



Losses of Stored Foods Due to Rats at Grain Markets in Pakistan

Ejaz Ahmad,* Iftikhar Hussain* & Joe E. Brooks

*Vertebrate Pest Control Laboratory, National Agricultural Research Centre, Islamabad, Pakistan

USDA/APHIS/ADC/Denver Wildlife Research Center, Denver, CO 80225, USA

ABSTRACT

*We estimated the sizes of rat populations (*Rattus rattus*) at 5 wholesale grain markets in four major cities of Punjab Province, Pakistan: Faisalabad, Lahore, Multan, and Rawalpindi. We estimated the populations using data from removal trapping and by measuring the change in activity at inked tracking tiles before and after the trapping. Population estimates ranged from five rats/grain shop in the new grain market in Faisalabad to 61 rats/grain shop at Lahore. We did surveys of rat populations in 13 out of 40 other smaller city and town markets in Punjab and confirmed they were rat-infested, with six ranked as severe, three as medium, and four as having little problems. We estimated an average grain shop in a Punjab market to contain 40 rats. Rice is the main commodity stored in these grain shops. In our laboratory, on average, adult roof rats ate 12.7 g of rice nightly. We estimated the annual grain losses/shop due to rodent consumption, contamination, spillage, and wastage to be 740 kg. There are about 5500 shops in the major and minor markets: the annual losses would approximate 4000 mt/year, or about 0.3% of the estimated 1.225 million mt that move through the markets yearly.*

INTRODUCTION

We examined vertebrate pest infestations in public-sector grain storage facilities as part of surveys of food losses in the post-harvest storage of wheat and other grains in Pakistan. The losses due to vertebrate pests in

the 4 million mt of wheat in public-sector grain storage facilities in Pakistan were estimated at 0.1–0.2% due to consumption and another 0.2–0.4% due to contamination and wastage (Brooks & Ahmad, 1986).

Because these are minimal losses as compared to the total amount of grain in storage, we turned our attention to other possible sources of post-harvest losses, i.e. wholesale grain markets and farm/village losses, to try to complete the picture of total post-harvest losses in the country. All major, and many minor, cities and towns in Pakistan have wholesale grain markets. These are usually located in the older, central parts of the cities. Grain and commodities merchants have small shops for the purchase and sale of grains, legumes, oilseeds, nuts, spices and dried fruits. The total amounts of grains and other commodities moved through these wholesale markets annually are usually not known, but rough estimates can be made. The markets may consist of several hundred dealers, and, in the case of Karachi, of up to a thousand or more. We detailed our findings on roof rat populations (*Rattus rattus*) in the market at Rawalpindi (Brooks *et al.*, 1994); the populations did not show seasonal variations in density. Consequently, we surveyed other markets and trapped them during the period November 1987–March 1988. This paper details our findings at four major city markets and 13 other minor markets in Punjab Province, Pakistan.

METHODS

The markets

Data on the wholesale grain markets which we trapped and studied in detail are given in Table 1. The shops averaged 50–60 mt of grain in storage, with floor areas of 24–45 m². All but two markets were located in the older city centers.

Survey and trapping procedures

We surveyed the markets physically for rodent infestations and information about the markets (number of shops, sizes, major commodities, age of structures, etc.) were collected by interview with either the Secretary of the market committee or from shopkeepers. We trapped rats from the major markets during the months from November 1987 to March 1988. We estimated rat populations by trapping eight typical shops in each market, four adjacent shops opposite another adjacent four across the road. Shops were not selected randomly but on the basis of whether the

TABLE 1
Details of the Wholesale Grain Markets where Trapping was Done

<i>Location</i>	<i>No. of shops</i>	<i>Age of market</i>	<i>Major commodities</i>	<i>Amount handled annually (mt)</i>
Faisalabad, old	> 300	6	Rice, pulses, groundnuts, wheat, cotton	170,000
Faisalabad, new	50	75	Rice, dried fruit, spices	—
Lahore	> 250	75	Rice, pulses, groundnut, dried fruit, sugar	50–100,000
Multan	270	8	Rice, pulses, cotton, oilseeds, chilies, sugar, wheat	55,000
Rawalpindi	> 200	75	Rice, pulses, groundnut, dried fruit	50–100,000

shopkeepers were willing to cooperate. The shops selected were typical of those found throughout the general market. Rat activity before and after removal trapping was checked by placing 20 inked tracking tiles (15 by 15 cm) in each shop for one night; these were set with equal numbers on the floor and on top of bags of grain. Tiles were scored positive or negative for rat footprints. Removal trapping was done by setting 10 rat-size live traps and five mouse-sized Sherman live traps in each shop in the late afternoon, again distributing them roughly equally on the floor and on bags of grain. Trapping was done for a minimum of five nights and up to eight nights, depending on the decline in captures. Captured animals were removed early each morning; they were euthanized, weighed, sexed and necropsied.

