

A simple fumigation method for disinfecting clothing or bedding containing body lice

BY J. R. BUSVINE AND C. VASUVAT

London School of Hygiene and Tropical Medicine

(Received 14 September 1965)

INTRODUCTION

The use of contact insecticides for de-lousing

The public health importance of body lice depends on their prevalence, and so does the most satisfactory method of controlling them. Under conditions of widespread lousiness (either in primitive communities or as a result of war or disaster) there is always a threat of louse-borne disease. The best method of preventing such a calamity, or of quenching an actual epidemic, is by rapid elimination of the vector. Application of DDT powder by dusting guns applied to openings in the clothing has proved ideal for this purpose, as in the Naples typhus epidemic (1943), in Korea (1951) and elsewhere.

The phenomenal success of DDT and other synthetic contact insecticides for coping with widespread lousiness has diverted attention from the less important matter of dealing with small but persistent numbers of infested people in civilized conditions. In Britain, these people are usually treated at local authority cleansing stations, at Public Assistance Board Hostels or on admission to H.M. Prisons. Since they are going into a clean environment, protection from reinfestation is not required nor is there need to treat large numbers quickly. On the other hand, the method should destroy eggs as well as lice on the clothing. For these reasons DDT and similar insecticides are not appropriate. Their action is somewhat slow and depends for ovicidal action on the continued wearing of treated underwear. Furthermore, heavy dusting with insecticide powder would be resented by infested persons, who would make extra efforts to avoid treatment. Light applications (e.g. by aerosols) cannot be relied upon and may lead to the development of resistance. We have, in fact, unpublished evidence of the existence of insecticide-resistant body lice in England which is recorded in the following paragraph.

Evidence of insecticide-resistant lice in England

In 1961 a colony of lice was started from an infected man in Stepney, London. The lice were needed to cross with a resistant strain in a genetical investigation (later published by Guneidy & Busvine, 1964). Preliminary tests by the method of Busvine & Lien (1961) revealed that the Stepney strain showed definite signs of resistance to both DDT and dieldrin and it was discarded (Table 1).

Table 1. *Results (% kill) of tests on louse strains*

Insecticide... Concentration (%)...	Dieldrin							DDT			
	0.01	0.025	0.05	0.1	0.2	0.4	0.8	1.6	1	2	4
Stepney	—	—	—	—	29	70	77	100	—	0	0
Cairo	5	48	97	—	—	—	—	—	38	68	—
Orlando	—	—	—	100	—	—	—	—	—	50	89

(The Cairo and Orlando strains are probably normally susceptible. Method, and data for Cairo strain, from Busvine & Lien (1961).)

Heat as an alternative de-lousing method

Many authorities rely on heat-disinfestation, often by rather old-fashioned steam sterilizers. This procedure is rather cumbersome and troublesome; and since most disinfestors are large, it is wasteful to employ them for the garments of only one or two infested people. Furthermore, the temperatures reached may be harmful to some articles of clothing unless care is exercised.

Fumigation for de-lousing

Fumigation has been used for many years to destroy lice in clothing. It can be perfectly satisfactory provided that protection from reinfestation is not required. The more volatile or gaseous fumigants are difficult to handle on a small scale (Busvine, 1943). It is possible to overcome this difficulty; for example, by using small ampoules of methyl bromide to be broken inside a gas-proof bag (Latta & Yeomans, 1943) or by using aluminium-phosphide tablets ('Phostoxin'). We considered both these methods, but there are certain technical drawbacks, apart from the toxicity of these gases, which require the inconvenience of airing out of doors.

In contrast to the wide variety of modern contact insecticides, scarcely any new fumigants have come into use in the past 20 years. We made some trials of the 'residual fumigant' dichlorvos which did not prove promising. Accordingly, it was decided to reconsider the range of liquid fumigants examined by David (1944), who described simple methods of de-lousing by six different compounds. A person seeking guidance on the most satisfactory of these fumigants may be somewhat perplexed and it seemed worth choosing one of them and making confirmatory tests. On balance, ethyl formate seems to combine the desirable properties of safety and convenience with fair potency at both high and low temperatures. Apparently this compound has been used successfully for de-lousing intakes at H.M. prisons for some years.

MATERIALS AND METHODS

The lice used in these experiments came from a normally susceptible colony obtained from the Orlando laboratories of the U.S.D.A. Entomology Research Division. We maintained them in mesh-covered tins, worn daily on the ankle, as described by Buxton (1947).

