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BEHAVIORAL CHANGES FROM CHRONIC EXPOSURE TO PESTICIDES USED IN AERIAL APPLICATION: EFFECTS OF PHOSDRIN ON THE PERFORMANCE OF MONKEYS AND PIGEONS ON VARIABLE INTERVAL REINFORCMENT SCHEDULES

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16. Abstract

The need for study of behavioral difficulties resulting from exposure to pesticides is based upon reports of behavioral difficulties in aerial applicators following organophosphate poisoning and is underscored by a recent plane crash of a cropduster pilot in which prior exposure to several organophosphate pesticides was implicated. The present study examines effects on performance of pigeons and squirrel monkeys of Phosdrin (mevinphos), a cholinesterase-inhibiting pesticide not previously studied in the laboratory. Variable interval schedules of reinforcement were used with both food and water as rewards. A dose related decrease in response rate was observed with all animals. Decrements in behavior were observed at doses below which external symptoms of Phosdrin poisoning occurred, indicating the need for further investigation of the behavioral actions of pesticides.

17. Key Words
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I. Introduction.

Although there have been several reports of behavioral difficulties in aerial applicators following organophosphate poisoning,[1 2] experimental evaluations of the effects that cholinesterase-inhibiting pesticides have on performance have been so limited that one recent reviewer[3] concluded that little evidence of behavioral deficits could be found apart from obvious somatic symptoms. The current study examines some performance changes resulting from acute doses of Phosdrin (mevinphos), a cholinesterase-inhibiting organophosphate not previously studied in the behavioral laboratory. The need for rapid detection of Phosdrin poisoning is illustrated by a recent case study of a plane crash of a duster pilot following repeated exposures to Phosdrin and other organophosphate pesticides.[4]

II. Method.

The subjects were two adult male King pigeons, maintained at 80% of their free-feeding weights, one adult male squirrel monkey (M14) (*Saimiri Sciurea*), maintained at 75% of his free-feeding weight and two squirrel monkeys (M12 and M13), run at 24 hours of water deprivation. All subjects were run in operant behavior chambers on variable-interval (VI) schedules of reinforcement, i.e., schedules in which a response (key peck for the pigeons and lever press for the monkeys) is reinforced by presentation of food (water for M12 and M13) following a variable interval of time from the preceding reinforced response. The monkeys were run on a VI 1.7 schedule in which the mean minimum time between reinforced responses was 1.7 minutes, while the pigeons were run on VI 5.9 (5.9 minutes mean minimum time between reinforcements).

Experimental training, reinforcement contingencies, and data recording were controlled by a Linc-8 computer (Digital Equipment Corporation) with an Iconix logic interface (Siliconix Corporation). Variable interval schedules were generated by random sampling from a table containing a Fibonacci series appropriate to the VI schedule employed.

All sessions lasted until a total of 60 reinforcements had been presented or until the maximum session time (3 hours for monkeys and 8 hours for pigeons) had elapsed. Reinforcement consisted of 3 seconds access to grain for the pigeons, 75 mg banana flavored pellets for M14, and .5 ml of water for M12 and M13.

Graded doses of Phosdrin were injected intramuscularly every 4 or more days with control (saline) injections given on intervening days. All doses were administered immediately before the start of each session. Except for the data of M13, all experimental points represent the average of two determinations at each dose.

III. Results.

Figure 1 shows the average dose-effect curves for monkeys M12, M13, and M14. Average response rates for the first hour of the session and for the total session are shown. With the exception of one reversal for monkey M13 at the highest dose, response rates decreased with increasing doses of Phosdrin.

Figure 2 (for pigeon B3764) and Figure 3 (for pigeon B4373) indicate similar effects with pigeons: as dose increases, response rate decreases.

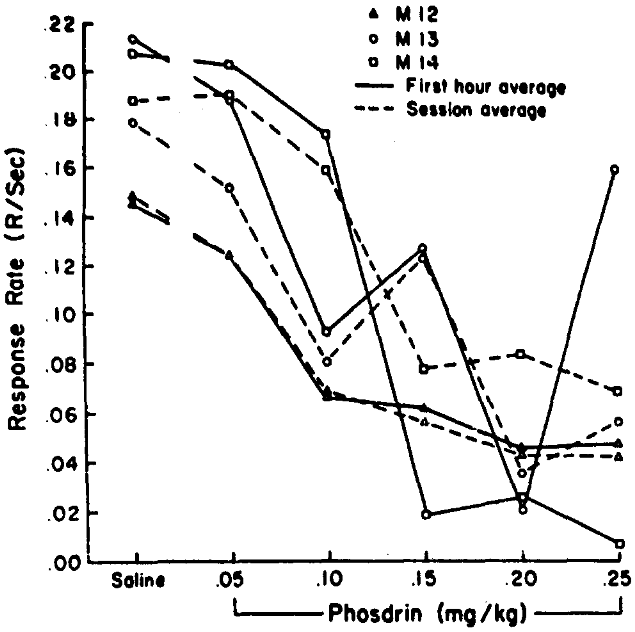

FIGURE 1. Dose response curves for the effects of Phosdrin on the performance of three monkeys in a VI 1.7 min schedule of reinforcement.

