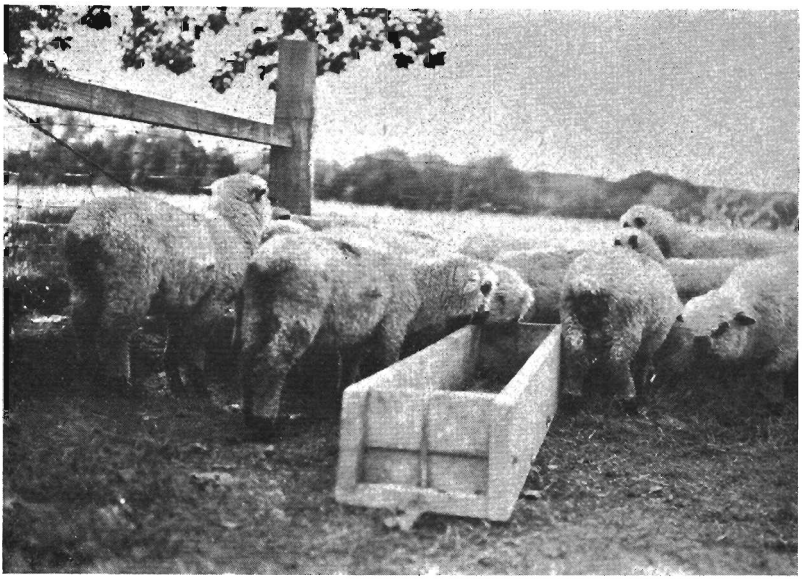

Figure 1. Lambs weighing below 55 pounds at start of clover feeding.

Figure 2. Part of one pasture. Note where clover leaflets have been browsed.

In 1940 about three acres of very good clay loam soil were divided into three approximately equal plots arranged for irrigation and sown to straight ladino clover. These plots were fenced and arranged so that they could be rotated. Each plot contained one or more large oak trees that furnished ample shade, and the water for irrigation, obtained from Oak Creek, was pumped onto the plots by the Soils Department. The first year the clover failed to grow in one of these plots, notwithstanding two seedings. The reason for this was not definitely determined. The clover grew very well in the other two plots for a time, but later died out in about one-third of plot 2. Examination of the soil and the clover was made by soil and plant specialists, but no reason could be found for this difficulty either. At no time were sheep allowed to pasture the clover close to the ground and it was definitely determined that the dying out of the clover was not due to pasturing. No record was obtained of the amount of water placed on these plots for 1940 and it was believed that possibly some of the trouble was due to lack of proper irrigation. Some difficulty apparently was experienced in obtaining water because of the shortage of water in the creek. Ewes with lambs were placed on the clover plots May 2.

In 1941 these pastures were used again and on the third plot a crop of clover was obtained. During the year, between June 1 and August 16, 56.28 acres inches of water were delivered to these plots in six different irrigations. In 1941 no difficulties were experienced with the clover. It grew abundantly at all times and at no time was it allowed to be pastured close to the ground.

Lambs. The lambs used each year on these plots were those dropped by the departmental flock. The ewes in this flock varied in age and breed. They had not been selected for any particular purpose and therefore were not expected to bring any better than average Willamette Valley lambs. They were fed all of the good second-cutting alfalfa hay that they could clean up during the winter, and except for some trouble with broken mouths were in excellent condition all of the year. The lambs were mostly dropped in February and handled under about the same conditions as average flock lambs in the Willamette Valley. Attempts were made to creep feed the lambs, but they had not learned to eat grain to any extent before they were ready for pasture.

These lambs and ewes were allowed to run in a one-acre field close to the sheep shed. This field was planted to fescue, which provided green feed at the time the lambs were born. The ewes and lambs were also used to pasture poultry yards that had been used by sheep the previous year. The lambs grew and developed well without showing any clinical evidence of parasitism. Some worm eggs, however, were found in the droppings of lambs four weeks of age.

Worms. Worm loads were estimated by preserving the abomasum and small intestine in a 2 per cent formalin solution overnight. These parts were then thoroughly washed and three 10-cc. samples were counted with the low power of a dissecting microscope. The worm load was then calculated from an average of the three samples counted.

Treatment. Seven lambs of the 1940 crop were used in trials with phenothiazine. Part of the lambs in both groups of 1940 trials were treated with small doses of tetrachlorethylene and mineral oil. Treatment was administered without keeping the lambs off feed. Four treatments were given between August 21 and September 21. Fly blown lambs were treated by destroying maggots with chloroform and applying bone oil. One application prevented further trouble. The bone oil used is sold under the trade name of REPELLA by Consolidated Chemical Industries, Inc., San Francisco, California.

RESULTS

In 1930, of the eleven lambs two months of age that were placed on pasture with their ewes, four died of parasitism. The lambs were placed on pasture in April and by the fifth of October only two had reached a weight of 100 pounds.

