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Susceptibility of Rattus norvegicus, Rattus rattus and Arvicanthis niloticus to Five Anticoagulant Rodenticides.

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ABSTRACT

Susceptibility of Rattus norvegicus, Arvicanthis niloticus and Rattus rattus to five different anticoagulant rodenticides were studied by feeding free-choice tests. these anticoagulants were brodifacoum (0.005 %), difenacoum (0.005 %); flocoumafen (0.005%) and chlorophacinone (0.005%); each as whole wheat grains bait; in addition to chlorophacinone (0.012 % + sulfachinoxaline (0.019%) as crushed maize mixed with husks of sun - flower seeds. The results showed that difenacoum proved to be more effective against R. norvegicus and Arvicanthis niloticus; chlorophacinone/sulfachinoxaline mixture was more effective against A. niloticus but chlorophacinone and brodifacoum were more effective against Rattus rattus ; at the recommended dosages. These compounds completely killed the mentioned rats with lowest cumulative dose during the shortest time to death. On the other hand, A. niloticus and Rattus rattus were less susceptible to chlorophacinone and difenacoum at the recommended dosage. Therefore, the recommended dosage of chlorophacinone and difenacoum should be increased to be more effective against A. niloticus and R. rattus. It could be concluded that,all the tested anticoagulant rodenticides could be used to control R. norvegicus, A. niloticus and R. rattus in exceptin of difenacoum and chlorophacinone against R. rattus and A. niloticus. In other wards , R. rattus and A. niloticus may have developed resistance to difenacoum and chlorophacinone at the recommended dosage.

INTRODUCTION

Control of the rodents is necessary both for economic and public health reasons. However , many of different formulated anticoagulant rodenticides have been used in rodent control programme, in Egypt. Almost nothing is known in Egypt about the susceptibility of different common rat species to the anticoagulants. However, the anticoagulants have been particularly successful in controlling Norway rats (Rattus norvegicus) whereas the roof-rats (R. rattus) are less susceptible (1). In the same respect, difenacoum (0.005 %) by feeding tests was found to be valuable for controlling warfarin-resistant common rats (Rattus norvegicus), but it was less favourable against ship rats (R. rattus) (2). Anticoagulant bromodiolone (0.005 %) in laboratory feeding tests completely killed warfarin non-resistant R. norvegicus and R. rattus after 1 and 5 days , respectively whereas warfarin-resistant R. norvegicus were all killed in 4 days and resistant Mus musculus in 12 days (3). Brodifacoum (0.005 %) gave a complete mortality against Rattus rattus , R. norvegicus and Mus musculus after one day feeding (4). Ship rats (Rattus rattus)

was found more susceptible to lower concentrations of calciferol (Vitamin. D2)(5). On the other hand, it was found that, most rats that have survived six-days feeding are able to survive much longer periods of feeding on the same concentration of warfarin (6).

Therefore, this rereach was conducted to study the susceptibility of Rattus norvegicus; Arvicanthis niloticus and Rattus rattus to five different anticogulant rodenticides in Egyptian environment.

MATERIALS AND METHODS

I- Tested Anticoagulant Rodenticides:

1- kelerat (0.005 % brodifacoum) as whole wheat grains (red bait).
2- Ratak (0.005 % difenacoum) as whole wheat grains (deep green bait).
3- Storm (0.005 % flocoumafen) as whole wheat grains (deep green bait).
4- Cereal-C (0.005 % Chlorophacinone) as whole wheat grains (red bait).
5- Lepit-E (0.012 % Chlorophacinone/0.019 % Sulfachinoxaline) as crushed maize mixed with husks of sun-flower seeds (red bait).

II. Tested Animals:

Three species were trapped from Abbis area. Norway rats (Rattus norvegicus) roof-rats (Rattus rattus) and Nile rats (Arvicanthis niloticus).

III. Experiment:

The trapped rats (A. niloticus , R. rattus and R. norvegicus) were individually caged and kept for 7-10 days with adequate water and food supply (5). Rats were preconditioned to the test diet from the time they were caged, and then fed on whole wheat diet until starting the test. Fresh bait and clean food pots were provided daily (7).

Two cups were palced inside the cage, one containing the non-poison bait (20 gm. whole wheat) and the other cup containing the poison bait (20 gm). Daily , fresh baits were supplied and the position of the two bait cups were interchanged. Untreated rats were concurrently caged in separate cages with non - poison bait (wheat grains).

