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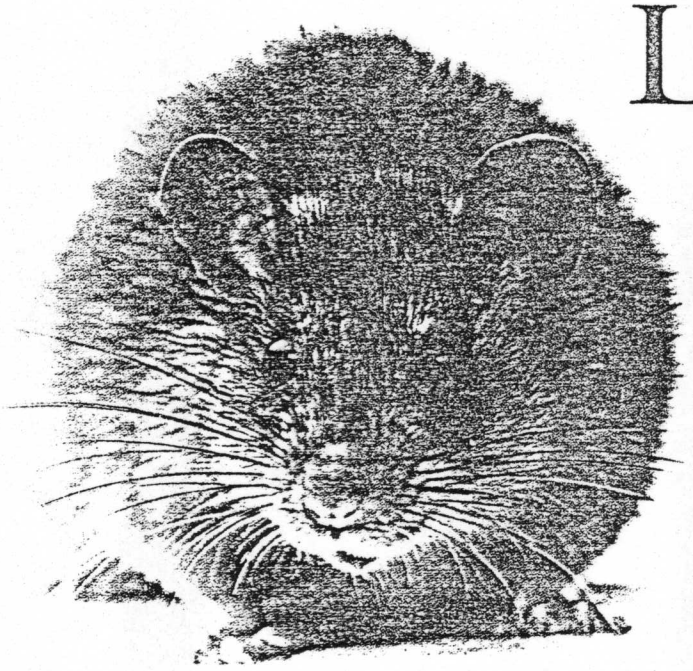
SPRINGING THE TRAP

ON POST-HARVEST FOOD LOSS



by Roger Bullard and Harlan Shuyler

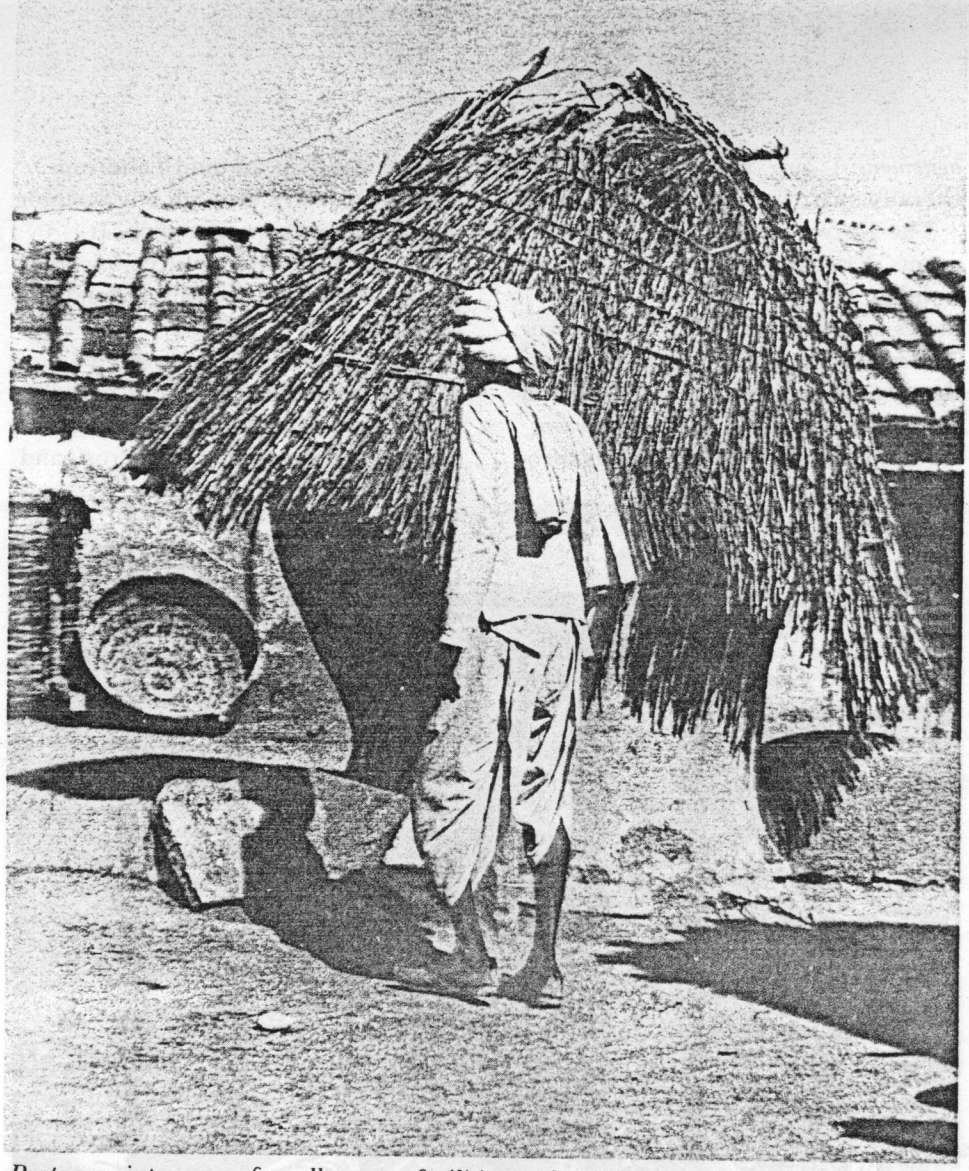
Calcutta, India—1968. At 3 a.m. I sat alone on the concrete floor of the grain godown (warehouse), amused by the group of 17 rats that had just walked across my lap. As long as I remained quiet, the wild rats investigated me as they would any object—sniffing, licking and walking over me.

