An Evaluation of Rat Control Methods

Edwin L. Tyson
(Smithsonian Institution, USA)

驅鼠法의 評價

에드윈 · 엘 · 타이슨
(美國 스미소니안 硏究所)

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摘 要

著者는 네가지 驅鼠法 즉 쥐덫, pyval, raticate, shoxin 및 warfarin을 比較 評價하였다. 이들 方法은 각기 特有의 長點을 갖고 있어서 優劣을 가리기 어려웠다. 네개의 마을을 대상으로 採한 쥐의 數는 平均 14.63마리 (1人當 2.01마리) 였으며 이들 마을에서 大部分의 집쥐類의 驅除에 따른 他齧齒類의 侵入은 볼수 없었다.

INTRODUCTION

Rats and mice are perhaps the most abundant vertebrates in Korea. In areas of human habitation, individuals of the species *Rattus norvegicus* and *R. rattus* are by far the most common. These are often excessively abundant, and may be found living in almost every place where they are able to find suitable areas within and around farm houses, in villages and in cities, and even in the fields and forests during the summer. These huge numbers of rats do untold damage to available objects such as rice straw bags, clothing, etc., and they consume millions of dollars worth of agricultural products such as grain and vegetables both in the field and in storage. Furthermore, rats are known to be implicated in the epidemiology of several serious diseases including hemorrhagic fevers.

This study was supported by the 406 th Medical Laboratory, Camp Zama, Japan, as part of its study on the epidemiology of Eastern or Korean Hemorrhagic Fever (KHF), in cooperation with the Smithsonian Institution, Office of Ecology, the U.S. Army 5th Preventive Medicine Laboratory, the 2nd Division Surgeon's Office and the offices of the Surgeon and Engineer, U.S. Eighth Army. Financial support was provided in part by contract No. F 44620-67-C-0013, U.S. Air Force Office of Scientific Research entitled Ecological Study in Korea.

PURPOSE

Tyson (1967) studied rats in military compounds in the epidemic area of KHF and pointed out a vast difference in the abundance and species between rat populations in military compounds as compared to local villages and farm houses. It appeared from these studies that KHF was more prevalent in areas not occupied by *Rattus*. These differences in rat populations were believed to be caused by the rat control program of the U.S. Army. Therefore, this study was designed to determine just what changes would take place during the winter, from mid-November 1967 through February 1968 if the abundance of *Rattus* was controlled in local villages. Further, control methods were devised in such a way as to determine the relative effectiveness of three rat poisons, namely; warfarin, pyval, and raticate, all commercially available anti-coagulants that are relatively harmless to most pets and children if properly employed.

DESCRIPTION OF VILLAGES

Four small villages were selected which were made up of from 12 to 16 houses excluding all storage bins and other outhouses usually associated with typical Korean farm villages. All villages were within two kilometers of each other in Kyonggi-Do, Paju Gun, at approximately 37° 50″ 30′ north latitude and 126° 52″ east longitude, approximately 40 kilometers north-northwest of Seoul. For purposes of identification, villages were numbered as follows: number 1, Daemun Ri; number 2, Kunmal Ri; number 3, Sam Ri; number 4, Kaya Ri.

Each village was distinctive in character, yet there were similarities which may allow them to be separated into two general types. First, villages No. 1 and 3 were built following the Korean War (1950-1953) and perhaps no more than half the houses were constructed in the typical sturdy Korean fashion. There are no ancient stone walls in either village where rats may dig dens outside the houses. Many of the people work on the local military bases and are not all farmers as in the other two villages. Therefore, there are fewer storage bins for grains, namely rice. Villagers often purchase their rice in large straw sacks and simply place it anyplace where it is always exposed to rats. Only a few of the houses have animals such as hogs and cattle which live in outside pens; therefore, these villages provide less available food and fewer habitable places for rats than the others. Second, villages No. 2 and 4 are both well over one hundred years of age, all houses are typical sturdy farm houses, most have storage bins, animal pens, and often other outhouses. The old stone walls and the typical houses provide ample living space for more rats, especially the burrowing *Rattus norvegicus*, than the other two villages. Village No. 4 has more walls than No. 2.

