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Robert M. Timm
University of Nebraska - Lincoln

Daryl D. Fisher
University of Nebraska - Lincoln

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AN ECONOMIC THRESHOLD MODEL FOR HOUSE MOUSE DAMAGE TO INSULATION

ROBERT M. TIMM and DARYL D. FISHER, Department of Forestry, Fisheries and Wildlife, University of Nebraska, Lincoln, Nebraska 68583-0819.

ABSTRACT: Commensal rodents have become increasingly troublesome and damaging pests in insulated structures. Modern poultry and livestock confinement buildings in the Midwest often have insulated walls and ceilings. These buildings usually provide an optimum habitat for rats and mice; the rodents gnaw, tunnel through, and nest in the insulation, decreasing its insulative value. Such structures are known to be heavily damaged within a matter of months when commensal rodents have access to wall spaces and attics.

We have developed an economic threshold model to help livestock producers or building managers decide when to conduct house mouse (Mus musculus) control in such situations. The model is based upon the cost of house mouse damage to commonly used types of insulation in walls, as measured in laboratory experiments. Components of the damage are 1) the cost of insulation replacement and 2) increased heating costs due to damaged insulation. Damage costs are compared to the expense of conducting mouse control using anticoagulant rodenticides in permanent bait stations located throughout the structure. The model concludes that it is cost-effective to implement a baiting program for mouse control in nearly all insulated confinement buildings. The cost of control is usually very small when compared to the cost of potential mouse damage.

INTRODUCTION

House mice (Mus musculus) have long been recognized as important vertebrate pests around human agricultural endeavors. Apparently first introduced into Nebraska by Major Long's expedition in the winter of 1819-20 (James 1823), these rodents subsequently thrived in their new human-modified habitat. By 1908, the house mouse was declared to be an "abundant and highly injurious pest throughout the state, frequenting both buildings and fields" (Swenk 1908).

Food and shelter for mice are readily available in most farmstead situations. In past times, farmers have been principally concerned with the house mouse's tendency to damage or contaminate feeds. House mice consume stored grains and prepared livestock feeds, and they increase spoilage of feeds and supplements by damaging sacks. Their urine and feces contaminate a considerably greater amount of feed than is eaten. Additionally, they are implicated in the spread of diseases which may affect livestock, such as swine dysentery (bloody scours) (Joens 1980).

In recent years, midwestern livestock producers have utilized insulated confinement buildings with increasing frequency. Poultry, swine, and occasionally other types of livestock are kept in such structures year-round. The insulated walls and ceilings aid in maintaining optimum temperatures in order to maximize livestock performance. Other livestock buildings or shelters that are not total confinement systems may also be insulated to help moderate temperature extremes. In a recent survey of Nebraska pork producers, it was found that more than 50% of respondents used at least one insulated structure in their livestock production operation (Timm et al. 1983).

These same producers reported a high incidence of house mouse infestations; more than 90% had encountered mice on the premises within the past year. When present, it is likely that these rodents will infest and damage the insulation. House mice can impair the ability of insulation to retard heat flow by creating air spaces in the insulation via tunneling, compacting, and nest building. Also, the insulation's conduction of heat can be increased as it becomes saturated with urine, and damage to vapor barriers further-allows moisture from the warm interior of buildings to condense inside walls and fill insulation spaces. This not only increases heat transfer but also leads to degradation of structures through decay of the wooden components of walls.

At this time, we know of no types of insulation which completely resist rodent damage. This is substantiated by a German report in which researchers studied 12 types of insulations including polyurethanes, mineral fiber, extruded polystyrenes, expanded polystyrenes, loose-fill perlite, spun glass, and pressed sawdust. They found none which house mice could not destroy by gnawing (Suss and Mittrach 1982).

QUANTIFYING MOUSE DAMAGE TO STRUCTURES

The greatest economic losses from house mice to midwestern pork producers may be the increased costs of heating confinement buildings in which insulation has suffered damage and the cost of replacing the damaged structural components. Because little objective information on rates of damage to insulation by house mice was available, we undertook a laboratory study to measure such damage under controlled conditions (Fisher 1984).

Following a 6-month period during which we allowed house mice to live and breed within insulated wall panels, we found a substantial decrease in insulative integrity of all types and combinations of insulations we tested. Fiberglass batt insulation, a very common type in livestock confinement buildings, suffered a 46.4% decrease in "R" value during this time.

