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Council for Scientific and Industrial Research

The Prevention and Treatment of Blowfly Strike in Sheep

REPORT No. 2

By the

JOINT BLOWFLY COMMITTEE

(Appointed by the Council for Scientific and Industrial Research and the New South Wales Department of Agriculture)

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FOREWORD.

The Joint Blowfly Committee has continued for some time to co-ordinate the research activities on the sheep blowfly problem carried out by officers of the Council for Scientific and Industrial Research on the one hand and by officers of the New South Wales Department of Agriculture on the other.

At the present time the members of the Committee are as follows:—

L. B. Bull, D.V.Sc., Chief, Division of Animal Health and Nutrition, C.S.I.R. (*Chairman*).

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I. M. Mackerras, B.Sc., M.B., Ch.M., Division of Economic Entomology, C.S.I.R. (on active service abroad).

The Committee has prepared the statement which is published in this Pamphlet for the guidance of graziers in the prevention and treatment of blowfly strike in sheep. It has been assisted in the preparation of the statement by the following officers:—

M. J. Mackerras, M.Sc., M.B., Division of Economic Entomology, C.S.I.R.

J. H. Riches, B.Sc.Agr., Ph.D., Division of Animal Health and Nutrition, C.S.I.R.

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There has been no attempt in this publication to place before readers the full evidence in support of the various recommendations made. Much of this evidence is to be found in publications already available, and references are made to the more comprehensive of these for the benefit of those who seek fuller information. The source of the information used in compiling the Pamphlet is thus revealed and acknowledged by the Committee.

As far as possible the statement has been confined to an outline of the practical applications of existing knowledge in the prevention and treatment of fly strike. It is hoped that this will place the various methods in proper perspective and will serve, for the time being, as a guide to flock masters and others.

The Prevention and Treatment of Blowfly Strike in Sheep.

I. INTRODUCTION.

1. General.

As a result of continuous work over the last ten years the *causes of fly-strike in sheep in Australia are now well known.* The most common form of strike occurs in the breech region in ewes, but it also occurs about the head of rams, in castration and tail wounds of lambs, on the body when the fleece is kept wet for a sufficient length of time by rain in warm months, and about the pizzle.

In the vast majority of cases the strike is due to the so-called primary fly, *Lucilia cuprina.*

Sheep are not struck simply by chance. Merinos are more liable to be struck than the British breeds of sheep, and within the Merino breed some classes of sheep are more predisposed than others. The conditions which contribute to make a strike possible or probable can each be attacked by appropriate preventive measures. *A sheep predisposed by breed and conformation must become attractive to the fly and present favorable conditions for the growth of maggots for an actual or effective strike to develop.* Stated simply, the conditions essential for strike are:—

(i) A sheep predisposed by breed and type;

(ii) A favorable site, usually on the breech, where the fleece and skin are affected by moisture with which are usually associated bacterial growth and inflammation of the skin;

(iii) Flies abundant and active. The proportion of actually susceptible sheep that becomes struck at any given time depends on the population of active, fertile, female flies present at the time.

The preventive methods to be described will therefore be grouped under the three heads:—

Measures to reduce inherent predisposition.

Measures to reduce immediate susceptibility.

Measures to reduce fly abundance.

No one method alone is completely successful. Thus, whatever method is adopted to reduce predisposition, it should be supplemented by others designed to prevent and control strike. These in turn should be supplemented by general station hygiene and by attempts to reduce the fly population. When all is done, some strikes will still occur, and this leads to the inclusion of a final section—"The Treatment of Strike."

Provided flies are sufficiently abundant, *moisture is a condition essential to strike.* Even sheep not naturally predisposed to strike will nevertheless become struck if, through rain or other conditions, the fleece is kept moist.

Weather influences both the sheep and the fly, and usually *strike occurs in fairly well defined seasonal waves, which vary greatly from district to district.* Local experience is at present the best guide to their occurrence.

The recommendations made are not confined to one specific method in any section. An attempt is made to give a clear description of the best of the available methods in each section, leaving the choice to the grazier in the light of his own requirements and experience with due regard to the published information that is already available.

2. The Basis of Predisposition to Strike.

The predisposition to strike of certain sheep is due essentially to characteristics of the sheep themselves, and it is not the result of external factors such as nutrition and management. Further, it has been shown that these characteristics are inherited and that a sheep showing a predisposition to fly strike is likely to produce progeny which are also predisposed and, conversely, a sheep that is less predisposed to fly strike will probably produce young with a similar lack of predisposition.

Crutch strike is the most common form, with body strike the next in importance. These two main types of fly strike have been investigated in relation to the predisposition of some sheep and its relative absence in others. The results have been fully reported* and need only brief recapitulation here.

Crutch Strike.—This term is used by stock owners to include all those cases where sheep are struck about the breech. The condition occurs more commonly in ewes than in wethers or rams. Ewes are more liable to fly attack in this part because of the possibility of wetting of the breech by urine. Moisture is essential for the establishment of a strike. Usually, however, in the field more than mere moisture is necessary to attract the fly. The continued wetting of the wool and skin leads to inflammatory changes with exudation, and in the wetted fleece soiled with urine and containing inflammatory exudate, bacteria, normally present on the skin and wool, multiply and cause decomposition. Thus conditions attractive to the fly are produced, and, if the flies are active and abundant, strike soon takes place. Hence, it is obvious that any conformation of the breech that creates conditions suitable for the holding of urine or maintaining wool in a damp condition will predispose the sheep to fly strike. The conformation renders the sheep predisposed, but the moisture and bacterial decomposition render the animal actually susceptible to strike.

One of the earliest observations made at the State Government Experiment Farm at Nyngan, New South Wales,† was on a flock

* References are to be found at the end of the section, p. 9.

† Reference 1, p. 9.

of 1,000 average western Merino ewes. Very careful examinations on individual sheep were carried out in an endeavour to find the main differences between the sheep which had not been struck and those which had been repeatedly struck. These observations have been supplemented over a period of years, and it has been found that—

(*a*) the sheep most frequently struck have very wrinkled breeches and, conversely, the sheep which have not been struck show plain breeches;

(*b*) malformation of the vulva is sometimes sufficient to deflect the urine on to the wool and so render some sheep susceptible to fly strike;

(*c*) sheep showing faulty conformation of the hindquarters with hocks approaching each other are prone to crutch strike; and

(*d*) ill-health is a negligible factor in predisposing sheep to fly strike.

Thus, predisposition to crutch strike is chiefly due to wrinkling of the breech, and sheep can be classified in three grades of potential susceptibility or predisposition according to the folds or wrinkles of the breech region, viz.,—A, "relatively no predisposition"; B, "partially predisposed"; and C, "predisposed".

The results of some of the observations made are shown in Fig. 1.

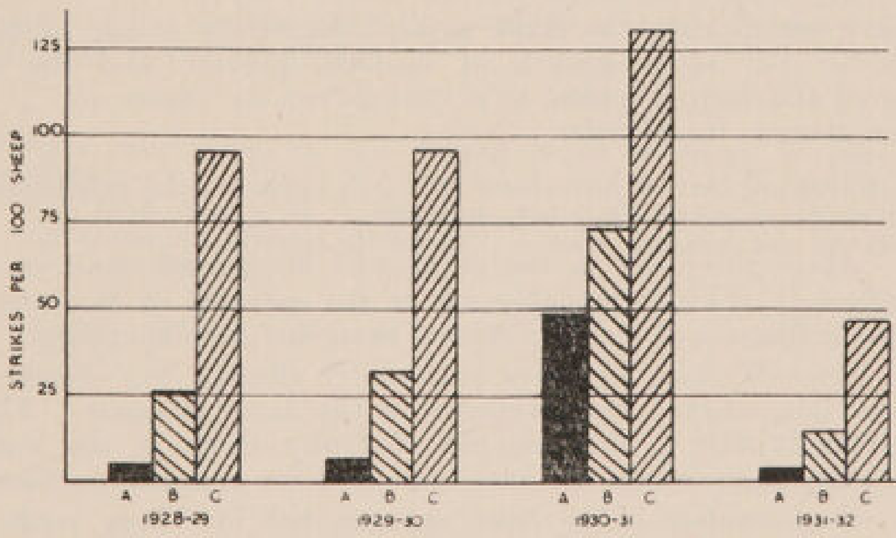

Fig. 1.—Showing comparative incidence of crutch strike in A, B, and C class sheep over four consecutive years. Note the very low incidence in A class sheep in average years and the great increase in strikes in all classes, A included, in the wet year 1930–31.

These observations indicate that sheep can be classified according to predisposition to fly strike, and that the development of an actual susceptibility can be anticipated in predisposed animals. Some explanation would appear to be required to account for the great proportion of A class sheep struck in the year 1930-1931. This was a year of high rainfall. Whilst under average seasonal conditions A class sheep are not predisposed to fly strike, they are, as are all sheep, much more susceptible to strike in seasons of high rainfall and high atmospheric humidity. Under the latter conditions the breech area of even the plainest sheep may be maintained in a continuously moist condition, thereby favouring a dermatitis (inflammation of the skin), the subsequent exudation forming an area attractive to the fly.

Further, it will be noted that the extent of fly strike in any year in the various groups of sheep is relative. For example, in the years of average rainfall, 1928-29, 1929-30, and 1931-32, only 5, 7, and 4 strikes per 100 sheep occurred in the plain-breeched sheep, as against 95, 96, and 47 strikes per 100 sheep in the wrinkly-breeched sheep, respectively. In the season of high rainfall, 1930-31, 48 strikes per 100 sheep occurred in the A class sheep, but a higher incidence of strikes occurred in the C class sheep, namely 131 per 100 sheep. In the years of average rainfall, the strikes in the C class sheep were from 10 to 20 times greater than in A class sheep, but in a high rainfall season they were only three times greater.

Body Strike.—The term "body strike" refers to strike on any part of the body except the breech, head, or pizzle. The common sites in order of importance are withers, back, loin, and sides. Wethers and ewes may become equally susceptible to fly attack in the situations named. Strike is much more likely to occur in sheep carrying six months wool or more than in more recently shorn sheep. Body strike occurs only in wet, humid seasons, and so may not be seen at all in some years but be commonly encountered in others.

In wet years, when the fleece is kept constantly moist, conditions suitable for the rapid growth of bacteria prevail, and the wool, discoloured and matted, passes to a state known as "fleece rot". This condition attracts the blowfly.

The following factors have been found to influence the predisposition of sheep to fleece rot and hence body strike:—

Age.—Sheep six to twelve months of age are most severely affected. This is probably due to the openness of the wool and the softness and mobility of the skin, due to immaturity.

Sex.—Wethers and ewes are equally affected, but classed ewes are less affected than wethers on the same property. This is probably due to the presence of faulty sheep in the wethers. Faulty sheep would not have been kept for breeding purposes.

Conformation.—The most common site of "body strike" is the withers, where fleece rot commonly occurs in sheep predisposed by the following types of conformation:—

(i) High shoulder blades, the movement of which leads to opening of the fleece above the withers, allowing water to enter.

(ii) Broad withers with depression between the shoulder blades from which water will not readily drain away.

(iii) "Pinched" behind the wither, with sometimes a definite "grip" present. Frequently, such animals have high shoulder blades. In the depression of the grip, moisture is retained.

Of these three faulty types, the third is the most frequent cause of fleece rot.