In 1940, eight lambs on young ewes and eleven lambs on old ewes were weighed and placed on ladino clover pastures on May 2. The lambs on young ewes averaged 39.1 pounds and those on old ewes averaged 41.4 pounds. These lambs on June 24 averaged, respectively, 78.5 and 76.4 pounds. Of the lambs on the young ewes, three were fat, while of the lambs on the old ewes, five were fat enough to market. The young ewes on June 3 weighed an average of 117 pounds and on June 24, 116 pounds. The old ewes on June 3 weighed 140.3 pounds and on June 24, 149.3 pounds.

This difference in gain by the old and young ewes cannot be explained. On September 24, 1940, lamb No. 37 was destroyed and an estimate of the worm load was made. This lamb had weighed 47 pounds on September 8. The estimated number of worms was as follows: 500 *Ostertagia circumcincta* (stomach worms) and 450 *Trichostrongyles* (intestinal worms).

When these lambs were removed from the pasture in the fall, worm estimates were made on three that were showing clinical symptoms of parasitism. Two of these lambs had been treated with phenothiazine and when killed on January 10 the following worm load was found: Lamb No. 9, *O. circumcincta*, 940, and *Trichostrongyles*, 640; Lamb No. 64, previously treated with 87 grams of phenothiazine and destroyed November 13, had a worm load of 4,600 stomach worms and 600 intestinal worms.

In two untreated lambs that were down, unable to stand, and scouring, the following worm loads were found: Lamb No. 7 had a worm load of 15,000 *O. circumcincta* and 20,100 *Trichostrongyles;* Lamb No. 18 had a worm load of 12,600 *O. circumcincta*, 1 *Haemonchus contortus* (eastern stomach worm), and 14,800 *Trichostrongyles.*

On July 29, two groups of lambs raised by the department were separated from the ewes and placed on lots 1 and 2. These lambs were divided into two groups as nearly equal in number as possible. Those on lot 1 averaged 53.1 pounds, while those on lot 2 averaged 54.6 pounds. These lambs were fed barley and at the end of ten days were getting a pound each. The average weights of these lambs on October 10 were: Lot 1, 62.2 pounds; Lot 2, 57.4 pounds. In 73 days these lambs had made an average gain of: Lot 1, 9.1 pounds, Lot 2, 2.8 pounds.

On June 6, 1941, 17 departmental lambs, all more than 52 pounds and averaging 59.19 pounds, were separated from the ewes and placed on plot 1. Clover in this plot was excellent and should have supported 9.6 mature sheep. These lambs were put on a pound of wheat in about ten days' time. On August 21, 56 days later, these lambs averaged 66.33 pounds, with the addition of one lamb weighing 66 pounds. One lamb weighed as much as 83 pounds, but none were fat. One lamb had died from what seemed to be pulpy kidney disease.[1] No others had died, although a good many had scoured.

These lambs over a month later weighed an average of only 57.33 pounds. One lamb had died and one was killed for a worm load estimate. On October 10, 1941, 23 days later, these lambs averaged only 57 pounds. On October 28 they were placed on dry feed and the following week two died and two others, too weak to stand, were killed for worm load estimates. Worm load estimates on lambs of this group were as follows:

Figure 3. One of the weakest lambs (note thinness and the lack of lustre to the wool).

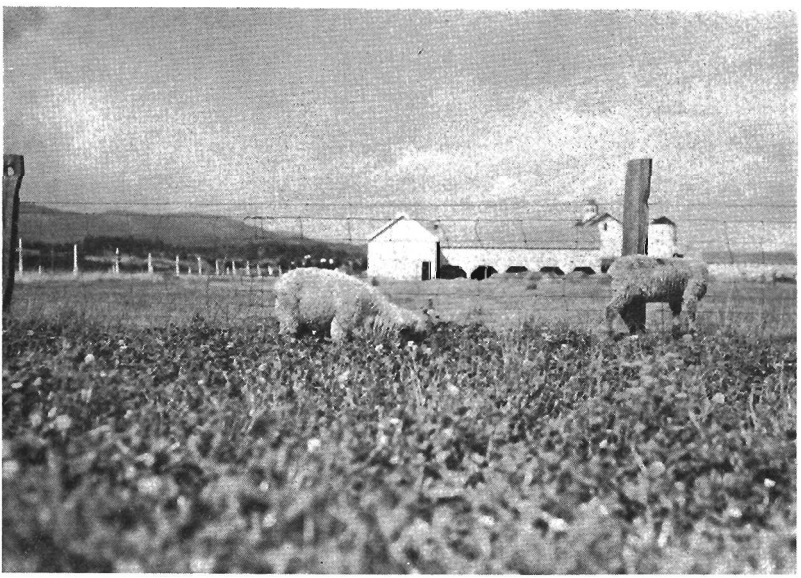

Figure 4. Two undersized lambs. Note condition of one on the dike.

Lamb No. 134. Weight on August 21, 1941, 70 pounds. Killed September 4. This lamb appeared to be the best of the lot but was not fat. Worm load estimate as follows: 1,476 *O. circumcincta* (small stomach worm) and *H. contortus* (eastern stomach worm), 1,500 *Trichostrongyles*.

