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Full Length Article

Effect of Certain Concentration of Zinc Phosphide and Lepit Mixed with Either Talc or Malathion as Tracking Powder on the Norway Rat (*Rattus norvegicus* ssp. Berken) under Field Conditions

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Abstract

The current study was conducted under field conditions to investigate the impact of specific concentrations of Zinc phosphide and Lepit, combined with either Talc or 1% Malathion, as tracking powder on the Norway rat (*Rattus norvegicus* Berkenhout), specifically the Berken subspecies. The acquired data disclosed that the application of Zinc phosphide in concentrations of 1, 2 and 3% mixed with Talc powder resulted in varying reduction percentages in the population of *R. norvegicus*. These reduction percentages averaged 37.3, 54.3 and 62.4% respectively. Notably, when Talc powder was solely employed and spread at the entrances of the burrows, a significant reduction of up to 11.5% was observed. Conversely, the examined concentrations of Zinc phosphide in combination with 1% Malathion yielded reduction percentages of 38.1, 50.5 and 58.6%, respectively. Moreover, the independent use of 1% Malathion powder led to a minor reduction of 3.3% in the rat population. In general, the most effective treatment against rats was observed with the 3% concentration of Zinc phosphide, both when mixed with Talc and when compared to the use of 1% Malathion. Similarly, the utilization of Lepit, which was diluted by blending it with either Talc or 1% Malathion powder in specified ratios (w/w) of 1:5, 1:10 and 1:15, resulted in the subsequent concentrations. Notably, the 1:5 ratio of Lepit mixed with either Talc or 1% Malathion demonstrated the highest reduction percentage in the Norway rat population. The rat traces disappeared after the second application of Lepit (with Talc or Malathion). Both Talc and 1% Malathion powders exhibited a reduction in the tested population of *R. norvegicus*. Talc powder exhibited a higher reduction percentage compared to 1% Malathion under various field crops in the Tell El Kebir district of Ismailia Governorate.

Keywords: Zinc phosphide; Lepit; Malathion; Talc; *Rattus norvegicus*

Introduction

In the early 1980s, Egypt encountered issues with rodent infestations in its agricultural areas. Rodents are considered as one of the most important pest groups in Egypt. Rodents cause untold economic loss to farmers, food manufacturers, and processors as well as causing damage to the structure and building fabric. Undoubtedly, the economic loss due to rodents is enormous. Rodent depredation on stored food and agricultural products is considered both an agricultural and public health problem because of the transmission of rodent-borne diseases as well as the destruction of human food. Rodents can carry diseases that can harm people. So, rodents' control has become a necessity.

The introduction of anticoagulant rodenticides marked a significant advancement in rodent control. These compounds generally demonstrate effectiveness against a wide range of rodent species when employed in excess baiting; however, in certain cases, prolonged periods of feeding might be necessary. Nonetheless, specific species such as the Egyptian spiny mouse (*Acomys cahirinus*) and the house mouse (*Mus musculus*) exhibit inherent resistance to certain anticoagulants, making their use likely to result in control failures (Gill 1992).

Zinc phosphide stands as the most utilized acute rodenticide and possesses a lengthy history of application. Zinc phosphide is an inorganic compound that combines phosphorus with zinc (Meehan 1984). It has emerged as a benchmark for comparing with newly developed rodenticides. When zinc phosphide is eaten by either an animal or a person, stomach acid causes it to release the toxic gas phosphine (Chitty 1954). The phosphine in the stomach then crosses into the body's cells and stops the cells from producing energy. This causes the cells to die. Zinc phosphide affects all cells, but targets cells in the heart, lungs and liver.

Lepit (chlorophacinone) is a member of coumarins which are widely used as an anticoagulant rodenticide

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for the eradication of rodents. Anticoagulant rodenticides have been used in the controlling of rodents in Egypt and all over the world.

The mechanism of intoxication with anticoagulants rodenticide is via a specific inhibition of blood coagulation. Vitamin K is needed for the functional synthesis of coagulation factors II, VII, IX and X. The most common vitamin K-responsive coagulopathy is anticoagulant rodenticide intoxication (Mount *et al.* 2003). Blood vessels lose their elasticity, and subsequently ruptures of large blood vessels occur, clinically manifested by massive haemorrhages and hematomas (Radi and Thompson 2004).

Zinc phosphide tracking powder represents a stable formulation with an extended shelf life. This tracking powder comprises a toxic substance blended with specialized carriers designed to cling to the fur and paws of rodents. The rodents inadvertently ingest the powder during grooming activities. Notably, tracking powder remains insoluble in water, thereby extending the duration of its effects. This characteristic renders it particularly suitable for challenging tasks.