Winter fuel in Korean villages and farm houses is almost exclusively rice straw and brush and grass which has been gathered from the surrounding hillsides and mountains. This fuel is baled and stacked in huge stacks within the house compound along with the rice straw, all affording good hiding places for rats that come into the villages from the rice fields and hillsides following harvest time. Most of the houses in all villages had rice straw thatched roofs from several inches to about a foot thick, and *R. rattus* could often be seen in these. The sunken kitchen areas adjacent to the warm-floor rooms afford ideal and warm rat harborages for the winter.

Method of food storage is probably more conducive to the huge rat populations than any other one factor. Rice is usually stored in open top bins often with rat holes at the bottom and sides, in rice-straw matted silos out in the open yard, in rice-straw woven sacks, but rarely in rat proof bins of any kind. Kimchi, common winter food of vegetables, is stored just below the ground surface in ceramic pots with the top covered only with small coverings that are often easily removed by rats. Food in the kitchens is almost always left in the open where rats can get to it. Waste food is usually tossed out the door and left for the rats or any other scavengers. Human excrement is collected in small shed and mixed with ashes or collected in huge storage tanks until it is used as fertilizer in the fields. Animals such as hogs, goats, chickens, cattle and dogs are fed either on the ground or in open and often small containers thus allowing for considerable waste of food stuffs which may be picked up by the rats.

Every house in every village had an abundance of rats, an abundance of food, but living space was usually more ample in villages No. 2 and 4. Each village is located between rice paddies and adjacent hills where all the brush and grass is removed each winter for fuel. Few trees are growing on the hills and few of these are over 10 meters tall, such as pines, oaks and black locust. Winter temperatures during the study ranged between 15°F below zero and up to 45°F above, occasionally. Snow was never over four inches deep but some was always on the ground in shady areas. The rice paddies were frozen from late November until late February.

METHOD

All villages were treated the same way as far as possible, only the baits varied, therefore, this description covers all four of them. Initial selection of work areas was made from a helicopter while flying at about one thousand feet above the surface. Villages made up of from 12 to 16 houses were chosen. After aerial selection of six possible sites, four were chosen for work following ground reconnaissance, considering availability of access roads primarily.

After villages were selected, a team of three persons,

one of which was Korean, returned during the week of November 20-24, 1967, to put out traps and prebait stations. First, each village was visited and an appointment was made with the head man of the village. He in turn called a meeting of the village people. Second, we returned to discuss our control program with as many people as the head man could get together. Usually, most of the women and children attended and showed considerable interest in the plan, but few men indicated any interest. Third, we placed the bait tubes and traps throughout the villages and baited them with a non-poisonous prebait.

Site selection for bait tubes was determined on the basis of distance between tubes and houses, an effort being made to keep tubes within fifty feet of each other and at least two tubes per house. Traps were placed where the most rat signs were in evidence regardless of the location of the tube. A bait cup with bait was placed in each trap and the traps were sealed open so rats could come and go. All traps and tubes were prebaited with a standard food made by mixing 450 pounds of corn meal, 4 gallons of salad oil and 8 ounces of charcoal, used to discolor the meal so it would not appear palatable to the many children.

Traps used were the standard Korean hand-made type which were purchased on the local market for 45 won each. They were poorly made of very light weight chicken wire with mesh sizes from 0.5 to 0.75 inches. This trap was suitable for adult and medium sized rats only, as smaller ones were able to escape through the meshes. Very satisfactory bait tubes were made of three beer cans with their ends cut out, and one inserted into the other, to provide a tube almost three beer cans in length. These were made on the local Seoul market for 6 won each. Tubes were painted on the outside in Korean indicating that they contained rat poison. Bait cans for traps were made by cutting about 0.75 inches off the bottom of beer cans at a cost of only 3 won each.