Five rats from each species were used as one treatment. The results were recorded daily on bait consumption (poison and non-poison baits). The total consumption of non-poison and poison

baits/rat and mean percentage of appetite were calculated by the following equation (5).

$$\% \text{ Appetite} = \frac{\text{Mean consumption of choice non-poison baits}}{\text{Mean consumption of non-poison baits for control}} \times 100$$

Mean percentage of palatability was determined by the following equation (5).

$$\% \text{ Palatability} = \frac{\text{Mean consumption of choice poison bait / 24 hrs.}}{\text{Mean weight of choice non-poison bait/ 24 hrs.}} \times 100$$

Mortality percentage and death time of each rat were manifested. The average amount of consumed poison bait in gm/Kg body weight as well as from active ingrediant in mg/kg were determined. In addition, the LFP50 and LFP98 (lethal feeding periods) in days, to obtain 50 and 98% mortalities were recorded on log probit paper(8)

RESULTS AND DISCUSSION

A- Effect of Anticoagulants on Rattus norvegicus:

The results of the five different anticoagulant rodenticides against Norway rats (Rattus norvegicus) are recorded in Table 1. The amounts consumed by the individual rat from different anticoagulants were low. The lower amounts consumed from poison baits may be due to the choice effect with non-poison baits in the same cage

In relation to non-poison treatments, the appetite and palatability of R. norvegicus to anticoagulants were slightly low. However , Kelerat was found to be more palatable for R. norvegicus whereas Ratak had more appetizing action for this rat.

Concerning the time to death and mortality percent, it was found that Cereal-C and Ratak poison baits resulted in 100% kill to the tested rat (R. norvegicus) during 4.2 days (3-5 days range) and 4.7 days (3-7 days range) , respecitvely. Kelerat caused 100% mortality during 4.8 days (4-5 days range) , Lepit-E and Storm cuased 100% kill (40-100 and 20-100% respectively), during longer time equal to 6.6 (5-8 days range) and 6.2 (5-7 days), respectively.

It was observed that Ratak with low cumulative dose (5.25 mg/Kg) caused 100% mortality to the tested rat during short time to death equal to 4.7 days. Storm with low cumulative dose (5.63 mg/Kg) gave also 100% kill but during long time to death equal to 6.2 days. whereas kelerat with relatively high cumulative dose

Table (1): Effect of five different anticoagulant rodenticides on R. norvegicus.

Anticoagulant rodenticides	Concentration (%)	Mean body weight (gm)	Mean poison bait consumed (gm)	Mean poison bait consumed %	Mean non-poison bait consumed (gm)	Mean non-poison bait consumed (%)	% appetite	% Palatability	% mortality Range	% mortality Final	Time to death (days) Range	Time to death (days) Mean	Average amount consumed per Kg body weight: Bait (gm)	Average amount consumed per Kg body weight: Active ingredient (mg)
Kelerat Brodifacoum	0.005	234.0	30.5	30.5	31.9	31.90	37.22	95.60	20-100	100	4-5	4.8	138.8	6.54
Ratak Difenacoum	0.005	248.4	26.1	18.6	47.8	34.10	56.80	54.60	40-100	100	3-7	4.7	105.1	5.25
Storr Flocoumafen	0.005	234.5	26.4	18.9	31.1	22.16	39.40	69.80	20-100	100	5-7	6.2	112.6	5.63
Cereal-C Chlorophacinone	0.005	249.8	35.7	35.7	47.0	47.00	53.90	75.95	40-100	100	3-5	4.2	142.9	7.14
Lepit-E		246.0	19.3	12.1	33.9	21.20	42.40	56.90	40-100	100	5-8	6.6	78.5	
Chlorophacinone	0.012													9.41
Sulfoquinoxaline	0.019													14.90

Table (2): Effect of five different anticoagulant rodenticides on Ratus rattus.

