Comparative Toxicities of Insecticides to House Fly Larvae and *Macrocheles muscaedomestica*, a Mite Predator of the House Fly[1]

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ABSTRACT

The concentration-mortality curves for 17 insecticides were determined for third-instar larvae of the house fly, *Musca domestica* L., and adult female *Macrocheles muscaedomesticae* (Scopoli), a manure-inhabiting mite predaceous on house fly eggs and first-instar larvae. The mites and fly larvae were exposed to insecticides incorporated into fly-rearing medium. Bayer 39007 (*o*-isopropoxyphenyl methylcarbamate), dichlorvos, fenthion, malathion, Ciodrin® (*alpha*-methylbenzyl 3-hydroxycrotonate dimethyl phosphate), and naled were more toxic to the mites than to the fly larvae. Dimetilan and chlordane were more toxic to the mites than to the fly larvae at the LC_{95} level although the converse was exhibited at the LC_{50} level. Diazinon was about equally toxic to the mites and to the fly larvae. DDT, trichlorfon, and ronnel were slightly more toxic to the fly larvae than to the mites. Kepone® (decachlorooctahydro-1,3,4-metheno-2*H*-cyclobuta[*cd*]pentalen-2-one), dimethoate, lindane, GC 9879 (4-hydroxy-2-mercaptobutyric acid, *gamma*-lactone, *S*-ester with *O,O*-diethyl phosphorodithioate), and coumaphos were more toxic to the fly larvae than to the mites with the first two exhibiting the greatest selectivity.

Intensified efforts to identify selective chemicals for house fly control is advocated as a step in the development of a reliable integrated house fly control program for use around animal shelters.

Certain predaceous species of mites of the families Macrochelidae and Uropodidae are common in the manure of dairy cattle and poultry where house fly, *Musca domestica* L., breeding is common (Axtell 1963a). These mites prey on the eggs and 1st-instar larvae of the house fly and are important biological agents suppressing fly populations (Axtell 1963b, O'Donnell and Axtell 1965, Rodriguez and Wade 1961). These mites, along with predaceous fly larvae (e.g. *Ophyra leucostoma* Wiedemann) and parasitic Hymenoptera, should be considered in the development of an integrated control program against the house fly (Anderson 1964, Anderson and Poorbaugh 1964). The effects on these mites of insecticides which may be used for house fly control have not been reported. Therefore, the comparative toxicities of 17 insecticides to house fly larvae and a common manure-inhabiting macrochelid mite, *Macrocheles muscaedomesticae* (Scopoli), were determined.

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MATERIALS AND METHODS.—The mites used in this investigation were reared in the laboratory from specimens collected from cow manure in 1961. The house flies were derived from the CSMA (Chemical Specialties Manufacturers Association) strain maintained by the Union Carbide Research Laboratory, Clayton, N. C.

In all evaluations, the insecticide (diluted with water) was incorporated into CSMA medium (Ralston Purina Co.). Wettable powders of Kepone® and coumaphos and the technical grade of trichlorfon were used. In all other cases, emulsifiable concentrates were used. Certain chlorinated hydrocarbons were included for comparative purposes although house fly resistance has made them useless in present-day control programs. The formulations used and sources of chemicals are presented at the end of this report.

Each replicate was composed of 10 g CSMA medium + 25 ml of the desired concentration of insecticide. These were mixed thoroughly in a plastic-coated drinking cup (5 cm diam × 9 cm high). Each control contained water in place of the insecticide. To each cup, 25 3rd-instar larvae of the house fly or 25 adult ♀ mites were added. The cups (with screen tops) were held at 27±2°C for 24 hr. They were then inverted (with top removed) into Tullgren funnels (15 cm diam) and the bottom of the cup was cut away. An overhead 15-w light bulb caused the live fly larvae or mites to migrate downward into an attached collecting jar containing 80% alcohol. The recovered mites or fly larvae were considered to be unaffected by the chemical. Abbott's formula was used to correct for control mortality, which was usually about 10%.

