RODENT CONTROL PROGRAMS: USE OF THE INKED TRACKING BOARD METHOD IN MEXICO[1]

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Despite the increasing problems posed by commensal rodent populations around the world, ideal methods for evaluating the effectiveness of control measures are lacking. This article describes a method that shows promise of promoting a major advance in rodent control program evaluation.

Introduction

It is readily apparent, with increasing densities of human populations everywhere, that there is a growing problem in controlling commensal rodents. Particularly in rapidly growing urban situations, where traditional values and services tend to deteriorate, fewer citizens tend to abide by long-established rules of community hygiene. More and more, garbage and other refuse is being disposed of simply by being dumped in empty lots or along roadsides, and in many places increasingly commonplace strikes by municipal refuse collectors aggravate the situation.

Rodents play a role as hosts or vectors of a very large number of important human and livestock diseases, 31 of which are listed in Table 1; and a long list of parasitic microorganisms (viruses, bacteria, etc.) not yet known to cause diseases in man or domestic animals have been isolated from rodents *(1)*. In addition, rodents' importance as a cause of food loss often exceeds their importance as disease hosts or vectors, a fact recognized by the United Nations and its member agencies *(2, 3)*. W. B. Jackson *(4)*, who has evaluated rodent depredations of crops and stored products, has compiled data indicating that rodents produce significant losses of many crops—including sugarcane, rice, corn, wheat, sorghum, coconuts, cacao, cotton, peanuts, and soybeans—in countries around the world.

Three rodent species are primarily responsible for such food losses and for other rodent damage such as destruction of electrical devices (by gnawing of insulation) or destruction of books and other supplies. These are the brown rat *(Rattus norvegicus)*, the black or roof rat *(Rattus rattus)*, and the house mouse *(Mus musculus)*. All three species, which originated in Asia, have long since spread throughout the globe and today are important pests everywhere. Other rodent species—such as *Sigmodon hispidus*, the cotton rat, which infests cotton fields in Central and South America, and *Holochilus brasiliensis*, the marsh rat, which infests rice-growing areas in South America—can do considerable harm. Overall, however, important damage by such other rodent species is relatively rare *(5, 6)*. On the other hand, many rodents other than the three aforementioned commensal species are involved in health problems *(7)*.

For these various reasons, it is not surprising that control of rodent populations has received considerable attention from both public authorities and private interests. On the one hand, extermination companies have tended to stress rodent control through application of poisons; and, on the other, more knowledgeable authorities have repeatedly pointed out that permanent control measures should be directed at removal of food sources, nesting sites, and other refuges *(8-10)*.

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Table 1. Some rodent-borne diseases of man.

Disease	Agent	Rodent host/vector
Viral diseases:		
Venezuelan encephalitis	VE virus	*Proechimys* sp.
West Nile encephalitis	West Nile virus	*Rattus rattus*
Kyasanur Forest disease	KFD virus	*Rattus rattus*, etc.
Omsk hemorrhagic fever	Omsk virus	*Ondatra zibethica*
Argentine hemorrhagic fever	Junin virus	*Calomys laucha, Calomys musculinus*
Bolivian hemorrhagic fever	Machupo virus	*Calomys callosus*
Lymphocytic choriomeningitis	LCM virus	*Mus musculus*, etc.
Crimean hemorrhagic fever	CHF virus	*Apodemus* sp.
Korean hemorrhagic fever	KHF virus	*Apodemus agrarius*
Lassa fever	Lassa virus	*Mastomys natalensis*
Russian spring-summer encephalitis	RSSE virus	*Apodemus* spp., etc.
Tick-borne encephalitis	TE virus	*Apodemus flavicollis*, etc.
California encephalitis	CE virus	*Spermophilus lateralis*, etc.
Rabies	Rabies virus	*Rattus* sp.
Rickettsial diseases:		
Murine typhus	*Rickettsia mooseri*	*Rattus* sp.
Scrub typhus	*Rickettsia tsutsugamushi*	*Rattus* spp., etc.
Spotted fever	*Rickettsia rickettsia*	*Microtus* sp., etc.
Q fever	*Coxiella burnelli*	*Meriones* sp., etc.
Bacterial diseases:		
Plague	*Yersinia pestis*	*Zygodontomys* sp.; *Oryzomys* sp.; *Colomys* sp.; *Rattus* sp., etc.
Salmonellosis	*Salmonella* spp.	*Mus musculus*, etc.
Leptospirosis	*Leptospira* spp.	*Rattus* sp., etc.
Tularemia	*Francisella tularensis*	*Meriones* spp.
Brucellosis	*Brucella* spp.	*Hydrochaeris hydrochaeris*
Rat-bite fever	*Spirillum minus*	*Rattus* sp.
Rat-bite fever	*Streptobacillus moniliformis*	*Rattus* sp.
Fungal diseases:		
Histoplasmosis	*Histoplasma capsulatum*	*Rattus* sp.
Trichophytosis	*Trichophton* sp.	*Mus musculus*, etc.
Parasitic diseases:		
Leishmaniasis	*Leishmania brasiliensis*	*Proechimys* sp.
Chagas' disease	*Trypanosoma cruzi*	*Rattus rattus*, etc.
Schistosomiasis	*Schistosoma mansoni*	*Nectomys squamipes*
Asian schistosomiasis	*Schistosoma japonicum*	*Rattus* sp.
Trichinosis	*Trichinella spiralis*	*Rattus* sp.