During the two weeks of prebaiting with the placebo alone, the rats ate most of the bait from both the traps and tubes. If a bait was not eaten within a few days, the tube or trap would be moved to another site nearby, and this practice was used during the entire study of 98 days. After prebaiting, poison was placed in all the tubes except in village No. 1, where we continued to use the placebo. Baits used were all commercial brands which may be purchased at almost any fertilizer or garden store in the United States, including powdered warfarin(5%), powdered pyval (5%), and raticate (shoxin) made up in a wax-based pellet form. Warfarin and pyval were mixed with the standard corn-meal oil bait as recommended by the manufacturer. Approximately six ounces of the bait was placed in each tube, in addition, five pellets of raticate were added to the standard prebait which was used in tubes in village No. 2. Table 1 shows the baits used in each village and the number of houses studied.

During the entire study, each tube was rebaited every

Table 1. The number of houses in each village indicating the type of poison and the number of traps and tubes used.

Village number	No. of houses	No. of houses not studied	No. of traps used	No. of tubes used	Type of poison
1	12	1	19	34	Placebo
2	16	0	26	40	Raticate
3	15	1	23	38	Pyval
4	16	1	30	49	Warfarin

2-7 days except for an absence of three weeks following January 20, 1968. Traps were baited, each time the village was visited, with little chunks of apple which had been rolled in the bait used in that village. Village people often baited traps with rice cake, meat, fish heads, rice, etc., all of which appeared satisfactory.

We encouraged village people to kill rats caught in the traps, to reset the trap and save the captured rat for

us. On each visit to a village we picked up all the previously caught or poison-killed rats for tabulation of catch. We recorded species, age, and sex of most of the rats captured. Due to the language barrier we were often unable to identify the house from which rats came. Often we were unable to tell if a rat was poisoned or died of exposure in the traps, especially when a native would bring us several rats. We simply indicated the rats removed from the village without indicating the method by which they were secured. However, we saw and killed several rats that were hemorrhaging, apparently from one of the poisons. We did not pay a bounty for rats, therefore, we believe that all the rats herein reported were captured in the villages being worked.

RESULTS AND DISCUSSION

During this study of from 93 to 98 days in four villages, rats were collected in every village on each of 23 to 28 trips to the villages. Visits averaged from 3-4 days apart throughout the study. Table 2 is a tabulation of all animals captured during the study that began on 20 November, 1967, and terminated on 28 February, 1968.

Table 2. The total number of animals captured by species.

Village number	1	2	3	4	Total
Rattus norvegicus	109	187	108	232	636
Rattus rattus	22	14	9	16	61
Rattus sp. (mutilated)	20	4	6	21	51
Rattus sp. (not seen by us)	14	17	22	63	116
Mus musculus	2	5	0	1	8
Crocidura sp. (shrews)	0	0	3	0	3
Apodemus agrarius	1	0	0	0	1
Total animals captured	168	227	148	333	876

The three shrews in village No. 3 and one of the specimen of *Mus* from village No. 2 and 4 were captured on the final day of the study. A total of 116 rats were disposed of by the village people and we did not see them. Unidentified rats were mutilated beyond recognition, usually by dogs. Rats were taken far from the villages and disposed of by tossing them in rice paddies.

Figure I shows graphically the percentage of the total catch of *Rattus* by days, beginning from the first day when bait stations and traps were placed in the villages. Note that each curve on the graph begins at zero and ends at 100 percent, thereby the capture success can be compared even though the numbers caught in the villages were very different. The curves are free-hand drawings through a series of points. Few rats were captured during the first two weeks since we were using the traps as prebait stations only in order to familiarize the rats with the new objects in their usual trails. However, several of the local villagers did set our traps and we simply recorded their capture. Note that the capture was much higher in the typical villages, numbers 2 and 4, than in the new, poorly constructed villages.