The aim of using tracking powders in rodent control is as follows: (1) Preserving wildlife and the environment from pollution, it is considered an alternative to using grafts and maintaining public health. The use of zinc phosphide as a powder for pathways is one of the ways to use phosphide continuously in the absence of blood thinners (to reduce the phenomenon of taste aversion). (2) The lepit was used as a tracking powder instead of as bait, thus providing the carrier, whether it was corn or wheat. (3) Tracking powders are a form of pesticide used in chemical control. Considering all these, the present study aims to investigate the effect of certain concentration of Zinc phosphide and Lepit mixed with either Talc or Malathion 1% as tracking powder on the Norway rat (*Rattus norvegicus* Berkenhout ssp. Berken) under field conditions.

Materials and Methods

Tested chemicals

The Zinc phosphide used in the study was obtained from Abou Zaapal Company, with 94% active ingredients. Meanwhile, the 1% Malathion powder was provided by Kafer El-Zayat Company, while lepit had 0.0385% active ingredients.

Chemical composition

The chemical formulation, Konzentrate, comprises two components: (1) Chlorophacinone: 2-[4-(Chlorophenyl)phenylacetyl]-1H-indene-1,3(2H)-dione, (2) Sulfaquinoxaline: 4-(quinoxalin-2-ylamino)benzenesulfonamide.

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Zinc phosphide and Lepit tracking powder were assessed in various field crops within the Tell El Kebir district of Ismailia Governorate. For anticoagulant tracking powder, the same infested field crops with *R. norvegicus* were selected, with an additional untreated area serving as a control check. The rat population size within each experimental plot was determined before and after treatment using a method based on the percentage of active burrows. This involved marking and carefully sealing the burrows in each plot with soil. After 24 h, the marked burrows were inspected, and the opened (active) burrows were recorded. The rat index was computed by dividing the number of active burrows by the total number of burrows, following the approach outlined by Abdel-Gawad and Maher in 1982.

To conduct the experiment, the entry point of each active burrow was covered with test dust, measuring 50 cm in length and 10 cm in width. The exposure period for the experimental rodenticide lasted for four consecutive days. During this time, all burrow entries were monitored daily, and additional material was added as necessary. An additional seven-day period was allowed for the poisoned rats to succumb or recover, as outlined by Rennison in 1977. The reduction in the rat population based on corrected mortality percentage was calculated using the Abbott (1925) following formula:

Population reduction (%) = (% active burrows pre-treatment - % active burrows post-treatment) / % active burrows pre-treatment

Statistical analysis

Obtained data was analyzed as two-way ANOVA using Proc ANOVA in SAS (Anonymous 2003). Means were compared by Tukey's HSD ($P = 0.05$ level) in the same program.

Results

The data presented in Table 1 illustrate the impact of specific concentrations of Zinc phosphide / Talc or Malathion as tracking powder on rats (*R. rattus* and *R. norvegicus*).

Table 1 exhibits that the employed concentrations of Zinc phosphide mixed with Talc powder at 1, 2 and 3% resulted in varying reduction percentages in the *R. norvegicus* population ($P < 0.01$). These respective averages were 37.3, 54.3 and 62.4 ($P < 0.01$). Furthermore, when Talc powder was administered alone and distributed at the entrances of burrows, a noticeable reduction of up to 11.5% was observed.

Conversely, the concentrations examined for the combination of zinc phosphide and 1% Malathion powder, specifically at 1, 2 and 3%, yielded population reduction percentages of 38.1, 50.5 and 58.6%, respectively ($P < 0.01$).

Table 1: Effect of certain concentration of Zinc phosphide and Malthion or Talc 1% as tracking powder on the Norway rat under field conditions Ismailia Governorate

Treatment	Concentration%	Population density		Reduction (%)	Average compounds regardless of concentrations	Observation
		Before	After			
Zinc phosphide and Malathion	1	18.9	11.7	38.1 C	40.479 A	No traces of rats after 4th day
	2	19.8	9.8	50.5 B		No traces of rats after 2nd day
	3	19.1	7.9	58.6 A		No traces of rats after 2nd day
Control (Malathion)		18.1	17.5	3.3 D		Traces still present
F value for conc.	1979.89***					
LSD	2.242					
Zinc phosphide and Talc	1	19.3	12.1	37.3 C	37.51 B	No traces of rats after 5th day
	2	18.4	8.4	54.3 B		No traces of rats After 5th day
	3	18.1	6.8	62.4 A		No traces of rats After 2nd day
Control (Talc)		19.2	17.0	11.5 D		Traces still present
F value for conc.	363.01***					
LSD	5.12					