Anticoagulant rodenticides	Concentration (%)	Mean body whight (gm)	Mean poison bait consumed (gm)	Mean poison bait consumed %	Mean non-poison bait consumed (gm)	Mean non-poison bait consumed (%)	% appetite	% Palatability	% mortality Range	% mortality Final	Time to death (days) Range	Time to death (days) Mean	Average amount consumed per Kg body weight: Bait (gm)	Average amount consumed per Kg body weight: Active ingredient (mg)
Kelerat Brodifacoum	0.005	108.8	17.63	11.01	18.67	11.7	42.6	94.4	20-100	100	4-8	6.4	162.0	8.1
Ratak Difenacoum	0.005	117.1	15.40	7.70	33.40	16.7	68.7	46.1	20-60	60	5-7	6.3	131.5	6.6
Storm Flocoumafen	0.005	138.8	19.90	20.80	21.20	17.7	47.2	95.7	20-100	100	4-8	5.6	149.4	9.0
Cereal-C Chlorophacinone	0.005	146.8	24.30	20.30	26.60	22.2	51.9	91.4	20-100	100	5-6	5.8	165.5	8.3
Lepit-E		191.2	33.60	24.50	34.30	24.4	60.7	97.9	20-100	100	5-7	6.6	179.4	
Chlorophacinone	0.012													21.5
Sulfoquinoxaline	0.019													34.1

(6.94 mg/kg) gave 100% mortality during 4.8 days. On the other hand, Cereal-C and Lepit-E required higher cumulative dosages to cause complete mortality against Norway rat during 4.7 and 6.6 days, since it required 7.15 and 9.4 mg/kg body weight, respectively.

It could be concluded that ratak proved to be more effective against R. norvegicus, since it completely killed the Norway rats with lowest cumulative dose (5.25 mg/kg body weight) during the shortest time to death (4.7 days).

Generally, all the examined anticoagulant rodenticides were effective killers against Rattus norvegicus.

B- Effect of Anticoagulants on Rattus rattus:

The results of the five different anticoagulant rodenticides against roof-rats (Rattus rattus) are listed in Table 3. The choice between poison and non-poison baits in the same cage decreased the consumption from each by roof-rats (R. rattus). So, the amounts consumed by individual rat from different anticoagulant baits were very low.

The roof-rats (R. rattus) showed slight appetite to anticoagulant baits with relation to appetite of non-poisoned treatments. On the other hand, Lepit-E, Storm, Kelerat and Cereal-C were palatable to R. rattus, whereas Ratak was relatively less palatable.

Concerning the mortality percentages and time to death, it was found that the anticoagulants gave 100% mortality of R. rattus within the same range 20-100 % except Ratak which gave 60% mortality within a range of 20-60 %. Time to death were nearly within the same range for all the tested anticoagulants. Time to death for Storm and Cereal-C were 5.6 and 5.8 days whereas it was 6.4 and 6.6 days in the case of Kelerat and Lepit-E,respectively.

With respect to the amounts consumed from the anticoagulant baits in gramme / Kg body weight and the average cumulative dosages inside the body of rat in milligramme of active ingredient / kg body weight, it was observed that Cereal-C and Kelerat were more effective against R. rattus, since they caused 100% mortality with low cumulative dosages (8.3 and 8.1 mg a.i/Kg body weight) during the short periods to death (5.8 and 6.4 days), respectively. Storm, with moderate dose equal to 9.0 mg a.i/Kg body weight, completely killed the roof-rats during short time of death equal to 5.6 days. Lepit-E, with highest cumulative dosages equal to 21.5 mg a.i/Kg body weight, caused 100% mortality in 6.6 days. On the other hand, Ratak was not able at the recommended dose to kill all the tested roof-rats,since it caused 60% mortality against R. rattus during 6.3 days. Therefore, it could be concluded that R. rattus may be tolerant to Ratak at the recommended dosage which should be increased to kill the roof-rats.

Table (3): Effect of five different anticoagulant rodenticides on A. niloticus.

