3-1-1988

STOPPING HOUSE MICE BUILDING INFESTATIONS THROUGH EXTERIOR CONTROL

Charles E. Knote
Cape-Kil Labs, Cape Girardeau, Missouri

STOPPING HOUSE MICE BUILDING INFESTATIONS THROUGH EXTERIOR CONTROL

CHARLES E. KNOTE, Cape-Kil Labs, Cape Girardeau, Missouri 63701.

Proc. Vertebr. Pest Conf. (A.C. Crabb and R.E. Marsh, Eds.), Printed at Univ. of Calif., Davis. 13:107-111, 1988

Norway rats (Rattus norvegicus). roof rats (Rattus rattus) and house mice (Mus musculus) make "bathroom" stops any time, any place. They can make their "deposits" directly on our foods and contaminate them with toxic microorganisms.

The United States (U.S.) Food and Drug Administration (FDA) is required by law to protect the quality of U.S. foods moving in interstate commerce against all toxic food contaminants. Therefore, they inspect for actual and potential rat and mouse contamination.

In recent years, two different district chiefs of the FDA stated that approximately 80% of their food contamination citations were for rodents in the U.S. Further, this contamination was caused by rodents inside buildings where the food was processed or warehoused. The FDA did not state whether the Rattus species or house mouse was the direct cause.

In food sanitation inspections of food warehouses previous to 1979, it was recognized that some exterior Norway rats become contaminating interior Norway rat problems. Therefore, exterior rat bait stations were one important facet of any recognized rodent control program where it was feasible to use them.

Also, previous to 1979, interior mice problems continued to plague food warehouses, bakeries, restaurants, etc. Exterior mice were rarely recognized as a potential source of interior mice by the vast majority of pest control operators (PCOs) and food sanitarians. All control efforts were programmed against established interior mice.

When PCOs' clients have interior mice in their business, institution or home, PCOs would automatically attack this problem with glue boards, self-setting multi-catch traps, single snap traps, tracking powders or toxic baits inside the building.

PCOs hear about "field-mice-coming-in" in the fall and contaminating products. Rarely did PCOs identify these mice scientifically. When these mice were identified, an estimated 95 % of them were house mice *(M.* musculus) in the U.S. Based upon some field observations previous to 1979, it was known that some of the interior mice in a large food warehouse were exterior mice (N.P.C. A. 1974). However, it was generally thought that bagged and boxed shipments (dog food, charcoal, flour, and sugar, etc.) from processors were the major source of interior mice because these "new mice" were "carried in" (Knotc, unpubl. data 1979-85). It was known that exterior mice cause much of the interior mouse problems in single-family urban residences because mice are rarely "shipped-in" or "carried-in" to a single-family home. It was hypothesized that rarely would exterior mice be less than 25% of the interior infestations. This would occur only where the concrete streets, sidewalks, gutters, and sewers had no 3/8" (9.52 mm) to 1/2" (12.7 mm) holes nor cracks, nor shrubbery, nor soil, nor 2" (5.08 cm) diameter rock placed in borders, ditches, etc. Also, the exterior garbage and equipment storage areas would be 100% mouse harborage free and exterior food would be practically non-existent (Knote, unpubl. data, 1979-85).

PCOs continue to ignore the first cardinal principle of any pest infestation in mouse control...SEEK OUT THE SOURCE, (SOS) of the interior mice and stop the "SOURCE." Many rodent control technicians are never taught that mice do not "self-generate" inside the building. In any interior mouse problem, the juveniles must come from three sources: (1) resident female mice, (2) carried-in-female mice, and (3) crawl-in-female mice (Knote 1986).

PCOs fail to check out how rapidly house mice reproduce and fail to remember that their juveniles sexually mature very rapidly, or how few "crumbs" a female mouse needs to raise a litter of pups. The PCO needs to concentrate on the SOS of the interior juvenile mice.