Those are the words recorded by Stephen Frantz as part of his doctoral study on the behavioral ecology of the lesser bandicoot rat. Every night, about 200 adult bandicoots visited Frantz's godown and consumed an estimated 11 pounds of rice, not counting that eaten by young rats and pregnant females in their harborages.

Frantz figured that in his five-acre study area of 40 godowns, there were 10,000 bandicoots. Just how many bandicoots there are in India is hard to imagine. But, assuming that bandicoots' consumption of rice throughout its native habitat of South Asia is consistent with the ones Frantz observed, the amount of rice and food grains annually lost to rats throughout the world is mind-boggling. In neighboring Bangladesh, the economic annual loss of rice and wheat to rats is $143 million. In Africa, the loss of sorghum and small grains is $100 million.

Rats and other vertebrate pests, such as bats and birds, are a major cause of the loss of millions of pounds of stored food—averaging as much as

Three AID projects aim to save tons of food lost to thieving rodents and other pests.



Proper maintenance of small storage facilities made of local materials can lead to postharvest grain conservation. This godown's shape near Calcutta discourages rats.

9%—in developing countries every year. But inadequate postharvest grain systems—from harvesting to distribution—contribute to the tremendous loss. Problems similar to the one in Frantz's Calcutta godowns exist throughout the world, including in the United States where one pair of rats living in a granary or warehouse consume about 27 pounds of food during fall and winter.

The U.S. Food and Drug Administration estimates that as much as 10% of the annual U.S. grain crop is consumed or contaminated by rodent droppings, urine and hair. Rodents continually dribble small amounts of urine. One adult rat roaming over the surface of stored wheat can contaminate as much as 10,000 kernels per day. In a U.S. study, a pair of rats voided 25,000 droppings and 1.5 gallons of urine a year. If the contamination is serious enough, the food must be destroyed. To make matters worse, contaminated grain often is mixed with clean grain as part of normal grain mixing and handling operations, increasing the amount of food affected.

A rat sheds its half-million body hairs twice a year. One rat dropping, which will dry and disintegrate, may contain as many as 200 hair fragments. Loose hairs will drift through normal air currents within a storage facility and contaminate food. Due to static electricity or the adhesive properties of urine residue, hairs often adhere to grain as it passes through cleaning processes. Millers, food processors and candy manufacturers particularly are plagued with the problem because the serial screening process needed to select the gluten fraction of wheat also concentrates rodent hairs.

Vertebrate pests present serious health problems. Bird droppings, for example, are a main source of *Salmonella* and such diseases as histoplasmosis, cryptococcosis, ornithosis and aspergillosis. Some of the more common diseases known to be transmitted by rats or their ectoparasites to humans include plague, murine typhus, rat-bite fever, salmonellosis, leptospirosis and trichinosis. Rats caused the Black Plague that killed 25 million people in Europe and the Middle East during the 14th century. Nearly 600 years later, they caused a similar plague epidemic, which killed 12.5 million people in India. In 1975, 20 Americans contracted plague; four died, victims of contaminated fleas harbored by ground squirrels.

Finally, rats cause extensive damage to food storage structures and equipment. The rat's chisel-like incisors grow throughout its life; incisor length is regulated by continuous gnawing. The chisel teeth exert a pressure of 24,000 pounds per sq. in.—enough to gnaw through lead pipes and cinder blocks.

