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A. B. CONNER, DIRECTOR
COLLEGE STATION, BRAZOS COUNTY, TEXAS

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DIVISION OF VETERINARY SCIENCE

In cooperation with
THE BUREAU OF ENTOMOLOGY, UNITED STATES DEPARTMENT OF AGRICULTURE, AND THE LIVESTOCK SANITARY COMMISSION OF TEXAS

The Common Sheep-Scab Mite and its Control

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**In cooperation with U. S. Department of Agriculture.
‡In cooperation with Texas Extension Service.

†As of October 1, 1933

Common sheep scabies is a serious skin disease of sheep caused by a small mite, *Psoroptes ovis* (Her.). It is known to occur in practically all parts of the world. The mite lives and thrives upon the skin of sheep and spreads from animal to animal by direct contact or through infested quarters or range. It does not thrive on any other domestic animal or on man.

In experimental tests the time elapsing between artificial infestation and the appearance of first symptoms of scabies varied from 12 to 51 days. Where clean animals were in contact with scabby ones the appearance of scabies symptoms varied from 54 to 154 days.

In a series of 51 tests under the most favorable conditions off the host, the mites lived from 1 to 38 days (average, 12 days and 6 hours).

Direct sunlight at summer temperatures in Southwest Texas will quickly destroy sheep-scab mites removed from the host. They may be starved for at least 13 days and still produce scabies when placed on a sheep.

In pens from which scabby sheep had been removed infestation of clean sheep was obtained in three instances only. In one of these the clean sheep were introduced into the pen immediately after the scabby ones were removed; in the other two after 6 and 10 days respectively. Infestation of clean sheep occurred in only one of three trials in which clean sheep were put in the pens 10 days after the scabby sheep were removed. No infestation of the clean sheep occurred in two cases in which the pens were vacant for 15 days before clean sheep were introduced and none in other tests in which the interval was longer.

It is possible for young mites to hatch off the host and to infest sheep if they gain access to the animal not later than the 17th day after the parent mites are removed from the host.

The mite can be destroyed and scabies completely eliminated by thoroughly dipping the sheep twice, 10 days apart, in an aqueous nicotine sulphate solution containing at least 0.07 per cent of nicotine or a lime-sulphur solution containing at least 0.18 per cent of polysulphides. Finely divided sulphur in suspension, sodium fluoride, sodium silicofluoride, and commercial extract of derris root also seem promising when two or more dippings are used. It is dangerous to use arsenical cattle dip on sheep for this purpose, for in the strength which has to be used to kill the mites it may prove poisonous to the sheep.

CONTENTS

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THE COMMON SHEEP-SCAB MITE AND ITS CONTROL*

O. G. BABCOCK† AND W. L. BLACK††

The common sheep-scab mite, *Psoroptes ovis*, (Her.), is an important parasite of sheep in Texas, as well as in many other states. There has been no lack of effort to control and eventually eradicate this pest, but complete elimination of it from Texas and certain other states had not been accomplished at the time this work was undertaken. This important objective appears to have been reached in Texas in 1932, as the Livestock Sanitary Commision of Texas reports that not a single case of sheep scabies was found in the State during that year. The reasons for failure have not always been apparent, but many of the difficulties have been due to a lack of whole-hearted cooperation of sheep owners and all others concerned in eradication work, and the failure to take necessary precautions to keep scab out after it has been eradicated from a given State. The reappearance of scab in supposedly clean flocks led many sheep-men to question the efficacy of the methods in vogue or to claim that the scab mite lived for long periods in pastures or corrals, and a further study of the life history and habits of the mite and their bearing on eradication procedure was requested.

Sheep scab is distributed over the greater part of the world. We read of it in the writings of Cato the Censor, about 180 B. C., and many times since it has been mentioned by other writers. According to Miller (10) Abildgaard proved, in 1787, that sheep scab could be cured by applying insecticides externally, but it was not until 1809 that Walz first demonstrated that mites were the cause of three kinds of sheep scabies.

The common sheep-scab mite attacks practically the entire surface of the animal, causing large areas of wool to be shed, pulled, or rubber off, sometimes until the animal is entirely denuded of wool. Two other species of mange mites, the head-scab mite (*Sarcoptes scabiei* var. *ovis* Megnin), and the foot-scab mite (*Chorioptes ovis* Railliet) attack sheep. The head-scab mite prefers areas where there is no wool, and is apparently confined to the head. Foot scab is caused by a much smaller mite than the head-scab mite; it is confined mainly to the hind legs, but the area about the udder is occasionally infested. The investigations reported in this Bulletin, however, are concerned solely with the common sheep-scab mite (*Psoroptes ovis*), which causes the common form of sheep scabies.

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*At the request of the Livestock Sanitary Commission of Texas, through J. E. Bogg-Scott, Chairman, and J. H. Rasco, Chief Scabies Inspector, this investigation was begun at Substation No. 14, Sonora, Texas Agricultural Experiment Station, early in 1924 under a cooperative agreement participated in by the Bureau of Entomology, U. S. Department of Agriculture, the Texas Agricultural Experiment Station, and the Livestock Sanitary Commission of Texas. The senior author was connected with the investigation through its course. The junior author was active in the investigation while he was veterinarian at Substation No. 14, from September 1, 1926, to January 1, 1928.

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IDENTIFICATION OF THE MITE

The adult of the common sheep-scab mite (Fig. 1) can be identified under the microscope by two characters which distinguish it from other sheep-

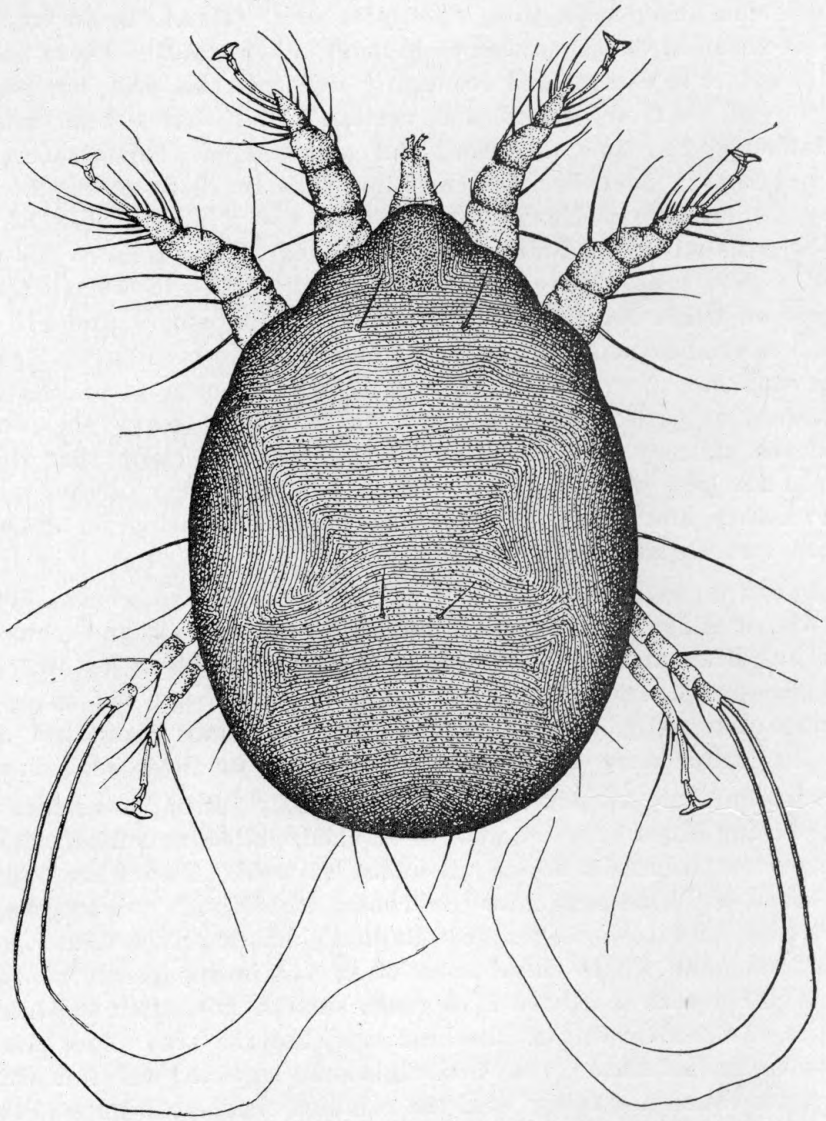

Figure 1—The common sheep-scab mite (Psoroptes ovis), female. Dorsal view, greatly enlarged. (After Salmon and Stiles, 1898.)

scab mites, namely, the presence of three-jointed pedicles (that portion of the leg just preceding and including the foot suckers) and of a pair of long silky hairs on each of the third pairs of legs.

