145

Efficacies of Mixtures of Disinfectants and Insecticides

C. J. GEDEN, T. D. EDWARDS, J. J. ARENDS, and R. C. AXTELL

Department of Entomology, North Carolina State University, Raleigh, North Carolina 27695-7613

(Received for publication August 8, 1986)

ABSTRACT Efficacies of mixtures of diluted commercial formulations of selected insecticides and disinfectants were evaluated. Insecticides tested included representative pyrethroids (fenvalerate [Ectrin WDL and WD] and permethrin [Ectiban EC]), organophosphates (dichlorvos [Vapona EC], tetrachlorvinphos [Rabon WP] and dichlorvos/tetrachlorvinphos [RaVap EC], and a carbamate (carbaryl [Sevin S]). Disinfectants tested included representatives of cresylic acid (Biolene), cresylic acid/phenol (BioGuard X-185), phenol (1-Stroke Environ), quaternary ammonium (BioGuard S-3 and PFP-4), quaternary ammonium/formalin (DC & R), and formalin classes of disinfectants.

Mixtures were tested for toxicity to two target insects (*Musca domestica* on plywood, *Alphitobius diaperinus* in litter) and two bacteria (*Pseudomonas aeruginosa* and *Staphylococcus aureus*). Of 56 mixtures evaluated, 24 showed reduced insecticidal toxicity and 35 showed reduced bactericidal activity compared with insecticides or disinfectants alone.

(*Key words:* insecticides, disinfectants, *Alphitobius diaperinus, Musca domestica, Pseudomonas aeruginosa, Staphylococcus aureus*)

1987 Poultry Science 66:659–665

INTRODUCTION

Poultry producers generally sanitize production facilities during the interval between flocks by spraying with appropriate dilutions of commercially formulated disinfectants. In addition, many also treat with insecticides to suppress populations of insect pests. To reduce labor costs and minimize application time, disinfectants and insecticides are often combined in the same sprayer tank, although there is little information on the compatibility of these chemicals with respect to germicidal and insecticidal activity (Harris *et al.*, 1975). The present study tested the effects of mixtures of several commercial formulations of disinfectants and insecticides commonly used in the poultry industry.

MATERIALS AND METHODS

Chemicals. Representative disinfectants from the following categories were used: cresylic acid (Biolene®), cresylic acid and phenols (BioGuard X-185®), quaternary ammonium compounds (Bioguard PFD-4®, Bioguard S-3®), phenols (1-Stroke Environ®), quaternary ammonium compounds and formalin (DC&R®), and formalin. Chemical sources were: BioLab Inc., P.O. Box 1489, Decatur, GA (Biolene, BioGuard X-185, BioGuard PFD-4, Bioguard S-3); CEVA Laboratories, Inc., 10560 Barkley, Overland Park, KS (1-Stroke Environ); Hess and Clark, Inc., Ashland, OH (DC&R); and Fisher Scientific, Inc., Fair Lawn, NJ (formalin).

Representative insecticides from the following categories were used: 1) synthetic pyrethroids: Ectrin® water-dispersable liquid (WDL) and wettable powder (WP) (fenvalerate), Ectiban® emulsifiable concentrate (EC) (permethrin), 2) organophosphates: Vapona® EC (dichlorvos), Rabon® WP (tetrachlorvinphos), RaVap® EC (dichlorvos and tetrachlorvinphos), CoRal® WP (coumaphos), and 3) carbamates: Sevin® sprayable (S) (carbaryl). Insecticide sources were: SDS Biotech, Inc., P. O. Box 348, Painesville, OH (Ectrin, RaVap, Vapona, Rabon); ICI Americas, Inc., Wilmington, DE (Ectiban); Union Carbide Agricultural Products, Inc., P. O. Box 12014, Research Triangle Park, NC (Sevin); Miles Laboratories, Bayvet Division, P. O. Box 390, Shawnee, KS (CoRal). The percent active ingredient and rates of dilution recommended on the label of the disinfectants and insecticides are shown in Table 1.

