March 1978

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C. Martinez-Palacios
Campana Nacional Contra Roedores-Rata de Campo, Dirección General e Sandidad Vegetal, SA.R.H. Allende No. 45, Coyoacán 21, D.F., Mexico

C. Chavez-Sanchez
Campana Nacional Contra Roedores-Rata de Campo, Dirección General e Sandidad Vegetal, SA.R.H. Allende No. 45, Coyoacán 21, D.F., Mexico

R. Ituarte-Soto
Campana Nacional Contra Roedores-Rata de Campo, Dirección General e Sandidad Vegetal, SA.R.H. Allende No. 45, Coyoacán 21, D.F., Mexico

A. Marquez Moreno
Campana Nacional Contra Roedores-Rata de Campo, Dirección General e Sandidad Vegetal, SA.R.H. Allende No. 45, Coyoacán 21, D.F., Mexico

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C. MARTINEZ-PALACIOS, C. CHAVEZ-SANCHEZ, R. ITUARTE-SOTO, and A. MARQUEZ MORENO, Campana Nacional Contra Roedores-Rata de Campo, Dirección General e Sandidad Vegetal, SA.R.H. Allende No. 45, Coyoacán 21, D.F., Mexico

ABSTRACT: Tests were conducted using 0.05% warfarin baits which were put into polietilinized paper bags with corn oil as attractants, in order to control cotton rats (Sigmodon hispidus major) throughout 4,000 ha. of crops in the Sinaloa State. Both the effectiveness of the warfarin bait and the security and efficiency of the handling of the polietilinized paper bags was demonstrated. Furthermore, the tests showed that there were economic advantages in using the warfarin baits instead of the zinc phosphide baits; to the extent of a 46.67% saving in the control expenses.

INTRODUCTION

Sinaloa is one of the most important agricultural states of Mexico; it has 500,000 ha. of irrigated land, in which mainly carthamus, wheat, sugarcane, orchards and vegetables are grown. Since extensive new areas have been opened to agriculture, the ecological balance has been modified and different pests have appeared, with rodents being the principal one.

Rodent control, of mainly field rats, has been applied for a long time in certain areas, but the use of poisons such as endrin, strychnine, and zinc phosphide have only been used in a National Campaign since 1974. These poisons cause a lot of problems such as death of wildlife and domestic fauna, rejection of the materials by the rodents, and, in addition to these, they can cause a lot of unnecessary pollution. These poisons also present a danger to man with respect to their handling. Moreover, the poisons are actually very expensive, especially because of high dosages which are often required, and the great amount of bait needed to kill the unpleasant odor and flavor of these poisons. For these reasons it has been necessary to test other rodenticides in order to resolve these problems.

Anticoagulants have been used in Mexico in sugarcane areas since 1951 to control Sigmodon hispidus (Carrasco and Abarca, 1963). However, anticoagulants have not been used outside the sugarcane areas for the control of other species of rodents. The reasons for this are that anticoagulants are considered expensive and their distribution requires a lot of manual labor because it is necessary to replace each bait after it has been consumed.

In other countries, many laboratory experiments have been carried out investigating the effects of varying dosages of anticoagulants on different species of rats (Howard, 1970; Abrams, 1974; Bull and Francis, 1976; Bull, 1976).

Anticoagulants have been proved and utilized to control rodents not only in farms and warehouses, but in agricultural land too; a number of examples are herewith shown: a mixture of grains with anticoagulants were soaked in liquid parafin to protect them against humidity and were used in some cities of the United States to control Rattus rattus and Mus musculus; the same method was used to control Microtus sp. in orchards (Marsh and Lloyd, 1960); the protection of anticoagulants against the rain by covering them with repellent paper tubes were used in Wisconsin to control Microtus pennsylvanicus in an apple orchard (Libby and Abrams, 1966); warfarin was used to control Sigmodon hispidus in Panama (Spencer, 1968); the use of 0.01% diphacinone has been used to control Peromyscus maniculatus in coniferous forest regeneration (Howard and Marsh, 1970); in Nicaragua, Racumin has been utilized to control the cotton rat (Sigmodon spp.) (Kuerno et al., 1971); and endrin has been substituted by diphacinone and clorophacinone to protect conifer seeds against Peromyscus maniculatus (Marsh et al., 1974). Finally, bagging baits with diphacinone were applied to control Rattus norvegicus in Hawaii (Teshima, 1976).

The objectives of this experiment were: 1) To test the effectiveness of warfarin as an anticoagulant rodenticide against Sigmodon hispidus major populations throughout 4,000 ha. on different crops in Sinaloa, Mexico; 2) to know if the poisoned baits in polietilinized paper bags are accepted by the rodents; and 3) to reduce the cost of poisoned baits.

