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**The Effect of various Dipping Fluids  
upon the Ovigerous Females of  
*Psoroptes Communis* var. *Ovis*  
and their Ova.**

By G. A. H. BEDFORD, F.E.S., Research Officer, Onderstepoort.

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# The Effect of various Dipping Fluids upon the Ovigerous Females of *Psoroptes Communis* Var. *Ovis* and their Ova.

G. A. H. BEDFORD, F.E.S., Research Officer, Onderstepoort.

IN 1914 a number of dipping tests were carried out at this Laboratory to ascertain the efficacy of the various dipping fluids in common use in South Africa at the time <sup>(1)</sup>, and the results of these experiments were most encouraging. All the dipping tests, with the exception of one or two, proved most successful, the sheep invariably being cured of scab so far as could be ascertained by a single immersion; yet failures on the part of the farmers to cure their flocks of scab are frequently brought to our notice.

The question now arises: Can we attribute the failures to the dipping fluids or to the methods employed by the farmers in dipping their sheep? In many cases no doubt the failures have been due to the inadequate means the farmers have adopted, such as not properly mixing the dip, or not leaving the sheep immersed in the dip a full two minutes, but probably the majority of the failures have been due to the sheep having become reinfected after dipping, and various other causes which will be discussed later.

It is a common belief that scabby sheep that are given a single immersion in a dip are not cured of scab, and that a second immersion is essential to destroy the acari that hatch from the eggs after the first dipping has been given. The following experiments were carried out, therefore, in order to ascertain as far as possible what actually happens to the ovigerous females and their ova after they have been immersed in a dipping fluid, and also to what extent the various fluids afford protection to the sheep against scab after they have been dipped. These tests were first undertaken during the winter months of 1922, with the exception of two which were carried out in July, 1917. As the results of these experiments proved to be rather startling it was thought advisable that they should be repeated, and this was done on a larger scale during the summer 1923-24.

Again in 1925, further experiments were undertaken at Sir Arnold Theiler's request to control the results of former tests giving the periods the various dips protect sheep against scab after dipping. It was considered advisable that these tests should not only be carried out on totally different lines, but also that they should be of a practical nature, and undertaken on even a larger scale than hitherto.

Except in one or two cases, the tests were carried out with various well known home-made and proprietary dips which have been extensively used by farmers in South Africa for eradicating scab.

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(<sup>1</sup>) G. A. H. Bedford. Report upon the dipping trials carried out with the different Proprietary and Home-made Sheep Dips in South Africa. 3rd and 4th Rep., Dir. Vet. Res., p. 163, 1915.

## 1. EFFECT OF VARIOUS FLUIDS UPON THE OVA.

The following experiments were carried out in order to ascertain

- (1) Whether ova dipped *in vitro* for various periods, and afterwards placed on clean sheep are destroyed, and if not, whether the acari on hatching are in any way affected.
- (2) Whether fresh ova, or ova that have been immersed *in vitro* for various periods and afterwards placed on sheep that have been dipped for two minutes are destroyed, and if not, whether the acari on hatching are killed by the chemicals that remain in the fleeces of the sheep after dipping.

EXPERIMENT No. 1.—Ova (25 were used in each test) were dipped *in vitro*<sup>1</sup> for two minutes in the following fluids:—

Lime and sulphur (home-made).  
 Capex.  
 Caustic soda and sulphur.  
 Cooper's Sheep Dip.  
 Jeyes' Fluid.  
 Delmore Sheep Dip<sup>2</sup>.  
 McDougall's Sheep Dip.  
 McDougall's Powder Dip.

Immediately after immersion they were placed on shaved patches on undipped sheep.

*Results*: All the ova hatched two to three days after dipping, and the larvae reached maturity.

EXPERIMENT No. 2.—25 ova were dipped *in vitro* in lime and sulphur (home-made) for ten minutes and were afterwards placed on a shaved patch on a clean sheep.

*Results*: All the ova hatched. After dipping it was noted that they were all more or less yellow in colour, the colour being due to the sulphur in the dip.

EXPERIMENT No. 3.—Test to ascertain the effect of lime and sulphur (home-made) on the ova.

Fresh ova were collected on the 23rd May, 1922, and placed in glass tubes in the laboratory. On the 24th they were immersed *in vitro* for various periods and then placed on (1) a clean sheep, (2) a dipped short-woolled sheep, and (3) a dipped long-woolled sheep immediately after the latter had been dipped for two minutes. The dip used was practically of correct official strength.

- (1) 75 ova were immersed for 2 minutes and afterwards placed on sheep 1, 2, and 3 (25 ova on each)<sup>3</sup>.
- (2) 75 ova were immersed for 5 minutes and afterwards placed on sheep 1, 2, and 3 (25 ova on each).

(<sup>1</sup>) The eggs were placed on a small circular piece of black cloth which fitted into a small wooden ring, to which was sewn a piece of fine muslin. This was placed in a small watch-glass containing the fluid, and kept submerged by holding the ring with a pair of forceps. Immediately after immersion, the cloth was placed on blotting-paper and the eggs collected.

(<sup>2</sup>) This dip is no longer on the market.

(<sup>3</sup>) The ova were placed on the skins of the dipped sheep at the bases of small pieces of wool tied with tape at their apices. The various batches of ova on each sheep were, of course, kept as far away as possible from each other.

- (3) 75 ova were immersed for 10 minutes and afterwards placed on sheep 1, 2, and 3 (25 ova on each).
- (4) 75 ova were immersed for 15 minutes and afterwards placed on sheep 1, 2, and 3 (25 ova on each).
- (5) 75 ova were immersed for 20 minutes and afterwards placed on sheep 1, 2, and 3 (25 ova on each).

*Results*: The ova that were placed on a clean sheep all hatched on the 3rd and 4th days following dipping, and the larvae reached maturity. Those placed on the short-woolled and long-woolled dipped animals all hatched, but the larvae died a few hours after hatching, except a few that were dipped for 5 minutes and placed on the short-woolled sheep. These became adults, and on the 25th July (2 months after dipping) the infected patch was roughly about 4 inches square.

It was observed that the short-woolled sheep did not take as long to dry as the long-woolled animal.