Continuing general rodent population survey and quarterly sanitation inspections were conducted from 1979 through 1985 of interior rodent problems in food warehouses, restaurants, bakeries, motels, etc., in the states of Missouri, Illinois, Indiana, Kentucky, South Carolina, Massachusetts, Pennsylvania, Kansas, New Hampshire, and Mississippi. From these findings it is estimated that from 80% to 98% of the food industry's rodent problems are caused by the house mouse (M. musculus). The exact percentage depends upon the building, the year, and the area of the U.S. surveyed. During these years, the Rattus group was rarely found to be 100% of the rodent problem. However, most quarterly sanitation inspections were 100% house mice. Pest control technicians in their monthly inspections for rodents confirmed these quarterly inspections (Knote, unpubl. data 1979-85).

The rodent populations at a food warehouse located in Southeast Missouri were studied over four years, 1980,1981, 1982 and 1983. This food warehouse contained approximately 250,000 sq. ft. (23,225 sq. meters) of enclosed floor space under one roof with various partition walls. Dry groceries, refrigerated boxed meats, dairy products and frozen foods were warehoused. It was located in a rural setting surrounded by an alfalfa field on the north side, soybeans on the south, a lawn/parking lot on the west with about 20 homes further west. A feed mill was located approximately 1,500 ft. (15 7 meters) from the warehouse across the main line railroad

track. This railroad hauled grain with some leakage from the cars. An occasional mouse hole was found along this track. The east side was mowed lawn for 200 ft., then a ditch, then heavy weeds and grass.

A combination of techniques was used to measure the total mouse population. These consisted of mouse-sized bait stations filled with first-generation anticoagulant baits (chlorophacinone 0.005%) and metal self-setting multi-catch lever-type TIN CAT[R] mouse traps (Wood Stream Mfg. Co.). Both were placed next to the exterior foundation walls only. Mouse carcasses found immediately next to, close by, or in the exterior bait stations or taken from the multi-catch traps were counted in this research. To evaluate the interior population (1) 16-gauge steel covered TIN CATS were used next to supporting posts in the palleted food areas, (2) a few localized glue boards, and (3) E.P.A. recognized tamper-resistant mouse-sized bait stations with first-generation anticoagulant baits were installed inside along the walls on both sides of the warehouse personnel doors and along the walls in the rail track wells along with TIN CATS traps.

Results of the total captured interior and exterior rodent populations found during the 48-month period are summarized in Table 1.

The following trends were noted during the 4-year study: (1) Exterior house mice were present for 47 months out of 48 months. (2) Exterior house mice populations varied yearly from 234 mice in 1981 to 120 mice in 1980 and 1983. (3) Exterior house mice cycled monthly from a high of 83 in November to 0 in April 1980. (4) The peak month of exterior house mouse activity was November in each of the 4 years. (5) Exterior house mouse populations peaked during 4 months of a "mouse year" October, November, December, and January. (6) Interior mice totaled only 45 for 4 years or 6.4% of the total mice collected. (7) Interior mice were present 19 months out of 48 months. (8) Interior mouse numbers cycled from a low of 0 for 29 months to a maximum of 7 mice in the month of December 1981. (9) During this 4-year study, only on 6 semi-monthly inspections by the pest control technician did the exterior rat bait stations show any feeding evidence on the plastic bait bags or contain feces of the Norway rat. In these 48 months, only one Norway rat gained entrance to the interior of this food warehouse. Therefore, the Norway rat was a very minor rodent problem during this 4-year study compared to the exterior/interior house mice.

Surveys were made of 6 other food warehouses which

Table 1. Mouse carcasses taken for each month for 4 years (1980-1983).

Month	1980 Ext.	1980 Int.	1981 Ext.	1981 Int.	1982 Ext.	1982 Int.	1983 Ext.	1983 Int.	4 yr. Tot. Ext.	4 Yr. Total Int.	Months Ext. Mice Pres./4 yrs.	Months Int. Mice Pres./4 yrs.
Jan.	12	0	6	2	16	2	9	0	43	4	4	2
Feb.	1	0	5	2	4	0	4	0	14	2	4	1
March	4	0	1	0	3	0	3	1	11	1	4	1
April	0	0	2	0	1	0	2	0	5	0	3	0
May	3	0	1	0	5	0	4	0	13	0	4	0
June	2	0	1	0	3	2	3	0	9	2	4	1
July	1	2	4	0	4	0	5	0	14	2	4	1
Aug.	5	0	2	1	4	0	6	2	17	3	4	2
Sept.	4	1	10	2	8	0	4	0	26	3	4	2
Oct.	22	1	51	1	18	1	14	0	105	3	4	3
Nov.	40	1	83	6	62	2	54	0	239	9	4	3
Dec.	26	3	68	7	55	6	12	0	161	16	4	3
Total	120	8	234	21	183	13	120	3	657	45	47 mo. out of 48 mos.	19 mo. out of 48 mos.