Fortunately, of the thousands of rodent and bird species, only a few threaten stored foods. Pigeons (*Columba* spp.) and English sparrows (*Passer domesticus*) invade storage facilities through unsecured openings. They also contaminate grain on drying and threshing floors. Three rat species—Norway (*Rattus norvegicus*), roof (*R. rattus*) and lesser bandicoot (*Bandicota*

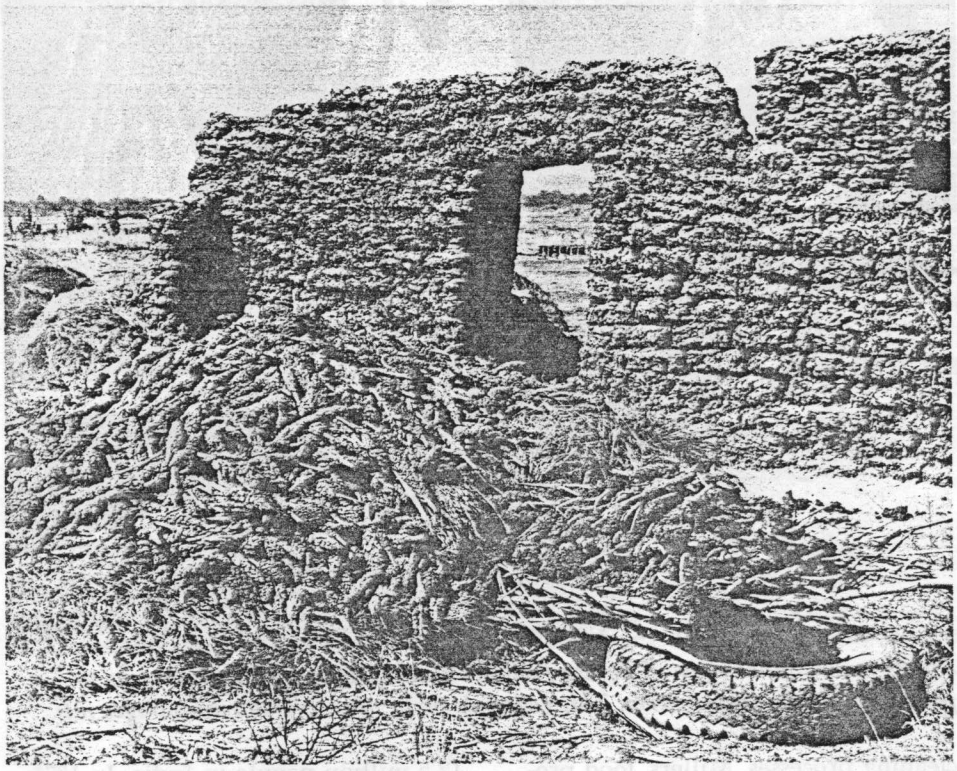
bengalensis)—are "commensal"—they literally share our table.

The Norway rat is large—up to 500 grams. Extremely aggressive, it is the number one rat pest in the United States and an international nuisance. The roof rat is a fleet, nimble climber that dwells mainly in rural areas and seacoast towns. The lesser bandicoot rat is the most prolific of all rats, producing a litter a month, seven pups per litter. One pair can easily produce 3,600 descendants in a year's life span even if half of the young die before sexual maturity. The bandicoot feeds in grain fields as well as granaries, hoarding in its burrow four to eight times as much as it devours on the surface.

One Bangladesh farmer dug up a bandicoot burrow and found 32 pounds of stored food.

The most troublesome rodent in the world may be the common house mouse (*Mus musculus*)—also commensal. An adult is only about six inches long from head to tail tip, weighs less than an ounce and can enter a structure through any opening larger than one-quarter inch. It begins to have litters of five to eight young at only 1.5 months, annually producing up to 10 litters.

Although technology to solve many of these vertebrate problems exists, much work remains to be done. In its rodent damage survey of crops and postharvest losses in tropical and subtropical regions, the Center for Overseas Pest Research and Tropical Products Institute in London found "widespread ignorance of the magnitude of the rodent problem." The center stressed the need for surveys to obtain realistic assessments of rodent-caused losses in stored products, research to find rodenticides suitable for use by illiterate farmers, development of inexpensive rodent-proof storage containers and extension programs to transfer awareness of the rodent problem and information regarding suitable control techniques to the farming population.