All the animals used in these experiments were kept isolated in stables. Had the above sheep been kept out-of-doors they would have dried much quicker, and it is possible that the results may have been somewhat different.

EXPERIMENT No. 4.—Ova (100 were used in each test) were immersed *in vitro* for 15 minutes in the following fluids:—

Capex Sheep Dip.  
Cooper's Sheep Dip.  
Tobacco Extract.  
McDougall's Powder Dip.

They were then placed on dipped sheep (animals dipped in the same fluid as the ova) immediately after they had been immersed for 2 minutes. Also 100 fresh ova were placed on the dipped animals 24 hours after they had been dipped.

*Results*: All the ova, except one or possibly two in one or two cases, hatched 3 to 4 days after dipping, but the larvae died very shortly after hatching.

EXPERIMENT No. 5.—The following test was carried out with Cooper's Sheep Dip:—

7 sheep (not infected with scab) were immersed in the above dip for 2 minutes on the 2nd July, 1917, and again on the 16th. On the second day after the second dipping 70 ova were placed on one of the sheep, one was infected with 70 ova on the 4th day, two on the 6th, and one each on the 10th, 14th and 18th day after dipping.

*Results*: None of the sheep became infected.

EXPERIMENT No. 6.—Tests were carried out with the following dipping fluids during the summer 1923-24:—

Capex.  
Cooper's Sheep Dip.  
White Cyolin.  
McDougall's Sheep Dip No. 4.  
Delmore Tobacco Dip (Strength .045).  
Delmore Tobacco Dip (Strength .07).  
Delmore Tobacco and Soap (Strength .077).  
McDougall's Powder Dip.  
McDougall's "Kymac."

Ova (25 were used for each test) were dipped *in vitro* in the above fluids for 2, 5, 10, 15 and 20 minutes, and afterwards placed on long-woolled and short-woolled sheep immediately after the animals had been immersed for 2 minutes in the same fluids. In addition to the above, 25 undipped ova were also placed on each sheep.

*Capex.*

Length of wool of (i) Long-woolled sheep, 2·6";  
(ii) Short-woolled sheep, ·9".

*Result:* All the ova hatched on the 3rd and 4th day after they were placed on the sheep, but the larvae died before reaching the nymphal stage.

*Cooper's Sheep Dip.*

Length of wool of (i) Long-woolled sheep, 2·0";  
(ii) Short-woolled sheep, 1·3".

*Result:* All the ova hatched in 2 to 4 days, except one which was immersed in the dip for 15 minutes. The larvae died almost immediately after they had escaped from the eggs.

*White Cyolin.*

Length of wool of short-woolled sheep, ·8".

*Result:* The long-woolled sheep died of pneumonia on the 3rd day after dipping when several of the undipped ova were observed not to have hatched. The patches upon which the other eggs had been placed could not be examined as the wool had been pulled out. The ova placed on the short-woolled sheep hatched on the 3rd and 4th day after they were dipped and placed on the animal, with the exception of one or two in each of the batches. The larvae died almost immediately after hatching.

*McDougall's Sheep Dip (No. 4).*

Length of wool of (i) Long-woolled sheep, 2·5";  
(ii) Short-woolled sheep, 1·2".

*Result:* The eggs took four days to hatch and the larvae died within a few hours after escaping from the eggs.

*Delmore Tobacco Dip (Strength .045).*

Length of wool of (i) Long-woolled sheep, 2·3";  
(ii) Short-woolled sheep, ·8".

*Result:* All the ova hatched in 3 to 4 days and a few of the acari in each batch reached maturity.

*Delmore Tobacco Dip (Strength .07).*

Length of wool of (i) Long-woolled sheep, 2·0";  
(ii) Short-woolled sheep, ·55".

*Result:* The ova that were placed on the long-woolled sheep hatched, but the larvae all died within a few hours after hatching. Those placed on the short-woolled sheep also hatched, and the majority of the larvae died a few hours after hatching. Only six reached the nymphal stage, and two the adult stage.

*Delmore Tobacco and Soap* (Strength .077).

Length of wool of (i) Long-woolled sheep, 1.5";  
 (ii) Short-woolled sheep, .8".

*Result*: All the ova that were placed on the long-woolled sheep hatched in 3 to 4 days, but the larvae died within a few hours after escaping from the eggs. Those placed on the short-woolled sheep also hatched, and a few of the acari in each batch, with the exception of those that hatched from ova immersed for 2 minutes, ultimately became mature.

*McDougall's Powder Dip.*

Length of wool of (i) Long-woolled sheep, 1.7";  
 (ii) Short-woolled sheep, .6".

*Result*: All the ova hatched in 3 to 4 days, with the exception of 2 (one immersed for 2 minutes and one for 3 minutes) that were placed on the long-woolled sheep, and 5 (two immersed for 2 minutes and three for 15 minutes) on the short-woolled sheep, but the larvae only lived a few hours.

*McDougall's "Kymac."*

Length of wool of (i) Long-woolled sheep, 2.4";  
 (ii) Short-woolled sheep, 1.2".

*Result*: Only a small percentage of the ova hatched, with the exception of the undipped lots that were placed on the sheep, and the larvae died almost immediately after hatching. As this was the only dipping fluid tested that appeared to have any effect upon the ova another experiment was carried out as follows:—

100 ova were immersed *in vitro* for 2 minutes, also 100 for 10 minutes, and afterwards they were placed on a clean sheep.

*Result*: All the ova hatched and in due course the larvae reached maturity. The ova that were immersed for 2 minutes took 2 to 3 days to hatch, whereas those immersed for 10 minutes took 3 to 4 days to hatch.

## 2. EFFECT OF VARIOUS FLUIDS UPON THE OVIGEROUS FEMALES.

The following experiments were carried out in order to ascertain:—

- (i) The effect of various dipping fluids upon the ovigerous females.
- (ii) To what extent sheep are protected against scab infection after they have been dipped.

## EXPERIMENT NO. 1.—The following tests were carried out with:

Lime and Sulphur (home-made).  
 Capex Sheep Dip.  
 Caustic Soda and Sulphur.  
 Cooper's Sheep Dip.  
 Jeyes' Fluid.  
 Delmore Sheep Dip<sup>(1)</sup>.  
 McDougall's Sheep Dip (No. 4).  
 McDougall's Powder Dip.  
 McDougall's "Kymac."