Anticoagulant rodenticides	Concentration (%)	Mean body weight (gm)	Mean poison bait consumed (gm)	%	Mean non-poison bait consumed (gm)	(%)	% appetite	% Palatability	% mortality Range	Final	Time to death (days) Range	Mean	Pain (hrs)	Average amount consumed per Kg body weight Active ingredient (mg)
Rafarat Brodifacoum	0.005	123.20	19.53	12.10	28.5	17.80	68.40	67.9	20-100	100	6-8	7.6	150.5	7.95
Ratak Difenacoum	0.005	79.70	10.70	7.64	26.4	18.86	81.20	40.3	20-100	100	6-7	6.8	134.2	6.71
Storm Flocoumafen	0.005	88.76	16.10	10.06	24.6	15.37	67.95	65.4	20-100	100	3-8	6.4	181.3	9.06
Cereal-C Chlorophacinone	0.005	88.90	10.70	10.70	33.4	33.40	80.30	32.1	60-100	100	7-10	8.2	120.4	6.06
Lepit-E		90.70	15.00	15.00	24.10	24.10	73.70	62.2	20-100	100	3-5	4.4	165.4	
Chlorophacinone	0.012													19.84
Sulfoquinoxaline	0.019													31.42

The effective anticoagulants against the roof-rats(R. rattus) could be arranged in a descending order according to the cumulative dose and time to death as follows: Cereal-C, Kelerat, Storm and Lepit-E.

Generally, it could be concluded that all the examined anticoagulant rodenticides except Ratak could be used for controlling roof-rats (R. rattus).

C- Effect of Antoicoagulants on Arvicanthis niloticus:

The results of the five different anticoagulants against the Nile rats (A. niloticus) are recorded in Table 2. The amounts consumed by inidividual rat from different anticoagulant were very low. These low amounts consumed from the poison baits may be due to the choice effect with non-poison baits in the same cages.

In relation to non-poison treatments , it was found that the appetite of A. niloticus was nearly good for Ratak and Cereal-C, whereas it was moderate for Lepit-E, Kelerat and Storm. On the other hand, in relation to the choice non-poison bait, it was observed that Kelerat, Storm and Lepit-E were slightly palatable to A. niloticus, whereas Ratak and Cereal-C were nearly less palatable.

With respect to the mortality percentages and time to death, it was observed that the mortality percentages against A. niloticus by Lepit-E, Storm, Ratak and Keleral were nearly equal, it was within a range of 20-100 %, whereas Cereal-C caused mortality within a range of 60-100 %. On the other hand, Lepit-E caused 100% mortality in a shortest time equal to 4.4 days (3-5 days range). The times to death caused by Storm and Ratak were 6.4 days (3-8 days) and 6.8 days (6-7 days range), respectively. Kelerat caused 100% mortality in 7.6 days (6-8 days range), whereas Cereal-C needed a longer time to produce complete death to A. niloticus, 8.2 days (7-10 days range).

On the other hand, the average amounts consumed from poison bait in gramme /Kg body weight indicated that the anticoagulant poison baits were highly acceptable by A. niloticus. However, the average dosage cumulated inside the rat body required to Kill the animal was calculated in mg active ingredient per Kg body weight.

It was found that Ratak with the lowest cumulative dose (6.7 mg a.i/Kg body weight) and short time to death (6.8 days gave 100% kill to the Nile rat (A. niloticus). Cereal-C with the lowest cumulative dosage (6.02 mg a.i./Kg body weight) and the longest periods to death (8.2 days) . and Storm with large cumulative dosage (9.1 mg/Kg body weight) and short time to death (6.4 days) compeltely killed the Nile rat (A. niloticus). Complete killing was also found by Kelerat with moderate cumulative dose (7.93 mg a.i/Kg body weight) and moderate time to death (7.6

Table (1): Lethal feeding periods (LFP 50 and LFP 98) of different rodent species by different rodenticides. (in days).

Rodenticides	Concentration (%)	R. norvegicus		A. niloticus		R. rattus	
		LFP 50	LFP 98	LFP 50	LFP 98	LFP 50	LFP 98
Kelerat Brodifacoum	0.005	3.8	4.8	6.0	7.2	5.1	6.5
Ratak Difenacoum	0.005	5.2	6.8	5.9	6.4	6.1	<10
Storm Flocoumafen	0.005	5.2	6.1	4.3	6.0	4.9	6.4
Cereal-C Chlorophacinone	0.005	3.2	4.0	6.9	8.3	5.1	5.4
Lepit-E Chlorophacinone	0.012						
Sulfaquinoxaline	0.019	4.6	6.3	3.6	4.3	5.2	6.1

days). Lepit-E caused also 100% mortality with largest cumulative dosage (19.84 mg a.i./Kg body weight) and shortest time to death (4.4 days).

