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Research Article

DAMAGE PATTERNS OF DIFFERENT BIRDS AND RODENT SPECIES IN GRAIN STORAGES IN BAHAWALPUR, PAKISTAN

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Abstract

Birds and Rodents can cause significant damage to grain stores in developing countries, affecting the food security and income of small-holder farmers. Methods for assessing storage losses by rodents under small-holder conditions will help farmers and policy makers understand the impact rodents may have on food security, nutrition, and health. The present study aimed to determine the different damage patterns by birds and rodents in grain storage in Bahawalpur, Pakistan. The study was conducted between August 2021 and February 2022. Twelve grain stores were selected for the observations based on environmental conditions and storage types. Damage patterns were observed through scan sampling by directly observing the damage patterns in terms of grain spreading, fecal contamination, hair contamination, packaging injuries, and feather presence. For loss assessment, the Bowls with known quantities (about 2kg) of grains were placed within grain storage and periodically monitored for weight loss, fecal contamination, and percentage of birds and rodent- damaged grains. The bowels were weighted before and after rodents or bird attack and difference in weight were used to calculate percentages losses. Grain spreading was observed as main damage pattern by birds. Its percentage was measured as 68%, followed by fecal droppings (14%), packaging injuries (13%), and feather presence (5%). Rodents main damage pattern was also grain spreading (47%), followed by packaging injuries (23%), fecal droppings (20%), and presence of hair (10%). Estimates of grain losses in the absence of measures were 23.1% annually. These losses were reduced when rodent control was implemented. So, by implementing control methods and propers storage strategies and using good quality packaging material the rodents and birds losses can be reduced.

Keywords: Birds, Rodents, stored grains, damage, management.
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1. INTRODUCTION

Several vertebrate pests heavily target crops and food storage in underdeveloped countries. In underdeveloped countries, food and agriculture output losses are not tracked in a necessary manner. Rats, mice, and pest birds devastate people's stored food and crops living in underdeveloped nations (Kumar & Kalita, 2017). Farmers and owners of grain storages that suffer from vertebrate pest damage during harvesting season and post-harvest face a twofold financial burden. While most crops are subject to vertebrate pests throughout their growing phases, preserved food remains vulnerable for the duration of their preservation (Rehman et al., 2019).The chewing, rotting, contamination, and hoarding behaviors of rodents have a devastating effect on many crops. Once established, rodents can reproduce rapidly and emigrate after harvest based on food availability in the agricultural system (Sarwar et al., 2011). Rodents degrade grain quality and quantity by causing direct damage, waste, and contamination of stored food (Drummond, 2001).

In certain regions of the globe, crop losses and food shortages result from rodent damage (Fayenuwo et al., 2007). Every year, many crops are lost in the pre-and post-harvesting stages (Meerburg &

Kijlstra, 2008). The capacity of rat pest species to thrive in a broad range of environmental circumstances and feed on a diverse range of foods is one of their most essential characteristics (Mmetwaly et al., 2009).One-fifth of the food crops grown each year throughout the globe are never consumed by humans due to rodent damage. Large rat populations result from poor building upkeep, a lack of cleanliness, careless food handling that results in spills, and a major absence of rodent proofing in most storage facilities and human houses.

Bird pests found in grain storage facilities are much the same as those found in urban homes and businesses, which cause damage. Pigeons, crows, mynahs, and sparrows are the most common bird pests that pose one of the largest threats to grain storage.With their powerful hooked beaks, birds can cause physical damage to buildings and engage in nuisance behavior as they consume and destroy grain.In the literature, post-harvest losses are estimated in the range of 9-40 percent, with the most common worldwide number being 9 percent (Hodges et al., 2014). According to Kumar and Kalita (2017), cereal grain losses in storage owing to technological inefficiency are in the range of 50-60%.In many parts of the globe, rodents constitute a serious pest problem. Rodents are a significant cause of damage to cereal grains, quality, and quantity (Mdangi et al., 2013).