AN ECONOMIC THRESHOLD MODEL

We have created an economic threshold model in order to assist livestock producers, or those who advise them, in determining when it is economically reasonable to initiate house mouse control in insulated confinement buildings. It is assumed in our model that when house mice are present in or near the structure and the insulation is not protected by rodent-proof construction, the mice will invade the insulated spaces and cause damage to the insulation at least as great as we measured during our 6-month laboratory trial.

Costs of Control

We have had experience in controlling house mouse populations within swine confinement buildings of various types, and from this experience and current costs of materials we estimate the following costs of conducting mouse control using anticoagulant rodenticides:

1) Plastic bait stations cost $0.50 each, assuming a minimum purchase of 25 stations.
2) Stations are placed 3.05 m (10 ft) apart around the building's inner perimeter.
3) Stations require 30 g of anticoagulant rodenticide each.
4) Stations are checked 20 times annually and bait is replaced each time; this includes initial placement.
5) The cost of rodenticide is $1.40/lb.
6) Fifteen minutes of labor are required prior to each of the 20 trips to fill stations, for such activities as locating and gathering equipment and for travel to the building.
7) Two minutes are required for checking and refilling each station.
8) Cost of labor is $5.00/hour.

The cost of control was calculated using four different sizes of hypothetical livestock confinement buildings. Building dimensions and calculated control costs are given in Table 1. The relationship between building perimeter and control costs is shown in Figure 1. A slight decrease in slope occurs at a building perimeter of 76.2 m (250 ft), because extra, unused bait stations are no longer purchased as the minimum purchase of stations (25) is exceeded beyond this point. Below this perimeter size the equation for the line described in the relationship between mouse control cost and building perimeter is approximately $Y = 0.52X + 37.5$.

Table 1. Relationship between building size and cost of mouse control.

Building dimensions	Square feet	Perimeter	Control costs	Control cost/ square foot
112 X 48 X 8 ft.	5376	320 ft.	$203.90	$0.04
56 X 24 X 8	1344	160	120.70	0.09
28 X 12 X 8	336	80	79.10	0.24
14 X 6 X 8	84	40	58.30	0.69

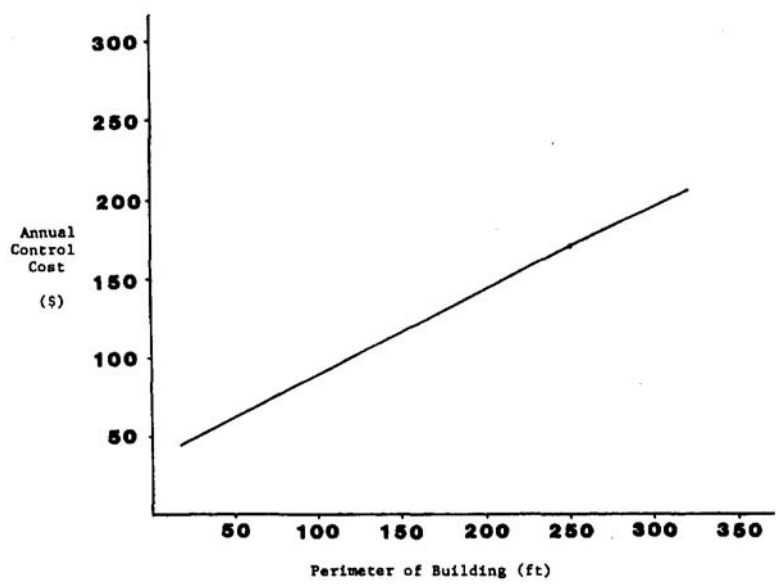

Figure 1. Relationship of mouse control cost to perimeter of building.

Costs of Damage

We utilized a computer program on the University of Nebraska's AGNET system in order to evaluate heating costs in the same four hypothetical swine confinement buildings, both before and after mouse damage to the insulated walls. Because our laboratory study investigated mouse damage only to insulated walls, not ceilings, we considered the ceiling or attic insulation to be undamaged in these simulations. The buildings were considered to be insulated with 3.5 inches of fiberglass batt, located at Lincoln, Nebraska, and maintained at 23.9° C (75° F). The dollar values obtained from the simulations depend on the energy source chosen, as well as the difference in insulation efficiency between intact and damaged insulation. For our purposes here, we give values for buildings heated with LP gas, a common heating fuel on Nebraska farms. This fuel's cost was set at $0.72 per gallon.