had exterior/interior mouse data. Specific data collected from a 350,000 sq. ft. (32,516 sq. meters) food warehouse located in mid-southern Indiana paralleled Southeast Missouri's data. Other pest control technicians were surveyed and the quarterly sanitation inspections were conducted in 5 other warehouses of 250,000 sq. ft. (23,225 sq. meters). These warehouses were located in central Missouri, eastern Missouri's border, central Kentucky, east central Kentucky, and eastern South Carolina. This general information indicated yearly and monthly cycles of house mice also, and heavy exterior mouse populations.

Two exceptions of the survey of these 6 food warehouses should be noted. These two collected their individual supermarket customers' empty cardboard food boxes. These supermarkets baled their empty boxes into a 4 ft. (1.2 meters) x 4 ft. (1.2 meters) x 6 ft. (1.8 meters) wire-tied bales. Most supermarkets stored these bales on their exterior awaiting shipment to the food warehouse. Upon collection, the warehouses stored these bales of boxes inside the food warehouses in one general location and finally shipped them by rail to a recycling center.

The multi-catch mouse trap collections surrounding these bales increased greatly in the peak mouse months of the year. Apparently, these bales were infested while standing on the exterior of the supermarkets. Some of the mice "rode along" with the loosely baled empty boxes, many of which contained scraps of food.

Summary of the study of these 7 food warehouses (after all resident mice were controlled): (l) Over90% of the potential source of interior house mice came from the exterior house mouse populations. (2) Mouse infestations from shipments of manufacturers' sacked or boxed foods were very minimal except three animal feed manufacturers in three warehouses. (3) Good interior rodent control procedures continued to stop the breeding of any mice entering the food warehouses. (4) Exterior house mice (M. musculus) feed upon larvae and adult insects, weed and grass seeds (Whitaker 1966) which were available in all locations. (5) the number of mice collected along the base of exterior walls of the warehouses in specific bait station/multi-catch trap locations indicated that some house mice were migrating over 200 feet across closely mowed grass. No secure mouse harborage for breeding and nesting was found in this mowed 200 ft. area or the asphalt parking areas. (6) Mouse stoppage in the warehouse received regular inspections and needed maintenance. (7) Waiting to control exterior mice on the interior is much like the "farmer locking the barn door after the horse is stolen."

This 90% plus potential source of interior house mice forces an in-depth re-examination of the recommendations for house mouse stoppage and recommendations for exterior control procedures.

First, many PCO managers think that mouse stoppage is not feasible. However, they have been told "Rat proofing is a must." Recommended rat proofing procedures have concentrated on techniques developed in the 1940's which are: (1) Use less that 1/2" (12.7 mm) clearance between the bottom of the door and its threshold to "rat proof" exterior doors. (2) Use 1/2" (12.7mm) wire mesh (hardware cloth) to rat proof windows, screens, and other openings. (3) Use cement mortar backed up with wire mesh (hardware cloth) to rat proof holes in walls. (4) Use only 26-gauge or heavier galvanized steel (no aluminum, brass, etc.) to cover openings into a wooden building. (5) Construct a 24" (60.9 cm) deep with a 12" (30.5 cm) concrete-lipped "curtain wall" in the ground to rat proof a building without a good foundation wall or on piers. (CDC 1948).

Many rat proofing recommendations do not solve mouse entry problems. The 0.5" (12.7 mm) clearance between the door's bottom and its threshold or 0.5" (12.7 mm) square wire mesh does not keep house mice from entering. Rat proofing recommendations, particularly the L-shaped curtain wall are so expensive that they are ignored completely.

Mouse stoppage recommendations should consider the mouse's physical size, and physical capacity and its observed behavior: (1) A mature house mouse weighs only 5.0% of the rat, about 20 grams compared to 400 grams. Very rarely will mice gnaw on the edge of a planed U.S. 1" (2.54 cm) thick wooden board, actual thickness 3/4" (1.9 cm), long enough to make an entry into a building.