Lamb No. 152. Weight on July 14, 1941, 76 pounds. Weight on November 4, 41 pounds. Worm load estimate as follows: 8,250 *O. circumcincta* (small stomach worm), with no *H. contortus* (eastern stomach worm), 16,368 *Trichostrongyles*.

Lamb No. 104. Weight July 14, 1941, 64 pounds. Weight October 31, 37 pounds. Worm load estimate as follows: 17,600 *O. circumcincta* (small stomach worm), 2,000 *H. contortus* (eastern stomach worm), 17,520 *Trichostrongyles* (intestinal worms) and *Bunostomum trigonocephalum* (hookworm).

On August 7, 1941, 21 lambs weighing between 22 and 56 pounds and averaging 43.9 pounds were separated from their ewes and placed on plot 1. They were started on one-fourth pound of wheat and it was planned to have them on one pound each in about ten days' time. These lambs with ewes had been on all the ladino clover plots and also on some irrigated grass plots belonging to the Soils Department. At all times the feed was good, but lambs and ewes did not do well. Some of the lambs scoured and the older ewes became quite thin. The average weight of lambs 14 days later was 41.75 pounds. During the next 35 days, two died and two that were about to die were killed. The average weight of those remaining was 44.8 pounds. Not counting those that died or were killed, 5 had lost weight and 14 had gained during the entire period. None, however, had gained enough to be free of clinical symptoms of parasitism.

On October 28 this group of lambs was placed on dry feed. During the time they were on clover with ewes, two that were so weak they were unable to stand were killed. After being removed from the ewes and until October 29, 1941, six had died, and two too weak to stand were killed. Observations on dead and destroyed lambs in this group were as follows:

Worm load estimates.

Lamb No. 150. Killed July 26. Weight, 10 pounds. This lamb was one of twins, the last lambs to be dropped. Its weight on June 26 was 10 pounds and when killed the lamb was very weak and scouring. Worm load estimated at 6,720 *O. circumcincta*, 210 H. *contortus*, and 4,275 *Trichostrongyles*.

Lamb No. 118. Killed July 28, 1941. Weight, 20 pounds. Lamb thin and weak, but not scouring. This lamb had weighed 50 pounds on July 14, losing 30 pounds in 14 days. Worm estimate—8,970 *O. circumcincta*, no *H. contortus*, and only a few intestinal worms. In the stomach were many nodules containing the protozoan *Globidium gilruthi*. It is possible that this parasite was largely responsible for the rapid loss in this lamb's weight.

Lamb No. 136. Killed September 6, 1941. Weight, 18 pounds. Weight on July 14, 37 pounds. Some scouring. Worm estimates—9,100 *O. circumcincta* and 17,480 *Trichostrongyles*.

Lamb No. 120. Killed September 17, 1941. Weight, 21 pounds. Weight on July 14, 39 pounds. Worm estimate—6,560 *O. circumcincta* and 15,300 *Trichostrongyles*. This lamb had been treated with tetrachlorethylene three times.

Lamb No. 123. Found dead in plot. Worm estimate not made. Lamb not treated.

Lamb No. 143. Found dead in plot. Weight August 7, 37 pounds. Weight, September 28, 30 pounds. Worm estimate not made. Lamb treated with 2½ cc. of tetrachlorethylene.

Lamb No. 121. Killed October 22, 1941. Weight, 28 pounds. Weight July 14, 52 pounds. Weight when separated from ewe and put on clover, 32 pounds. Worm load estimate—10,500 *O. circumcincta* and *H. contortus*, 40,500 *Trichostrongyles*.

Lamb No. 153. Down. Killed November 17. Weight not taken. Weight July 14, 47 pounds. Weight October 21, 36 pounds. Worm load estimate– 4,960 *O. circumcincta* and 33,755 *Trichostrongyles*. No *H. contortus* counted.

Worm load averages. The average worm load estimated in 14 stomachs was 7,856, while that for 13 small intestines was 14,091. Little knowledge is available as to the minimum and maximum worm loads that lambs can carry successfully under any and all conditions, but apparently the loads carried by

Figure 5. Undersized lambs at their best.

Figure 6. Undersized lambs. Note evidences of scouring.

these lambs were many times what one would expect to find in lambs that were being fattened normally.

Species of worms found. The worms that were found are discussed in order of their importance.

Ostertagia circumcincta or lesser stomach worm, sometimes known as the western stomach worm, is a small hair-like worm, the female of which is about § of an inch in length. This parasite seemed to be present in greater numbers fairly early in the summer. It has what is known as a direct life cycle. The eggs hatch in a comparatively short time and the young worms reach the stage when they are capable of infesting other animals in from 7 to 14 days. They are taken in with the feed after migrating to the grass or clover leaflets. One stage of the life of this parasite is passed in small nodules in the walls of the fourth stomach. It reaches maturity after three weeks to a month. The larvae have been known to remain alive on the grass for as long as two years, but under Oregon conditions probably will live about ten months.