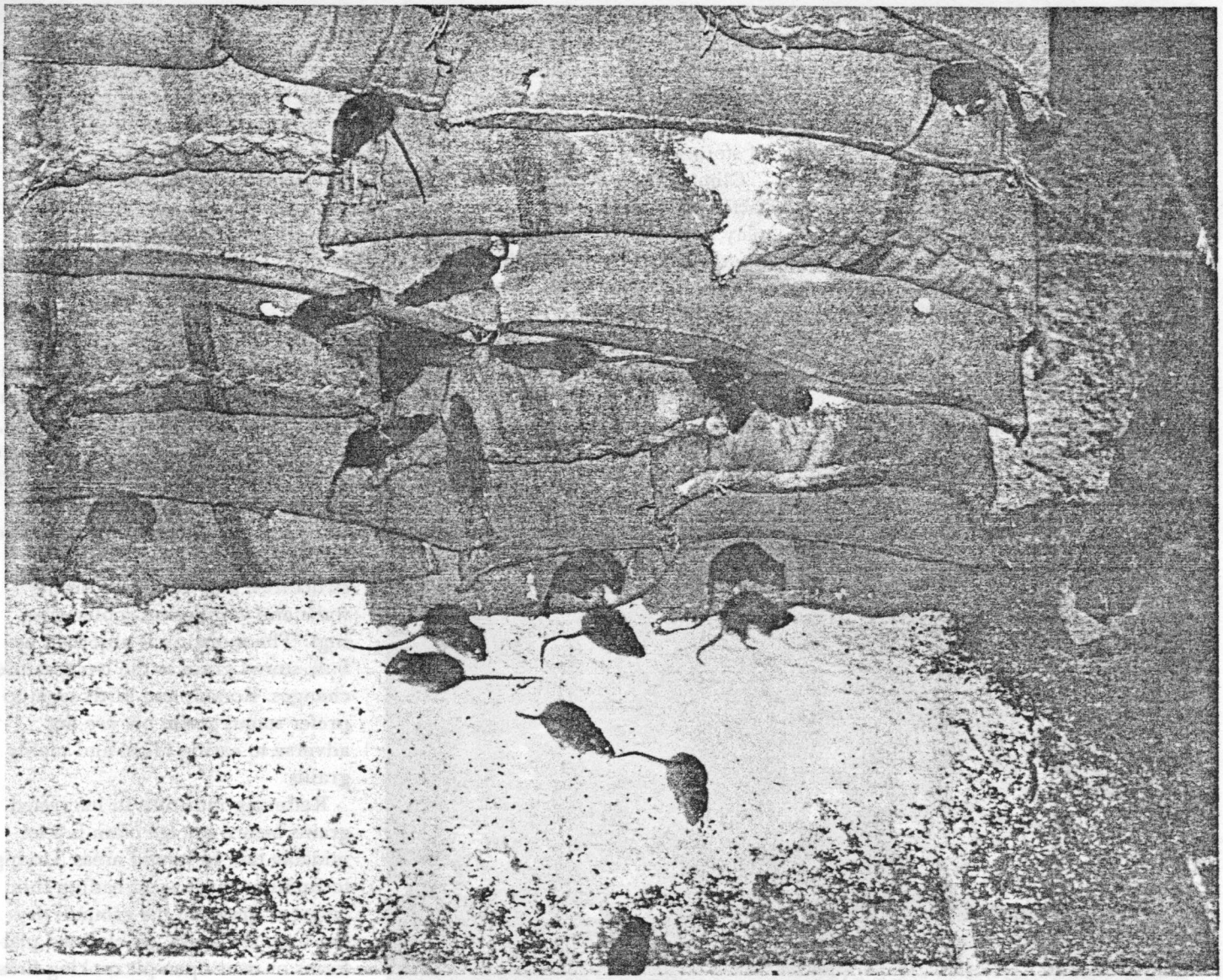
This pile of sorghum, left by a Chad farmer in a field for later storage, is exposed to alternating heat and moisture as it lays in a heap day and night, leading to the grain's cracking which in turn leads to further losses during processing.

AID Postharvest Efforts

These objectives are similar to those of the Department of Interior's Denver Wildlife Research Center (DWRC) which has cooperated with the Agency for International Development (AID) since 1967 to reduce preharvest food losses due to vertebrate pests. The center has expanded its technical assistance and research programs to help reduce postharvest losses. AID also has agreements with two other institutions to reduce postharvest losses and conserve food—the University of Idaho and Kansas State University. While AID has been concerned with postharvest losses for several years, its attention has increased in response to a 1982 U.S. General Accounting Office report that said "AID should change its agriculture policy to recognize food production and food conservation as complementing rather than competing functions. . . ."

DWRC is one of the leading world research centers of preharvest vertebrate pest damage problems in agriculture crops. Its projects have resulted in considerable savings for African, South and Southeast Asian and Latin American countries. For example, emphasizing practical control methods to fit existing operational programs and institutional capabilities, cooperative work between DWRC and the National Crop Protection Center in the Philippines resulted in the development and extension of an effective method (sustained baiting with anticoagulants) to reduce rodent damage to lowland rice on small farms. In Bangladesh, a campaign using zinc phosphide bait cakes is helping prevent rat damage to wheatfields. Similar successes have been achieved with rats damaging sugarcane and coconut crops. Chemical repellents and other management methods developed or adapted by DWRC are used on bird problems.