Assays for Insecticidal Toxicity. The insecticides and mixtures of insecticides with disinfectants were evaluated for toxicity to two insects: 1) larvae of the lesser mealworm (litter beetle), *Alphitobius diaperinus* (Panzer) and 2) adult house flies, *Musca domestica* L. Most tests were conducted using the concentrations recommended on the label of the insecticides; however, synthetic pyrethroids (Ectrin and Ectiban) were so highly toxic to the insects that more

TABLE 1. *List of chemicals and recommended concentrations of disinfectants and insecticides*

Chemical[1]	Active ingredient	Recommended concentration
	(%)	(product: water)
Disinfectants		
Biolene	82.0	1:32
BioGuard X-185	76.7	1:100
BioGuard PFD-4	25.8	1:100
BioGuard S-3	8.2	1:64
1-Stroke Environ	23.0	1:256
DC&R	23.8	1:128
Formalin	37.0	1:18
Insecticides		
Ectrin, WDL	10.0	1:40
RaVap, EC	28.5	1:25
Ectiban, EC	5.7	1:50
Vapona, EC	21.8	1:50
Rabon, WP	50.0	1:50
Ectrin, WP	13.9	1:55
Sevin, S	80.0	1:160
CoRal, WP	25.0	1:106

[1] WDL = Water-dispersable liquid, EC = emulsifiable concentrate, WP = wettable powder, S = sprayable.

dilute solutions were used in order to detect changes in toxicity which might occur after mixing with disinfectants. These dosage rates, representing the highest concentration which caused less than 100% mortality, were .25 and .01 the recommended concentration for beetle larva and house fly assays, respectively. Mixtures of Sevin and CoRal with disinfectants could not be evaluated by house fly assays because those insecticides had extremely low toxicity to flies.

Solutions were prepared by diluting the appropriate amount of the formulated chemicals with 100 ml of deionized water. Each insecticide was tested alone and in mixture with each disinfectant at the recommended concentration (1 ×) and twice the concentration (2 ×) recommended on the label. Deionized water alone was used as a control in each test. The solutions were stirred, allowed to stand for one hour, and stirred again immediately prior to application to treatment surfaces. The pH of the following solutions was determined: 1 × insecticide alone, 1 × disinfectant alone, and a 1 ×:1 × combination solution of the insecticide with the disinfectant.

For beetle larva assays, 2 ml of each solution (water, insecticide alone, insecticide with 1 × disinfectant, insecticide with 2 × disinfectant) was pipetted over the surface of 50 cm^3 of used poultry litter (containing pine shavings, manure, and feed) in screen-topped plastic cups. Litter was frozen and thawed prior to use in order to kill extraneous insects. Treated litter was allowed to dry for 24 hr, after which 20 beetle larvae were added to each cup (4 cups/treatment). Larvae were middle to late instars (.5 to 1.5 cm in length) and were extracted from recently established cultures collected from heavily infested poultry houses in North Carolina. Beetle mortality was determined three days after introduction into treated litter by spreading the litter in a pan and counting dead (no movement) and live larvae.

For house fly assays, 1 ml of each solution was pipetted onto a 8.3-cm diameter plywood disk placed in a 8.7-cm petri dish. Plywood was weathered by exposure to natural outdoor conditions for 2 to 3 months before the tests. Treated plywood disks were allowed to dry for 24 hr (four disks/treatment). Twenty adult house flies (2 to 4 days old) were briefly (<10 min) anesthetized with CO_2 and added to each plywood disk in a petri dish. The petri dish cover, with holes to permit air exchange, was placed on each dish, and fly mortality (no movement) was determined 8 hr later.

Beetle larvae and house fly mortality after exposure to the insecticides alone was compared with mortality after exposure to insecticides combined with 1 × and 2 × disinfectant solutions by a one way analysis of variance (ANOVA) and Duncan's multiple range test at $P = .05$, using the ANOVA procedure of the Statistical Analysis System (Ray, 1982). None of the disinfectants alone caused mortality which was significantly different from the water control under the assay conditions. Control mortality (water alone) ranged from 0 to 14%.

Assays for Bactericidal Activity. Insecticide-disinfectant combinations were assayed for bactericidal activity against *Pseudomonus auroginosa* (ATCC 15442) and *Staphylococcus aureus* (ATCC 65380) by BioLab, Inc., Decatur, GA, using the same lots of chemicals which were used in the assays with beetles and flies.