For the most part, the house rat (R. Rattus), the house mouse (M. musculus), and the lesser bandicoot rat (B. bengalensis) infest food storage and processing facilities like grocery stores and grain markets in rural and urban areas alike as well as in major metropolises like Bombay, Calcutta, Delhi, and Madras. These often result in significant losses while being stored (Prakash & Mathur, 1987). As in Pakistan, where the number of R. rattus varies from 5 rats per grain shop to 61 rats per grain shop in Lahore, the province of Punjab suffers about 4000 metric tonnes of annual loss as a result of rat-caused spills, consumption, contamination, and other losses of grains and commodities, all of which amounts to 0.3 percent of the total amount handled annually by 5500 shops (Ahmad et al., 1996). The urine, feces, and hair of rodents contaminate food. There is a wide range of contaminant levels around the storage facility.

Only a few studies have examined the impact of rodents on stored fruits and vegetables. Manufacturing buildings, silos, vehicles, equipment, and open fields are some of the infrastructures in the grain storage region that need care. There is also a difficulty with grain facilities because of the large number of crops and the wide range of food they keep. Pest bird populations may grow rapidly, attracting a wide variety of non-native species.

The main objectives of the study were to identify different birds and rodent species causing damage to grain storage, observe the patterns of damage by birds and rodent species in grain stores, and assess grain loss by birds and rodents damages in different grain stores in Bahawalpur

2. Materials and Methods

2.1. Study Area

Bahawalpur is the district of Punjab Province, Pakistan. According to the 2017 Census of Pakistan, the country had a population of 3.668 million, with urban areas accounting for 27.01 percent of the total. The district of Bahawalpur has an area of 24,830 km2. Bahawalpur is a location in the Pakistan in the Cities place category with the GPS coordinates of 29° 25' 5.0448" N and 71° 40' 14.4660" E. It is situated at the latitude and longitude of 29° 25' 5.0448" N and 71° 40' 14.4660" E Bahawalpur. Pakistan has an elevation of 115 meters, which is equivalent to 377 feet. The Cholistan Desert, which stretches into India's Thar Desert, covers almost two-thirds of the district (16,000 km2). Agriculture is the primary source of income for the majority of the inhabitants in the region. Cotton is an important crop in this region.

2.2. Selection of grain stores

Grain stores were selected on the basis of the presence of rodents and birds; the store has options for the entry of birds and rodents. The stores that were noted to be highly contaminated above the margin were not included in the final measures. Also, the stores having extraordinary environments having no chances for rodents or bird entry were also eliminated. In total, 12 stores having mixed environments and feasibilities for rodents and bird entries were finalized for study. These stores were selected in different and variable localities in Bahawalpur. These include open stores like PASSCO and open maiz collection storages; closed stores include grain markets, Godowns, warehouses, and mixed types of storage, including flour mills and some local farmer storages and grain markets.

Using a 5-point scale, the environmental state of the grain storage facilities was evaluated qualitatively in order to determine their appropriateness for occupancy or access by mice in order to feed on the grain stored there. The categories were as follows:

Very poor: rats thrive in these settings. There is enough cover and shelter, as well as food and drink, and there is little or no disturbance. It's about as terrible as it gets in this situation.

Poor: environmental conditions that are marginally less favorable for rat infestation than category 1.

Average: circumstances that provide some shelter for rats but not a great deal of protection.

Fairly good: the environment is orderly and clean, but there is room for improvement.

Excellent: Provides no opportunity for rodent populations to survive. Very orderly, clean, and welcoming

Storage types

Three types of storage were observed, including close, open, and both close & open types of storage.

Open Storage: The store has free availability to birds and other pest species, having no or little boundaries and coverings, like storage in local farmer fields and PASSCO were regarded as Open storage. In total, three open stores were studied in this study.

Close Storage: Close storages consist of warehouses, godowns, and local farmer storages having walls around and roofs. In total, five close storages were studied for birds' and rodents' damage patterns.