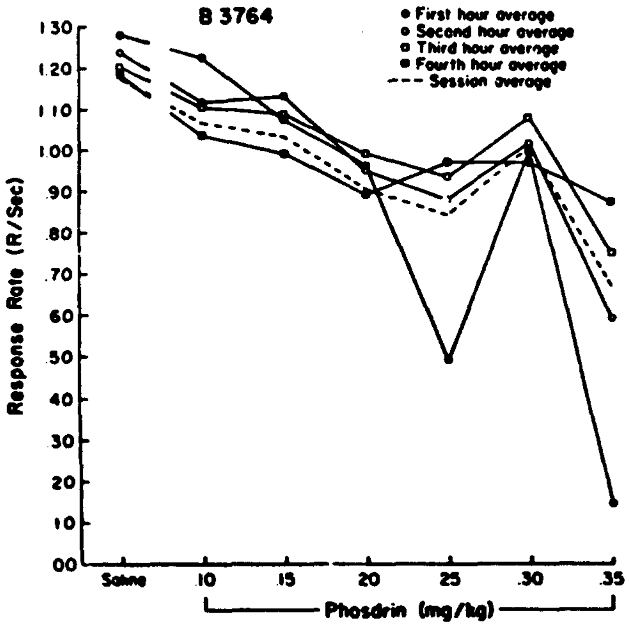

FIGURE 2. Dose response curves for the effects of Phosdrin on the performance of pigeon B3764 in a VI 5.9 min schedule of reinforcement.

Although the dose-effect curves suggest the time course of drug action, cumulative response records demonstrate this action more clearly. Figure 4 for monkey M12 (food deprived) shows that the effect of each dose is evident at the beginning of each session and continues without indicated recovery. For monkey M14 (water deprived), recovery is evident (Figure 5), with length of suppression dose-dependent. Similar effects are seen in pigeon B4373 at low doses (Figure 6) and high doses (Figure 7).

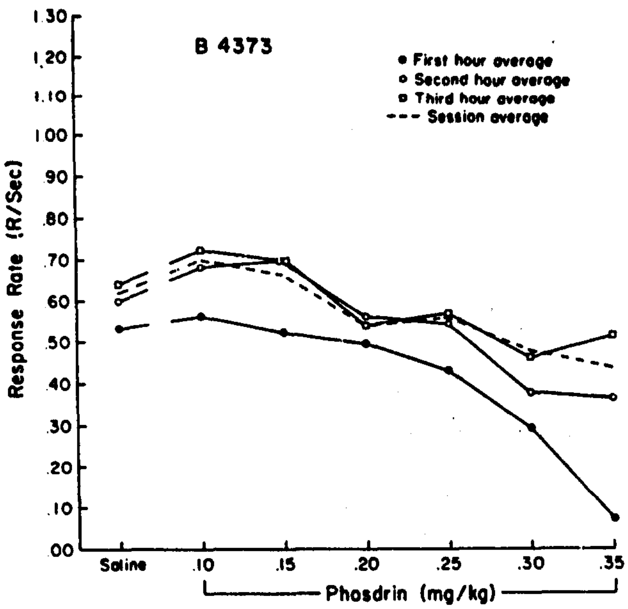

FIGURE 3. Dose response curves for the effects of Phosdrin on the performance of pigeon B4373 in a VI 5.9 min schedule of reinforcement.

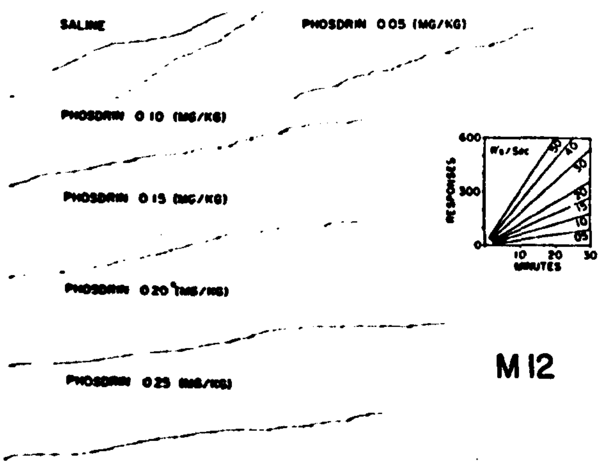

FIGURE 4. Cumulative records of responding of monkey M12 during the second presentation of the Phosdrin dose series.

The subjects were observed for external symptoms of cholinesterase-inhibition. At doses in excess of 0.20 mg/kg Phosdrin, peripheral symptoms (tremor, salivation, and lack of coordination) were evident in the monkeys, while at doses below 0.15 no somatic symptoms were seen.

