PN-ABD-264

VERTEBRATE PEST CONTROL PROJECT

Food Security Management
Post-Harvest Management Component

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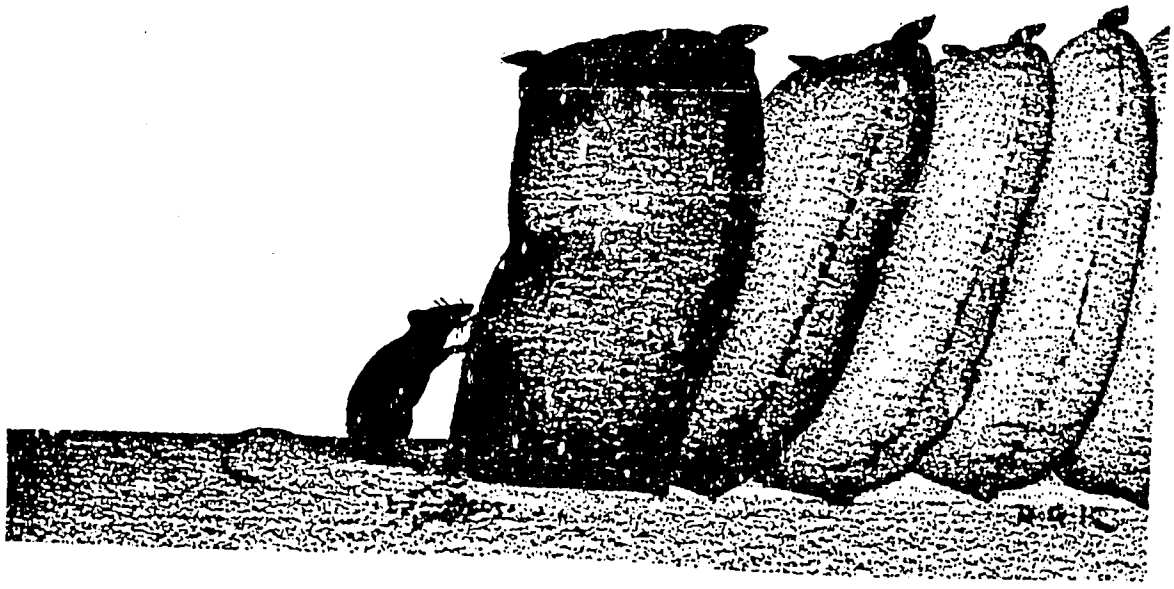
Technical Report No. 12

August 1987



A GOP/USAID/DWRC PROJECT

NATIONAL AGRICULTURAL
RESEARCH CENTRE

ISLAMABAD, PAKISTAN

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A Govt. of Pakistan/USAID Project
Vertebrate Pest Control Project
Denver Wildlife Research Center
Animal Damage Control
Animal and Plant Health Inspection Service
U.S. Department of Agriculture

Technical Report No. 12 (Unpublished)

August 1987

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RAT POPULATIONS AND STORED FOOD LOSSES AT A PAKISTAN GRAIN MARKET

By Joe E. Brooks,* Ejaz Ahmad* and Iftikhar Hussain*

Abstract: Rat populations in the wholesale grain market in Rawalpindi, Pakistan (some 200-plus individual small shops) were estimated by removal trapping and change-in-ratio (CIR) of activity at tracking tiles before and after animals were captured. The only animals captured were roof rats, *Rattus rattus*. In January 1987, a total of 244 rats was captured in 792 trapnights from 8 grain shops. The population was estimated by CIR methods as 297 rats and by the linear regression of daily captures on cumulative captures as 355 rats (95% confidence limits were 265 to 445 rats as calculated by the CAPTURE computer program). In April 1987, a total of 481 rats was captured in 735 trapnights, indicating that rat densities had increased, apparently due to the breeding effort since January. Population estimates by the CIR method were invalid but the CAPTURE program estimate was 785 rats (with a 95% confidence limits of 591 to 979). These numbers of rats could be expected to consume and contaminate from 28 to 34 kg of grain/month/shop in January and from 56 to 94 kg of grain/month/shop in April. The average losses due to rat consumption and contamination per shop per year could be from 500 kg to 770 kg. The average losses of grain in the entire market represent from 0.12 to 0.24% of stocks on hand.