The following mouse stoppage recommendations are made based upon the above considerations and successful field use: (1) Thin sheet steel, brass or aluminum, solid wood boards, plywood, 1/2" (12.7 mm) thick tire rubber, or even 3/16" (4.76 mm) reinforced belting all will keep migrating mice from entering provided there is no "edge" available for gnawing. (2) The clearance between the door's bottom and its threshold should be 1/4" (6.35 mm) or less to stop entry by juvenile mice. (3) One-quarter inch (6.35 mm) wire mesh closes windows and other openings to juvenile mice. (4) The two large open rodent entries exist beside each side of the rail track at the overhead door of a rail track well in many kinds of warehouses. They are most difficult to rodent-stop. The overhead door must open frequently to admit rail-sized boxcars weighing 80 tons (88.19 T) which have a steel flange on the side of each car wheel. This flange, along with the car's weight, crushes steel wool, rock, and other items used for stoppage of these rail track holes. They have been successfully closed to both house mice and rats in cold and hot temperatures by using a Pest-A-Rester^{R}. It is a molded patented uniquely designed trapezoid of rubber with compression holes to accommodate the passage of rail cars. The Pest-A-Resters have a history of functioning well for over 5 years before replacement. (5) An effective, comparatively inexpensive "mouse wall" to prevent mouse invasion can be constructed for an "open" building built on piers. Use aluminum flashing in 50 ft. (15.24 M) lengths around the open perimeter of the building, burying the bottom side 10" (25.4 cm) in the ground next to the building piers, fastening the top side to the building with nails. Join the lengths together with pop-rivets. Aluminum flashing is manufactured in the U.S. in 20" (50.8 cm), 24" (60.9 cm), and 36" (0.914 M) widths. Standard U.S. thicknesses available are 0.013" (0.33 mm), 0.016" (0.40 mm),and 0.019" (0.48 mm). (6) Standard steel

wool grades 1,2, and 3 can be cut with tin snips and pushed tightly into mouse-sized holes for *2-year* mouse stoppage. However, steel wood collects dust and will breed insects. Standard steel wool rusts. Stainless steel - steel wool is very expensive. Therefore, when using standard steel wool it should be sealed with a building mastic or mortar to prevent dust accumulation and rust. It then becomes permanent mouse stoppage. (7) Effective mouse stoppage must include plugging finger-sized and larger holes in interior walls, construction holes in concrete floors, holes in expansion contraction joints, etc., with mortar or steel wool. These holes provide permanent non-moving interior mouse nesting sites (Knote, unpubl. data 1979-85).

Conclusions on mouse stoppage

PCO managements must "sell" their clients on good house mouse stoppage. Most of the food clients' maintenance departments consider mouse stoppage a "real bother." Therefore, the PCO should be able to provide effective mouse stoppage service. Pest control technicians have not been taught effective mouse stoppage procedures nor have they been provided with the simple installation tools. Finally they have not been expected to perform any of these procedures by the management of the PCO company. Simple procedures such as using steel wool, tin snips and a building mastic and a 3/16" (4.76 mm) reinforced belting, a rechargeable electric screw driver, and a rechargeable electric drill are tools that management could provide the technician along with training. This is an opportunity for the PCO to supply the client with effective mouse stoppage and provide a potential profit for the company. PCO managers must change their attitude about mouse stoppage: It is practical! They can't expect a miracle from it. However, they should not miss this one basic premise of practical mouse prevention and a golden opportunity.

Assuming the interior building's sanitation rates "good," the two distinct components of practical mouse management are: (1) exterior/interior mouse stoppage. (2) effective exterior/interior elimination techniques (baits, multi-catch traps, glue boards, etc.) which need to work together. PCOs should never expect either component to be 100% effective by itself. But combined, these two components should protect processed foods and stored merchandise so that they are nearly free of mouse contamination and damage.

