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VERTEBRATE PEST CONTROL PROJECT

Food Security Management
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VERTEBRATE PEST INFESTATIONS IN PUNJAB
PROVINCIAL FOOD STORAGE FACILITIES

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VERTEBRATE PEST INFESTATIONS IN PUNJAB PROVINCIAL FOOD STORAGE FACILITIES

By Joe E. Brooks and Ejaz Ahmad *

Abstract: A stratified (by regions) random sample of Punjab Provincial Food Department grain storage centres was selected. The chosen sites were visited for an interview/inspection for vertebrate pest infestations and causitive conditions. At 66 wheat storage centres, some 194 structures, comprising 173 house-type godowns, 8 bini shells and 13 bulk-storage bins, were physically inspected. Rodent infestations were seen in 50 structures (25.8% of the total examined). Thirty five were due to house mice (*Mus musculus*), 27 to roof rats (*Rattus rattus*), and 4 to desert gerbils (*Meriones hurrianae*) and striped squirrels (*Funambulus pennanti*). Rodent infestations were frequently of more than one species. Bird infestations were much commoner, occurring at 118 godowns (60.8%), principally due to house sparrows (*Passer domesticus*) and common pigeons (*Columba livia*). Very few infestations, either of rodents or birds, were recorded as severe, only 2 for rodents and 2 for birds. Even here, grain losses could not have exceeded 0.1 to 0.2% of total grain stocks over a 9-month period. Structural defects conducive to rodent and bird problems were found at 75% of all the godowns and bini shells inspected. Bulk-storage bins are not infested by vertebrate pests. Despite these structural deficiencies, vertebrate pest problems in Punjab Food Department wheat storage centres are minimal, perhaps in part because of routine fumigation of grain stocks with phosphine to keep insect infestations in check.

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1. INTRODUCTION

Background

A search of the literature in Pakistan revealed that no good background data had ever been collected on the problems of vertebrate pest infestations in provincial grain storage facilities nor had any good assessments of overall losses due to vertebrate pests been attempted, except for some preliminary studies by the Vertebrate Pest Control Laboratory at Karachi in grain stores at Landhi and Thole and in some private grain dealers in the Karachi area.

The original project document for the Vertebrate Pest Control Laboratory (VPCL) at Karachi laid great emphasis upon the

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need to reduce rodent losses in grain storage, but subsequent studies by the VPCL showed that in the Karachi area, the losses from rodents, although of economic importance, were overall of much less magnitude than pre-harvest losses in the field and post-harvest losses at farm/village level. This is due to several factors: 1) there is a fairly rapid turnover of grain stocks in the main storage depots, not giving rodent populations adequate time to build up, 2) most of the bulk storage depots have been built within the past 2 decades, are of brick and concrete house-type construction with some attention paid to rodent and bird-proofing needs , and 3) the strict regimen of insect fumigation used has prevented also the development of large rodent populations.

There are a number of reports and statements of the extent of grain losses in Pakistan but research studies which give reliable estimates are few. An early report (Anon. 1952) states a loss of 6% annually in Pakistan for food grain. Another report of a survey of food grain stores at Bahawalpur and Hyderabad, gave average estimated losses as 3 to 6% by insects and 5 to 6% by rats in stores of farmers, grain merchants and government godowns (Anon. 1953).

The Dept. of Agricultural Marketing, University of Agriculture, Faisalabad, carried out some detailed studies on losses during threshing and storage at farm level, market level and public sector grain storage. Results are given in Table 1. This study is perhaps the best available to date but it was based partly upon questionnaires and analysis of a relatively small number of samples (Chaudhry 1980). There is, however, no breakdown on losses due to insects or vertebrates.

Table 1. Losses (%) in wheat, rice and maize at various post-harvest operations in Pakistan (Chaudhry 1980).

	Threshing and Winnowing	Farm Level	Market Level	Public Sector
Wheat	1.6	1.5	7.9	6.4
Rice	2.3	1.4	10.6	4.2
Maize	1.2	1.3	3.2	3.0

The Punjab Economic Research Institute did a study in 1976 of storage losses of four major commodities: wheat, rice, gram and potato, at farm level and in government godowns in the Punjab, mainly by questionnaire to obtain the farmers or storage facility managers perception of the problem (Khan and Cheema 1978). Findings are given in Table 2. This study suffers from the fact that the authors did not define what they meant by partially damaged foods and those completely damaged.

Table 2. Storage losses at farm level of four commodities in the Punjab (Khan and Cheema 1978).

	Total Production (maunds)	Quantity Retained (maunds)	Percentage Partially Damaged	Percentage Completely Damaged
Wheat	31,932	17,989	27.2	2.3
Rice	5,602	958	----	0.65
Gram	6,661	2,802	10.5	3.7
Potato:				
Spring	83,040	26,169	----	3.25
Winter	159,299	33,808	----	3.27

Annual losses of wheat in government godowns, taken from figures supplied by the Punjab Provincial Department of Food itself, ran an average (over 5 years) of 0.38% in Bahawalpur region and 0.33% in Lahore region. These low levels of losses may be due to the policy of the food department of allowing only zero loss in the grain stores (Khan and Cheema 1978).

Wheat procurement, storage and distribution

Wheat production is concentrated in Punjab and Sind and only small quantities are grown in NWFP and Baluchistan. Punjab produces a surplus of wheat which is utilized in the deficit areas of NWFP and Baluchistan. Sind produces enough wheat for its own requirements but large quantities are moved south to feed the urban population in Karachi (Ahmed 1984).

Wheat is procured during the months of April to September, often at small temporary procurement centres from where it is moved to the larger storage sites, while some of the the larger storage sites also are procurement centres.

Table 3. Storage capacities of provincial food department grain storage centres (1985). Data from Food Grain Transport and Logistics Study, Min. of Food, Agric.

Province	Existing Capacity	Under Construction	ADP/ Others	Total
Punjab	2,318,000	290,400	69,000	2,677,000
Sind	616,020	104,500	15,000	735,520
NWFP	339,200	50,150	78,000	467,350
Baluchistan	169,852	55,000	4,500	229,352
Totals	3,443,072	500,050	166,500	4,109,622

Punjab Province has by far the greatest capacity for grain storage, followed by Sind, NWFP and Baluchistan (Table 3). The capacity of the different storage sites varies with the importance of the location. For example, in sparsely populated areas of Baluchistan, a storage capacity of 500 to 1,000 tons may be all that is needed, while storage sites in major production/procurement areas may have capacities of 5,000 to over 50,000 tons.

The storage facilities are of various different designs but the predominant form is the house-type godown. Other designs include hemispherical shells of reinforced concrete, called bini shells, bins of concrete and brick, and steel silos. In some areas, where there may be a shortage of storage capacity, grain may be stacked in the open, covered by tarpaulin sheets.

House-Type Godowns

House-type godowns are the most common storage structures throughout the country (Fig. 1). Capacities and designs vary since different agencies have designed and constructed them over the last four decades. They are usually rectangular with concrete floors (only rarely are brick floors seen), with walls made of stone, brick or concrete, and with flat or shallow-sloping roofs of reinforced concrete. In the larger godowns of 1000 metric tons (mt) or more capacity, internal columns are used to support the roof beams.

Fig. 1. House-type godown

The house-type godowns are generally raised about 1 m above ground, with a platform extending about 2 m out from the walls, which serves as a loading platform on at least two sides of the building. Some godowns are built with the floors at ground level but these are not commonly seen.

Windows and/or ventilators are provided at the eaves and at the ends of the structure. Most were designed to be opened and closed but many are now broken, window glass is frequently missing and many are unscreened. The doors are of metal in several designs. Some are single doors, others double. Both sliding and hinged doors are common. Roller shutter doors are sometimes found in newer structures but these are easily damaged.

The capacities of the house-type godowns visited varied from 500 mt to 8000 mt. Most were of 500 or 1000 mt capacities. The actual quantity of grain stored can be doubled by storing the grain in bulk, using bulk-heads of bagged grain. Stacks of bagged grain are usually built 12 to 16 bags high.