INTRODUCTION

All major, and many minor, cities in Pakistan have wholesale grain markets. These are areas, usually in the older, central part of the cities where grain merchants have small shops for the purchase and sale of grains, legumes and oilseeds. Some of the larger merchants have, in addition, godowns where they stock surplus bagged commodities. The total amounts of grains, legumes and oilseeds moved through these wholesale markets annually is not known with any precision but some rough estimates can be made. The markets may be comprised of several hundred dealers and, in the larger cities, of up to a thousand or more. In this study we will confine our remarks to the wholesale grain market at Rawalpindi.

The Rawalpindi market consists of several hundred dealers Fig. 1). Most occupy small shops measuring 25m^2 to 45m^2 in floor area and with capacities of 500 to 800 bags of commodities (50 to 80 mt). The main grain handled is rice; other foods are lentils, grams, sorghums, wheat flour, and groundnuts. The amounts of grains and other foods sold per year per shop varies greatly. Large dealers may sell up to 60,000 bags, while small dealers sell only 1000 to 1500 bags per year.

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The overall sales from the total market are difficult to estimate because accurate sales are not reported by the shopkeepers for purposes of avoiding revenue taxes, although each dealer probably knows to the exact kilogram how much he has sold each day. However, an educated estimate can be made that in the 200 or so shops making up the Rawalpindi market between 50,000 and 100,000 mt of rice move through this market annually if each dealer turns over his stocks four times per year.

Fig. 1. Typical grain shop.

A cursory inspection of the shops reveals that each is rodent-infested, no matter how clean the individual shopkeeper tries to maintain his premises. Rodent droppings are easily found, waste grain is abundant, damaged bags (with gnawed holes) are frequent and the shopkeepers freely admit that rodents are present. None of the shops are rodent-proof; many shops interconnect with others and with the offices or living quarters on the floors above.

Approaching this situation from the standpoint of estimating the rodent populations present, the species composition, and the amounts of grains and other foods lost through consumption and contamination, we realized that there was a virtual lack of any information about any of these problems. We began initial studies in January 1987, and a follow-up in April, to determine the rodent species present, their abundance and to derive an estimate on how much grain and other foods were being lost due to rodent damage. Other data were collected on the population structure and reproductive biology of the rodents as they were collected from the market. The results of this preliminary study are presented in this report. Other wholesale grain markets in major Pakistan cities will be surveyed for similar information during the balance of the year.

MATERIALS & METHODS

An initial study of rat populations in the wholesale grain market at Raja Bazar, Rawalpindi was conducted in January 1987. For this purpose the President of the Market Committee was contacted and 8 shops (4 on each side of the road) were selected in that area. Rodent activity pre- and post-trapping was checked by placing 20 tracking tiles (15 by 15 cm) coated with duplicating ink in each shop. Ten tiles were placed off the floor and 10 on the floor in each shop. The next day the tiles were picked

up and scored as to the number of foot prints per tile. Rats were trapped using 10 live capture traps and 5 kill rat and 5 kill mouse traps set the first night in each shop. We had expected house mice to be present but they were not found. Accordingly, the procedure was changed on the second through the sixth night, setting only the live capture traps and the 5 rat snap traps per shop. Twenty inked tracking tiles were placed in each shop for one night at the conclusion of trapping to check the reduction in rat activity.

The second study was done in April, 1987 in Raja Bazar but the shops were located approximately 500 m away from the first site. In this locality 8 shops (4 on each side of road) were selected. Twenty tracking tiles were placed in each shop and picked up and scored the next day. In each shop 10 live capture traps were set and rats were captured for 6 nights. Again 20 tracking tiles were placed and picked up the next day. In this case, there was virtually no reduction in the rat activity at the tiles as compared to the pre-trapping activity. An additional 4 nights of trapping was carried out and tiles were again set at the end. Additional information about the size of the shops, commodities, capacities and annual sales were collected from the dealers of each shop from both sites.