What is surprising is the general failure of otherwise responsible authorities to appreciate the importance of rodent control program evaluation *(11-14)*. In this regard, it should be noted that authoritative recommendations for entomological control programs (especially vector control programs) always call for post-control evaluation *(15)*.

Furthermore, evaluation of rodent control measures should not be based simply upon counting the rodents killed by an extermination project. For even when the control program involves the use of poisons, some of the better agents have a delayed effect, resulting in the rats dying underground and thus not being visible for counting. And, of course, the best control measures, those involving environmental modification and resulting in permanent elimination of the pest, do not produce mass die-offs. Proper evaluation must therefore be based upon censuses or other measures indicating rodent population abun-

dance that are carried out before and after the control program. The observed degree of rodent population reduction then indicates the degree of success of the program.

Far too often, however, the success of rodent control programs is loudly proclaimed in the newspapers and other public media without evidence from any evaluative procedure to support such claims. Perhaps it is the cost of repeated visits to sites that makes so many exterminators reluctant to have evaluation made a part of the overall project. Nevertheless, truly responsible authorities do recommend making evaluation a part of rodent control programs *(15, 16)*.

Typically, most evaluations are based either on censuses involving capture and recapture (a laborious procedure in which the statistical confidence limits give less than satisfactory results) or on indices of relative abundance such as trapping success data or counts of rodent signs. These indices have the advantage of being readily adaptable to statistical analyses such as the chi-square test.

Trapping provides one of the best foundations for evaluation, partly because the species caught can be readily verified. Unfortunately, traps are expensive and tend to be stolen when used in urban settings. Nevertheless, when funds are available to purchase sufficient traps and trap losses can be borne, this method is worthwhile.

Evaluation based on counts of rodent signs (e.g., active dens, fresh fecal material, gnawing of wood or other materials) has several disadvantages. Even when experienced specialists make independent counts of the same area, such as a city block, their results seldom match. Thus, whenever counts are to be made before and after control measures, it is very important that the same individual make both counts. In addition, the results may be influenced unconsciously by the fact that the specialist knows a control program has been carried out—and so, expecting to see fewer rodent signs, he may now classify as old signs what previously might have been classified as recent or fresh signs.

One useful method that eliminates any need to have the same person make before and after counts, and also eliminates the factor of subconscious prejudice, involves the use of tracking powder. Evaluators employing this method treat strategic areas with talc or some other powder and leave the powder for one night (rarely longer, due to possible disturbances), after which the presence or absence of rodent tracks is recorded. When counts are made before and after successful control measures, the proportion of positive stations (sites treated with tracking powder) will be significantly smaller on the second count, a result that can be analyzed by means of the chi-square test.

A useful variation on this technique, involving use of inked tracking boards, has been employed less often *(17, 18)*. The original studies that used these tracking boards successfully were designed to gauge rodent abundance in various habitats as part of work concerned with the presence of Junin virus, the causative agent of Argentine hemorrhagic fever. However, no attempts were made to determine the rodent species composition involved, nor were permanent records made of the results.

The object of the present article is to describe further developments in the use of tracking boards that permit a determination of the species composition and the relative abundance of populations to be made, allow operations to be conducted in the open or under field conditions despite rain, and provide a direct and permanent record of rodent tracks that can be filed and used for future reference.

Methods

The tracking boards used in this study were uniformly smooth, semirigid vinyl floor tiles, 30 cm square, and white or gray in color. A piece of white paper 21 x 28 cm (8-1/2 x 11 inches) was attached by paper or plastic adhesive tape to the middle of each board. The two sides of the board not covered by the paper

were painted with a mixture of one part of newspaper printing ink and three parts of an edible cooking oil (corn or safflower oil) or mineral oil (paraffin oil, oil of vaseline). This oily mixture was applied with either a paintbrush or a rubber roller.