Bini Shells

Bini shells are hemispherical (dome-shaped) structures of reinforced concrete (Fig. 2). They have been used only for the last 8 years or so. They are approximately 32 m in diameter and about 10 m high, with a nominal capacity of 1500 mt. A single ventilator is located at the apex of the roof dome and two windows are located in the sides. Two doors with roller shutters are provided. Some bini shells are raised about 1 m above ground while others are at ground level. These latter have sometimes suffered from seepage of ground water into the storage areas. Bini shells are prone to extreme over-heating in the hot summer months.

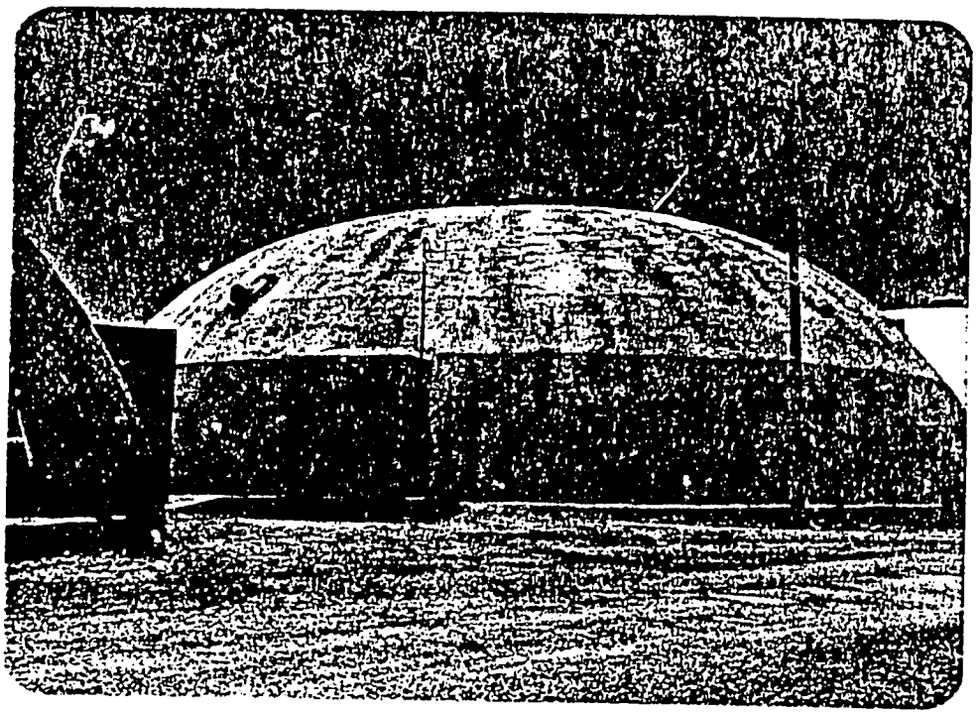


Fig. 2. Bini shell godown

Bins

Blocks of bins constructed of brick and concrete were seen in some centres (Fig. 3). These were built 20 to 40 years ago. The bins each hold 35 to 40 mt of grain in bulk and are supported on brick or reinforced concrete pillars. Grain is discharged through a spout at the bottom of each bin. Steps on the outside of the block lead to the top and bags of grain are carried up the steps to be emptied into the openings of individual bins. The openings are covered with metal plates or doors. They are built in a hexagonal design fitting together like the cells in a beehive.

Steel Silos

A steel silo complex was constructed in 1970 at Multan, consisting of 10 silo bins (4 of 6000 mt and 6 of 3000 mt capacity). These are the only steel silos in the country.

Storage

Wheat is stored at certain centres for periods ranging from 2 to 12 months. In wheat-surplus areas, the storage periods are long, while in wheat-deficit (consuming) areas the storage may be as short as 1 to 2 weeks. Some of these storage centres are transit godowns, as at Islamabad where grain destined for the Northern Areas arrives from procurement/storage areas of Punjab. In general, the wheat stocks are turned over (emptied from the procurement/ storage areas) within a duration of 9 to 12 months. Emptied godowns are cleaned, sprayed with insecticide and readied for the next season's procurement.

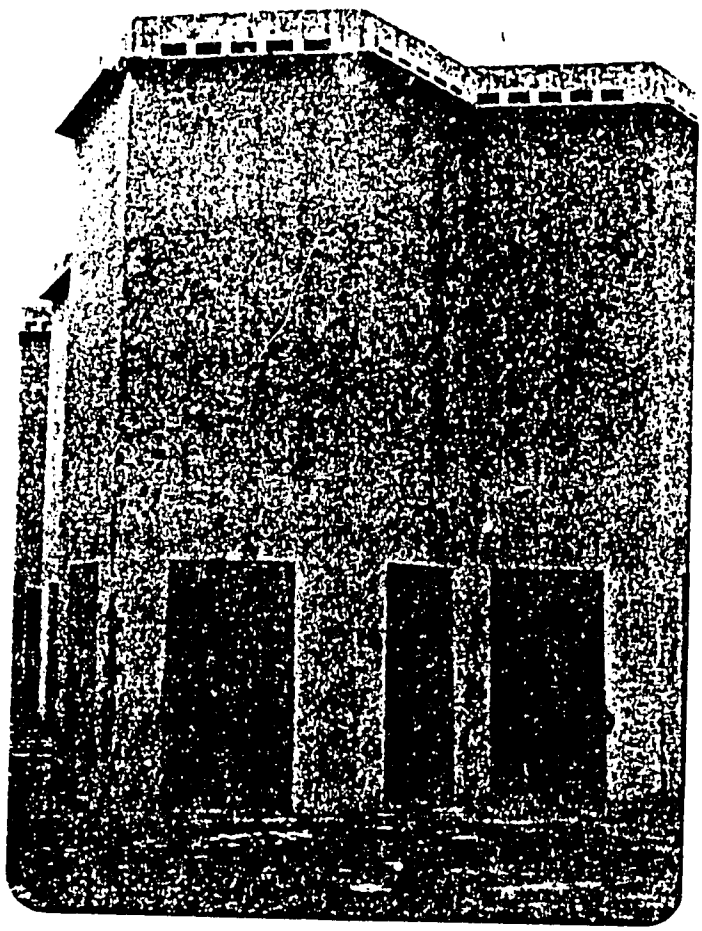


Fig. 3. Bulk-storage bins

Distribution

Wheat is transported in bags mainly by road in trucks of 10 mt capacity. Larger quantities are moved on the trucks of the National Logistic Cell (NLC) and other larger-capacity trucks are appearing on the roads recently. Wheat tends to move from the the sparsely populated surplus wheat production areas towards the larger urban centres through one or more storage centres. Small centres at district level will send grain to larger centres within the region (3 or more districts). From there it may again be transshipped to a consuming or reserve centre in or near the larger cities.

Vertebrate Pests of Food Stores

The usual vertebrate pests that cause damage and losses of stored grains are rodents and birds, although other vertebrates may be found infesting food stores, such as bats or cats. The common rodent pests are house mice (*Mus musculus*), roof rats (*Rattus rattus*) and Norway rats (*R. norvegicus*), although the latter species is rare in the tropical and sub-tropical areas of the world. Other rodent species that may enter grain storage structures in Pakistan and consume and contaminate stored grains, but continue to live outside the buildings themselves, are the striped squirrel (*Funambulus pennanti*), desert gerbils or sand

rats (*Meriones hurrianae*) and the Indian gerbil (*Tatera indica*), which was reported by the VPCL as living in grain storage structures in the Karachi area. The desert gerbils may become quite numerous around certain types of grain storage facilities, such as bini shells, and constitute a significant pest problem from a food loss standpoint.

The major bird pest species found around grain storages are house sparrows (*Passer domesticus*) and domestic or wild rock pigeons (*Columba livia*). House sparrows can nest inside and outside the godown structures and fly in through open doors and unscreened windows. Pigeons rarely enter the structures but are common outdoors, where they feed upon the grain spilled while loading or unloading from trucks. The common myna (*Acridotheres tristis*) is sometimes seen scavenging spilled grain from around storage areas but is not considered a pest of any significance. Sparrows can inflict bag damage by pecking holes in jute bags to get to the wheat and cause contamination by the numerous droppings they deposit on the bags and into spilled wheat.

