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EXPERIMENTS ON DIRECT AND SECONDARY POISONING BY FLUOROACETAMIDE (1081) IN WILDLIFE AND DOMESTIC CARNIVORES

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Abstract: Fluoroacetamide (1081 or F.A.A.) is used in Israel for field rodent control. Experiments on direct and secondary, short and long term poisoning caused by 1081 were carried out. Mongoose *(Herpestes ichneumon),* hyena *(Hyaena hyaena),* cats and dogs were susceptible. Barn owls *(Tyto alba),* buzzards *(Buteo buteo)* and black kites *(Milvus m. migrans)* were markedly resistant. Barn owls tolerated total direct poisoning ranging from 6.8 to 10.9, and a final dose ranging from 0.8 to 2.0 mg/kg. In secondary poisoning, total doses ranging from 1.7 to 7.1, and final doses ranging from 0.2 to 1.3 mg/kg were tolerated. Buzzards tolerated total direct poisoning ranging from 6 to 12.0, and final doses ranging from 0.7 to 1.3 mg/kg. In secondary poisoning, doses ranging from 0.8 to 10.3 and final doses ranging from 0.2 to 2.4 mg/kg were tolerated. One black kite tolerated a total direct dose of 6.1 and final dose of 0.7 mg/kg, another survived a total dose of 2.3 and final dose of 0.2 mg/kg in secondary poisoning. A small-scale secondary poisoning experiment on two Palestine vipers *(Vipera palestinae),* a Syrian black snake *(Coluber jugularis)* and two Montpellier snakes *(Malpolon monspessulanus)* indicated that these species were resistant to total doses ranging from 0.1 to 3.2 and final doses of 0.1 to 0.8 mg/kg.

INTRODUCTION

Fluoroacetamide (F.A.A.) has been used in Israel since 1964 for the control of field rodents, i.e. jirds *(Meriones tristrami)* and levant voles *(Microtus guentheri).*[10]

There are relatively few reports on secondary poisoning caused by F.A.A. (1081) and sodium fluoroacetate (1080).[4,5,11,12,14] Neither are considered to be an accumulative poison. However, a lethal synthesis which occurs in the body of the victim causes the accumulation of fluorocitrate which is a hundred times more poisonous than F.A.A.[9] According to Peacock[12] the most susceptible animals are dogs and the least susceptible are hawks, black vultures and opossums. Frogs are exceptionally resistant to fluoroacetate.[3]

This investigation was undertaken to clarify the extent poisoned field rodents constitute a risk of secondary poisoning to wildlife and domestic carnivores in Israel.

MATERIALS AND METHODS

Some experiments were carried out at the quarantine kennels of Tel-Aviv Municipality using cats and dogs scheduled for euthanasia and the remainder at the Research Zoo of the University of Tel-Aviv. The number of carnivores and birds of prey available were limited, thus only a few dosage regimes could be tried.

The jirds used in the experiments were either captured wild or bred in the laboratory. Those offered poisoned

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wheat grains were kept singly in cages, the floor of which was covered with sand. The number of poisoned wheat grains consumed was determined by sifting the sand.[1]

The concentration of 1081 in the wheat grains could be estimated only by calculation, as there is no simple quantitative method for the assay of 1081 in baits. The amount of poison per wheat grain was calculated on the basis that the weight of 1000 wheat grains is 39.7 g.[1] Although in reality the amount of 1081 actually consumed was 97%, for calculation purposes the concentration of active ingredient of the poison was considered as 100%.

The experiments on direct poisoning of 1081 to carnivores were done by administering gelatine capsules with 1081 in powder form. Capsules were placed into the center of meat cubes. Direct poisoning of birds of prey was done by drenching with an aqueous solution of the poison.

Secondary poisoning generally was done by offering the test animals carcasses of jirds, which had fed freely on poisoned grains. In several cases jirds also were poisoned by drenching. Cats used as primary animals were poisoned via gelatine capsules. Varying time intervals were used in the secondary poisoning experiments to simulate field conditions. The number of times poison was administered according to the tables does not always reflect the planned numbers because the test animals in a considerable number of cases refused to eat poisoned feed.

RESULTS

The results of direct (primary) poisoning of domestic carnivores and birds of prey are shown in Table 1. Of four cats, three died following administration of total doses of 0.7 and 1.1 mg/kg and final doses of 0.1 and 0.2 mg/kg F.A.A., respectively. One cat survived a total dose of 1.1 mg/kg and final dose of 0.1 mg/kg.

A dog survived a total dose of 0.3 mg/kg and a final dose of 0.02 mg/kg.

As the table indicates, barn owls tolerate comparatively high doses. Of 12 barn owls, three died following total doses of 15, 22.7 and 34.4 mg/kg and final doses of 2.1, 3.2 and 3.8 mg/kg F.A.A., respectively.

Buzzards survived total doses of 6 and 12 mg/kg and final doses of 0.7 and 1.3 mg/kg, respectively.