It was also found that a dense fleece, especially over the withers, tends to prevent the penetration of water, whilst a fleece lacking in density permits the entrance of moisture, and so is especially liable to fleece rot.

Colour, handle, and character of the fleece also play most important parts in the predisposition to fleece rot. Considering them in this order, it was found that the brighter wools were least susceptible, and there was a progressive increase in susceptibility through fairly bright, light cream, cream, to yellow wools. Variation in handle, that is, the softness of the wool to the touch, also affected susceptibility to fleece rot; harsh wools were more prone to be affected. Lastly, it was observed that the higher grade, better character, more stylish wools were least susceptible to fleece rot.

A high incidence of fleece rot was observed in cull sheep (slack and generally inferior-woolled sheep).

Briefly then, the insusceptible type of fleece is that which is bright in colour, is soft to handle, and exhibits good character, whilst the susceptible fleece shows a good deal of yellow colouration of yolk, is harsh to handle, and lacks character.

When sheep carrying high quality wool are affected with fleece rot, some fault in the conformation of the animal should be looked for.

Body strike depends almost entirely upon the pre-existence of fleece rot, and it is obvious that there exists a type of sheep definitely predisposed to this condition.

Further information on this subject is to be found in the following publications:—

1. H. R. Seddon, H. G. Belschner, and C. R. Mulhearn (1931), "Studies on Cutaneous Myiasis of Sheep". Science Bulletin No. 37, Department of Agriculture, N.S.W.

2. H. G. Belschner and H. R. Seddon (1937), "Studies on the Sheep Blowfly Problem." Science Bulletin, No. 54, Department of Agriculture N.S.W.

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II. MEASURES TO REDUCE PREDISPOSITION TO FLY STRIKE.

In approaching the problem of the prevention of fly strike, we must bear in mind that the first step is to reduce or remove, if possible, the inherent predisposition of sheep to fly strike. When this is done, the state of susceptibility is less likely to develop in the animals. In other words, sheep that are little predisposed by virtue of conformation are less likely to develop and harbour moist areas which not only attract the fly but supply essential conditions for the early development of the maggot.

The measures which can be employed to reduce this inherent predisposition are (i) selective breeding, (ii) the Mules operation, and (iii) adequate docking of the tail. These measures are briefly discussed and described in this section.

1. Selection and Breeding.

Since the characteristics which determine predisposition to fly strike or its relative absence are attributes of the sheep itself, if we are to reduce the predisposing factors it will be necessary gradually to breed away from them.

Let us consider the knowledge which we have and try to discover what evidence there is to suggest that we can develop a sheep not predisposed to strike by conformation, yet producing the desired type of wool in the required bulk.

Experiments in New South Wales have shown that to a great degree *wrinkliness of the breech is inherited, and plain breeched and wrinkly breeched sheep will tend to produce like progeny.* Mating A class ewes with A class rams gave progeny of which over 50 per cent. were A class, and less than 6 per cent. C class. When C class ewes were mated with B and C class rams, 10 per cent. of the lambs were A class, and nearly 40 per cent. C class. In a later test, three lots of ewes were divided into A, B, and C classes and mated with rams of their own class; the progeny classification was:—

Ewe Lambs.	*A.* Per cent.	*B.* Per cent.	*C.* Per cent.	*Total.*
From A class parents ..	55 ..	43 ..	2 ..	119
„ B „ „ ..	16 ..	72 ..	12 ..	117
„ C „ „ ..	4 ..	48 ..	48 ..	44
				280

These figures indicate that by breeding from A class parents we obtain a majority of A class progeny and a very small percentage of C class, but that by breeding from B and C class parents we tend to obtain a greater percentage of B and C class sheep.

Whilst it may be admitted by graziers that wrinkliness of the breech is undesirable in that it predisposes the sheep to strike, and that sheep may be bred so that they have plain breeches, it is contended by some that, by constantly breeding towards the ideal of A class sheep, density would be lost and the amount of wool produced by the sheep lessened. Others have claimed that quality of wool would be lowered. These fears are based on the opinions that it is necessary to have a certain amount of "development" (skin folds and wrinkling) in order to maintain density and bulk of fleece, and that plain-bodied, plain-breeched sheep carry light open fleeces.

As opposed to these opinions, the following facts are quoted:—

(i) Plain breeched Merino ewes retained in studs carry dense soft wool of high character.

(ii) Some of the best Merino rams seen on stud properties and at Sydney Sheep Shows are perfectly plain behind and would be classified as A.

(iii) Breeders themselves have realized that density is not necessarily dependent upon wrinkliness, since during the past 25 years, there has been a great change in the conformation of Merino sheep, and even those breeders who believe in the need for "development" do not favour the excessively wrinkled animals that took prizes some years ago.

(iv) In making alterations in their standards of what constitutes a good sheep, breeders have not had the blowfly problem especially in mind, but they have evolved a larger framed sheep of good constitution, comparatively plain in the body, and carrying long stapled wool of good density.

(v) Low predisposition to blowfly attack need not be accompanied by lack of quality in the wool. The relatively plain-breeched sheep at Nyngan Experiment Station have furnished a larger percentage of top line wool than the more wrinkly-breeched sheep. (See Figs. 2 and 3.)

(vi) Although the A class sheep may produce a lower weight of greasy fleece, the yield is higher, so that less difference is apparent in the weight of clean scoured wool produced*.

(vii) Examination of a considerable number of ewes culled at the annual sheep classing on both stud and flock properties has revealed that a very high percentage of the ewes culled are of the C class. These sheep were culled not on account of their breech wrinkles, but because the ewes were undesirable for other reasons, chiefly unevenness of the wool. The following two examples are given:—

(*a*) A line of sheep in which practically no attention was paid to the breech region during classing revealed the following figures:—

Class.	Unculled Flock.		Retained Flock (Breeding Ewes).		Culls.	
	Number.	Percentage Culled.	Number.	Per cent.	Number.	Per cent.
A.	119	27	86	46	33	24
B.	104	44	59	32	45	32
C.	101	60	41	22	60	44

* Reference 8, p. 24.

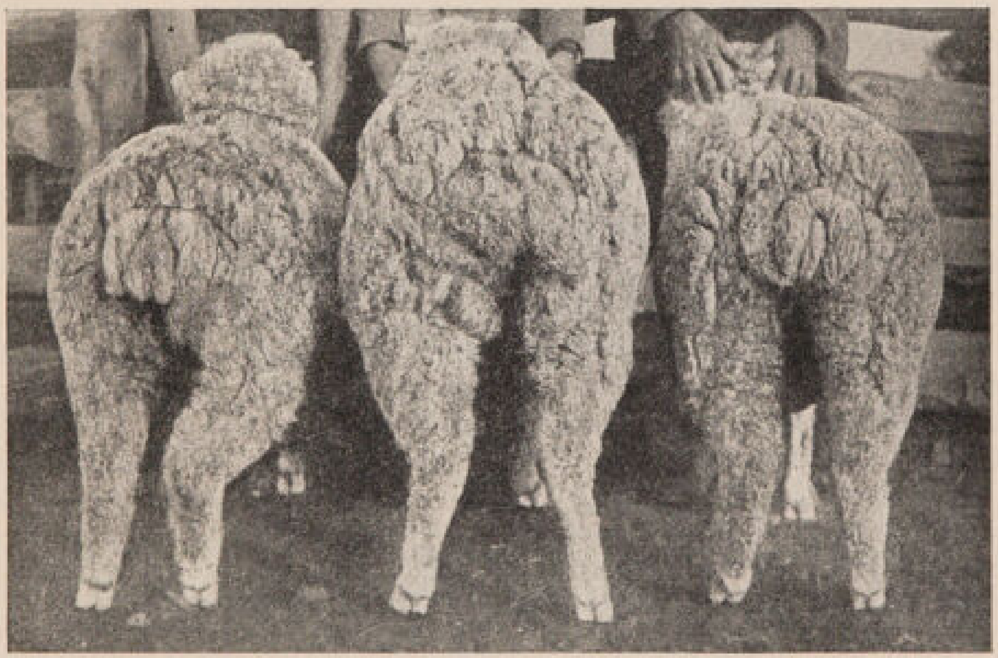


FIG. 2 (*top*).—Group of A class sheep (dense wool type).

FIG. 3 (*bottom*).—Group of C class sheep (dense wool type).

If more attention were paid at sheep classing time to predisposition to blowfly strike, having due regard to desirable characteristics in wool and conformation, owners would build up flocks of sheep with better constitutions and a more even type of wool, and there would be a reduced amount of blowfly strike to contend with, both on the breech and the body of the sheep.

Although artificial methods for the control of fly strike have been evolved, it is sound practice for flock masters to aim at the elimination of sheep highly predisposed to fly strike, particularly as less predisposed animals can produce the quantity and quality of wool required.

As, at best, only a gradual improvement in the building up of flocks more resistant to fly strike can be effected, we must depend at this time on artificial means of protection without slackening endeavours to evolve more resistant types of Merino sheep.

2. The Mules Operation.

The Mules operation is the removal of the wool-bearing skin-folds about the centre of the breech which are the most likely to be soiled by urine or dung (see Fig. 4). It does not involve the removal of all skin-folds about the breech and tail. By these artificial means the main predisposing factors to crutch strike can be eliminated. Reports on the method of performing the operation and on experimental, controlled trials have already been published.*

For example, in a carefully controlled experiment involving 616 sheep over a period of fourteen months, there were at least 13, and at most 22, crutch strikes among the sheep not operated upon for every one crutch strike among those that had been operated upon. If we consider only the last six months of the experiment when some of the sheep requiring further operative treatment had been attended to, the results were even better, viz., there were at least 23 and at most 46 crutch strikes in the sheep not operated upon for every one among those that had been operated upon. The lower figures in each case express results when the tail, as well as the breech, was involved, and the strikes may have started in either position.

During the whole period of the experiment there were 23 true crutch strikes contracted by 15 of the 310 sheep that had been protected by the operation, and 505 true crutch strikes contracted by 150 of the 306 sheep that had not been operated upon. Under conditions similar to those obtaining in this experiment, one could therefore expect the number of treated sheep struck in the crutch to be only one tenth of the number struck among untreated sheep, and the actual number of strikes to be about 22 times greater in the untreated sheep.

It was also observed in this trial that, while the results of the operation on less wrinkly sheep (B class) were less spectacular than with the more wrinkly types (C class), the percentage reduction in strike incidence was greatest in the less wrinkly animals. Thus, in the C class sheep, the number of pure crutch strikes was reduced from 448 to 22 (a reduction of 95 per cent.), whereas among the B class sheep the reduction was from 57 to 1 (98 per cent). These results are similar to those obtained by the N.S.W. Department of Agriculture.

A concise description of the method of carrying out the operation is given in the following paragraphs.

Selection of Sheep to be Treated.—Sheep can be treated at any age, but if the method is adopted as a more or less permanent policy in a flock the yearly operations will involve treating the ewes usually as

* See references at end of section.

weaners. Wethers can be treated if thought desirable. The operation can be carried out at marking time, but a larger proportion of the animals will probably require re-treatment as weaners or later. The

FIG. 4.—An example of a type of sheep requiring the Mules operation (see also Figs. 5 and 6).

protection of lambs, however, has advantages which under some circumstances will outweigh any disadvantages. The operation can be performed properly only on sheep crutched or shorn within a week or two; otherwise the presence and extent of wrinkles are masked by wool. It is desirable to treat all sheep except those with plain breeches free from wrinkles, and these are drafted off before operations commence.