It could be concluded that Ratak was found to be more effective against the Nile rats (Arvicanthis niloticus), it completely killed the Nile rats with lowest cumulative dosage during short time to death. Also, Lepit-E was very effective against A. niloticus. since it caused 100% mortality with highest cumulative dosage during the shortest periods to death. However, Cereal-C concentration should be increased to decrease the time to death.

The effective anticoagulant rodenticides against A. niloticus, could be arranged in a descending order according to the cumulative dose and time to death as follows : Ratak and/or Lepit-E, Kerlerat, Storm and Cereal-C.

Generally; it could be concluded that all the tested anticoagulants can be used to control the Nile rats (Arvicanthis niloticus) in the filed except Cereal-C (Chlorophacinone).

On the other hand, the lethal feeding periods (in days) from anticoagulants required to obtain 50 and 98% mortalities for different rodents (LFP50 and LFP98) are recoreded in Table 4 and Figures 1,2 and 3). The results indicate that the values of LFP50 and LFP98 for different rodents. LFP50 against Rattus norvegicus were 3.2, 3.8, 4.6 , 5.2 and 5.2 days in the case of Cereal-C , Kelerat, Lepit-E, Ratak and Storm in an ascending order, respectively. Then, the lethal feeding periods required to obtain 50% mortality by Cereal-C and Kelerat against R. norvegicus are less than that of any of the other tested rodenticides, whereas LFP50 for Ratak or Strom (5.2 days) are the longest followed by Lepit-E (4.6 days). LFP98 against R. norvegicus are still the shortest in the case of Cereal-C (4.0 dayas) and kelerat (4.8 days), whereas it is nearly equal in the case of Storm (6.1 days), Lepit-E (6.33 days) and Ratak (6.8 days). So, Kelerat and Cereal-C proved to be more effective against R. norvegicus.

With respect to R. rattus , it was found that Storm showed short LFP50 equal to 4.9 days whereas the other tested rodenticides exhibited long LFP50 values against R. rattus. These values were nearly equal for kelerat, Cereal-C and Lepit-E (5.1 days), whereas it is equal to 6.1 days for Ratak. Concerning LFP98 against R. rattus , it was found that there is no difference between LFP50 and LFP98 for Cereal-C , which were equal to 5.1 and 5.4 days, respectively, whereas LFP98 was more equally longer in case of Lepit-E (6.1 days), Storm (6.4 days) and Kelerat (6.5 days). Rattus rattus may became tolerant for Ratak becasue it required LFP98 more than ten days (Table 4 and Figs. 1,2 and 3).

Lethal feeding periods required to obtain 50% mortalities against Arvicanthis niloticusin were 3.6, 4.3 5.9 , 6.0 and 6.9 days in case of Lepit-E, Storm, Ratak , Kelerat and Cereal-C, respectively. Lepit-E and Storm were very effective against A.

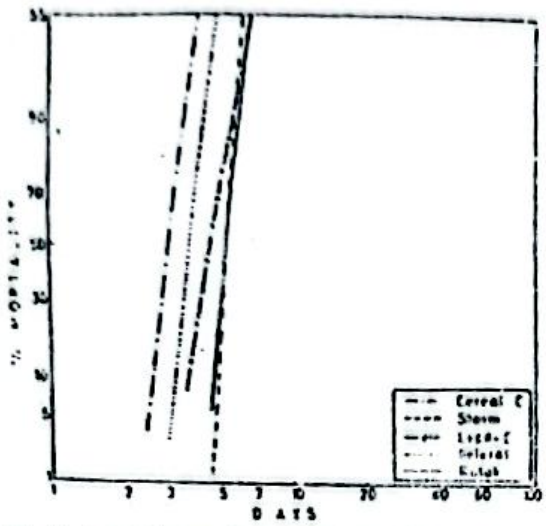

Fig 1: Lethal-feeding Period (LFP_{50} and LFP_{90}) for Rattus norvegicus by the anticoagulants.