All the curves in Figure I are very similar in shape and steepness, indicating little difference in the relative

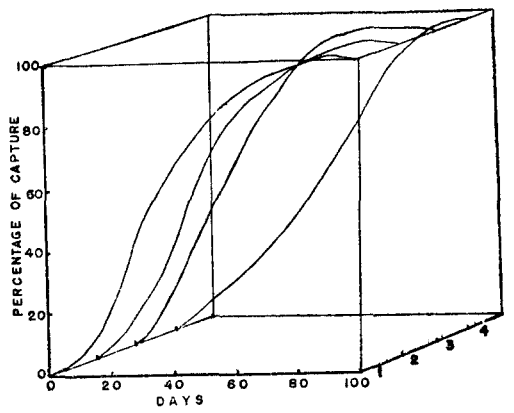

Fig. 1. The percent of rats captured by days in four villages.

rate of removal of the rats from villages regardless of the method used for their removal or the number ultimately captured.

When this study began, every house in all villages reported an abundance of rats. On the last trip to bait the stations and set the traps, persons in as many houses as possible were asked to express an opinion concerning the abundance of rats in their homestead. Table 3 gives the results of this questionnaire.

Note that people living in villages 1 and 2 all said they had rats. Many rats were reported in over half of these homes. Over half the houses in villages No. 3 reported no rats, and No. 4 had few rats in approximately 70 percent of the houses.

Table 3. The villagers opinion of the abundance of rats showing an estimate of the removal success.

Village number	1	2	3	4	Total
Number of houses questioned	9	15	15	14	53
Number with no rats	0	0	8	2	10
Number with few rats	3	7	4	10	24
Number with many rats	6	8	3	2	19
Point rating per house	3.33	3.07	0.80	1.85	2.12
Estimated removal success(%)	79.38	80.81	95.00	88.44	86.75

In view of the varying number of houses with no, few or many rats, it was necessary to devise a method for determining relative success in rat removal. Therefore, I used the opinions of the inhabitants of the houses being studied. Throughout the study, we caught an average of 14.63 rats per house. At the end, many houses still had rats but it was quite obvious that there were considerably fewer than at the beginning. Therefore, for a point rating system for determining relative success, I allotted each house 16 points before work began or approximately 1.5 pionts more than the number of rats ultimately caught. On concluding the field work, points were reassigned on the basis of the opinions of the people living in the houses. If no rats were reported, I assigned a value of minus one point to that house. If few rats were reported, a value of two points was given. It became obvious in questioning the people that few rats indicated perhaps two at most. A house reporting many rats was assigned four points. Many rats seemed to indicate that more than two rats were believed present in the house, but we had no way to confirm a specific number. All the assigned points for houses in a village were added and the sum was divided by the number of houses in question. This point rating was compared with the initial number of points assigned, thus I arrived at a rate of success in percent as shown in Table 3. There is no way to judge accurately these arbitrary points assigned but I believe this is very close to the actual facts, i.e., one point for one rat. This does not take into consideration the rats that may have been killed by poisons but not retrived by us. This method is suitable for comparing relative removal success between villages, thus poisons and trap success as a means of controlling rats. Any logical point system change would merely change point ratings and percentage and not the relative ratings between villages.

It can be seen from these comments and data in Table 3 that a greater degree of success may have been obtained in village No. 3 where pyval was used, followed by village No. 4 where warfarin was used as being next most successful. Village No. 1, where only traps were used, and No. 2 where raticate was used, were about equally successful. Considering our small samples, there probably is not enough difference between success in the villages to say with any degree of confidence that one method of control is superior to any other.