General Arrangement of the Work.—The operation is best carried out in temporary yards in a clean paddock as for lamb marking. If lambs are to be treated, the folds should be removed before the tail is docked. A drum or some receptacle should be handy into which the skin folds can be thrown after removal. As soon as possible the skin folds should be burnt.

Instruments.—The most convenient instrument is a pair of dagging shears. For adult sheep one with 6-in. blades is best. Two or three pairs of shears should be used, as they must be kept sharp with blades riding each other closely, especially towards the tip. They are placed in an antiseptic solution and kept in it while not in use. They should be dipped in the solution after each sheep is dealt with, and after operating on a "dirty" sheep the shears should be placed back in the antiseptic fluid and another pair taken. (See Fig. 8.)

Holding the Sheep for the Operation.—The sheep is held on a rail in the same position as for lamb marking, except that the *hind legs must be held with the hocks bent* so as to slacken the skin on the breech. If the skin is stretched by straining the hind legs forward, the skin-folds are partly obliterated and cannot be successfully removed. (See Figs. 5 and 6.)

The Operation.—The folds to be removed run down from the butt of the tail one on each side of the vulva (the genital opening of the ewe). Hold the fold in the fingers of one hand and slightly lift it so that the shears can cut about half an inch of skin on either side of the base of the fold. *Start well up at the butt of the tail* and finish the cut well below the vulva. (See Figs. 7 and 8.) On no account should the bare skin surrounding the vulva be included in the skin removed.

If the skin about the breech is very slack and loose, another strip of skin should be removed from about 2 inches to the outside of each fold and level with the vulva. Actually, there is frequently a fold of skin in this position, and its removal is desirable when the skin of the breech is very slack. (See Fig. 9.)

All cuts should have a clean regular edge to facilitate quick healing. On no account should two adjacent wounds be allowed to join.

Precautions.—The operation should not be carried out when flies are active. This applies not only to blowflies, but also to bush flies, particularly when they are numerous. Cleanliness is essential. Infected wounds will attract flies and delay healing, which otherwise is remarkably rapid. A light application of dry boracic powder to the wounds is desirable in order to reduce the risk of infection by harmful organisms. The operation should be carried out in temporary yards in a clean paddock as for marking. The sheep should be kept quiet in the clean paddock for some days.

Retreatment.—If the operation is performed at marking time, the animals should be carefully inspected at weaning time or immediately after the first crutching. If the central fold on each side of the vulva is still evident it should be removed. Even when the operation is performed later, at weaning time or on adult sheep, a small proportion of animals may require retreatment, particularly if they are found to have urine-stained areas in the breech. If the sheep are struck, they should be brought into a hospital mob where they are carefully dressed. After the strike wound has healed, they should be examined with a view to retreatment by operation if necessary.

General.—The operation is simple to perform, and one man can operate on 100 or more weaners per hour with two or three catchers. The wounds heal quickly, and the majority of sheep require no re-treatment.

FIG. 5.—Sheep correctly held for the Mules operation. Note position of the legs and the prominent central breech folds (compare Fig. 6).

FIG. 6.—Same sheep as in Fig. 5 but held, as for lamb marking, with the legs stretched. Note apparent absence of central breech folds.

FIG. 7.—Showing how to commence the Mules operation. Note relative positions of tail, vulva and skin fold.

FIG. 8.—Finishing the removal of a wrinkle. Note disinfectant bucket with spare pair of shears. Receptacle for skin folds was on ground below bucket.

The degree of protection effected by the operation is permanent and, under normal conditions, the sheep will be as resistant to crutch strike as a naturally A class sheep. (See Fig. 1.) Fig. 10 shows in graph form the results obtained with C class sheep in the trial at "Dungalear" conducted by the Council for Scientific and Industrial Research. Apart from greatly reducing the incidence of crutch strike, the operation increases the ease and efficiency of crutching and jetting.

Fig. 9.—Showing position from which a second strip of skin is removed when necessary.

The Mules operation must not be regarded as an alternative to the policy of breeding towards plain-breeched sheep. As has already been pointed out, it is a valuable means of reducing the incidence of crutch strike to a minimum during the period which will be required to eliminate undesirable breech wrinkles by breeding, while yet retaining desirable fleece characteristics.

If the recognized operation is carried out on C class sheep, sufficient wrinkles will still remain to indicate the true conformation of the breech of the sheep.

If, however, more wrinkles are removed, or when the operation is performed on B class sheep, difficulty will be experienced subsequently in differentiating surgically treated from naturally plain-breeched sheep, and this may interfere with purchasers' breeding arrangements.

It is suggested that, in order to safeguard the breeders' programme, a uniform earmark be used in the unregistered ear to distinguish sheep which have been subjected to the Mules operation from naturally plain-breeched animals.

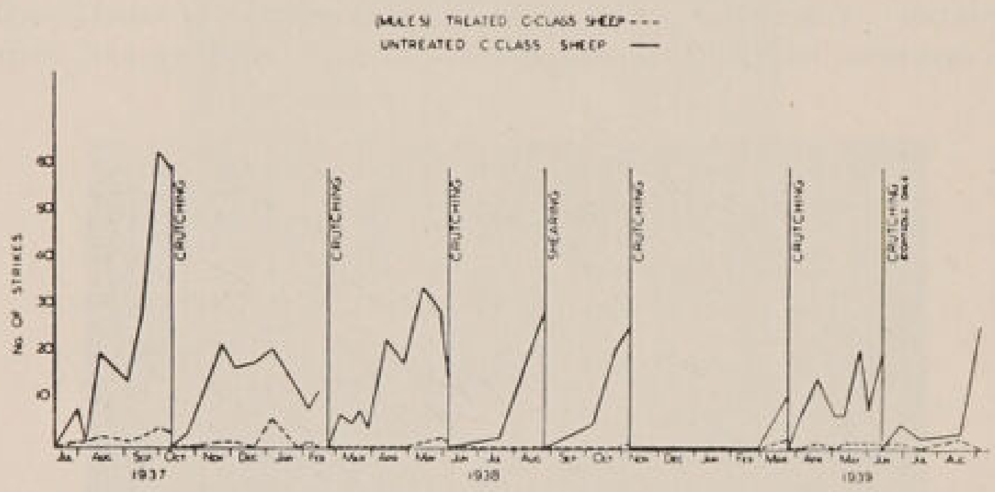


Fig. 10.—Showing the continued low incidence of true crutch strike in treated C class sheep compared with the rising incidence in untreated C class sheep, between crutchings. Note the continued low incidence of crutch strike in the treated sheep between March and September, 1939, although they were omitted from the routine crutching in June.

3. The Docked Tail: The Significance of Length.

The docking of the tails of lambs is a time-honoured process. Its main purpose is to prevent the accumulation of dung about the tail and breech. Whether or not an undocked lamb is more predisposed to fly strike under Australian conditions than a docked lamb is not certainly clear.

It is not suggested that the tail predisposes to fly strike as does the medial fold in the breech, but the importance of the proper length of the docked tail may best be discussed in this section dealing with measures to reduce predisposition.

The length at which the tail is docked is significant, both as regards the prevention of tail strike in the wound immediately after docking, and the prevention of crutch or breech strike later in the life of the animal. We are concerned here with the significance of the length of the docked tail in the prevention of crutch strike.

There has been difference of opinion between graziers on the effect of longer or shorter tails in relation to predisposition to strike. Recently, careful observation and experimentation have been carried out.

Observations published in 1939* by Gill and Graham describing an experiment on the Mules operation carried out at "Dungalear" station showed a marked correlation between tail length and incidence of breech strike (including both true tail strikes and true breech strikes). It was noted that the shorter the tail the greater the crutch strike incidence. At "Gilruth Plains," Cunnamulla (Q.), an experiment was carried out by Dr. J. H. Riches in 1938, in which approximately 390 ewe lambs were divided into three groups in which the tails were docked "short," "medium," and "long" respectively. The long tails were obtained by leaving a stump 4 inches long, the short tails by removing close to the buttock, and the medium tails by leaving a stump about 2 inches long, at marking time.

Up to the time these lambs were first crutched, at about 8 months of age, the strike incidence in the three groups, exclusive of strikes at marking, was as follows:—

	Long.	Medium.	Short.
Percentage sheep struck ..	26.2	39.7	49.2
Number strikes per 100 sheep ..	30.2	54.7	61.3

The higher incidence in the groups with shorter tails was not due to tail strikes, but to true breech strikes and strikes in which both breech and tail were involved. These results confirm the observations of Gill and Graham, and it therefore appears that length of tail has a definite bearing on the predisposition to breech strike in ewes; excessively short tails are associated with a higher incidence of strike, but tails left somewhat longer than is the usual practice are associated with a lower incidence.

From an examination of a number of sheep with various lengths of tail, it appears probable that the explanation of this effect is that the longer tails tend to press the inner breech folds apart and so reduce the liability to wetting. There may also be some brushing action on the wool.

Sufficient work has not yet been done to state the length at which tails should be docked to obtain the best results, but for the present it is recommended that tails be docked at a length of about 4 inches. Such tails, when uniform throughout a flock, are not unsightly and do not detract from the appearance of the sheep. Figs. 11 and 12 show the appearance of the sheep in the three groups at "Gilruth Plains," taken after the first shearing.

It is necessary to mention one important point in actual tailing or docking. In order to obtain adequate skin flaps to cover the stump, it is essential to retract the skin towards the base of the tail, more particularly on the under surface, before the amputation cut is made. This simple procedure not only provides an adequate skin flap to cover the stump, but also encourages the bare skin of the under surface to form the main covering of the stump, thus preventing an absorptive woolly surface coming in contact with the excreta.

* Reference 11, p. 24.

FIG. 11.—Showing (from left to right) "short," "medium," and "long" tailed weaners.

