THE USE OF ARSENICALS FOR THE CONTROL OF HOUSEFLY LARVAE

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For several years the Entomology Department of Oklahoma A. and M. College has been responsible for the fly control work on the campus. The primary objectives have been the elimination of the breeding places of flies by the frequent removal and proper storage or disposal of manure, and an educational campaign to obtain the cooperation of the workmen. Because experimental work and economic factors frequently made it undesirable to remove the manure, it soon became evident that chemical treatment of the breeding media constituted one of the most valuable suppressive measures.

Early in the work it was found that the present recommendations for the chemical control of fly larvae were not effective under conditions prevailing in central Oklahoma, and war shortages have made it very difficult to obtain suggested materials. Trained men following the most recent directions for chemical control (Bishopp 1939) were not successful in preventing the breeding of fly larvae in manure. These recommendations were based on the work of Cook, et al. (1914, '15, '16), who suggested the use of hellebore, borax, calcium cyanamide, or acid phosphate. More recent workers have suggested sodium fluosilicate, tar acids, pyrethrum, carbolic acid, "polychlorides," paradichlorobenzene, and sodium arsenite. It has been recently suggested by Hoskins (1940) that thiourea be used because of its extreme toxicity in laboratory tests.

In order to find a satisfactory material for use in the control of fly larvae a project was set up to test under laboratory conditions all the materials which had been suggested and if possible to discover more useful chemicals whose use would be economically feasible.

MATERIALS AND METHODS

Tests were carried out in wide mouth quart mason jars containing 100 grams of crimped oats and 100 grams of water to which had been added 0.3 cc formalin (37-38 percent formaldehyde). The formalin checked the development of molds, yet had no apparent ill effects on the fly larvae. Water-soluble chemicals were dissolved in the water before being added to the oats; those not soluble were finely ground and carefully mixed with the oats before and after the addition of water.

Tests involving 5.0, 1.0, 0.5, 0.1 and 0.05 grams of chemical were run for each material. Each series also included a check containing crimped oats and water containing formalin and unless fly emergence was normal in the check the results were discarded.

One hundred third-instar larvae were counted into each jar with as little handling as possible. These larvae had been grown in a constant temperature from (85°F±1; R.H. 75±4) according to the methods described by Eagleson (1937, 1938). The jars were placed in the constant temperature room and kept there until all the flies had emerged and died normally. The adults were then counted and the rating of the chemical thus determined. Several chemicals caused the development of abnormal individuals or materially decreased the rate of development, but only total emergence was considered in determining the rating of a chemical.

At least two series of tests were run for each chemical and those of which 0.1 gram or less killed all larvae were further tested in amounts successively smaller by 0.01 gram until a median lethal dose could be determined.

The results of these tests are shown in table I and table II. Table I, covering all chemicals which killed in amounts of 0.1 gram or less, gives the number of tests, the lowest concentration that killed all larvae, and the average concentration providing a median lethal dose. Table II lists the chemicals in groups according to the lowest concentration which killed 100 percent of the larvae. Materials which failed to kill 100 percent of the larvae when 5 grams of material were used were considered nontoxic. No further data are given in table II, as chemicals listed therein are considered not toxic enough to have real value in larval fly control.

Abbott's formula (1925) $100(x-y)/x$ has been used to correct for normal mortality as determined by the decrease in population in the check jars.

TABLE I

Results of tests with chemicals killing 100 percent of larvae at concentrations of 0.1 percent or less

Chemical	No. of tests	Concentration giving 100% mortality	Ave. concentration giving 50% mortality
Sodium arsenite $NaAsO_2$ (C.P.)	18	0.04	0.012
Arsenious oxide As_2O_3	8	.04	.017
Sodium arsenite Crude solution (8 lbs. As_2O_3 per gal.)	9	.05	.015
Paris green $(CH_3COO)_2Cu.$ $3Cu(AsO_2)_2$	8	.05	.023
Arsenic pentoxide As_2O_5	8	.05	.024
Sodium arsenate Na_2HAsO_4	8	.08	.028
Cupric arsenate $Cu_3(AsO_4)_2$	8	.08	.031
Mercuric chloride $HgCl_2$	8	.09	.037