A black kite died after consuming a total dose of 12.3 mg/kg and a final dose of 1.4 mg/kg.

The results of secondary poisoning in carnivores are shown in Table 2. Of three mongoose, the only one that died consumed the smallest dose, 0.6 mg/kg.

The hyena exposed secondarily to multiple small doses of F.A.A. died on day 78 after consuming a total dose of 7.9 mg/kg and a final dose of 0.8 mg/kg.

A small total dose of 0.3 mg/kg and a final dose of 0.2 mg/kg F.A.A. was enough to kill a dog.

Two cats died from small total doses of 0.2 and 0.4 mg/kg and final dose of 0.2 mg/kg F.A.A. consumed indirectly, whereas five other cats survived following total doses of 0.7 to 1.7 mg/kg and final doses of 0.1 to 0.2 mg/kg.

The four barn owls in the secondary poisoning experiment (Table 3) survived total doses ranging from 1.7 to 7.1 mg/kg and final doses from 0.2 to 1.3 mg/kg.

Four buzzards survived total doses ranging from 0.8 to 2.6 mg/kg and final doses from 0.2 to 0.5 mg/kg. The fifth survived a total indirect dose of 226.2 mg/kg which was given over a period of 197 days. The final dose was 2.4 mg/kg.

A black kite tolerated a total indirect dose of 2.3 mg/kg given over 8 days. The final dose was 0.2 mg/kg.

A hybrid purple and grey heron died after consuming a total indirect dose of 25.6 mg/kg given over 21 days. The final dose was 3.4 mg/kg F.A.A.

TABLE 1. Direct poisoning of fluoroacetamide in domestic carnivores and birds of prey.

Test animal	No. doses of poison administered	Calculated total dose of F.A.A. mg/kg consumed	Final dose of F.A.A. mg/kg consumed	Duration of the experiment (days)	Days till death
*Cat	8	0.7	0.1	10	10
*	4	0.7	0.2	7	7
*	11	1.1	0.1	15	15
*	11	1.1	0.1	15	S
Dog (Spaniel)	13	0.3	0.02	14	S
Barn Owl *(Tyto alba)*	3	7.2	2.4	9	S
	9	6.8	0.8	9	S
	5	10.2	2.0	9	S
	5	9.8	1.9	9	S
	5	10.8	2.2	9	S
	3	10.9	3.7	9	S
	7	15.0	2.1	7	7
	9	15.1	1.7	9	S
	9	20.2	2.2	9	S
	5	15.1	3.0	9	S
	7	22.7	3.2	7	7
	9	34.4	3.8	9	9
**Buzzard *(Buteo buteo)*	9	6.0	0.7	9	S
**	9	12.0	1.3	9	S
**Black kite *(Milvus m. migrans)*	9	6.1	0.7	9	S
	9	12.3	1.4	9	10

*An average weight of 2.9 kg was used based on weight of 29 stray male and female cats.

**An average weight of 850 g was used based on literature.[8]

S Survived.

Two Palestine vipers survived a single dose of 0.1 and 0.4 mg/kg (Table 4). A Syrian black snake and montpellier's snakes tolerated total indirect doses of 3.2 and 1.6 mg/kg and final doses of 0.8 and 0.4 mg/kg, respectively.

In the course of this study it was found that individual jirds consumed from 1 to 20 poisoned wheat grains, each containing 0.2% F.A.A. before they died. The average for 117 individual jirds tested was 4.3 grains and the calculated amount of F.A.A. was 0.3 mg.

DISCUSSION

Although F.A.A. is not a true cumulative poison like the rodenticide thallium sulfate, its metabolite, fluorocitrate, is more poisonous than F.A.A.[9] So it is logical to include all the doses of poison administered to the test animal.

The results in Table 1 show a similar degree of susceptibility of the experimental animals as reported for sodium fluoroacetate (1080).[12] One cat tolerated a total dose of 1.1 mg/kg, almost four times

TABLE 2. Secondary poisoning by fluoroacetamide in carnivores.

Test Animals	No. doses of poison administered	Calculated total dose of F.A.A. mg/kg consumed	Final dose of F.A.A. mg/kg consumed	Duration of the experiment (days)	Days till death
♀Mongoose *(Herpestes ichneumon)*	1	0.6	0.6	1	1
*	25	4.0	0.6	25	S
*	15	4.5	0.5	15	S
♂Hyena *(Hyaena hyaena)*	17	7.9	0.8	78	78
♂Mongrel dog	3	0.3	0.2	3	3
♀Cat	1	0.2	0.2	1	1
**	3	0.4	0.2	4	4
♀	3	0.7	0.2	14	S
**	4	0.7	0.1	12	S
♀	7	1.5	0.2	14	S
**	13	1.3	0.2	16	S
**	12	1.7	0.1	15	S

*An average weight of 2.375 kg was used (Mendelssohn, H., pers. comm.).
**An average weight of 2.9 kg was used based on weight of 29 stray male and female cats.
S Survived.