Purpose of This Survey

The purpose of this survey was to obtain data on the degree and severity of vertebrate pest infestations in provincial grain storage centres and to record structural defects and management problems that may cause or contribute to the continuation of vertebrate pest infestations. In addition, data were collected on pesticide usage, frequency of pest inspections, training needs and staffing at each centre. This information was not available from any previous surveys nor had there been any reliable past attempts to estimate storage losses due to vertebrate pests from provincial food department stores. The surveys were done during the period 19 January to 20 February 1986.

2. METHODS AND MATERIALS

Initially we had planned on obtaining a complete listing of all the wheat storage centres from the Punjab Provincial Department of Food in Lahore. Such a listing was not immediately available, however, at the time of our visit in late January and so we decided to obtain this information directly from the Deputy Directors, Food (DDF), in each of the eight regional offices in Punjab. Appointments were made with each DDF or his senior staff members and the information on the location, type of structures and storage capacities of each wheat storage centre in the region was requested. In all cases, this information was made available to us at the time of our visit. The eight regional offices in Lahore, Gujranwala, Faisalabad, Multan, Bahawalpur, D. G. Khan, Sargodha and Rawalpindi were visited in a period of five days to obtain this data. It was found that there are approximately 270 wheat storage centres in Punjab under the control of the Provincial Department of Food. The complete listing of all centres is given in Appendix 1.

Since it would have been too laborious and time-consuming to visit all of the 270 or so provincial grain storage centres in Punjab, a stratified random sample was used. The centres were chosen at random from each region, drawing a 20 to 25% sample from numbered cards. This resulted in the selection of 56 centres to be visited. After the selection of the centres in each region, a trip route and itinerary was planned to give the most efficiency in visiting all sites within the least time.

An interview/inspection survey form was used to record the observations and data collected (Appendix 2.). The general information on each centre was recorded at the top of the sheet (location of the centre, date visited, names of persons contacted, number and titles of employees at the centre, pesticide usage and frequency of pest infestation inspection, other types of control methods used, if any, and training received and training needs). The specific information on each godown structure was recorded in the remaining sections of the survey form (quantity and quality of wheat in storage, duration of storage, method of grain storage, structural condition, age, and defects noted, vertebrate pest infestations and degree of severity of infestation and types of vertebrate pest damage).

The general procedure used was to interview the person in charge to obtain the details of staff, operations and structure capacity and age, and then to make a physical examination of several godown structures, looking for structural defects and evidence of vertebrate pest infestations. The degree of infestation was determined from visible evidence, such as live or dead animals, fecal droppings, burrows, bag damage, etc. The definitions used to categorize grain quality, structure condition, structural defects, and severity of rodent and bird infestations are given below:

a. <u>Grain Quality</u>

Excellent - Grain without insect damage, no impurities or seeds, and no broken grains.

Good - Grain without insect damage, mixed with some small amount of impurities or seeds, a few broken grains.

Fair - Slight insect damage, mixed with impurities and/or seeds, obvious broken grains, some rodent or bird fecal droppings.

Poor - Obvious insect damage, mixed with impurities and/or seeds, many broken grains, many rodent or bird droppings, moldiness.

b. Strcture Condition (as judged from appearance on outside observation)

Good - No obvious defects visible.

Fair - Few defects visible, may or may not need repair.

Poor - Many obvious defects, in need of repair.

c. Structural Defects

Doors - Marked as defective if they allowed a gap large enough for rodents to enter the godown when closed. This was usually due to doors being bent out of shape, broken hinges, guard plates missing or actual doors missing.

Floors - Marked as defective if they were cracked (more than 1 cm wide), floors had sagged or dropped, if they contained holes or rodent burrows, if grain was germinating in cracks. We did not count as defects the expansion joints in the floors unless more than 1 cm wide.

Windows - Marked defective if glass or screens were broken, torn or missing.

Walls - Marked defective if plaster or concrete had broken away from surface, or if they contained holes or cracks.

Roofs - Marked defective if there were cracks and/or leaks, or with cracks in the joints between the pillars and roof.

d. Severity of Rodent Infestations

Few - One to 10 rodents (mice or rats) estimated per godown based upon abundance of fecal droppings, dead or live rodents seen and no evidence of bag damage.

Medium - Ten to 25 rodents estimated per godown, fecal droppings easily seen in spilled grain or in unswept areas, little bag damage, live or dead rodents seen, few rodent burrows outside godowns.

Severe - Twenty five to 100 or more rodents estimated per godown, numerous fecal droppings and distributed everywhere, obvious bag damage (gnawed holes), live or dead rodents seen and/or numerous rodent burrows outside godowns.

e. Severity of Bird Infestations

Few - Few bird droppings or feathers found inside godowns, occasional sparrow or pigeon seen inside and/or feeding on spilled grain outside.

Medium - Ten birds or more seen inside godown, obvious bird droppings on bags or in grain, numerous sparrows and/or pigeons feeding outside.

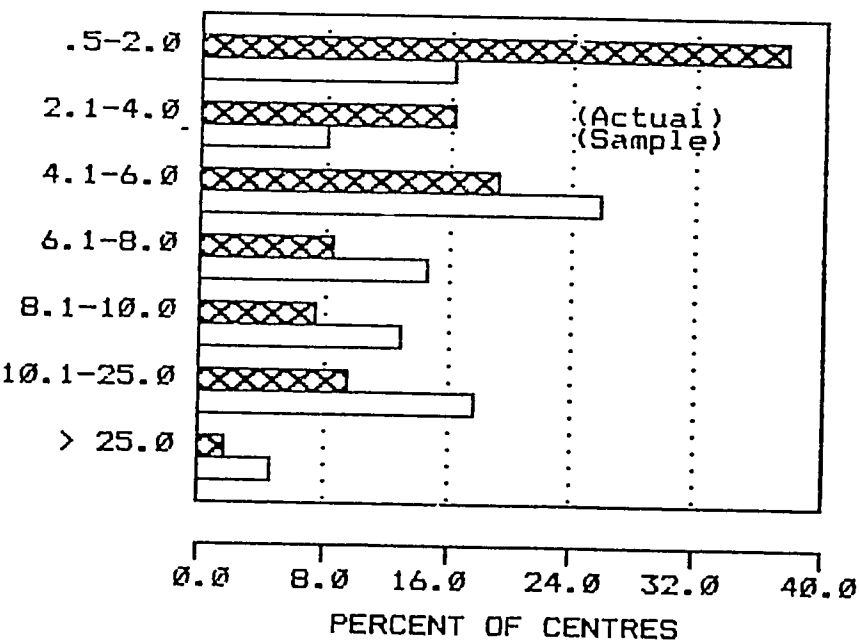
Severe - Many birds (50 to 200) flying inside and outside godown, many droppings and feathers throughout godown interior, presence of nests inside godown.

3. FINDINGS

Sample size and characteristics

A total of 66 out of the 274 grain storage centres in the Punjab were visited for interviews/inspections. Actual physical inspections were made of 194 structures, comprised of 173 house-type godwons, 8 bini shells and 13 bins. The total quantity of grain lying in storage in the 194 structures at the time of our visits was 157,043 mt (equal to 6.8% of total Punjab existing capacity). The rated capacity of the 194 structures was 180,000 mt. The quality of the grain was judged as excellent in 40.4% of samples examined, good in 48.9%, fair in 10.1% and poor in only 0.6% of all samples. The quantity of wheat stored in bags was 72.9% of the total stocks examined, while 27.1% was in bulk storage. Most bulk storage was done by building a retaining wall with bagged wheat and emptying the bulk into the bagged enclosure. In this way, godowns could contain up to double their rated capacity. All stocks examined were stored inside structures; no outdoor storage on plinths or under tarpaulins was observed. The duration of storage averaged 8 months and ranged from one week to 22 months. The 66 centres were staffed by 178 technical personnel and 538 non-technical persons (chowkhidars and sweepers).