The rat population in the 8 shops was estimated in two ways. One was from the change-in-ratio (CIR) of activity on the tracking tiles before and after removal trapping and using the known number of animals removed. The formula for population estimation is:

$$\frac{T_1 - T_2}{n} = \frac{T_1}{N_1} = \frac{T_2}{N_2}$$

where n is the number of animals removed, N_1 is the population before removal and N_2 after removal, T_1 is the proportion of tiles scored positive before trapping and T_2 is the proportion positive after removal trapping (Davis and Winstead 1980). The equation is solved for N_1. This method previously had been used to estimate small mammal populations in farm households in Bangladesh (Mian et al. 1987).

The second method uses the daily decline in captures plotted against the cumulative total captures. A regression line is fitted to the plotted points. The point of intercept of the regression line with the x-axis gives the estimated population, P (Blower et al. 1981). The 95% confidence limits of the regression estimate were calculated by the Research Support Branch at the Denver Wildlife Research Center (DWRC) using a computer program called CAPTURE.

All captured animals were returned to the laboratory, killed with chloroform and all were autopsied. Data were taken on head and body lengths, tail length, body weights and scars and wounds were noted. The breeding condition of both sexes was recorded.

RESULTS

January Trapping

The tracking tile findings and the animal captures from the January 1987 trapping are given in Table 1. Roof rats, *Rattus rattus*, were the only small mammals captured from the grain shops. A total of 244 rats was taken in 792 trapnights. Activity at tracking tiles was reduced by 82.2%.

The estimated original (before trapping) rat population as calculated by the change-in-ratio of activity at tracking tiles, was 297 rats. The estimated population using the regression of cumulative captures on daily numbers of rats captured was 355 rats (95% confidence limits are 265 to 445 rats). The linear regression is given graphically in Fig. 2. Immature animals constituted a small portion of the population (16% <100 g body weight). The number of rats removed from each shop ranged from a low of 16 to a high of 51. In some shops the trap catch declined markedly while in others (numbers 1 and 8) it either showed little decrease or increased.

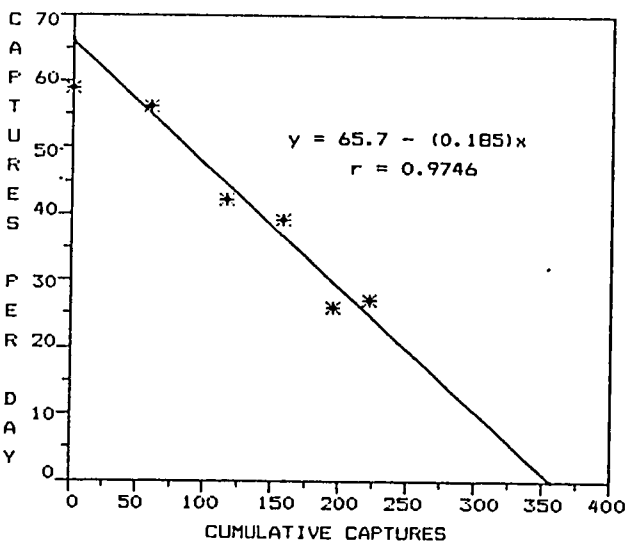

Fig. 2. Estimate of January grain shop populations.

Table 1: Captures of Roof Rats in January 1987 from Wholesale Grain Market Shops in Rawalpindi.

Shop No.	Pre-Trapping Tiles (% Pos.)	Post-Trapping Tiles (% Pos.)	Captures Per Day						Total Captures
			1	2	3	4	5	6	
1	82.4	20.0	10	10	7	9	8	7	51
2	95.0	25.0	9	8	8	*	5	4	34
3	94.7	4.5	6	6	6	9	1	3	31
4	94.7	25.0	8	6	5	8	0	1	28
5	45.0	5.0	8	5	1	1	0	1	16
6	80.0	15.0	9	5	3	*	0	1	18
7	100.0	5.0	7	9	3	0	0	0	19
8	58.8	16.7	2	7	9	7	12	10	47
	81.3	14.5	59	56	41	34	24	27	244

* Traps were not set.