Each disinfectant was tested alone at the recommended concentration and in mixtures with each insecticide at the recommended concentration (1 ×) and twice the concentration (2 ×) recommended on the label. Assays were conducted using the standard use-dilution method for disinfectants (Engler, 1984). This assay involved

the exposing of stainless steel cylinder carriers to nutrient broth containing test bacteria and allowing the carriers to dry. Carriers were then exposed to chemical mixtures for 10 min and transferred to subculture tubes containing sterile broth. Tubes were examined after a 48-hr incubation period and scored on growth- or no-growth basis. Ten carriers were tested for each insecticide-disinfectant combination. Tests with 2× insecticide solutions were sometimes omitted if 1× insecticide assays indicated loss of bactericidal activity.

RESULTS

When Biolene was mixed with each insecticide, except Vapona, Ectrin WP and CoRal, there was a significant reduction of insecticidal toxicity to beetle larvae and house flies (Table 2). Losses in bactericidal activity occurred only in mixtures of Biolene with Ectrin WDL and Ectiban. The pH of all mixtures remained within one unit of the pH of Biolene alone; conversely, the pH of the mixtures was at least one unit different from that of every insecticide alone, except CoRal (Table 3).

When BioGuard X-185 was mixed with RaVap, Ectiban, and Sevin there were significant reductions of insecticidal toxicity to beetle larvae (Table 2) In house fly assays, reductions in toxicity were observed in combinations of Bioguard X-185 with Ectrin WDL and Ectiban EC. Losses in the bactericidal activity of BioGuard X-185 were observed in all combinations, except with RaVap and Vapona. Changes in pH were similar to those observed in tests with Biolene (Table 3).

When BioGuard PFD-4 was combined with Ectiban, Rabon and CoRal, there was a significant reduction of insecticidal toxicity to beetle larvae (Table 2). In house fly assays, reductions in toxicity occurred in mixtures with Rabon and Ectrin WP. Losses in bactericidal activity of Bioguard PFD-4 occurred in all combinations, except with RaVap, Vapona, and Sevin. The pH of mixtures differed from the disinfectant alone by at least one unit in combinations with Ectrin, RaVap, Vapona, Rabon, and Sevin; conversely, the pH of the mixtures was at least one unit different from that of Ectrin WDL, Ectiban, Vapona, and Ectrin WP alone (Table 3).

Mixtures of BioGuard S-3 with Ectrin WDL, RaVap, Vapona, and Ectrin WP resulted in significant reductions of insecticidal toxicity to beetle larvae (Table 2). In house fly assays, reductions in toxicity were observed in mixtures with Ectrin WDL and Ectrin WP. Losses in bactericidal activity of BioGuard S-3 occurred with all of the mixtures with insecticides. The pH of the mixtures differed from the disinfectant alone by at least one unit in combinations with RaVap, Vapona, Rabon, and Sevin; conversely, the pH of the mixtures was at least one unit different from each insecticide alone (Table 3).

When 1-Stroke Environ was mixed with Rabon and Sevin, there was a significant reduction of insecticidal toxicity to beetle larvae (Table 2). In house fly assays, a reduction in toxicity was only observed in the mixture with Rabon. Losses in the bactericidal activity of 1-Stroke Environ occurred with all of the mixtures with insecticides, except RaVap. The pH of the mixtures differed from the disinfectant alone by at least one unit in combinations with RaVap and Vapona; conversely, the pH of mixtures was at least one unit different from each insecticide alone, except RaVap (Table 3).

In DC&R and insecticide mixtures, the only significant reduction in insecticidal toxicity was with CoRal (Table 2). Losses in bactericidal activity of DC&R occurred in mixtures with all of the insecticides except RaVap. The pH of mixtures differed from the disinfectant alone by at least one unit in all cases except for the mixture with Ectiban; conversely, only the mixture with Ectrin WDL differed by more than one unit from that of the insecticide alone (Table 3).

When formalin was combined with Ectrin WDL, RaVap, and Vapona there was a significant reduction in toxicity for beetle larvae (Table 2). There were no losses of toxicity to house flies and no losses in bactericidal activity. The pH of the mixtures differed from the disinfectant alone by at least one unit in combination with RaVap, Rabon and CoRal; conversely, the pH of mixtures was at least one unit different from that of Ectiban, Sevin, and CoRal alone (Table 3).