TABLE 3. Secondary poisoning by fluoroacetamide in birds of prey

Test Animals	No. doses of poison administered	Calculated total dose of F.A.A. mg/kg consumed	Final dose of F.A.A. mg/kg consumed	Duration of the experiment (days)	Days till death
Barn Owl	3	1.7	0.2	9	S
	5	1.9	1.3	9	S
	7	2.9	0.5	9	S
	9	7.1	1.0	9	S
*Buzzard	3	0.8	0.2	9	S
*	9	2.0	0.2	9	S
*	5	2.3	0.2	9	S
*	9	2.6	0.5	9	S
* 1	130	226.2	2.4	197	S
Black kite	8	2.3	0.2	8	S
Heron *Ardea cinerea* cross *A purpurea*	9	25.6	3.4	21	21

*An average weight of 850 g was used.[8]
[1]Done by Mr. Z. Zook-Rimon of the Tel-Aviv University.
S Survived.

TABLE 4. Secondary poisoning of fluoroacetamide in snakes.

Test Animals	No. doses of poison administered	Calculated total dose of F.A.A. mg/kg consumed	Final dose of F.A.A. mg/kg consumed	Duration of the experiment (days)	Days till death
*Palestine viper *(Vipera palaestinae)*	1	0.1	0.1	1	S
*	1	.4	0.4	1	S
**Syrian black snake *(Coluber jugularis)*	4	3.2	0.8	41	S
**Montpellier's snake *(Malpoplon monspessulanus)*	4	1.6	0.4	41	S
**	4	1.6	0.4	41	S

*An average weight of 1.5 kg was used.[6]
**A maximum weight of 1.0 kg for Syrian black snake and 2.0 kg for Montpellier's snake was used. (Shulov, A. pers. comm.)
S Survived.

the LD_{50} for cats given 1080. Dogs are very susceptible to 1081, but a dog could tolerate a small total dose of 0.3 mg/kg given during 14 days. No data on the toxicity of 1080 and/or 1081 for birds of prey given in Table 1 could be found for purposes of comparison. Other birds of prey were very resistant to 1080, which agrees with the results obtained in this study.

Secondary poisoning results in carnivores were quite variable (Table 2). One mongoose died after indirectly consuming 0.6 mg/kg F.A.A. on one day. Two cats died after indirectly consuming a total of 0.2 and 0.4 mg/kg F.A.A. The susceptibility shown by dogs in this study has been reported by others.[4,11,12] The hyena indirectly consumed a relatively small amount (7.9 mg/kg F.A.A.) which is the total received in 17 doses. According to calculation, in 15 days it consumed only a total of 1.5 mg/kg, which is less than two of the surviving mongooses consumed. Since only one hyena was used, one cannot draw any conclusion on the degree of susceptibility of the hyena. No mortality occurred in birds of prey (Table 3) as a result of secondary poisoning with F.A.A. The doses used were not high, the aim being to simulate various conditions which might occur in the field. The buzzard studied for 197 days received indirectly, according to calculation, a total of 10.3 mg/kg during 9 days, the highest dose given to birds of prey in this experiment. It is not surprising that no mortality occurred in the birds of prey in the secondary poisoning experiment because, as indicated in Table 1, they can tolerate much higher doses given directly.[12] The heron cannot be considered susceptible because the doses used were proportionally high. The doses used in the secondary poisoning of snakes (Table 4) were higher than those used by Brock[2] in a similar experiment with 1080, but the snakes tolerated this dose. According to Brock[2] two snakes reacted to the secondary poisoning with 1080 by regurgitation and this reaction can serve as a defense mechanism. The snake population of Israel seems to be stable,[7] so it is reasonable to assume that

the use of 1081 in rodent control has not had any affect.

The average amount of 0.3 mg consumed by jirds via wheat grains containing 0.2% F.A.A. does not constitute a hazard of secondary poisoning to birds of prey. However, carnivores, such as mongooses, could be endangered by secondary poisoning. Mongooses can eat up to eight jirds (Mendelssohn, H. pers. comm.) in one meal and this certainly could be fatal. Other carnivores, such as the hyena, cat and dog could be endangered in incidental cases if they consume a few poisoned jirds. The risk is especially high if the carnivore eats the exceptional jirds which have consumed up to 20 poisoned wheat grains containing 1.6 mg F.A.A.

Any means of control designed to cause field rodents to consume only two times the LD_{50} of F.A.A. will avert the possibility of secondary poisoning. By reducing the amount of poison per area unit, the hazard of direct poisoning to wild and farm animals will be reduced.

Generally the risk of secondary poisoning depends on the feeding habits of the carnivore or the bird of prey.[13] If the predators eat the intestine of the poisoned animal the risk of secondary poisoning is increased because of the chance that unabsorbed, concentrated poison is still present.

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