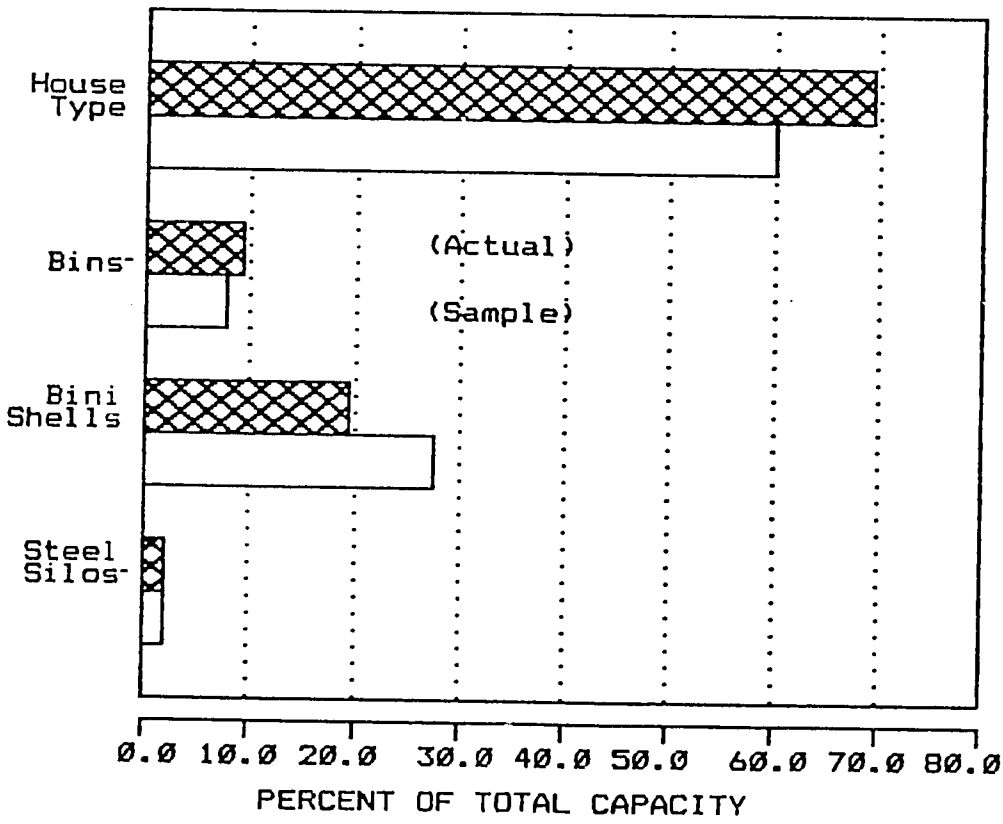
Fig. 4. STORAGE CAPACITY (000 mt)



How well did the selected and sampled storage centres compare in characteristics to the whole of the Punjab Provincial Department of Food storage centres? Several criteria were used to examine sample characteristics: 1) rated capacity of grain storage and 2) proportion of types of structures by capacity. The rated capacity of the storage centres was categorized into 7 classes, the first five each covering 2000 mt increments to 10000 mt and the last 2 covering from 10000 to 25000 mt and >25000 mt. When the proportion of sampled centres is compared to the actual proportion of all centres (Fig. 4), it is seen that the sample was light on the smaller centres (up to 4000 mt) and heavier on the centres holding more than 4000 mt. This is not necesarily disadvantageous because larger centres are more likely to have one or more problem structures with pest infestations and the quantity of grain exposed to pest infestations is economically more important (there is a larger amount of grain at risk). For example, there are 146 storage centres containing 4000 mt of grain or less (constituting 53.3% of the total), but their capacity is 12% of the Punjab total.

When the sample is compared by type of structure examined with the actual proportion (Fig. 5), it is found that the sample is a close approximation of the actual. Only in the case of bini shells is the sample proportionately larger. Bini shells, however, are found to have serious structural deficiencies and high potential for vertebrate pest infestations.

Fig. 5. STORAGE CAPACITY BY STRUCTURE TYPE



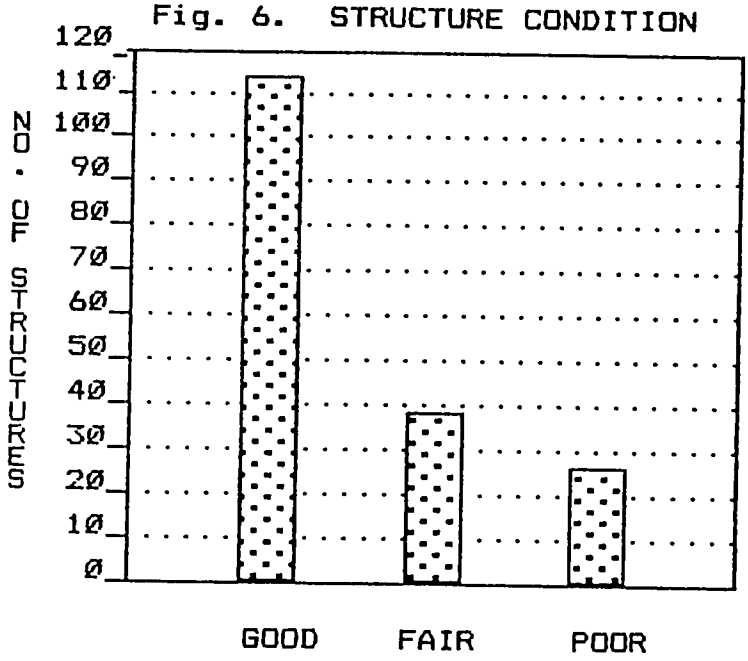
Structure Condition

The structure condition, as judged by an appraisal from the outside, of the 170 house-type godowns and the 8 bini shells examined is given in Fig. 6. The age of the structures ranged from 1 year to 40 years; the mean age was 12 years. Forty percent of the godowns were 5 years or less in age, while 10.2% were more than 20 years old (Fig. 7).

Structural Defects

Structural defects were noted in 136 godowns (75.1%) of 181 examined (bins were not recorded in these categories). Defective walls (94) were the most frequently noted defects, followed by floors (86), doors (65), windows (62) and roofs (33). Defective doors and windows, of course, are most conducive to vertebrate pest in festations. Forty of the defective godowns had only one defec tive item, 30 had two, 29 had three, 32 had four and only 5 had all five defects noted. There was a good correlation (Fig. 8) between age and the number of different structural defects noted per godown ($r=.929$, $p < .05$, $(y=0.559+0.111x)$).

Fig. 6. STRUCTURE CONDITION



Vertebrate Pest Infestations

Vertebrate pest infestations were noted in 138 (71.1%) of the 194 structures checked. Fifty structures were infested with one or more rodent species (35 due to house mice, 27 due to roof rats and 4 due to desert gerbils or striped squirrels),(Table 4). A total of 118 infestations were due to birds, mostly house sparrows and pigeons. The severity of infestations due to rodents was noted as severe in only 2 instances and of medium severity in only 7 cases. In the 2 cases of severe infestation, it was because of the desert gerbil (*M. hurrianae*) infesting the outdoor areas at bini shells at Bahawalpur. Approximately 100 burrow openings were counted around each bini shell at this centre. The gerbils were active in the daytime hours and were running into and out of the open doorways of the godowns and feeding on the spilled bagged wheat. These bini shells also were infested with house mice and roof rats. In the 7 cases of medium