Lice, or their eggs, were exposed to very low concentrations of dichlorvos

vapour in the simple apparatus described by Khattat & Busvine (1965). Various concentrations of ethyl formate for treatment of lice (or eggs) were prepared in 5 l. flasks. Appropriate volumes of liquid (0.05–1.4 ml.) were pipetted on to glass filter papers suspended in the flasks.

Some practical trials were done in which lice or eggs, in mesh-fronted metal tins, were secreted in four folded blankets. The blankets were then stacked, either in a small metal bin (about 2.8 cu.ft.) with a tight-fitting lid, or in plastic bags (about 30 × 40 in.). The plastic bag is 'sealed' during fumigation by rolling up the open end as far as possible, the final volume then being little more than that of the four folded blankets. The volume was measured by immersing the bag containing blankets in a drum of water and measuring the volume of water displaced, which was about 1.8 cu.ft.

In some trials of ethyl formate, vapour concentrations were determined by the method outlined by David (1944). The samples were drawn from a point about one-quarter the height of the container, usually from the middle of a folded blanket.

RESULTS

Experiments with dichlorvos

The vapour of dichlorvos is extremely potent against flying insects, such as flies and mosquitoes, which are killed by 30 min. exposure to 0.2 $\mu\text{g./l.}$ (Maddock & Sedlak, 1961; Maddock, Sedlak & Schoof, 1961). Unfortunately, lice and their eggs are much more tolerant, the former requiring 9.5 hr. for knock-down and the latter suffering only about 30% kill after 24 hr, when exposed to concentrations of this order.

In a practical trial, a Shell 'Vapona' resin vaporizer was included in a plastic bag with four folded blankets among which were tins of louse eggs. No reduction of hatch was observed after 6 hr. exposure at room temperature and only about 60% reduction after 24 hr.

Dichlorvos was therefore considered unsuitable for this purpose.

Experiments with ethyl formate

Measurement of lethal concentrations

Lice and other eggs were exposed to various concentrations of ethyl formate at 10° C. for periods of 1, 2, 5 or 10 hr. In a preliminary test, the gas concentrations attained were determined by samples taken from a flask at the beginning and end of a 5 hr. exposure. They were found to agree very well with expectations based on the dosage.

After exposure, lice were put in tins worn against the skin and examined next day for mortality. The eggs were put into an incubator at 27° C. and 80% R.H. and examined about 2 weeks later. The kills of louse eggs were corrected for control mortalities, nearly always assessed from an untreated portion of the same batch. These results are given in Table 2.

These data were plotted on logarithmic probability paper and the median lethal concentrations were estimated graphically. Except at the 10 hr. exposure, the

eggs were consistently more tolerant than adult lice, the LC 50 values for the latter being about 80–90 % of the values for eggs. Even greater differences will be found for the lowest lethal concentrations in Table 2, probably because more eggs were used per batch. A more precise statistical treatment would probably be unrewarding, because of disparate defects in the data. Thus, numbers of lice were rather low (average thirteen per batch), and egg numbers, though satisfactory (average forty-seven per batch), were subject to a high, variable, control mortality (average 32 %).

In brief, it appears that eggs are slightly more tolerant of ethyl formate than adult lice.

Table 2. *Results of flask fumigation tests, with ethyl formate, at 10° C*

Concentration (mg./l.)	% kill of lice				Corrected % kill of eggs			
	1 hr.	2 hr.	5 hr.	10 hr.	1 hr.	2 hr.	5 hr.	10 hr.
13	—	—	0	14	—	—	23	—
17	—	—	10	33	—	—	—	50
20	—	—	—	75	—	—	27	64
24	—	—	—	100	—	—	—	100
25.5	—	—	70	—	—	—	55	100
34	—	23	100	—	—	0	90	—
51	—	63	—	—	—	52	100	—
68	—	100	—	—	—	66	—	—
85	—	—	—	—	10	100	—	—
102	40	—	—	—	46	100	—	—
119	66	—	—	—	58	—	—	—
135	100	—	—	—	68	—	—	—
204	—	—	—	—	91	—	—	—
238	—	—	—	—	100	—	—	—
LC 50	108	44	20	17	115	56	24	17

Semi-practical trials

In the earlier work mentioned previously (Busvine, 1943; David, 1944) ordinary metal dust-bins were used for de-lousing fumigations. While this method may be found adequate, we thought that plastic sacks might be more convenient in some ways. Accordingly, we have tried using various plastic bags (about 30 × 40 in.) which are simply sealed during fumigation by rolling up the mouth of the bag. Some experimental fumigations were made with these bags in a cold room at 10° C.; the results may be compared with the recommendations for bin fumigation given by David (1944). In addition, gas samples were taken to estimate concentrations in the bags and in a metal bin under comparable conditions.