A summary of the changes in bactericidal and insecticidal activities of these 56 mixtures of disinfectants and insecticides is shown in Table 4.

DISCUSSION

Reductions in insecticidal and bactericidal activity were common, and there were no clear relationships to the classes of active ingredients, indicating that formulation components other than the active ingredients may have affected

TABLE 2. *Effect of mixing insecticides (Ins) with disinfectants (Dis) on insecticidal and bactericidal activity*

Insecticide[1]	Mortality, Ins + Dis[2]						Carriers supporting bacterial growth, Dis + Ins[3]					
	Beetle larvae			House flies			*Pseudomonas aeruginosa*			*Staphylococcus aureus*		
	0 Dis	1× Dis	2× Dis	0 Dis	1× Dis	2× Dis	0 Ins	1× Ins	2× Ins	0 Ins	1× Ins	2× Ins
	(%)											
Mixed with Biolene (cresylic acid)												
Ectrin WDL	70.0[a]	48.8[b]	55.0[b]	91.2[a]	82.5[ab]	72.5[b]	0	0	100	0	0	0
RaVap EC	80.0[a]	70.0[ab]	61.2[b]	61.2[a]	71.2[ab]	81.2[b]	0	0	0	0	0	0
Ectiban EC	96.2[a]	75.0[b]	86.2[b]	48.8[a]	36.2[a]	6.2[b]	0	100	100	0	100	100
Vapona EC	85.0[a]	81.2[a]	87.5[a]	98.8[a]	100.0[a]	100.0[a]	0	0	0	0	0	0
Rabon WP	81.2[a]	93.8[a]	67.5[b]	77.5[a]	71.2[ab]	62.5[b]	0	0	0	0	0	0
Ectrin WP	77.5[a]	86.2[a]	81.2[a]	63.8[a]	21.2[b]	27.5[b]	0	0	0	0	0	0
Sevin S	68.8[a]	52.5[ab]	23.8[b]	...	...	...	0	0	0	0	0	0
CoRal WP	40.0[a]	37.5[a]	45.0[a]	...	...	...	0	0	0	0	0	0
Mixed with BioGuard S-3 (quaternary ammonium)												
Ectrin WDL	82.5[a]	38.8[b]	15.0[c]	80.0[a]	1.2[b]	1.2[b]	0	100	...	0	100	...
RaVap EC	80.0[a]	85.0[a]	66.2[b]	90.0[a]	93.8[a]	87.5[a]	0	0	...	0	100	...
Ectiban EC	63.8[a]	50.0[a]	45.0[a]	2.5[a]	.0[a]	.0[a]	0	0	100	0	0	100
Vapona EC	88.8[a]	70.0[b]	46.2[c]	78.8[a]	95.0[a]	90.0[a]	0	0	0	0	0	100
Rabon WP	63.8[a]	73.8[a]	66.2[a]	65.0[a]	85.0[b]	73.8[ab]	0	100	...	0	100	...
Ectrin WP	81.2[a]	21.2[b]	11.2[b]	37.5[a]	18.8[b]	10.0[b]	0	70	...	0	0	...
Sevin S	46.2[a]	40.0[a]	41.2[a]	...	...	...	0	100	...	0	30	...
CoRal WP	57.5[a]	63.8[a]	52.2[a]	...	...	...	0	20	...	0	30	...
Mixed with 1-Stroke Environ (phenols)												
Ectrin WDL	81.2[a]	85.0[a]	82.5[a]	40.0[a]	88.8[a]	83.8[a]	0	100	...	0	100	...
RaVap EC	77.5[a]	80.0[a]	81.2[a]	97.5[a]	95.0[a]	98.8[a]	0	0	0	0	0	0
Ectiban EC	80.0[a]	57.5[a]	78.8[a]	31.2[a]	18.8[a]	23.8[a]	0	100	...	0	100	...
Vapona EC	85.0[a]	88.8[a]	91.2[a]	91.2[a]	91.2[a]	96.2[a]	0	10	...	0	100	...
Rabon WP	77.5[a]	73.8[a]	60.0[b]	78.8[a]	65.0[ab]	60.0[b]	0	100	...	0	10	...
Ectrin WP	86.2[a]	100.0[a]	83.8[a]	96.2[a]	90.0[a]	100.0[a]	0	100	...	0	100	...
Sevin S	65.0[a]	73.8[a]	50.0[b]	...	...	...	0	100	...	0	100	...
CoRal WP	41.2[a]	48.8[a]	47.5[a]	...	...	...	0	70	...	0	30	...
Mixed with BioGuard X-185 (cresylic acid and phenols)												
Ectrin WDL	83.8[a]	76.2[a]	76.2[a]	90.0[a]	67.5[ab]	55.0[b]	0	0	100	0	0	100
RaVap EC	97.5[a]	85.0[b]	81.2[b]	97.5[a]	98.8[a]	95.0[a]	0	0	0	0	0	0
Ectiban EC	68.8[a]	45.0[b]	36.2[b]	57.8[a]	23.8[b]	27.5[b]	0	0	100	0	0	100