DESCRIPTION OF THE TWO EXPERIMENTAL AREAS

One of the experimental areas is located 45 km. SW of the town of Guamuchil which has 1,600 ha. of agricultural crops. The other area is 6 km. NW of the town of Carrizo which also has 1,600 ha. of agricultural areas. The land in both areas had been ploughed but nothing, at the time of our experiments, had been sown, but immediately surrounding both experimental areas crops such as corn, wheat, chickpea, and sorghum had been sown.

A total of 400 ha. having the same environmental conditions as the experimental areas and situated near each experimental area was used as check plots.

METHODS

Trapping

In order to evaluate the effectiveness of warfarin, trapping surveys were made during 2 consecutive nights. The purpose was to determine the rodent population before and after the experimental treatment in both the experimental areas and the check plots. In the Guamuchil area, 2 plots were chosen in which 200 traps were placed each night in the experimental and untreated areas. In the Carrizo area, 3 plots were selected in the experimental area in which 300 traps were placed, and in the check plot only 100 traps were placed.

For the trapping surveys snap traps baited with one piece of corn-tortilla soaked in corn oil were used. These snap traps were then placed in selected areas in rows of 100 traps per plot, with 20 m. between each trap. The next morning all captured rats were collected and details of sex and species were noted; in the afternoon, the traps were again placed in the same position as described above. Seven days after the application of the poison, a repetition of the above trapping exercise was carried out, again over two consecutive nights. Details of haematosis and hemorrhaging were observed in captured rats (eliminating these samples from the final results).

BAIT PREPARATION

Formula

Material	Percentage
Wheat	46.5
Sorghum	46.0
Sugar	2.5
Corn oil	1.0
Industrial oil	3.0
Wheat meal	0.5
Warfarin 0.05%	0.5
	100.0

Bait Preparation

Using 0.05% warfarin, 3.2 and 3.5 tons of bait formulation were prepared for the experimental areas of Guamuchil and Valle del Carrizo, respectively.

A. Mixture: The warfarin was premixed with wheat meal before its incorporation with the remainder of the material, then all were mixed in a grain compounder for 20 minutes.

B. Bagging: An automatic machine made in Mexico which fills and seals bags automatically and is labeled PAS-76 (Automatic Process Simplified Model 1976 by Carlos Carballo, Inc.) was utilized to bag the poisoned baits. These bags are made of polietilinized paper and adequately labeled with signs of danger and caution. The bags size are 15x6cm. The machine fills each bag with 40 grms. of bait and produces 60 bags/min. With a sprayer the bags were sprinkled with corn oil as an attractant.

Bait Application

In Guamuchil the bags were manually placed 2 m. apart on each side of the drains to ditches, irrigation canals, roads, etc., for an average application of 2 kg/ha.

At the Valle del Carrizo there 3 bags were placed 1.5 m. apart, applying 2.18 kg/ha.

RESULTS

Acceptability and Duration of Bags

Seven days after the treatment it was observed that there had been good acceptance of the baits by the rodents, with a great many of the bags partially or totally consumed.

Five months after this test, the experimental locations were again visited and the untouched bags had not been damaged by humidity.

Population Index

The result of the trapping surveys at the Guamuchil plots is shown in Table 1.

In plot I, in Guamuchil, the average number of rodents captured in two nights before treatment was 47.5 (100%); the average after treatment was 17.5, meaning a control effectiveness of 63.16%.

The average number of rats captured on plot II before poisoned baits were applied was 37.5 (100%); the post-treatment result was 9.5, therefore the percentage control with warfarin in this area was 74.67%.

Table 1. Field results of 0.05% warfarin bait bags (at 2 baits/ha).

Experimental Areas	Plots	No. Rodents Captured (2 Nights Before)	No. Rodents Captured (2 Nights After)	No. Rodents Captured (2 Nights Nontreated)	% Reduction
Guamuchil, Sin.	I	47.5	17.5	--	63.16
	II	37.5	9.5	--	74.67
	III	57	--	54	--
	IV	49	--	35	--
El Carrizo, Sin.	I	26.5	5.0	--	81.13
	II	45.4	3.0	--	93.40
	III	25.5	7.0	--	72.54
	IV	43.5	--	37.0	--

On plots III and IV of the same area, the average number of captured rats before treatment was 57 and 49, respectively; the average post-treatment was 54 and 35, with a difference of 3 rats in plot III and 14 rats in plot IV.

The trapping results, before and after treatments, in Valle del Carrizo are also presented in Table 1. The percentage of reduction in the population index observed in the experimental areas were 81.13, 93.40 and 72.54%.

If any of the trapped animals showed symptoms of poisoning (having a slow motion, hirsute hair, trembling), these rats were dissected. They all showed subcutaneous haematosis and hemorrhages, thus confirming that they had eaten the bait and the effectiveness of warfarin with these species.