The following synoptic key will aid in distinguishing the three species:

Psoroptes ovis, causing body scabies, or common scabies: Pedicles three-jointed. Male: Suckers on first three pairs of legs. Length, 0.45 mm. or

442.8 microns; width, 0.35 mm. or 344.40 microns (1). Female: Suckers on first two pairs and on fourth pair of legs. Length, 0.61 mm. (600.24 microns) to 0.65 mm. (639 microns); width, 0.38 mm. (373.92 microns) to 0.41 mm. (403.44 microns) (1). Hairs on third pair of legs nearly as long or as long as entire body. Copulatory tubercules at apex of abdomen. Adult somewhat brownish in color as it grows older.

Chorioptes ovis, causing foot scab: Mite very small. Pedicles two-jointed. Hairs on third pair of legs one-fourth longer than length of body.Mites usually present on legs, feet, udder, ears, and neck of sheep.

Sarcptes scabiei ovis, causing head scab: Mite somewhat globular. Pedicles one-jointed. Hairs of third pair of legs of female approximately one-half the length of the body. Generally found on head of sheep. Prefers any part of body free from wool. Approximately half size of common scab mite. Females burrow into the skin, where they deposit eggs.

LIFE HISTORY

Gerlach (5, p. 124) stated that it is hard to determine the number of eggs deposited by the female of the common sheep-scab mite, but estimates it to be about 15. Shilston (14) found that 24 eggs may be deposited in two days or 76 within ten days. Stockman and Berry (16) confirm the observations of Gerlach that the average number of eggs laid is about 15. They are, nevertheless, of the opinion, as the result of numerous observations, that this number may be considerably exceeded, in some cases rising to more than 30. (Stockman (15) reported that the scab mites do not lay eggs at a temperature that is not incubative.

According to Shilston (14), when the eggs are placed next to the animal's skin, they hatch in about two days; usually all the eggs are hatched by the end of the third day, but they have never been observed to hatch in less than two days. Shilston also noted that, when tied in a lock of long wool fibers two inches away from the skin at atmospheric temperatures between 60° and 100° F. in the shade, the eggs hatched in from six to eight days. Gerlach (5, p. 122) recorded from three to four days as the incubation period. Stockman (15), however, gave a record of incubation varying from four to six days, and concluded that viable eggs are unlikely to hatch much later than the sixth day.

From eggs of scab mites carried in a vial in his pocket, Gillette (6) obtained incubation records varying from five to nine days. He also gives records on the incubation of 76 eggs kept out of doors. These eggs were exposed to various temperatures from 11.8° to 37° F. for periods of one to thirty-five days. His results showed that the eggs can withstand a temperature of 8.3° F. and still hatch when returned to a warm place.

It is obvious from the foregoing records that the incubation of the eggs depends directly upon the temperature. Undoubtedly it is also influenced to some extent by moisture. In nature the eggs are invariably deposited upon the healthy skin adjacent to the scabby area. In such a

location the skin is warm and tender and the wool fibers afford protection to the eggs.

From these tiny, elliptical, pearly-white eggs minute six-legged larvae hatch and quickly begin to feed and grow. According to Gerlach (5, p. 123) they become eight-legged mites after three or four days and develop to maturity in eight days without molting. He also disputes (5, p. 124) the claims of Bourgignon and Delafond that the young mites molt several times. Regarding molting in mites in general, Gerlach states that, according to Bourgignon, female *Sarcoptes hominis* (*S. scabiei* var. *hominis* Raspail), as well as females of all mange mites, molt three times but the males only once (5, p. 37). According to Shilston (14) and Bedford (1), both the female and the male molt as larvae to become nymphae and then both molt as nymphae to become adults. Mating follows and after this the female molts a third time before depositing her eggs. The mites are inactive just before molting. This inactivity is so marked that the mite appears to be dead and can hardly be induced to move or to show any signs of life. This inactive or resting stage may last from one to several days. Gerlach (5, p. 124) found that the life cycle of this mite from egg to egg required fourteen or fifteen days, but according to Shilston (14) this period occupies only nine days and rarely ten.

According to Gerlach (5, p. 124) the proportion of males to females is 1 to 5. This proportion is misquoted as being 1 to 2 by Shilston (14), who found that "the females are more often three or occasionally four times as numerous as males."

Gerlach (5, p. 123) removed mites from an animal 15 days after one pregnant female mite had been transferred to it. The same author quotes Hertwig as finding 5 young mites 14 days after transferring a fertilized female mite to a sheep. In another test by Stockman (15), in which living mites were stored 12 days before being transferred to a healthy animal, the scab developed after 4 days, and 9 days afterwards the mites were found reproducing.

GOATS DO NOT CARRY SHEEP SCABIES

According to Gerlach (5) the common sheep-scab mite does not thrive on any other domestic animal or on man. The authors' observations substantiate those of Gerlach.

The possibility of the Angora goat acting as a carrier and transmitter of sheep-scab mites is an important question in districts where both sheep and goats are kept on the same range. Gerlach (5, p. 132) has reported that he has repeatedly transferred sheep-scab mites to goats but always with negative results. He has also observed that when three goats and five very scabby sheep were confined in the same stall for three months the goats remained healthy. Shilston (14) has shown that the sheep-scab mite would not thrive in the ear of the goat.

In order to determine whether goats contract sheep scabies or whether they would act as mechanical carriers of sheep-scab mites from scabby

sheep to clean sheep, several goats were placed in a pen with scabby sheep and left in association with them for one to six months, at the end of which time they were taken out and placed in clean pens with clean sheep. Fifteen such tests were made, but every one proved negative, thus indicating that sheep scabies is rarely, if ever, carried by Angora goats from scabby sheep to clean sheep, and that the goats do not contract sheep scabies. During the progress of these studies, goat scabies was encountered, the causative agent being *Chorioptes caprae* Gervais and Beneden, a mite associated specifically with the goat.

SYMPTOMS OF SCABIES

The careful observer of a flock of sheep may detect the action of one or more animals as not being normal. If the wool appears a little rough, and the animal bites itself persistently or rubs and scratches itself, one may suspect that scabies is present in the first stages. At this stage of the disease small pinpoint red spots, nodules, vesicules, and pustules may be found on the skin of the animal; later small yellow scabs will form as the fluid exuding from the irritated skin dries. This irritation and the consequent licking, scratching, rubbing, or biting finally results in a loss of wool over the areas affected, indeed sometimes the loss of all wool. When these lesions are found one may be assured that scabies is present, and if, upon further examination, the mite is found the disease is then definitely diagnosed.

DISTRIBUTION OF SCABIES ON THE HOST

The normal habitat of the sheep-scab mite is the skin of the animal, but sometimes the living mite is found on the wool fibers. Although it is generally believed that common sheep scabies is found only on the body, careful examination of many animals did not bear this out. The disease breaks out on the body or legs and in a few months spreads over the animal. The head becomes infested and sometimes very scabby and more or less bare of wool. Common scab mites have been found in large numbers upon the heads of Merino and Rambouillet sheep.

The mites do not scatter all over the animal's body. However, as they feed upon the skin, causing inflammation and the formation of scabs, the infested area soon becomes unsuitable as a feeding ground, and the mites are forced to the edge of the old scabs and thus spread to the healthy skin. On one sheep, which was half denuded of wool, the authors observed active mites from the neck to the hind legs. This row of mites was located on the healthy skin just outside the scabby area and among the wool fibers. In the course of time this animal lost all its wool (Fig. 2). After this stage was reached, scabies apparently died out and the animal grew a new coat of wool but later again manifested symptoms of the disease.

DORMANT PERIOD OF THE SHEEP SCAB MITE

There are times when scabies seems to die out in the flock, but in reality it is only inactive. Its recurrence after such a dormant period is therefore a surprise to sheep raisers. This has also been a puzzling matter to inspectors, and has caused considerable controversy and hampered the determination of the length of the quarantine period. Since during this inactive period there is little, if any, irritation from the mites, it is difficult to detect scabby animals at such a time.

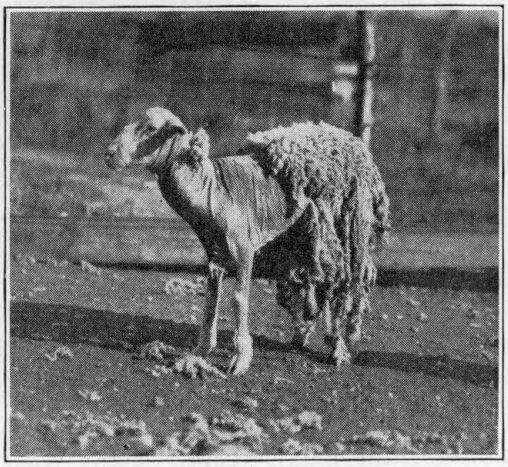

Figure 2—An extreme case of sheep scabies. This animal eventually became entirely denuded of wool.