F value for tracking powders = 14.82*** LSD = 1.56

Table 2: Effect of certain concentration of Lepit and Talc or Malathion as tracking powder on the Norway rat under field conditions Ismailia Governorate

Treatment	Concentration%	Population density		Reduction (%)	Average compounds regardless of concentrations	Observation
		Before	After			
Lepit and Talc	1:5	16.7	0.5	97 A	70.40 A	No traces of rats after 2nd day
	1:10	16.5	1.4	91.5 B		No traces of rats after 5th day
	1:15	13.4	1.5	88.8 B		No traces of rats after 5th day
Control (Talc)		19.5	18.6	4.6 C		
F value for Conc.	3453.07					
LSD	3.05					
Lepit and Malathion	1:5	14.7	1.4	90.5 A	66.88 B	No traces of rats after 2nd day
	1:10	18.8	2.1	88.5 A		No traces of rats after 6th day
	1:15	16.5	2.2	86.7 B		No traces of rats after 6th day
Control (Malathion)		18.1	17.8	1.7 C		
F value for Conc.	8307.54					
LSD	1.93					

F value for tracking powder = 45.99 *** LSD = 1.05

As a result, the utilization of Malathion powder (1%) on its own led to a minor reduction in the rat population by 3.3%. Generally, 3% Zinc phosphide emerged as the most effective treatment against rats, whether used alone or in combination with Talc. Additionally, Zinc phosphide demonstrated superior control when employed in conjunction with Talc (62.4%) compared to the use of 1% Malathion (58.6%) ($P < 0.01$).

Regarding Lepit, it was diluted by incorporating Talc or 1% Malathion powders in specific ratios (w/w) of 1/5, 1/10 and 1/15. The outcomes detailed in Table 2 demonstrated that the 1/5 concentration yielded the highest reduction percentages: 97% when paired with Talc, and 90.5% when combined with Malathion. Notably, traces of rats disappeared after the second day of the experiment. Conversely, the use of the 1/15 concentration of Lepit resulted in the lowest reduction percentages in the targeted Norway rat population (*R. norvegicus*). In this case, footprints and tail traces of the Norway rat were evident starting from the sixth day of the experiment. As previously mentioned, both Talc (4.6%) and Malathion (1.7%) independently caused only a marginal reduction in the Norway rat population, with traces observed throughout the experiment's duration ($P < 0.01$).

In general, the 1/5 concentration of Lepit, whether combined with Talc or 1% Malathion, led to the highest reduction percentages in the population of the Norway rat, *R. norvegicus* ($P < 0.01$). Rat traces vanished after the second day from the start of the Lepit experiment. Additionally, this 1/5 Lepit concentration mixed with either Talc or 1% Malathion yielded the highest reduction percentage in the Norway rat population. Rat traces disappeared after the second day for Lepit combined with either Talc or Malathion. Both Talc and Malathion powders contributed to a reduction in the tested *R. norvegicus* population. Specifically, Talc powder exhibited a higher reduction percentage compared to 1% Malathion across various field crops in the Tell El Kebir district of Ismailia Governorate ($P < 0.01$).

Discussion

Rodents cause significant damage to a wide range of crops from planting to preharvest, and during postharvest storage and processing. Rodents can also transmit a variety of human and animal diseases via ectoparasites or via hair, bodily waste products and secretions (Brooks and Lavoie 1990; EPA 1998).

Zinc phosphide (ZP) has been used as a rodenticide worldwide since the 1940s to control a variety of animals including rats, mice, squirrels, prairie dogs, voles and gophers (EPA 1998). Zinc phosphide (ZP) was considered a quick-acting (acute) rodenticide.

ZP is an acute, single-dose rodenticide. When ingested, ZP reacts immediately with stomach acids to produce small quantities of phosphine gas that are quickly absorbed into the bloodstream to adversely affect the lungs, liver, kidneys, heart and central nervous system (Guale *et al.* 1994). While liberation of phosphine is the primary method of toxicosis, there is some suggestion that intact ZP may also be absorbed into the liver to cause some toxic effects.

Lepit is a highly toxic rodenticide for rodents while it has reduced toxicity for humans or other non-target species, so it is recommended for the control of rats, mice and voles in warehouses and on agricultural and forest lands, where other species can later eat the rats and mice without suffering the effects of the rodenticide *i.e.*, Derivative of diphenylindane.