Even with excellent mouse stoppage, exterior mice have some easy entries into buildings because buildings are "used" by people. Every doorway and ramp provide easy open entries. Exterior electrical and plumbing connections, every weep hole, every breakdown in the established mouse stoppage due to wear and tear, may develop finger-sized (mouse-sized) holes, entry cracks or openings for mice. To keep buildings free of mice means that PCOs must protect essential people entries, but also small potential mouse entries effectively and safely from mouse invasion.

One's first thought would be to broadcast a very effective single feeding but very toxic rodenticide on the exterior of these urban buildings frequently to reduce these exterior mouse populations. This is not a safe practice around humans, animals and wildlife. Plus there is no rodenticide registered in the U.S. for this type of application at this time. Therefore, safe treatment procedures must be devised to capitalize on any known mouse behavior which would contribute to exterior mouse elimination.

Based upon research, (Crowcroft 1966) a migrating exterior mouse should approach a "new" entry into a building with great natural caution. This "new" mouse should investigate and approach a new entry very carefully and then return to reasonably safe harborage it "knows" several times before entering. However, at a given moment if it's running next to the entry which is open and it's under extreme stress, it will dash in. This "new" mouse's natural cautiousness, plus the very high stress of the mouse's exterior environment (rain, snow, cold, high heat, little or moldy food) work to our advantage when designing an exterior mouse elimination system.

The exterior elimination system begins with an elevated, totally enclosed bait station. Its interior remains dry in rain and snow. It is mouse-sized, making it easier for the mouse to warm and feel protected compared to a rat-sized station. It is mounted directly to the foundation wall at the ground level with a building mastic making it a stable non-moving nesting site. A very palatable anticoagulant (chlorophacinone 0.005%) mouse bait is placed in a plastic bag in the bait station. This plastic bag protects it from molding in the station in humid weather. This bait serves as the migrating mouse's food supply.

When a migrating stressed mouse finds this attractive bait station as a harbor and the bait for its "food-supply," it will use it as a "mouse house." During its prolonged stay it will continuously investigate the surrounding environment for even better housing and food (Crowcroft 1966).

To capitalize on the mouse's continuous investigative behavior a self-setting multi-catch lever-style mouse trap (TIN CAT) is installed about 18" (45.7 cm) from the mouse-sized bait station. This trap, with a 3 1/2 ft. (1.06 M) steel dog chain and a wooden block, is fastened to the wall with a building mastic. This prevents easy "walk-away" theft. The TIN-CAT lever-type multi-catch trap was chosen over the wind-up multi-catch traps (KETCH-ALL^{R}) because of the blowing dust, dirt, sand, rain and snow. These exterior conditions caused wind-up traps to malfunction quickly.

The very effective finalized exterior mouse elimination system consisted of the elevated, totally enclosed, foundation wall-mounted, E.P. A. rated mouse MAJ-ik-BOX^{R} (N.I.P.M) bait station and the multi-catch lever TIN-CAT mouse trap. One, two, or three bait stations were "bunched" at 3 ft. intervals on each side of an exterior doorway or other potential mouse entry or dumpster feeding area. Then one or two multi-catch lever mouse traps were installed on each side of the entry among the bait stations.

This "bunched" equipment led to a realization that up to 250 ft. (76.2 meters) of solid foundation wall could be utilized as a "mouse funnel" to "herd" migrating mice to the "bunched" mouse-sized bait stations/multi-catch lever traps

located at doorways. This "bunched" equipment was much more efficient for inspection, baiting and servicing.

The exact number of bait stations "bunched" around a doorway was based upon the estimated mouse production potential (called a "Mouse Pressure Index") of the outlying areas so that enough bait remained available to feed all migrating mice between services at each "bunched" location. One baited MAJ-ik-BOX and TIN-CAT trap was installed on each side of the ramp and personnel doors on the interior for any "escaped exterior mice" that did enter.

This bait station/multi-catch trap system was the basis of the successful maintenance and elimination after the initial interior clean-up of the mice in one large food warehouse. In that warehouse, 120 mice were taken on the exterior and only three on the interior for the complete 12 months. Inspections of food and merchandise during the year revealed no mouse contamination nor mouse damage. A very limited number of totally enclosed elevated rat-sized bait stations were spaced among the mouse stations. They received very limited feeding by the mice when competing against the mouse-sized station.