Close & Open storage: Close and open storage have the conditions of both types, open and close. Some parts of these storages are accessible to birds and other local species, and some parts are covered or enclosed. These are the types where farmers keep some of their grains inside the godown, and some are kept either as spread grains on the floor or stalked in bags but kept outside the store. In total, 4 out of 12 store studies obey this type of storage.

2.3. Data collection

Direct observation is most importantly used in observing physical factors. The stores were observed from one end to the other, identifying the damaged spots either in the form of spread grains on the floor, packaging damages, feces contaminations, hair contaminations, fins, or other contamination and damage patterns. The diary was used to write up the no. of each kind of damage pattern and the environmental condition of the store. A bio-data form was filled out while communicating with the farmer. The damaged spots were captured by the camera for the recording. The figure below shows the researcher observing the grain store.

2.4. Determination of Loss Assessment

Post-harvest losses from rats are well-known, and farmers are taking steps to prevent rodents from entering their storage facilities. When it comes to these safety precautions, the most common ones are the "rat caps" and "rat guards," which are metal sheets wrapped around each stilt. Brown et al. (2013) devised a technique that was employed in this investigation. Following the owners' approval, 12-grain stores were chosen for the research. Each of these grain shops was located in a different part of town and had a different design. The grain storage facilities and their surroundings were studied for their characteristics. Each business was given two bowls. The farmer's shop provided two kilograms of grain for each of these bowls. They were placed such that the contents were level with the grain storage around them. Rodents like to eat towards the edges of the shop, so the bowls were put there. Prior to the bowls being put in the shop, each bowl's weight and grain content were recorded using an electronic balance. We kept track of the two bowls' weights and looked for signs of contamination from rodent feces and hairs. One bowl was left uncovered to enable rats to get in, while the other was covered with wire mesh to keep rodents away from the grain it contained. The closed bowl was used to determine the grain moisture loss or increase, which was then tallied with the grain weight in the open bowl before being analyzed. Insects could also be kept out of the closed bowl, preventing any loss or harm. So that reliable weight and contamination measurements could be conducted, farmers agreed not to add or remove rice from the bowls within the grain store. As there were no physical changes seen in the closed bowl, we just considered the open bowl for further analysis.

2.5. Sampling protocol

Every two weeks, the researcher visited each of the grain stores on the list. At the end of each visit, bowls were removed from the grain storage, and the weight of each bowl was recorded with the use of an electronic scale. As a result, grain samples weighing 100g were gathered from both the open and closed bowls, as well as from the farmer's grain storage facility. The sample was obtained from each bowl by collecting the top l cm layer of rice toward the middle of the bowl and scooping it out with a spoon. The removed layers were replenished with extra grain from the store, resulting in a total weight in the bowl of 2kg of the initial grain weight. The grain store sample was always obtained at random from the store's periphery, regardless of the location. These samples were then separately spread out on a white plastic sheet, and the amount of rodent and bird droppings and hairs found in each sample were counted and recorded.

3. Results:

3.1. Damage patterns of Birds

Birds cause damage to grains in different ways. They feed on spread grains and cause injuries to packaging, drop their feces and fins and also cause direct weight loss.

3.1.1. Spreading grains:

Most birds feed on spread grains causing direct weight loss. The birds were also observed spreading the grains with their beak and palms. This type of damage was 68% of the total damage. The species observed feeding on spread grains include myna, house crow, rock pigeon, collard dove, and house sparrow.

3.1.2. Fecal droppings:

After grain damaging and spreading, fecal droppings were observed as another major damage type by birds. When birds stay for a long time at a place like a warehouse and have free access with less or no human interruption, they contaminate the grains with their fecal droppings. In the figure below researcher is observing fecal droppings of rock pigeons sighted in a warehouse.

3.1.3. Packaging injuries:

Packaging injuries by birds were also observed in excess and were observed in most of the stores. Birds peck holes with their beaks and palms and cause severe damage and losses to grain storage. The stores with lower-quality bags seemed to be easily damaged by birds. In the figure below researcher is collecting evidence of birds' packaging injuries.