The center's postharvest emphasis is on storage, particularly to find ways to mesh vertebrate pest management activities with all other postharvest



Rats contaminate or hoard two to three times the amount of grain they consume, and transmit up to 23 human diseases.

loss-reduction efforts. DWRC scientists have undertaken an extensive literature survey, analysis and evaluation. In Bangladesh and the Philippines, DWRC workers and host-country counterparts have initiated loss surveys, tried some small-scale loss-assessment techniques and conducted trials of loss-reduction techniques. Similar studies are scheduled for Haiti. DWRC may soon expand its work into Pakistan.

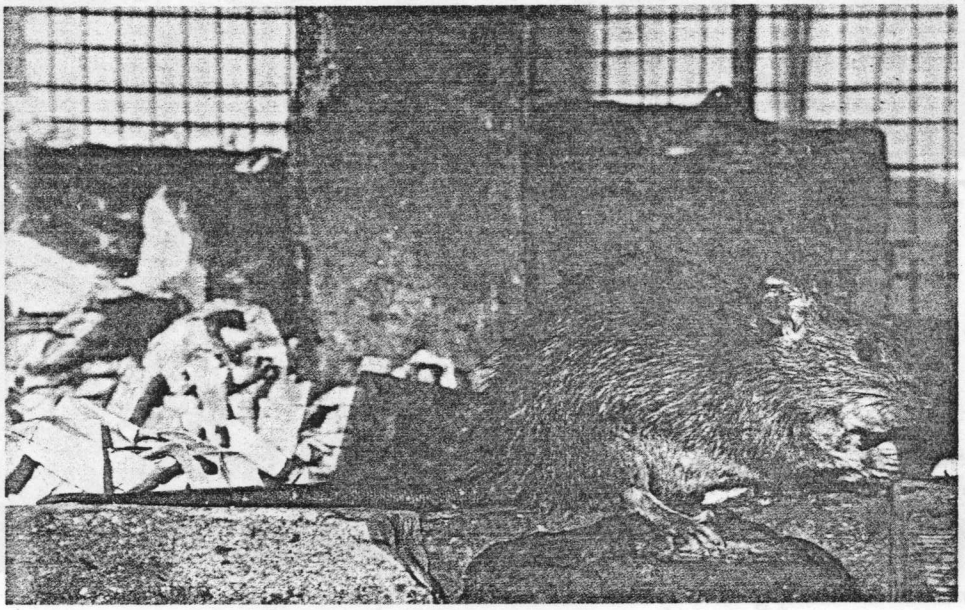
The improvement of postharvest grain systems is the aim of the Kansas State University Food and Feed Grain Institute (FFGI) project. Working on durable food products, FFGI's goal is to improve harvesting, threshing, drying, cleaning, storing, transporting, processing, packaging, marketing and distributing of cereal and leguminous grains and products. This is at the small farmer and village level, at buying points and at collection, central storage and distribution levels. Training in all areas is emphasized.

Efforts to reduce losses due to physical factors, such as excess moisture content, and losses due to molds and stored-product insects are FFGI's main considerations. The institute's extensive economic analyses of postharvest grain systems are designed to lead to improved developing country grain marketing and food security. Opportunities for increased agribusiness development involving grains are another frequent result. AID officials anticipate that FFGI and DWRC will collaborate, especially on controlling insect and vertebrate pest problems in storage.

The goal of the University of Idaho Postharvest Institute for Perishables (PIP) is to improve fruit and vegetable storage and processing. By reducing postharvest losses, the availability of fruits, roots, tubers, spices and other vegetables will be increased. By improving marketing efficiency, the cost of these commodities will be reduced and agribusiness development in perishables will be encouraged. Perishable losses, postharvest processing, ef-

ficient domestic and export marketing and conservation of fruits, roots, tubers, and vegetables are the targets of PIP's technical assistance and training efforts. Losses of these commodities due to vertebrate pests most likely will lead to requests for cooperative work with the DWRC.

All three projects—whose activities fall within AID's agricultural research priorities—are committed to minimizing environmental concerns and to developing integrated post-harvest pest management, using pesticides only when needed and in a safe, effective manner. Each project uses an interdisciplinary approach and each has strong information-sharing and institution-building components. Developing country professionals and experts request and receive research, technical, extension and review papers to assist them in their work. Many travel to the institutions for short- and long-term study.



Rats are pernicious and prolific pests. Only a few species threaten food stored by man but they cause millions of dollars in damage and are incredible health hazards.