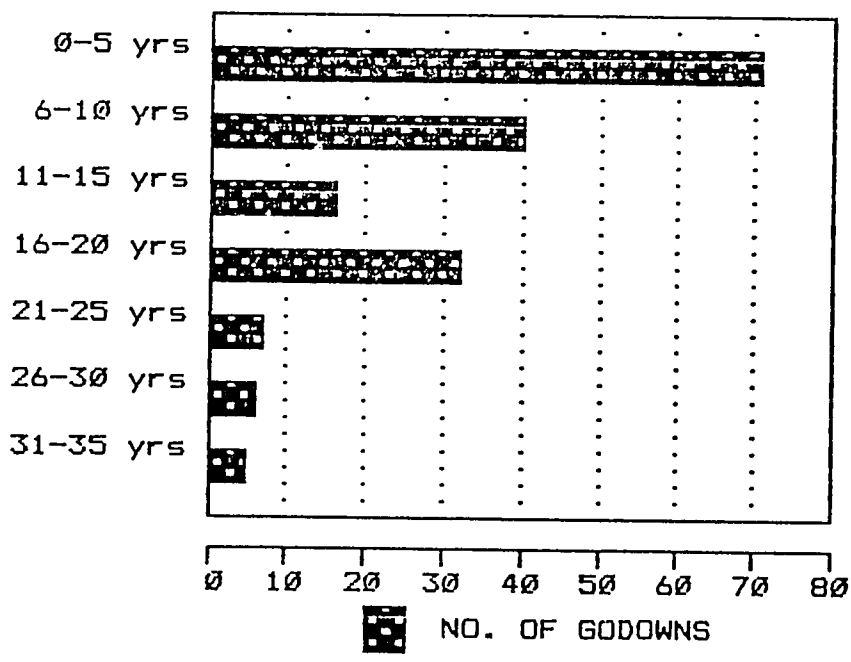
infestations, 6 of them were of mixed populations of house mice and roof rats.

Table 4. Vertebrate pest infestations recorded.

No. of structures inspected	194	Severity of infestations:		
Rodent infestations, total	50	Rodents:		
House mice	35		Low	41
Roof rats	27		Medium	7
Squirrels or gerbils	4		Severe	2
Other vertebrates, total	29			
Cats	22	Birds:		
Bats	3		Low	99
Dogs	2		Medium	17
Goats	2		Severe	2
Birds, total	118			

Bird infestations were marked as severe in only 2 cases where 100 birds or more and many bird droppings were found inside a particular godown structure. In one centre, only one of 5 godowns examined had a severe bird problem. The second case was caused by house sparrows and only 1 of 3 godowns examined at the centre had the severe problem. Bird infestations were noted as medium in 17 godowns and few at 99 structures.

Fig. 7. AGES OF GODOWNS



Other vertebrates noted inside godowns, either live or dead animals or their fecal droppings, were cats (22), bats (3), dogs (2) and goats (2). There was no apparent positive correlation between the presence of cats and rats and/or mice. What the cats were feeding upon in most cases was not apparent, unless they were scavenging food scraps from the godown workers and using the godowns as a place to live.

4. DISCUSSION

Preventive Maintenance

The large proportion of godowns structures with structural

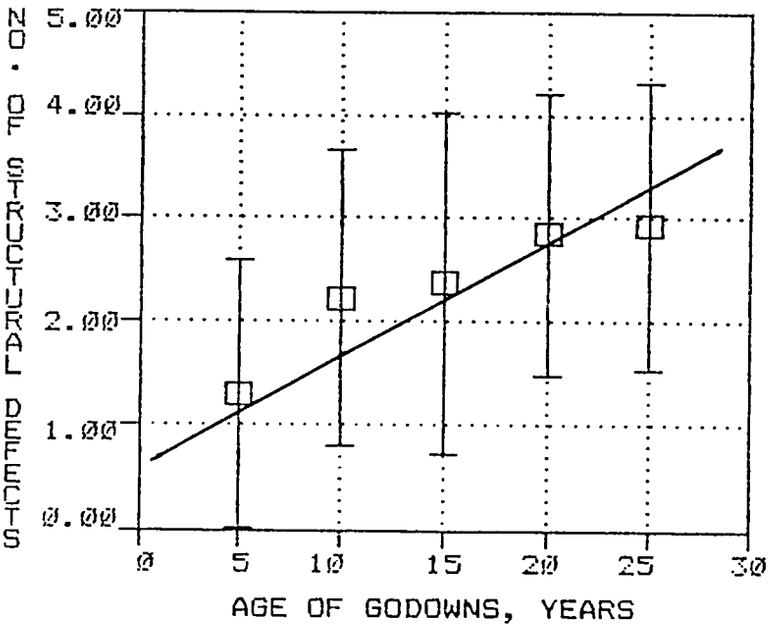
defects points to the need for a preventive maintenance program in the provincial grain storage centres. Unfortunately, the responsibility for structural maintenance and repair rests with the provincial Public Works Department. In many cases the staff at the storage centres reported they had made numerous complaints and requests to have screens or glass replaced in the window ventilators to no avail. Getting simple repairs to doors, cracks in floors and walls and leaking roofs had proved very difficult. Funds are provided annually by the Food Department to the Public Works Department for structural maintenance but whether much of it is actually expended for this purpose is problematical.

However, much could be done to remedy simple problems, such as broken doors, unscreened windows or broken glass panes. Some of these repairs could be done by the local staff if a small amount of funds were made available to purchase the needed supplies. Ventilator windows, particularly, seem not to be repaired once they become broken. In some cases, the window openings themselves were bricked in or permanently sealed with mud plaster, probably to make it easier to seal the building for fumigation the next time it was required.

Pest Control Methods

Pest control measures consist of cleaning the godowns at the beginning of the procurement season, white-washing the walls and ceilings, and spraying the walls and floors with malathion. After the grain is placed in storage, it is inspected for insect infestation usually once weekly or twice per month by the Food Inspector or the Supervisor at each storage centre. The grain is usually fumigated with phosphine at the end of the monsoon rainy season, in September or October, or when necessary if insects appear. Fumigation is done by sealing the window ventilators and doors with mud-plaster and distributing 2 to 3 tablets (3 g each) of aluminum phosphide per metric ton of grain in storage. A 500 mt house-type godown would be treated with 1000 to 1500 tablets. Three different brands of aluminum phosphide are in use in Punjab: "Celphos", made by Excel Industries Ltd., Bombay, India; "Detia", made in East Germany and "Phostoxin", made by Degesch in

Fig. 8. AGE vs. NO. OF STRUCTURAL DEFECTS



West Germany. Sometimes when insect infestations appear, additional spraying of bagged stocks with malathion and another one or more fumigations with phosphine are carried out. Because it is laborious to seal window ventilators several times, they are sometimes left permanently sealed.

The effects of phosphine on vertebrates living inside the godown structure when fumigation is done is fatal, in almost all cases. Phosphine is slightly heavier than air and would slowly settle into the bottom parts of the godown structure. It would be difficult even for climbing rodents such as house mice and roof rats to escape its effects. It is thought that this, in part, accounts for the lack of virtually any severe rodent infestations in most of the structures inspected.

Training

All of the respondents indicated that the Department of Food provided refresher training once or more per year, usually before the procurement season, in methods of grain procurement, grain quality evaluation, godown management and pest control teqhniques including the proper use of fumigants. Training was reported as lasting from a few days to two weeks. We did not ask for any curricula materials regarding this training and have no real evaluation of the quality of the training given. The annual wheat procurement manual issued by the Department of Food covers many of the items mentioned above.

Estimates of Damage and Losses

In most cases, personnel at the grain storage centres were not able to give any valid estimate of grain losses due to vertebrate pests except to comment that it was believed to be minimal. We noted virtually no rodent damage to wheat bags (gnawed holes), in contrast to what may be seen in many wholesale or retail grain shops. Rodents and birds were feeding upon spilled grain, where the sacks at the bottom of the stacks had split thier seams and were leaking grain. The losses of wheat from Punjab provincial grain storage centres due to rodents and birds would be insignificant at 90 to 95% of all godowns where the grain is stored. The estimated losses due to rodents at the 5% of godowns where medium to severe infestations were noted would still range only between 0.02 to 0.2% of total stores per 9-month storage period. Similarly, losses due to birds in the 10% of godowns where medium to severe bird infestations were seen would account for only 0.05 to 0.1% of the wheat. The derivation of these estimates is explained below.