3.1.4. Feather droppings:

Feather contamination was also observed in some cases, but it's the least common damage pattern, and it was just 5% of all types. Feather droppings affect the quality of grain. Different types of damage by birds in 12 selected grain stores are comparatively described in table 1 below.

Table 1: Damage patterns of Birds observed from grain stores

Store No.	Storage type	Store Condition level	Spread Grains spots	No. of Feces droppings	No. of Packaging damages	No. of Feathers	Total
Store 1	close	Poor	12	0	0	1	13
Store 2	Open & close	Poor	9	2	3	0	14
Store 3	open	Fairly good	6	0	0	0	6
Store 4	close	Very Poor	11	3	5	1	20
Store 5	Open & close	Average	7	1	2	0	10
Store 6	close	Very poor	10	0	2	3	15
Store 7	close	Very poor	8	2	4	1	15
Store 8	Open & close	Poor	5	3	3	0	11
Store 9	open	Excellent	12	1	0	0	13
Store 10	open	Poor	9	0	0	1	10
Store 11	close	Poor	8	8	1	0	17
Store 12	Open & close	Average	6	1	0	0	7
	Total		103	21	20	7	151

The stores having poor and very poor environmental conditions showed more no of damages than with average, fairly good or excellent environmental conditions. The maximum number of damages observed for a store was 20, and the minimum no of damages was recorded as 6 for one store.

Figure 1 below describes the percentage type of damage caused by birds.

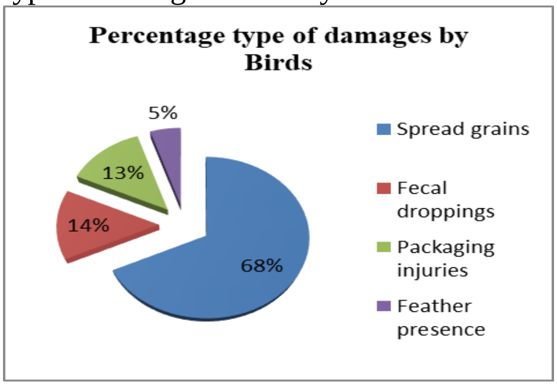

Figure 1: Percentage type of damage by Birds

3.2. Damage patterns by Rodents

3.2.1. Grain spreading:

Almost every selected store showed spread grains upon each visit. This type of damage was calculated as 47% of total damages types. The stores with poor environmental conditions showed more spots of spread grains; the splitter grains confirm the presence of rodents in the store. Larger numbers of damage were observed in wheat and rice.

3.2.2. Packaging injuries:

Plant seeds, including barley, are often not housed in metal silos but rather in packets made of paper, cardboard, plastic, or wood. These packages are easily penetrated by all three of the principal rodent pest species, which dine on the contents within them. A mouse population may also grow within or amid seed sacks without leaving any visible evidence of activity. Molds and storage insects and mites commonly degrade the contents of the damaged bags during storage or handling, which is why it is important to keep the bags in a clean and dry environment. Wet or dispersed grains from damaged bags may also make flooring slippery, increasing the risk of an accident occurring (Hamel, 2010).

3.2.3. Fecal contamination:

Rat and mouse urine and feces pollute the environment, stored goods, and food items. Astonishingly, there was no empirically assessed information on the feces rates of different mouse species. Preparation for early detection of mouse feces requires an understanding of the typical distribution patterns of rodent poo. The feces density of house mice was recently studied by Aulicky et al. (2015), who examined the distribution of feces in a typical mouse home range surrounding its shelter. Food deterioration was shown to be a significant problem. It was shown that even one mouse might cause substantial floor pollution, and the average daily defecation rate for each person was 102.2 feces/individual, out of which 7 percent were situated within the food and water proximity (Aulicky et al., 2015).