Main Species Captured

In the trapping done in the experimental area of Guamuchil before the treatment, Sigmodon hispidus major was the dominant species (91.57%), Rattus rattus (1.5%, Mus musculus (1.5%), Oryzomys sp. (2.10%), Perognathus golmani artus (2.89%), and Reithrodonthomys sp. (0.26%)

In the same trapping in Valle del Carrizo, Sigmodon hispidus major dominated (81.01%), over Perognathus golmani artus (8.74%) and Rattus rattus (5.24%).

Cost-benefit Relationships

The total cost of material to prepare one ton of poisoned baits with 0.05% of warfarin was 45.50% cheaper over the material needed to prepare one ton of poisoned baits with 2% zinc phosphide, which is commonly utilized in these areas, if both formulations used the same inert material.

The amount of paper to bag one ton of bait with warfarin (in 40 g bags) was 45.45% less than the total cost to bag one ton of bait with zinc phosphide (in 10 g bags). The time utilized to bag a ton of bait with the machine was 37.59% less and 37.57% cheaper with warfarin than with zinc phosphide.

The costs of application in the field of the baits with warfarin in 40 g bags was 46.67% cheaper than of baits with zinc phosphide in 10 g bags.

DISCUSSION

In Mexico the inert material utilized in the formula is ostensibly cheaper than those materials recommended by other authors, which suggest oat groats, broken rice, and integral meal (Kuerno, 1971; Abrams, 1974; Teshima, 1976).

The idea of distributing bait in bags is not new. It was done in Nicaragua to control Sigmodon sp. (Kuerno et al., 1971); the warfarin baits in bags, without attractant, gave negative results. In Hawaii baits in bags (300 g.) have been used to control Rattus norvegicus, with good results (Teshima, 1976). The polietilinized paper bags with corn oil as attractant that were utilized in this experiment proved to have very good acceptance by the rodents present. It is possible that the plastic bags utilized by Kuerno (op. cit) would have had better results if they had been covered with a good attractant. The results obtained by Kuerno and Teshima and the results of this test suggest that the acceptance of bags is variable depending upon the species involved, but in general it is considered to be necessary to use attractants.

The use of anticoagulants in the field is not accepted due their high cost and the amount of hand labor that is required to rebait with the material (Howard and Marsh, 1970); in many developing countries as Korea, acute poisons such as endrin, 1080, and strychnine are still in use for rat control due to their low cost (Marsh, 1973).

With the method utilized in this experiment, it is calculated that the anticoagulants are more economical than acute poisons such as zinc phosphide; the automatic bagging eliminates much hand labor, which is then needed only to distribute the baits. This method is sufficient to control the species mentioned, which do not require rebaiting.

Actually, in Mexico (with sugar eliminated and the corn oil changed in the formula mentioned to industrial oil poisoned baits have been utilized with 0.05% warfarin in 40 g. bags in 500,000 ha. of irrigated crops in the state of Sinaloa. With this method in 1977, there was a considerable reduction in the cost, from $630,295.00 to $263,085.00, which means 58.27% less.

In the United States (Marsh, 1973) recommended not to use the same kind of poison continuously. Following the suggestions of Marsh, it is considered that it is necessary to use the same rodenticide for only a short period of time then rotate with a different anticoagulant.

Not all anticoagulants have the same activity with different species of rats, nor is the same amount required to be consumed to be lethal, and for this reason it is necessary to make more tests so as to regulate the concentration used in different localities.

CONCLUSION

1. The bait with 0.05% warfarin was effective over populations of Sigmodon hispidus major, Perognathus golmani artus, Reithrodonthomys sp., Rattus rattus and Mus musculus.

2. The specie of rat dominant in the experimental area was Sigmodon hispidus major with 91.57% in Guamuchil and 86.01% in the Valle del Carrizo.

3. The total cost of the baits utilized in this experiment was 50% cheaper than baits used with zinc phosphide.

4. The trapping of two consecutive nights with 100 snap traps is sufficient to know the population index in each area, before and after the treatment.

5. The 40 g. polietilinized paper bags are easy to distribute, resist high precipitation, and permit impregnation with attractants.

6. The automatic bagging saves in cost of preparation and distribution.

7. With the utilization of anticoagulants and automatic bagging, the bags can be labeled with warnings so that the hazards of poisoning to man, domestic animals and wildlife are reduced.

ACKNOWLEDGMENTS

This research was conducted with funds provided by the Dirección General de Sanidad Vegetal, S.A.R.H., México, and the Patronatos para el Fomento e Investigación de Sanidad Vegetal of Sinaloa, México.

We are grateful to Ing. Victor Flores Sánchez and his group for their help and excellent cooperation, which made this test possible. The authors are particularly grateful to Dr. Federico Sánchez Navarrete for his help in preparing this manuscript.

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