This use of paper in a field or in other open and exposed situations requires the use of a simple plywood roof to cover the tracking board in case of rain or heavy dew. This roof provides additional service by blocking off both sides of the tracking board that are not inked, making it necessary for rodents to traverse the inked areas before walking on the paper (see Photos 1 and 2).

In order to identify the tracks of different rodent species, it was necessary to have on hand a file of the tracks of indigenous species. These were obtained by trapping the species alive and transporting them to the laboratory, where their tracks were recorded. This recording was accomplished by placing each animal in a deep, smooth-sided container (a plastic wastebasket) from which it could not escape. A piece of white paper (21 x 28 cm) and an open ink pad were also placed in the container, and the rodent was permitted to walk around at will, passing over the ink pad and leaving tracks on the paper. In most cases, more than one individual of a given species was used to make the record for that species, and between four and 10 record-papers were obtained for each species. This procedure assured that high-quality tracks were obtained (see Photo 3).

The tracking boards described above were subsequently used in two projects. The Municipality of Toluca, Mexico, used them to evaluate its rodent control program in a municipal market; and the State of Mexico used them to evaluate the effectiveness of different rodenticides in agricultural fields.

For the municipal market evaluation, tracking boards were placed in the market stalls; some were also placed in aisles, bathrooms, and other locations. In all, 127 tracking boards were used. These were placed in the same positions both before and after the control measures were carried out. Because food was readily available, peanut butter was used as an attractant, each tracking board being baited with about a gram placed in the center of the paper.

For the agricultural field evaluation, five one-kilometer strips 10 meters wide were selected, all these being located between fields of mature corn. Each of four strips received a different type of rodenticide, while the fifth strip received no rodenticide and served as an experimental control area. Tracking boards were placed in a line at intervals of 10 meters before and after application of the rodenticides. No bait attractant was used in this evaluation.

Results

Of the 127 tracking boards placed in the municipal market before implementation of the rodent control program, 16 (12.6 per cent) were positive for *Rattus* and 11 (8.7 per cent) were positive for *Mus*.

The subsequent control measures consisted partly of placing 12 bait boxes containing warfarin baits in suitable locations over a period of four months. These boxes were placed according to the tracking-board results, emphasis being given to the areas showing the highest prevalence of *Rattus*. The control program also instituted a change in the time of sweeping up waste food, so that such food was swept up in the late evening rather than the early morning, thereby removing most of the food that had been available at night.

Of the 127 tracking boards placed in the market after these measures were carried out, four (3.2 per cent) were positive for *Rattus* and seven (5.5 per cent) were positive for *Mus*. The 75 per cent reduction of *Rattus* was statistically significant at .995 ($X^2 = 9.0$). The 36 per cent reduction of *Mus* was not statistically significant ($X^2 = 1.45$, $p > 0.05$).

Regarding the agricultural field studies, Table 2 indicates the results of the field trials of different rodenticides as estimated by use of

Photos 1 and 2.
Used tracking board with roof lifted to show rodent tracks (above) and with roof removed (below).