3.2.4. Hair droppings:

Rodents also contaminate the food materials with their hair droppings. The total number of hair droppings observed in all 12 stores was 15, which is 10% of all types of damage, and hair droppings are the least found. Figure 26 below shows that fecal and hair droppings are contaminent.

The table below shows a comparative detail of different types of damage patterns for each store.

Table 2: Damage patterns of Rodents observed from grain stores

Stores	**Storage type**	**Store Condition level**	**Spread Grains spots**	**No. of Feces droppings**	**No. of Packaging damages**	**No. of Hairs**	**Total**
Store 1	close	Poor	4	1	3	1	11
Store 2	Open & close	Poor	7	2	4	0	13
Store 3	open	Fairly good	3	0	1	0	4
Store 4	close	Very Poor	13	4	3	2	22
Store 5	Open & close	Average	2	1	2	0	5
Store 6	close	Very poor	11	4	4	3	22
Store 7	close	Very poor	8	6	7	2	23
Store 8	Open & close	Poor	6	3	3	1	13
Store 9	open	Excellent	1	0	0	0	1
Store 10	open	Poor	4	2	3	3	12
Store 11	close	Poor	5	3	2	2	12
Store 12	Open & close	Average	3	2	1	1	7
	Total		67	28	33	15	145

The maximum number of damage spots observed was 23 for store 7, and minimum damages were observed in store 7 with just 1 damage. The store with a maximum number of damages was apparently very poor in environmental conditions and had a lot of possible ways of rodents entry and residency. However, the store, with just 1 damage, was excellent against rodents.

Figure 2 below shows percentages for each type of damage pattern. The most recorded damage type was the spreading of grains which constituted 47 % and moved to 23%, 20%, and 10% or packaging injuries, fecal droppings, and hair droppings, respectively.

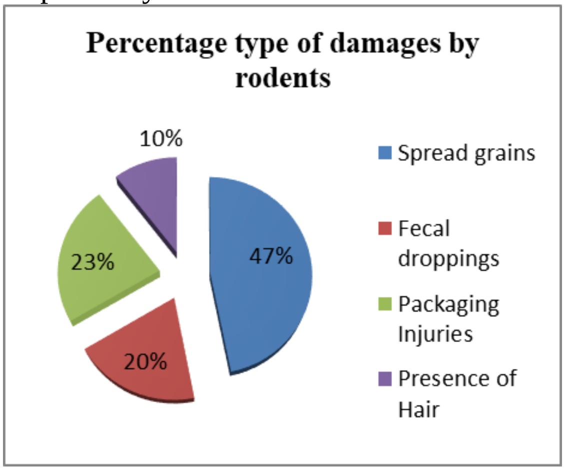

Figure 2: Percentage type of damage by rodents

3.2.5. Loss assessment

Loss assessment was calculated by keeping the grain-filled bowls within the grain storage, and their weight was measured before and after the attack. 2 bowls, each having 2kg grain, were placed in the store, one as a control group and was covered with a net cloth, another bowl was kept open. After each 15 days gap, the bowls were weighed, and their weights were recorded, as shown in the table below. The difference in losses helped us to calculate the percentage loss. The data was recorded for 5 months, and calculations were made.

Percentage loss assessment was calculated by using the formula:

$$\frac{m1 - mx}{m1} \times 100 = \%\ \text{weight loss}$$

Where:

m1 = grain mass before the attack

mx = grains mass after the attack

Figure 3 below describes the percentage loss for each grain store for the 10 trials.

