REFERENCES


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Use of fumigants for control of body lice.³

Introduction

Historically, much effort has been expended developing body lice control methods. Researchers have recommended control methods ranging from the wearing of silk underwear to the use of highly odoriferous oils (9). The search for ideal fumigants has also consumed a considerable amount of research time. Unfortunately, no ideal fumigant has ever been discovered because of the variety of control situations that exist (3).

The development of the synthetic contact insecticides provided a new tool for health workers tasked with body lice control. These chemicals made it possible to control lice on individuals, thereby reducing the threat of louse-borne diseases and eliminating the need for broad-use fumigants. We are now confronted with insecticide resistance in body lice (7, 8, 13), however. New control concepts for the abatement of louse-borne disease epidemics will be forthcoming, but it is doubtful if they will be available for several years. This may force workers to use previously developed chemicals and techniques until newer methods become available. For this reason, we have again become interested in the potential of fumigants for the control of body lice.

Discussion

The establishment of criteria to screen fumigants is a subjective process. Such factors as human toxicity, cost, odor, volatility, flash point, boiling point, effect on clothing, time required for destruction of lice and eggs, and availability are all factors that must be analyzed. Many data have been accumulated on the physical characteristics and effectiveness of fumigants (4, 5, 6). The compounds and techniques that are available are too numerous to review at this time, but the most promising ones have been included for consideration.

In theory, one of the simplest methods of control includes the use of hot air. This method, which destroys both eggs and lice, can be accomplished if the proper techniques and equipment are used (1). One limiting factor is the difficulty of organizing and moving the infested people and their clothing to a central treatment facility.

Hydrogen cyanide has been widely used for clothing and house fumigation (12, 15). HCN is dangerous to use, however, because of its poor warning properties and high mammalian toxicity. This gas can also be adsorbed and retained by fabrics. Ample airing of bedding, clothing, or structures is necessary when HCN is employed as a louse fumigant.

Methyl bromide has been shown to be very effective against lice (10, 11, 14). It does not damage or stain clothing and rapidly dissipates from the treated product. It has no odor and is not flammable. Normally,
gases of this type have been restricted in use to permanent delousing stations, but the U.S. Army has developed two techniques that have made methyl bromide usable in field situations. Portable fumigation vaults were procured and shipped to the field where they were used as central fumigation points for small military units. The most inventive technique involved packaging the methyl bromide in 20 cc ampoules for individual usage (Figure 1). Soldiers were issued a neoprene bag and ampoules of methyl bromide, with instructions directing that the infested clothing be placed in the bag with the ampoule. After sealing the bag, the ampoule was broken and the gas released into the clothing.

Ethyl formate has been the most recently recommended fumigant for louse control (2). This compound is flammable, but it is reasonably safe to use in small quantities. Toxicity or expense should not prove to be limiting factors.

In addition to the previously reviewed fumigants, we considered two others in our search for stopgap control measures. Aluminum phosphide (Phostoxin) was tested in practical field studies and found to provide control, but it proved difficult to use. This gas is highly toxic, but its physical characteristics make it potentially valuable for use in portable fumigation chambers, provided the chambers are well constructed and airtight. It would seem unwise to consider the use of aluminum phosphide by untrained personnel. House fumigation would not be possible because this fumigant severely damages many common metals.

Our most extensive work has been conducted on dichlorvos (2,2-dichlorovinyl dimethyl phosphate, or DDVP) resin strips. Other workers found that lice and their eggs were difficult to kill with dichlorvos (2). In 1968, however, a dichlorvos strip was accidentally placed in one of our lice rooms at Camp Lejeune and the results were very dramatic.

Our tests were first conducted using two 26-liter cans bolted together end to end. Each can contained a hole 13 cm in diameter in the end. Before the cans were bolted together, sandwiches of military uniform cloth were placed between them (Figure 2). The cans were connected with either 30 or 40 layers of cloth between them. After the cans were connected and sealed together, 20 adult (Gainesville standard) lice and 20 to 30 eggs were placed in one can and a dichlorvos resin strip was placed in the other can. The tests were conducted at 30°C and 4°C. The results of these tests are shown in Table 1.

A second series of tests was initiated to provide a more practical test. Standard military seabags (duffel bags) containing 12 kg of uniforms were used for the test. Twenty adult lice and 20 to 30 one- to five-day-old eggs were placed in the middle of the uniforms. A dichlorvos resin strip was placed on top of the clothes and the bag sealed with masking tape. All tests were conducted for 24 hours, and the lice and eggs were then
obvious from these tests that while dichlorvos performed well in tests involving limited quantities of fabric, some factor—possibly adsorption—prevented the vapors from reaching the lice when bulk clothing was used. Our tests also indicated that the vapor levels generated at 4°C were insufficient to provide adequate penetration and control.

Summary

The fumigants considered have included: hydrogen cyanide, methyl bromide, ethyl formate, aluminum phosphide, and 2,2-dichlorovinyl dimethyl phosphate (dichlorvos). HCN has been widely used and much is known concerning its behavior, so we have concluded that it may yet be a useful compound if close supervision is available. Methyl bromide has also proved effective and has been used in individual clothing treatments by untrained personnel. Aluminum phosphide is also highly toxic and difficult to control, but it could be used in chambers provided they were constructed properly. Ethyl formate has not been extensively used for louse control, but enough studies have been conducted to indicate that this compound would be effective for individual clothing treatment. Dichlorvos will probably be effective only if resin strips are placed with very small amounts of clothing. Because of its inability to kill lice and eggs quickly, however, resistance will be accelerated if people began to underexpose their clothing.