Stockman (15) observed that there were periods when scabies did not manifest itself. In one of his dipping experiments scabies did not break out until seven months after his animal had been dipped.

The first experiment recorded in Table 1 is an interesting illustration of such dormant periods. One grown sheep was placed inside a screened house having three sides and the roof lined with tar paper. The roof contained a ventilator. This animal was treated to remove stomach worms and later, on December 13, 1924, a number of sheep-scab mites and freshly collected scabs were placed upon the right shoulder. Winter weather followed within a few days, and symptoms of scabies did not develop until the 78th day after infestation (Fig. 3). By the 80th day the animal was restless, scratching and rubbing all day and all night, and by the 82nd day it had pulled out the wool over an area of 4 inches in diameter. On the 84th day a scab three-fourths of inch in diameter was present and many living and dead mites were found in it. Intense irritation developed on the same day and the animal was very restless, but 21 days later irritation had ceased. During the next 15 days, or from the 101st to the 116th day, new areas of scab gradually developed with only a slight irritation, but from the 116th to the 123rd day there was an increase in the irritation. From the 124th to the 128th day practically all irritation had ceased. The original area of scab was then covered with a new growth of wool three-eighths of an inch long (Fig. 4), but a new diseased area was

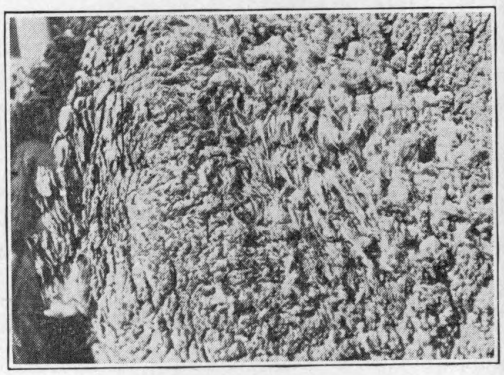

Figure 3—Area of initial stages of sheep scabies, where animal has been licking wool.

just beginning to develop thereon. A heavy rain during the next 3 days caused temporary increase in irritation. By the 139th day there was a severe outbreak of scabies on the left shoulder and side, which soon made the area bare. This severe outbreak lasted for 8 days and then irritation decreased, and from the 248th day after infestation there was no sign of scabies until the 315th day, when scabies broke out again at the base of the tail. Again from the 492nd day to the 596th day but little irritation was apparent and the animal gained rapidly in weight. From the 596th day to the 780th day, there was no sign of scabies, but by the 789th day it had again become fully established (Fig. 5). The observations were then discontinued and the animal was used in a dipping test.

Figure 4—Scabby sheep showing new growth of wool over healed area of shoulder and more recently developed area of scabies over loin and right side.

There were leaks in the roof of the screened house where this animal was kept; hence whenever it rained the animal received a partial soaking. The sudden outbreaks of scabies followed each rainy spell that lasted for several days indicate that there must be a reliationship between moisture and egg deposition. This experiment also shows that the development of scabies is not continuous, but is interrupted by varying intervals of inactivity, and that scabies may not die out on the individual animal for at least two years. F. C. Bishopp reported, however, that he kept a scabby animal in Dallas, Texas, under similar circumstances, under the observation of the Livestock Sanitary Commission, and that scabies died out completely in a year's time.

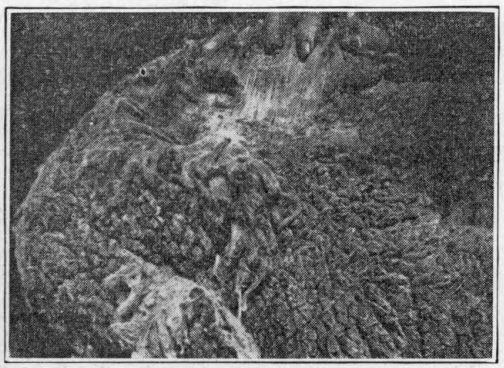

Figure 5—Scabby area on sheep 789 days after artificial infestation.

INTERVAL BETWEEN INFESTATION OR EXPOSURE AND APPEARANCE OF SYMPTOMS OF SCABIES

In order to find out how long it takes for scabies to develop, sheep were infested artificially either with scabs containing eggs or with a definite number of live female mites. The results are recorded in Table 1. The infestations or exposures were made at different seasons of the year in order to cover different weather conditions. With one exception (sheep infested March 30, 1928), the scabs or mites were taken from an infested

sheep and placed upon a clean sheep as soon as collection was completed. In all tests but one where mites or scabs were transferred to animals, two sheep were used. The mites and scabs were divided about

Table 1. Interval between infestation or exposure of sheep and the appearance of symptoms of scabies. Animals in long wool except as noted.

Date of infestation or exposure	Sheep Number	Method of exposure	Appearance of first symptoms after exposure Days
1924			
December 13	1	Contact with scabby animal	78
1926			
December 15	2	10 mites	43 to 51
December 15	2	Scabs	43 to 51
1927			
April 23	22	One freshly shorn sheep in contact with 21 scabby ones	54
December 3	2	27 mites	38
December 3	2	Scabs	12
December 23	2	3 mites	18 to 33
December 23	2	Scabs	33
1928			
March 30	2	26 mites starved for 13 days before being placed on animal	20
April 10	2	Mites	Scab failed to develop after 76 days
April 12	24	Twenty-two clean sheep in contact with two scabby ones	154
June 13	1	5 mites	Scab failed to develop after 92 days
June 13	2	Scabs	*Do*

equally between the two sheep and the animals were kept in the same pen. The mites or scabs were put next to the skin in the long wool. The time elapsing between these artificial infestations and the appearance of the first symptoms of scabies varied considerably in the different pens, the two extremes found being 12 and 51 days. Where clean animals were in contact with scabby sheep, the scabies symptoms appeared within 54 to 154 days after exposure. In a few cases scabies did not develop, but the two lots of animals in question were kept under observation for only 76 and 92 days, respectively. In the light of later experience this period of observation may have been too short.

In two tests where infestations with eggs in scabs and with female mites were run parallel, no difference was found in the time between infestation and appearance of the first symptoms of the disease. In another test, however, the disease became manifest after twelve days where scab infestation was practiced, but not for thirty-eight days where mites were used. These three experiments were made in the month of December, though in different years.

An interesting case of exposure such as often occurs in nature is recorded in Table 1. A badly infested sheep having wool fibers that varied in length from one inch to two inches was put in a clean pen with twenty-two clean sheep having wool of the same variation in length on April 12. In this pen ample shade was provided for the animals at all times. Symptoms of scabies were not observed in any of the exposed sheep until the middle of September, or after 154 days. At the time it was placed in the pen the infested animal had areas that were bare of wool and scab mites were readily detectable. In the course of the experiment, however, new wool grew over these bare areas, and upon repeated careful examination scab mites could no longer be detected. This corroborates the many field observations that scab mites may be present in a flock of sheep for a long time before the animals show any signs of scabies.

In the experiments recorded above two breeds of sheep, Merino and Rambouillet, were used. No uniform difference between the time of infestation and the appearance of the first symptoms of scabies could be observed in the two breeds.

On September 29, 1926, a 70-pound Corriedale sheep was placed in a pen with a number of scabby sheep. After about twenty-nine days scabies was well developed on this animal. About thirty days later most of the wool was gone from the left hind leg, which was sore from rubbing and scratching, and the wool was also beginning to come off the right hind leg. The sheep was in a very unhealthy and scabby condition.

IRRITATION IN SCABBY SHEEP

Scabby sheep resort to biting, scratching, and rubbing more often than to tongue play. The animal responds to the irritation quickly, biting the irritated area with vigor and usually pulling out a strand of wool. Sometimes the hoofs are used for scratching and with similar results, but if a tree or post is near at hand the animal is very likely to resort to rubbing. The time consumed in rubbing is generally longer than in biting or scratching, but rubbing is resorted to less often. Tongue play is simply a very slight response to irritation that is not severe enough to cause the animal to bite, scratch, or rub. The sheep simply turns its head towards the irritated area and then works its tongue rapidly as though it wanted to lick or bite the area.

