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Effects of Cold Ambient Temperatures on Acute Mortality of *Peromyscus leucopus* Dosed with Parathion

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Organophosphate (OP) insecticides are widely applied to crops, forests, lawns, and other areas where wildlife exists. Such application may expose wildlife to a multitude of different OP compounds under a variety of environmental conditions which may alter the toxicity of the OPs.

Exposure to OPs reduces body core temperatures in some species. Meeter and Wolthuis (1968) found that core temperatures of rats injected with several different OPs declined up to 6 C within 3 hours, followed by a recovery from 12 to 20 hours after treatment. They found that during hypothermia, core temperatures were abnormally dependent on ambient temperatures and concluded that cholinesterase inhibitors cause thermoregulation to malfunction for about 6 hours in the rat. Rattner et al. (1982) found that bobwhite quail (Colinus virginianus) fed 100 ppm parathion had 2- to 5-fold increases in plasma corticosterone concentrations. These data suggested that tolerance to cold may be reduced by ingestion of parathion. Coudray-Lucas et al. (1981) found that paraoxon administered to rats intraperitoneally caused a reduction in core temperatures, but there was no relationship between the degree of hypothermia and inhibition of brain acetylcholinesterase. These studies suggest that wildlife exposed to OPs might succumb to intoxication following even mild decreases in temperature (e.g., overnight changes in ambient temperatures). Therefore, we conducted studies to determine whether mild cold temperatures imposed on a common wildlife species, white-footed mice (Peromyscus leucopus), reduce rectal temperature and increase acute mortality.

MATERIALS AND METHODS

Forty male white-footed mice (age range 74 to 171 days) were taken from littermate groups established at birth. Animals were randomly assigned to 1 of 4 groups (10 animals per group). Each animal was singly caged in a plastic shoebox cage and provided Wayne Lab

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Blocks (Chicago, Illinois) and water ad libitum. All animals were maintained on 14L:10D throughout the experiment and at 23 ± 1 C (room temperature) or 10 ± 1 C (cold room).

After a 3 day acclimation period, 1 group was chosen to receive one of the following treatments: 0 mg parathion/kg body weight and maintained at room temperature (room temperature, control), 10 mg parathion/kg body weight and maintained at room temperature (room temperature, treated), 0 mg parathion/kg at 10 C (cold room, control), and 10 mg parathion/kg at 10 C (cold room, treated) (hereafter these groups will be referred to as RT-C, RT-T, CT-C, and CT-T, respectively). Each animal was weighed and administered either corn oil (controls) or 10 mg technical grade parathion (O,O-diethyl O-nitrophenyl phosphorothionate) per kg of body weight (corn oil carrier). Controls were given corn oil on a body weight basis equivalent to treated animals. Doses were administered by stomach intubation and total volume did not exceed 0.35 ml. Rectal temperatures were taken immediately after dosing using a fast-reading mercury thermometer. The entire procedure was began at 0725 hours and was completed by 0850 hours. After dosing, the CT-C and CT-T groups were immediately moved to an environmental chamber maintained at 10 C and 70% relative humidity. Mortality of all groups was monitored and recorded for 7 days after dosing.

Rectal temperatures of all surviving mice were taken periodically to determine whether treatment with parathion causes hypothermia in white-footed mice. Temperatures were measured at 6, 12, 24, and 36 hours, and 4.0 (morning), 4.5 (evening), 7.0 (morning), and 7.5 (evening) days after treatment. Because the stress of capture and handling tends to increase body temperature, temperature readings of animals that could not be measured within 60 seconds after opening the cage were omitted from statistical analyses.

Differences between mortality rates of all groups were statistically compared using Chi-square tests. Differences in mean rectal temperatures of all groups were compared by ANOVA (Helwig and Council 1979). Data on animals dying during the experiment and those for which an observation was missing were deleted resulting in a balanced subplot design.

RESULTS AND DISCUSSION

Mortality rates of the four experimental groups were not significantly different (Chi-square = 6.0, $P < 0.20$, 3 d.f.) (Table 1). All animals that died did so within 12 hours of dosing.

Mean body temperature of the RT-T group was 9.7% lower ($P < 0.05$) than the RT-C group only at 6 hours after treatment (Duncan's multiple range test) (Figure 1A). The mean temperature of the CT-T group was 9.2% lower than that of the CT-C group at the 6 hour sampling interval (Figure 1B). In addition, mean body temperatures of both cold-exposed groups were reduced approximately 1-2 C compared with those housed at room temperature. Mean rectal

Table 1. Summary of proportions of the four treatment groups dying within 7 days following dosing with parathion.

Group	Dosage (mg/kg)	Proportion dying
Room temperature-controls	0	0/10 (0%)[1]
Room temperature-treatment	10	1/10 (10%)
Cold temperature-controls	0	0/10 (0%)
Cold temperature-treatment	10	3/10 (30%)

[1]Numbers in parenthesis are percentages of preceding proportions.

temperatures varied significantly ($P < 0.0001$) with time of sampling. Significant treatment*time of sampling interactions ($P < 0.001$) were also observed.

