ARTICLES

PRECAUTIONS IN THE USE OF INSECTICIDES FOR MOSQUITO CONTROL

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Insecticides have come to play a dominant part in mosquito control. To a large degree the more expensive yet more permanent work of eliminating breeding places has given way to spraying for the elimination of larvae and adult mosquitoes.

The great success that has attended the use of DDT as a residual spray in buildings and as a spray or fog to kill adults and larvae out of doors has caused many agencies to adopt this insecticide as practically the sole means of fighting malaria and other mosquitoes.

It has long been recognized by entomologists that some hazards attend the use of any insecticide and that certain materials must be handled with extreme care. DDT is the most effective and widely used mosquito-killing material. The facts that it is relatively low in acute toxicity to higher animals (from the acute standpoint) and that it has received such popular acclaim have caused some users to overlook certain important safety considerations. On the other hand, some of the extreme and often unfounded statements regarding the dire consequences that are resulting from its use have caused certain elements of the public to be excessively critical.

An important factor that enters into the hazards associated with the use of insecticides is that DDT-resistant flies, mosquitoes, and other pests are developing, which may lead to the use of increased dosages and more frequent applications. It should be remembered also that DDT and other chlorinated hydrocarbon insecticides are being extensively employed in combating forest and field-crop insects and pests of livestock against which insecticides were previously used little if at all.

The public reaction against the use of DDT has led some mosquito-control workers to turn to some extent to other insecticides, and the resistance factor is making it necessary to give consideration to alternative materials.

It is obviously necessary, therefore, for mosquito fighters to have knowledge not only of the mosquito-killing powers of the several insecticides that may be used, but also of the possible hazards to the operator and to the public from their improper use.

Many factors must be considered in appraising the potential health hazards of an insecticide in connection with its preparation and use for controlling mosquitoes. These include their effect on the workers in manufacturing, processing, and packing plants; on field workers who may mix and apply the materials, on people through contamination of utensils, foods and even the air in buildings; on people who consume contaminated crops, either directly or indirectly; and on birds, fish, reptiles, amphibians, bees, parasites, and predaceous insects and other beneficial forms of life.

Some indication of the relative acute and chronic toxicity of a number of the insecticides now being used is given in the Tables 1 to 3, which were prepared by A. J. Lehman (1948), of the Food and Drug Administration.

It is obvious from these tables that DDT does not possess sufficient acute toxicity to cause concern when used with reasonable

TABLE 1.—Comparison of the acute oral toxicities of insecticides with DDT to several species of laboratory animals.

Insecticide	Mean lethal dose mg./kg.	Ratio
DDT (dichloro-diphenyl-trichloroethane)	250	1
TEP (tetraethyl pyrophosphate)	2	125
Parathion (O, O-diethyl O-p-nitrophenyl thiophosphate)	3.5	70
HETP (hexaethyl tetraphosphate)	7	35
Nicotine	10	25
Chlorinated Camphene (68% chlorine)	60	4
Rotenone	60 (to 3,000)	4
GBH (gamma isomer of benzene hexachloride)	125	2
Lethane-384 Special (a mixture of three parts Lethane-60 (beta-thio-cyano-ethyl esters of aliphatic acids with 10–18 carbon atoms) and one part of Lethane-384 (beta-butoxy-beta-thio-cyano-diethyl ether) plus refined paraffin)	400	5/8
Lethane-60 (beta-thio-cyano-ethyl esters of aliphatic acids with 10–18 carbon atoms)	500	1/2
ABH (alpha isomer of benzene hexachloride)	500	1/2
Chlordane (1, 2, 4, 5, 6, 7, 8, 8-octachloro-4, 7 methano-3a, 4, 7, 7a-tetrahydroindan)	500	1/2
Thanite (isobornylthiocyanoacetate)	1,000	1/4
DBH (delta isomer of benzene hexachloride)	1,000	1/4
Pyrethrins	1,500	1/6
TDE (dichloro-diphenyl-dichloroethane)	2,500	1/10
BBH (beta isomer of benzene hexachloride)	>6,000	>1/24
Methoxychlor (dimethoxy-diphenyl-trichlorethane)	>6,000	>1/24
N-propyl isome (di-n-propyl-6, 7-methylene-dioxy-3-methyl-1, 2, 3, 4-tetrahydronaphthalene-1, 2-dicarboxylate)	>10,000	1/40
Piperonyl butoxide (butylcarbityl) (6-propyl piperonyl) ether)	12,800	1/50

TABLE 2.—Chronic Toxicity in Rats

Insecticide	Lowest level producing gross effects p.p.m. *	Duration weeks	Remarks
DDT	100	104	
Parathion	25	4	
HETP		12	1000 p.p.m.; no effect
Nicotine	60	43	
Chlorinated camphene	–	8	1200 p.p.m.; no effect
Rotenone	31.2	16	
GBH	400	52	
Lethane-384 special			No data
Lethane-60			No data
ABH	800	43	
Chlordane	250	12	
Thanite			600 mg./kg./day fatal in 4–12 weeks
DBH	3,200	52	
Pyrethrins			500 mg./kg./day fatal in 2 weeks
TDE	2,500	104	
BBH	10	36	
Methoxychlor	5,000	16	
N-propyl isome			No data
Piperonyl butoxide			No data

* p.p.m., parts per million.