In order to determine just how much time the animal consumed in reacting to the irritation of scab-mite infestation two extended observations were made, one on a severely infested sheep and the other on a sheep with a moderate infestation. The data obtained during a period of observation covering approximately 14 hours show that the animal occupied 3,420 seconds, or 6.87 per cent of the time, in reactions to the irritation. Of this, scratching occupied 44.71 per cent, biting 35.26 per cent, rubbing 17.81 per cent, and tongue play 2.22 per cent. This animal had a severe case of scabies. In another animal with a moderate infestation, a continuous record was made for 24 hours. It was found that rubbing occupied

45.99 per cent of the total time engaged in responding to the irritation, scratching 45.34 per cent, biting 6.88 per cent, and tongue play 1.79 per cent. A total of 1,061 seconds, or 1.22 per cent, was consumed by the animal in responding to irritation during the 24-hour period. Although these observations were made on sheep in isolated pens, it is thought that under range conditions nearly as much time would be consumed in reacting to the irritation.

Sheep ranchmen believe that the animal responds more to scab irritation towards evening than at any other time of the day. There seems to be some foundation for this. In the case of the moderately infested sheep it was observed that while the animal was very quiet, from 1 a.m. until 7 a.m., the other animals of the flock in the same pen were also very quiet. During the quiet period just after midnight, practically all of the animals were lying down, sleeping or resting. It was also noted that while the animals were being fed they would stop feeding to bite or scratch. In the case of the severely infested animal the greatest amount of irritation occurred from 7 to 9 p.m. and from 5 to 11 a.m., in the milder case of scabies from 3 to 5 p.m. and from 11 p.m. to 1 a.m.

It thus appears that the detrimental effect of scabies upon the animal is not due directly to the time consumed in responding to irritation. It is due mainly to the changes in the skin which at times, depending upon the severity of the case, greatly hinder its functions. The effect upon the nervous system of infested animals is manifested by their irritability.

INDIVIDUAL RESISTANCE TO SCAB MITES

All animals do not show the same degree of scabbiness or irritation. Some animals under test in pens grossly infested with sheep-scab mites where they were continually subjected to reinfestation by contact with other scabby sheep, were never observed to shed their wool, although their skin was scabby, whereas other animals were entirely denuded of wool, even on the head.

LONGEVITY OF THE SHEEP-SCAB MITE OFF THE HOST

There seems to be an opinion prevailing among sheep ranchmen and many inspectors that the scab mites may live for months, and even years, in corrals where there are no sheep and still be able to infest a clean animal. In the report of the Nevada State Sheep Commission (17) for 1920 a case is described in which three bucks became infested in a corral that had been vacant for five years, and the commissioners assumed that the sheep-scab mites lived in the vacant pens for that length of time. Reports of similar instances covering periods varying from one to six months are not uncommon but without definite proof.

Dill (3) states that during the hot, dry months the mites may live off the host on the range for 30 to 40 days and that under cool, damp conditions in stables, corrals, etc., protected from the sun, they may live

for years. Shilston (14) found that male mites, after reaching maturity, lived on the host for periods varying from 22 to 34 days, but when adult females were removed from the host and kept under favorable conditions, they lived 16 to 20 days.

du Toit (4) showed that corrals infested with scab mites were safe and free from the mites 17 days after scabby animals had been removed. Clean sheep placed in such corrals and left there for one year failed to develop scabies.

Stockman (15) transferred 56 samples of scabs, eggs, and mites to an incubator and kept them there at a temperature of 25° C. (77: F.). Under such controlled conditions two mature mites lived 30 days, but none of the eggs hatched. He also collected scabby fleeces, stored them for a month, and then transferred them to sheep by tying them upon their bodies. Although some mites were still alive in these fleeces, in all 10 attempts scabies failed to develop. In other experiments he confined healthy animals to scabby pens. He found that "In relation to the slow progress of the disease it may be said that, although it usually progresses slowly in sheep infected with a small number of mites, it does not follow that gross infestation always brings about a rapid development."

Stockman (15) conducted three other longevity tests in which, among healthy animals infested with living mites, scabies broke out in 77, 47, and 168 days, respectively. In another experiment with two lots in which he infested sheep with living mites, scabies did not break out for five and seven months, respectively. Gillette (6) stated that he was able to keep sheep scab mites alive off the host for 20 days. According to Oppermann (12, p. 167) Guenther was able to infest sheep with mites that had been kept in a cold room for eight weeks, wrapped in paper.

To test the longevity of the sheep-scab mite off the host, the mites were collected from scabby sheep and kept under different environmental conditions. Known numbers of the mites were placed on a small tag of wool containing no scab, and this wool was then put into a container. They were examined daily until they died.

At first the mites were confined in glass tubing, but this was found to be unsuitable, as too much moisture collected on the glass. Pasteboard pill boxes were satisfactory for this purpose except for the fact that termites would eat ther way into them and destroy the mites. By placing the pill boxes inside of tin boxes, however, this difficulty was overcome. Some of these containers were kept in the insectary under what seemed to be most favorable conditions, and others out of doors and at times exposed to the direct rays of the sun under as unfavorable conditions as might be met in nature.

Under Favorable Conditions

In the insectary the variation of temperature was slight, from 70° to 80° F. The containers were always in the shade and the mites in them always in the dark. Under these conditions the mites lived from 1 to 38 days, with an average (for 51 tests) of 12 days and 6 hours. Out

of 640 mites used in these tests only 1 mite survived longer than 21 days, 3 died on the 21st day, 8 on the 20th day, 10 on the 19th day, 4 on the 18th day, 1 on the 17th day, 6 on the 16th day, 9 on the 15th day, and 36 on the 14th day. The number of mites living for 15 days or longer was 36, or 5.6 per cent, and only 4, or 0.6 per cent, lived more than 20 days (Fig. 6). These tests indicate that the mites perish soon after they are removed from the host and that reports of a survival period of months are incorrect.

It is believed by some that scabby sheep sometimes secrete themselves in caves and die there, and that even months later other sheep visiting these caves, pick up surviving scab mites. This explanation has been

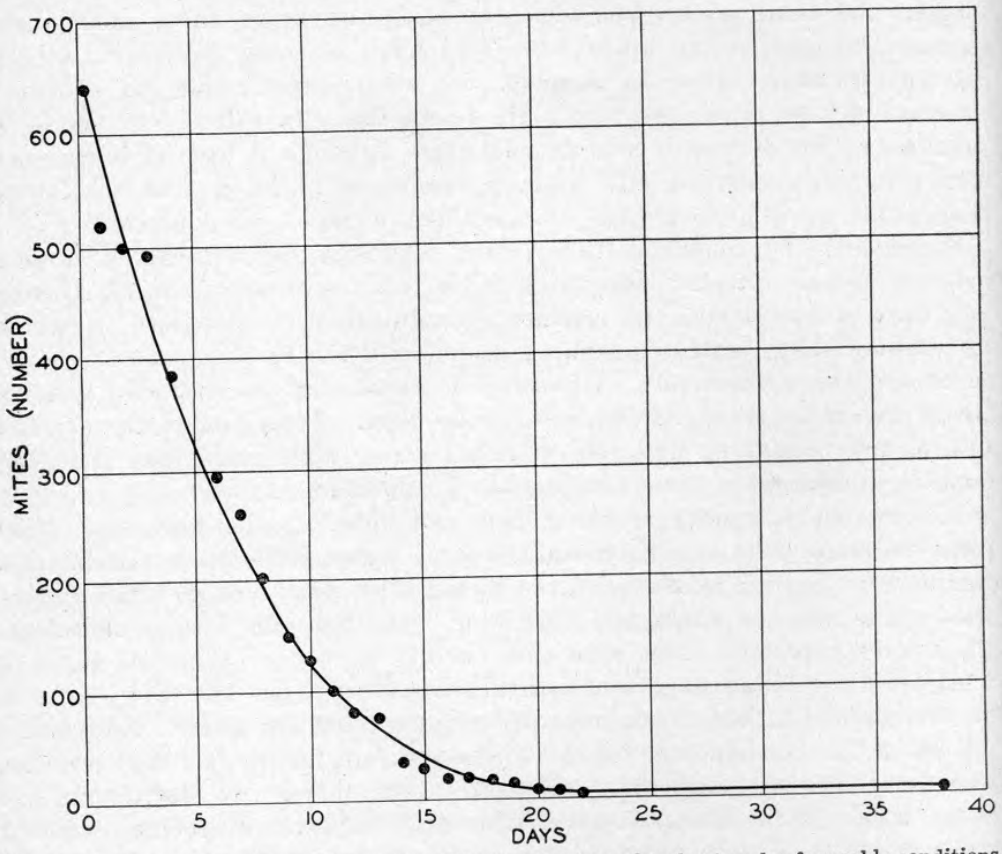

Figure 6—Rate of mortality of common sheep-scab mites when kept under favorable conditions.

given for the reappearance of sheep scabies in flocks in which the owner or inspector had failed to detect the disease. That sheep will sometimes enter caves, especially when they have become infested with the larvae of the common screw-worm fly, is well known.

