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Journal
Proceedings of the Vertebrate Pest Conference, 20(20)

ISSN
0507-6773

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Publication Date
2002

DOI
10.5070/V420110060

An Economic Model of Integrated House Mouse Control in Swine Production Facilities

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Abstract: We conducted a comprehensive economic analysis of rodent control in swine production facilities. An interdisciplinary working group was assembled to identify all necessary input variables and values associated with rodent damage and control. We incorporated data from production models, scientific literature, product literature, producers and personal experience into an interactive STELLA systems model. The model generates cost-benefit analyses and predicts outcomes of various levels of control of house mice for site-specific swine confinement facilities. We developed a website on rodent control (http://rodent.swine.unl.edu/) to promote use of the model, increase producer awareness of the costs associated with house mouse damage, and provide information on integrated strategies for managing rodents. Although the model is relatively robust and comprehensive, we noted important gaps in research-based information, particularly associated with the economic impacts of rodents in disease transmission, feed contamination, food safety, quality assurance, and human dimensions. We will continue to improve the model and website as new information becomes available.

Key Words: house mice, *Mus musculus*, model, STELLA model, economics, rodent damage, rodent control, cost-benefit analysis, pork producers, swine production facilities

Proc. 20th Vertebr. Pest Conf. (R. M. Timm and R. H. Schmidt, Eds.)
Published at Univ. of Calif., Davis. 2002. Pp. 53-58.

INTRODUCTION

Norway rats (*Rattus norvegicus*) and house mice (*Mus musculus*) caused estimated annual losses of 6.35 million due to structural damage in the Nebraska pork industry alone (Johnson and Timm 1987). In addition, the value of livestock feed consumed annually was estimated at $0.75 million. The cost of rodent damage has increased in recent years as the use of insulated confinement structures has become more prevalent. House mice, in particular, can be very destructive, causing damage to all types of building insulation (Hygnstrom 1995). Rats and mice are also reported to serve as reservoirs and vectors of swine diseases including swine dysentery, encephalomyocarditis, porcine rotaviruses, trichinosis, and pseudorabies (Henzler 1997). We believe that producers have limited awareness regarding the consequences of rodent damage in swine facilities, and that there is a continuous demand for information on integrated strategies for rodent control. Integrated approaches to rodent control are effective and recommended (Corrigan et al. 1992, Timm et al. 1997, Corrigan 2001), but little is known about the overall cost-effectiveness of various methods of rodent control. A comprehensive economic evaluation of rodent control in swine production facilities is needed to increase the efficiency of producers and to aid in decision-making processes. Our goal was to increase the awareness of swine producers and others in the swine industry regarding the potential costs associated with damage caused by rodents and cost-effective strategies for controlling rodent damage. Specific objectives of this project included:

1) identify the costs of rodent damage in various types of swine production facilities,
2) identify the costs and benefits of various levels of rodent control, and
3) develop an interactive systems model that conducts cost-benefit analyses and predicts best management practices.

METHODS

We assembled an interdisciplinary group of experts to identify all necessary input variables and values associated with rodent damage and control in swine facilities. Members of the group represented the fields of rodent ecology, rodent control, swine production, facilities management, agricultural economics, swine health, ecological modeling, and distance education. The working group met twice during 2000 and 2001 and attempted to identify and prioritize all known variables that affect the economics of rodent control in swine facilities. We incorporated information from existing models, scientific literature, product literature, producers, and personal experience.

An interactive systems model was developed, using STELLA 6.0 simulation software (High Performance Systems, Inc., Hanover, New Hampshire, USA) to conduct cost-benefit analyses based on prioritized variables and associated values. The default variables in the model represent a typical farrow-finish swine production facility in the Midwest, with a 20-crate farrowing house, a 200-head nursery, and a finishing barn. We restricted this model to include only damage by house mice, as this species of commensal rodent is much more widely found on swine production facilities than is the Norway rat. Further, considerable information on house mouse damage and control on such facilities was available in the literature. All models assume an initial population of 3 male and 3 female mice with natural reproduction and immigration. Costs of control may vary, with initial expenditures for mouse-proofing ranging from \$0 to \$10,000. In addition, the model allows the investment of \$0 to \$500 each month in efforts to control mice (sanitation, trapping, and toxicants). Total costs are the sum of the costs of house mouse damage and the cost of control.