TABLE 3.—Chronic Toxicity in Dogs

Insecticide	Dietary levels p.p.m.	Remarks
DDT	2,640	Death in 50 days
Chlorinated Camphene	330	Death in 33 days
Rotenone		2 gm./kg. single doses; survival
GBH	330	Death in 30 weeks
ABH	2,000	Death in 44 days
Chlordane	660	Death in 4 weeks
DBH	3,960	Death in 14 weeks
Pyrethrins	Large amounts	Survival
TDE	1,650	Survival for 19 months
BBH	1,320	Death in 90 days
Methoxychlor	10,000	Survival for 6 months

precautions, nor is it irritating to the skin. However, the fact that it is stored in the fatty tissues and is excreted in the milk of animals exposed to DDT, either directly or by consuming feed that bears a residue, is an important consideration. Furthermore, the Food and Drug Administration has reported that the daily intake by rats of 5 p.p.m. of DDT will develop liver damage that is minimal but characteristic.

PRECAUTIONS SUGGESTED

It is difficult to lay down hard-and-fast rules for the safe handling, storage, and use of all insecticides that may be used in mosquito control. The same set of precautions are not applicable to all materials or all conditions. However, all insecticides should be stored out of the reach of children and where they will not be accidentally used as baking powder or other food materials. When mixing and applying insecticides it is a good plan to consider all of them as poisonous.

Solvents—A number of different solvents are being used in the preparation of insecticide solutions and emulsions. Xylene, the alkylated naphthalenes, fuel oil, and kerosene are most commonly employed. Each of these solvents has some toxicity, and some of the reported ill effects of DDT are clearly chargeable to the solvents.

Xylene and some other volatile solvents are inflammable, and breathing the fumes may cause headache and nausea. Some of these materials cause the skin to become dry and crack. Some of the alkylated naphthalenes may irritate the skin and even cause severe dermatitis, especially when the sensitized skin is exposed to the sun.

DDT—Emulsions and solutions of DDT in concentrated form which come in contact with the hands or body should be removed immediately with soap and water. Dilute solutions, emulsions, and wettable-powder preparations should not be left long in continuous contact with the skin. DDT emulsions often contain xylene as the solvent. When mixing emulsions rubber gloves should be worn to protect the hands, and prolonged breathing of the vapors should be avoided. Indoor spraying with xylene sprays should be done in well-ventilated rooms. During the spraying the eyes should be protected with goggles, and it is advisable to wear a respirator and make frequent changes of filter pads.

Tables and shelves where food is placed, as well as baby beds and children's toys, should be completely covered or removed from the room while it is being sprayed. Foods and utensils should be well protected from the spray.

DDT should not be applied to cats or dairy animals, and DDT-oil solutions should not be applied heavily to any animal.

In general aerial applications of DDT sprays over towns, vegetable gardens, and pastures should be avoided if other means of mosquito control are feasible. Single or infrequent light applications, less than one-third of a pound of DDT per acre, applied to populous areas from the air to wipe out swarms of mosquitoes probably present no health hazard to humans but fish in ornamental pools might be affected.

Since DDT consumed by dairy cows will readily appear in their milk, no DDT sprays should be applied to pastures where dairy animals are grazing or to crops that are to be harvested for feeding to these animals.

Insecticidal mists or fogs when properly applied are less likely to leave appreciable residues on gardens and meadows than are sprays. Questions have been raised as to the hazard of breathing such fogs. There is no indication that breathing such fogs or mists for a short time will produce ill effects. The use of fogs in some situations has been reported to create traffic hazards because of effect on visibility.

Aerial applications of DDT at rates up to one pound per acre have been found to cause no serious injury to fish and other forms of wildlife (Linduska and Surber 1948). However, spraying of open water, such as wide rivers and lakes, should be avoided, since the insecticide may be drifted to the margins by the wind and thus concentrated sufficiently to kill fish.

Remnants of spray from tanks and the washings from spray equipment should be drained into a hole in the earth or in places where they will not gain access to streams and ponds. Insecticides should never be mixed on or near wells.

Toxaphene, TDE, Methoxychlor, Benzene Hexachloride, Lindane, and Chlordane—The same general precautions should be followed in handling each of these chlorinated hydrocarbon insecticides. Although they are not now widely used in combating mosquitoes, it is possible that these and other new related materials may come into more extensive use. Methoxychlor and TDE are less toxic than DDT to warm-blooded animals from both acute and chronic standpoints. However, toxaphene, chlordane, and lindane have much greater toxicity than DDT when absorbed through the skin. Moreover, toxaphene is particularly poisonous to fish. TDE, on the other hand, appears to be considerably less toxic to fish than DDT or any of the other chlorinated hydrocarbon insecticides in the above heading. Benzene hexachloride, lindane, and chlordane have a fumigating effect, and it is conceivable that in confined spaces the fumes may produce ill effects.