Table 1. Mortality of body lice and eggs exposed to dichlorvos for 24 hours through 30 to 40 layers of cloth.

<table>
<thead>
<tr>
<th>No. of cloth layers</th>
<th>No. of tests</th>
<th>Temp. of test chamber</th>
<th>Adult mortality (%)</th>
<th>Control mortality (%)</th>
<th>Egg mortality (%)</th>
<th>Egg mortality control (%)</th>
<th>Total lice exposed</th>
<th>Total eggs exposed</th>
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<tr>
<td></td>
<td></td>
<td>30°C</td>
<td>24 hr 48 hr</td>
<td>24 hr 48 hr</td>
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<tr>
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<td>97 100</td>
<td>10 11</td>
<td>36 5</td>
<td>60 20</td>
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<td>20 30</td>
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<td>60 20</td>
<td>95 35</td>
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<tr>
<td>30</td>
<td>6</td>
<td>4°C</td>
<td>23 46</td>
<td>30 45</td>
<td>22 27</td>
<td>120 40</td>
<td>165 60</td>
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</tr>
</tbody>
</table>
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2. ———. A simple fumigation method for disinfecting clothing or bedding containing body lice. *J Hyg (Camb)* 64:45-51, 1966.
6. ———. Fumigation as a method of controlling the body louse *Pediculus humanus corporis* De Geer. 3. Practical tests *Bull Entomol Res* 35:101-12, 1944.

M. M. Cole. Synergistic compounds. The greatest amount of work with synergistic compounds for use against lice has undoubtedly been in the search for those that were effective with pyrethrins. In the early days of World War II, before DDT was developed, synergized pyrethrins were the most effective material available as a louse powder. Hundreds of compounds were tested as synergists for this plant product and its synthetic relatives such as allethrin (1, 2, 3, 4, 6, 9, 10). Sulfoxide was the most effective synergistic material developed in that program. A later development detracted somewhat from the value of synergized pyrethrins, however. A strain of lice, selected in the laboratory with pyrethrins plus sulfoxide, not only developed resistance to this combination but also an extremely high cross-resistance to DDT (7).

After the success with pyrethrins and their related compounds, interest was stimulated in materials that might increase the effectiveness of other classes of compounds. Sulfoxide was found to be synergistic with certain organophosphorus compounds, especially potosan (O,O-diethyl O-(4-methyl-2-oxo-2H-1-benzopyran-7-yl) phosphorothioate), the activity of which it increased 10 times (10). Of several materials tested, sulfoxide and piperonyl butoxide were the most effective with rotenone (5). They were also found to be effective with carbaryl (Sevin), a representative of the carbamates (8). Later, however, this combination in a louse powder was found to be uneconomical for practical use.

In conclusion, the use of synergistic compounds either has not been economical for most insecticides or other single compounds were developed that were more effective.

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Eugene J. Gerberg. Head lice: control and nit removal. *Pediculus humanus capitis* de Geer has undoubtedly plagued man throughout his entire evolution as a mammal. The relationship and similarity between *P. h. capitis* and *P. h. corporis* (*P. humanus humanus* L.) has been detailed by Bacot (1), Ferris (3), Keilin and Nuttall (8), Sikora (15, 16), and others. Whatever difference may exist, it is probably a physiologic rather than morphologic one. If there is a taxonomic difference, *P. h. corporis* apparently derived from *P. h. capitis*. This probably occurred when man began to clothe himself.

In 1909 Nicolle and coworkers (11) noted the role of *Pediculus* in the transmission of epidemic typhus. Da Rocha-Lima (12) in 1916 demonstrated the causative relationship of *Rickettsia prowazeki* to epidemic typhus. Though *P. h. corporis* has been considered the prime vector of epidemic typhus, the capabilities of *P. h. capitis* should not be disregarded. Goldberger and Anderson (4) succeeded in transmitting typhus experimentally to monkeys by cutaneous injection of infected, crushed head lice. Haight (5) discussed the possibility that a typhus case in Toronto might have been transmitted by *P. h. capitis*. Bequaert (2) reported that *P. h. capitis* was a carrier of exanthematic typhus in Guatemala. Ruiz Casteñeda (13) believed that *P. h. capitis* was responsible for a mild form of typhus in Mexico. Mackenzie (10) stated that the body louse was an evolutionary form of the head louse and that both are regarded as vectors of typhus. As infestations of head lice are generally more abundant in urban populations than body lice, the possibility of a potential hazard exists.

The materials used for control of head lice have changed over the years, from herbs and secret formulas to the more mundane pesticides. Some of the more recent chemicals used to control or eliminate head lice are listed below.

**Lindane (gamma benzene hexachloride)**
- 1 per cent in water dispersible cream (Kwell cream)
- 1 per cent in lotion (Kwell lotion)
- 1 per cent in alcohol (Lorexane), diluted 1:5 in water

**DDT**
- 10 per cent in pyrophylin
- 68 per cent benzyl benzoate, 6 per cent DDT, 12 per cent benzocaine, and 14 per cent emulsifier (NBIN), diluted 1:5 with water

**Malathion**
- 0.5 per cent lotion (Prioderm)

**Pyrethrum**
- 0.16 per cent pyrethrins, 2 per cent piperonyl butoxide, 5 per cent kerosene (A-200 Pyrinate liquid)