The model consists of three layers: an interactive controls layer, a model diagram layer, and an equations layer. In the controls layer, users can run simulations under varying scenarios (Figure 1). The diagram layer shows the layout of the model variables in the form of stocks (mouse population, cumulative dollars spent on control, cumulative dollars of damage), flows (death, damage, spending on sanitation), converters (damage, death fraction, total cost), and connectors (single-lined arrows). The equations layer includes all computer code and algorithms used to generate the model output (Table 1). The STELLA model provides interactive input, value defaults and sliders, feedback loops, and variable crosslinks. We ran several simulations of the model to determine the effects of various levels of rodent control on house mouse population levels, subsequent damage, and benefit-cost ratios.

RESULTS

During the first meeting of the working group, we generated six pages of single-spaced notes on variables and values associated with rodent control in swine facilities. Through discussions and a prioritization process, we identified the most important factors associated with this project (Table 2) and identified research gaps that impeded the inclusion of some variables in the model (Table 3).

When the model is run with no control effort, the population grows slowly at first, but increases exponentially as juveniles become mature and mice continue to immigrate from surrounding areas (Figure 2). After six months the population would be only about 25 mice but by 12 months there would be over 2,200 mice. By 24 months, the population might approach 500,000. The only mortality that occurs is due to natural causes such as limitations in food, space, and nesting sites. As the population climbs, the cost of damage (i.e., amount of feed consumed, insulation damaged) and the probability of a catastrophic event (i.e., fire caused by wiring damage, major equipment failure) also increases. The model indicates that total costs for no control were relatively low up to 12 months. By 18 months, however, total costs exceeded \$50,000 and increased exponentially beyond (Figure 3).

When the model is run with maximum efforts in house mouse control, no immigration occurred during the 24-month period because mice were completely excluded from the facility. In addition, the 6 mice that were initially in the building and the few young they produced were eliminated in 6 months (Figure 4). After the initial investment in rodent-proof construction (\$10,000), monthly costs of control were static (\$500 per month) and no costs associated with mouse damage were experienced. Total costs after 12 and 24 months were \$16,000 and \$22,000, respectively (Figure 5).

DISCUSSION

Gaps in research-based knowledge inhibited our modeling efforts in three areas: feed contamination, disease transmission, and human dimensions. We found little information on the effects of rodent feces and urine on feed consumption. Although rodents have been implicated in the transmission of diseases to swine, few studies

