MULTIPLE AND CROSS-RESISTANCE CHARACTERISTICS IN PHOSPHINE-RESISTANT STRAINS OF *RHYZOPERTHA DOMINICA* AND *TRIBOLIUM CASTANEUM*

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ABSTRACT

Phosphine-resistant strains of lesser grain borer, *Rhyzopertha dominica* (Fabricius), and rust-red flour beetle, *Tribolium castaneum* (Herbst) were tested for cross-resistance to DDT, lindane, malathion, fenitrothion, carbaryl and bioresmethrin. DDT and bioresmethrin were applied topically, and the impregnated filter paper method was used to test the other insecticides.

Comparisons with laboratory susceptible strains showed that two phosphine-resistant strains of *R. dominica* with resistance factor (RF) 8-10x, and one of *T. castaneum* (RF 5.3x), had no cross-resistance to all insecticides used. Another phosphine-resistant strain of *R. dominica* (RF 8.6x) was also resistant to malathion and fenitrothion (RF 7.2; 4.8x respectively Furthermore, a phosphine-resistant strain of *T. castaneum* (RF 6.4x) was also resistant to lindane and malathion (RF 5.2 and 77.9x respectively). These data show that there is no obvious correlation between the response to phosphine and the DDT, lindane, organophosphorus, carbaryl and bioresmethrin resistance status in these insects, but some strains have multiple resistances to pesticides including phosphine.

INTRODUCTION

Grain insects are usually controlled by insecticides applied to the grain on intake at the storage in Australia, but as storage time increases the residues can fall below the lethal level and re-infestation can occur. Turning of the grain and re-treatment with the currently used grain protectants is expensive and can also cause increased selection pressure on insects with a more rapid development of resistance to these insecticides. Where this selection has occurred fumigation with phosphine is the usual method of disinfestation.

Phosphine has been highly effective against strains of grain insects that are resistant to contact insecticides. However, resistance to phosphine has now been identified (Attia and Greening, 1981) and it is essential, therefore, to determine whether or not development of this resistance will exacerbate resistance to grain protectants. This paper provides data on cross-resistance to insecticides in phosphine resistant strains of lesser grain borer, *Rhyzopertha dominica* (Fabricius) and rust-red flour beetle, *Tribolium castaneum* (Herbst).

TABLE 1

Dose response data[+] obtained by the impregnated filter paper method (FP) or the topical application method (TA) for several insecticides using phosphine-resistant strains of *R. dominica* and *T. castaneum*[1]

Strain and RF of phosphine	DDT (TA)		Biores (TA)		Lind (FP)		Mala (FP)		Fenitro (FP)		Carb (FP)	
	LD50	RF[2]	LD50	RF	KD50	RF	KD50	RF	KD50	RF	KD50	RF
R. dominica												
CRD2 (S)	0.025	-	0.00032	-	0.018	-	0.44	-	0.15	-	0.063	-
NRD184 (x7.7)	0.034	1.4	0.00041	1.2	0.022	1.2	0.49	1.1	0.21	1.4	0.064	1.0
NRD197 (x8.6)	0.035	1.5	0.00040	1.2	0.027	1.5	3.15	7.2	0.73	4.8	0.075	1.2
NRD459 (x9.9)	0.031	1.5	0.00031	1.0	0.021	1.2	0.48	1.1	0.22	1.5	0.079	1.3
T. Castaneum												
NTC138 (S)	0.28	-	0.035	-	0.28	-	0.17	-	0.11	-	0.81	-
NTC395 (x6.4)	0.38	1.4	0.045	1.2	1.46	5.2	13.2	77.9	0.14	1.3	0.83	1.0
NTC414 (x5.3)	0.35	1.3	0.039	1.1	0.29	1.0	0.26	1.5	0.13	1.2	0.91	1.1

1 LD50 expressed as (%) with lindane, malathion, fenitrothion and carbaryl (FP), but µg/adult with DDT and bioresmethrin (TA).

\+ The slope of ld-p lines for susceptible and resistant strains ranged from 3.7 to 8 and X^2 values for goodness of fit were non-significant (P greater than 0.05).