In general, there was no immediate change in consumption rate of baits in villages following the introduction of poisons where plain bait had previously been used. There was an abundance of food in all the villages and apparently the rats seldom ate enough poison from the bait stations at any one time to be immediately fatal. For these reasons, the villages with poisons showed very little increase in removal rates as expressed by the curves

in Figure 1. The pellets of raticate in village No. 2 were almost ignored, yet the rats continued to eat most of the corn meal bait in which the pellets were placed. Considering the cost of bait and the added expense of placing it in the villages, traps alone are as effective in decreasing rat populations in Korean villages as poisons alone or in combination with traps during the winter months.

A population estimate can be arrived at for each village from the asymptomatic level of the curves in Figure 2. I suspect this population level would not be a true picture of the number of rats, but it will more likely be an estimate of the number of rats that could have been captured had we continued the program for a reasonable length of time.

Both *Rattus norvegicus* and *R. rattus* appear to be able to live in almost every conceivable place and some individuals appear to be particularly shy of anything new in their area of familiarity. For this reason, I think we should think in terms of two distinct and separate populations. First, the one that can be trapped, and which includes the vast majority of rats, and second, the one that cannot be trapped by ordinary methods used by us.

The total rat population in each village and the time required to eliminate them by the methods we used can be determined by plotting the cumulative total capture against the number of day (Mosby, 1963) as shown in Figure 2. This method gives a good comparison of the number of rats caught in village No. 4 with the lesser numbers in other villages. It was obvious when inspecting the villages in November that total populations would vary more or less as shown in the graph, but we had no real idea of the magnitude of this variation.

This high rat population which we captured results in an average of 14.63 rats per house or 2.01 rats per person(see Table 4).

If the number of rats per person or per house is representative of the Republic of Korea there will be approximately 60,000,000 rats that can be captured with a minimum of effort by the people in the country, assuming 2.01 rats each for a population of 30,000,000.

Table 4. The rat vs. human population based on the numbers of rats killed.

Village number	1	2	3	4	Total
Number of people per house	7.33	7.93	7.87	6.53	7.43
Number of rats per house	13.75	13.88	9.76	20.67	14.63
Number of rats per person	1.88	1.76	1.17	3.17	2.01

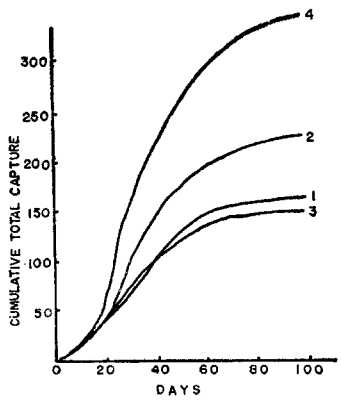

Fig. 2. The cumulative total of rats captured by days.

On the final night of our study we placed four museum special mouse traps in or near each house in our four study villages and in 15 houses of an adjacent village. In each house, one trap was placed in each of the following areas: the kitchen, the store room, on the porch, unless it was completely open and without harborages for mice, and under any trash heaps available which was adjacent to the house. We caught only two mice, *Mus musculus*, one in village 2 in the store room and one in village 4 under a trash heap. Neither of these was caught in a dwelling houses and the number is too small to warrant the conclusion that *Mus* will replace *Rattus* if the latter is removed from the village during the winter months. In addition, we caught three shrews (*Crocidura* sp.) in village 3, all under trash heaps adjacent to houses which were located on the side of the village adjacent to the forest.

CONCLUSION

1. All houses in Korean villages are infested with large numbers of rats, with the traditional villages supporting the largest numbers.

2. The average number of rats per house was found to be 14.63 in 59 houses studied, or 2.01 rats per person.

3. Of the rat control methods used, pyval, warfarin, and raticate (shoxin) in combination with traps or traps alone, neither method proved to be obviously superior to the other. Pyval and warfarin, however, may be slightly better when used in combination with traps.

4. We could find no evidence that *Mus* will replace *Rattus* in the houses if *Rattus* is controlled during the winter months.

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