An investigation was therefore made to obtain definite information on this point. A general survey of the temperature and humidity in several caves around Sonora, Texas, revealed that the temperature ranged between 70° and 72° F. and the humidity from 95 to 97 per cent throughout the

year. In one of these caves some longevity records were taken of 167 mites that were put upon small tags of wool in pill boxes. Some of the pill boxes were placed on shelves of dry stalagmites approximately 6 feet from the floor and 30 feet from the cave entrance; others were set on the floor of the cave and 125 feet from the entrance. It was found that the mites lived 8 to 19½ days.

These longevity records agree closely with those obtained in the insectary, and indicate that such caves do not furnish a focus of infestation for long periods of time.

Under Adverse Conditions

To determine the longevity of the sheep-scab mites under adverse conditions, 243 mites were collected as before and kept in the open, more or less exposed to the sun, simulating conditions found in scabby pens. A total of 23 tests was made. In some tests the mites were placed in open pill boxes and kept in the shade of a piece of white paper or corrugated cardboard, or in the shade provided by bunches of grass; in others the open pill box was set out in the direct sun and covered only with a piece of organdy cloth, a piece of glass, or left uncovered. In the above cases the pill boxes were placed directly upon the ground, but other tests were made in which a tag of wool containing mites was fastened on a wire fence about 3½ feet above the ground. In all tests the main object was to note the effect of the heat of the sun upon the mites.

The mites in the pill box covered with glass died within 10 minutes when exposed to a temperature of 100° F. More frequently an exposure of one to three hours at temperatures around 113° to 120° was necessary to destroy the mites. The temperature at the surface of the soil is usually 20 to 24 degrees higher than it is 3 to 4 feet above the ground level. This is reflected in the survival period of the mites in a tag of wool fastened to a wire fence 3½ feet above the ground. Such mites avoided the sun as far as possible and survived five days and longer following a 15-minute exposure. From these experiments we see that the sun will destroy the sheep-scab mites.

We have seen that the survival period at temperatures around 70° to 80° F. in the shade is much longer and may represent the maximum longevity off the host. It is probable that under such conditions the mite is not influenced by its environment but rather perishes from a lack of food. It is common knowledge that in western Texas sheep scab is greatly retarded during the hot summer months. It was also observed that during the hot season the scab mites generally remain more or less active on the under side of the animal, where they are protected from the direct rays of the sun.

Duration of Infestation in Sheep Pens

Practically speaking, the length of time that pens or other inclosures vacated by scabby sheep remain infested is equivalent to the length of time

a sheep-scab mite can live off the host. After it is removed from the host, however, the mite gradually starves to death and a time is reached when, although still alive, it is too feeble to attach itself again to an animal and reproduce.

To obtain more information on these points experiments were conducted in a series of pens all of which contained sheds with two sides open. The pens were built of heavy net-wire fencing and were separated from one another by a space of 10 feet. Ditches were cut so that no pen could drain into another. These pens were arranged in parallel rows. The end pen on the east of each row was used for check animals only. Five clean animals were introduced into each check pen and retained there throughout the four years of experimental work. At no time did they contract scabies.

In the experiments conducted in 1924 and 1925, and in part of those conducted in 1926, five scabby sheep were placed in each of a row of clean pens and retained therein for at least one month in order to give the pens an opportunity to become thoroughly infested. The scabby sheep were

Table 2. Length of time pens remained infested with sheep scab mites after scabby sheep were removed. Moderate exposure.

Expt. No.	Period between removal of scabby sheep and introduction of clean ones Days	Clean sheep used Number	Date clean sheep were introduced	Period exposed sheep were observed Days	Results
			1923		
11	0	5	May 16	277	No infestation
			1924		
1	Check	5	Sept. 27	277	No infestation
2	0	5	Nov. 6	230	Do.
3	10	5	Nov. 16	234	Do.
4	19	5	Nov. 26	224	Do.
5	29	5	Dec. 7	213	Do.
6	60	5	Jan. 6	183	Do.
7	120	5	Mar. 6	228	Do.
			1925		
12	Check	5	May 21	228	No infestation
13	0	5	Do.	176	Infestation developed
14	10	4	Do.	228	No infestation
15	15	4	Do.	217	Do.
16	20	4	Do.	182	Do.
17	30	3	Do.	206	Do.
18	40	4	Do.	192	Do.
			1926		
19	Check	5	April 2	204	No infestation
20	1	4	Do.	190	Do.
21	7	4	Do.	184	Do.
22	16	4	Do.	175	Do.
23	21	4	Do.	204	Do.
24	31	4	Do.	194	Do.
25	44	4	Do.	181	Do.

then removed after one of them had been sheared and the scabby fleece left beneath the shed. At intervals from 0 to 120 days after the scabby sheep had been removed, three to five clean sheep were introduced into each pen. In all the tests after the clean animals were introduced they were under almost daily observation for symptoms of scabies. Any evidence of infestation was checked by a thorough examination.

This series of tests was repeated each year for three years. The results are recorded in Table 2. In only one case out of three (experiment No. 13) when the clean sheep were introduced immediately after the removal of the scabby ones did the clean sheep contract scabies.

Another series of experiments was performed in which the clean sheep introduced into the scabby pen were subjected to a more severe exposure to infestation and the intervals between the removal of the scabby sheep and the introduction of clean sheep were shorter. One scabby sheep in each pen was shorn and the fleece was put in a burlap bag and left on the ground under the shed. The scabby sheep were then removed from the pen and at intervals as short as 1 hour and varying up to thirty days, clean sheep were introduced. As the clean sheep were introduced, the wool was taken from the bags, divided about equally, and tied upon the backs of two of them (Fig. 7). The experiments were conducted in two successive years. The results are recorded in Table 3.

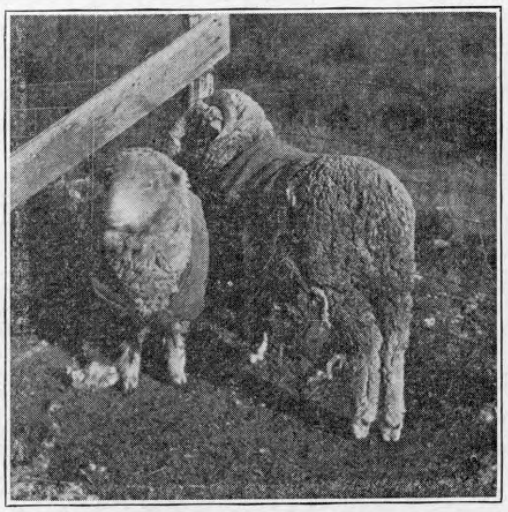

Figure 7—Scabby wool tied upon backs of test sheep.

In this series of tests infestation of clean sheep was obtained in three instances only. In one of these (experiment No. 32) the clean sheep were introduced immediately after the scabby ones were removed from the pen; in the other two (Nos. 33 and 40) the clean sheep were introduced after 6 and 10 days, respectively. Negative results were obtained however, in one test each, where 1 day, 5 days, 7 days and 8 days had elapsed before the introduction of clean animals, and in four trials where 9 days had elapsed. Negative results were also obtained in two cases (Nos. 28 and 35), in which the pens were vacant for 15 days before clean sheep were introduced. No tests were run after intervals between 10 and 15 days, but in the light of the variable results obtained in the shorter intervals, it is probable that infestation may occasionally occur. It will be recalled that in the longevity test reported in Table 1 the mites removed from a sheep and kept under very favorable conditions brought about

severe infestation after being starved for 13 days and then placed on a clean sheep.

Ovipositing and Hatching of Eggs and Longevity of Young Mites off the Host

Very little work was done in which the eggs of the sheep-scab mites were under close observation; yet in most of the longevity tests off the host undoubtedly many eggs were carried in the scab and wool. In two

Table 3. Length of time pens remained infested with sheep scab mites after scabby sheep were removed. Severe exposure and short intervals between removal of scabby sheep and introduction of clean sheep

Expt. No.	Period between removal of scabby sheep and introduction of clean ones Days	Clean sheep used Number	Date clean sheep were introduced	Period exposed sheep were observed Days	Results
			1926		
19	Check	5	Oct. 6	172	No infestation
26	5	2	Do.	164	Do.
27	10	2	Do.	150	Do.
28	15	2	Do.	147	Do.
29	20	2	Do.	148	Do.
30	25	2	Do.	136	Do.
31	30	2	Do.	132	Do.
			1927		
19	Check	5	Feb. 27	159	No infestation
32	0	2	Do.	87	Infestation developed
33	6	2	Do.	81	Do.
34	10	2	Do.	124	No infestation
35	15	2	Do.	130	Do.
36	20	2	Do.	93	Do.
37	25	2	Do.	159	Do.
19	Check	5	July 8	139	Do.
38	8	2	Do.	137	Do.
39	9	2	Do.	136	Do.
40	10	2	Do.	79	Infestation developed
41	9	2	Do.	139	No infestation
42	9	2	Do.	139	Do.
43	9	2	Do.	139	Do.

tests in which a large quantity of scabby material was placed in pill boxes at soil temperatures for 23 and 29 days, respectively, not a single egg hatched and not a single mite was found.

