Carbophenothion as a Sheep Dip for the Control of Blowfly, Lice and Keds

P. J. TREEBY
Robert Young & Company Limited, Glasgow

SUMMARY.—Carbophenothion used in a sheep dip at a dipping (or bath) strength of 0.042 per cent. protects from crutch strike for at least eight weeks, and from body strike for 10 to 12 weeks.

At 0.021 per cent. it will eradicate the sheep body louse *Damalinia ovis*, and ked *Melophagus ovinus*, and protect from reinfestation for at least 16 weeks. Methods for the evaluation of the insecticide and the influence of wool growth on the depletion of the active ingredient are described.

Introduction

DIELDRIN is one of the most effective sheep dip insecticides because of its extreme persistence in the fleece and its property of diffusing down the staple to the skin, providing continued protection against cutaneous myiasis as the wool grows. Moreover, its persistence in dermal fat is such, that a return movement (translocation) back through and across the skin occurs. Beesley (1960) found evidence of insecticide in the wool of Welsh ewes dipped in 0.05 per cent. dieldrin three years previously. Unfortunately, the very persistence of dieldrin led to the ban on its use.

Apart from efficacy, stability and other properties allowed dieldrin to be formulated as the normal traditional phenolic type of sheep dip, which is so desired by sheep farmers and to which they are accustomed. Also, although the initial loss of active ingredient was high, a replenishment rate of one and a half times the original dilution would maintain the concentration of dieldrin at an effective level.

Because zero residues are now required for the amount of insecticide retained in the tissues of dipped sheep, it was realised that an alternative to dieldrin would probably have a lowered residual activity against fly strike. There are many claims for long periods of protection afforded by organo-phosphorus compounds against cutaneous myiasis using the implantation techniques of Macleod (1937) and Stones (1950). We consider these claims to be optimistic as judged by our experience when using the implantation method described below, and in field tests.

The phosphoric ester carbophenothion* is stable, effective and safe, and can be formulated with phenols, a property uncommon among the numerous organo-phosphorus insecticides now available as sheep dips. This paper described the results of an evaluation of carbophenothion as a sheep dip at these laboratories and in field trials since 1962, in Britain and in New Zealand.

Methods and Materials

Laboratory Tests

Screening Against Blowfly Myiasis

Implant Test. Sheep of different breeds were challenged by direct implantation of *Lucilia sericata* eggs at sites over the tail and shoulder. Fifty to 100 eggs on the point of hatch were placed near the base of the wool staple and a small plug of damp cotton wool was securely fastened on top, using a "Rexel" stapler with No. 56 size staples. Two control sheep were run with a test group of five; this method was found to be 80 to 100 per cent. reliable in control animals, regardless of the air temperature. Moreover, it is more closely correlated with the result which can be expected in the field, than with the larval implantation method of Macleod (1937) and Stones (1950). As an example, sheep dipped in 0.03 per cent. dieldrin can be "struck" ten weeks after treatment by this technique whereas sheep are protected for 15 weeks on the basis of the larval implantation method.

Bioassay of Wool. The bioassay method was described by Treeby (1966); briefly, it depends upon the initial preparation of a time/mortality curve for second instar larvae of *L. sericata* exposed to carbophenothion. 0.02 g. of wool is placed in 75 mm. × 15 mm. Wasserman tubes and 2 ml. of a solution of "Difco" beef blood serum added (prepared at 50° C. with distilled water). The larvae are floated in a watchglassful of serum and two drops are pipetted into each tube. Racks of loaded tubes are incubated under strip lights at 30° C.; time/mortality observations are made and the mean of three results plotted against a prepared calibrated curve.

The quantitative assay of wool for insecticide is carried out on the "tip" wool, *i.e.* the outermost part at the time of treatment, and the "new growth" wool, *i.e.* the proximal 10 mm. removed each week, and separated by an increasing length of median segment from the tip wool. The rate and amount of diffusion is measured; failure of new wool to kill a mixture of first and second instars of *L. sericata* within six hours of exposure indicates a failure to protect from myiasis in the field.

Control of Lice and Keds

The method for screening against these two parasites is identical, and was described by Treeby (1966).

