Duck Hepatitis Virus Interactions with DDT and Dieldrin in Adult Mallards

by M. FRIEND[a] and D. O. TRAINER[b]
Department of Veterinary Science
University of Wisconsin
Madison, Wis. 53706

There has been considerable speculation regarding possible interactions within biological systems between synthetic environmental pollutants and infectious disease agents (1-11). This type of interaction has been studied in our laboratory using the mallard, Anas platyrhynchos, as a test species (5,6). Since adult ducks are refractory to the overt manifestations of duck virus hepatitis (DVH) (12) and because duck hepatitis virus (DHV) has a predilection for the liver, the organ responsible for the metabolism of many chemicals, (13) an experiment was undertaken to determine if infection with DHV had any effect on the toxicity to adult mallards of p,p'-DDT or technical grade dieldrin.

Experimental

Forty-eight hours prior to chemical exposure, adult mallards were inoculated via the brachial vein with either $10^{6.5}$ duckling lethal dose 50's (DLD_{50}) of a duckling lethal strain of DHV or with a normal duck-liver-suspension. Test groups of 20 birds each were utilized when exposure was to both the virus and a pesticide; 60 bird test groups were used when exposure was to only DDT, dieldrin, or neither (Table 1). Virus-only controls were not employed in this study since the inability of DHV to cause mortality among adult ducks has been well documented (12).

Pesticide-treated rations were calculated to contain either 500 or 900 ppm of DDT, or 40 or 80 ppm of dieldrin, and were fed from day 3 through 12 of the experimental period. A standard duck-grower ration was provided during the remainder of the 22-day experiment. Birds were observed three times a day, at which time dead birds were removed and mortality recorded.

[a]Present address: Bureau of Sport Fisheries and Wildlife, U. S. Fish and Wildlife Service, Denver Research Center, Denver, Colorado 80225

[b]Present address: Wisconsin State University, School of Natural Resources, Stevens Point, Wisconsin 54481

Bulletin of Environmental Contamination & Toxicology, Vol. 7, No. 4, 1972, © by Springer-Verlag New York Inc.

Results and Discussion

Mortality in all but one group receiving both DHV and either pesticide was less than the mortality in the corresponding group receiving only DDT or dieldrin (Table 1). The single exception was the 40 ppm dieldrin exposure level where no birds died in either test group. The greatest differences in mortality occurred in the test groups which received 900 ppm of DDT in their diet (30% vs. 10%). However, when tested by Chi-square, these differences in mortality were not significant ($P<.10>.05$).

TABLE 1

Summary of mortality results of adult mallards exposed to pesticides and pesticides plus duck hepatitis virus

	Mortality**				
	Pesticide only		DHV + Pesticide		Difference
Pesticide level*	No.	%	No.	%	(%)
500 ppm DDT	4/60	7	0/20	0	- 7
900 ppm DDT	18/60	30	2/20	10	-20
40 ppm dieldrin	0/60	0	0/20	0	0
80 ppm dieldrin	16/60	27	2/20	10	-17

*ppm in the diet for 10 days of the 22-day experimental period.

**Number dead/total number in test group.
DHV exposure = $10^{6.5}$ DLD_{50} of DHV 48 hours prior to pesticide exposure.

The onset of mortality among test groups receiving DHV prior to pesticide exposure was at least 2 days later when compared with pesticide-only test groups. Also, deaths among the DHV treated birds occurred during a shorter period of time than those of pesticide-only test groups (Figure 1).

Chemical residue analyses* determined by gas chromatography indicated that the average ratios of brain to whole-carcass pesticide residues for mallards at the end of the experiment were approximately 2 to 3 times greater among pesticide-only groups than for groups exposed to both DHV and a

*Residue analyses were done by the Wisconsin Alumni Research Foundation, Madison, Wisconsin.

pesticide. Sample sizes were small, however, only two specimens from each high pesticide dosage level test group were assayed. In birds, which had received 900 ppm DDT in the diet, the ratio of brain to whole-carcass DDT** residues were .0960 for DHV-plus DDT-exposed birds and .2245 for the DDT-only birds. In the 80 ppm dieldrin test groups the ratios were .0883 for birds exposed to DHV plus dieldrin and .2873 for the dieldrin-only test group.

Under the conditions of this experiment, adult mallards exposed to DHV 48 hours prior to pesticide exposure had an apparent "protective effect" against the toxicity of DDT and dieldrin. This "protective effect" was manifest as reduced total mortality, delayed onset of mortality, and altered mortality pattern. The failure to detect statistical differences in the total mortality response may in part result from the low power of the Chi-square method used for analysis, and also from the length of the experimental period.