(1) This dip is no longer placed on the market.

Ovigerous females (25 were used in each test, except for testing McDougall's "Kymac" in which case 100 females were used) were dipped *in vitro* in the above fluids for 2 minutes and were afterwards placed on clean sheep<sup>(1)</sup>.

*Results*: All the acari, with the exception of those immersed in McDougall's Powder Dip and McDougall's "Kymac," remained active after dipping and laid a number of ova, all of which hatched. Those dipped in McDougall's Powder Dip were found to be all dead the day following dipping, except three, one of which died on the second day after dipping and two on the third day. They did not lay any eggs. A further test was made with this dip on 100 ovigerous females, with the result that all the acari died within 24 hours after dipping, except three which lived for a number of days and laid numerous eggs. All the females that were immersed in McDougall's "Kymac" for 2 minutes were found to be dead the day following dipping.

EXPERIMENT No. 2.—25 ovigerous females were dipped *in vitro* in lime and sulphur (home-made) for 10 minutes, and also 100 ovigerous females in Capex for the same length of time and afterwards placed on clean sheep.

*Results*: All the acari remained active after dipping and laid a number of eggs, all of which hatched.

EXPERIMENT No. 3.—The following tests were carried out during the winter, 1922 with:—

Capex Sheep Dip.  
Cooper's Sheep Dip.  
Tobacco Extract (McDougall's).  
McDougall's Powder Dip.

Ovigerous females (100 were used in each test) were placed on sheep that had been immersed for 2 minutes in the above fluids at various intervals after the animals had been dipped<sup>(2)</sup>.

*Results*: *Capex Sheep Dip*.—Of the females that were placed on a sheep 4 hours after dipping, several were observed to be alive the following day, but they were all dead on the second day after being placed on the sheep. They did not lay any ova. The majority of the females that were placed on patches on the sheep 24 and 48 hours after the animal had been dipped were not killed (only about 9 dead females of the 24-hour lot were observed and 3 of the 48-hour lot) and they laid a number of ova. The patches were badly infected three weeks after the acari were placed on the sheep.

(1) The ovigerous females were placed on small circular, closely clipped patches on the sheep's backs. The acari were prevented from escaping by placing either a glass or cardboard ring, about half an inch high and covered on top with fine muslin, on the patches. This was kept in position by placing paraffin-wax that had been previously melted by heating and allowed to cool round the outside of the cover and by gathering the wool round it and tying it on top.

(2) The same method was employed for keeping the acari under observation as that adopted in Experiment No. 1, except that the wool was only cut short where the cardboard ring came in contact with the skin of the sheep. The various patches on each sheep were, of course, kept as far apart from each other as possible.

As larvae which hatch from ova placed on dipped sheep die a few hours after hatching (3 to 4 days after the sheep has been dipped), and females that are placed on dipped animals 24 and 48 hours after dipping survive, we can conclude that the larvae are more easily killed by the dip than the adults.

*Tobacco Extract.*—Of the females that were placed on a sheep 3 hours after the animal was dipped, four were found alive the second day after dipping and three on the third day, but they were all dead on the 4th day. Of the females that were placed on the sheep 24 hours after the animal was dipped, one lived 8 days, laid a number of eggs which hatched, and the larvae reached maturity. A few of the females that were placed on the sheep 2, 4, 6, and 8 days after dipping lived, and the patches became infected in due course.

*McDougall's Powder Dip.*—The females that were placed on the sheep 1½ hours to 10 days after dipping all died within 24 hours after being placed on the animals. Those placed on the sheep 12, 14, and 16 days after dipping all died in 2 days, and the majority within 24 hours. Several of the females that were placed on the sheep 18 and 20 days after dipping lived and the patches became infected.

It was noted that the skin of the sheep was always inflamed where the acari had been feeding, and there was a certain amount of pus present. At first there was never sufficient pus to interfere with the acari because they always died before they were able to set up much inflammation, but after a time the amount of pus present was considerable and a number of the acari were drowned in it, in fact, practically all the acari that were placed on the animals 12 to 16 days after dipping were found dead in the pus. The inflammation of the skin was probably entirely due to the fact that the sheep had a very tender skin and not to the dip.

*Cooper's Dip.*—The females that were placed on a sheep 3 hours to 14 days after dipping all died within 24 hours after being placed on the animal. Several of the females that were placed on the sheep 16 and 18 days after dipping lived, and the patches became infected.

EXPERIMENT No. 4.—A similar experiment to the above was carried out with Cooper's Dip in 1917, the details of which are as follows:—

12 long-woolled sheep (not infected with scab) were dipped for 2 minutes on the 2nd July, 1917, and again on the 16th. On the second day after the second dipping 2 sheep were infected with 100 ovigerous females each, and two more after 4, 6, 10, 14, and 18 days respectively. The animals were kept in an enclosure out-of-doors throughout the experiment.

*Results:* None of the sheep upon which the acari were placed up to the 6th day after dipping became infected. Of the two upon which acari were placed on the 10th day only one became infected. All those that were infected on the 14th and 18th day after dipping remained infected.

EXPERIMENT No. 5.—Similar tests to No. 3 were carried out during the summer 1923-24 with the following dipping fluids:—

Capex.  
Cooper's Sheep Dip.



White Cyolin.

McDougall's Sheep Dip (No. 4).

Delmore Tobacco Dip (Strengths .045 and .07).

Delmore Tobacco and Soap (Strength .077).

McDougall's Powder Dip.

McDougall's "Kymac."

Ovigerous females (100 used in each test) were placed on (i) a long-woolled sheep, and (ii) a short-woolled sheep at various periods after the animals had been immersed in the dipping fluids for 2 minutes.

*Results: Capex.*—(i) Long-woolled sheep (1.8")<sup>(1)</sup>. Of the 100 females that were placed on the sheep 3 hours after dipping one lived 3 days and laid several eggs. The majority of those that were placed on the sheep 24 hours after dipping lived for a number of days and laid numerous eggs. (ii) Short-woolled sheep (1.1"). All the females that were placed on the sheep 3 and 24 hours after dipping died within 24 hours. A few of those that were placed on the sheep 2 and 3 days after dipping lived for several days and laid eggs.