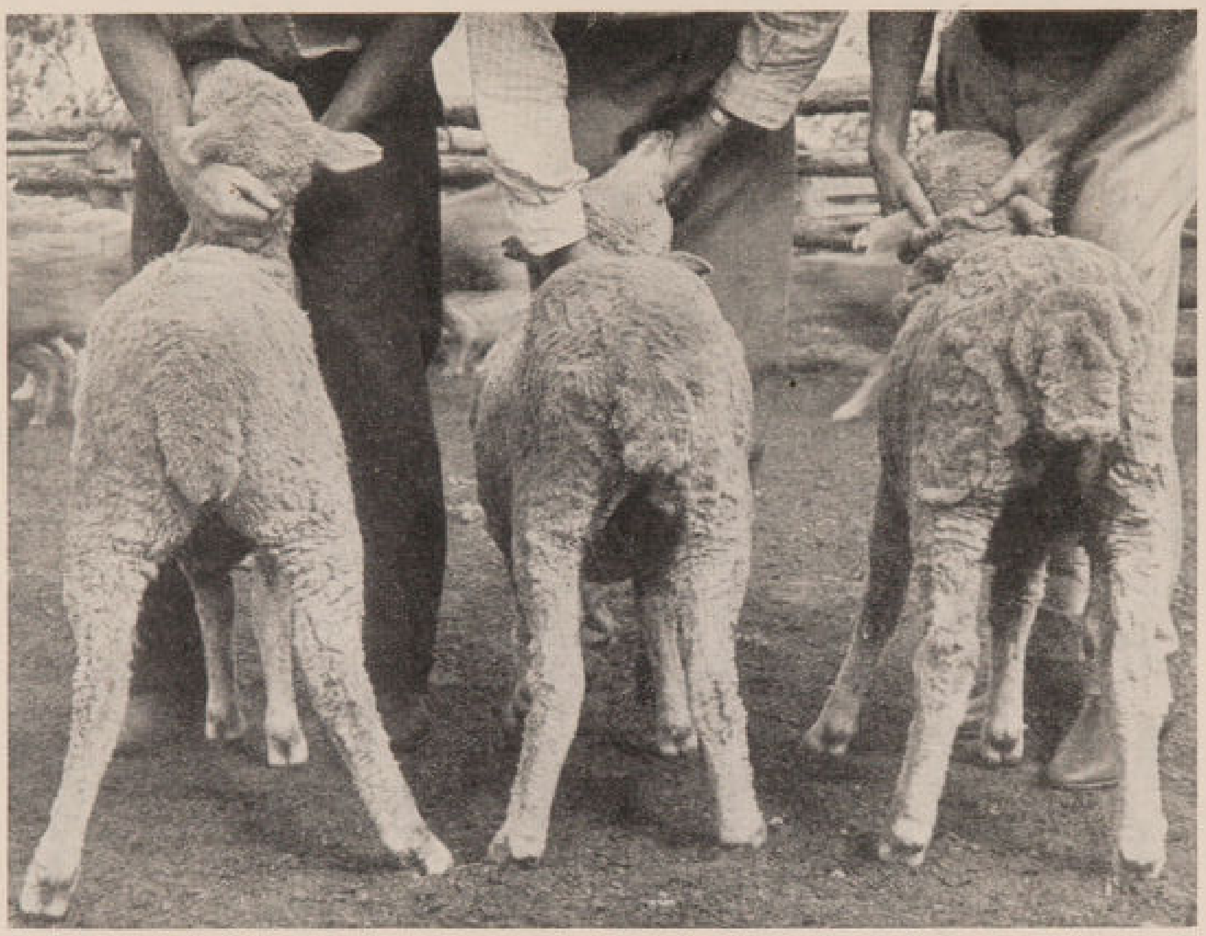


FIG. 12.—Showing the appearance of the " long " tail in (from left to right) A, B, and C class sheep.

Further information is to be found in the following publications:—

3. H. R. Seddon, H. G. Belschner, and C. R Mulhearn (1931).—"Studies on Cutaneous Myiasis of Sheep." Science Bulletin No. 37, Department of Agriculture, N.S.W.

4. W. I. B. Beveridge (1935).—The Mules Operation: Prevention of Blowfly Strike by Surgical Measures. *Australian Veterinary Journal*, vol. 11, p. 97.

5. I. M. Mackerras (1935).—Observations on the Mules Operation. *Journal of the Council for Scientific and Industrial Research*, vol. 8, p. 169.

6. J. H. W. Mules (1935).—Crutch Strike by Blowflies in Sheep: A Preventive Operation. *Queensland Agricultural Journal*, vol. 44, p. 237.

7. H. R. Seddon (1935).—Blowfly Attack in Sheep: Its Prevention by Fold Removal (Mules Operation). *Journal of the Council for Scientific and Industrial Research*, vol. 8, p. 25.

8. H. G. Belschner and H. B. Carter (1936).—"Fleece Characteristics of Stud Merino Sheep in Relation to the Degree of Wrinkliness of the Skin of the Breech." *Australian Veterinary Journal*, vol. 12, pp. 43-54, 80-89.

9. H. G. Belschner and W. L. Hindmarsh (1937).—"The Operative Procedure for the Control of Blowfly Strike of the Breech of Sheep (Mules Operation)." Veterinary Research Report No. 7, Department of Agriculture, N.S.W.

10. H. G. Belschner and H. R. Seddon (1937).—"Studies on the Sheep Blowfly Problem." Science Bulletin No. 54, Department of Agriculture, N.S.W.

11. D. A. Gill and N. P. H. Graham (1939).—"The Effect of Mules Operation on the Incidence of Crutch Strike in Ewes." *Journal of the Council for Scientific and Industrial Research*, vol. 12, pp. 53, 71-82.

12. "Method of Performing the Mules Operation for the Prevention of Crutch Strike." Pamphlet, Australian Wood Board (1940).

III. MEASURES TO REDUCE IMMEDIATE SUSCEPTIBILITY.

After adequate measures have been taken to establish a flock in which inherent predisposition to fly strike has been reduced to a minimum, attention will have to be given to those measures which may become necessary to control actual susceptibility to strike that will develop under certain conditions.

It is unsound practice to depend entirely on the measures to be described in this section for the control of fly strike in a flock. In nearly all cases, they are to be regarded as supplementary to the measures outlined in the preceding section.

1. Shearing : Crutching (and Ringing).

(a) Shearing.

By common consent, shearing is probably the most efficient method yet known of reducing susceptibility to fly strike, and it forms an integral part of any programme for its control or prevention.

Shearing just prior to, or at the beginning of, what is normally the worst fly season of the year will usually give a good deal of protection, and may even completely tide over that particular fly wave. If fly strike commences earlier than expected, and shearing is in progress during a wave, there may occasionally be serious trouble from strike in shear cuts, but this is exceptional and may be guarded against by the use of boric acid dressings on the more serious cuts. Sheep with plain breeches or those that have been previously subjected to the Mules operation are less likely to be injured on the breech.

In some districts, it is advisable to shear at a certain time in order to evade the effects of a heavy crop of grass seed. Under these circumstances, it may be necessary to shear at some time other than the optimal for the control of fly strike.

As the time of the worst fly wave varies from district to district, it is impossible to make any general recommendation as to dates. It must be left to the flock master, bearing in mind the efficiency of shearing as a preventive measure, to weigh carefully such factors as availability of shearers, lambing dates, and grass seeds, in selecting the time which will meet each combination of circumstances to the best advantage.

(b) Crutching.

Crutching is the measure most commonly adopted for the prevention of strike in the region of the breech. It consists of shearing the wool away from the breech, over the tail, and down the back of the hind legs. The object of crutching in blowfly strike control is to make the area unattractive to the fly by keeping it clean and dry.

One crutching at or near mid-season has value, in addition to the protection it confers, by preventing the occurrence of excessively dirty wool at shearing.

The value of crutching in the prevention of fly strike of the breech area is undoubted. *It is a most efficient method of reducing susceptibility of sheep to crutch strike,* and, as its value is so well known, it is unnecessary further to stress its importance.

From general observations that have been made, it is considered that, to lessen the trouble from blowfly strike in the region of the breech, owners might with considerable advantage crutch twice, first either in the spring or summer and then in the autumn, the actual dates depending upon the times of shearing and lambing, and upon the seasonal incidence of strike in their particular district. When a thorough system of jetting is carried out in conjunction with the single crutching, there is not the same necessity for a double crutching.

When extra crutchings are used to prevent damage in fly waves, they must be applied early if satisfactory results are to be obtained. In tests, where crutching has been applied before fly wave conditions developed, it has given protection for about six weeks. Where severe strike is experienced in less than six weeks after crutching, it is considered to have resulted from the crutching of flocks already showing many strikes or heavy soiling, both of which undoubtedly lead to inefficient removal of wool from the area and tend to increase the chance of infected shear cuts.

Objections to multiple crutchings are the labour costs and the loss from reduced return on the shorter breech wool.

It is frequently necessary to shear the wool away from the prepuce of rams and wethers, to prevent fouling of the area and consequent strike by flies. This is known as "ringing," and it is generally carried out at the same time as crutching.

2. Jetting.

Jetting has been widely employed for many years as a preventive method against fly strike. It consists essentially of forcing a jet of water containing a maggot poison in suspension or in solution into the fleece so as to saturate areas susceptible to fly strike. Jetting is most commonly used for protection against crutch and tail strike in ewes, but can also be applied to the breeches and heads of rams and the breeches and bellies of wethers; it has also given some promise in tests against body strike in ewes and wethers.

Success of the method depends on attention to essential details, and *especially to the early treatment of flocks* when fly activity begins. The most effective methods so far devised by officers in the N.S.W. Department of Agriculture are described in the following paragraphs. References to published works are cited at the end of this section.

(*a*) Jetting Mixtures.

No substitute for arsenic in jetting mixtures has so far been found. Calcium arsenite is the most protective and one of the cheapest of the materials available. It is recommended for general use, because it is considered that the extra period of practical protection which it affords against strike (four to five weeks as compared with about three weeks from sodium arsenite) more than compensates for some difficulty in its preparation and management.

Preparation of Calcium Arsenite Jetting Mixtures.—Calcium arsenite is made by boiling together white arsenic (arsenious oxide), caustic soda, and lime. The lime must not be air-slaked, and it is necessary to procure and keep it in drums with press-in lids. To prepare the mixture, proceed as follows:—

Place four 4-gallon buckets full of water on a fire; take four similar, but empty, buckets and into each weigh first ½ lb. of caustic soda and, secondly, 4 lb. of white arsenic. Weigh out four 4-lb. lots of stone lime (calcium oxide). A kitchen scale with weights and pan, or a clock-face spring balance, will make for speed.

Take the first full bucket of water which comes to the boil. Pour half of its contents into a bucket of soda and arsenic and place this on the fire to continue the boiling and dissolving of the arsenic. Use the other half to slake 4 lb. of lime, putting in the lumps 1 lb. or so at a time and stirring as slaking takes place. Stand the slaked lime (milk of lime) beside the fire.

When the liquid in the arsenic-soda bucket is clear (though still boiling vigorously), lift it away from the heat of the fire and pour a half-bucket of boiling milk of lime into it. Although on leaving the fire the arsenic solution will have ceased to boil, it will react violently with the lime added to it, and the mixture will boil over if the lime is poured in too rapidly. Place the full bucket of white mixture beside the fire to simmer for fifteen minutes.

When the four buckets of water have been used in this way, there will be four buckets full of calcium arsenite mixture, each enough to make 40 gallons of jetting fluid containing 1 per cent. of arsenic. To save time, plenty of buckets should be available, e.g., if 2,000 sheep are to be jetted per day it is best to start with two dozen buckets.

The concentrate can be stored for months in closed containers, preferably in screw-top 5-gallon drums, but larger containers are not recommended.

Calcium arsenite drops out of suspension unless the jetter tank has an agitator working in it. Similarly, a drum of mixture must be stirred before any of it is bucketed into the tank.

Sodium Arsenite Mixture.—Sodium arsenite solution for jetting, as originally officially recommended in Queensland, contained 0.7 per cent. of arsenious oxide. It continues to be fairly generally used at approximately that concentration. It may be made by boiling in 2 or 3 gallons of water, 3 lb. of white arsenic with washing soda (3 or 4 lb.) or soda ash (about 1½ lb.) or caustic soda (about 1 lb.) and adding the concentrated solution formed to 40 gallons of water in the jetter tank. Or, at a moderate additional cost, powdered sodium arsenite may be purchased for weighing direct (in proportions recommended by the manufacturer since there is some variation in the arsenical content of different brands) into the jetter tank. The addition of soap to make a lather with the sodium arsenite solution increases the apparent ease with which the fleece is wetted, but in tests has not resulted in increased protection.