Three replications of each of 5 or 6 concentrations of an insecticide were tested on 1 day. This procedure was repeated on different days and each concentration-mortality curve based on the combined results of 9–12 replications. Concentrations were expressed in percent on a wt/wt basis. The regression line was determined by probit analysis with the maximum likelihood procedure (Finney 1952).

The possibility that different results might be obtained by exposing the organisms together rather than separately was considered. Mixed populations of 25 mites and 25 3rd-instar fly larvae per replicate were exposed to certain concentrations of 4 insecticides by the procedure just described. Eight replicates/treatment were used.

RESULTS.—The LC_{50} values, 95% confidence limits, and slopes of the regression lines are presented for each insecticide in Table 1. The fly:mite ratios of the LC_{50} and LC_{95} for each insecticide are presented.

Bayer 39007 was considerably more toxic to the mites than to the fly larvae while dichlorvos, fenthion, and malathion were slightly more toxic to the mites than to the fly larvae. Ciodrin® and naled were about equally toxic to the mites and fly larvae at the LC_{50} levels but at the LC_{95} levels were more toxic to the mites than to the flies. Diazinon was about equally toxic to the mites and to the fly larvae. Kepone, dimethoate, lindane, GC 9879, and coumaphos were considerably more toxic to the fly larvae than to the mites. Dimetilan and chlordane were more toxic to the fly larvae than to the mites at the LC_{50} level, but the converse was exhibited at the LC_{95} level. The remaining insecticides (DDT, trichlorfon, and ronnel) were slightly more toxic to the fly larvae than to the mites.

The toxicities of coumaphos, dimethoate, GC 9879, and Kepone to mixed populations of mites and fly larvae are presented in Table 2. These insecticides exhibited the predicted differences in toxicities to mites and fly larvae at some of the concentrations tested. However, the toxicities to both mites and fly larvae generally were greater than predicted from the regression lines derived from testing the organisms separately.

DISCUSSION.—On the basis of these data it appears that most chemicals used for fly control are toxic enough to threaten destruction of the predaceous manure-inhibiting macrochelid mites. Possible exceptions are Kepone, dimethoate, GC 9879, and coumaphos, with the 1st two exhibiting the greatest degree of selectivity in laboratory tests. The selectivity ex-

Table 1.—The comparative toxicities of insecticides to the 3rd-instar larvae of the house fly and the adult females of the predaceous mite *Macrocheles muscaedomesticae*.

Insecticides	Fly larvae		Mites		Ratio fly:mite	
	LC_{50}[a] (%)	Slope	LC_{50}[a] (%)	Slope	LC_{50}	LC_{95}
Bayer 39007	0.008 (.0013–.051)	0.828	0.00022 (.00016–.00031)	2.850	36:1	988:1
Dichlorvos	.00050 (.00025–.0010)	1.573	.00026 (.00017–.00041)	3.987	2:1	8:1
Fenthion	.00087 (.00027–.0027)	1.036	.0013 (.0012–.0014)	2.689	1.5:1	6:1
Malathion	.0042 (.0038–.0047)	1.997	.0028 (.0017–.0047)	2.040	1.5:1	1.5:1
Ciodrin	.018 (.014–.022)	1.045	.016 (.015–.018)	3.125	1:1	12:1
Naled	.00043 (.0029–.00064)	1.639	.00044 (.00028–.00068)	3.677	1:1	4:1
Diazinon	.00058 (.00053–.00064)	2.346	.0010 (.00070–.0014)	2.266	1:2	1:1
DDT	.037 (.033–.042)	1.947	.095 (.076–.12)	0.885	1:3	1:26
Trichlorfon	.00098 (.00068–.0014)	1.972	.0077 (.0017–.035)	1.195	1:8	1:27
Ronnel	.00054 (.00047–.00061)	2.543	.0047 (.0011–.021)	1.927	1:9	1:7
Chlordane	.076 (.030–.19)	1.305	.66 (.60–.73)	2.266	1:9	3:1
Coumaphos	.0046 (.0025–.0082)	2.092	.044 (.0085–.23)	.697	1:10	1:357
GC 9879	.0049 (.0012–.020)	1.074	.058 (.0074–.45)	1.029	1:12	1:13
Lindane	.0032 (.0030–.0035)	3.254	.040 (.018–.090)	.905	1:12	1:262
Dimetilan	.0019 (.000029–.121)	.744	.024 (.022–.026)	2.698	1:13	3:1
Dimethoate	.000054 (.000051–.00057)	3.373	.0026 (.0023–.0028)	2.390	1:48	1:75
Kepone	.045 (.042–.047)	3.062	2.55 (.69–9.37)	1.219	1:57	1:380

[a] 95% confidence limits are given in parentheses.