Field Tests

Between 1962 and 1965, 15,737 sheep were dipped in 0.042 per cent. carbophenothion, 8,691 in New Zealand and the remainder in Britain. Dipping was carried out in the North and South Islands of New Zealand but concentrated in Blenheim

* Stauffer compound R.1303. S-(p chlorophenylthio) methyl-0,0-diethyl phosphorodithioate.

province. In Britain, dippings were located in Devon, Gloucestershire, Lincoln, East Riding of Yorkshire, Cumberland and Dumfries. Two formulations were used, a 42 per cent. water-miscible concentrate diluted 1 : 1,000 with water, and a phenolic formulation containing 8.4 per cent. active ingredient diluted 1 : 200 with water.

A further 5,750 sheep were dipped in 0.021 per cent. carbophenothion in the late winter and autumn of 1965 in a phenolic formulation which had been diluted 1 : 100 with water. Those dipped in the autumn were part of the same programme of work already reported on resistant lice control (Treeby, 1966).

In the field tests against myiasis, control sheep were usually dipped in another organo-phosphorus insecticide or in dieldrin, because farmers are understandably reluctant to provide entirely unprotected animals. In the tests against lice and keds, 2 per cent. of the sheep were left undipped as controls.

The tests were designed to:—

(1) Measure efficacy against myiasis and lice/keds in 12 breeds of sheep.
(2) Provide data on depletion by the bioassay of wool samples from the first, middle and last dipped groups of sheep.

Results

Laboratory Tests

Table I summarises the results of an implantation test comparing 0.042 per cent. carbophenothion with 0.03 per cent. dieldrin, using Swaledale ewes and Suffolk cross ewes to indicate any influence of breed upon the results.

Table II compares the effect of the form of the emulsion on the rate of depletion of active ingredient. Fig. 1a illustrates how the droplets of the xylene emulsion lack uniformity. Fig. 1b shows the droplets of the phenolic emulsion to be minute and uniform. The result of a comparison dipping in each type of emulsion can be followed for the last five of 50 sheep dipped, where a bioassay of carbophenothion showed that the wool of those treated in the phenolic type contained 10 times that contained in the wool of the animals dipped in the xylene preparation. Palmer (1965), working with compound GC.4072* in cattle, was able to show a significant relationship between emulsion droplet size and depression of cholinesterase, so that a depression of cholinesterase could occur where an emulsion lacked droplet uniformity.

TABLE I
INFLUENCE OF BREED UPON ESTABLISHMENT OF STRIKE BY IMPLANT TECHNIQUE

Insecticide concentration in dip	Establishment of strike (weeks) by implant in tail and shoulder sites after treatment of two breeds			
	Suffolk half-bred		Swaledale	
	Tail	Shoulder	Tail	Shoulder
0·042% carbophenothion	11	13	9	10
0·03% dieldrin	11	13	9	10
Wool growth from treatment to establishment of strike (mm).	10-65		15-115	

TABLE II
EFFECT OF FORMULATION ON DEPLETION OF CARBOPHENOTHION DURING DIPPING

	P.p.m. carbophenothion in proximal wool segments four weeks after dipping in 0·042%. Mean of five results, two formulations, 50 sheep dipped	
	(a) Xylene	(b) Phenols
First five dipped	200	150
Last five dipped	25	250

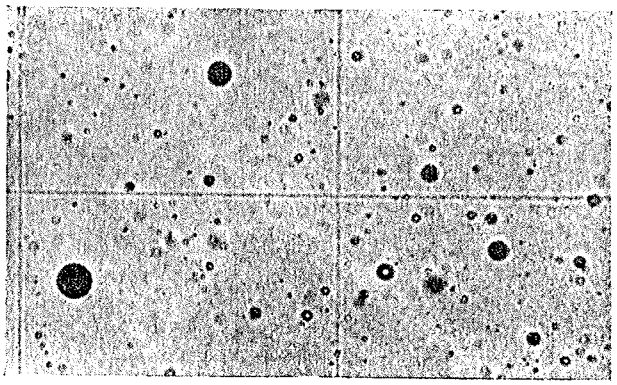

FIG. 1a.—Photomicrograph of droplets in xylene emulsion (haemocytometer × 120).