*Cooper's Sheep Dip.*—(i) Long-woolled sheep (1.9"). All the females that were placed on the sheep 24 hours to 5 days after dipping died within 24 hours. Of those that were placed on the sheep 7 days after dipping two lived 24 hours, one for 2 days and one for 4 days. Of those placed on the sheep 9 days after dipping, one lived 24 hours and one 4 days, but they did not infect the sheep. Several of the females that were placed on the sheep 10 days after dipping lived 24 hours, but they were all dead the following day except two which lived for over 10 days and infected the animal. The majority of those placed on the sheep 12 and 14 days after dipping lived for a number of days and also infected the animal. (ii) Short-woolled sheep (1"). All the females that were placed on the sheep 24 hours to 7 days after dipping died within 24 hours. Of those that were placed on the sheep 9 days after dipping only one lived 24 hours, and out of the hundred that were placed on the sheep 10 days after dipping only two lived for 48 hours. Those placed on the sheep 12 days after dipping all died within 24 hours. Of those placed on the sheep 14 days after dipping 4 lived several days and infected the animal. The majority of those placed on the sheep 17 days after dipping also lived and infected the sheep.

*White Cyolin* (1% solution).—The long-woolled sheep died on the second day after dipping. (ii) Short-woolled sheep (.85"). All the females that were placed on the sheep 3 hours to 13 days after dipping died within 24 hours. Of those placed on the sheep 15 days after dipping several lived for a number of days and ultimately infected the sheep, but all the females placed on the sheep 2 days later died within 24 hours. 100 females were also placed on the sheep 19 days after dipping, a few of these lived for a number of days, and the patch eventually became infected but not to the same extent as the 17 day patch.

*McDougall's Sheep Dip* (No. 4).—(i) Long-woolled sheep (1.8"). All the females that were placed on the sheep 3 hours to 7 days after dipping died within 24 hours. The majority of those placed on the sheep 9 and 12 days after dipping were found to be alive 24 hours

(<sup>1</sup>) The figures in brackets refer to the length of the wool of the sheep.

after they were placed on the animal, but only one or two in each lot were alive 48 hours after dipping. These lived for 4 days. (ii) Short-woolled sheep (1"). All the females that were placed on the sheep 3 hours to 5 days after dipping died within 24 hours. Of those placed on the sheep 7 and 9 days after dipping a number lived for several days, and scab ultimately became established on the animal.

*Delmore Tobacco Dip.*—(i) Strength .045. The majority of the females that were placed on both a long-woolled sheep (1.9"), and on a short-woolled sheep (.9") 3 and 24 hours after the animals were dipped died within one to four days, but a few remained alive for over a week, laid eggs, and the infected patches gradually increased in size. The majority of the females that were placed on the sheep 48 hours after dipping lived for a number of days. The patches on the long-woolled sheep ultimately became more badly infected than those on the short-woolled animal.

(ii) Strength .07. All the females that were placed on a long-woolled sheep (2.2"), and a short-woolled sheep (.9") 2½ hours after the animals were dipped died within 48 hours, and the patches did not become infected. Of those that were placed on the sheep 24 hours after the animals were dipped, the majority died within a few days. Immature acari were afterwards found but the infections eventually disappeared entirely. Females placed on the sheep 48 hours after the animals were dipped lived a few days longer, and in due course scab became established on the short-woolled animal.

*Delmore Tobacco and Soap.*—Strength .077. Females that were placed on a long-woolled sheep (2.1"), and a short-woolled sheep (.6"), 3, 24, and 48 hours after the animals were dipped infected their hosts, the patches on the short-woolled sheep being more badly infected than those on the long-woolled animal.

*McDougall's Powder Dip.*—(i) Long-woolled sheep (3.4"). The females that were placed on the sheep 48 hours to 13 days after dipping all died within 24 hours after being placed on the animal, with the exception of one which was placed on the sheep on the 9th day after dipping and three that were placed on the animal on the 11th day after dipping. These, however, also died within 48 hours after being placed on the sheep. Of the females that were placed on the sheep 15 days after dipping, 20 to 30% were alive the following day, but they all died within 48 hours. Several of the females that were placed on the sheep 18 days after dipping lived for a week, laid eggs which hatched, but the young acari all died on reaching the nymphal stage. Of the females that were placed on the sheep 20 days after dipping, one lived for 5 days and one for 12 days. They laid eggs, and in due course the patch became infected. 100 females were also placed on the sheep on the 22nd day after dipping, but they all died, except 8, within 24 hours. Two lived for three days, one for 4 days, and one for 5 days, but they did not infect the animal.

(ii) Short-woolled sheep (1.2"). All the females that were placed on the sheep 48 hours to 9 days after dipping died within 24 hours, except one that was placed on the animal on the 9th day which died within 48 hours. Of the females that were placed on the sheep 11 days after dipping all died within 24 hours after being placed on the animal, except two which lived for 2 days. The majority of the females that were placed on the sheep 15 days after dipping lived several days, and a few for a number of days. They laid eggs and ultimately the infection became established.

In the previous experiment with this dip it was observed that the patches on the sheep upon which the acari were placed were inflamed, and that there was always a certain amount of pus present. In this experiment, however, inflammation of the skin was only noticed on one occasion, namely, on the patch on the short-woolled sheep upon which acari were placed 13 days after dipping. A certain amount of pus was present the day after the acari were placed on the patch, but the following day it was observed to have dried up and the inflammation ceased, although the patch remained infected.

*McDougall's "Kymac."*—(i) Long-woolled sheep (3.7"). The females that were placed on the sheep 4 hours to 11 days after the animal was dipped all died within 24 hours. Of those placed on the animal 13 and 15 days after dipping several lived for a number of days. Larvae were observed about a week after the females were placed on the sheep; these reached maturity and the infections became established.