Grain consumption per rat

We used 10 individually-caged adult roof rats (average weight of 126 g), five of each sex, they were given broken rice nightly for 10 nights and the amount consumed was averaged for the 10 rats for a 10-day period and found to be 12.7 g/rat/day. We used this value in estimating grain losses in the markets and shops.

Population estimates

We estimated rat populations in the eight shops in each market in two ways: one was from the change-in-ratio (CIR) of activity at the tracking

tiles before and after removal trapping, using the number of animals removed and the formula:

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

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 & Winstead, 1980). The equation is solved for N_1 . This method was previously used to estimate small mammal populations in farm households in Bangladesh (Mian *et al.*, 1987; Ahmad *et al.*, 1994).

A second method used the daily captures of rats as processed by the computer program CAPTURE (Otis *et al.*, 1978), and was calculated for us by Dr Gary C. White, Department of Fishery and Wildlife Biology, Colorado State University. The program used maximum likelihood estimates and permits the calculation of 95% confidence limits.

Survey of other grain markets

In March 1988, we surveyed 13 other grain markets, selected at random from a list of 40 in various cities and towns in Punjab Province. Information on market size, age and main commodities were taken by interview, either from the market committee or from shopkeepers. An average of at least six shops were physically examined for condition, commodities and evidence of rat infestation. Generally if rat signs were found in some shops, the entire market was usually infested. Markets were scored as having *little* infestation if only five or six rat droppings were observed in the shops checked; as *medium* infestation if rodent droppings were easily observed, burrows were found and rat runs easily observed; as *severe* if rat droppings were abundant, bags of grain were damaged, rat rub marks easily found, and burrows and rat runs were abundant in the shops.

RESULTS

The tracking tile activity measures and animals captured daily are given in Table 2. Total captures per day differed considerably between the markets. Roof rats, *R. rattus*, were the only species captured at Faisalabad, Multan and Rawalpindi. A few house mice, *Mus musculus*, and 1 musk shrew, *Suncus murinus*, were captured in the Lahore market.

The rat populations, estimated by the CIR and the CAPTURE program, are given in Table 3. There is reasonably good agreement

TABLE 2
Tracking Tile Activity and Trapping Results at the Punjab Markets

Location	Tracking tile activity (percent positive)		Animals captured per day								Total	
	Pre-trapping	Post-trapping	1	2	3	4	5	6	7	8		
Faisalabad												
New	76	5	20	4	5	4	5	1	0	—	39	
Old	52	30	22	16	16	16	11	—	—	—	81	
Lahore	75	40	39	33	29	38	26	30	12	22	229	
Multan	52	14	35	45	17	19	11	11	—	—	138	
Rawalpindi	81	15	59	56	41	34	27	27	—	—	244	

TABLE 3
Estimated Populations in Eight Shops at Each Wholesale Grain Market

Location	Total captured	Estimated populations		Rats/shop	
		CIR	CAPTURE (95% cl)	CIR	CAPTURE
Faisalabad					
New	39	42	39 (36–42)	5	5
Old	81	182	151 (45–257)	23	19
Lahore	229	491	412 (255–569)	61	52
Multan	138	192	166 (141–191)	24	21
Rawalpindi	244	299	362 (278–466)	37	45

between the estimates by the two methods. The estimated numbers of rats per grain shop varied from 5/shop at the Faisalabad new market to 61 rats/shop at Lahore.

Wholesale minor grain markets

In Punjab Province there are more than 40 other wholesale commodities markets in cities and small towns. They mainly deal with grains, pulses, sugar, oilseeds, animal feed, etc. Market size varied from 30 to over 300 shops; shop size varied from 20–50 m². Other details of the 13 markets surveyed are given in Table 4. Six markets had severe rat infestations, three were medium, and four had little or no problems. Some markets were quite new (8 years), some were nearly 100 years old. Severity of infestation did not necessarily correlate with market age; Jaranwala and Gujranwala had little infestation even though they were 50 years old. Size of market had little effect of rat infestation, either, since 30 dealers at Jhang were severely infested as were 200 dealers at Hafizabad.

TABLE 4
Wholesale Grain Markets Surveyed in Punjab Province, Pakistan

<i>Location</i>	<i>No. of shops</i>	<i>Age of market (years)</i>	<i>Major commodities</i>	<i>Rodent infestation</i>
Sheikhpura	150	66	Rice, pulses, wheat	+
Pir Mahal	47	8	Wheat, rice, cotton, sugar	+
Jaranwala	110	50	Sugar, maize	+
Gujranwala	125	50	Wheat, rice	+
Sargodha	250	60	Wheat, pulses, mustard, gram	++
Gojra	109	80	Sugar, wheat, maize	++
Muridke	50	80	Rice, wheat, pulses	++
Jhang	30	80	Cotton, wheat, sugar	+++
Toba Tek Singh	125	50	Maize, wheat, sugar, cotton	+++
Hafizabad	200	60	Rice, wheat	+++
Sialkot	100	100	Rice, wheat, pulses	+++
Kamoke	100	60	Wheat, rice, pulses	+++
Gujrat	80	60	Wheat, rice, pulses	+++

+ = Little infestation, ++ = medium infestation, +++ = severe infestation.