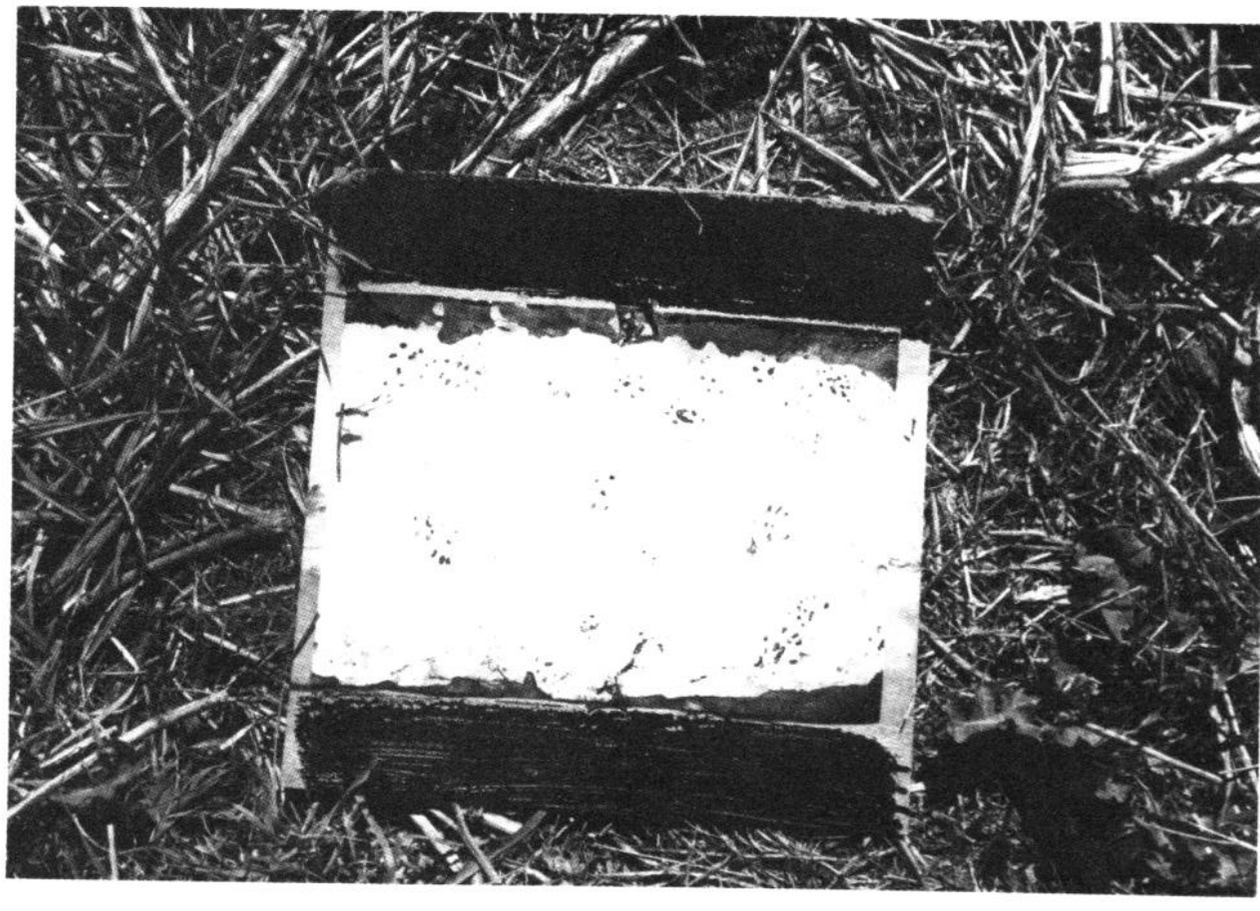


Table 2. Tracking-board results obtained at four land-strips receiving different rodenticides and at one untreated control strip.

Rodent genus		Land-strips receiving the following rodenticides.				
		Zinc phosphide %	Warfarin %	Type I chlorophacinone %	Type II chlorophacinone %	Control strip (untreated) %
Rattus	(1) boards positive before treatment	12	17	8	17	35
	(2) boards positive after treatment	23	16	12	11	33
	Difference (1 minus 2)	+11	-1	+4	-6	-2
	% change	+92	+45	+50	-35	-6
Microtus	(1) boards positive before treatment	11	7	9	5	6
	(2) boards positive after treatment	4	3	2	1	7
	Difference (1 minus 2)	-7	-4	-7	-4	+1
	% change	-64	-57	-78	-80	+16
Peromyscus	(1) boards positive before treatment	3	0	1	0	6
	(2) boards positive after treatment	1	2	2	2	7
	Difference (1 minus 2)	-2	+2	+2	+2	+1
	% change	-	-	-	-	+16
All three types of rodents	(1) boards positive before treatment	25	24	19	23	46
	(2) boards positive after treatment	28	21	16	14	47
	Difference (1 minus 2)	+3	-3	-3	-9	+1
	% change	+12	-13	-16	-39	+2

Table 3. Dead rodents found after application of rodenticides.