(ii) Short-woolled sheep (1.2"). All the females that were placed on the sheep 4 hours to 4 days after the animal was dipped died within 24 hours. All the females that were placed on the animal 5 days after dipping likewise died within 24 hours, except four, one of which lived 4 days but it did not infect its host. Of the 100 females that were placed on the sheep 7 days after dipping, 10 were found alive the following day; three of them lived 4 days and one 5 days. They laid eggs and the infection became established. Of those that were placed on the sheep 9 days after dipping, 14 were alive the following day but only two were alive on the second day, of which one lived 5 days and one several days longer. They both laid eggs and infected the sheep. All the females that were placed on the sheep 11 days after dipping died within 24 hours. Of the females that were placed on a sheep 13 days after dipping all died within 24 hours, except 2, one of which lived for 6 days and one about a fortnight. They infected the sheep. Of those placed on the animal 16 days after dipping a number lived for several days and infected their host.

EXPERIMENT No. 6.—The following tests were carried out in 1925 with :—

- (1) Lime and sulphur dip (Capex).
- (2) Tobacco Dip (McDougall's "Lion Brand" concentrated).
- (3) Cooper's Sheep Dipping Powder.
- (4) McDougall's Powder Dip.

From 45 to 75 dipped sheep and 4 to 14 undipped sheep (controls) were used for each test. The animals were dipped for 2 minutes in the ordinary way, and an hour or two after dipping both the dipped animals and their controls were placed in an enclosure containing a large number of badly infected scabby sheep. These animals were kept in close contact with the scabby sheep for various periods, and afterwards each batch was transferred to a separate pen and kept under close observation. Of the sheep that were dipped in lime and sulphur, 15 were kept in the infected enclosure for 2 days, 15 for 4 days, and 15 for 6 days, and their controls (fourteen) for the same periods. At first it was intended that each batch should only be kept in the enclosure for 1, 2 and 3 days respectively, but as they were

found to be wet on the day following dipping the periods were prolonged. The sheep dipped in tobacco dip and their controls were kept in the infected enclosure for the same periods. Those dipped in Cooper's Sheep Dipping Powder were kept in the infected enclosure for 2, 4, 6, 10, and 14 days, and the animals dipped in McDougall's Powder Dip for 4, 6, 10, 14, and 18 days respectively. Their six controls, which also acted as controls for the sheep dipped in Cooper's were kept in the scabby enclosure 2, 4, and 6 days.

*Results:* The results of these experiments are shown in the following table:—

Dip.	Dipped Sheep,						Controls.		
	Total Number of Sheep and Number Infected.						Total Number of Sheep and Number Infected.		
Lime and Sulphur.....	15 — 3	15 — 12	15 — 14	—	—	—	5 — 5	5 — 5	4 — 4
Nicotine.....	15 — 1	15 —* 3	15 — 13	—	—	—	5 — 5	5 — 5	4 — 4
Cooper's.....	15 — 0	15 — 1	15 — <sup>†</sup> 8	15 — <sup>†</sup> 14	13 — <sup>‡</sup> 12	—	2 — 2	2 — 2	2 — 2
McDougall's.....	—	15 — 0	15 — 2	15 — 7	15 — 14	15 — 13	—	2 — 2	2 — 2
No. of days animals kept in infected enclosure.....	2	4	6	10	14	18	2	4	6

After removal from the infected enclosure the sheep were kept in isolated pens and examined almost daily for outward symptoms of scab, and whenever any of the animals were found to be infected they were immediately removed from the pens. At the conclusion of the experiments all the remaining sheep were thoroughly examined all over before being discharged. Scab was usually detected on the control animals within a day or two after their removal from the infected enclosure, and as a rule it only took a few seconds to find the infected patches although there was usually only one female and sometimes a few ova or larvae present on each patch. On the other hand it usually took much longer to detect scab on the dipped animals.

The majority of the animals became infected on the sides of their bodies, but some became infected on their necks, tails or hind legs above the knee. Only one sheep was found infected on the leg below the knee, one on its belly and one on its head.

\* One sheep infected in four places.

† In addition to these, one sheep in each batch was found infected in one of its ears, but not on the head or body.

‡ One sheep infected on head only.

In addition to the two sheep that were found infected in their ears, we have, during the last year, found one other sheep that was infected in one of its ears but not on the head or body. The majority of the control sheep and some of those dipped in lime and sulphur and nicotine became infected in more than one place, but very rarely did an animal that was dipped become infected with more than 3 to 4 females.

It will be observed that the results with the nicotine dip were more favourable than those with the lime and sulphur, whereas one would have expected the lime and sulphur dip to have given slightly better results than the nicotine, more especially as the sheep that were dipped in the tobacco dip took about 24 hours to dry, whereas those dipped in lime and sulphur took nearly 48 hours. The sheep dipped in lime and sulphur, therefore, only remained in the infected enclosure in a dry condition for 1 to 2 hours, 2 and 4 days, whereas those dipped in tobacco remained in the enclosure in a dry state for 1, 3, and 5 days. The sheep that were immersed in both Cooper's and McDougall's were dipped in summer and only remained wet a few hours after dipping. Better results were anticipated with Cooper's dip, but it was observed about 10 days after dipping that there was no sign of dip in the wool of some of the animals, whereas others still retained dip in their fleeces. At first it was thought that either the length or quality of the wool was responsible for this, but such appears not to have been the case.

#### SUMMARY.

1. *Lime and Sulphur Dip*.—This dip, which is the most extensively used dip in South Africa to-day for eradicating scab, does not kill the ovigerous females of *P. communis* var. *ovis* after they have been immersed in the fluid for 10 minutes, nor does it destroy their ova either when submerged in the fluid for 20 minutes or when freshly laid on sheep before the animals are given a 2 minutes immersion, but the larvae which hatch from ova laid on sheep before dipping are invariably killed by the dip which remains in the wool of the sheep. Only in one instance did the fluid fail to kill larvae which hatched from ova that had been dipped *in vitro* and placed on a sheep immediately after it was dipped. The reason for this failure may have been due to the fact that the patch upon which the ova were placed dried up very quickly, it being a fact that some parts of a sheep dry up much more quickly after dipping than others. However, as this experiment, which was carried out in the winter, was afterwards repeated in summer with the result that neither the long-woolled nor the short-woolled sheep that were used became infected, the failure was probably due more to the quality of the wool of the sheep than to the actual length of time the animal took to dry. This dip also does not protect sheep against scab to any great extent. The majority of the acari that were placed on dipped sheep 24 and 48 hours after the animals had been immersed for 2 minutes survived, except in one instance when 100 females that were placed on a short-woolled sheep 24 hours after the animal was dipped all died within 24 hours, and even a small percentage of the acari that were placed on sheep 3 and 4 hours after the animals were dipped lived for over 24 hours. Of the sheep that were dipped and an hour or two afterwards kept in contact with scabby sheep for various periods, 3 out of 15 became infected after being kept with the infected sheep 2 days;

12 out of 15 after 4 days, and 13 out of 15 after 6 days. In spite of the results of these experiments it must be admitted this dip has proved very satisfactory on the whole in practice in South Africa. It should, however, not be used if sheep are to be kept in infected places after dipping.