2 Resistance factor (RF): LD50 for resistant strain divided by LD50 for susceptible strain.

MATERIALS AND METHODS

Insect Strains

R. Dominica:

Strains NRD184, NRD197 and NRD459, collected from N.S.W. in May 1974, June 1974 and March 1980 respectively, were diagnosed with the discriminating concentration (DC) recommended by F.A.O. (Anon., 1975) to be resistant to phosphine. The survivors of the DC were kept for breeding and were subjected to 9, 10 and 5 generations of selection respectively with phosphine. Resistance factors (RF's) to phosphine of x7.7, x8.6 and x9.9 respectively were thus obtained. They were compared with a standard susceptible strain CRD2.

T. castaneum:

Strains NTC395 (RF 6.4), NTC414 (RF 5.3), were diagnosed resistant to phosphine as described above. They were collected from N.S.W. in 1977 and 1978 and selected with phosphine for 8 generations. For comparison a susceptible strain NTC138 was used.

Cultures of susceptible and resistant strains of *R. dominica* and *T. castaneum* , established from field samples, were maintained at 27°C and 65% relative humidity. The diet used for *R. dominica* was whole wheat grain with 12% moisture content. *T. castaneum* was cultured in a mixture of finely ground wholemeal flour and dried yeast powder (12:1 by weight). Adults 2-3 weeks old were used for testing.

Chemical bioassay procedures

The insecticides used in these tests were technical grade (Table 1), dissolved in either ethyl methyl ketone or in Risella 17 oil for dosing. Using a method developed by Needham and Devonshire (1973), an automatic micro-applicator with a Hamilton gas-tight syringe of 250 micro litre capacity fitted with 0.2 mm O.D. stainless steel cannula was used to apply 0.08 and 0.1 ul of DDT and bioresmethrin dissolved in ethyl methyl ketone to the abdominal sternites of adults of *R. dominica* and *T. castaneum* respectively.

After treatment adults were placed in vials 4 cm diameter and 6 cm deep, supplied with flour and yeast (12:1), covered with perforated lids and held at 27 $\pm$ 2°C and 55% RH. Mortality was assessed 5 days after treatment. Adults showing no response to prodding with a needle were recorded as dead.

The insecticide impregnated filter paper was used to assess the response of the strains to lindane, malathion, fenitrothion and carbaryl, according to a method described by Champ (1968). Exposure periods of 24 h were used for *R. dominica* and for *T. castaneum* 5 h were used, with malathion, fenitrothion and carbaryl, and 24 h with lindane. After exposure the insects were examined and the numbers of adults responding were recorded. The criteria of response was mortality, as determined 5 days after for DDT and bioresmethrin and was knockdown for lindane, malathion, fenitrothion and carbaryl. Other results have shown that when insects are knocked down by these insecticides about 90% are killed.

Dose response data were analysed using the probit method of Finney (1971).

RESULTS AND DISCUSSION

Table 1 shows the LD50 values for each insecticide treatment and resistance factors for each phosphine resistant strain of *R. dominica* and *T. castaneum*. It can be seen from Table 1 that two phosphine-resistant strains of *R. dominica*, NRD184 (RF x7.7) and NRD459 (RF x9.9) had no cross-resistance to DDT, lindane, organophosphorus, carbaryl and bioresmethrin. The differences in response were greater than 1.5x at the LC50 level. Another phosphine-resistant strain, NRD197 (RF 8.6x) was also resistant to malathion and fenitrothion (RF 7.2 and 4.8x respectively). A similar situation exists with a phosphine-resistant strain (NTC414) of *T. castaneum*(RF 5.3x), which had no cross-resistance to all insecticides tested. Strain NTC395 (RF 6.4x) was also resistant to lindane and malathion with RF 5.2 and 77.9x respectively (Table 1).

The data presented in this paper and those published by Attia and Greening (1981) indicate that there is no correlation between the response to phosphine and responses to DDT, lindane, organophosphorus, carbaryl and bioresmethrin resistances in these species. Some strains, though, have multiple resistances to pesticides including phosphine. The results agree with the data given by Kem (1979) from his studies on the cross-resistant strain of *T. castaneum* in India. His results showed that there was no cross-resistance to contact insecticides. Also Monaro *et al.* (1972) showed no appreciable cross-resistance to other fumigants (except chloropicrin) in a strain of *S. granarius* selected for resistance to phosphine.

This study indicates that phosphine should be effective for controlling grain insects which survived treatment with other insecticides in sealed storages.

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