In the course of the longevity experiments with mites removed from the host it is noted that from time to time young mites would appear in the containers. The intervals between the collection of the scabby material and the appearance of these young mites were as follows: In two cases 2 days, in one case 3 days, in two cases 4 days, in two cases 5 days, in five cases 6 days, in nine cases 7 days, in three cases 8 days, in one case each 9 and 10 days, in two cases 11 days, in six cases 12 days, in five cases 13 days, in three cases 14 days, and in two cases 15 days. These

records show two periods when the young mites appeared in the containers with greatest frequency—namely, the sixth and seventh days and twelfth and thirteenth days after adult mites were removed from the host. This is strong evidence that many sheep-scab mites are capable of depositing fertile eggs for several days after their removal from the host, and that these eggs hatch if kept under favorable conditions of temperature and humidity. Thus it is possible for young mites to hatch off the host and to infest a clean sheep if they gain access to it not later than the 17th day after the parent mites are removed from a host. In most cases the young mites did not live more than two days. In one or two cases only were the mites observed to molt, although mites in the premolt stage were observed several times. First instars were observed on the third day after removal of scab from the host, on the sixth day and fourteenth hour, on the eighth day and tenth hour, and on the twelfth day and twenty-third hour. In one case a mite in the premolt stage lived for five days.

DIPS FOR THE CONTROL OF SHEEP SCABIES

History of the Development of Dips

As early as 1854 the efficiency of two dippings in sulphur-tobacco solution for eradication of scab was demonstrated by John Rutherford in New South Wales. Salmon and Stiles (13) in this country cited Rutherford's demonstration in 1898 and recommended that the dippings be placed 10 days apart and that a dip containing sulphur be used. They mentioned several formulas for such a dip, giving preference to the 24-8-100 formula (24 pounds of flowers of sulphur, 8 pounds of unslacked lime, and 100 gallons of water) in cases of fresh scab, and to the 33-11-100 formula in cases of very hard scab. They also gave commendation to the sulphur-tobacco dip. These writers say further that "Sulphur is one of the oldest known remedies for scab, its use dating back to Columella in the early part of the Christian era." Salmon and Stiles also suggest several ointments for the control of sheep-head scabies and foot scabies, all of which contain sulphur with various mixtures of oil, turpentine, lard, iodine, mercurial ointment, and carbolic acid.

In 1911 Stockman (15) in England, after extensive tests, in which both arsenical and carbolic dips were used, recommended two dippings preferably eight days apart, especial care being taken that the head, neck, and tail of each animal be properly and thoroughly wet with the dip. He found that "where a very large number of sheep have to be dipped, and it is impossible to put them all through the bath in one day, and to keep the dipped securely isolated from the undipped, there is no great risk in allowing the two to come in contact provided (a) all the sheep are dipped within a few days of each other, and (b) a second dipping of all the sheep is carried out within eight days of the first."

Green (8) in South Africa experimented with caustic soda-sulphur and lime-sulphur dips. He found that, when properly made, so that penta-

sulphides were formed in the reaction, these dips were harmless to the wool fibers. If improperly made, however, the fibers so treated would swell, the structures break down, and in extreme cases become gelatinous, owing to the formation of hydrosulphides and monosulphides.

Lime-sulphur dips are made according to several formulas. A very satisfactory dip is obtained by boiling 50 pounds of lime, 100 pounds of sulphur, and 50 gallons of water for 50 to 60 minutes. Such dips, when made of a high-grade rock lime, are harmless to the wool fibers and to the skin of the animals.

Gillette (6) in 1897 showed that the mites are very resistant to several substances, among them kerosene-oil emulsion. In fact, all mites were found to be alive two hours after being dipped in pure kerosene and all but five mites survived the dipping. He also found that only a few of the mites were killed by putting them in 95 per cent grain alcohol for 48 hours. In other tests he used flowers of sulphur in water in the proportions of 1 pound to 8 gallons of water and 1 pound to 12 gallons of water. In the former dip four out of nine mites lived 16 hours, while but one mite was found alive after 40 hours. When the weaker dip was used, however, all the mites were active after 12 hours. Gillette (6) developed what is known as the Fort Collins dip, which consisted of 33 pounds of sulphur, 11 pounds of lime, and 100 gallons of water. This dip was especially recommended for very bad cases of scabies.

Imes (9) recommended the nicotine dip testing 0.07 per cent nicotine. He also recommended a lime-sulphur dip consisting of 8 pounds of unslacked lime (or 11 pounds of hydrated lime), 24 pounds of sulphur, and 100 gallons of water. The lime and sulphur are mixed in 30 gallons of hot water and boiled for two hours, or until no free sulphur appears on the surface, when more water is added to make 100 gallons of dip. This is allowed to settle and the sediment is discarded.

Another dip used in the early days of sheep-scab eradication was the arsenical dip, which seemed to kill scabies best when sulphur was added (13). Many tests have shown that the arsenical dips are uncertain and in fact often dangerous to use on sheep.

Some cooperative experiments carried on between the Bureau of Animal Industry and the Kentucky Experiment Station by Good and Bryant (7) proved that a nicotine sulphate solution containing 0.07 per cent of nicotine was efficient in destroying sheep-scab mites, and that the addition of flowers of sulphur did not increase the efficiency of the dip.

In South Dakota Moore (11) showed that "arsenic must be considered as of doubtful efficacy as a scab eradicator."

In the use of the recommended dips for the control of sheep scabies the temperature is very important. This was recognized by Curtice (2) in 1890, who found that the most desirable temperature of the dip was between 100° and 110° F. The same conclusions were reached in the experiments reported herein. In fact, some of the experiments with lime-sulphur and nicotine dips strongly indicated that a temperature of 100° F.

or less is not very effective. It was also found by experience that sheep are capable of withstanding a higher dip temperature in hot weather than in cold weather.

Dipping Tests

The United States Bureau of Animal Industry (9) recognizes two official dips for scabies—the lime-sulphur dip testing 0.18 to 0.19 per cent polysulphides, and the nicotine sulphate dip testing 0.07 per cent nicotine. Such dips are supplied by a number of commercial firms. Some experiments with these standard dips, and also with sulphur, arsenical, and other dips suggested for the eradication of sheep scabies, are described in the following paragraphs.

In these tests all the animals were dipped by hand in a 100-gallon tank. The animal's head was ducked many times during each test, as it was essential that every part of the animal be thoroughly wet.

All the dipping tests reported herein were carried out at Substation No. 14, where the water and climatic conditions generally are similar to those found on much of the Edwards Plateau region of Texas.

When dipping sheep it is important that two pastures be available. One pasture should be emptied of all sheep several days before dipping and immediately after dipping the sheep should be placed in this pasture; the other pasture should be "ridden" for a week or 10 days to pick up and dip all stray animals and those that were missed at the roundup.

As both nicotine and sulphur dips become very foul soon after the first dipping, the vats should be cleaned before the second dipping.

Lime-Sulphur Dips

The lime-sulphur dip was prepared by boiling prepared dry lime and sulphur in a tub of water until it had acquired a deep coffee color and a thin sirupy consistency, and then added to warm water in the vat until the required strength was reached. The animals were dipped at temperatures ranging from 103° to 113° F., and then placed in clean pens and observed for at least six months. The results are recorded in Table 4.

It will be noted that in one of the tests (No. 7) carried out in 1925 the scabby sheep were dipped only once, whereas in the other tests two dippings were given at various intervals. Although the single dipping proved 100 per cent effective, it is unsafe to depend entirely upon one dipping. The difficulty of rounding up all the animals in a pasture and the possibility of mites living in tags of wool off the host for several days make a second dipping imperative in actual eradication work. Furthermore, some animals may not be so thoroughly wet as in these experiments. The proper interval between the two dippings depends upon the life cycle of the mite. It should be long enough to permit all the eggs to hatch but not allow time for the young to reach maturity and lay eggs. The interval of 10 days usually recommended is satisfactory.