2. *Cooper's Sheep Dip*.—This dip does not destroy either fresh eggs or eggs immersed *in vitro* from 2 to 20 minutes and placed on sheep immediately after they have been dipped for 2 minutes, but the larvae are killed very shortly after hatching. Fresh ova placed on sheep at intervals from 2 to 18 days after the animals had been given a second dipping did not infect the sheep.

Ovigerous females are not killed by being immersed in the dip *in vitro* for 2 minutes, but sheep dipped in the fluid are protected against scab for several days. In one experiment a sheep that was infected with ovigerous females at intervals up to 6 days after it was dipped remained clean. In another, females that were placed on a sheep from 24 hours to 9 days after dipping died without infecting their host. In another, females that were placed on a sheep from 24 hours to 12 days after dipping also failed to infect their host, and in one experiment females that were placed on a sheep 3 hours to 14 days after dipping all died within 24 hours after being placed on the animal<sup>(1)</sup>. Of the sheep that were dipped and an hour or two afterwards kept in contact with scabby sheep for various periods, 1 out of 15 became infected after being kept with the infected sheep 4 days, 8 out of 15 after 6 days, 14 out of 15 after 10 days, and 12 out of 13 after 14 days, one of which became infected on the head only.

3. *White Cyolin (1%)*.—Very satisfactory results were obtained with this fluid. Ova immersed *in vitro* for 2 to 20 minutes and then placed on a dipped sheep are as a rule not destroyed but the larvae which hatch are killed. Ovigerous females placed on a sheep 3 hours to 17 days after the animal was dipped died within 24 hours with the exception of a few that were placed on the sheep 15 days after dipping; these lived for a number of days and infected their host.

4. *McDougall's Sheep Dip (No. 4)*.—Ova immersed *in vitro* in this fluid for 2 to 20 minutes and then placed on a dipped sheep are not destroyed, but the larvae are killed almost immediately after hatching. The dip protects sheep that have been immersed in it for 2 minutes against scab for 5 to 7 days.

5. *Delmore Tobacco Dip*.—This fluid does not kill the ovigerous females after they have been immersed in it *in vitro* for 2 minutes, nor does it destroy ova after they have been dipped for 20 minutes *in vitro* and then placed on sheep immediately after they have been given a 2 minutes immersion. Furthermore, it is not a dip that could be relied upon to any extent in protecting sheep against scab. A number of the females that were placed on sheep three hours after the animals had been dipped in a .045% solution lived for 2 to 4 days, and in one instance a few acari lived for over a week and succeeded in infecting their host. Some of the females that were placed on sheep 2½ and 24 hours after the animals were dipped in a .07% solution (the maximum strength recommended for use) lived 24 hours or longer, and those placed on the sheep 48 hours after

(1) When dipping infected sheep in Cooper's Powder Dip we have, however, frequently found living parasites 24 hours after dipping.

they were dipped infected their hosts. Even some of the larvae which hatched from ova dipped *in vitro* and placed on animals that had been immersed in .045% and .07% solutions were not killed.

6. *Delmore Tobacco and Soap* (.077).—This dip, like the preceding one, does not protect sheep against scab after they have been immersed in it. Females that were placed on a long-woolled and a short-woolled sheep 3, 24, and 48 hours after the animals had been dipped in it infected their hosts, and in one experiment some of the larvae which hatched from ova immersed *in vitro* and placed on sheep immediately after they had been dipped were not killed.

7. *McDougall's Tobacco Dip*.—("Lion Brand" concentrated). Out of 15 sheep that were dipped and an hour or two afterwards kept with a number of badly infected scabby sheep for two days, only one became infected. Of the 15 dipped sheep that were kept with the infected sheep for 4 days 3 became infected, one in three places, and of the 15 dipped sheep that were kept with the infected sheep 6 days 13 became infected.

8. *McDougall's Powder Dip*.—Ova immersed *in vitro* for 20 minutes and then placed on sheep immediately after they have been dipped are not destroyed, but the larvae are killed almost immediately after they hatch. Out of 125 ovigerous females that were immersed *in vitro* for 2 minutes and afterwards placed on clean sheep only 3 lived and laid eggs. For protecting sheep against scab this dip is excellent. All the females (about 2,000 were used) that were placed on sheep 1½ hours to 16 days after the animals were dipped died within 48 hours, and the majority within 24 hours, with the exception of one batch of 100 that was placed on a sheep 15 days after dipping. The majority of these lived for several days, and a few for a number of days. In one experiment only 8 out of 100 females that were placed on a sheep 22 days after it was dipped were alive 24 hours after being placed on the animal. The experiment in which sheep were kept in contact with a number of scabby sheep after having been dipped demonstrated that this dip protected sheep against scab for 6 to 18 days.

9. *McDougall's "Kymac."*—Only a small percentage of the ova hatched that were immersed *in vitro* for 2 to 20 minutes and then placed on sheep immediately after the animals had been dipped, and the larvae which succeeded in hatching died almost immediately after they had escaped from the eggs. On the other hand, all the ova that were immersed *in vitro* for 2 and 10 minutes respectively and afterwards placed on clean sheep hatched and the larvae reached maturity. This preparation is also an excellent one for protecting sheep against scab infection. Females that were placed on a long-woolled sheep 4 hours to 11 days after the animal was dipped died within 24 hours after being placed on the animals, and those that were placed on a short-woolled sheep 4 hours to 4 days after dipping did likewise. A few of the females that were placed on the same short-woolled animal 7 and 9 days after it was dipped lived for several days, although the females that were placed on this animal 11 days after dipping all died within 24 hours, and so did the 100 that were placed on it 13 days after dipping, with the exception of two.