April Trapping

The tracking tiles activity and the animal captures for the April 1987 trapping is given in Table 2. A total of 481 rats was taken in 917 trapnights. Small rats were escaping from the traps during the entire trapping period, since 182 traps were released, the baits were eaten but no animals were inside. These 182 traps should be subtracted from the trapnights, giving a total of only 735 trapnights. Shopkeepers reported that when they closed in the evening, usually all traps contained animals, but some escaped during the night. In an attempt to correct this situation, we set between 26 to 35 smaller, mouse-sized live traps in the 8 shops the last 4 nights of trapping. This resulted in the capture of 28 extra rats. These captures were not used in calculating the linear regression. Immature rats accounted for 16% of the sample. Captures per shop ranged from 30 rats to 76 rats and averaged 60 rats. Again, as in January, trap catch declined as expected in some shops but in shops number 1,3,4, and 5, very little change in numbers of rats occurred.

Table 2: Captures of Roof Rats in April 1987 from Wholesale Grain Market Shops in Rawalpindi

Shop No.	Pre-Trapping Tiles (% Pos.)	Post-Trapping Tiles (% Pos.)	Captures Per Day										Total Captures
			1	2	3	4	5	6	7	8	9	10	
1	100.0	100.0	7	8	5	4	5	7	6	4	6	8	60
2	100.0	100.0	6	1	6	0	6	6	3	2	0	0	30
3	95.0	35.0	4	10	11	7	7	10	8	9	3	7	76
4	90.0	55.0	9	11	9	7	6	8	6	5	7	7	75
5	100.0	100.0	9	7	5	7	6	5	5	7	3	9	63
6	20.0	0.0	8	2	4	6	6	2	6	4	2	1	41
7	95.0	70.0	10	10	4	5	8	7	6	11	7	5	73
8	80.0	100.0	10	10	9	9	7	6	8	4	0	0	63
Totals	86.6	67.8	63	59	53	45	51	51	48	46	28	37	481

The activity at tracking tiles at the end of 6 nights removal trapping had changed only a few tenths of one percent, not allowing for any valid CIR population estimate to be made, so another 4 nights of removal trapping was done. After this, the activity at tracking tiles was reduced from 86.6% positive to 67.8% positive, a reduction of 21.7% in activity.

The estimated original rat population as calculated by the CIR method would be 2217 rats in the eight shops. We don't believe this is a realistic estimate but are unable to account for why activity was so little reduced by the removal of 481 rats. The population estimate derived from the CAPTURE computer program run at DWRC gave an estimate of 785 rats (with a 95% confidence interval of 591 to 979) in the eight shops Fig. 3).

DISCUSSION

It is obvious that there is considerable seasonal fluctuation in the population densities of roof rats in the grain shops, as there was basically no difference in the shop samples in January and April as regards size, kinds and amounts of commodities on hand. We do not know whether either density is normal at this time. Additional trapping and monthly population estimates will give us a better idea of expected average densities. Already, the estimates derived from 4 nights' of removal trapping done in May, June and July from the same market suggest that densities of around 40 to 50 rats per shop may be the norm.

The April rat population estimates in the wholesale grain market are about 2- to 3-fold greater than those of January. The increase in roof rat numbers was undoubtedly due to the breeding effort during the ensuing three months. In January immatures made up 16% of the captures and 29% of the adult females (>100 g body weight) were pregnant. In January the two populations estimates were 297 and 355 rats, respectively from the CIR and regression methods, giving an average of 37 to 44 rats per grain shop.

In April, the removal of 481 rats from 8 grain shops indicated that easily twice as many rats were present. We did not obtain a reliable population estimate using the CIR method since tracking tile activity was reduced on 21.7% despite 10 nights of removal trapping. The estimated population from the regression method was 785 rats, or an average of 98 rats per grain shop.