Sodium arsenite provides a cheap mixture relatively simple to prepare, which does away with the necessity for fitting an agitator to the jetting machine. It is to be preferred where jetting is required within three weeks before crutching, because under such conditions calcium arsenite dulls the edges of cutters and combs. It may well serve for all jetting on properties of small area where an extra treatment during a fly-wave may be unimportant from the point of view of mustering.

In Queensland, jetting is controlled by regulations which make illegal the use of suspensions such as calcium arsenite within eight months before the jetted sheep are shorn, and limit the concentrations at which solutions such as sodium arsenite may be used at different periods before shearing.

(*b*) Jetting Equipment.

Pumps.—There are many brands of reliable jetting pumps on the market suitable to flocks of various sizes.

Jetting Race.—For the small property where a man may need to jet unassisted, a race of the branding-race type is best. It should be floored with concrete or battens and for preference be about 2 ft. 9 in. wide.

Where two or more men are available, the raised portable single sheep pen (Figs. 13 to 19) is recommended. A detailed description with plans is given at the end of this chapter.

Multi-jet Nozzles.—The number and size of jets that may be used depend on the capacity of the pump available. Fluctuations in pressure as the cut-off is opened should not exceed about 15 lb. up or down when jetting at 80 lb. per square inch. For the largest pumps, a five-jet nozzle, each having a bore of 1/16 inch or 5/64 inch, the whole delivering nearly 4 gallons of liquid per minute at 80 lb., is recommended, provided the run-off can be re-used. With the smallest power jetting plants, one three-jet nozzle, each 1/16 inch bore, may be used.

Multi-jet nozzles with a powerful plant and the raised race allow thorough treatment at great speed. For example, three men (one jetting, one managing mixing, and one penning) have treated 200 to 300 ewes per hour. The advantage of the multi-jet nozzle is reduced when sheep carry more than about four months' wool.

Re-using Jetting Liquid.—If the fastest nozzles are fitted, arrangements should be made to return to the jetter tank the liquid that splashes from the sheep, in order to avoid waste of mixture, excessive requirements in water, and the accumulation of poison in the vicinity of the yard. If calcium arsenite is being re-used, readily-mixed new mixture must be added continuously to keep the jetter tank full and so avoid progressive lowering of the arsenical content of the fluid passing through the pump. The system allows continuous jetting without any stop for refilling of the tank. It also allows each 100 gallons of new mixture to treat 400 to 600 sheep, depending on the length of the breech wool.

To prevent blockages, a sieve fine enough to protect the nozzle and fitted at the outlet from the jetter tank is essential. A sieve of 24 mesh gauge at the outlet will prevent nearly all blockages in 1/16 inch nozzles, but is hardly fine enough for 3/64 inch nozzles.

Protection for the Operator.—In jetting, the operator is exposed to repeated splashing and should therefore protect himself with such equipment as an aluminium face screen having a changeable celluloid window, rubber "canning" gloves, and home-made sleeves of light canvas (See Fig. 16).

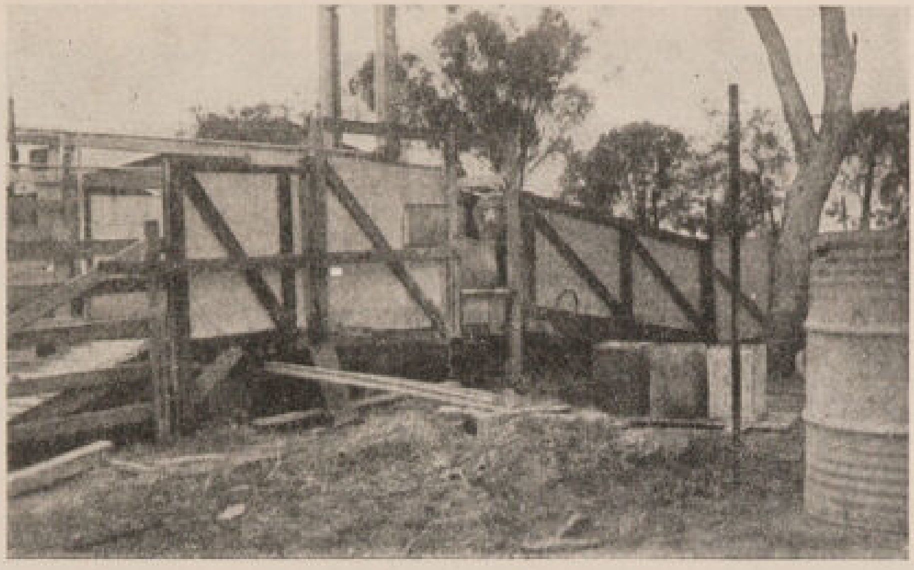


FIG. 13 (*top*).—Single-sheep portable race ready for use

FIG. 14 (*bottom*.)—The step before the entrance ramp consists of a four-foot slope followed by a nine-inch drop, which has the effect of keeping the main ramp full of sheep

(*c*) Systematic Jetting.

A programme can be devised for the effective control of strike involving shearing, one crutching, and jetting at repeated intervals. With systematic jetting, treatment of crutch strike within the flock is rarely necessary. Sheep may be attacked by flies, but strikes develop slowly in the area permeated by the calcium arsenite.

The maintenance of plain-breeched flocks, either naturally plain sheep or those treated by the Mules operation, increases the time of protection afforded by shearing or crutching, and probably by jetting.

The object should be to fill the fleece with mixture. A colour in the fluid is of great value (see below under "Jetting Injury"); to jet upwards in the crutch is usually essential; and raised races, multi-jet nozzles, &c., encourage thoroughness as well as speed.

In New South Wales, for sheep shorn in July or August, it is recommended that jetting be instituted at the onset of fly activity in the spring. Under "fly wave" conditions, calcium arsenite prevents the development of strikes which cause serious harm for from four to five weeks. The jetting is repeated as the sheep need it, until the heat of summer lessens fly activity, or until crutching at the end of summer. Jetting is required again a month or two after crutching, and is repeated at intervals until the winter, or, in exceptional circumstances, until shearing. As the fly is usually not active in summer or winter, the programme may require five jettings in the year, rarely more and usually less.

(*d*) Cost.

The cost of carrying out this programme of five jettings, for the purchase of calcium arsenite, interest and depreciation on plant (except in the smallest properties), and labour (apart from mustering) need not exceed 2½d. per head per annum. Calcium arsenite fluid costs about 1d. per gallon. The labour cost of preparing the concentrate is small. One man can make four buckets of concentrate in an hour.

It is clear, therefore, that jetting, associated with one mid-season crutching, can provide extremely economical management of sheep for protection from blowfly strike.

(*e*) Special Considerations.

There are, however, a number of difficulties to be overcome or objections to be met in employing such a thorough jetting programme.

(i) *Lambing.*—The normal lambing period occupies about six weeks. Jetting applied a week before lambing begins will not protect the most susceptible ewes from serious harm until lamb-marking; nor is treatment during lambing practicable on the majority of properties.

Shearing, crutching, or jetting before lambing does, in practice, result in freedom from serious crutch strike during lambing in many seasons. The time of protection afforded by shearing or crutching is, however, greater in plain-breeched flocks.

(ii) *Mating.*—The fear is sometimes expressed that a thorough jetting programme may interfere with mating. Experiments carried out during the past four years have failed, however, to show any disadvantage when test flocks were jetted with the rams joined. Where complete figures have been obtained, such flocks have produced at least as many lambs as have the controls.

(iii) *Small Strikes.*—No jetting methods have succeeded in preventing strikes for more than about two weeks. For a further period of two or three weeks, the increase in size of individual strikes is greatly delayed.

Nevertheless, these small strikes, up to 2 inches in diameter, may be numerous in a jetted flock, and their presence causes many graziers to condemn jetting or to expend unnecessary effort in dressing them.

During the past four years, experimental flocks receiving no treatment for these small strikes, except the periodical jettings, have shown no loss in wool production but, on the contrary, a gain in comparison with untreated sheep.

(iv) *Jetting Injury.*—Sheep may be seriously injured or killed, if arsenic is forced through the skin. Jetting injury may occur either in (*a*) unstruck or (*b*) struck sheep.

(*a*) Jetting injury on unstruck sheep can cause serious losses. It results from the forcing of the fluid through the sheep's skin. Pressures in the pump which are safe or dangerous vary with the length and type of fleece, degree of burr, size and type of nozzle, and obviously with the distance at which the nozzle is held from the fleece, while it is probable that the presence of penetrating grass seeds in the pelt may make sheep unusually susceptible. Accurate control over the operation is obtained by holding the nozzle 2 inches or 3 inches from the wool, reducing pressure to the lowest at which the fleece can be wetted to the skin, and compensating for lost speed of delivery by using larger or multi-jet nozzles. Sound advice, especially to the beginner, is that he should use a coloured mixture (red oxide of iron powder at the rate of ½-1 lb. per 100 gallons will colour the fleece and it will scour out) and start operations at an excessively low pressure, increasing it until satisfactory filling of the fleece is attained. At several experiment stations, many thousands of sheep have been jetted effectively and without injury during the past six years at pressures ranging from 40 to 90 lb. per square inch, when carrying four to twenty weeks' wool. It is realized that many graziers jet at much higher pessures, but careful observations over many years have shown that these lower pressures are satisfactory and they are undoubtedly safer.

(*b*) The policy of economical blowfly control by jetting involves the jetting of many small strikes. *To jet seriously struck sheep is most dangerous.* To distinguish clearly between "jettable" and "unjettable" strikes is difficult. A practice which has given satisfactory results for many years consists in refraining from jetting and substituting dressing for strikes of which the stained area is more than 3 inches across, jetting the smallest strikes as if they did not exist, and treating strikes of intermediate or doubtul size at reduced pressure by drawing back the nozzle while jetting the surrounding fleece at normal pressure.

(*f*) Single-sheep Raised Portable Jetting Race or Pen.

The jetting race, which is shown in the illustrations and plans, is made in sections of hardwood and sheet iron, in such a way that it can be dismantled for transport. It consists of entrance ramp (with a "step" at its lower end), central box (with its level floor 18 inches above the ground), and exit ramp. Overall length is 25 feet. The race is adjustable in width to 12 inches, 14 inches, or 16 inches to take sheep in single file without allowing them to turn. It is essential that the sheep being jetted be unable to turn anywhere in the entrance ramp or central box.

Sheep are made to walk through the race, being stopped for treatment by a sliding gate controlled by a lever in the operator's left hand.

They are held and prevented from backing by a "rake" (or small hinged door) attached to the offside wall (and controlled by the same lever) and jetted through an opening in the near-side wall. The operator stands in a hole in the ground beside the race. The depth of the hole is adjustable and may vary from 6 inches to 12 inches, as small changes in a man's height relative to the sheep are important to his comfort.

This race is suited to the fastest multi-nozzles, since it makes convenient the re-using of waste fluid at temporary as well as permanent yards. It allows fast work with ewes of all ages and is satisfactory for small flocks of rams. For large numbers of rams, it should be made wider (at least 18 inches) and with the rake 6 inches further from the sliding gate.