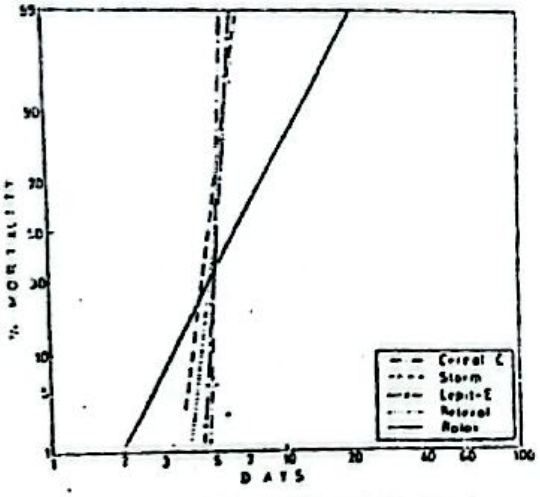

Fig 2: Lethal-Feeding Period (LFP_{50} and LFP_{98}) for Rattus rattus by the anticoagulants.

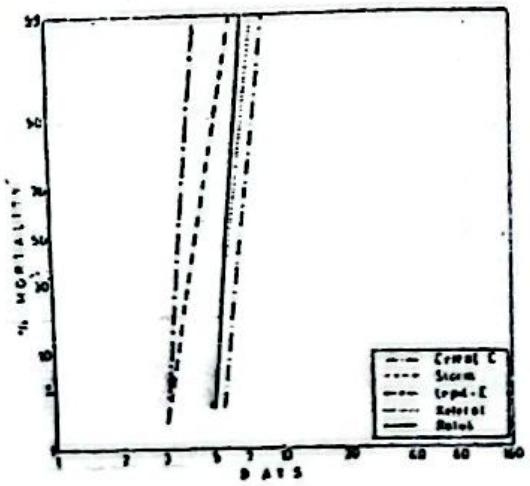

Fig 3: :Lethal-Feeding Period (LFP_{50} and LFP_{98}) for Arvicanthis nilaticus by the anticoagulants.

niloticus because of their shortest LFP50 . On the other hand, LFP98 against A. niloticus was found to be the shortest for Lepit-E (4.3 days), whereas it is long in the case of Storm (6.0 days) . Ratak (6.4 days), Kelerat (7.2 days) and Cereal-C (8.3 days). It could be noted that Lepit-E was more effective against A. niloticus because of its short lethal feeding periods whereas Cereal-C was less effective because of its lethal feeding period.

It could be concluded that Cereal-C and Kelerat were more effective against R. norvegicus, followed by Lepit-E, Storm and ratak. Lepit-E proved to be more effective against A. niloticus, whereas Cereal-C was less effective. The tested rodenticides were equally effective against R. rattus, except for Ratak which required more than ten days of feeding to cause complete mortality against R. rattus. In other wards, the previousley mentioned results reveal that Rattus rattus and Arvicanthis niloticus might develope resistance to Ratak (0.005% difenacoum) and Cereal-C (0.005 % chlorophacinone).

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الملخص العربى

حساسية الفار النرويجى، والفار المحلق والفار النيلى لخمسة مبيدات قوارض مانعه للتجلط
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تمت دراسة حساسية فار الحقل النرويجى والفار المحلق والنيلى لخمسة مبيدات قوارض مانعه للتجلط بواسطة اختبارات التغذيه بالاختيار الحر. كانت المبيدات المختبره هى بروديفاكوم (٠٠٥ر٠ %)، دايفنياكوم (٠٠٥ر٠%)، فلوكومافين (٠٠٥ر٠%) وكلوروفاسينون (٠٠٥%) وكل مبيد محمل فى صورة طعوم على حبوب القمح المليمة. ذلك بالاضافة الى كلوروفاسينون (١٢ر٠) + سلفاكينو اكسالين (١٩ر٠) فى صورة طعم من الذرة المجروش مخلوطا مع قشور بذور عباد الشمس. اظهرت النتائج انه عند التركيزات المسجلة دايفنياكوم له فعالية عالية ضد الفار النرويجى و الفار النيلى. بينما كلورو فاسينون مخلوطا مع سلفاكينو اكسالين كان اكثر فعالية ضد الفار النيلى فى حين ان الفار المحلق كان اكثر حساسية لكل من كلورفاسينون وبروديفاكوم. وهذه المركبات المذكورة قتلت الفئران المختبرة كلية بأقل جرعة تراكمية خلال اقل زمن للموت. من ناحية اخرى فان كلا من الفار النيلى والمحلق اظهرا حساسية اقل لكل من كلور فاسينون ودايفناكوم لذلك يجب زيادة الجرعة المسموح بها لتزيد فعاليتهما بدرجة مؤثرة للنوعين المذكورين.