Lepit was considered as one of anticoagulant rodenticides, so it works as vitamin K antagonists, prevent blood from clotting and the animal that ingests it dies due to internal bleeding. The death of the animal occurs a few days after ingestion, which avoids mistrust in the rodent population. It is the rat poison considered to have the fastest action. It can cause up to 96% mortality with a single ingestion (Radi and Thompson 2004).

The results above demonstrate that the utilized concentrations of Zinc phosphide mixed with Talc powder namely 1, 2 and 3% yielded varying reduction percentages in the population of *R. norvegicus*. These respective averages were 37.3, 54.3 and 62.4%. Furthermore, the application of Talc powder alone, spread at the entrances of burrows, resulted in a noticeable reduction of up to 11.5%. Conversely, the concentrations investigated for the combination of zinc phosphide with 1% Malathion powder, specifically at 1, 2 and 3%, yielded population reduction percentages of 38.1, 50.5 and 58.6%, respectively.

Therefore, when Malathion powder (1%) was utilized individually, it led to a minor reduction in the rat population by 3.3%. In general, the most effective treatment against rats was observed with 3% Zinc phosphide, whether used alone or in conjunction with Talc. Additionally, Zinc phosphide exhibited superior control when mixed with Talc compared to the use of 1% Malathion.

Arafa and Salit (1972) reported that Crimidine, a fast-acting poison, was evaluated in confined areas highly infested with Acomys and *Rattus* species. Crimidine demonstrated greater effectiveness and cost efficiency in localities primarily infested with Acomys species as opposed to *Rattus* species.

Mourad (1997) found that the highest efficacy of zinc phosphide bait was observed when applied inside burrows, whether targeting *M. shawi* or *G. gerbillus*. This application led to a population reduction of 46.6% for *M. shawi* and 40.0% for *G. gerbillus*.

Abou-Hashem and Fatma Khidr (2021) demonstrated that zinc phosphide cake exhibited the highest effectiveness at 83%, followed by tracking powder at 75%, crushed maize at 66.7%, and the least effective was the wax block at 50% in terms of reducing the numbers of *R. norvegicus*. The combination of applied zinc phosphide formulations with snap traps resulted in a high level of control against Norway rats.

Regarding Lepit, it was diluted by incorporating either talc or 1% Malathion powders in specific ratios (w/w) of 1/5, 1/10 and 1/15. The obtained results indicated that the 1/5 concentration yielded the highest reduction percentages: 97% when mixed with Talc, and 90.5% when combined with Malathion. Notably, traces of rats disappeared after the second day of the experiment. Conversely, the utilization of the 1/15 concentration of Lepit resulted in the lowest reduction percentages in the targeted Norway rat population (*R. norvegicus*). In this scenario, footprints and tail traces of the Norway rat were visible starting from the sixth day of the experiment. As previously mentioned, both Talc (4.6%) and Malathion (1.7%) independently led to a modest reduction in the Norway rat population, with traces observable throughout the entire experimental period.

In general, the 1/5 concentration of Lepit, whether combined with Talc or 1% Malathion, yielded the highest reduction percentages in the population of the Norway rat, *R. norvegicus*. Rat traces disappeared after the second day from the start of the Lepit experiment.

In general, the 1/5 concentration of Lepit, whether combined with Talc or 1% Malathion, yielded the highest reduction percentage in the Norway rat population. Rat traces disappeared after the second day for Lepit (whether with talc or Malathion). Both Talc and Malathion powders contributed to a reduction in the tested *R. norvegicus* population. Notably, Talc powder achieved a higher reduction percentage compared to 1% Malathion under various field crops in the Tell El Kebir district of Ismailia Governorate. Khan (2007) reported that, following five bait applications, rodent activity decreased by 90–96% across treatments, except for the zinc phosphide treatment, where the rodent activity decreased by 76.04%.

Conclusion

Since problems of rodents in Egypt are seriously increasing in both agricultural and public health aspects reason must be directed to reach a quick and effective way of control. An attempt is made in this study to use Zinc phosphide and

Lepit, combined with either Talc or 1% Malathion, as tracking powder.

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Author Contributions

Rizk AM Proposed the idea of research, Naglaa HM Amer and Ghada G Zaki collaborated in writing the research protocol, do the applied part in the field and writing the research and results and preparing the research for publication.

Conflicts of Interest

The authors declare that they have no competing interests.

Data Availability

The data will be available on a fair request to the corresponding author.

Ethics Approval

None

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