10. Caustic Soda and Sulphur, Jeyes' Fluid, Delmore Sheep Dip, McDougall's Sheep Dip all failed to either kill ovigerous females or destroy their ova after they had been immersed in the fluids *in vitro* for 2 minutes.

## CONCLUSIONS.

Experiments carried out with Lime and Sulphur Dip, Cooper's Sheep Dip, White Cyolin (1% solution), McDougall's Sheep Dip (No. 4), Delmore Tobacco, Delmore Tobacco and Soap, McDougall's Powder Dip, and McDougall's Kymac prove that none of these dipping fluids, with the exception of Kymac, destroy ova that are laid on sheep a day or two before the animals are immersed in the fluids, and even with Kymac only a certain percentage are destroyed. However, with the majority of these dips this is of no importance, since the larvae are killed within a few hours after hatching by the dipping fluids that remain in the wool of the sheep after the dipping operations. The only dips that failed to destroy all the larvae after hatching were the Delmore Tobacco and Tobacco and Soap Dips, and also the lime and sulphur. The tobacco dips killed the majority of the larvae, and in the case of the lime and sulphur dip, out of 457 larvae which hatched from ova dipped *in vitro* and placed on various sheep after immersion, only a small percentage of one batch of 25 reached maturity. Apart from Kymac, the only effect the dips have upon the ova is to retard development. Normally the eggs take 2 days to hatch, but after being dipped *in vitro* and placed on dipped animals, they invariably take 3 to 4 days to hatch. Theoretically speaking, any dip that either destroys the ova or kills the larvae after hatching should cure sheep of scab after they have been given a single immersion.

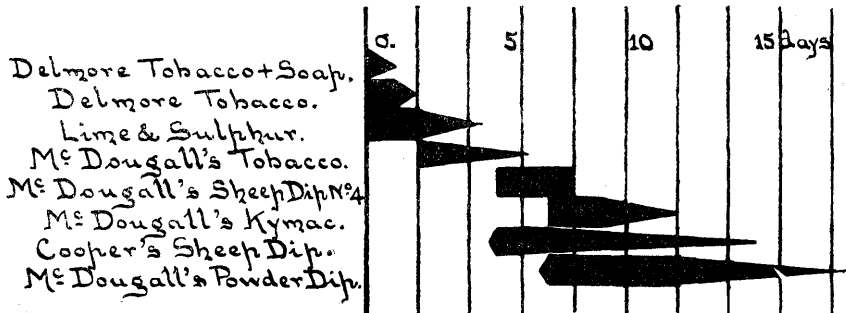
Ovigerous females that were immersed *in vitro* in lime and sulphur, caustic soda and sulphur, Cooper's Sheep Dip, Jeyes' Fluid, Delmore Sheep Dip, and McDougall's Sheep Dip (No. 4) for 2 minutes were not killed. The lime and sulphur dip also failed to kill ovigerous females that were immersed in it for 10 minutes.

Females that were immersed in McDougall's Kymac for 2 minutes and afterwards placed on a clean sheep, all died within 24 hours, and likewise the 125 females that were dipped in McDougall's Powder Dip for the same period, except 6, three of which died on the 2nd and 3rd day after immersion without laying eggs.

Some of the experiments recorded in this paper have clearly shown that certain dips afford protection to sheep against scab for longer periods than others, and this is an important factor that should be taken into consideration, especially if sheep are kept in infected places after dipping. Moreover, the chances of a scab parasite being able to survive on an animal after it has been immersed in a fluid that does not protect it against scab after dipping are naturally greater than that of an acarus living on a sheep that has been immersed in a fluid that protects it against infection for several days. This would especially apply in the case of a dipping fluid failing to reach an acarus living under a crust. Should the parasite migrate from under the crust within a few days after dipping it would be destroyed if the dip retained its killing powers after drying but not otherwise.



The following chart shows the minimum and maximum periods the tests have demonstrated various dips afford protection to sheep against scab after immersion:—



What is most remarkable is why the periods certain dipping fluids may be relied upon to protect sheep against scab after immersion should be so variable. This is impossible to explain as all the animals used in these experiments were the same class of sheep, and the quality of their wool was also about the same standard. Some of the sheep took longer to dry than others, and some possessed longer wool than others, but these differences were not responsible for the great variations. It was observed in one of the dipping tests with Cooper's, as has already been stated, that there was no sign of dip in the wool of some of the sheep about 10 days after dipping, whereas others still retained dip in their fleeces. Neither the length nor quality of the wool appeared to be responsible for this.

In attempting to eradicate scab from a country there are, however, other important factors besides the qualities of the various dipping fluids in general use that have to be taken into consideration; these are:

1. *Personal Element.*—Speaking generally, it may be stated that the go-ahead farmers in South Africa have succeeded in freeing their flocks of scab, they having realized how important it is that their sheep should be free of scab if their animals are to maintain a high standard. They have in consequence spared neither energy nor expense in achieving their object. They not only continued to dip their flocks until they had stamped out the disease on their farms, but they have also taken every precaution to see that their animals did not become afterwards reinfected through coming in contact with their neighbours' infected sheep. It is, therefore, one might say, only the farmers who either lack sufficient inclination to see that their animals are properly dipped, or lack sufficient capital to continue dipping until success has been obtained, who are breeding scab in South Africa to-day.