Parathion and Other Phosphorus Compounds—Parathion is highly effective in destroying mosquitoes, but, as is shown in the tables, *it is an extremely poisonous compound. Already three deaths of operators have been reported from its use for the control of crop pests.* Parathion residues do not persist long. Parathion has not been recommended for mosquito control, but in the event some may use it under special circumstances, operators should be provided with gas masks fitted with appropriate cartridges to neutralize organic poisons of that type. Protective clothing and gloves should be worn, so that the spray will not come in contact with any part of the body. Special care should be taken in handling concentrates (15% or more), particularly in emptying this material into spray tanks. The operator should have available soap and water and a change of clothing. If through some accident the parathion insecticide should come in contact with the clothing or skin, the clothing should be removed immediately and the contaminated parts of the body washed. Atropine should be available in the event of actual poisoning (see "Antidotes").

Hexaethyl tetraphosphate and tetraethyl pyrophosphate are extremely poisonous, but it is unlikely that these materials will be used in mosquito control because of their lack of residual effect.

2, 4-D and Other Weed Killers—Al-

though weed killers are not insecticides, they are of value in mosquito control under some conditions. The toxicity of these materials to animal life is very low (Mitchell, Hodgson, and Gaetjens 1946). However, their potency in destroying broadleaf plants is not confined to weeds along pool margins and ditch banks. Their application from the air is prohibited by law in some states, because of the danger of the spray drifting onto susceptible crops. Every precaution should be taken to prevent drift, as extremely small quantities carried by the wind may cause serious damage.

Spray equipment used to apply weed killers preferably should not be used to apply insecticides, especially near crops. If it is so used, it should be thoroughly cleaned. It is recommended that the spray tank be filled with lye water (13 oz. of lye per 100 gal.), and after it has stood for several hours the material is pumped out through the lines.

ANTIDOTES

In the case of suspected poisoning from any insecticide, a physician should be called immediately. However, in view of the newness of this group of insecticides, physicians may not be aware of the antidotes recommended. Hence the following information is presented:

There is no specific antidote for accidental poisoning by DDT and other chlorinated hydrocarbon insecticides, although phenobarbital has been found to allay the tremors resulting from such poisoning. The usual procedure of emptying the stomach with emetics, or better, stomach pump, is indicated in cases where these insecticides are swallowed.

Atropine is the antidote usually advised for parathion poisoning. Morphine should never be given.

SOME RULES TO OBSERVE

1. Be sure an insecticide is needed.
2. Choose the most effective and safest insecticide.
3. Apply the insecticide properly, which means use suitable equipment properly adjusted.
4. Apply the material under favorable weather conditions.
5. Use the best formulation for the purpose.
6. Apply the minimum quantity consistent with effective control.
7. Time the applications in relation to mosquito development in order to accomplish the greatest good.
8. Make no more applications than necessary.
9. Follow all practices to safeguard the operator and the health and interests of the public.
10. Be familiar with antidotes and have them and other precautionary devices at hand when working with highly toxic materials such as parathion.

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THE RELATIVE EFFECTIVENESS OF SEVERAL INSECTICIDES AGAINST MOSQUITO LARVAE IN ALASKA [1]

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Tests to determine the effectiveness of a number of insecticides against *Aedes* mosquito larvae were made on 146 one-eighth- to one-half-acre plots in the Anchorage, Eklutna, and Gulkana, Alaska, areas in May and June of 1947 and 1948. Several of the insecticides were also tested against *Culiseta* larvae.

The test areas in 1947 ranged from clear, open pools to pools almost completely filled with sedges. In some pools the water was covered with a heavy scum. The most common species of larvae were *Aedes punctor* (Kby.), *A. pionips* Dyar, and *A. communis* (Deg.). Nearly all the larvae were in the fourth instar, and many were pupating when the tests were made.

Fuel-oil solutions of DDT, benzene hexachloride, chlordane, and toxaphene (chlorinated camphene), and water emulsions of DDT were applied with a small hydraulic-type hand sprayer that produced a fine mist spray. The DDT and benzene hexachloride wettable powders were applied with a small hand sprayer, and the DDT dusts were dispersed with a small plunger duster.

The results of the tests against *Aedes* larvae (Table 1), indicated that oil solutions and water emulsions of DDT were about equally effective and somewhat better than benzene hexachloride in oil solution. These two chemicals appeared superior to the other chemicals and formulations tested. The tests against *Culiseta* larvae (Table 2), further showed DDT and benzene hexachloride to be superior to chlordane and toxaphene.

A suitable sprayer for dispersing wettable DDT powder was not available, and

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