Assume there are 100 desert gerbils (*M. hurrianae*) per bini shell (as at Bahawalpur) and each bini shell contains 1500 mt of wheat. Study has shown that an adult gerbil (85 g) will consume 11.8 g of grain daily (Sharma and Saxena 1983). At each bini shell, therefore, 100 gerbils could consume 1180 g (1.18 kg) of grain daily. Assume they feed on the wheat stocks for 9 months (270 days); then the total amount of wheat consumed from

each shell would equal 318 kg. This represents a loss of only 0.02% of the grain in storage over the 9-month period. It would take a population of 10,000 gerbils per bini shell to cause a loss of 2% of the wheat in storage in 9 months! This would, indeed, be a plague of rodents.

Assume there are 100 roof rats and 1000 house mice living in a house-type godown containing 500 mt of bagged wheat. Each roof rat consumes about 9 g of wheat daily and each mouse eats 3 g daily. Assume they feed on the wheat stocks for 9 months (270 days). The total amount consumed by the 1100 rodents in the godown would be 1053 kg in 9 months. This represents approximately one mt out of 500, or a net loss of 0.20%. To cause a significant loss of wheat in storage (2%), these rodent numbers would have to be increased ten-fold (1000 roof rats and 10,000 house mice). This density of rodents in such a small space would not be possible despite an unlimited food supply because of increased population stresses, social contacts, aggressive encounters, etc., among the individual members. Several studies have shown that rodent populations will not grow beyond a certain density because of these population limiting factors.

Assume 200 house sparrows and 20 pigeons with free access to a 500 mt house-type godown. Each house sparrow eats about 4 g of w[illegible]/day and each pigeon consumes 25 g/day. Assume they feed on the wheat stocks for 9 months (270 days). The total losses due to bird consumption would be 350 kg, or equal to 0.07% of total stocks in storage in the godown. Even a ten-fold increase in bird numbers would result in only a 0.7% loss in 9 months.

These hypothetical examples point out that loss estimates of 5 to 6% due to rodents in grain storage centres are usually grossly overestimated, since they physically and practically are not possible due to limiting factors within rodent populations themselves. Losses of this magnitude are possible only in small grain stocks where 3 to 5 mt are being held in a space that could accomodate say 20 roof rats and 100 to 200 house mice (such as in a grain dealers shop). Here over a 9-month period, the 120 to 220 rodents could consume 130 to 210 kg of grain, roughly 4 to 5% of the stocks. These densities of rodent numbers might also be encountered in farmers grain storage stocks and comparable losses suffered.

Potential Health Hazards

Even if wheat losses due to vertebrate pests are minimal, the contamination of wheat stocks by fecal droppings, urine, hair, and feathers can be a real problem in 5 to 10% of all godowns. Rats and mice can transmit to humans several helminth and potozoal parasites in their fecal droppings, such as the rat tapeworm, *Hymenelopis nana* and the protozoal parasites, *Entamoeba histolytica* and *Giardia muris*. They can transmit leptospira in their urine, which causes leptospirosis in humans. Sparrows and pigeons can cause contamination of grain with coc-

cidia via their droppings.

Furthermore, the contamination of wheat with rodent and bird feces, urine, hairs and feathers means the grain should be thoroughly cleaned before milling or these contaminants would end up in the flour. In some cases, the contamination may be serious enough that the grain should be declared unfit for human consumption and utilized instead for livestock feed or other purposes. In most cases that we noted, the contaminated grain was only a small amount of the total stocks in storage, and this amount was usually on the floor and consisted of the portion of the grain that had spilled out of the bags when their seams had opened.

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5. RECOMMENDATIONS

a. Transfer authority and responsibility for structural maintenance and repair from PWD to the Food Dept.

b. Decentralize the maintenance and repair of structural defects down to district level from regional level.

c. The Dept. of Food should conduct an annual physical inventory of godown condition at all centres. The deteriorated condition of many structures indicates to us that this is not done in any routine manner and we suspect that an inventory of structure condition, age of structures, and need for physical repairs is not available at the Department of Food headquarters.

Such an inventory would take only a few hours or less at most centres, could be done by the officer-in-charge and submitted to the DDF's at each region, with copies for forwarding on to head-quarters.

d. Chowkhidars and food inspectors need re-training in fumigation and pesticide spraying procedures, since many times these are the individuals assigned to this task. The use of phosphine is hazardous and the dangers and the safety precautions necessary should be reviewed at least once each year before the start of fumighation.

e. Avoid putting stairways or access ways onto PASSCO house -type godowns - this defeats the purpose of the rodent guard.

f. Use grilled doors inside the regular doors to allow ventilation but block entry of rodents and birds. Examples of these types of doors were seen and could provide an excellent means of keeping vertebrate pests out of storage structures.

g. Retain the use of the verandah cover or roof over the loading dock and especially over the doorways. This will help greatly in keeping rain from entering the doorways.

h. The In-Charge should have a residence at the grain storage centre. In this way, he will be aware of the activities taking place at the centre. In numerous cases, the in-charge had come from as far as 20 miles away to reach his offices at the storage centre.

i. Boundary walls should be provided at all storage centres. We saw a few cases where the walls were incomplete or missing. The staff at the storage centre can never secure the centre without boundary walls and good gates and the lack of walls easily allows dogs and goats (and camels and cattle) access to the storage centre grounds.

j. Vertebrate pest problems should be dealt with on an individual basis. Severe infestations of rodents should be cleaned out with the appropriate use of fumigants and rodenticides.

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APPENDIX 1.

VERTEBRATE PEST SURVEY
OF FOOD STORAGE FACILITIES

District _____ Town _____ Date _____
Name and Address of Facility _____
_____ Govt. [] Private [] Other []
Manager's Name/Person Contacted _____
Number of Employees/Titles _____
Pesticide Application: fumigant Used _____
Schedule of Treatments _____ Frequency of Inspection _____
Any Other Control Methods: Traps [] Predators [] Barriers [] Other []
Training Needs: Present Refresher Training Given: Yes [] No []
Schedule of Training _____ Duration of Training _____

Godown No. _____ Stored Food _____ Quantity _____ mt. Duration _____ mo.
Quality: Excellent [] Good [] Fair [] Poor [] Bagged [] Bulk []
Bulk under tarps outdoors [] Bagged under tarps outdoors [] Bagged outdoor uncovered []
Structural: Type of structure _____ Age _____ Capacity _____
Structural condition: Good [] Fair [] Poor []
Structural Defects: Yes [] No [] Doors not fitting [] Floor cracked/broken []
Wall cracked [] Windows unscreened/broken [] Leaking Roof [] Grilled doors []
Vertebrate Pest Problems: Yes [] No [] House mice [] Roof rats [] Other rodents []
Pest Birds [] Other vertebrates [] (Cats, dogs, bats, etc.)
Severity of infestation: Rodents: Few [] Med [] Severe [] Birds: Few [] Med [] Severe []
Evidence: Droppings [] Live or dead animals [] Burrows outside [] Burrows inside []
Kinds of damage: Food consumption [] Contamination [] Bag damage [] Structural []
Remakrs: _____

Godown No. _____ Stored Food _____ Quantity _____ mt. Duration _____ mo.
Quality: Excellent [] Good [] Fair [] Poor [] Bagged [] Bulk []
Bulk under tarps outdoors [] Bagged under tarps outdoors [] Bagged outdoor uncovered []
Structural: Type of structure _____ Age _____ Capacity _____
Structural condition: Good [] Fair [] Poor []
Structural Defects: Yes [] No [] Doors not fitting [] Floor cracked/broken []
Wall cracked [] Windows unscreened/broken [] Leaking Roof [] Grilled doors []
Vertebrate Pest Problems: Yes [] No [] House mice [] Roof rats [] Other rodents []
Pest Birds [] Other vertebrates [] (Cats, dogs, bats, etc.)
Severity of infestation: Rodents: Few [] Med [] Severe [] Birds: Few [] Med [] Severe []
Evidence: Droppings [] Live or dead animals [] Burrows outside [] Burrows inside []
Kinds of damage: Food consumption [] Contamination [] Bag damage [] Structural []
Remarks: _____

APPENDIX 2.