Plastic-bag fumigation tests. Batches of lice (average thirty-seven) and eggs (average 188) were divided into four lots, put into mesh-topped tins and secreted in the folds of four army-type grey blankets. These blankets weighed about 4 lb. each; they were folded four times and fumigated in a pile. The fumigant was applied by one of two methods: (A) by dividing the dose into three lots and sprinkling between the blankets; or (B) by sprinkling the full dose on the top blanket.

Table 3. Results (% kill) of fumigation trials with ethyl formate in plastic bags, at 10° C

(Method A: fumigant applied in three portions between blankets. Method B: fumigant applied to top blanket.)

Method...		Dose/cu.ft.							
		3 oz.	2 oz.		1 oz.		½ oz.		¼ oz.
		(90 c.c.)	(60 c.c.)		(30 c.c.)		(15 c.c.)		(7.5 c.c.)
	B	A	B	A	B	A	B	A	
1 hr. exposure	Lice	100	100	68	82	—	—	—	—
	Eggs	88	100	56	62	—	—	—	—
5 hr. exposure	Lice	—	—	—	—	100	100	100	100
	Eggs	—	—	—	—	100	100	98	92

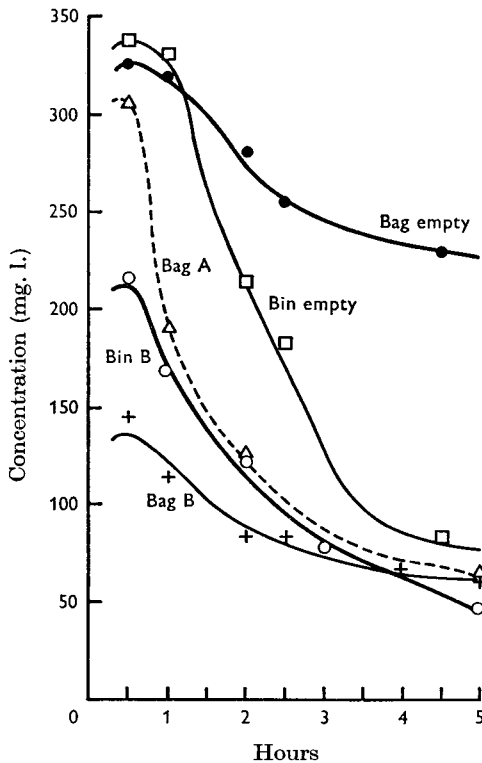


Fig. 1. Concentrations of ethyl formate estimated from samples drawn from a metal bin or a plastic bag. A and B refer to method of applying the dose on a load of blankets. In A it is applied in three portions, between the blankets; in B as a single dose on the top. In all cases the full dose was ½ oz./cu.ft. (corresponding to 500 mg./l.)

The results of trials with 1 or 5 hr. exposure at 10° C. are given in Table 3. It will be seen that method A (as recommended by David, 1944) was more efficient, though it is slightly more troublesome.

Vapour concentration measurements. The concentrations of ethyl formate attained by a dosage of ½ oz./cu.ft. in plastic bag or metal-bin fumigations are

shown by the curves in Fig. 1. These curves are based on results of two or three trials each. The results were reasonably consistent when the dose was applied by method B, the coefficient of error for various points being 11.6%. When method A was used, the estimation of the initial concentration (after $\frac{1}{2}$ hr.) was very variable, depending on whether some of the liquid applied was close to the sampling point in the blanket fold; but by 2 hr. the levels in three different tests were much the same.

The following points emerge from consideration of these results.

(i) In experiments without blankets the bag volume was maintained by a wire frame. The dose was applied to a cloth suspended at the top of bag or bin. It will be seen that the initial concentration in bag and bin was about the same; but the concentration fell much more sharply in the bin, probably due to leakage.

(ii) When four blankets were present, and the dose was applied by method B, the initial concentration at the sampling point in the blankets was higher in bin than bag. This could have been owing to the smaller total dose in the bag, where the same load as in the bin was packed more tightly in a smaller volume. By the end of the 5 hr. fumigation test, the more rapid loss from the bin had brought down concentrations to that of the bag or below it.

Very similar curves for bag and bin were obtained with a dosage of 1 oz./cu.ft.; but naturally these were at about double the concentration levels attained with $\frac{1}{2}$ oz./cu.ft. (They are not shown in Fig. 1.)

(iii) When the dose of $\frac{1}{2}$ oz./cu.ft. was applied by method A, the initial concentration in the blankets was considerably higher than after application by method B. This was almost certainly due to the fact that with 'A' a portion of the fumigant dose was applied close to the sampling point. After a few hours, however, the concentrations produced by the two methods were about equal, presumably as a result of diffusion.