Table 4. Data on dipping tests with powdered lime-sulphur solution against sheep scabies. Four healthy infested sheep used in each test; immersed for three minutes

Expt. No.	Date of		Interval between dippings	Polysulphide		Temperature of dip		Length of wool	Time after dipping when indications of scabies were observed	Results
	First dipping	Second dipping	Days	First dipping Per cent	Second dipping Per cent	First dipping °F.	Second dipping °F.	Inches	Days	
	1924	1924								
1	Nov. 5	Nov. 12	7	0.19	0.18	111.2	111.2	0.5-1	7	No infestation developed.
2	Do	Nov. 14	9	0.195	0.185	112.1	109.5	0.5-1	—	No infestation developed.
3	Do.	Nov. 16	11	0.195	0.188	109.4	108	1-2.5	8	Scabies developed.
4	Nov. 6	Nov. 18	12	0.18	0.185	111.2	105	0.5-2.5	—	No infestation developed.
5	Do.	Nov. 20	14	0.18	0.185	113	106.5	0.5-1.5	—	No infestation developed
6	Do.	Nov. 22	16	0.18	0.18	113	105	1-2	—	No infestation developed
	1925	1925								
7	Oct. 8	none	—	0.17	——	105		1-2.5	15	No infestation developed.
8	Do.	Oct. 25	17	0.18	0.185	103	108	1-2.5	17	Scabies developed.
9	Do.	Oct. 23	15	0.175	0.18	104	107	1-2.5	—	No infestation developed.
10	Do.	Oct. 21	13	0.18	0.185	105	106	0.5-2	—	No infestation developed.
11	Do.	Oct. 19	11	0.18	1.185	106	106	1-2.5	—	No infestation developed.
12	Do.	Oct. 17	9	0.18	0.185	106	106	1-2.5	—	No infestation developed.
13	Do.	Oct. 15	7	0.18	0.185	106	106	1-2.5	—	No infestation developed.

Nicotine Dips

The tests with nicotine (Table 5) during 1925 and 1926 were conducted in a manner similar to those with lime and sulphur. The dip contained 0.065 to 0.0675 per cent of nicotine. The temperature of the dip was about 102° F., and the sheep were held in it for three minutes. Three animals were used in each test except one (experiment No. 15), in which four animals were used. All animals were dipped twice except those in one pen (experiment No. 14), which were dipped only once. The period of observation lasted six months. The results of these tests show that a single dipping (No. 14) in a solution having a nicotine concentration of 0.065 per cent may kill all scab mites and their eggs.

In 1927 three other pens of scabby sheep were dipped once in nicotine testing 0.055, 0.040, and 0.030 per cent, respectively. Scabies developed when 0.030 and 0.040 per cent nicotine sulphate were used, indicating that 0.055 per cent is the minimum concentration that will kill all the mites. This concentration, however, is so close to the point where the mites are not killed that it is unsafe to rely upon it.

In an experiment in 1930 involving six animals (No. 47), the animals were not injured by a solution testing 0.095 per cent nicotine at a dip temperature of 107° F. All the animals lived for six months without a setback, thus further demonstrating that nicotine dip in the strength of 0.07 per cent, as usually recommended, is safe to use if the animals are properly handled, not only during but also just before and after dipping. In another experiment (No. 48) two animals were dipped twice, first in a solution testing 0.095 per cent of nicotine and 10 days later in a 0.125 per cent solution. The object of the second dipping was to see if a sheep could stand a strength of 0.125 per cent nicotine. No injurious effect was noted during the six months that the animals were held for observation. However, in large-scale operations the fumes of the dip would no doubt be fatal to many of the sheep, for even at a strength of 0.07 per cent an animal will sometimes succumb to the nicotine fumes.

As both nicotine and sulfur dips become very foul soon after a large number of sheep have been dipped, the vat should be cleaned before the second dipping.

Sulphur Dips

Sulphur is usually marketed in grades of varying degrees of fineness as determined by the screen test. The materials tested had a fineness of 325-mesh, 300 to 325-mesh, 200 to 300-mesh, 80-mesh, and 30 to 50-mesh (granulated). In making up the dips, water was added to the sulphur until it was thoroughly wetted, as indicated when the mass became the consistency of a thick paste. When soap was used it was dissolved in water before being added to the sulphur. The addition of the soap greatly facilitated the mixing of the sulphur with the water. Just before the sheep were dipped the sulphur paste was added to the water in the vat and the whole thoroughly stirred. In this manner dips were pre-

Table 5. Data on dipping tests with nicotine sulphate solution against sheep scabies (Animal held 3 minutes in dip)

Expt. No.	Date of first dipping	Date of second dipping	Interval between dippings	Nicotine* first dipping	Nicotine* second dipping	Temperature of dip first dipping	Temperature of dip second dipping	Sheep	Length of fiber	Scab killed	Time after dipping when indications of scabies were observed	Remarks
			Days	Per cent	Per cent	°F.	°F.	Number	Inches		Days	
	1925	1925										
14	May 21	None	—	0.065	——	102.2	——	3	1-2.25	Yes		
	1926	1926										
15	May 21	May 28	7	.065	0.065	102.2	102.2	4	1-2.25	Yes	2	Scabies did not develop
16	Do.	May 30	9	.065	.065	102.2	102.2	3	1-2.25	Yes		
17	Do.	June 1	11	.065	.065	102.2	102	3	1-2.25	Yes		
18	Do.	June 3	13	.065	.0675	102.2	102	3	1-2.25	Yes		
19	Do.	June 5	15	.065	.0675	102.2	102	3	1-2.25	Yes		
20	Do.	June 7	17	.065	.0675	102.2	102	3	1-2.25	Yes		
	1927	1927										
39	Oct. 28	None	—	.055	——	100	——	3	2	Yes		
40	Do.	Do.		.040	——	100	——	3	2	No	8	Mites found on 87th day
41	Nov. 4	Do.	—	.030	——	101	——	2	2-2.5	No	39	Do.
	1930	1930										
47	Sept. 30	None	—	.095	——	107	——	6	1-4	Yes		
48	Do.	Oct. 10	10	0.095	0.125	107	105	2	1-4	Yes		

*Average quantity of dip carried out is 2.85 gallons per animal; ¼ ounce of fish-oil soap added to each gallon of dip.

pared containing 10, 20, 25, 30, and 35 pounds of sulphur to 100 gallons of water. The dip was used at temperatures varying from 62° to 115° F. All animals were dipped by hand in a 100-gallon galvanized-iron tank and held therein for one to three minutes. Care was taken that the animal's head was thoroughly wet. Only one dipping was used except in experiment No. 55, where two dippings were employed.

The results, with the exception of those tests with 80-mesh sulphur and 30 to 50-mesh granulated sulphur, which showed very low efficiency, are recorded in Table 6.

In the two experiments (Nos. 33 and 36) in which a concentration of 10 pounds of 200 to 300-mesh sulphur to 100 gallons of water was used, scabies was again evident 87 and 88 days, respectively, after dipping. In an experiment (No. 50) in which flotation sulphur was used in a single dipping at the rate of 10 pounds to 100 gallons of water, scabies broke out 27 days later. In one (No. 37) of two experiments in which 20 pounds of 200 to 300-mesh sulphur was used in 100 gallons of water, scabies developed, while in the other (No. 34) scabies did not develop although the animal showed signs of the disease 21 days after dipping. In one experiment (No. 30) in which 25 pounds of 200 to 300-mesh sulphur was used scabies did not again appear. Six experiments (Nos. 27, 28, 29, 31, 35, 38) were conducted with 30 pounds of 200 to 300-mesh sulphur to 100 gallons of water, in three of which scabies reappeared after the dipping. In another experiment (No. 32) where 35 pounds of 200 to 300-mesh sulphur was used in 100 gallons of water, scabies likewise developed after the dipping. In the last two experiments (Nos. 55 and 56), four animals were given two dippings, the second 14 days after the first, in a dip containing 10 pounds of 325-mesh sulphur to 100 gallons of water. Scabies did not again develop in any of these four animals.

The results indicate that finely divided sulphur suspended in water in a concentration of 10 to 35 pounds per 100 gallons cannot be relied upon to destroy sheep-scab mites at a single dipping. The results of the single test in which two dippings were given are, however, quite significant.

Arsenical Dips

As the arsenical cattle dip is a standard dip for cattle-tick eradication and as most of the ranchmen are familiar with its use, it was tested on sheep scabies, as shown in Table 7. Each animal was held in the dip for three minutes. A single dipping in solutions containing 0.14, 0.18, and 0.225 per cent arsenic trioxide did not kill all the mites. The sheep in one pen were all poisoned by the arsenic at a strength of 0.18 per cent.

In another series of tests the sheep were dipped twice, with an interval of 10 days between the dippings, in solutions testing 0.18, 0.20, and 0.22 per cent of arsenic trioxide. On the 207th day after the second dipping live mites were found on the sheep dipped in 0.18 per cent soultion, but in those sheep that were dipped in the 0.20 per cent solution scabies did not again develop.