The next in importance are the small worms found in the small intestine. These worms are *Trichostrongyles*. The species found in the animals on these experiments were not identified. At least three different species, however, have been identified in Oregon sheep. This worm is not as large as the small stomach worm, but has a very similar life cycle, apparently taking longer to develop than the *Ostertagia circumcincta*. One stage of this worm is passed in the walls of the small intestine, where it is said by Monnig[2] to cause desquamation. The worm load with this parasite seemed to increase as summer lengthened. This worm is sometimes known as the "bankrupt" worm.

Strongyloides papillosa was present to a limited extent and was counted in with other worms in estimated intestinal worm loads.

Haemonchus contortus, the so-called eastern stomach worm or large stomach worm, was more common in these experimental lambs than in any other lambs studied by members of this department. It was believed that this parasite was introduced to departmental pastures with animals that had come in contact with ram lambs that had been on the show circuit. In at least one lamb the worm load with this parasite was quite heavy. The life cycle of this worm is similar to that of the first parasite described. This worm, however, is much larger than the others and when alive has a peculiar barber-pole appearance.

The hookworm (*Bunostomum trigonocephalum*) was present to a very limited extent, being found only in two or three lambs in very small numbers. This worm is the largest nematode that we find in the small intestines of sheep in this state.

Nematodirus filicollis was present in some of the lambs examined later in the summer, but at no time did it appear in any great numbers. This worm lays an egg that is quite easily distinguished from the eggs of all other worms that we find in sheep.

Observations on other parts of the digestive tract resulted in the finding of *Chabertia ovina* in the large colon, and *Trichuris ovis*, or the whipworm, in the cecum or the so-called blind gut, but at no time were these worms present in sufficient numbers to cause any damage. *Monezia sp.*, or tapeworm, did not appear to be present in any of the lambs examined. This was hard to explain because this parasite is very common in Oregon sheep.

Lungworms, *Dictyocaulus filaria*, were found in a few of the lambs examined, but only in small numbers.

Careful examination for *Fasciola hepatica,* or the common liver fluke, failed to reveal any of these parasites in any of the animals examined. In lambs fattened on ladino clover pastures by the Animal Husbandry Department in 1940, however, this parasite caused the condemnation of practically 100 per cent of the livers. The water for pastures used in these studies was obtained from the same creek as that used by the Animal Husbandry Department pastures. The water used on the clover pastures of the Animal Husbandry Department, however, ran through pastures used by the cattle of the Department of Dairy Husbandry, and animals examined from that department previously had shown them to be infested with this parasite.

Symptoms produced in experimental lambs. The most noticeable symptom observed was the loss of weight. Lambs also lost their bloom, the wool having a dry appearance. Scouring, which was a common symptom, did not develop in all animals, but was common enough to indicate that something was seriously wrong with most of the lambs. Those that were extremely thin developed an unusual thirst and would stand by the watering troughs for long periods of time, drinking small amounts of water. Along with the scouring, the fly problem developed and was responsible for the death of at least one animal. No cases of bloat were observed.

DISCUSSION

It is difficult to understand just why there was such a great difference in the way the pastures were browsed. At first, the sheep showed a very definite preference for the grasses growing on the dikes used to retain the water on the plots. These dikes were covered with grasses, but carried no ladino clover. In some areas in the pastures it was clearly evident that the lambs were eating the tops of the clover. In other places it was apparent that the clover was not being used. In one plot the clover was browsed until it was almost completely killed. Though it was believed that there was some very definite reason for this, neither soil nor farm crops specialists could offer any explanation. Examination of clover leaflets revealed the presence of some worm larvae, but whether these were free-living nematode larvae or parasitic nematode larvae was not determined. It was believed that there was some carry-over of the pasture parasite load from 1940 to 1941. This, however, was not indicated by early infestations of worms in the lambs.

There was some difficulty in maintaining the clover. At the present time (1942) almost no clover can be found in the middle plot. No explanation can be made for this fact; from the amount of use one would expect the clover to last longer than two seasons.

Taylor[3] has shown that average pastures will contain sufficient worm larvae on the grasses so that the average sheep will obtain as many as 200 larvae per pound of grass. Heavily infested pastures contain as many as 2,500 larvae per pound of grass. It was not determined just how much grass each lamb would eat per day.

These pastures might have given better results if the supplement used had been a good quality of chopped alfalfa hay rather than wheat or barley. It was noted that the lambs had to learn to use wheat, and, of course, might not have utilized chopped alfalfa hay at all.

It is quite possible that the susceptibility of these lambs was increased by the lack of use of the clover. Fraser[4] has shown that infestation with *Oster-*

Figure 7. One of the lambs weighing more than 55 pounds at the start. Note height of clover.