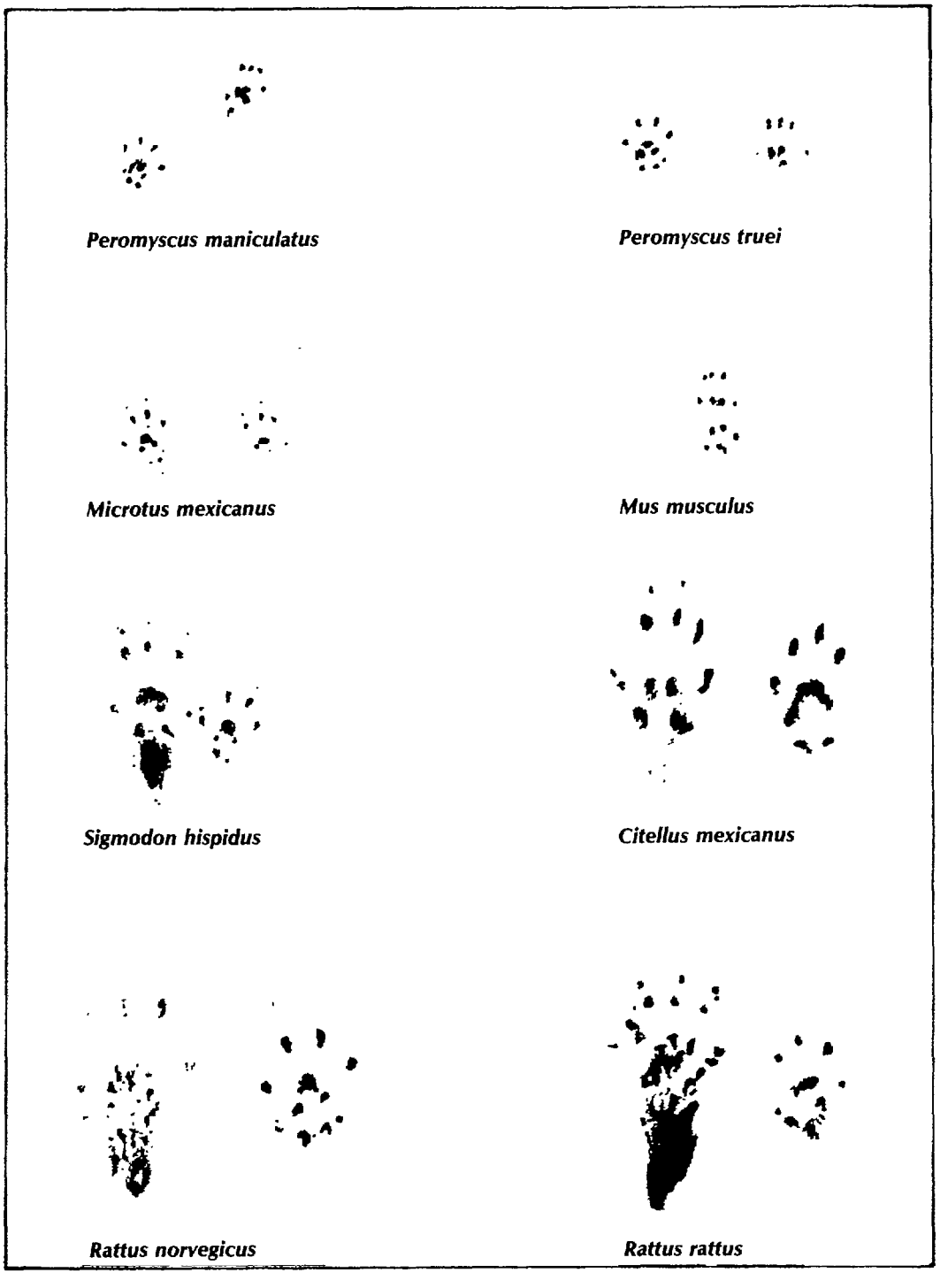
Rodent genus	No of dead rodents found on land-strip where indicated rodenticide was applied				Total
	Zinc phosphide	Warfarin	Type I chlorophacinone	Type II chlorophacinone	
Rattus	0	2	1	4	7
Microtus	6	3	1	4	14
Peromyscus	0	1	1	6	8
Total	6	6	3	14	29

the tracking boards, showing the percentages of boards positive before and after treatment. Table 3 indicates the number of dead rodents recovered in this test. No dead rodents were found in the reference area. The differences in the results obtained with chlorophacinone type I and chlorophacinone type II (for all rodents) was statistically significant ($X^2 =$ 14.5) at .995. In addition, the results clearly show differences in species susceptibility which are also amenable to statistical analysis.

Discussion

The tracking-board evaluation of the rodent control program in the municipal market

Photo 3.
Inked track samples of eight rodent species common in Central Mexico.



showed a 75 per cent reduction in *Rattus,* a statistically significant change demonstrating the utility of a reliable evaluation technique. The reduction was realistic and the evaluation was unbiased, thus providing data which cannot be disputed. Also, the lack of a significant reduction in the *Mus* population indicated a control program shortcoming that could possibly have been due to the emphasis placed on elimination of *Rattus.*

The results also show the advantage of taking a census before implementing control measures. Among other things, this made it possible to pinpoint the locations of *Rattus* within the market, and thus permitted more accurate placement of the bait boxes, reducing the number of boxes needed and increasing their effectiveness.