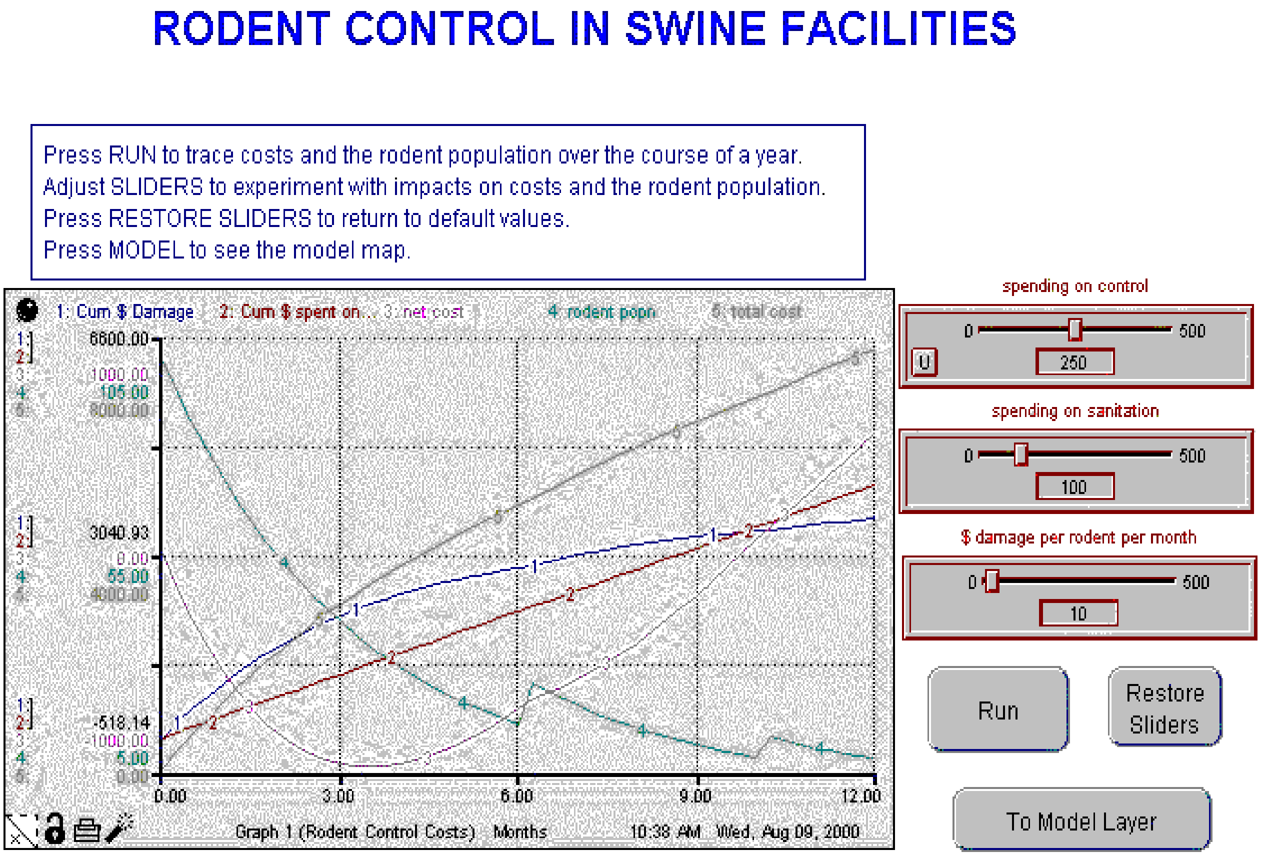

Figure 1. The controls layer of the STELLA model. On this layer, users can vary input values and run the model to see how their changes influence the values depicted on the graph.

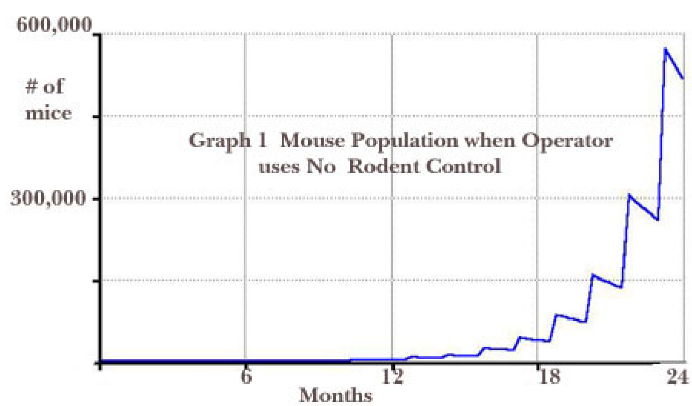

Figure 2. Predicted population of house mice when no control efforts are applied in a typical farrow-finish swine production facility in the Midwest, with a 20-crate farrowing house, a 200-head nursery, and a finishing barn. The model assumes an initial population of 3 male and 3 female mice with natural reproduction and immigration.

Table 1. The equations layer of the STELLA model lists the equations depicted in the diagram layer.