Listing of Food Storage Centres under the Punjab Department of Food by Type and Facility

District	Centre	House Type		Bins	Bini Shells	Total
		Prov. Govt.	Hired			
Gujranwala	o Gujranwala I	7000	-	2000	-	9000
	o " II	6000	-	1000	-	7000
	o " III	8000	-	-	-	8000
	Rahwali	1000	-	-	-	1000
	Gakhar	5000	-	-	-	5000
	Wazirabad	2000	-	-	-	2000
	Khewali	-	3000	-	-	3000
	Alipur Chatta	3000	-	-	-	3000
	o Hafizabad	6500	-	1000	-	7500
	Kalake	1000	-	-	-	1000
	o Sukhake	2000	-	-	-	2000
	Noshera Virkan	12000	-	-	-	12000
	" "	(8000 UC)	-	-	-	(8000)
	Eminabad	8500	-	-	-	8500
	Kamoke	8000	-	2000	-	10000
					Total	87000
Sialkot	o Sialkot	9000	-	-	-	9000
	Mushrale	-	2000	-	-	2000
	Phuklian	500	-	-	-	500
	Daska	5000	-	-	-	5000
	Sambrial	1500	-	500	-	2000
	Siranwali	4000	-	-	-	4000
	Pasrur	5500	-	-	-	5500
	Porab Kalir	-	1000	-	-	1000
	Narowal	1000	-	-	-	1000
	Shakargarh	4000	-	-	-	4000
	Noorkot	1500	-	-	-	1500
	Kotnaina	500	-	-	-	500
					Total	36000
Gujrat	Gujrat	5500	-	-	-	5500
	Lala Musa	2500	-	-	-	2500
	Mandibahauddin	1500	-	5000	-	6500
	Malakwal	1000	-	-	-	1000
	Manochak	(12100 UC)	-	-	-	(12100)
					Total	27600
Lahore	o Mughalpura	48000	-	-	-	48000
	Badami Bagh	1000	-	10000	-	11000
	o Gulberg	9000	-	-	-	9000
	Signal Shop	6000	-	-	-	6000
	Raiwind	3000	-	-	-	3000
					Total	77000
Kasur	Kasur	10000	-	2000	-	12000
	o Khudian	2000	-	-	-	2000
	Pattoki	4000	-	-	-	4000
	Wan Radha Ram	5000	-	-	-	5000
					Total	23000

o Surveyed for Vertebrate Pests

District	Centre	House Type		Bins	Bini Shells	Total
		Prov. Govt.	Hired			
Sheikhupura	Sheikhupura	9000	-	2500	-	11500
	Chuharkana	6000	-	-	-	6000
	Dhaban Singh	3000	-	-	-	3000
	Khanqah Dogran	15000	-	-	-	15000
	Sangla Hill	4500	-	500	-	5000
	Shahkot	2000	-	-	-	2000
	Muridke	4000	-	-	-	4000
	Narang	2000	-	-	-	2000
	Nankana Sahib	22000	-	2000	-	24000
	Warburton	5000	-	500	-	5500
	Manawala	8000	-	-	-	8000
	Panwan	6000	-	-	-	6000
					Total	92000
Okara	o Okara	9000	-	5000	-	14000
	6/4-L	4400	-	-	-	4400
	Renala	8000	-	1500	-	9500
	o Shergarh	55800	-	-	-	55800
	Dipalpur	2000	-	-	-	2000
	Basirpur	4000	-	-	-	4000
	Haveli	5000	-	-	-	5000
	o Akhtarabad	7400	-	-	-	7400
					Total	102100
Faisalabad	PR-I Faisalabad	3000	-	-	-	3000
	PR-II "	4000	-	-	-	4000
	PR-III "	14500	-	-	-	14500
	PR-IV "	1000	-	4000	-	5000
	PR-V "	5500	-	-	-	5500
	Chak Jhumra	2000	-	3000	-	5000
	Dar-ul-Ehsan	2000	-	-	-	2000
	Sarshamir Road	2000	-	-	-	2000
	Jaranwala	12000	-	3000	-	15000
	Jhoke Ditta	4000	-	-	-	4000
	Rurala Road	3000	-	-	-	3000
	Buchiana	4000	-	-	-	4000
	Sammundri	8000	-	-	-	8000
	Tandlianwala	5500	-	4500	-	10000
	Mamukanjan	6000	-	3000	61000	70000
	Kanjwani	5000	-	2000	-	7000
					Total	162000
T.T. Singh	T.T. Singh	16500	-	7500	-	24000
	Janiwala	2000	-	-	-	2000
	Chuttiana	5000	-	-	-	5000
	"	(2200 UC)	-	-	-	(2200)
	o Rajana	4000	-	-	-	6000
	"	(2000 UC)	-	-	-	(2000)
	o Gojra	5000	-	5300	-	10300
	Chiraghabad	1000	-	-	-	1000
	Kamalia	7400	-	3000	-	10400
	Pirmahal	9400	-	5500	-	14900
					Total	75800

District	Centre	House Type		Bins	Bini Shells	Total
		Prov. Govt.	Hired			
Jhang	o PR-I Jhang	6500	-	2000	-	8500
	PR-II "	4700	-	-	-	4700
	PR-III "	6000	-	-	-	6000
	Chak Kurriana	-	-	-	66000	66000
	o Shah Jewana	6000	-	1000	-	7000
	Mochiwala	3300	-	-	-	3300
	Chak No.170/JB	4000	-	-	-	4000
	Chiniot	-	-	1000	-	1000
	o Rabwah	5000	-	-	-	5000
	Lalian	2000	-	1000	-	3000
	Chak No.11/JB	8000	-	-	-	8000
	Jamiaabad	9900	-	-	-	9900
	o Shorkot Road	4500	-	-	-	4500
	o Shorkot Town	1500	-	-	-	1500
	Waryam	1000	-	-	-	1000
	Rustam Surgna	1000	-	-	-	1000
	Garhmaharaja	1000	-	-	-	1000
	Garh More	8000	-	-	-	8000
	Ahmadpur Sial	5000	-	-	-	5000
					Total	148400
Rawalpindi	Rawalpindi	18500	-	5000	-	23500
	Islamabad I	14000	-	-	-	14000
	o Islamabad II	36000	-	-	-	36000
	o Gujar Khan	7500	-	-	-	7500
	Sehala	6000	-	-	-	6000
	Taxila	2000	-	-	-	2000
	Wah Cantt	7500	-	-	-	7500
	Kahuta	2000	-	-	-	2000
	Murree	1500	-	-	-	1500
					Total	100000
Attock	o Attock	8000	-	-	-	8000
	Lawrencepur	1000	-	-	-	1000
	Hassan Abdal	2000	-	1000	-	3000
	Fateh Jang	1500	-	-	-	1500
	Pindi Gheb	1000	-	-	-	1000
	Basal	4500	-	-	-	4500
	Jand	500	-	-	-	500
	Talagang	1000	-	-	-	1000
					Total	20500
Jhelum	Jhelum	8000	-	-	-	8000
	Sohawa	3000	-	-	-	3000
	Chakwal	5500	-	-	-	5500
	Khewara	2500	-	-	-	2500
	Dina	1000	-	-	-	1000
					Total	20000