Handling and Storage Factors

As the three institutions go about their work, they consider the factors that dictate why a food is handled and stored in a particular way. Marketing systems, including home or village storage, grain movements from farmers to brokers to large centralized facilities often dictate the way the structure is constructed, and the method and length of storage.

Climate is an even more important factor. Environmental conditions play a crucial role in determining the difficulties and complexities of storing produce. In the temperate zone, long periods of cool, dry weather after harvest make grain storage relatively easy. But storage becomes more difficult in the tropical zone where long periods of warm, humid weather frequently prevail.

High temperature and humidity can rapidly deteriorate stored durables. Together, they lead to mold formation, rapid growth of insect populations and oxidative changes in the grain. Stored grain generally should have less than 14% moisture; 12% is ideal.

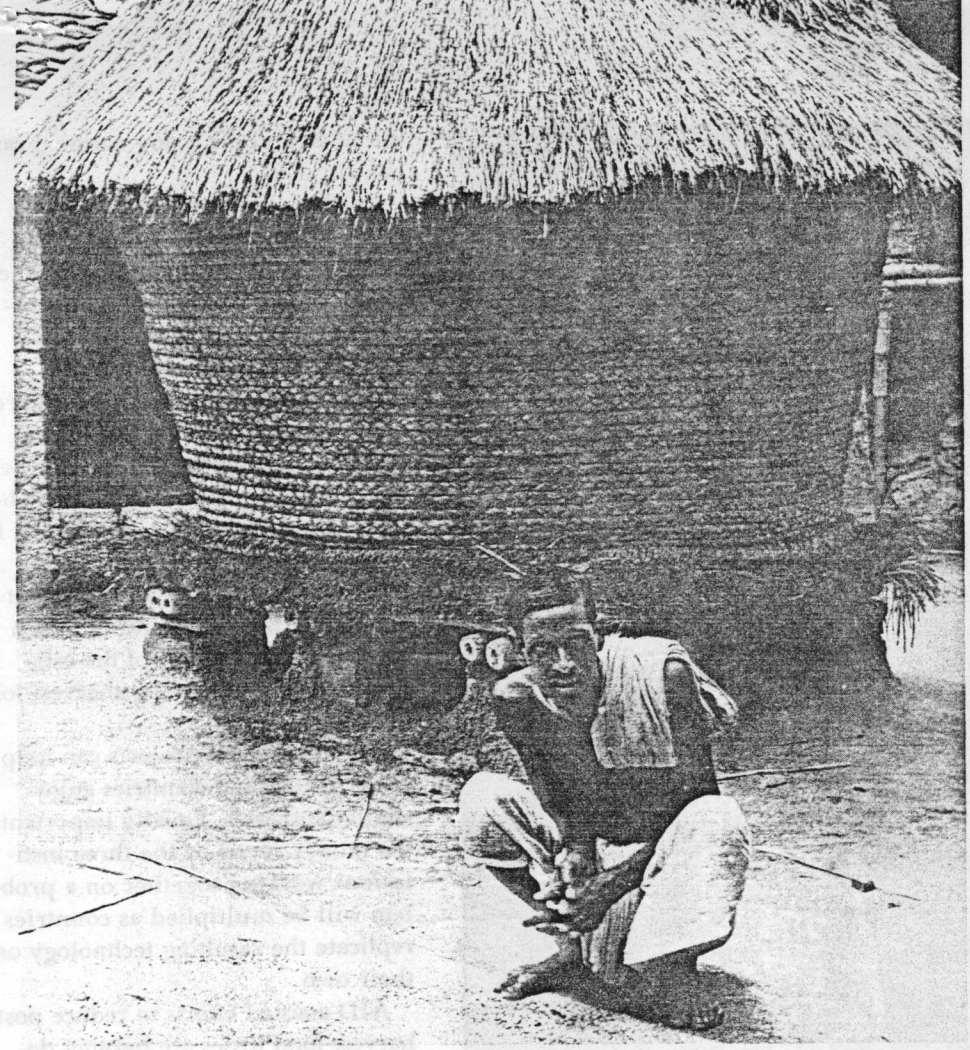
Seed embryos are sensitive to temperature and humidity. As long as both factors are low, the embryo remains inactive but viable and the grain can be stored for years. But as temperature and humidity increase, viable embryos become active. Metabolic heat and moisture is triggered and the embryos start to grow, drawing nourishment from nutrients—starches and proteins—stored in their endosperms. The grain mass begins to warm. Insects and molds and microorganisms frequently present in the kernels become active, producing more heat and moisture. Deterioration and rotting of the grain is soon visible, with some fungi forms producing toxic products such as aflatoxins.