2. *The Length and Quality of the Wool of the Sheep.*—In some of the experiments discussed in this paper, the results with the short-woolled sheep were more favourable than with the long-woolled animals, in others the reverse was the case, and in some cases there were no apparent differences. Theoretically one would expect short-woolled sheep to be more easily cured than long-woolled animals on account of it being easier for the fluid to penetrate to the skin. On the other hand one would expect long-woolled sheep to be more

easily cured because they take longer to dry than short-woolled animals. However, it is not only the length of the wool that has to be taken into consideration but also the quality. With sheep that have very fine loose wool it is an advantage if their wool is long when they are dipped in a fluid that does not protect them afterwards against scab, but with sheep that have thick wool, the thicker the wool and the longer the length, the less will be the quantity of dipping fluid that will penetrate to the skins of the animals, and so reach the acari. This probably explains why in many instances certain dipping fluids have proved a success and at other times a failure. Sheep that are in first class condition and carry first class wool on them are immune from scab, likewise are sheep that have an abnormal amount of yolk in their wool, and so are sheep that have exceptionally dry skins and wool to a great extent. Not only would it be impossible to infect certain classes of pedigree animals in the pink of condition, but if it were possible to infect them it would also be impossible to cure them of scab by dipping because the fluid would, owing to the thickness of the wool, be unable to penetrate to the bodies of the animals.

3. *Length of Time it takes an Animal to dry after Dipping.*—The length of time an animal takes to dry after being dipped is of no importance if the animal has been dipped in a fluid that will protect it against scab for a number of days, but if the dip is slow in its killing action on the mites and does not protect the sheep against scab for more than a few hours after they have been dipped, it may be the direct cause of either a cure or a failure to cure.

4. *Infection of the Sheep.*—In the dipping trials that were carried out in 1914, mention of which was made in the beginning of this article, only sheep that were *very* badly infected with scab were used, yet the various dips tested cured the animals of scab, with the exception of one or two which proved useless. Had sheep possessing various qualities of wool and in various degrees of infection been selected for these experiments, it is possible that at least in one or two instances the results might have been different, because sheep, as soon as they become badly infected, fall off rapidly in condition, their wool becomes thin, and is frequently lost entirely on the parts where the animals are infected worst. It is, therefore, an easy matter for the dip to gain access to the acari on these bare places, especially if the crusts which are usually present where the wool has fallen off and under which numerous acari live are loose. On the other hand, with sheep that are only slightly infected, the wool may be sufficiently long and thick to protect the acari from the dipping fluid, if not entirely, to a sufficient extent to preserve their lives.

Infection may start anywhere on the sheep where there is wool, but as a rule it commences on the body, and if not checked may spread to the head, and even to the ears of the animals.

As it is only possible to immerse the heads of animals for a few seconds during the time they are in a dipping tank it is quite likely that the head infection has in many instances been the cause of failures to cure scab, especially when we consider that in practice failures have, at any rate in some cases, been due to acari not being killed on the bodies of sheep after they have been immersed in a fluid a full two minutes. It is not generally known that the *Psoroptes* of

the sheep can live in the ears of its host. When carrying out the experiments recently it was necessary to keep a number of infected sheep for obtaining material, and of these the ears of 35 out of 52 were found to be badly infected. In order to ascertain whether the parasites were the same variety as those found on the body, a number of acari (all stages) were collected from the ears of an animal and placed under a cover on the body of a healthy sheep. The result was the acari lived for a number of days and within 2 months the animal was very badly infected. We have also found three sheep infected with scab in their ears but not on either the head or body. Recently we carried out a dipping test with McDougall's Powder Dip which proved that sheep that are infected with acari in the ears are not always cured of scab when given two dippings in the ordinary way. These observations prove how important the ear infection is and how essential it is to hand-dress the ears of sheep when dipping for scab.

5. *Dipping Operations.*—When dipping sheep it is not only of the utmost importance that the dipping fluid should be properly mixed but it is also very essential that the following rules should be strictly adhered to:—

- (a) Before dipping, all animals should be shorn unless they possess very fine and loose wool, and the crusts on the bodies of infected sheep should be removed by hand-dressing to allow the dipping fluid to reach the acari. This should be done by rubbing the sheep with a brush, and to facilitate the work, the brush should first be steeped in a mixture consisting of two parts of oil to one part paraffin.
- (b) The ears of all sheep in an infected flock should be treated before dipping. This will not only prove to be quicker but will also be more satisfactory than examining the ears and only treating them should parasites be found. If crusts are present in the ears they should be removed as far as possible with a pair of forceps, without causing bleeding. Forceps are better than a knife to use owing to it being easier to remove the crusts from the ears with them after they have been loosened. After removal of the crusts the ears should be treated with one of the following oils:—

- (i) Stockholm tar ... .. 2 parts.  
Oil ... .. 2 parts.  
Turpentine ... .. 1 part.
- (ii) Oil ... .. 2 parts.  
Paraffin ... .. 1 part.

The Stockholm tar mixture should be well stirred before using. The mixture may be applied with some rag or cotton-wool bound round the end of a stick which should be pointed like a pencil. If the ears are rubbed lightly with this it will be found that any small crusts not removed with the forceps will become detached from the skin very easily. It is also a good plan to squeeze the ears when the rag or wool mop has been placed inside them, as this will cause the oil to run into the ears. If the

mixtures are properly applied one application will be found to be sufficient. However, as it is often a difficult matter to reach some of the acari in the ears, it is recommended that two applications should always be made, the second to be applied when the sheep are given a second dipping.

- (c) The animals should be kept in the dipping tank a full 2 minutes, the period to be timed with a watch or sand glass.
- (d) During the time the animals are in the tank they should have their bodies kept completely submerged, and their heads should be immersed two or three times.
- (e) The second dipping should always be given 9 or 10 days after the first.
- (f) After dipping, the animals should not be returned to infected ground for sixteen days or longer. Although this precaution is not necessary when using a dipping fluid that protects sheep against scab for a number of days, it is, in order to be on the safe side, advisable to adhere to this rule whenever possible.

As scabby sheep are invariably owned by farmers who either lack sufficient enterprise or knowledge to eradicate the disease on their farms it is advocated that stringent laws should be passed that will either force these farmers to eradicate scab or give up breeding sheep until such time arrives when the disease will be exterminated. Furthermore, in order to eradicate scab at the earliest possible period, which is everybody's aim, it is recommended that only dipping fluids that protect sheep against scab for a number of days be used, because these are the only dips which are likely to prove a success under adverse dipping conditions. We cannot guarantee that a fluid which will not protect sheep against scab will cure animals of the disease when the dipping operations are in the hands of incompetent men, but we can, with a fair margin of safety, guarantee that a dipping fluid that will protect sheep against scab will prove a success even when the dipping operations are in the hands of such men.