Upon the recommendations of their national sanitation consulting firm, the warehouse management chose to establish their own in-house rodent control program using conventional wind-up mouse traps in the interior and a limited number of exterior rat bait stations. In 19 months, after starting their own in-house program, over 50 interior mice were reported caught in a short period of time. Upon inspecting the exterior of the building, only two non-functioning, multi-catch traps remained on the exterior of the warehouse. One wind-up trap would not "trip" and the lid of the lever trap was sprung and would not close to hold a trapped live mouse.

This bait station/multi-catch trap system was the basis for successfully protecting six other food warehouses, two large wholesale bakeries and a very difficult totally enclosed sanitary hog rearing/feeding operation. The hog operation was a sheet-metal building located on top of a hill surrounded by thick, tall fescue grass. The surrounding bottom land was flooded for approximately 10 days producing very heavy mouse migration along with mouse breeding in the heavy fescue.

The field successes of this exterior bait station/multi-catch trap system led to some hypothesizing about this combination's total potential. It was observed that the very palatable anticoagulant bait (0.005% chlorophacinone) was accepted heavily by the exterior mice from the bait stations. However, over90% of the exterior mice collected were found in the multi-catch traps. Some pockets of house-mouse resistance to first-generation anticoagulant rodenticides have been found or reported in the Southeast Missouri area (Cape-Kil 1981-85). A combination of two to three days of feeding by an anticoagulant-resistant mouse on the first-generation bait with the constant availability of the multi-catch trap might have some bearing on the spreading resistance problem to specific rodenticides.

CONCLUSIONS

(1) Exterior house mice (M- musculus^ were the source (SOS) of 90% or more of the potential interior house mouse problems in these food warehouses and other buildings. (2) The use of a palatable bagged mouse bait inside a totally enclosed elevated mouse-sized bait station (MAJ-ik-BOX), along with self-setting multi-catch lever mouse traps (TIN CATS) "bunched" together at potential mouse entries safely and effectively eliminated an estimated 99% or more of the migrating exterior mice living or running next to the foundations of buildings. (3) The effectiveness of the "bunched" mouse-sized bait station/multi-catch trap in controlling 99% of the exterior mice greatly reduced the need for interior control procedures. (4) Bunching equipment at entries reduced the number of exterior bait stations and traps needed, saving service time, expensive bait, plus being easier and quicker to inspect and service. (5) Long lengths of foundation wall served as a "mouse funnel" to "herd" the surrounding areas' migrating mice to this "bunched" equipment. 6) Expensive glue boards and labor-intensive mouse snap traps, along with the expensive "call backs," were not needed for interior mouse control. (7) The use of toxic baits and toxic tracking powders placed among the palleted packaged processed food was not used. This use violates recognized Good Manufacturing Practices (GMP) in the food industry. (8) Effective house mouse stoppage was accomplished with a minimum of tools and expense. (9) House mice *(M.* musculus) were approximately 80% or more of the total interior rodent contamination problem for the food warehouses in the localized areas studied and surveyed during the six year period compared with the Norway rat (R. norvegjeus), which was only 20% or less.

Facing the potential legal problems in mouse control, this system protects the PCOs and the food sanitarians from: (1) Loss of effective rodenticides due to lawsuits filed by the National Coalition Against the Misuse of Pesticides (NCAMP), because the rodenticides are exposed in tamper-resistant bait stations just as the label specifies. (2) FDA citations of clients or the food sanitarian employer due to interior rodenticide contamination or mouse contamination of food products. (3) A lawsuit for contamination by a rodenticide in the food by the general public. (4) Excessive costs to control exterior mice which have invaded the interior of the building.

LITERATURE CITED

COMMUNICABLE DISEASE CENTER (CDC). 1948. Rodent Borne Disease School's Training Sheets.

CROWCROFT, P. 1966. Mice All Over. Dufour Editions Inc. pp. 12-13.

KNOTE. C.E. 1986. Thirty Four Kinds of Mice. Pest Management. Sept.

NATIONAL PESTCONTROL ASSOCIATION. 1976. Pest Control Technician's Training Manual, p. 94.

WHITAKAR, J.0.1966. Food of the Mus musculus (House Mouse), Vigo County, IN, 1962-65. J. Mamm. 47:473-486.