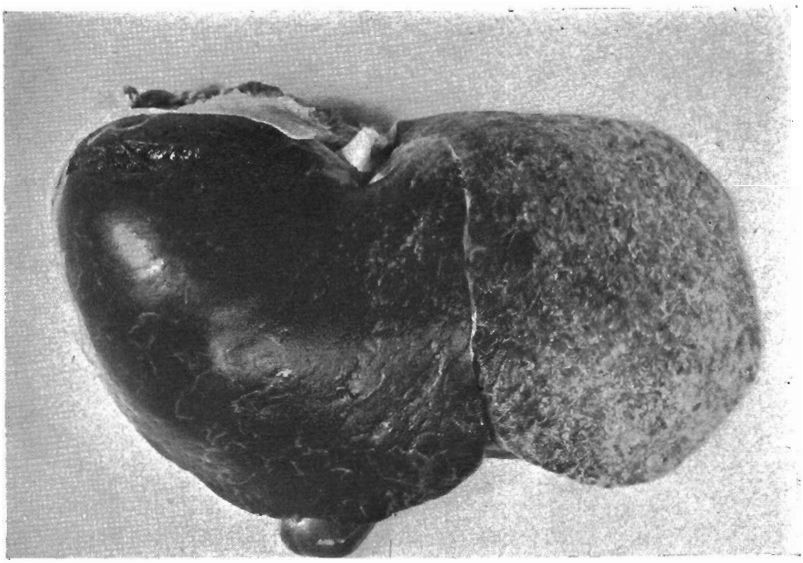

Figure 8. Appearance of livers condemned by packing plant as parasitic (immature liver fluke).

tagia, Haemonchus, and *Trichostrongyles* was 20, 40, and 3 times as heavy, respectively, in ill-fed lambs as it was in well-fed lambs. Taylor[5] has observed that wet ground and long herbage are more important for the development of parasites than short herbage. This has been contrary to our observations, but might be true as far as clover is concerned. The clover leaflets perhaps furnish some shelter for larval parasites that would not be provided by the short blades of grass.

The number of lambs involved in these experiments was not as large as desirable, but the pastures available for use would not have supported any larger number of animals. It is also quite possible that lambs free from parasites would have made proper gains if allowed to use the pastures before they were contaminated with droppings from other sheep. It was believed that the lambs used in this experiment should have developed some degree of immunity. Taylor[6] has shown that gradually acquired infestation leads to fairly well-established immunity after four months. This immunity, according to him, is not so powerful for the species of worms that seem to cause most of the trouble in the lambs in these experiments. Since these lambs were placed on infested pastures early in life, it was thought that they would gradually be infested. It is also possible that close confinement to small acreages was responsible for an overload of parasites. It is planned that lambs to be used in this work next year will be obtained from worm-free sources or sources comparatively free from the parasites involved. Some of these lambs may have been underweight at the start, as a result of lack of milk production by their ewes. The difference in size of lambs was not explained by the difference in lambing times. Some of the later lambs apparently obtained more milk, made faster gains and weighed more than some of the earlier lambs. This could be avoided in the future by culling ewes according to the amount of milk produced. Age in case of some of the older ewes was doubtless responsible for some of the smaller lambs. Another reason for a great difference in size of lambs involved was that many were twin lambs.

The worms responsible for most of the trouble were those that are very commonly found in Oregon sheep and the observations made on the lambs on these pastures compare favorably with observations made on lambs throughout the Willamette Valley. In most cases where losses have been reported in July, the *O. circumcincta* has been apparently responsible. This particular worm seemed to increase in numbers in the experimental lambs before the *Trichostrongyles* that were found in the intestine. This can no doubt be explained by their life histories.

An effort was made to keep the methods used in these experiments as practical as possible and comparable with the methods that might be employed by the small-flock owner. It is realized that the area of land involved would not equal that of the average farm owner in the Valley, but it has been observed on privately owned, irrigated plots that in a great many cases only a small amount of land actually was used in the beginning. It is possible, also, that too many animals were used in accordance with the amount of land involved, but this does not seem true according to the amount of forage produced, since the lambs at no time were able to consume all of the available clover. Closer studies of the pathology produced in the lambs should have been made. It is entirely possible that blood studies would have indicated when the worm load was reaching a maximum. More time should also have been spent in studying the clover leaflets for the presence of larval worms. A different method of determining pasture infestation could have been used.

Treatment did not seem to give results, which was not at all surprising. The lambs were thin, some were very weak; and it was realized that a maximum dose of any worm remedy might have increased the losses. The smaller doses used had no apparent effect. It is difficult to believe that any remedy, regardless of its efficiency, would overcome the effects of the parasites in these lambs. In many instances their body weight was less than half of what it should have been, and even with a remedy 100 per cent effective it seems hardly possible that they would make the necessary gains. If the lambs had been treated before clinical symptoms had developed, the results might have been entirely different.