District	Centre	House Type		Bins	Bini Shells	Total
		Prov. Govt.	Hired			
Layyah	o Layyah	11500	-	3000	-	14500
	138/TDA	7500	-	-	-	7500
	Karor	4200	-	-	-	4200
	Fatehpur	8600	-	-	-	8600
	Chowk Azam	4200	-	-	-	4200
	Chumbara	2200	-	-	-	2200
	o Jaman Shah	2000	-	-	-	2000
					Total	43200
D.G. Khan	D.G. Khan	6000	-	2500	-	8500
	Taunsa	1000	-	-	-	1000
					Total	9500
Rajanpur	Rajanpur	3000	-	1000	-	4000
	"	(2200 UC)	-	-	-	(2200)
	Jampur	2000	-	1000	-	3000
	Fazalpur	1000	-	-	-	1000
					Total	10200
Muzaffargarh	Muzaffargarh	5000	-	1000	-	6000
	Khan Garh	1000	-	-	-	1000
	o Rakh Harpalu	12400	-	-	-	12400
	Shair Sultan	1000	-	-	-	1000
	Alipur	500	-	500	-	1000
	o Jhalarin	11100	-	-	-	11100
	Chak Bodla	1000	-	-	-	1000
	Kot-Adu	500	-	-	-	500
	Patal Munda	9200	-	-	-	9200
	Rangpur Codara	5200	-	-	-	5200
					Total	48400
Sargodha	Sargodha-I	500	-	11000	-	11500
	o " II	15000	-	1000	-	16000
	Asianwala	50000	-	-	-	50000
	Sillanwali	3000	-	2000	-	5000
	"	(1100 UC)	-	-	-	1100
	Shah Nikdar	-	-	1000	-	1000
	" "	(3000 UC)	-	-	-	(3000)
	Shahpur	8300	-	-	-	8300
	"	(2000 UC)	-	-	-	(2000)
	Bhalwal	3000	-	3000	-	6000
	o Phullarwan	4000	-	1000	-	5000
					Total	108900
Khushab	Khushab	2000	-	-	-	2000
	Jauharabad	8400	-	2000	-	10400
	Quaidabad	3000	-	3000	-	6000
					Total	18400

District	Centre	House Type		Bins	Bini Shells	Total
		Prov. Govt.	Hired			
Mianwali	Mianwali I	500	-	3000	-	3500
	o " II	1000	-	-	-	1000
	o Wah Bachran	1000	-	-	-	1000
	Piplan	500	-	2000	-	2500
	Mari-Indus	1000	-	-	-	1000
					Total	9000
Bhakkar	Bhakkar I	1500	-	3000	-	4500
	o " II	7000	-	-	-	7000
	Darya Khan	1000	-	-	-	1000
	" "	(2200 UC)	-	-	-	(2200)
	Kalur Kot	3000	-	-	-	3000
	" "	(2000 UC)	-	-	-	(2000)
	Asif Wali	3300	-	-	-	3300
	Mankera	2200	-	-	-	2200
					Total	25200
Multan	o Multan PR-I	500	-	3000	-	3500
	" PR-II	7300	3500	-	-	10800
	o Steel Silos	10000	-	42000*	-	52000
	o Khanewal	18900	2000	8500	-	29400
	Kacha Khu	3000	500	-	-	3500
	o Musa Virk	-	-	-	61500	61500
	o Mianchannun	5500	2000	5000	-	12500
	Jahanian	5000	2000	5000	-	12000
	Abdul Hakim	13600	1500	2000	-	17100
	o Lodhran	17700	1500	-	-	19200
	Dhanot	5000	-	-	-	5000
	Kororpucca	10000	-	2000	-	12000
	o Dunyapur	22800	-	-	20000	42800
	Shujaabad	5000	2000	-	-	7000
	o Jalalpur Pirwala	10200	-	-	-	10200
	o Dirapur	10400	-	-	-	10400
	Lar	-	2000	-	-	2000
	Basti Malook	-	1000	-	-	1000
					Total	311900
Vehari	o Vehari PR	6500	1500	5000	-	13000
	o Bini Shells Vehari	2000	-	-	70500	72500
	o Burewala	6000	2500	5000	-	13500
	Gaggoo	2000	1000	3000	-	6000
	Mailsi	-	2250	-	-	2250
					Total	107250

* Steel Silos

District		Centre	House Type		Bins	Bini Shells	Total
			Prov. Govt.	Hired			
Sahiwal	o	Sahiwal	6000	1500	5000	-	12500
	o	Harappa	5300	3000	-	-	8300
	o	Kamir	8400	-	-	-	8400
		138/9-L	2000	-	-	-	2000
		182/9-L	2000	-	-	-	2000
	o	Chichawatni	9000	1500	6000	-	16500
	o	Kassowal	9000	2000	2000	-	13000
		Iqbalnagar	4000	500	-	-	4500
		Ghaziabad	8000	-	-	-	8000
		170/9-L	17600	-	-	-	17600
	o	Dad Fatiana	3000	-	-	-	3000
		Kamand	2200	-	-	-	2200
	o	Pakpattan	5500	-	1000	-	6500
		Arifwala PR	500	1100	5000	-	6600
	o	Bini Shells A.Wala	-	-	-	75000	75000
	o	Ahmadyar	6000	-	-	-	6000
		Noorpur	12000	-	-	-	12000
		Bunga Hayat	6000	-	-	-	6000
						Total	210100
Bahawalpur	o	Bahawalpur	5500	-	1500	-	7000
	o	Bini Shells BHP	-	-	-	55500	55500
		Khanqah Sharif	-	2000	-	-	2000
		Yazman	9000	-	-	-	9000
		Tail Wala	4000	-	-	-	4000
		Head Rajkan	5000	-	-	-	5000
		Chak 51/DB	2000	-	-	-	2000
		Ahmadpur East	8000	-	1000	-	9000
		Mubarakpur	1000	-	-	-	1000
		Chani Goth	-	-	500	-	500
	o	Hasilpur	3500	-	1000	-	4500
		Israni	12000	-	-	-	12000
						Total	111500
Bahawalnagar	o	Bahawalnagar	1500	-	2000	-	3500
		Dounga Bounga	-	-	1000	-	1000
		Khattan	500	-	-	-	500
	o	Haroonabad	4000	-	3000	-	7000
		Chak 107/6-R	1500	-	-	-	1500
	o	Faqirwali	10200	-	-	-	10200
		Chak 58/4-R	500	-	-	-	500
		Chak 70/4-R	1000	-	-	-	1000
		Chak 71/4-R	2000	-	-	-	2000
		Fortabbas	12000	-	1000	-	13000
		Chak 268/HR	4400	-	-	-	4400
		Chak 311/HR	4000	-	-	-	4000
		Khichi Wala	3300	-	-	-	3300
		Chak 134/M	500	-	-	-	500
	o	Chishtian	5500	-	3000	-	8500
		Bakhshan Khan	500	-	-	-	500

District	Centre	House Type		Bins	Bini Shells	Total
		Prov. Govt.	Hired			
Bahawalnagar	Dahranwala	10000	-	-	-	10000
	o Chak 12/G	5000	-	-	-	5000
	o Chak Abdullah	4400	-	-	-	4400
	Minchanabad	1000	-	500	-	1500
	Chabiana	1000	-	-	-	1000
	Sadiq Ganj	500	-	-	-	500
					Total	83800
Rahim Yar Khan	Sadiqabad	2000	-	500	-	2500
	Jamal Din Wali	3300	-	-	-	3300
	Bhuttan Wahin	500	-	-	-	500
	Wahid Bux Lar	7000	-	-	-	7000
	Chak 158/P	1000	-	-	-	1000
	Nawazabad	2000	-	-	-	2000
	Rahimyar Khan	5500	-	-	-	5500
	Iqbalabad	4000	-	-	-	4000
	Chak 64/NP	16000	-	-	-	16000
	Taranda S. Khan	500	-	-	-	500
	Kot Samaba	500	-	-	-	500
	o Khanpur	6000	-	-	-	6000
	Bagho Babar	5000	-	-	-	5000
	o Chak 63/P	10000	-	-	-	10000
	Mari A.B.	500	-	-	-	500
	o Zahir Pir	500	-	-	-	500
	o Jajja Abbasian	500	-	-	-	500
	Chak 70/A	15000	-	-	-	15000
	o Liaquatpur/89-A	20700	-	1000	-	21700
	Allahabad	500	-	-	-	500
	Changni	4400	-	-	-	4400
					Total	106900
					Grand Total	2175650