Table 2.—The mortalities of predaceous mites *Macrocheles muscaedomesticae* and 3rd-instar house fly larvae held together for 24 hr in CSMA medium treated with insecticides.

Insecticide	Concn (%)	% mortality[a] Mites	Fly larvae
Coumaphos	0.01	96	100
	.001	38	87
	.0	15	14
Dimethoate	.001	91	100
	.0001	14	100
	.0	17	21
GC 9879	.01	90	100
	.001	24	95
	.0	18	21
Kepone®	.5	32	100
	.1	20	100
	.0	17	20

[a] Based on 8 replications/treatment with 25 mites and 25 fly larvae/replicate.

hibited by lindane is of academic interest only since house flies are in general resistant to that insecticide.

Extrapolation from the laboratory results to the field situation is complicated by: (1) longer exposure periods, (2) exposure of additional stages of the mites and flies, (3) interactions between the manure and insecticides, and (4) fluctuating environmental conditions. Nevertheless, the differences in toxicities in the case of some insecticides suggest that selective chemicals and selective dosage levels could be developed for house fly control around animal shelters. Selectivity should be considered in the development of insecticides to be used as feed-additives or adulticides for house fly control.

Selective application methods should be investigated further, since the toxicities of most chemicals to the predaceous mites indicate that the application of most insecticides to the manure is not desirable. Manure contamination by insecticides would be reduced by the low-volume spraying of selected areas which was shown by DeFoliart (1963) to be adequate for house fly control. Anderson and Poorbaugh (1964) suggested that spraying be restricted to the ceilings of poultry houses, since house flies congregate there at night. They suggested also that vegetation adjacent to poultry houses should not be treated because the dipterous predators and hymenopterous parasites of the house fly rest there at night. The effects of bait stations and treated cords on these insect enemies of the house fly are unknown.

A reliable integrated house fly control program (around animal shelters) appears to be feasible. Prerequisites to the development of such a program are more information on (1) the behavior of the parasites and predators of the house fly and (2) the selectivities of various chemicals, dosage levels, and application methods.

FORMULATIONS, SOURCES, AND IDENTITIES OF CHEMICALS.—
dimethoate, 4 lb/gal EC, American Cyanamid Co.
naled, 8 lb/gal EC, Chevron Chemical Co.
dichlorvos, 2 lb/gal EC, Shell Chemical Co.
fenthion, 4 lb/gal EC, Chemagro Corp.
ronnel, 2 lb/gal EC, Dow Chemical Co.
malathion, 5 lb/gal EC, American Cyanamid Co.
trichlorfon, 98% tech., Chemagro Corp.
DDT, 25% EC, W. B. Grace and Co.
diazinon, 4 lb/gal EC, Geigy Chemical Co.
coumaphos, 25% WP, Chemagro Corp.
dimetilan, 12.5% EC, Geigy Chemical Co.
chlordane, 8 lb/gal EC, W. B. Grace and Co.
lindane, 1.65 lb/gal EC, Chevron Chemical Co.
Kepone®, 50% WP, decachlorooctahydro-1,3,4-metheno-2H-cyclobuta[*cd*]pentalen-2-one, General Chemical Div.
Ciodrin®, 3.2 lb/gal EC, *alpha*-methylbenzyl 3-hydroxycrotonate dimethyl phosphate, Shell Chemical Co.
Bayer 39007, 1.5 lb/gal EC, *o*-isopropoxyphenyl methylcarbamate, Chemagro Corp.
GC 9879, 4 lb/gal EC, 4-hydroxy-2-mercaptobutyric acid, *gamma*-lactone, *S*-ester with *O,O*-diethyl phosphorodithioate, General Chemical Div.

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