Effects of Nonpersistent Pesticides on Liver Weight, Lipids and Vitamin A of Rats and Quail

by

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The effects of persistent pesticides on liver lipids and vitamin A have been characterized. Repeated exposure of rats to DDT results in degenerative changes in liver tissue, an increase in liver size, and an increase in liver lipids. PHILLIPS (1963) and TINSLEY (1969) have also shown that DDT decreases utilization of carotene and liver storage of vitamin A in rats and cattle. We recently reported that DDT or polychlorinated biphenyl (Aroclor 1242) fed to rats or Japanese quail produced an increase in liver weight and liver lipids and a decrease in liver vitamin A (CECIL et al. 1973).

The present report compares the effects of three nonpersistent pesticides (the organochlorine, methoxychlor; the carbamate, carbaryl and an organophosphate, malathion) on liver weight, lipid and vitamin A in the laboratory rat (Rattus norvegicus) and Japanese quail (Coturnix japonica). Males and females of both species were studied.

METHODS

Japanese quail (39 days old) and rats (21 days old) were fed a control diet or one containing 100 ppm methoxychlor, carbaryl or malathion[1/] for 2 months. The quail and rat diets contained 10,500 and 9,120 μg vitamin A per kg feed, respectively.

The animals were killed by decapitation and the liver quickly excised and weighed. Liver lipids were determined by extraction of the homogenized tissue with acetone:ethanol. Liver vitamin A was determined by the antimony trichloride colorimetric procedure (CARR and PRICE 1926) after the liver was digested in KOH and extracted with ethanol and ethyl ether.

1/ The pesticides used were: methoxychlor, 1,1,1-trichloro-2,2-bis (p-methoxyphenyl) ethane; technical methoxychlor, Grade II, 90% Sigma; carbaryl, 1-naphthyl N-methylcarbamate, Union Carbide; malathion, 0,0-dimethyl S-(1,2-dicarbethoxyethyl) dithiophosphate, 99.7%, American Cyanamide Co. Mention of proprietary products does not imply endorsement or approval by the U. S. Department of Agriculture to the exclusion of other suitable products.

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Statistical comparisons were made using the Student's "t" test with correction for unequal group size.

RESULTS AND DISCUSSION

There were both species differences and sex differences in untreated controls (CECIL et al. 1973). The male rat had a larger liver with a higher percentage of liver lipids than the female rat ($p<0.001$), but in quail the opposite was found. The female quail had a larger liver and more liver lipids than the male quail ($p<0.001$).

Liver weight and lipids (Table 1). Only in females did the liver weight and lipid of treated quail increase significantly with all three pesticides. The liver weight of treated female quail were 1 1/2 times heavier than livers of control female quail. An increase of the same magnitude also occurred in the concentration of liver lipids of treated female quail. In the male quail no changes in liver weight or lipids occurred.

The changes in liver weight and lipids of male and female rats were inconsistent and varied with the treatments. Methoxychlor lowered liver weight and increased liver lipids in the male rat but had no effect in the female, while carbaryl and malathion increased liver weight and lowered liver lipids in the female.

TABLE 1

Liver weight and lipids of female and male Japanese quail and rats after feeding 100 ppm methoxychlor, carbaryl or malathion for 2 months.

	gm Liver Weight			
	Quail		Rats	
	Female	Male	Female	Male
(n)	(12)	(12)	(8)	(8)
Control	3.62	1.47	7.1	10.8
MeOCl	4.70[e]	1.58	7.3	9.5[b]
Carbaryl	4.36[d]	1.38	7.8[b]	10.6
Malathion	4.64[e]	1.38	7.7[a]	10.4
	% Liver Lipid			
Control	11.2	7.3	4.3	4.2
MeOCl	14.8[b]	7.4	4.0	4.5[b]
Carbaryl	16.2[c]	7.6	3.9[d]	4.8[a]
Malathion	17.8[e]	7.8	3.7[e]	4.3

Treated is significantly different from control:
[a] $p<0.05$, [b] $p<0.025$, [c] $p<0.01$, [d] $p<0.005$, [e] $p<0.001$

Liver vitamin A (Table 2). Carbaryl had a definite effect in reducing both the concentration and total liver content of vitamin A in female quail and rats. Even though the liver weight was increased in the carbaryl-treated females, it was not enough to accommodate for the decreased vitamin A concentration. Malathion tended to decrease liver vitamin A of female rats, but, due to increased liver weight, total liver vitamin A of females treated with malathion was similar to the control value. None of the pesticide treatments decreased liver vitamin A of male rats or quail. The increase in liver vitamin A in male quail fed malathion was unexpected.

In these studies the diets were standard commercial diets with adequate levels of vitamin A. The exact mechanism by which vitamin A is affected by pesticide treatment is unknown. The decrease in liver vitamin A may be caused by increased vitamin A destruction or by altered lipid metabolism.

TABLE 2

Liver vitamin A of female and male Japanese quail and rats after feeding 100 ppm methoxychlor, carbaryl or malathion for 2 months.

	μg Vitamin A/100 mg liver			
	Quail		Rats	
	Female	Male	Female	Male
(n)	(12)	(12)	(6)	(6)
Control	37.9	116.9	56.7	38.7
MeOCl	27.2	105.1	54.4	43.9
Carbaryl	19.0[b]	125.4	43.5[d]	45.5
Malathion	33.8	159.5[b]	49.4[e]	42.0
	mg Vitamin A/total liver			
Control	1.33	1.72	4.0	4.2
MeOCl	1.26	1.64	3.9	4.2
Carbaryl	0.82[b]	1.70	3.4[a]	4.8
Malathion	1.56	2.14[a]	3.8	4.4

Treated is significantly different from control:

[a] $p<0.05$, [b] $p<0.025$, [c] $p<0.01$, [d] $p<0.005$, [e] $p<0.001$

The results of our study demonstrate that although these pesticides are nonpersistent and readily metabolized, they do exert some effects in mammals and birds. There appears to be a sex as well as species difference in the liver response to these

three nonpersistent pesticides, with the female quail being affected to a greater extent than female rats. The liver weight and liver lipid content of male quail were virtually unaffected by methoxychlor, carbaryl or malathion. None of the treatments decreased liver vitamin A in males. With DDT treatment (CECIL et al. 1973), liver weight and lipid increases and liver vitamin A decreases were greater in male rats than female rats and DDT had little effect on liver composition of female quail. In contrast, the non-persistent organochlorine, methoxychlor, appears to have a greater effect on the livers of female quail than males.

REFERENCES

CARR, F. H. and E. A. PRICE: Biochem. J. 20:497 (1926).

CECIL, H. C., S. J. HARRIS, J. BITMAN and G. F. FRIES: Bull. Environ. Contam. Toxicol. 9:179 (1973).

PHILLIPS, W. E. J.: Can. J. Biochem. Physiol. 41:1793 (1963).

TINSLEY, I. J.: J. Nutr. 98:319 (1969).