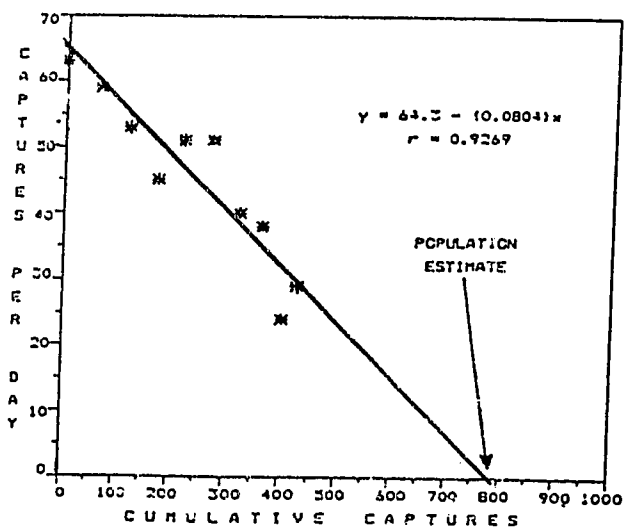

Fig. 3. Estimated rat population in grain shops in April.

These rat densities are unusual. In January the density of rats per square meter of floor area in the shops would be 1.23 to 1.47. By April, this density had increased to 3.27. Roof rats are capable of exploiting all levels of the grain shop interior, from floor to ceiling, so densities per m^2 floor area are somewhat misleading. Even so, these are quite high densities for this species of rat. Occasionally, one might approach population densities of this kind where roof rats are living in poultry houses where little or no effort is made to control their numbers. Frantz's (1972) studies of the lesser bandicoot rat, *Bandicota bengalensis*, utilizing grain godowns in Calcutta, India, showed that they reached densities of 2.7 rats per m^2 in this habitat, but

most of the bandicoots lived outside the godowns and only moved into them at night to feed.

The other reference we have found on population estimates of rats in grain shops and godowns is that of Krishnamurthy et al. (1967). They estimated rat populations (*R. rattus*) in villages, houses, shops and godowns in Hapur, India. They used capture, mark, release and recapture (CMR) methods in their estimates, but trapped only 3 nights in each habitat. The grain godowns (averaging 100 m^2 area) were approximately three times larger in area than the shops we trapped, but the rat densities they estimated were only 11 to 30% of those we found. They found that rats per godown averaged 10.7 and estimated the annual food grain losses at 21.5 kg per godown.

Results equivalent to ours were reported in a 1978 unpublished report of the Vertebrate Pest Control Laboratory (VPCL), Karachi. Trapping was carried out in private sector grain storage godowns operated entirely by rice dealers in the old part of the city of Karachi. Very high infestation levels were found, averaging 30 rats in small, single room warehouses of about the same size of the shops we trapped in Rawalpindi.

In our laboratory, caged *R. rattus* were found to consume an average of 12.7 g of broken rice per night. The amounts of rice consumed by 37 to 44 rats/grain shop in January would be 470 to 560 g nightly, or a loss of 14 to 17 kg per month per shop. The losses in April due to 98 rats eating rice every night would be 1245 g per night, or 37 kg per month per shop.

We observed spilled and contaminated grain in each shop due to cut bags, etc. in amount equal to or exceeding the amounts consumed by rats (Fig. 4). One shop keeper had kept records of the amount of rice swept from the floor in one month and found that this equalled one bag, or 95 kg. This spilled, contaminated grain must be sold for animal feed only, so the shop keeper suffers an economic loss.