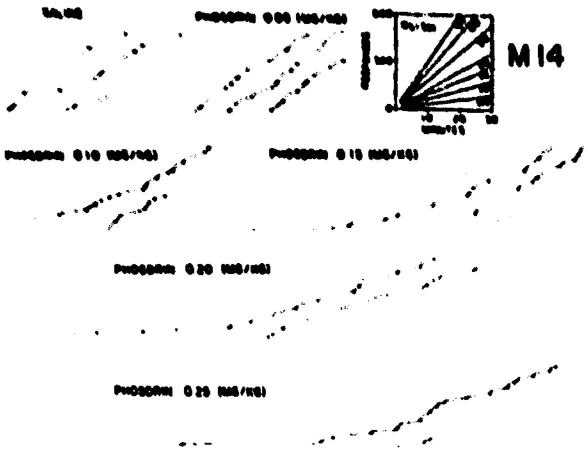

Figure 5. Cumulative records of responding of monkey M14 during the second presentation of the Phosdrin dose series.

In pigeons, symptoms (rapid, excessive blinking and pennerection) were seen only at the highest dose studied (0.35 mg/kg).

IV. Discussion.

In both pigeons and monkeys, reduction of response rates occurred at doses below which external somatic symptoms of Phosdrin poisoning occurred, although greater response suppression was accompanied by somatic symptoms at higher doses. Consequently, these data support the conclusion that performance changes can occur after acute doses of Phosdrin that do not produce peripheral parasympathomimetic signs of pesticide action. Because these signs or subjective symptoms are often used by aerial applicator personnel as early indicants of excessive exposure, our data indicate that Phosdrin (mevinphos) may be more hazardous than previously thought. Certainly, additional data are needed to elucidate the behavioral variables affected by cholinesterase inhibition.

The present experiment is the first to study the acute behavioral effects of Phosdrin, and one of the few to examine the acute effects of cholinesterase inhibition on behavior under appetitive control. Vaillant[5] observed complete suppression of responding in pigeons on a multiple fixed-interval fixed-ratio schedule; the duration of response suppression increased with dose of physostigmine. Behavior after resumption of responding was essentially normal. Doses not large enough to produce complete suppression did not produce significant effects on the behavior. These findings have been replicated in pigeons and squirrel monkeys[6] and may be contrasted with the data of the present study in which complete suppression was obtained in only one monkey (M14) at the highest dose studied. This discrepancy may be a consequence of the use of different reinforcement schedules or of different drugs. However, data presented by Olds and Domino[7] suggest a similar difference in the effects of physostigmine and arecoline on self-stimulation. Their data suggest complete response suppression with physostigmine and partial suppression with arecoline.

The present report of behavioral effects of Phosdrin at doses below levels producing somatic symptoms of poisoning is in agreement with the

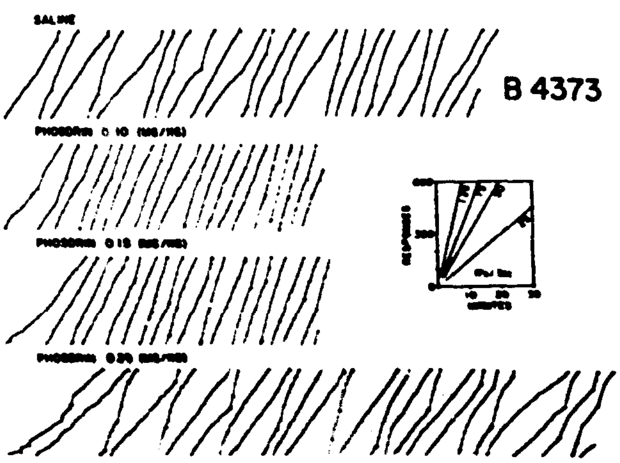

Figure 6. Cumulative records of responding of pigeon B4373 during the second presentation of the low Phosdrin doses.

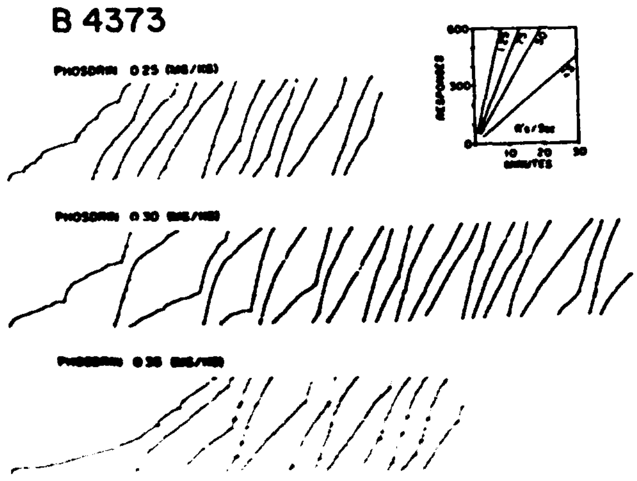

Figure 7. Cumulative records of responding of pigeon B4373 during the second presentation of the high Phosdrin doses.

findings of others. Vaillant[6] reported that doses of physostigmine which did not produce apparent loss of coordination did yield decrements in performance. Rosić and Bignami[8] found decrements in avoidance behavior at doses of physostigmine which yielded "no visible symptoms" of drug action. These reports strengthen the need for additional research information, pertinent to the safety of cropduster pilots, regarding the behavioral actions of pesticides.

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