Even after drying, humidity can continue to be a problem. For example, as relative humidity rises from 70% to 90% for a prolonged period, the moisture content of yellow corn gradually increases from about 13.5% to 19%. Moisture may be absorbed directly from the atmosphere by the stored grain or, in some storage structures, may condense on the walls and ceilings on cooler evenings. The moisture is absorbed by bulk-stored grain as the temperature changes. Rodent and birds seem to prefer sound grain, but are not adverse to eating moist and moldy grains.

Reducing moisture in harvested grains before storage often is a formidable task in humid areas. Drying techniques, such as spreading thin layers of grain on the ground; drying it on the stalks, on elevated platforms or over open-pit cooking fires; and sophisticated fan-driven aeration systems, merely offer additional opportunities for rodent and bird attack.

Any management methods to improve storage or processing must be compatible with practices that guarantee low-moisture levels. For example, in the tropics, grain is commonly stored in jute or burlap sacks to allow for air circulation and to lessen "hot spots." However, the spaces between sacks provide rodents harborage. Fabric is shredded for nesting and bedding.

Integrated approaches are essential. Properly applied fumigants can temporarily eliminate insects and rodents from storage structures; rodentproofing can be designed into



An Indian farmer proudly poses in front of his well-designed, effective jute and straw godown. Postharvest storage construction also creates local jobs.

simple storage structures; sanitation programs can include both insects and rodents. For example, a study of Ohio grain elevators found that rats were consuming 25% of farmers' annual net profits. A small investment in sanitation maintenance resulted in an annual savings of several thousand dollars in both rodent and insect losses.

One often overlooked factor in developing postharvest food-loss programs is the migration of rodents between field and storage structures. This is an important part of DWRC's Bangladesh and Philippines studies. In India, baiting and sanitation practices have been combined to carry out successful campaigns in the fields, in homes and in storage facilities. Rodent problems were drastically reduced as long as people participated in the program. The field-storage migration factor should be considered when deciding where to locate storage structures and when developing marketing systems.

The need for a comprehensive loss assessment effort is great. Only recently have any serious attempts been made to establish reliable and replicable loss-assessment methods. A 1977 bibliography on postharvest losses in cereals and pulses showed only 11 studies related to three countries outside the United States. Many estimates have been highly inflated and fail to identify the true source of losses.

The loss situations in farms or villages are perhaps the most ill defined of all. Because 70-90% of the cereal grains produced in many developing countries are stored and consumed on the farm, this sector requires urgent attention. One exception is Bangladesh, where grain losses at the farm level are far lower than had been assumed thanks to the development of efficient storage systems by subsistence farmers over the centuries.

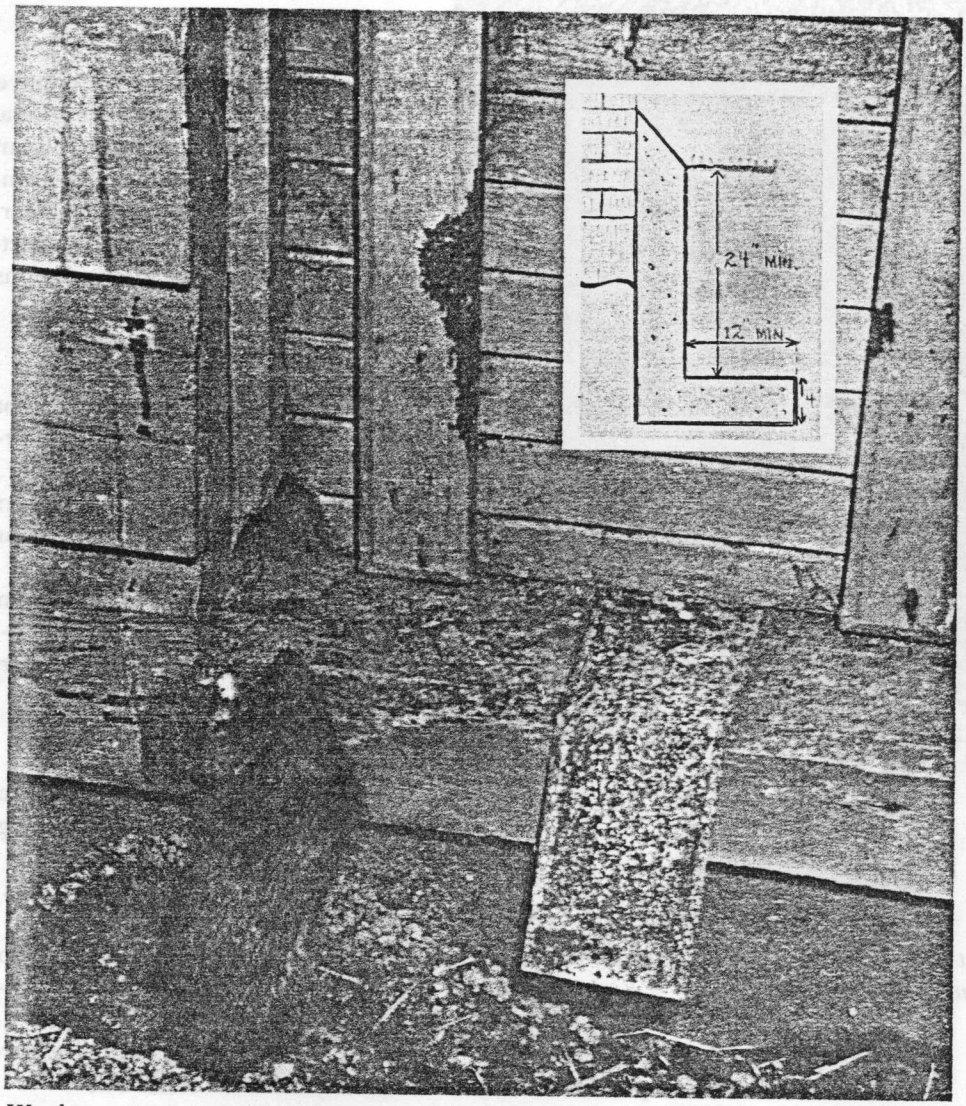
After postharvest food losses have been appropriately assessed, several problems remain: a multidisciplinary appraisal of the problem and recommended solutions; careful consideration of socio-cultural practices affecting the problems and their solutions; field testing for technological and economic efficiency; redesign of manufacturing or construction of storage facilities using existing capabilities; operations research involving use of new technology to help government planners, policy makers and central management make sound decisions; and training manpower and developing an extension system. It is important to extend the technology to women who frequently are responsible for storage.