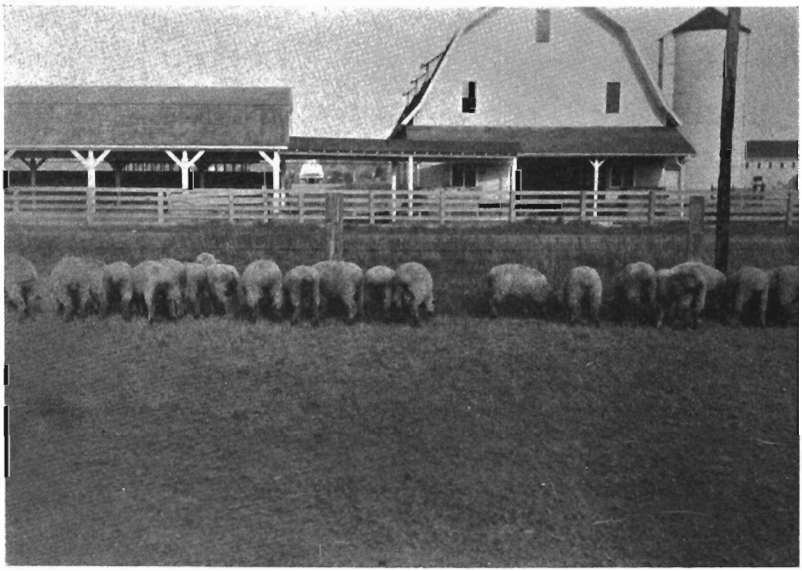

Figure 9. Appearance of lambs at the end of feeding period.

SUMMARY

1. Only 8 out of 95 lambs became fat in 126 days on irrigated ladino clover pastures.
2. Supplements of wheat and barley were used.
3. A death loss of 17 lambs resulted from parasitism.
4. Worm load estimates average 7,856 for 14 stomachs and 14,091 for 13 intestines.
5. The parasites mainly responsible were the small stomach worm, *O. circumcincta*, and the small intestinal worm, *Trichostrongyles*.
6. Other parasites found were eastern stomach worm, *H. contortus*, *Strongyloides papillosa*, *Bunostomum trigonocephalum* (hookworm), *Nematodirus filicollis*, *Chabertia ovina*, *Trichuris ovis*, *Monezia sp.* (tapeworm), and *Dictyocaulus filaria* (lungworm).
7. Symptoms shown were extreme loss of weight, scouring, and thirst.
8. No bloat was observed.
9. Treatment after clinical symptoms appeared was not successful.

REFERENCES

1. SHAW, J. N., MUTH, O. H., SEGHETTI, L. (1939) Pulpy Kidney Disease in Oregon Lambs. Ore. Exp. Sta. Bul. 367.

2. MONNIG, H. O. (1934) *Veterinary Helminthology and Entomology*, Bailliere, Tindall and Cox, London. p. 189.

3. TAYLOR, E. L. (1939) Technique for the Estimation of Pasture Infestation by Strongyloid Larvae. *Parasitology* 31, 473-478.

4. FRASER, A. H. H., THOMSON, W., ROBERTSON, D., and GEORGE, W. (1939) Nutritional Condition of Lambs and Their Susceptibility to Artificial Infestation. *The Veterinary Journal* 95, No. 10, 406-412.

5. TAYLOR, E. L. (1934) The Epidemiology of Parasitic Gastritis in Sheep. *Journal of Agricultural Science* 24, Part 2, 192-208.

6. TAYLOR, E. L. (1934) Field Experiments on the Immunity of Lambs to Parasitic Gastritis Caused by a Mixed Infection of Trichostrongylid Nematodes. *Journal of Helminthology* 12, No. 3, 143-164.

OREGON STATE BOARD OF HIGHER EDUCATION

R. E. Kleinsorge ..... *Silverton*
Beatrice Walton Sackett ..... *Marshfield*
C. A. Brand ..... *Roseburg*
E. C. Sammons ..... *Portland*
Robert W. Ruhl ..... *Medford*
Edgar William Smith ..... *Portland*
Willard L. Marks ..... *Albany*
R. C. Groesbeck ..... *Klamath Falls*
Mac Hoke ..... *Pendleton*
Frederick M. Hunter, Ed.D., LL.D. ..... Chancellor of Higher Education

STAFF OF AGRICULTURAL EXPERIMENT STATION

*Staff members marked * are United States Government investigators stationed in Oregon*

Francois Archibald Gilfillan, Ph.D. ..... Acting President of the State College
Wm. A. Schoenfeld, B.S.A., M.B.A. ..... Director
R. S. Besse, M.S. ..... Assistant Director
Esther McKinney ..... Accountant
Margaret Hurst, B.S. ..... Secretary

Division of Agricultural Economics

E. L. Potter, M.S. ..... Agricultural Economist; In Charge, Division of Agricultural Economics

Agricultural Economics

W. H. Dreesen, Ph.D. ..... Agricultural Economist
D. B. DeLoach, Ph.D. ..... Agricultural Economist

Farm Management

D. C. Mumford, M.S. ..... Economist in Charge
G. W. Kuhlman, Ph.D. ..... Associate Economist
H. L. Thomas, M.S. ..... Associate Agricultural Economist, Conservation Economic Division, Soil Conservation.*
J. C. Moore, M.S. ..... State Representative, Division of State and Local Planning, Bureau of Agricultural Economics*
G. B. Davis, B.S. ..... Research Assistant (Farm Management)