Vapona EC	93.8[a]	85.0[a]	87.5[a]	95.0[a]	97.5[a]	100.0[a]	0	0	0	0	0	0
Rabon WP	63.8[a]	66.2[a]	81.2[b]	87.5[a]	83.8[a]	67.5[a]	0	0	0	0	0	50
Ectrin WP	91.2[a]	78.8[a]	86.2[a]	82.5[a]	80.0[a]	70.0[a]	0	0	100	0	0	100
Sevin S	58.8[a]	72.5[a]	41.2[b]	...	...	...	0	0	0	0	0	100
CoRal WP	82.5[a]	78.8[a]	73.8[a]	...	...	...	0	0	0	0	0	100
Mixed with BioGuard PFD-4 (quaternary ammonium)												
Ectrin WDL	68.8[a]	83.8[a]	80.0[a]	80.0[a]	82.5[a]	98.8[b]	0	60	100	0	0	40
RaVap EC	82.5[a]	73.8[a]	65.0[a]	86.2[a]	85.0[a]	87.5[a]	0	0	0	0	0	0
Ectiban EC	65.0[a]	70.0[a]	16.2[b]	15.0[a]	6.2[a]	5.0[a]	0	10	100	0	0	100
Vapona EC	88.8[a]	95.0[a]	93.8[a]	83.8[a]	100.0[a]	100.0[a]	0	0	0	0	0	0
Rabon WP	73.8[a]	58.8[b]	60.0[b]	71.2[a]	71.2[a]	56.2[b]	0	100	100	0	0	80
Ectrin WP	91.2[a]	93.8[a]	87.5[a]	27.5[a]	5.0[b]	2.5[b]	0	0	100	0	0	100
Sevin S	46.2[a]	47.5[a]	46.2[a]	...	...	...	0	10	0	0	0	0
CoRal WP	55.0[a]	51.2[a]	22.5[b]	...	...	...	0	0	100	0	0	100
Mixed with DC&R (quaternary ammonium and formalin)												
Ectrin WDL	97.5[a]	96.2[a]	98.8[a]	93.8[a]	98.8[a]	97.5[a]	0	100	...	0	0	...
RaVap EC	83.8[a]	81.2[a]	76.2[a]	85.0[a]	95.0[a]	88.8[a]	0	0	0	0	0	0
Ectiban EC	80.0[a]	82.5[a]	92.5[a]	16.2[a]	8.8[a]	10.0[a]	0	100	...	0	100	...
Vapona EC	95.0[a]	91.2[a]	95.0[a]	85.0[a]	92.5[a]	90.0[a]	0	0	...	0	80	...
Rabon WP	88.8[a]	75.0[a]	83.8[a]	78.8[a]	75.0[a]	76.2[a]	0	100	...	0	100	...
Ectrin WP	77.5[a]	87.5[a]	92.5[a]	83.8[a]	91.2[a]	97.5[a]	0	100	...	0	100	...
Sevin S	61.2[a]	62.5[a]	68.8[a]	...	...	...	0	20	...	0	100	...
CoRal WP	43.8[a]	51.2[a]	23.8[b]	...	...	...	0	100	...	0	100	...
Mixed with formalin												
Ectrin WDL	90.0[a]	80.0[a]	68.8[b]	83.8[a]	88.8[a]	96.2[a]	0	0	0	0	0	0
RaVap EC	78.8[a]	36.2[b]	36.2[b]	75.0[a]	80.0[a]	77.5[a]	0	0	0	0	0	0
Ectiban EC	77.5[a]	88.8[a]	77.5[a]	21.2[a]	11.2[a]	15.0[a]	0	0	0	0	0	0
Vapona EC	95.0[a]	36.2[b]	23.8[b]	93.8[a]	80.0[a]	80.0[a]	0	0	0	0	0	0
Rabon WP	75.0[a]	67.5[a]	58.8[a]	75.0[a]	78.8[a]	75.0[a]	0	0	0	0	0	0
Ectrin WP	83.8[a]	76.2[a]	92.5[a]	73.8[a]	83.8[a]	78.8[a]	0	0	0	0	0	0
Sevin S	76.2[a]	67.5[a]	66.2[a]	...	...	...	0	0	0	0	0	0
CoRal WP	46.2[a]	57.5[ab]	62.5[b]	...	...	...	0	0	0	0	0	0