Cold ambient temperatures did not appear to significantly increase parathion-related mortality. The mortality observed in this experiment fell within the range of expected mortality when compared with previous studies in which white-footed mice were similarly dosed (Montz and Kirkpatrick 1985). The thermoneutral zone for white-footed mice is 20 to 26 C (King 1968:519). Therefore, both the RT-C and RT-T groups were housed at temperatures which required only minimal expenditures of energy to maintain body temperatures. Although 10 C represented only mild cold stress, more energy should have been required to maintain body temperatures of both CT groups than RT groups.

White-footed mice are not ideal animals for studying the effects of OP-induced hypothermia because they are capable of undergoing facultative torpor following exposure to a variety of stressors (Falls 1968, Lynch et al. 1980). The statistical analyses revealed that both CT-C and CT-T groups had significantly lower mean rectal temperatures than both RT groups. Therefore, mild cold ambient temperatures reduce mean rectal temperatures in this species. A temperature*time of sampling interaction suggests that moving room temperature housed animals to a cold room immediately after dosing caused a substantial reduction in rectal temperature. However, over the course of the experiment, differences between rectal temperatures of room temperature and cold temperature housed animals diminished. Lynch et al. (1980) found that white-footed mice on short days exhibited body temperature reductions of 15 C. Other studies (Falls 1968) found that food deprivation also causes reduction in activity and an increase in torpor. No animals in the present study were observed in torpor (taken as rectal temperatures below 30 C) such as that described by Lynch et al. (1980).

Decreases in rectal temperature were dramatic in both RT-T and CT-T groups. The reductions in rectal temperature in this study are comparable to those observed at 6 hours in the rat by Meeter and Wolthuis (1968) although differences in their methods (i.e., hexobarbitol anesthesia) partially confound the effect of OPs in reducing rectal temperature. By contrast, they also found that

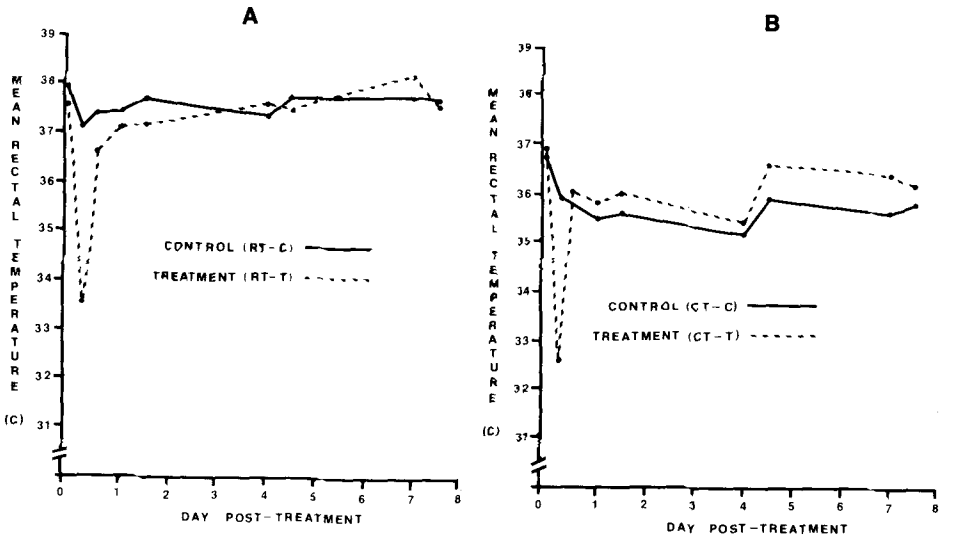

Figure 1 Mean rectal temperatures of P. leucopus administered a single 10 mg/kg oral dose of parathion. (A) Room temperature (23 C) housed treatment and control groups. (B) Cold room (10 C) housed treatment and control groups.

laboratory rabbits and mice did not exhibit hypothermia following treatment with OPs.

Rectal temperatures of the RT-T and CT-T groups recovered rapidly following dosing with parathion and resulted in a significant treatment*time of sampling interaction. Means of treated groups were not significantly different from controls 12 hours after dosing. Such rapid recovery is similar to that seen in brain ChE activity following dosing with OPs (Montz and Kirkpatrick, 1985). Both the mechanisms causing OP-induced hypothermia and that governing recovery are not understood.

These studies show (1) that transient impaired thermoregulation occurs in Peromyscus leucopus at subacute dosages and (2) that mild cold stress does not significantly increase acute mortality following OP treatment. Thus, this common wildlife species is one of those mammals which exhibit hypothermia following exposure to certain OPs which can cross that blood-brain barrier.

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