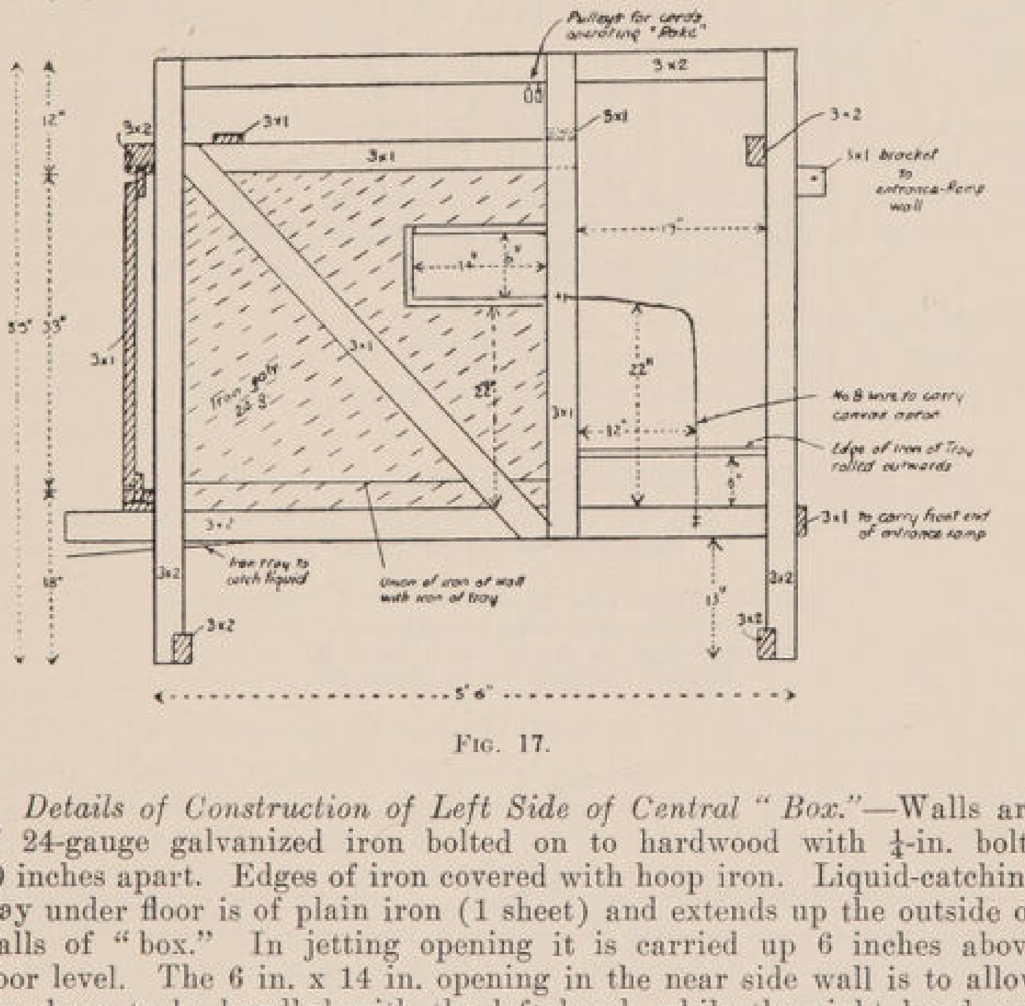
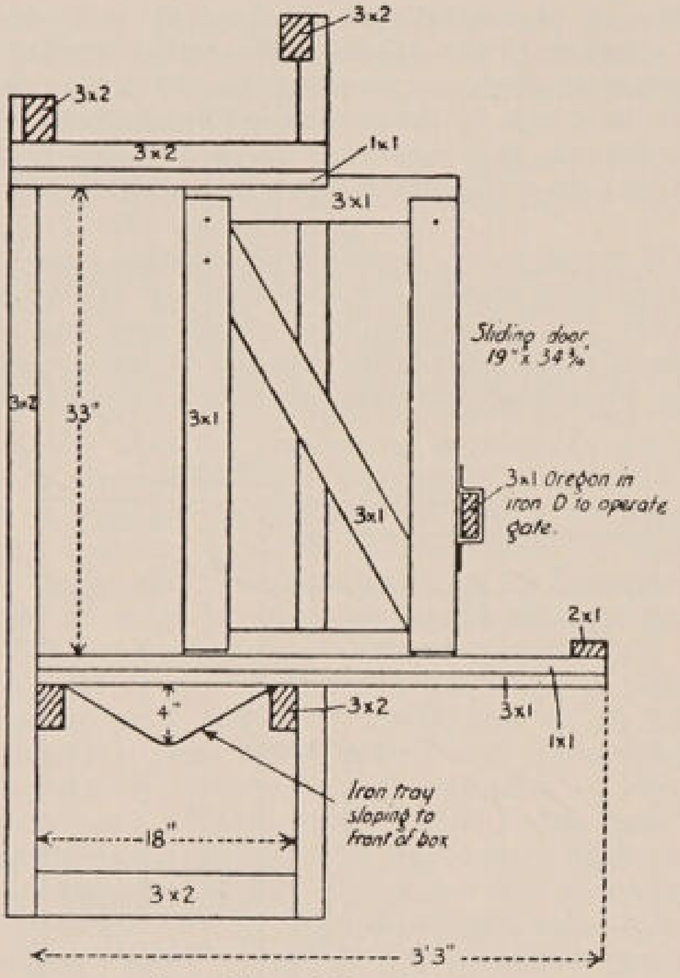


Fig. 17.

Details of Construction of Left Side of Central "Box."—Walls are of 24-gauge galvanized iron bolted on to hardwood with ¼-in. bolts 10 inches apart. Edges of iron covered with hoop iron. Liquid-catching tray under floor is of plain iron (1 sheet) and extends up the outside of walls of "box." In jetting opening it is carried up 6 inches above floor level. The 6 in. x 14 in. opening in the near side wall is to allow the sheep to be handled with the left hand, while the right hand and hose pass behind the canvas apron. (See Fig. 17.)

Dimensions and Position of Rake are Important.—The rake is to prevent sheep from backing out of the jetting position. One cord from the rake passes over two pulleys (the first on the off-side wall, the second on the near-side wall) to the lever operating the sliding door. Another cord passes from the rake over one pulley (on the near-side wall) to a weight near the operator's feet. When the sliding door is opened the rake is pulled back against the off-side wall. When the sliding door is shut the rake is pulled by the weight into the race to the limit of a check chain. The rake should come to within 10 inches of the near-side wall. It then holds the sheep, leaving the crutch open for jetting. (See Fig. 19.)



Front View of Central "Box."

FIG. 18.—Front view of central "box." Horizontal wires 3 inches apart complete the door. The moveable floor rests on the horizontal bearers.

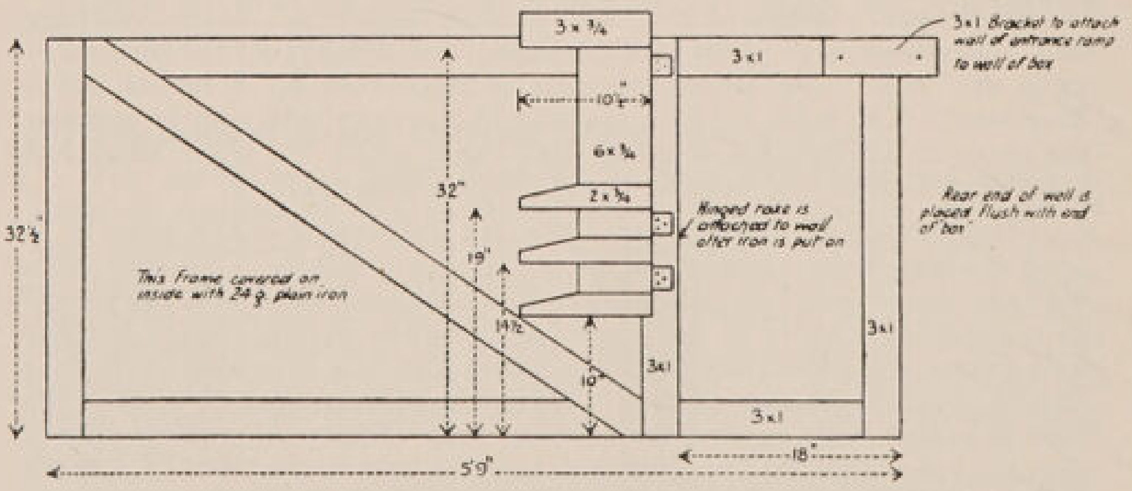


FIG. 19.—Frame of movable off-side wall of central "box," as seen from the inside.

3. Breech Dipping.

The practice of dipping the hind legs and breech of sheep by means of special mechanical dipping appliances has not yet been tested in adequately controlled experiments, and therefore its value in the control of strike cannot be discussed here.

Breech dipping was apparently first thought of and put into practice by Mr. J. Y. Shannon, of "Rodney Downs," Ilfracombe, Queensland, who first used this method some time prior to 1934. The dip evolved and patented by Mr. Shannon consists of a platform (with sides) which is pivoted in such a way that it can be tilted, thus submerging one end in an iron dip over which it is suspended. An iron grill is lowered in front to prevent the sheep from running straight through, and a leather cradle, or breeching, comes down over the sheep's rump and supports it while in the dip. The tilting of the platform is done by means of levers, and, although this is fairly heavy work, it is not unduly so. By the operation of the dip the whole of the hind legs and the breech area, including the rump to a point some inches above the tail, are submerged in the dipping fluid. The sheep is held in the fluid for some seconds, to allow complete wetting.

A second type of breech immersion dip, which is smaller and lighter but slightly more complicated, has been patented by Mr. T. Rigby, of Cracow. In this dip, although the breech and tail are fully immersed, the legs are not.

Sheep after dipping are allowed to remain in draining pens for some time, and the fluid running off is returned to the dip.

4. Protection of Rams' Heads.

There is an absence of reliable data on the best method for prevention of strike on rams' heads and no large scale experiments have yet been carried out. Shearing rams twice yearly should prove beneficial, especially if shearing be carried out in the autumn and spring. This method may, however, be inconvenient and inadequate, in which case other methods will have to be applied.

Methods are at present under observation but, as results are not yet available, their value cannot be assessed. The suggested methods and those which are in general use, however, are referred to below.

(*a*) *Jetting.*—Heads are jetted with a reliable arsenical jetting fluid, such as the calcium arsenite jetting mixture described on page 26. The rams are treated in a jetting or branding race with one man assisting the operator by placing one horn over the top rail and holding the other, thus more or less keeping the ram quiet. Jetting must be done carefully to avoid splashing occasioned by the jet coming in direct contact with the horn. A lower pressure than that used for breech jetting is advisable, one of 30 to 50 lb. per square inch being sufficient. The area jetted is around the rear base of the horns and well back across the poll.

(*b*) *Swabbing.*—The mixture used, preferably warm, must be worked in well round the horns and on the poll, by hand. In the light of present knowledge, glycerine diborate or other solutions containing high concentrations of boracic acid are suitable. Jetting fluids, such as calcium arsenite, could be used in this way.

(*c*) *Dry Dressings.*—For this purpose, dry boracic acid powder worked in thoroughly at the base of the horns is of value.

5. General Prevention of Sepsis (Bacterial Infection).

Occasionally, an outbreak of strike will occur in shearing cuts and more frequently in tailing and castration wounds. Such strikes are usually preceded by a bacterial infection of the wounds. The infecting organisms may be transferred by flies, and by the sticks and swabs used in dressing the wounds. Infected wounds attract flies.