Amounts of commodities handled annually

The overall annual sales from the different markets were not available in some cases. Since the Lahore market is similar in age and size to Rawalpindi, the estimate from Rawalpindi of 50,000–100,000 mt annually was used. Data obtained from market committees in Faisalabad and Multan indicated that 170,000 mt were handled at Faisalabad and 55,000 at Multan. The average of 50–100 thousand mt at Lahore and Rawalpindi is more than the smaller city and town markets; here we estimated that the 40 markets would handle an average of 25,000 mt each annually. The total for the 40 markets was estimated at 1.225 million mt annually being handled by about 5500 dealers. This does not take into account all the little village markets sprinkled throughout the Punjab.

DISCUSSION

The roof rat was the only rodent species trapped in the grain markets aside from two house mice caught at Lahore. It is highly probable that roof rats are the predominant rat in other grain markets in Punjab. Krishnamurthy *et al.* (1967) also found that roof rats predominated in towns, village houses, shops and godowns (storage warehouses) in Harpur, India. Mushtaq-ul-Hassan (personal communication) found that

roof rats predominated in village structures and farm houses in Faisalabad District in central Punjab.

Estimated population densities of 52–61 rats/shop at Lahore and 37–45 rats/shop at Rawalpindi were maximum; lower densities of 24 rats/shop and 5 rats/shop were found at Multan and the new market at Faisalabad, respectively. These variations in density are due to several factors, e.g. structural condition of the market, age of the market, location in the city, type of commodities handles, shop sanitation, and use of rodent control methods by the shopkeepers. The market at Faisalabad was constructed only 6 years before and the shops were open, airy and clean. The shopkeepers used traps and poisons for rodent control. The old markets at Lahore and Rawalpindi are more than 75 years old, unsanitary and in poor structural condition.

We estimate that the average grain shop in wholesale markets in the Punjab has a year-round population of 40 rats. We base this on the densities observed at Lahore (52–61) and Rawalpindi (37–45) and the 19–23 rats/shop and 21–24 rats/shop seen at Multan and old Faisalabad, respectively. In the smaller markets in Punjab Province, 6 out of 13 were judged as severe (equal to Rawalpindi and Lahore) and 3 as medium (about equal to Multan and old Faisalabad).

We found that roof rats ate an average of 12.7 g of broken rice per night. Forty rats could consume 185 kg of rice in a year. Moreover, we observed spilled and contaminated grain in many shops in amounts easily exceeding what could be eaten by rats in one night. One shopkeeper at Rawalpindi found that spilled and contaminated rice swept from the floor in one month equalled one bag, or 95 kg. This spilled and contaminated grain must be sold for animal feed only, so the shopkeeper suffers an additional economic loss. Based upon his records and our observations in other shops, where torn and gnawed bags were common, we estimated the amount of grain spoiled by rodent contamination and spillage equals three times the amount rats consume.

Thus the annual losses per shop are 185 kg to rat consumption, and 555 kg due to spillage and contamination; a total of 740 kg/shop/year. Since there are 5500 shops in the major and minor markets throughout Punjab, the aggregate losses in the Province approximate 4000 mt annually, or 0.3% of the 1.225 million mt of grain moved through the markets each year.

While this may seem like a small amount when expressed in terms of the total amounts of grain handled, the public health aspects of large rat populations living in close association with human foodstuffs are serious. A study by Haque (1987) of ecto- and endoparasites of roof rats from the Rawalpindi grain market showed that rats were infected with several

cestodes transmissible to humans, such as *Hymenelopsi nana*, *H. diminuta*, *Acanthocephalia spp.*, and *Capillaria hepatica*. Haque made no search for protozoal parasites, but some undoubtedly were present. The eggs of cestodes and nematodes are shed in rats' feces and could easily contaminate grains and other stored foods in the shops, resulting in human infection if the foods were undercooked. Findings similar to ours were reported in an unpublished report of the Vertebrate Pest Control Laboratory, Karachi. They trapped in private-sector grain storage godowns operated entirely by rice dealers in the old part of Karachi. High densities of roof rats, averaging 30 rats/shop were seen.

The study of Krishnamurthy *et al.* (1967) is the only other that is similar to ours. The authors estimated populations of roof rats in villages, houses, shops and godowns in Harpur, India, using capture-mark-release- and recapture methods. Trapping only three nights in godowns averaging 106 m² in area, they found 10.7 rats/godown, capable of consuming 21.5 kg of grain per godown. Part of the difference between their estimates and ours was that their roof rats consumed only 5.5 g of grain/night and no accounting was taken of spillage, wastage and contamination.

The economic impact of grain losses to the grain dealers in these wholesale markets is significant. Not only does the dealer lose about 3/4 of a metric ton of grain out of every 200 mt handled, but the damage to bags, the need to sweep up and reclean contaminated and spilled grain, or sell it at a loss, constitutes a considerable drain over and above the actual loss by consumption.

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