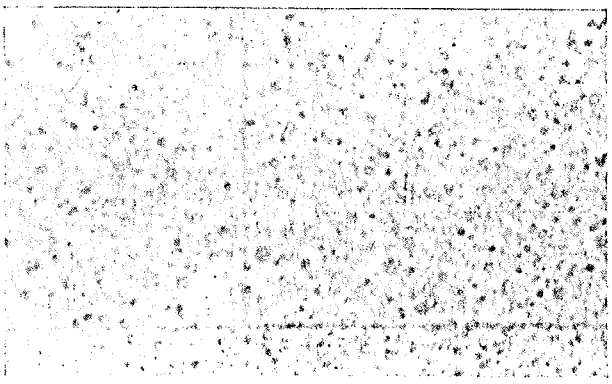

FIG. 1b.—Photomicrograph of droplets in phenolic emulsion (haemocytometer × 120).

Field Tests

Table III indicates the numbers of recorded strikes in flocks dipped in carbophenothion compared with sheep dipped in dieldrin or another organophosphorus insecticide. The incidence of strike in the dipped sheep was similar for New Zealand and

* GC.4072 2-chloro-1-(2,4-dichlorophenyl) vinyl diethyl phosphate.

U.K. tests, 0.058 per cent. and 0.056 per cent., respectively.

Table IV shows the depletion of insecticide in the wool of sheep dipped in the autumn against sheep body louse *D. ovis*, when 5,750 were treated at 0.021 per cent. In two tests against keds, *M. ovinus*, using 0.002 per cent. and 0.021 per cent., the results were parallel to those reported for lice. No reinfestation of lice/keds occurred in sheep dipped in Tests 1, 2 and 3 even up to clipping, 30 weeks after treatment, nor could lice be detected in the balance of 4,262 sheep dipped, up to 20 weeks after treatment.

Up to the end of 1966, more than 20 million sheep have been dipped in 0.042 per cent. or 0.021 per cent. carbophenothion in Britain alone, and the results confirm the experimental data presented here.

Discussion

In the British Isles, dipping of lowland sheep takes place usually once a year to provide protection against blowfly strike; whereas hill sheep are dipped at least twice a year, in summer to protect against infestations of lice and keds. The concentration of insecticide required for blowfly control is usually at least double that required for lice and keds.

Harrison and Johnston (1961) suggest that depletion of insecticide is not due to particularly rapid growth of wool in the summer months. In Table V, the amount of wool growth, as a percentage of the yearly total, which occurs in the four months June to September, can be followed

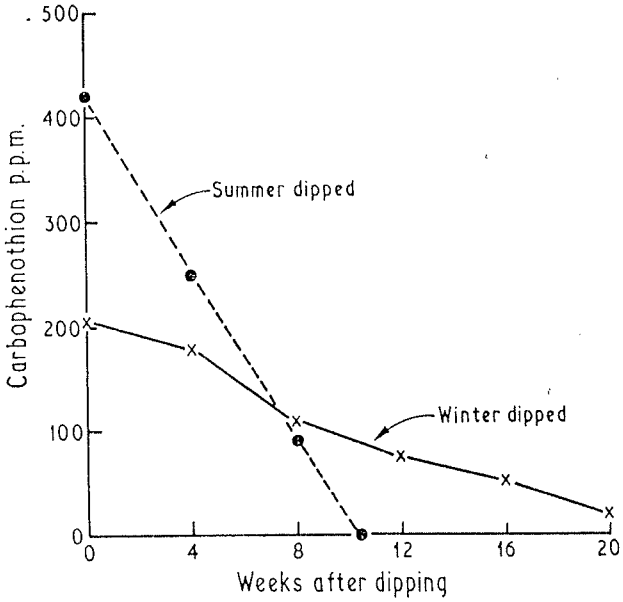

FIG. 2.—Comparison of depletion of carbophenothion in proximal wool segments of sheep dipped in summer and winter. (Mean of 20 results for Swaledale ewes.)

TABLE III
THE INCIDENCE OF STRIKE IN FIELD TESTS IN BRITAIN AND NEW ZEALAND
(8,691 SHEEP IN NEW ZEALAND, 7,046 IN BRITAIN)