Division of Animal Industries

P. M. Brandt, A.M. ..... Dairy Husbandman; In Charge, Division of Animal Industries

Animal Husbandry

R. G. Johnson, B.S. ..... Animal Husbandman
O. M. Nelson, M.S. ..... Animal Husbandman
A. W. Oliver, M.S. ..... Associate Animal Husbandman
B. W. Rodenwold, M.S. ..... Assistant Animal Husbandman

Dairy Husbandry

G. H. Wilster, Ph.D. ..... Dairy Husbandman
I. R. Jones, Ph.D. ..... Dairy Husbandman
H. P. Ewalt, B.S. ..... Research Assistant (Dairy Husbandry)
R. E. Stout, M.S. ..... Research Assistant (Dairy Husbandry)†
John H. Byers, M.S. ..... Research Assistant (Dairy Husbandry)

Fish and Game Management

R. E. Dimick, M.S. ..... Wildlife Conservationist in Charge
F. P. Griffiths, Ph.D. ..... Assistant Conservationist*
A. S. Einarsen, B.S. ..... Associate Biologist, Bureau of Biological Survey*
Jay B Long, B.S. ..... Research Assistant (Fish and Game Management)
Harvey D. Ronne, B.S. ..... Research Assistant (Fish and Game Management)

Poultry Husbandry

H. E. Cosby ..... Poultry Husbandman in Charge
C. E. Holmes, Ph.D. ..... Associate Poultry Husbandman
W. T. Cooney, B.S. ..... Research Assistant (Poultry Husbandry)

Veterinary Medicine

J. N. Shaw, B.S., D.V.M. ..... Veterinarian in Charge
E. M. Dickinson, D.V.M., M.S. ..... Veterinarian
O. H. Muth, D.V.M., M.S. ..... Associate Veterinarian
R. W. Dougherty, D.V.M., M.S. ..... Assistant Veterinarian
A. S. Rosenwald, B.S., D.V.M. ..... Assistant Veterinarian
M. P. Chapman, D.V.M. ..... Research Assistant (Veterinary Medicine)
K. S. Jones, D.V.M. ..... Research Assistant (Veterinary Medicine)
W. R. Jones, D.V.M. ..... Junior Veterinarian, Bureau of Animal Industry*

† On leave.

STATION STAFF—(*Continued*)

Division of Plant Industries

G. R. Hyslop, B.S.....Agronomist; In Charge, Division of Plant Industries

Farm Crops

H. A. Schoth, M.S.....Agronomist; Division of Forage Crops and Diseases*
D. D. Hill, Ph.D.....Agronomist
R. E. Fore, Ph.D.....Associate Agronomist*
L. E. Harris, M.S.....Associate Agronomist
H. H. Rampton, M.S.....Assist. Agronomist (Division of Forage Crops and Diseases)*
H. E. Finnell, M.S.....Assistant Agronomist
Elton Nelson, B.S.....Agent, Division of Cotton and Other Fiber Crops and Diseases*
Louisa A. Kanipe, B.S.....Junior Botanist, Division of Seed Investigations*
L. R. Hansen, M.S.....Research Assistant (Farm Crops)
Henry R. Fortmann, B.S.....Research Graduate Assistant (Farm Crops)

Food Industries

E. H. Wiegand, B.S.A.....Technologist in Charge
T. Onsdorff, M.S.....Associate Technologist
E. W. Harvey, Ph.D.....Assistant Technologist
H. S. Madsen, B.S.....Assistant Technologist

Horticulture

H. Hartman, M.S.....Horticulturist (Pomology) In Charge
W. S. Brown, M.S., D.Sc.....Horticulturist
A. G. B. Bouquet, M.S.....Horticulturist (Vegetable Crops)
C. E. Schuster, M.S.....Horticulturist (Division of Fruit and Vegetable Crops and Diseases)*
W. P. Duruz, Ph.D.....Horticulturist (Plant Propagation)†
G. F. Waldo, M.S.....Associate Pomologist (Division of Fruit and Vegetable Crops and Diseases)*
E. Hansen, M.S.....Assistant Horticulturist (Pomology)
A. N. Roberts, M.S.....Research Assistant (Horticulture)

Soil Science

W. L. Powers, Ph.D.....Soil Scientist in Charge
C. V. Ruzek, M.S.....Soil Scientist (Fertility)
M. R. Lewis, C.E.....Irrigation and Drainage Engineer, Soil Conservation*
R. E. Stephenson, Ph.D.....Soil Scientist
E. F. Torgerson, B.S.....Associate Soil Scientist (Soil Survey)
J. M. Haley, B.S.....Assistant Irrigation Engineer, Cooperative Agent, Soil Conservation Service*
A. W. Marsh, M.S.....Research Graduate Assistant (Soils)
H. E. Dregne, M.S.....Research Graduate Assistant (Soils)

Agricultural Chemistry

J. S. Jones, M.S.A.....Chemist in Charge
R. H. Robinson, M.S.....Chemist (Insecticides and Fungicides)
J. R. Haag, Ph.D.....Chemist (Animal Nutrition)
D. E. Bullis, M.S.....Associate Chemist
P. H. Weswig, Ph.D.....Assistant Chemist