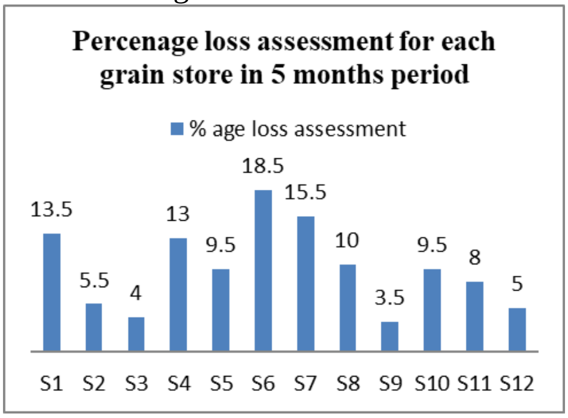

Figure 3: Percentage loss assessment for each grain store in 5 months period

Annual % age loss assessment:

Annual %age loss was assessed by using the following calculations

5 months loss assessment: X

1-month loss assessment: X/5

12 months loss assessment: X/5 × 12

Using this formula, the annual calculated percentage loss assessment is described in the table below:

Table 3: Weight measurements of bowls after every 15 days intervals

Store No.	Storage type	Store condition	Weight placed	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6	Visit 7	Visit 8	Visit 9	Visit 10	Mean	% loss
1	C	P	2.00	1.85	1.72	1.87	1.82	1.79	1.64	1.71	1.62	1.67	1.68	1.73	13.5
2	O & C	P	2.00	1.94	1.91	1.93	1.88	1.92	1.72	1.90	1.93	1.91	1.87	1.89	5.5
3	O	FG	2.00	1.92	1.98	1.93	1.90	1.92	1.89	1.94	1.90	1.92	1.93	1.92	4.0
4	C	VP	2.00	1.87	1.85	1.67	1.72	1.64	1.69	1.73	1.78	1.72	1.74	1.74	13.0
5	O & C	A	2.00	1.79	1.82	1.78	1.85	1.83	1.88	1.81	1.78	1.77	1.81	1.81	9.5
6	C	VP	2.00	1.67	1.72	1.71	1.62	1.58	1.52	1.63	1.65	1.59	1.64	1.63	18.5
7	Close	VP	2.00	1.66	1.69	1.72	1.67	1.64	1.70	1.69	1.78	1.68	1.74	1.69	15.5
8	O & C	P	2.00	1.77	1.73	1.89	1.79	1.76	1.84	1.86	1.90	1.79	1.73	1.80	10
9	O	E	2.00	1.97	1.95	1.93	1.92	1.96	1.91	1.90	1.92	1.98	1.95	1.93	3.5
10	O	P	2.00	1.88	1.83	1.82	1.78	1.87	1.79	1.77	1.83	1.76	1.80	1.81	9.5
11	C	P	2.00	1.92	1.87	1.88	1.83	1.78	1.84	1.79	1.87	1.90	1.78	1.84	8.0
12	O & C	A	2.00	1.90	1.87	1.93	1.92	1.90	1.93	1.88	1.90	1.93	1.90	1.90	5.0

Table 4: Annual percentage loss

Store No.	% age loss assessment (5 months)	% age loss assessment (Annual)= X/5× 12
1	13.5	32.4
2	5.5	13.2
3	4.0	9.6
4	13.0	31.2
5	9.5	22.8
6	18.5	44.4
7	15.5	37.2
8	10	24
9	3.5	8.4
10	9.5	22.8
11	8.0	19.2
12	5.0	12
Mean total	9.62	23.1

From the table above, we can calculate the mean weight loss for all twelve stores. It was calculated as 23.1%. In fact, for a population like Bahawalpur, it's a greater number.

4. Discussion

In our research, the owners of grain storage said that they had no idea how much grain was being devoured by rats while it was being stored. Their grain storage was plagued by rats, which were considered the most serious threat. In contrast to what the storage owners predicted, we discovered that grain losses might be as high as 23.1 percent. Although farmer grain storages are often well-built, rats and other pests have easy access to the granaries since the area surrounding them is poorly maintained. Post-harvest losses in Bahawalpur are likely due to poor sanitation and insufficient rodent-proofing of grain stockpiles, according to our findings. Several factors influenced the quantity of rice grain lost during storage in Pakistan, including differences in the types of storage structures, the quality of local sanitation, how long grains were held, and how densely rodent populations lived in the region. Community trapping efforts (Belmain et al., 2003) and improvements in village cleanliness and grain storage rodent-proofing have both been shown beneficial in decreasing post-harvest losses due to rats (Mdangi et al., 2013; Belmain et al., 2015).Birds have been known to enter warehouses from time to time. The packaging of the stored items is sabotaged by birds. This results in product losses due to spills and birds consuming grain.