The increased heating cost values were plotted against the corresponding building perimeters in Figure 2, along with the control cost relationship. The equation of the line describing the relationship between the increase in annual heating cost and the building perimeter is approximately Y = 1.03X - 6.27.

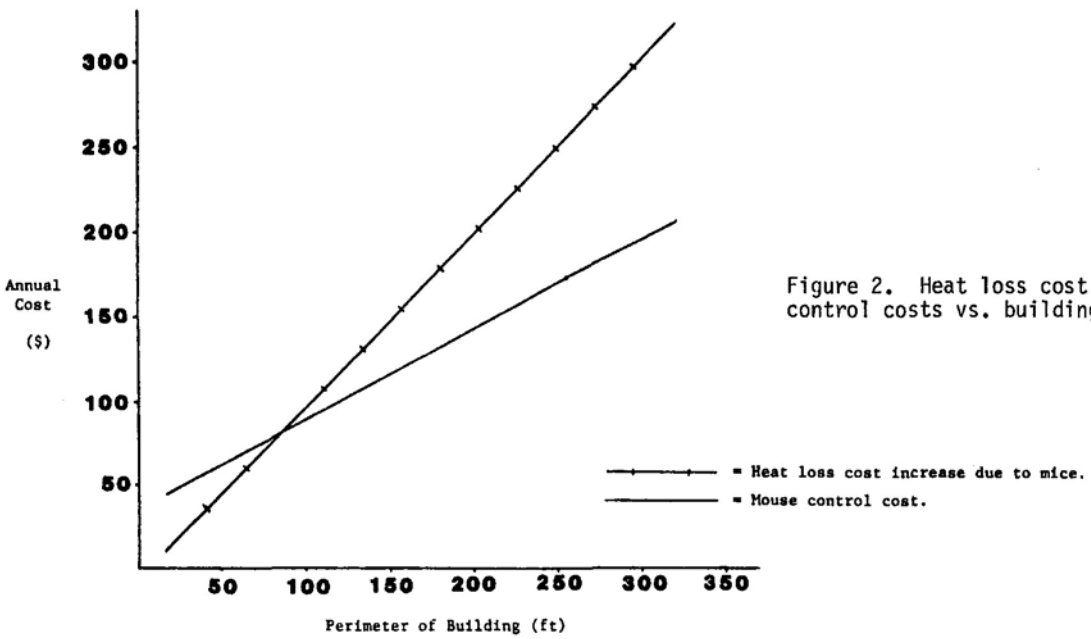

Figure 2. Heat loss cost and mouse control costs vs. building perimeter.

If the annual increased heating cost is considered to be the only element of mouse damage, then the threshold model in Figure 2 indicates that a producer with a building having a perimeter of 26 m (85.5 ft) or larger should incur the cost of mouse control, as the annual heating losses will be greater than this if no control measures are taken. Buildings smaller than this size would have heating losses, due to uncontrolled mice, costing less than a rodenticide-based control program. Since control of an existing mouse population, after it has already caused insulation damage, will not reduce heating costs, this relationship is best understood as a need to do preventive control in buildings larger than 26 m in perimeter in order to prevent incurring these losses.

Increased heating costs are not the only economic losses due to house mice. If the insulation is replaced, there will also be the costs of partial wall dismantling, old insulation removal, purchase and installation of new insulation, and reassembling the walls. For this more complete model, most of these additional costs were obtained from Godfrey (1983). Since the insulation would not be replaced annually, replacement at 5-year intervals was assumed. Five years is not too soon to assume insulation will need replacement in the absence of mouse control or rodent-proofing, as we have seen actual swine confinement buildings needing insulation replacement following as few as 3 years of mouse damage.

We have therefore added one-fifth of the reinsulating costs to the annual heating loss costs to obtain estimates of "total" losses due to mouse damage. Table 2 lists the calculated total cost of damage for each of the four hypothetical swine confinement buildings. The equation describing the relationship between total yearly damage costs and the building perimeter becomes Y = 1.88X - 11.4. Figure 3 shows this relationship and the mouse control cost relationship. This model indicates that a producer should have a mouse control program if the building has a perimeter of 11.0 m (36 ft) or larger. This recommendation is conservative inasmuch as we considered only costs of mouse damage to insulated walls and the resulting increased heating costs. We did not consider damage to insulated ceilings or other aspects of mouse damage (e.g., feed consumption and contamination, disease spread, other structural damage).