Agricultural Engineering

F. E. Price, B.S.....Agricultural Engineer in Charge
W. M. Hurst, M.A.....Agricultural Engineer, Bureau of Agricultural Chemistry and Engineering*
H. R. Sinnard, M.S.....Associate Agricultural Engineer (Farm Structures)
C. I. Branton, B.S.....Assistant Agricultural Engineer†
G. R. Stafford.....Engineering Aid, Bureau of Agricultural Chemistry and Engineering*
H. F. Carnes, B.S.....Junior Agricultural Engineer, Bureau of Agricultural Chemistry and Engineering*
L. M. Klein, B.S.....Mechanical Engineer, Bureau of Agricultural Chemistry and Engineering*

Bacteriology

G. V. Copson, M.S.....Bacteriologist in Charge
J. E. Simmons, M.S.....Associate Bacteriologist
W. B. Bollen, Ph.D.....Associate Bacteriologist
Carl Lamanna, Ph.D.....Research Assistant (Bacteriology)

Entomology

D. C. Mote, Ph.D.....Entomologist in Charge

† On leave of absence.

STATION STAFF—(*Continued*)

B. G. Thompson, Ph.D.....Associate Entomologist
S. C. Jones, M.S.....Associate Entomologist
K. W. Gray, M.S.....Associate Entomologist
Joe Schuh, M.S.....Assistant Entomologist
H. E. Morrison, M.S.....Assistant in Entomology

Home Economics

Maud M. Wilson, A.M.....Home Economist

Plant Pathology

C. E. Owens, Ph.D.....Plant Pathologist in Charge
S. M. Zeller, Ph.D.....Plant Pathologist
F. P. McWhorter, Ph.D.....Plant Pathologist*
B. F. Dana, M.S.....Plant Pathologist (Division of Fruit and Vegetable Crops and Diseases)*
F. D. Bailey, M.S.....Associate Plant Pathologist (Agricultural Marketing Service)*
P. W. Miller, Ph.D.....Associate Pathologist (Division of Fruit and Vegetable Crops and Diseases)*
G. R. Hoerner, M.S.....Agent (Division of Drug and Related Plants)*
John Milbrath, Ph.D.....Assistant Plant Pathologist

Publications and News Service

C. D. Byrne, Ed.D.....Director of Information
E. T. Reed, B.S., A.B.....Editor of Publications
F. L. Ballard, B.S.....Agricultural Editor of Publications
D. M. Goode, M.A.....Editor of Publications
J. C. Burtner, B.S.....In Charge of News Service

Branch Stations

L. Childs, A.B.....Superintendent, Hood River Branch Experiment Station, Hood River
F. C. Reimer, M.S.....Superintendent, Southern Oregon Branch Experiment Station, Talent
D. E. Richards, B.S.....Superintendent, Eastern Oregon Livestock Branch Experiment Station, Union
H. K. Dean, B.S.....Superintendent, Umatilla Branch Experiment Station (Division of Western Irrigation Agriculture), Hermiston*
H. B. Howell, B.S.....Superintendent, John Jacob Astor Branch Experiment Station, Astoria
G. A. Mitchell, B.S.....Superintendent, Pendleton Branch Station (Dry Land Agriculture), Pendleton*
M. M. Oveson, M.S.....Superintendent, Sherman Branch Experiment Station, Moro*
E. S. Degman, Ph.D.....Superintendent and Associate Pomologist, (Division of Fruit and Vegetable Crops and Diseases), Medford*
Kenneth C. Ikeler, M.S.....Superintendent, Squaw Butte-Harney Cooperative Range and Livestock Station (U. S. Grazing Service), Burns*
Obil Shattuck, M.S.....Assistant Superintendent, Squaw Butte-Harney Cooperative Range and Livestock Station, Burns
G. G. Brown, A.B., B.S.....Horticulturist, Hood River Branch Experiment Station, Hood River
Arch Work, B.S.....Associate Irrigation Engineer (Division of Irrigation), Medford*
L. G. Gentner, M.S.....Assistant Superintendent, Associate Entomologist, Southern Oregon Branch Experiment Station, Talent
J. F. Martin, M.S.....Assistant Agronomist (Division of Cereal Crops and Diseases), Pendleton*
R. E. Hutchison, M.S.....Assistant Agronomist, Squaw Butte-Harney Cooperative Range and Livestock Station, Burns
Lawrence R. Swarner, B.S.....Agent (Division of Fruit and Vegetable Crops and Diseases), Medford*
J. R. Kienholz, Ph.D.....Associate Pathologist (Division of Fruit and Vegetable Crops and Diseases), Hood River*
Joseph Belanger, B.S.....Cooperative Research Agent, Conservation Experiment Station (Division of Soil Conservation), Moro*
A. E. Gross, M.S.....Superintendent, Nematode Project, Klamath Falls
T. H. DeArmond, B.S.....Superintendent, Red Hill Soils, Experiment Area, Oregon City