Rodents may eat a wide range of stored raw and completed goods and products, even if they aren't ready to eat. Post-harvest losses caused by rodents may range from 3 percent to 50 percent, according to the Food and Agriculture Organization of the United Nations (Brooks & Fiedler, 1999). In underdeveloped nations, post-harvest losses are said to be much greater than in rich ones (Brown et al., 2013). The urine, feces, and hairs of rats and mice are a major source of unpleasant odors in the environment, as well as in stored commodities and food items. While the large daily poo output of rodents has long been recognized, little scientific information on species-specific defecation rates has been available until recently. Frynta et al. (2012) found the average daily feces output of a single confined rat to be 66. Researchers have studied the number and distribution of house mouse feces in a typical mouse home range surrounding the shelter. Food deterioration was shown to be a significant problem. This study found that the average daily defecation rate was 102.2 feces/individual, with 7 percent of those droppings being found near food and water sources after only one mouse incursion into a simulated shop (97.3 feces/m2).

Most of these packages can be penetrated by all three of the primary rodent pest species, allowing them to devour the contents. Furthermore, mouse populations may grow secretly inside or amid seed sacks without leaving visible traces of their presence. Storage insects and mites and molds can contaminate the contents of damaged bags when they leak out during storage or handling of the containers. Accidents may occur as a result of wet flooring and/or grains distributed from damaged bags (Fraková et al., 2016).

Birds and rats have easy access to grain storage facilities, which may be reduced greatly by making simple adjustments. Actions such as the use of open-weave mesh and the removal of rodent-infested items from beneath and around the shops are part of this strategy. Such measures would need to be accompanied by frequent village-level traps in order to minimize the rat population.

5. Conclusion

It's critical to know the kind of bird involved, as well as the type and amount of harm. To prevent birds from entering the shop, high standards of sanitation are maintained, and exclusion measures are used to keep them out. Bird pests may be controlled by a variety of methods, including culling, exclusion, anti-roosting procedures, and scare tactics.

Many assessments, like this one, show that rodents pose a wide range of threats to the human population and human resources, not to mention their abundance. Anticoagulant rodenticide resistance, rodenticide harmful effects on non-target species, and the ecology of rodent pests are all investigated extensively. Alternatively, there are still certain challenges and/or problems that regularly arise in the food processing business but which are either sparse or missing from peer-reviewed literature, including the risk of rodent contamination and particular studies dealing with risk assessments in grain and food storage. Rodents are a neglected pest category in many EU nations, despite their severe pest impacts and frequency of issues in retail establishments and the food business, according to a recent study.

Many factors contribute to post-harvest losses, including crop type, harvest method, climate, and national economy, which are all interrelated. In underdeveloped nations, grain storage losses make up the majority of all post-harvest losses, putting farmers' livelihoods at risk. The typical storage structures are insufficient to prevent insect infestation and mold development during storage and result in significant losses for the majority of produced grains. Post-harvest losses may be reduced, and farmers' incomes can be increased by technological interventions and better storage arrangements. Using sealed waterproof bags or structures, hermetic storage generates a modified environment with a high concentration of carbon dioxide gas that considerably lowers infection losses. Storage losses have been reduced by up to 98 percent thanks to the use of hermetic storage structures that keep seeds viable and of high quality for lengthy periods of time. Food security and poverty reduction may be improved by adopting better farming techniques and using appropriate storage technology.

6. Conflict of Interest

There is no conflict of interest among the authors.

7. Acknowledgments

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8. REFERENCES

Ahmed, M.S., M. Y. Mian, M. E. Haque, and J. E. Brooks. 1996. Estimating rat damage in deep water rice. Int. Rice Res. Inst. 1(1) : 23–34.