The practice of putting the struck sheep of a flock over the board first is definitely unhygienic and must result in the contamination of combs and cutters with pus-forming organisms. If very wrinkly sheep follow and are much cut about, suppuration in some of the shearing cuts is likely to occur. It is a remarkable testimony to the resistance of sheep to pus-producing bacteria that such infections are the exception and not the rule but, nevertheless, this resistance can be broken down by gross contamination.

In order to avoid widespread infections, attention should be paid to general hygienic measures. Shearing sheds should be airy and well-lighted, for sunlight is a good germicide. Solutions used to disinfect boards or instruments should be strong and preferably hot. If lysol or phenol is used, the solution should be at least 2 per cent.—i.e., 13 oz. (or about $\frac{2}{3}$ pint) to a kerosene tin full (4 gallons) of water.

6. Lamb Marking.

(*a*) *Age.*—Observations show that the younger the lambs are when they are marked, the less is the likelihood of serious trouble from strike in the tailing and castration wounds. Lambs marked at 2 to 3 weeks stand the operations well, and their wounds heal more rapidly with less liability to sepsis than those in lambs 6 weeks or older. Docking the tail too short delays healing and favours sepsis and strike.

(*b*) *Cleanliness and the prevention of sepsis.*—The general measures for the prevention of infection dealt with in the previous sub-section should be applied. Rapid, skilful operation carries less risk of infection and is followed by rapid healing. The less lambs are driven or handled after marking the better. Marking should be carried out in temporary yards erected in clean paddocks in a different place each year.

Instruments used for marking should be duplicated, kept sharp, and allowed to stand in a good disinfectant solution. After operating on a dirty animal, the instrument can then be replaced in the disinfectant and a clean one taken.

(*c*) *Repellent dressings.*—Although assiduous search has not yet revealed an effective and lasting repellent against blowfly, experiment has shown that various dressings do give a measure of protection at lamb-marking. The dressing is not applied directly to the wound, but to the wool above the tail and on the purse. The time-honoured remedy of 1 part of kerosene and 2 parts of Stockholm tar is not to be recommended on account of its tar content, but it has been shown by experiment to give a definite degree of protection.

Citronella is one of the best repellents tested*, and a 10 per cent. solution in 10 per cent. soft soap solution has given promising results.

The citronella dressing is prepared as follows. Take 10 parts by weight of oil of citronella, 10 of soft soap, and 80 of water. The soft soap is dissolved in 50 parts of water by mixing thoroughly and heating almost to boiling. The citronella is then added *slowly* to the hot soap solution with continuous stirring: if added too quickly the solution may boil wildly and froth over. A cover is placed over the vessel to prevent loss by volatilization, and warming is continued for several minutes until the preparation becomes uniformly transparent and syrupy. The remainder of the water is then stirred in and the solution allowed to cool.

Further information is to be found in the following publications:—

Jetting.

13. R. N. McCulloch and K. R. Howe (1935).—"Jetting and Crutching for the Control of Sheep Blowfly Attack." *Agricultural Gazette of N.S.W.*, Vol. 46, p. 569.

14. R. N. McCulloch, K. R. Howe, and J. Hockley (1936).—"Jetting and Crutching for the Control of Sheep Blowfly Attack." *Agricultural Gazette of N.S.W.*, Vol. 47, p. 561.

15. R. N. McCulloch (1937).—"The present position in Blowfly Control in N.S.W." *Journal of the Australian Institute of Agricultural Science*, Vol. 3, No. 3, p. 129.

16. R. N. McCulloch and J. Hockley (1938).—"Blowfly Control by Jetting." *Agricultural Gazette of N.S.W.*, Vol. 49, p. 131.

17. R. N. McCulloch (1938).—"A five-jet nozzle." *Agricultural Gazette of N.S.W.*, Vol. 49, p. 136.

18. R. N. McCulloch (1939).—"Economy in jetting sheep." *Agricultural Gazette of N.S.W.*, Vol. 50, p. 196.

19. R. N. McCulloch (1939).—"A Single-Sheep Raised Jetting Race." *Agricultural Gazette of N.S.W.*, Vol. 50, p. 481.

Repellents

20. F. G. Lennox (1940).—*Journal of the Council for Scientific and Industrial Research*, Vol. 13, p. 65.

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* Reference 20, on this page.

IV. MEASURES TO REDUCE FLY ABUNDANCE.

Before discussing means of reducing fly abundance, it must be clearly understood which flies are enemies and which are not, for, obviously, the destruction of flies which never attack living sheep cannot reduce the amount of strike.

In the report No. 1 of the Joint Blowfly Committee*, the species of flies commonly involved in strike are illustrated in colour and are described on pages 11-14. The flies are divided there into three series—primary, secondary, and tertiary. The primary flies are those which will start a strike single-handed, so to speak; the other two groups merely follow on and infest the wound made by the more enterprising pioneers. Among the primary flies, the green-bottle—*Lucilia cuprina*—is the arch offender, the brown blowflies (the Calliphoras) taking second place as initiators of strike.† Among the secondary flies, *Chrysomyia rufifacies*, a green fly, which is quite often confused with *L. cuprina*, is the most important. If compared carefully, it will be seen that *Chrysomyia rufifacies* is a more thick-set fly and tends to have a bluish-green colour, whereas *L. cuprina* is a more slenderly-built fly and tends to a bronzy-green shade.

From studies carried out over the last ten years in Canberra and elsewhere, certain definite facts can be stated—

(1) Strikes only occur when primary flies are present in considerable numbers.

(2) By far the most important primary fly is *L. cuprina*.

(3) An increase (or decrease) in the abundance of *L. cuprina*, as recorded by regular trapping, shows a general correlation with a rise (or fall) in the incidence of strike.

(4) *Chrysomyia rufifacies* seldom, if ever, initiates a strike, although in company with primary flies it will produce very serious ones.

It follows, therefore, that attempts to reduce fly abundance must be directed systematically against the primary flies and, in particular, against *L. cuprina*.

The primary flies may be attacked either in the adult or in the maggot stage. Adults may be trapped or poisoned, and maggots may be destroyed in their breeding grounds, viz., carcasses and struck sheep.

1. Traps and Poison Baits.

Carefully planned experiments‡ have shown that extensive use of traps will reduce the incidence of strike by over 50 per cent. In these tests, however, the trapping was done on a scale hardly likely to be of practical application. The average distribution of traps was one to about 25 acres, but the concentration varied somewhat in the different sets of experiments. In one, in which no less than 46 traps were used to protect a 480-acre paddock, the strike incidence was one-third of that in the control paddock completely unprotected by traps. It seems clear, then, that the present methods of trapping do not provide economical control of strike.

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* Reference 21, p. 42.
† Reference 23, p. 42.
‡ Reference 22, p. 42.

Poison baits are subject to the same disabilities as traps, and they need not be discussed here, since no definite recommendations can be made regarding their use at present.

2. Carcass Disposal.

There is a definite succession of species of blowflies visiting and breeding in carrion. The chief factor which limits the number of blowflies emerging from a carcass is competition between the maggots themselves for available food; parasitic and predatory insects play minor roles.

During the early spring, the primary flies (which can develop at lower temperatures) breed freely in carcasses. When the secondary fly *Chrysomyia rufifacies* appears, the maggots of the primary flies cannot compete with the vigorous, hairy maggots of this species, and only those which are deposited early, i.e., immediately after the death of the animal, can obtain sufficient food for complete growth. Later arrivals will find the carcass overcrowded with secondary, and eventually tertiary, maggots.

The life cycle of *Lucilia cuprina* in the summer may be summarized briefly as follows:—Egg, 12 to 24 hours, maggot or feeding stage three days or more, prepupal or wandering stage two to three days, pupal stage eight days. The times vary greatly with climatic conditions and increase with reduction of temperature. Although the maggots normally feed for three days or more, they can assimilate enough food in two days (i.e., by the end of the third day after the death of the animal) for complete development, and the resulting fly, though smaller than the average, is fertile and normal in other respects.

It follows, therefore, that if carcass destruction is to reduce the primary fly population, it must be done while the feeding maggots of the primary flies are still present and before any have completed their feeding and left the carcass (i.e., within the first three days after the animal's death).

Methods of Carcass Disposal.

(1) *Burial.*—It has been shown that burial under 2 feet of soil will not prevent the emergence of primary flies. In one experiment, it was found that half a sheep's carcass exposed for three days and then buried produced many primary flies, including a few *L. cuprina*. Burial alone, therefore, is not an effective method of control, but it may be usefully combined with poisoning. The poisoning may be done by slashing the carcass and pouring over it a weak solution of sodium arsenite (1 lb. in 20 gallons of water), or by dusting with arsenical sheep dip or with borax. Burial is a laborious method for any except small carcasses, but is sometimes necessary in disease control.

(2) *Burning.*—Where possible, complete burning within three days of death is the most efficient means of carcass disposal.

(3) *Poisoning.*—Poison may be applied as in (1). If powdered poison is used, it may be mixed with an equal quantity of dry sand or soil and applied by means of an improvised pepper pot—any large tin

with some holes punched in the lid will serve. It is essential to dust the carcass thoroughly and to turn it over and treat both sides. Particular care must be paid to the mouth and all openings where flies congregate to lay their eggs. This method kills adult flies as well as maggots and, if applied in time, discriminates against the primary flies, as it prevents them breeding when the carcass is fresh. Later on, the poison may be washed off by rain, or the collapse of the carcass may allow the flies access to parts unaffected by the poison. Such unpoisoned parts will quickly become crowded with *Chrysomyia* maggots, which render it an unfavorable breeding ground for primary flies. In any case, these parts will be in such an advanced stage of decomposition as to be unattractive to *L. cuprina* which likes its meat relatively fresh.

It is evident then that poisoning is particularly efficient under summer conditions, for it then makes use of the antagonism which exists between the hairy maggots and the smooth. *It cannot be too strongly emphasized that unless the carcass contains the maggots of primary flies, or has been found very shortly after death, when only eggs are present, it is too late, and a complete waste of time, from the point of view of blowfly control, to destroy it.* It is, of course, obvious that this applies only in the absence of infectious diseases, and to carcasses found well away from homesteads.

Apart from the large carcasses of domestic and native animals, there is an enormous number of tiny carcasses available, e.g., birds, lizards, snakes, and even snails and large insects—each capable of producing a few flies. It is quite impossible to find, or even attempt to find, these small carcasses, and so a natural breeding ground sufficient to keep all species of fly from extermination must remain untouched. With this reservoir of flies, it only needs the presence of a favorable medium, such as is afforded by C class sheep, for *L. cuprina* to breed very rapidly, each female being capable of producing over 2,000 eggs.

3. Treatment of Crutchings.

In the experiment mentioned above, half a sheep's carcass, exposed for three days and then buried, produced very few *L. cuprina*; the other half, which was exposed for a longer period and left unburied, produced none at all. This was not because *L. cuprina* was inactive at the time. The experiment was carried out in March, during the usual autumn fly-wave, and *L. cuprina* was relatively abundant. Other experiments have supported this finding. From five sheep carcasses studied in Canberra, approximately 90,000 flies were bred out, and of these only 84 were *L. cuprina*. Where then do all the Lucilias come from?