Table 2. Relationship between building size and "total" cost of mouse damage.

Building dimensions	Square feet	Perimeter	Damage costs	Damage cost/ square foot
112 X 48 X 8 ft.	5376	320 ft.	$590.20	0.11
56 X 24 X 8	1344	160	289.40	0.22
28 X 12 X 8	336	80	139.00	0.41
14 X 6 X 8	84	40	63.80	0.76

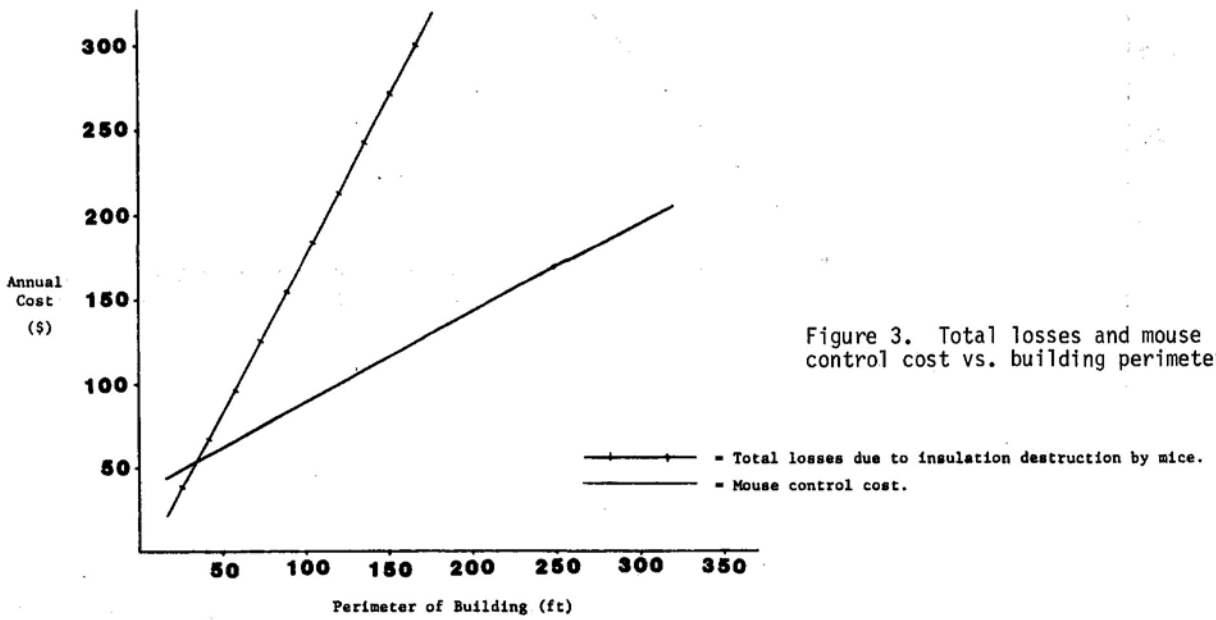

Figure 3. Total losses and mouse control cost vs. building perimeter.

CONCLUSIONS

Most insulated confinement livestock buildings are considerably larger in perimeter than 11 m (36 ft). Our calculations, based only on the increased cost of heating buildings with mouse-damaged walls and costs of replacement of damaged insulation, indicate that producers with such buildings would be wise to initiate and maintain a program of mouse control as part of their livestock operation. Further, if energy costs continue to increase as they have during the past decade, the economic damage in terms of additional heating costs caused by mouse damage will be even greater. Other potential mouse damage, including destruction of attic insulation, consumption and contamination of feed, and spread of disease, further justify the control of commensal rodents.

Although we have not studied or attempted to simulate the value of rodent-proof construction, we believe producers building or remodeling confinement buildings will find it cost-effective to attempt to exclude rodents from insulated spaces within walls, attics, etc., whenever possible. These efforts, combined with good sanitary practices and storage of feeds in rodent-proof structures, should increase the profitability of agricultural production in such situations by avoiding the serious costs which commensal rodents can inflict upon today's livestock producers.

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