Location	Year	Treatment	Total Sheep	No. Flocks	Number of strikes weeks after dipping*						
					4–5	6–7	8–9	10–11	12–13	14–15	15–16
U.K.	1962	Carbophenothion dipped 0·042%	1007	6	—	—	2	—	—	—	—
		Controls (all dieldrin)	280		—	—	—	—	—	—	—
N.Z.	1962	Carbophenothion dipped 0·042%	5997	6	—	—	2	—	1	—	—
		Controls	1300		11 dead myiasis	59	Re-dipped in carbophenothion 0·042%				
U.K.	1963	Carbophenothion dipped 0·042%	2102	16	—	—	2	—	—	—	—
		Controls	393		—	—	2	—	—	—	—
N.Z.	1963	Carbophenothion dipped 0·042%	2694	9	—	—	2	—	—	—	—
		Controls	449		7	Re-dipped in carbophenothion 0·042%					
U.K.	1964	Carbophenothion dipped 0·042%	2422	9	—	—	—	—	—	—	—
		Controls	692		—	—	—	—	—	—	—
U.K.	1965	Carbophenothion dipped 0·042%	1515	7	—	—	—	—	—	—	—
		Controls	400		—	4	—	—	—	—	— —

*All strikes in treatment groups were in crutch or tail area.

for six breeds of sheep kept at these laboratories. Clearly, wool grows faster in this period, especially on shorn ewes and particularly on coarser woolled sheep. Moreover, as can be seen (Table III), the length of wool at the time of dipping, and the varying density due to breed differences, influences greatly the amount of wash removed from the bath. This differential for close woolled Suffolk crosses compared to coarse woolled Swaledales explains clearly the results set out in Table I. Also, as can be seen from Fig. 2, exhaustion of carbophenothion from proximal wool segments is greater and much more rapid in the same breed for summer than winter dipping, even though in winter they are dipped in half the summer concentration.

In an earlier paper on the control, with carbophenothion, of lice which had become resistant to gamma-BHC (Treeby, 1966), dippings were carried out in late winter and further work was proposed for the following autumn. The results (Table III) confirm that eradication of body lice and persistence of activity is comparable in sheep dipped in 0.021 per cent. carbophenothion in the autumn, to those dipped in late winter. The initial deposit of insecticide in the fleece of hill breeds dipped in the autumn and late winter is not significantly different and, therefore, understandably the exhaustion rate is similar.

TABLE IV
DECREASE OF CARBOPHENOTHION IN WOOL OF FIRST AND LAST SHEEP, DIPPED IN 0·021% CARBOPHENOTHION

All sheep dipped in phenolic liquid giving 0·021% carbophenothion in initial bath. Test No.	Wool segment	Concentration (mean of five results) of carbophenothion in wool at indicated intervals after dipping at 0·021% (as p.p.m.). All sheep dipped first week November 1965	
		10 weeks	20 weeks
Test (1) 114 rough hoggs (infested lice and keds) First five dipped 200 g. bath, no replenishment made	Tip	34	30
	Mid	200	54
	Lower	12	37
Last five dipped	Tip	2	33
	Mid	70	7
	Lower	26	26
Test (2) 124 Swale ewes First five dipped 150 g. bath, two replenishments at 1½x.	Tip	50	46
	Mid	60	50
	Lower	56	45
Last five dipped	Tip	200	160
	Mid	150	200
	Lower	120	66
Test (3) 1,250 Swale ewes First five dipped 200 g. bath, 10 replenishments at 1½x.	Tip	22	6
	Mid	160	25
	Lower	95	20
Last five dipped	Tip	12	3
	Mid	60	20
	Lower	2	4

TABLE V
WOOL GROWTH COMPARED FOR SIX BREEDS

Breed (all sheep kept on in bye land, mean of 10 results for each breed)	Total yearly growth mm.	Wt. lb. at clipping	Wool growth mm. June-Sept. (inclusive)	June-Sept. growth as % of years total
Scots Blackface ewes	250	5	115	46
Swaledale ewes	200	3	95	47
Welsh Mt. ewes	100	2·5	40	40
S.C. Cheviot ewes	100	4·5	50	50
Mule hoggs	250	6	110	44
Suffolk ewes	90	5	30	33

TABLE VI
RELATIONSHIP OF BREED TO VOLUME OF WASH REMOVED FROM DIPPING BATH

Length of wool at dipping mm.	Breed of Sheep	Volume of wash removed per sheep, gallons
30	Corriedale	0·78
70	Corriedale	1·035
70	Half-bred	0·9
20	Suffolk ewes	0·3
40	Suffolk cross lambs	0·7
10-40	Shorn Swaledale ewes and their cross lambs	0·25
55	S.C. Cheviot	0·6
100	Dalesbred	0·5
100	Swaledale	0·3
200	Rough fell ewes	0·75

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