Conclusions

Our practical trials were all done at 10° C., which was assumed to be the lowest probable room temperature and consequently represented most unfavourable conditions. The results of plastic-bag fumigation tests under these conditions, confirmed the dose recommended by David (1944) for a 5 hr. exposure; but we found recoveries of both lice and eggs with his suggested 30 ml./cu.ft. dose for a 1 hr. exposure. The results of the sampling tests suggest that this may be due to a relatively lower efficiency of the bag method (as compared to a bin) for short exposures.

RECOMMENDATIONS

All the work confirms our good opinion of ethyl formate, one of the compounds advocated by David (1944). In addition to its use in metal bins, it can be conveniently used to disinfest clothing or bedding in plastic bags. Under the most unfavourable conditions likely to be encountered indoors, a dose of 2 oz./cu.ft. should be used for a short (1 hr.) exposure; but for 5 hr. or longer $\frac{1}{2}$ oz./cu.ft. is adequate. It is suggested that an overnight treatment is convenient. Using plastic

bags about the size of potato sacks, four army blankets can be disinfested by 25 ml. ($\frac{1}{2}$ oz./cu.ft.) costing about 1s. The time to load and treat blankets (or garments) is a few minutes. On their removal there is only a mild smell of the fumigant, which dissipates in a few minutes.

Ethyl formate has the formula HCOOC_2H_5 ; M.W. 74; B.P. 54°C . (135°F). At 25°C . (77°F .) the density of the vapour is 1.52 times that of air. At 20°C . (68°F .) its vapour pressure is 95 mm. Hg., corresponding to a saturation concentration of 837 mg./l. According to Browning (1953) a concentration of 32 mg./l. is lethal to cats after $1\frac{1}{2}$ hr. and dogs after 4 hr. Its toxicity is not greatly different from that of, say, benzene. It appears that 'no severe effects from the industrial use of ethyl formate have been recorded' (though apparently it is extensively used, at least in the shoe industry). Ethyl formate is inflammable, but in the quantities recommended the danger is negligible.

SUMMARY

Modern contact insecticides (like DDT) in powder form are ideal for combating widespread lousiness; but for various reasons they are not suitable for disinfecting small numbers of infested people under civilized conditions. It appears that the most convenient, efficient method in these circumstances is a small-scale fumigation of the infested garments, in either a metal bin or a plastic bag. Ethyl formate, one of the liquid fumigants suggested for this purpose by W. A. L. David in 1944, has been further tested and found efficient. In a plastic bag the size of a potato sack (about 30×40 in.), four blankets can be deloused by a dose of 100 ml. with an hour's exposure or a quarter of this dose with an exposure of 5 hr. or more. An overnight treatment with this dose would be safe and convenient, costing about 1s. and the actual operations would take only a few minutes.

REFERENCES

- BROWNING, ETHEL (1953). *Toxicity of Industrial Solvents*. H.M.S.O.
- BUSVINE, J. R. (1943). The toxicity of some common fumigants to body lice. *Bull. ent. Res.* **34**, 19.
- BUSVINE, J. R. & LIEN, J. (1961). Methods for measuring insecticide susceptibility levels in bed-bugs, coned-nosed bugs, fleas and lice. *Bull. Wld Hlth Org.* **24**, 509.
- BUXTON, P. A. (1947). *The Louse*. London: E. Arnold. 164 pp.
- DAVID, W. A. L. (1944). Fumigation as a method of combating the body louse. *Bull. ent. Res.* **35**, 79, 101.
- GUNEIDY, A. M. & BUSVINE, J. R. (1964). Inheritance of dieldrin-resistance in *Cimex lectularius* and *Pediculus h. humanus*. *Bull. ent. Res.* **55**, 509.
- KHATTAT, F. H. & BUSVINE, J. R. (1965). A modified test method for resistance to dichlorvos vapour. *Bull. Wld Hlth Org.* **32**, 551.
- LATTA, R. & YEOMANS, A. H. (1943). Methods and equipment for fumigation of clothing infested with body lice. *J. econ. Ent.* **36**, 402.
- MADDOCK, D. R. & SEDLAK, V. A. (1961). Dosage-mortality response of *Anopheles quadrimaculatus* to DDVP vapour. *Bull. Wld Hlth Org.* **24**, 644.
- MADDOCK, D. R., SEDLAK, V. A. & SCHOOF, H. F. (1961). Dosage-mortality response of *Musca domestica* to DDVP vapour. *Bull. Wld Hlth Org.* **24**, 643.