Appropriate Solutions

After defining the postharvest food loss problem, appropriate technological resources must be adopted to solve it. Technological capabilities are available to handle most loss situations and there are examples of well-coordinated and executed campaigns that have been highly successful in developing countries, particularly in South Asia. The immediate need is to identify and organize the existing resources, especially with respect to vertebrate pest problems, and to apply the best ones for a given problem.

In the meantime, existing technology is being expanded and "fine-tuned" by ongoing research. New or improved control methods are being developed for vertebrate pests at the DWRC and elsewhere. At the DWRC, technicians are investigating alternative chemicals and working on more palatable baits and biologists are improving baiting techniques. Several other concepts involving physical (structural, ultrasound, electric, etc.) or chemical methods are being evaluated for protecting foods from vertebrate pest losses.

Existing new and improved methods for preventing food losses must be adapted to a country's crops, climate, as well as cultural, economic



Wooden or even metal doors fail to deter rats from reaching their objective. When a rat burrows down the side of this barrier (inset), it will reach the bottom and give up, thinking it can't get under or around it.

and technological conditions. Technological skills and resources will be of little use in reducing postharvest food losses unless they are effectively transferred to users. A major DWRC goal is to develop effective training and extension programs that can be readily adapted to a given situation in any country. National extension leaders must be selected and trained to carry out campaigns involving users at the village and farm level. Training manuals, aids and materials should be developed not only for these leaders but for the farmers and villagers they will instruct. For example, photonovellas, similar to U.S. comic books, have been very effective in training farmers and villagers in Latin America. Where appropriate, materials may be developed for radio and television.

Such a campaign is being conducted in Bangladesh by a cooperative AID/DWRC and German technical assistance project. The campaign is carried out in 11 wheat-growing districts, covering 85% of the wheat crop. The main components of the campaign are training protection and extension specialists; creating awareness among farmers through the use of posters, leaflets, radio and television; distributing inexpensive zinc phosphide rat baits; and declaring national rat-control days.

Postharvest food losses can be reduced. Success is evident by successful campaigns in India and the development of an improved storage bin—the "Ferrumbu"—in Zambia, which is made from indigenous materials, making it affordable by small farmers. DWRC researchers and extensionists may be challenged again soon by the problems of small commercial farmers in the northwest part of the Central African Republic, an environment amenable to rodents and in which rats are a main source of the estimated 25-30% annual postharvest loss of food grains.

The three AID projects can help other developing countries enjoy similar successes. Equally important, the money saved by the three institutions working together on a problem will be multiplied as countries replicate the resulting technology on their own.

AID-assisted efforts to reduce postharvest food losses are helping developing country farmers save millions of pounds of food—to help feed the 250 million chronically hungry people—that would otherwise be lost to pests and inadequate storage and processing. ■

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The two scientists together claim 49 years of experience in their respective fields of expertise.

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