Aulicky, R., V. Stejskal S. Pekar. 2015. Risk evaluation of spatial distribution of faecal mice contaminants in simulated agricultural and food store. Pak. J. Zool. 47(4) : 56-59.

Belmain, S. R., N. M. Htwe, N. Q. Kamal and G. R. Singleton. 2015. Estimating rodent losses to stored rice as a means to assess efficacy of rodent management. Wild. Res. 42(2) : 132-142.

Belmain, S. R., A. N. Meyer, R. Timbrine and L. Penicela. 2003. Managing rodent pests in households and food stores through intensive trapping. ACIAR. Mon. Ser. 96(1) : 440-445.

Brooks, J. E. and L. A. Fiedler.1999. Compendium of post-harvest operations. chapter III: vertebrate pests: damage on stored foods, agro-industries and post-harvest management service. Food and agriculture organization , Rome, Italy.

Brown, P. R., A. McWilliam, and K. Khamphoukeo. 2013. Post-harvest damage to stored grain by rodents in village environments in Laos. Int. Bio. 82(3) : 104-109.

Drummond, D. C. 2001. Rodents and biodeterioration. Int. Bio. 48(4) : 105-111.

Fayenuwo, J. O., S. A. Olakojo, M. Akande, M. Amusa and O. A. Olujimi. 2007. Comparative evaluation of vertebrate pest damage on some newly developed quality protein maize (QPM) varieties in south western Nigeria. Afr. J. Agri. Res. 2(11), 592-595.

Fraňková, M., V. Stejskal, P. Rödl and R. Aulický. 2016. Current threats of rodents and Integrated pest management (IPM) for stored grain and malting barley. Kva. Prum. 62(10) : 306-310.

Frynta, D., B. Eliášová, M. Fraňková, R. Aulický, P. Rödl and V. Stejskal. (2012). Production of UV-light-detectable faeces from house mice (Mus musculus domesticus) after consumption of encapsulated fluorescent pigment in monitoring bait. Pest Mang. Sci. 68(3). 355-361.

Hamel, D. 2010. Rodents–health risk and control measures. Jul. K. Arch. 4(2) : 18.

Hodges, R., M. Bernard and F. Rembold. 2014. APHLIS-Postharvest cereal losses in Sub-Saharan Africa, their estimation, assessment and reduction. J. R. C. Tech. Reports. Nat. Res. Inst. Italy

Kumar, D. and P. Kalita. 2017. Reducing post-harvest losses during storage of grain crops to strengthen food security in developing countries. Foods. 6(1) : 8-9.

Mdangi, M., L. S. Mulungu, A. W. Massawe, S. J. Eiseb, V. Tutjavi, F. Kirsten and S. R. Belmain. 2013. Assessment of rodent damage to stored maize (Zea mays L.) on smallholder farms in Tanzania. Int. J. Pest. Man. 59(1) : 55-62.

Meerburg, G. and W. A. Kijlstra. 2008. The ethics of rodent control. Pest. Man. Sci. 64(12) : 1205-1211.

Mmetwaly, A. M., S. A. Montasser and A. R. Al-Gendy. 2009. Survey of rodent species and damage assessment caused by meriones shawiisis (thomas) in some field crops at bustan area. J. App. Sci. Res. 5(1) : 40-45.

Prakash, I. and R. P. Mathur. 1987. Management of rodent pests. Ind. Coun. Agri. Res. New Delhi, India.

Rehman, Q. S. U., K. W. Ali, M. Waqar, N. Muhammad, S. Abdul and K. A. Ullah, 2019. Damage impact of vertebrate pests on different crops and stored food items. Gsc. Bio. Pharm. Sci. 6(1). 13-19.

Sarwar, M., M. Ashfaq, and M. Y. Baig. 2011. The species complex, damage pattern and control of rodents (Mammalia: Rodentia) in Sugarcane (Saccharum officinarum L.) fields. Int. J. Agro. Pl. pro. 2(4) : 145-150.