[a–c]Means within rows under the same insect subheading followed by different letters are significantly different ($P \leq .05$).

[1] WDL = water-dispersable liquid, EC = emulsifiable concentrate, WP = wettable powder, S = sprayable.

[2] $\bar{X}$% mortality of beetle larvae and adult house flies after exposure to surfaces treated with either Ins alone or in combination with Dis at 1× and 2× the recommended concentration.

[3] Percent of carriers which supported bacterial growth after exposure to either Dis alone or in combination with Ins at 1× and 2× the recommended concentration.

TABLE 3. *The pH of disinfectants and insecticides alone and in mixtures at recommended concentrations*

Insecticide[1]	Disinfectant							
	None	Biolene	BioGuard X-185	BioGuard PFD-4	BioGuard S-3	1-Stroke Environ	DC&R	Formalin
None	...	8.8	9.3	9.6	11.2	10.2	6.2	4.1
Ectrin WDL	4.0	9.6	9.1	8.4	11.5	10.9	5.0	4.3
RaVap EC	2.8	8.8	8.4	3.4	9.0	3.6	2.6	2.6
Ectiban EC	6.7	9.3	9.7	9.4	11.5	10.8	6.4	4.1
Vapona EC	3.2	8.8	9.4	5.2	5.2	9.0	3.4	3.4
Rabon WP	8.0	9.0	9.3	7.8	10.0	9.4	7.3	7.2
Ectrin WP	5.1	8.6	9.0	9.0	10.8	10.1	4.8	4.4
Sevin S	5.6	8.6	9.2	7.8	10.0	9.9	4.8	4.1
CoRal WP	8.3	8.5	9.2	8.8	11.1	10.1	7.5	6.4

[1] WDL = water-dispersable liquid, EC = emulsifiable concentrate, WP = wettable powder, S = sprayable.

efficacies of the mixtures. In some cases, physical evidence of incompatibilities was observed. For example, wettable powder (WP)-formulated insecticides formed less stable suspensions and settled out more rapidly when combined with disinfectants containing formalin than in water alone. Such physical differences were not reflected in our results since the solutions were thoroughly mixed immediately prior to application to treatment surfaces. Under field conditions, where spray tanks may lack adequate agitators, this settling out of mixtures would greatly affect efficacies.

In several of the insecticidal toxicity assays, there were differences in the susceptibilities of beetle larvae and house flies to insecticide-disinfectant mixtures. In most instances these differences represented losses of toxicity to beetle larvae but not to house flies. The highly organic litter used in the beetle larva assays may have caused toxicity losses in the insecticide-disinfectant mixtures which did not occur on the plywood surfaces which were used in the house fly assays. These differences were probably more a result of the substrate treated than of innate differences in susceptibility between beetle larvae and house flies.

Insecticide-disinfectant mixtures resulted in more instances of reduced batericidal efficacy than reduced insecticidal toxicity. The only disinfectant which appeared to be unaffected by the addition of insecticides was 2% technical grade (i.e., unformulated) formalin. A mixture of formalin and quaternary ammonium compounds, DC&R, was the most frequently affected disinfectant, and showed loss of bactericidal activity in combinations with every insecticide except RaVap EC. As was observed in the insecticidal assays, the effects of mixtures on bactericidal activity followed no clear pattern with respect to the chemical classes of the disinfectants and insecticides.