Table 6. Data on dipping tests with sulphur in suspension against sheep scabies

Expt. No.	Date of dipping	Sulphur per 100 gallons of water	Temperature of dip	Sheep dipped	Time in vat	Length of fiber	Scab killed	Time after dipping when first indications of scabies were observed	Live mites were found	Remarks
		Pounds	° F.	Number	Minutes	Inches		Days	Days	
	1926	300-325-mesh								
27	Oct. 21	30	80	3	3	0.5	Yes	—		
28	Do.	30	100	3	3	.5	Yes	—		
29	Do.	30	115	3	3	.5-1	No	7		Scabies developed Oct. 28
	1927	200-300-mesh								
30	Oct. 29	25	100	3	2	.5-1.5	No	13		
31	Do.	30	100	3	2	.5 1.5	No	7		
32	Do.	35	100	3	2	.5-1.5	No	9	87	Scabies well developed Feb. 24, 1928.
33	Apr. 12	10	100	4	3	2	No	—	87	
34	Do.	20	100	4	3	2	Yes	21		
35	Do.	30	100	4	3	2	No	19	88	Scabies observed Nov. 23, 1927.
36	Oct. 28	10†	100	3	2	2	No	26	65	
37	Do.	20†	100	3	2	2	No	65	87	Mites observed.
38	Do.	30†	100	3	2	.5-2	No	8	27	
		Flotation dust								
50	May 22	10	78	2	1	1-4	No	27		
		300-325-mesh								
51	May 22	10	78	2	1	1-4	Yes	—		
55	Oct. 11	10††	70	4	1	0.5-5	Yes	—	None	First dipping.
56	Oct. 25	10††	62	4	1	0.5-5	Yes	—	None	Second dipping, sheep greatly improved in vigor.

†One half ounce of fish oil soap added to each gallon of dip.

††One quarter ounce of fish oil soap added to each gallon of dip.

Table 7. Data on dipping tests with commercial arsenical cattle dip against sheep scabies.

Expt. No.	Date of		Interval between dippings	Water-soluble arsenic		Temperature of dip		Sheep	Length of fiber	Time after dipping when indications of scabies were first observed	Remarks
	First dipping	Second dipping	Days	First dipping Per cent	Second dipping Per cent	First dipping ° F.	Second dipping ° F.	Number	Inches	Days	
	1926	1926									
21	Oct. 22	None	—	0.18	—	80	—	3	1.5	53	Live mites found. Arsenical poisoning.
22	Do.	Do.	—	.14	—	80	—	3	1.5	53	Live mites found.
23	Do.	Do.	—	.225	—	80	—	3	1.5	53	Two live mites found.
	1927	1927									
24	Apr. 11	Apr. 21	10	0.18	0.18	100	100	5	1-2	30	Mites found on 207th day.
25	Do.	Do.	10	.20	.20	92	100	4	1-2	22	Scabies did not develop.
26	Do.	Do.	10	.22	.22	92	100	4	1-1.5	43	Do.

Table 8. Tests with miscellaneous dipping materials against sheep scabies (animal held one minute in dip)

Expt. No.	Date of dipping	Dipping material	Concentration Ounces per gallon	Temperature of dip ° F.	Sheep Number	Length of fiber Inches	Scab killed	Time after dipping when indications of scabies were first observed Days	Remarks
	1928								
42	Mar. 28	Paradichlorobenzene	½	94	3	½	No	9	Live mites found on 48th day.
43	Do.	Do.	1	94	2	½	No	7	One live mite found on 40th day
44	Apr. 5	Sodium silicofluoride, 70 cent	1	90	3	0-4	Yes	7	Scabies not developed after a year's holding of animals in pen.
45	Do.	Sodium fluoride, commercial	1	73	3	0-4	No	1	Live female mite found on 35th day. Sign of scab activity never ceased.
46	Do.	Fluospar	1	73	3	0-4	No	1	Greatly retarded scabies. Many live mites found on 35th day.
	1930								
48	May 22	Sodium fluoride	1	78	2	1-4	No	7	Greatly reduced infestation.
49	Do.	Sodium silicofluoride	1	78	2	1-4	No	7	Do.
52	Do.	Commercial extract of derris root	Parts 1-800	78	2	1-4	No	14	Do.
53	Do.	Do.	1-1,000	78	2	1-4	No	7	Do.
54	Do.	Do.	1-1,200	78	1	1-4	No	108	Live mites found on the 128th day.

These results indicate that while arsenic in certain strengths may be effective in two dippings, there is danger of injury to the sheep by its use.

Miscellaneous Dips

A number of other dips, shown in Table 8, were tested at lower temperatures and on a single dipping basis.

Saponified paradichlorobenzene, dissolved in benzol and then saponified, and used in strengths of one-half ounce and one ounce per gallon of water did not kill all the mites in either case. When sodium fluoride was used in a strength of 1 ounce to 1 gallon of water, one female mite was found on the 35th day after dipping: this mite apparently had been present for some time, as scab irritation at no time ceased entirely. Dipping in fluospar at a strength of 1 ounce to 1 gallon of water also greatly reduced the infestation, but scab irritation did not cease and many live mites were found 35 days after dipping. In view of the greatly reduced infestation of the animals following the first dipping in these substances, it is possible that a second dipping after a proper interval would have entirely eradicated sheep scabies. Paradichlorobenzene, however, is so irritating to the animal that it probably will never be used as a dip.

Somewhat better results were obtained with sodium silicofluoride at a strength of 1 ounce to 1 gallon of water. In one experiment involving three animals it completely eradicated the scabies, while in a second experiment involving two animals it reduced the scab infestation.

Single dippings in commercial extract of derris root in dilutions of 1 part to 800 parts water, 1 to 1,000, and 1 to 1,200 greatly reduce the infestation, but in all cases scabies again broke out. With this substance, too, it is possible that a second dipping at the proper time would have eradicated the scabies.

SUMMARY

Sheep scabies is caused by a small mite that normally spends its entire life upon the host. The eggs hatch into six-legged larvae, which transform into adult eight-legged mites. Mating takes place before the last molt of the female, but the eggs are not deposited until after the last molt.

When mites or eggs are transferred to clean sheep, scabies may break out within 12 days or it may be delayed for 154 days; most frequently, however, it will break out after one month.

Sheep scabies is introduced on clean animals by contact, either from animal to animal or by corral. Infestation of clean sheep sometimes results when they were introduced into scabby pens either immediately after the removal of the scabby sheep or 6 and 10 days thereafter. In each case fleeces from the scabby animals were left in the pens.

Common sheep scabies may develop on any part of the animal, including the head. Some animals are more resistant to scabies than others. Corriedale sheep are just as susceptible to scabies as are the Rambouillet and Merino.

It is not uncommon for animals to have scab mites and yet show no outward symptoms for periods as long as six months. During this time such animals can not be detected in a flock by experienced inspectors. Scabies developing upon any isolated animal will have periods of rapid development and periods of inactivity in either winter or summer.

Sheep scabies, on isolated animals, may die out completely within a year's time or may continue to thrive at least 2 years and 50 days.

Sheep-scab mites do not live much longer than 10 to 15 days in corrals and sheds. Under the most favorable artificial conditions they may survive for 21 days, or in rare cases 38 days, apart from the host. When removed from the host the mites under test lived longest when placed at a comparatively even temperature of 70° to 80° F. and a fair percentage of humidity, as when buried in the soil and protected in a suitable manner. Under these conditions most of the mites lived 10 to 20 days, and one mite lived for 38 days. Scab mites have not been proved to live longer in caves than in containers in protected places.

Sheep-scab mites are able to withstand rather high temperatures for a short period of time. When exposed to the direct rays of the sun, at temperatures ranging from 113° to 120° F., the mites are injured or even killed. The mites avoid the direct rays of the sun whenever possible.

The two recognized dips, lime-sulphur testing 0.18 to 0.19 per cent, and nicotine sulphate testing 0.07 per cent nicotine, are satisfactory for killing the scab mite. With both of these dips the high temperatures of 103° to 110° F. is a very important factor in successful dipping. The higher temperatures should be used in summer. Two dippings for 3-minute periods should eradicate sheep scab if care is taken to have all parts of the animal thoroughly wet, including the head. Every animal should then be put immediately in a clean pasture and all stray and hiding animals in the infested pastures rounded up and dipped, the pasture being ridden for a week or 10 days.

Arsenical cattle dips, finely divided sulphur in suspension, sodium fluoride, sodium silicofluoride, and paradichlorobenzene show promise, the 300-mesh sulphurs and flotation sulphurs being the most promising, but none of these will be recommended as effective until further experimental work justifies it.

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