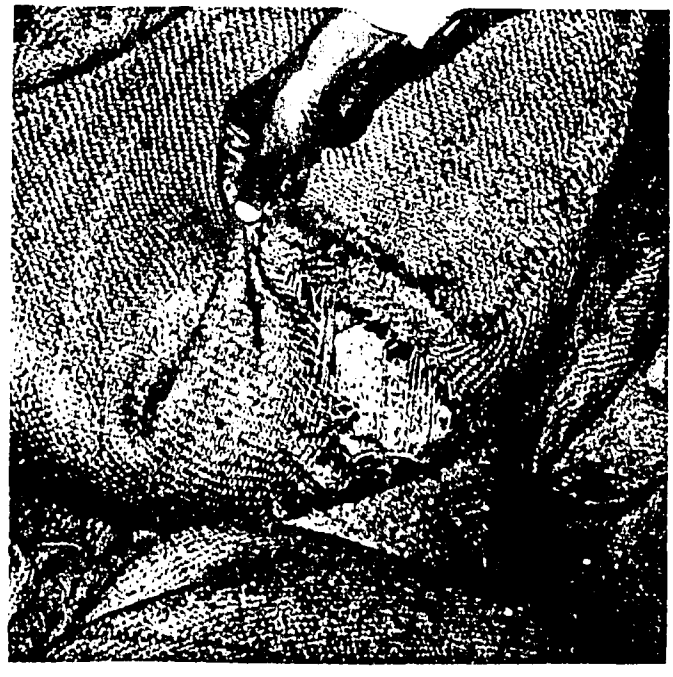

Fig. 4. Grain bags cut by rats allowing spillage.

The public health aspects of a large rat population living in close association with human food stuffs are serious. A study of the parasites (both ecto- and endo-) of *R. rattus* from this same grain market was carried out by Fayyaz-ul-Haque, an M.Phil. candidate graduate student in the Department of Biology at the

Quaid-i-Azam University at Islamabad. He found that the rats were infected with several cestodes transmissable to man, such as *Hymenelopis nana* and *H. diminuta*, and *Acanthocephala* spp. and by *Capillaria hepatica*. No search was made for protozoal parasites but some undoubtedly are present. The eggs of the cestodes and the nematodes are shed in the rats' feces and could easily contaminate the grain and other stored foods in the shops and human infection could result from undercooked foods.

If the estimated amount of grain consumed is added to the amount estimated to be contaminated, spilled and wasted, assuming this amount is equal to consumption (it may easily be 2 to 3 times as much), the average losses per grain shop per month run to 28 to 34 kg in January and 74 kg in April, when rat populations supposedly were at peak abundance. Taking an average then of about 50 kg per month per shop, the annual losses in the whole market of 200 shops would be in the order of 120 metric tons. This would represent a loss of between 0.12 to 0.24% of the amount of grain moving through the market in a year's time. The losses to the individual shopkeeper of about 600 kg of grain and other foodstuffs per annum amounts monetarily to Rs. 4800 (equal to about U.S. $ 276).

These losses expressed as a percent of the total amount of grain moving through the market are extremely low despite the high densities (or peak densities, as seen in April) of the rat populations in the market. It illustrates the fact that rats are able to consume and contaminate only so much grain in a year's time and that even when food supplies are unlimited, the populations can grow only to a certain point before inherent factors within the animals themselves acts to restrict the upper population level.

Nonetheless, such high density rat populations in continual contact with human food supplies should not be tolerated. There are, however, almost insurmountable difficulties involved in trying to organize an effective control effort to minimize the rat populations. None of the shops are rat-proof and to attempt to proof them would require an enormous effort and expense. Since the shops interconnect or are easily invaded by rats from the street, rat control efforts by an individual shopkeeper are not feasible. What would be needed would be an organized and cooperative effort by all the shopkeepers at once to utilize poisons, probably anticoagulant rodenticides, in a concerted campaign to reduce the rat numbers over the entire market. Whether they would agree to this degree of cooperation and the attendant expense involved is problematical. While they perceive the problem of rats individually, an organized effort is not thought of. And the effort would have to be repeated approximately every three months to maintain any real pressure upon the rat populations. This is not likely to happen.

Acknowledgements

We thank Dave Otis and Rick Engemann, Denver Wildlife Research Center, for their assistance in running the animal data on the computer program CAPTURE to derive the population estimates and their 95% confidence limits.

This work was supported by funds provided by the U. S. Agency for International Development under the Project "Food Security Management, Vertebrate Pest Control, PASA IPK-0491-P-IF-5017-04". We appreciate the help of the National Agricultural Research Centre (NARC), Islamabad and the Pakistan Agricultural Research Council for providing laboratory and office space at NARC for the Project.

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