Changes in the pH of the solutions following mixing probably contributed to the losses of bactericidal activity, because some disinfectants are most effective within a relatively narrow pH range (Huber, 1982). Comparison of the data in Tables 2 and 3 indicates that pH shifts cannot solely account for changes in bactericidal activity, however. In some cases, differences of over 6 pH units in the insecticide-disinfectant mixtures relative to the disinfectants alone were not accompanied by losses in bactericidal activity (e.g., BioGuard PFD-4 with RaVap), while with many other mixtures the losses in efficacy were

TABLE 4. *Summary of effects of mixing insecticides with disinfectants*[1]

	Disinfectant						
Insecticide[2]	Biolene	BioGuard X-185	BioGuard PFD-4	BioGuard S-3	1-Stroke Environ	DC&R	Formalin
Ectrin WDL	I,b	i,b	B	I,B	B	B	i
RaVap EC	i	I	0	i,B	0	0	I
Ectiban EC	I,B	I,b	i,B	b	B	B	0
Vapona EC	0	0	0	I,b	B	B	I
Rabon WP	i	b	I,B	B	i,B	B	0
Ectrin WP	I	b	I,b	I,B	B	B	0
Sevin S	i	i,b	0	B	i,B	B	0
CoRal WP	0	b	i,b	B	B	i,B	0

[1] Symbols in the table have the following meaning: I = Significant loss of insecticidal toxicity in combination with label rate (1×) disinfectant solutions; i = significant loss of insecticidal toxicity detectible only in combination with 2× disinfectant solutions; B = loss of bactericidal activity in combination with 1× insecticide solutions; b = loss of bactericidal activity detectible only in combination with 2× insecticide solutions; 0 = no detectible loss of any activity.

[2] WDL = water-dispersable liquid, EC = emulsifiable concentrate, WP = wettable powder, S = sprayable.

not associated with pH changes (e.g., BioGuard S-3 and 1-Stroke Environ with Ectrin WP).

The data show that many mixtures result in losses of insecticidal or bactericidal efficacy or both. Harris *et al.* (1975) examined the compatibility of One-Stroke-Environ with five insecticides, including RaVap, and reported no significant losses of insecticidal toxicity for adult and larval flies; however, no bactericidal tests were conducted. There appear to be no *a priori* criteria for determining the potential compatibility of commercially formulated insecticides and disinfectants. Therefore, such mixtures should not be used unless there is conclusive data on the specific formulations to demonstrate that there is no loss in bactericidal and insecticidal activity. Presumably, if separate applications of insecticides and disinfectants are made with a sufficient interval for drying, there will be no compatibility problems, but data are not available to confirm that. The surfaces to be treated may also be a factor because disinfectants can have varying effectiveness depending on the porosity and organic nature of surfaces (Fate *et al.*, 1985).

ACKNOWLEDGMENTS

Support for this project was provided by the Southeastern Poultry and Egg Association. Additional support was provided by BioLab Inc., and SDS Biotech. Paper Number 10612 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, NC 27695-7601. Use of trade names in this publication does not imply endorsement of the products named nor criticism of similar ones not mentioned.

REFERENCES

Engler, R., 1984. Disinfectants. Pages 65–77 *in*: Official Methods of Analysis of the Association of Official Analytical Chemists. 14th ed. S. Williams, ed. William Byrd Press, Richmond, VA.

Fate, M. A., J. K. Skeelers, C. E. Whitfill, and I. D. Russell, 1985. Evaluation of four disinfectants under poultry grow-out conditions using contact agar sampling technique. Poultry Sci. 64:629–633.

Harris, R. L., D. D. Oehler, D. Coggin, and R. A. Bram, 1975. Compatibility of insecticides and a disinfectant. J. Econ. Entomol. 68:852–854.

Huber, W. G., 1982. Antiseptics and disinfectants. Pages 693–716 *in*: Veterinary Pharmacology and Therapeutics. 5th ed. N. H. Booth and L. E. McDonald, ed. Iowa State Univ. Press, Ames, IA.

Ray, A. A., ed., 1982. SAS User's Guide: Statistics. SAS Inst., Inc., Raleigh, NC.