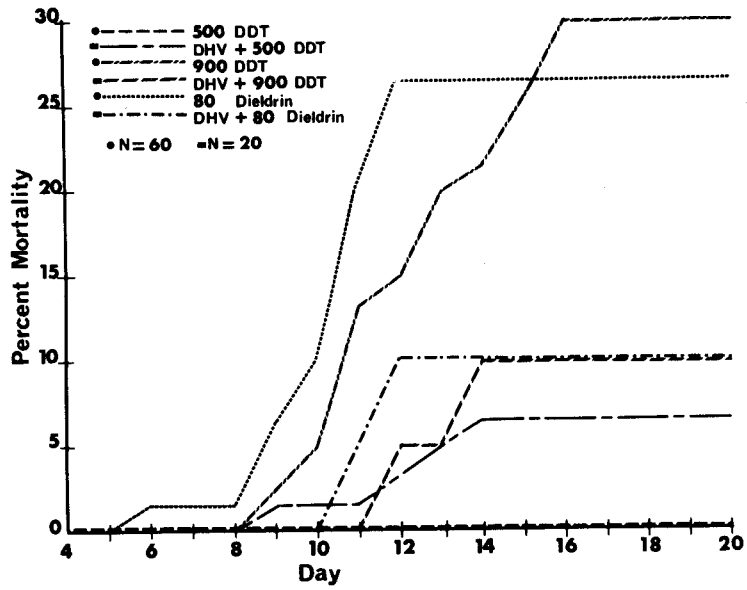

Figure 1. Comparative mortality among different treatment groups of adult male mallards in a DHV-pesticide interaction experiment. Pesticide levels fed are given in ppm in the diet. Virus exposure occurred 48 hours prior to experimental day 0. Sample size equals 20 for interaction groups and 60 for pesticide controls.

**DDT plus DDD and DDE.

The delay in onset of mortality appeared to be the most significant biological observation, and was the basis for a hypothesis that DHV may stimulate enzyme systems in the mallard responsible for DDT and dieldrin metabolism, i.e., the microsomal-enzyme system. If this hypothesis is correct, larger amounts of pesticides should be degraded in the liver of mallards which received DHV and less chemical residue reaches the brain. This would account for the delayed onset and reduction of mortality among groups receiving both DHV and pesticides, and is supported by the reduced ratio of brain to whole-carcass pesticide residues in these birds as compared to residue ratios in pesticide-only groups. The reduced ratios in DHV-exposed birds were due to decreased brain levels of pesticides rather than an increase in whole-carcass residues.

Since clinical DVH does not occur in adult mallards, (4) stimulation of the microsomal-enzyme systems by DHV is probably short-lived and the increased capacity of these stimulated systems probably soon returns to normal. The systems may operate in a manner analogous to the stimulation of hexobarbital and strychnine metabolism reported for murine hepatitis virus (14).

In other studies, (15) DHV by itself was found to slightly decrease hepatic microsomal mixed-function oxidase activity in adult mallards, but in combination with DDT appeared to enhance hepatic microsomal mixed-function oxidase activity by DDT. Involvement of the microsomal-enzyme systems in interactions of pesticides with other agents has been reviewed by Durham (3) who noted that "the unifying concept which underlies many of the interactions of pesticides with other factors involves the drug-detoxifying enzyme systems in the liver microsomes".

This study provides additional evidence of biological interactions between organochlorine chemicals and an infectious disease agent, and further illustrates the complexity of these interactions relative to host age and exposure time by contrasting with results from other studies with different age mallards (4,5,6).

Acknowledgment

Research supported in part by the Patuxent Wildlife Research Center, Bureau of Sport Fisheries and Wildlife and the College of Agricultural and Life Sciences, University of Wisconsin. We thank the Max McGraw Wildlife Foundation for supplying mallards for this study.

References

1. Allison, D., Kallman, B. J., Cope, O. B., and Van Valin, C. C., U. S. Bureau Sport Fish. Wildl. Res. Rep. 64, (1964).

2. Cain, S. A., in Rept. on the U. S. - Japan planning meeting on pesticide research, Honolulu, 12 (1965).

3. Durham, W. F., Residue Rev., 18, 22 (1967).

4. Friend, M., Ph.D. thesis, U. of Wisc., Madison, (1971).

5. Friend, M. and Trainer, D. O., Science, 170, 1314 (1970).

6. Friend, M. and Trainer, D. O., J. Wildl. Dis., 6, 335 (1970).

7. Holden, A. V. J., Proc. Inst. Sewage Purif., Part 4, 361 (1964).

8. Johnson, D. W., Am. Fish. Soc. Trans., 97, 398 (1968).

9. Lowe, J. I., Bull. Environ. Cont. Tox., 2, 147 (1967).

10. Peterle, T. J., in Rept. on the U. S. - Japan planning meeting on pesticide research, Honolulu, 27 (1965).

11. Rudd, R. L., Pesticides and the Living Landscape, U. of Wisconsin Press, (1966).

12. Rispens, B. H., Avian Dis., 13, 417 (1969).

13. O'Brien, R. D., Insecticides. Action and Metabolism, Academic Press, (1967).

14. Kato, R., Nakamura, V., and Chiesara, E., Biochem. Pharmacol., 12, 365 (1963).

15. Ragland, W. L., Friend, M., Trainer, D. O., and Sladek, N. E., Res. Comm. Chem. Path. Pharmacol., 2, 236 (1971).