Lucilia cuprina is not a wide-ranging fly. Four miles was its maximum flight in the experiments* conducted during the mid-winter of 1926. Under favorable conditions, its range may be greater, but generally, most of the flies on a given property have bred there, and their most favorable breeding ground is the living sheep. On the sheep, the food supply of the maggots is fresh and abundant, and not only are the maggots protected from parasites and predators, but also from their worst enemy—the cannibalistic maggots of *Chrysomyia*, which are usually late in invading a struck area.

* Reference 24, p. 42.

In order to gain some idea of the numbers of flies which might be bred from a struck sheep, three crutch strikes were selected and all maggots carefully collected and bred out. The results are given below. Strike 1 was very small, strike 2 moderately large, and strike 3 very severe, involving the whole breech and rump.

Species of Fly.	Number of Flies Bred Out.		
	Strike 1.	Strike 2.	Strike 3.
L. cuprina	87	1,692	4,343
L. sericata	0	0	44
C. stygia	0	31	168
C. augur	0	13	3
Chr. rufifacies	0	0	31
P. rostrata	0	0	301
Total	87	1,736	4,890

Thus, over 90 per cent. of the flies from each strike were *L. cuprina*—a very different result from that obtained from a carcass, for which less than 1 in 1,000 emerging were *L. cuprina*. Even a tiny strike bred more *L. cuprina* than any sheep's carcass studied in Canberra. This finding may apply only to the southern part of the continent. Further north, and in the dry inland areas, there is some evidence that carcasses may breed more *L. cuprina* than they do in the south.

The usual practice of scraping maggots out of a strike and allowing the crutchings to be trampled in the dust, gives L. cuprina every chance to complete its life history.

It is evident then that crutchings from struck sheep may be a greater potential source of danger than carcasses. Recognition of the importance of this source of primary flies should serve to stress the fact that, in adopting measures aimed at the prevention of strike, the pastoralist is also attacking the main breeding ground of the fly itself. However, while it is easy to recommend the complete destruction of all maggots in the crutchings, it is very difficult to do this in the field. Unless sheep are brought into the shed and crutched on the board, it is extremely difficult to collect all maggots with the crutchings. If crutching is done in the yards, most of the maggots will escape into the soil. This may possibly be overcome by the use of a large piece of strong canvas for the collection of the crutchings.

When the maggots have been collected, they must be destroyed. No one method is applicable in all circumstances. A choice may be made of one of the following suggestions. The maggots may be shaken on to a fire, or into a tin of hot water, or they may be dropped into a tin containing poison. If this method is used, it must be remembered that dilute solutions of disinfectants, and even arsenical solutions, are not rapid contact poisons, and maggots will soon crawl out of such solutions and escape. Strong solutions of coal tar oils, such as are contained in many proprietary dressings, are good maggot killers. Petrol is a very rapid killer, but is expensive. A solution of carbon tetrachloride is a rapid contact poison, and some dressings contain this substance in sufficient strength to kill maggots very quickly. Kerosene is a slow killer, but crutchings can be soaked in kerosene and set alight.

To sum up the methods of reducing fly abundance:—As the fly breeds mainly on the living sheep, the prevention of strike is the first essential. The next most hopeful line of attack is to destroy all maggots from crutchings. Unless this is done, it is futile to spend money on traps and carcass destruction. Carcasses must be destroyed immediately after death, or while primary maggots are present.

Further information is to be found in the following publications:—

21. Report No. 1, Joint Blowfly Committee (1933). (Pamphlet No. 37, Council for Scientific and Industrial Research; Science Bulletin No. 40, Dept. Agriculture, N.S.W.)

22. I. M. Mackerras and others (1936). "The Effect of Trapping on the Incidence of Strike in Sheep." *Journal of the Council for Scientific and Industrial Research*, Vol. 9, p. 153.

23. I. M. Mackerras and M. E. Fuller (1937). "Survey of the Australian Sheep Blowflies." *Journal of the Council for Scientific and Industrial Research*, Vol. 10, p. 261.

24. W. B. Gurney and A. R. Woodhill (1926). "Investigations on Sheep Blowfly. I. Range of Flight and Longevity. II. Notes on Bionomics and Parasites." Science Bulletin, No. 27, Dept. Agriculture, N.S.W.

V. TREATMENT OF STRIKE.

Blowfly strike may be defined as the condition produced by the development of blowfly maggots on the living sheep. It is characterized by an inflammatory condition of the skin and underlying tissues, exudation of fluid, and the presence of living, growing maggots. In the treatment of the condition, therefore, it is necessary:—

(1) To remove the maggots with as little damage as possible to the sheep's tissues.

(2) To encourage healing by the use of astringent and antiseptic dressings.

Early treatment is necessary; the sooner the struck sheep are detected the sooner can treatment be adopted; hence the inspection of the flock for evidence of strike must be frequent and regular.

As a first step, it is desirable to shear the wool over and around the struck area and to remove as many maggots as possible. The dressing is then applied. The struck area should be dressed with a soothing, protective dressing which will (*a*) not poison the sheep, (*b*) not induce an excessive scab formation, (*c*) kill the maggots, although rapid destruction is not essential, and (*d*) protect against restrike. The method of application varies because of the variable consistencies of preparations used.

Much experimental work has been carried out with dressings, proprietary and otherwise, to find a fully satisfactory preparation. Whilst a number of dressings will kill the maggots and assist the healing of the injured tissue, no satisfactory repellent has yet been discovered for incorporation in a blowfly dressing. In other words, if the breech area of a sheep is attractive to the flies, no repellent yet known will keep them away for any length of time. On the other hand, however, if the struck area is dressed so as to render it dry, and healing takes place without excessive scab or pus formation, then the area is rendered unattractive to the fly for some time.

In endeavours to evolve an efficient dressing, the following properties have been taken into account:—Stability, ease of application and penetration, maggot-killing power, astringent and antiseptic qualities, non-irritability to the sheep, and cost.

A dressing which complies with all requirements has not yet been found. Many dressings are satisfactory in certain directions but fail in others.

Probably the most widely used dressing is a solution of *bluestone* (5 per cent. copper sulphate in water). This is an effective dressing but has the disadvantage of staining the surrounding wool. Another simple dressing is *dry boracic acid* dusted on to the struck area.

Many dressings have been compounded by individuals and commercial bodies in an endeavour to control infestation. These have varied greatly in composition and efficacy. A large number have been tested by the New South Wales Department of Agriculture, but few of those tested gave even reasonably satisfactory results. Many have some larvicidal action (i.e., killed maggots), but were irritating to the tissues and retarded healing. Some, however, proved valuable in that they destroyed maggots and assisted healing, but no dressing of outstanding value has yet come under notice.

Among many substances tried, boric (boracic) acid is valuable by virtue of the fact that it is highly poisonous to insects, but harmless to animals such as sheep. It may be used as a dry powder, but many attempts to compound it in a useful dressing have been made.

*Glycerine diborate** proved a valuable dressing, as glycerine has the important property of causing a flow of lymph from the wound and thus washing it from within outward. Glycerine, however, is now prohibitive in price, although small stocks of the diborate might be kept on hand for the treatment of valuable stud animals. Another useful dressing is the *camphor, boric acid emulsion* (C.B.E.).†

Other boric dressings are at present being tested.

The New South Wales Department of Agriculture evolved the *zinc sulphate compound* dressing after many trials at the Nyngan and Trangie Experiment Farms. This dressing is easily prepared and has given satisfactory results in comparative trials. The formula is—

Sulphate of zinc, 10 oz.
Powdered starch, 4 oz.
Carbon tetrachloride, 8 oz.
Water, 7 pints.

The zinc sulphate is dissolved in the water. The starch is then added, and the fluid gently heated until the starch is dissolved and the mixture becomes a watery jelly. When cool, the carbon tetrachloride is added and well mixed. This is best done by the use of a syringe such as a garden syringe, the preparation being drawn up and forcibly expelled into the container until the carbon tetrachloride is well mixed with the starch-zinc sulphate solution.

The mixture forms a white fluid with a consistency of thin paste. There is a tendency for the carbon tetrachloride to settle out on standing, and hence the dressing must be well shaken before use.

The substitution of boric acid for the zinc sulphate has been found by the Department to give satisfactory results.

Further information is to be found in the following publications:—

25. M. R. Freney and others (1935).—"A Note on New Dressings for Fly-Struck Sheep." *Journal of the Council for Scientific and Industrial Research*, vol. 8, p. 161.

26. M. R. Freney and N. P. H. Graham (1939).—"A New Dressing for Fly-Struck Sheep." *Journal of the Council for Scientific and Industrial Research*, vol. 12, p. 311.

27. J. C. Keast (1939).—"Sheep Blowfly Dressings. Zinc Sulphate and Boric Acid Compound." *Agricultural Gazette of N.S.W.* Vol. 50, p. 537.

* For method of preparing glycerine diborate dressing, see Reference 25, p. 44.

† For method of preparing C.B.E. dressing, see Reference 26, p. 44.

VI. CONCLUSIONS.

1. In selective breeding for wool production care should be taken as far as possible, to select against inherent predisposition to blowfly strike. The most predisposed sheep (the so-called C class) are frequently undesirable for other reasons, such as lack of uniformity in the fleece staple and quality of the wool. The necessary quantity and quality of wool can be obtained from sheep less predisposed to fly strike.

2. The majority of Merino sheep are moderately predisposed to fly strike (the so-called B class). To remove or reduce the predisposition in these and in the more predisposed ewes, the medial crutch fold should be removed and the sheep ear-marked. This operation, known as the Mules operation, may be carried out at marking time or at weaning time. The results obtained are permanent, and subsequent crutching can be carried out more easily without injury to the skin of the sheep.

3. Excessively short tails increase the predisposition of sheep to crutch strike. In docking, attention should be given to the leaving of adequate skin flaps, and short docking should be avoided. A tail left about 4 inches long at docking, later affords a definite measure of protection against crutch strike.

4. A complete programme of jetting with arsenical preparations can be used to keep crutch strike under control. The method, however, should not be used to the exclusion of others designed to reduce the primary predisposition of sheep to crutch strike. It may be of great value in supplementing the primary methods, particularly to give protection during severe "fly waves" when all classes of sheep may be struck.

5. In any programme of work designed to prevent fly strike, shearing and crutching play an essential part.

6. Special precautions usually have to be taken to protect the heads of Merino rams from strike. Removal of the wool from around the horns is valuable, and dressings containing boracic acid or arsenic can be used to supplement this removal.

7. The limitation of bacterial infection of wounds is desirable at all times, especially during a "fly wave," if strike is to be avoided.

8. Lambs should be marked as early as possible, short docking should be avoided, cleanliness should be rigidly enforced, and a repellent dressing of oil of citronella can be applied. If these precautions be taken, strikes in tailing and castration wounds can be reduced to a minimum.

9. Reduction in the abundance of the primary sheep blowfly, *Lucilia cuprina,* will assist in reducing the incidence of strike. The most valuable method of reducing fly abundance is the early treatment of all strike and the destruction of all maggots in the crutchings. The present trapping methods have little value in reducing strike incidence. Efficient disposal of carcasses should receive attention on strictly sanitary grounds.

10. When a strike occurs, it must be treated as early as possible with a soothing, non-irritating dressing containing a substance toxic to the fly maggots.

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