Elsewhere, a similar census of rodents has been made by deploying tracking boards at another municipal market in Toluca prior to a rodent control program. (At the time of this writing the program's control measures had not been implemented.) Comparison of that census with the other "before" census in a municipal market shows how the tracking-board method can help to demonstrate differing degrees of rodent infestation. In the first market, the total proportion of positive tracking boards was 21.3 per cent *(Rattus* and *Mus* tracks combined). In the second market this same proportion was 43.2 per cent (29.7 per cent *Rattus* and 13.5 per cent *Mus).* The difference was statistically significant ($X^2 = 18.98$), indicating a considerably greater rodent problem in the second market.

While the test in the markets also demonstrated the feasibility of differentiating between mice and rats by means of tracking boards, this advantage of the technique became more obvious in the agricultural field test, where *Rattus* and two species of native mice *(Microtus mexicanus* and *Peromyscus maniculatus)* were involved. Here the results indicated clear differences in the three rodents' susceptibility to the various rodenticides applied. As Table 2 shows, the mice were affected by the zinc phosphide baits but the rats were not. Possibly the rats were repelled because the baits contained 1.86 per cent of the toxic ingredient, well above the 1.0 per cent recommended *(19).* These results provide a good illustration of the tracking-board technique's capabilities, as compared with other techniques using smoked paper or tracking powder *(20).*

Although none of the rodenticides tested drastically reduced the rodent populations, perhaps because natural food was available in abundance, the tracking-board technique was able to demonstrate that type II chlorophacinone was significantly more effective than the other rodenticides tested ($X^2 = 14.5$). It is also clear that while the few dead rodents found did reflect the tracking-board results, they did not provide a useful basis for evaluation because their numbers were too low.

Conclusions

In view of human population trends, it seems evident that rodent control programs will be increasingly needed, and it should be clear that proper programs must be evaluated with unbiased methods. While trapping before and after control programs is possibly the most desirable method, variations in trap size can introduce important biases with respect to the rodent species caught; and the cost of the traps, plus the likelihood of incurring important losses due to theft, make this method impractical in most cases. Thus, a procedure using inked tracking boards and incorporating the improved features presented in this article would appear to provide a comparatively useful and practical method for evaluating rodent control programs. The method lacks the aspect of bias which is present in most other techniques currently employed; and although analyses of the data obtained should be carried out by specialists, other aspects of the technique can be performed by relatively unskilled persons.

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SUMMARY

Rodents are posing increasing problems around the world as the densities of human population rise, so it is not surprising that public authorities are devoting considerable attention to their control. Unfortunately, nothing like proportionate attention has been devoted to evaluating these control efforts, making the efforts' success hard to gauge and follow-up measures hard to plan.

A prime reason for this is the difficulty of conducting such evaluations. Merely counting the rodents killed by control measures is ineffective; trapping is expensive; traps in urban settings may be stolen; and counts made of rodent signs (dens, feces, and tooth-marks) tend to be subjective.

One procedure that could make evaluations considerably easier involves the use of inked tracking boards to assess rodent abundance. Portions of each board are inked, the rest of the board is covered with white paper to record rodent tracks, and in outdoor settings the board is covered with a roof to protect against the weather. Numerous boards are then placed in the area to be assessed for one night. The percentage of boards found with tracks the next day yields a rough index of rodent abundance, and the tracked papers provide a storable record of the particular tracks and rodent species involved.

Use of this procedure at municipal markets in Toluca, Mexico, showed it to produce realistic and unbiased results; employing the boards before control measures were taken made it possible to pinpoint areas where such measures were most needed; and deploying them after the measures had been taken gave a statistically significant reading of those measures' relative success.

Elsewhere, use of the tracking boards in rodent-infested cornfields made it possible to distinguish between the three rodent species involved and the susceptibility of these various species to four rodenticides. In this case, although none of the tested rodenticides drastically reduced the rodent populations, perhaps because natural food was abundant, the tracking boards showed that type II chlorophacinone was significantly more effective than the other rodenticides applied.

All in all, the results of these trials suggest that the inked tracking-board technique can provide a useful and practical method for evaluating rodent control programs. This technique avoids the element of bias present in most other evaluation methods currently employed; and preparation, deployment, and collection of the boards can be performed by relatively unskilled personnel.

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