TABLE II

Results of tests not killing 100 percent of larvae at 1.0 percent concentration

Chemical	No. of tests	Concentration giving 100% mortality
Borax	8	0.22
Lead arsenate	4	0.50
Zinc phosphide	8	0.50
2, 4-Dinitro-6-cyclohexylphenol	4	0.50
Thallous acetate	4	0.50
Thallous sulfate	4	0.50
Paradichlorobenzene	4	0.50
Ethylene dichloride	5	0.50
Ethylene chlorohydrin	5	0.50
Ferrous sulfate	4	0.50
Ferric sulfate	4	0.50
Sodium fluosilicate	4	0.50
Sodium fluoride	4	0.50
Carbon disulfide	5	0.50
n-Butyl mercaptan	4	0.50
Mercurous chloride	8	0.50
Magnesium arsenate	4	0.50
Barium arsenate	4	0.50
Orthodichlorobenzene	4	1.0
Ethyl mercaptan	4	1.0
p-Dibromobenzene	4	1.0
Lethane 384 (β-butoxy-β-thiocyanodiethyl ether)	4	1.0
Lethane 384 special	4	1.0
Barium fluosilicate	2	5.0
Paraformaldehyde	2	5.0
Pine oil	2	5.0
Barium chloride	2	5.0
American hellebore *Veratrum viride*	4	5.0
Carbon tetrachloride	4	5.0
Hexachlorobenzene	2	5.0
Naphthalene	2	5.0
Anthracene	2	5.0
Cresylic acid	2	5.0
Tartar emetic	2	5.0
Cryolite	2	Nontoxic
Calcium fluoride	2	Nontoxic
Barium fluoride	2	Nontoxic
Phenothiazine	2	Nontoxic
Diphenylamine	2	Nontoxic
White hellebore *Veratrum album*	4	Nontoxic
Black hellebore *Helleborus niger*	4	Nontoxic

DISCUSSION

Laboratory and field tests show that several arsenicals are effective and economic larvicides. Sodium arsenite is the most effective and arsenious oxide is almost as good if it can be properly mixed with the medium. Paris green, arsenic pentoxide, and sodium arsenate are almost as effective as these and are still much more toxic than borax, which is usually recommended.

The effect of these arsenicals on the soil has not been studied by us, but considerable data on this subject have been accumulated by various workers.

Greaves and Anderson (1914) showed that arsenicals, excepting Paris Green, increased the nitrogen-fixing power of the soil. In concentrations above 40 parts per million, however, sodium arsenite exerted a toxic influence while sodium arsenate was not toxic at 400 parts per million.

Soil types were shown to alter toxicity materially (Reed and Sturgis 1936). Rice on light soils was seriously injured by the application of 50 pounds of calcium arsenate per acre, while that on heavy soils showed no signs of injury when 150 pounds were similarly used. Crafts and Rosenfels (1939) showed that a minimum of 320 pounds As_2O_3 per acre is needed in coarse gritty soils, while clay and adobe clay soils may require as much as 1920 pounds per acre for soil sterilization by arsenic. They further showed that soluble forms of arsenic leach out of the soil very easily and may be entirely removed by seeping water.

Work at this station indicates that wetting infested manures with a 0.1 per cent solution of commercial sodium arsenite is the most satisfactory and economical chemical control of house fly larvae we have used. Even under conditions of severe infestation, when all of the manure must be wet with arsenic solution, this means an application of less than two pounds of sodium arsenic per ton. Some field data observations indicate that this amount of arsenic in the manure does not seem to be harmful to crops fertilized with it, and since the arsenic is in a soluble form and readily leaches out the danger of building up a toxic concentration is slight.

When carefully handled and applied by one familiar with the use of poisons, sodium arsenite should not endanger farm animals.

The use of borax-treated fertilizers has been shown to be dangerous to some crops by the recent work of Eaton (1935) and others, which demonstrated that boron concentrations as low as 0.5 part per million in irrigation waters may be injurious to boron-sensitive plants such as lemons, grapefruit, oranges, peaches, grapes, apples, navy beans, etc., while concentrations above two parts per million are toxic to semi-tolerant plants. The toxic effects are less noticeable in regions of heavy rainfall, and soil types influence materially the action of boron. It should be noted that some soils are deficient in boron and the addition of small quantities may improve the crop substantially. Heart rot of sugar beets (de Haan 1934) and deficiency diseases of celery, asters, broccoli, and cabbage may be controlled by the addition of boron (Powers 1939).

SUMMARY

1. Laboratory tests have been made to determine the toxicity to house fly larvae of chemicals which have been recommended for their control and others which offered promise because of their toxicity to other insects.

2. Satisfactory control under field conditions was not obtained with borax or hellebore when used according to U. S. D. A. recommendations, even though great care was taken in their application.

3. Commercial sodium arsenite was the most effective and economical chemical tested. It provided satisfactory control with a minimum of effort.

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