Equations

Cum. dollars damage(t) = cum. dollars damage(t - dt) + (damage) * dt
Initial cum. dollars damage = 1
Damage = rodent popn.*dollars damage/rodent/month
Cum. dollars spent on control(t) = cum. dollars spent on control(t - dt) + (spending on sanitation + spending on control) * dt
Initial cum. dollars spent on control = 1
Spending on sanitation = 100
Spending on control = 110
Rodent popn.(t) = rodent popn.(t - dt) + (birthing & immigrating - death - emigration & starvation) * dt
Initial rodent popn. = 100
Birthing & immigrating = birth & immigration rate*rodent popn.
Death = rodent popn.*death fraction
Emigration & starvation = rodent popn.*emigration fraction
Dollars damage/rodent/month = 10
Benefit:cost = cum. dollars damage/cum. dollars spent on control
Birth and immigration_rate = .3+PULSE(.7,6,4)
Death fraction = natural death rate+impact of control df
Natural death rate = .1
Net cost = cum. dollars spent on control-cum. dollars damage
Total cost = cum. dollars damage+cum dollars spent on control
Emigration fraction = GRAPH(spending on sanitation)
(0.00, 0.035), (50.0, 0.04), (100, 0.06), (150, 0.09), (200, 0.11), (250, 0.2), (300, 0.36), (350, 0.445), (400, 0.475), (450, 0.51), (500, 0.515)
Impact of control df = GRAPH(spending on control)
(0.00, 0.03), (50.0, 0.135), (100, 0.215), (150, 0.285), (200, 0.365), (250, 0.44), (300, 0.52), (350, 0.61), (400, 0.7), (450, 0.82), (500, 0.895)

Table 2. Variables included in the interactive STELLA systems model on rodent control in swine facilities.

Facility type	Stochastic events
Facility condition	Value of assets
Structural damage	Cost amortization
Insulation damage	Monitoring
Wiring damage	Rodent density
Equipment damage	Rodent population dynamics
Repair costs	Density-dependent cost functions
Energy costs	Levels of rodent control
Feed consumption	Costs of rodent control
Animal performance	Benefits of rodent control
Risk probability	Operating costs
Time sequence analysis	Benefit-cost ratios

Table 3. Variables not included in the interactive STELLA systems model on rodent control in swine facilities.

Feed contamination	Down time
Disease transmission	Community/social issues
Opportunity costs	Human dimensions
Food safety-certification, accountability, quality assurance	

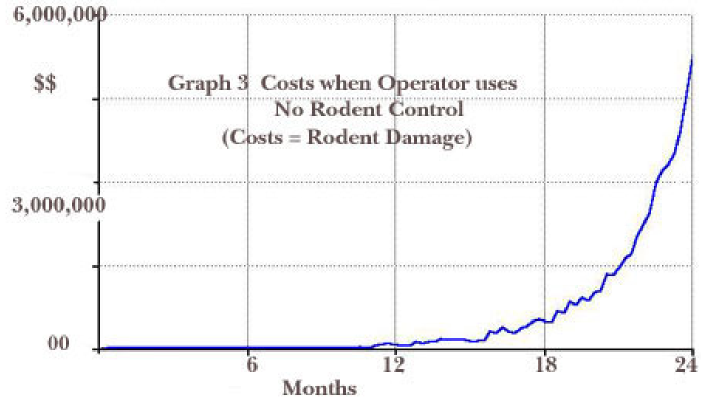

Figure 3. Predicted total costs of damage caused by house mice when no control efforts are applied in a typical farrow-finish swine production facility in the Midwest, with a 20-crate farrowing house, a 200-head nursery, and a finishing barn. The model assumes an initial population of 3 male and 3 female mice with natural reproduction and immigration.

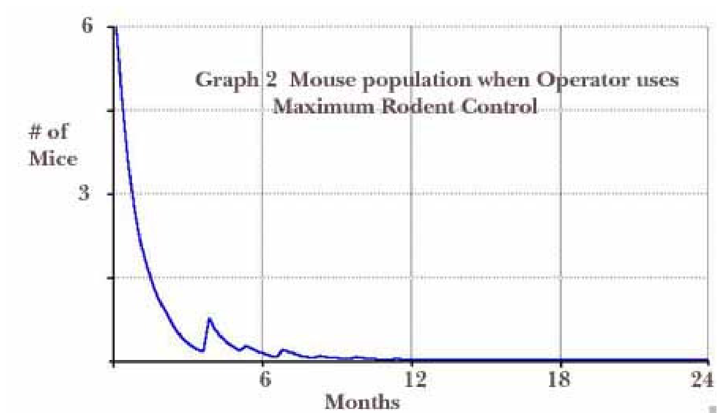

Figure 4. Predicted population of house mice when maximum control efforts are applied in a typical farrow-finish swine production facility in the Midwest, with a 20-crate farrowing house, a 200-head nursery, and a finishing barn. All models assume an initial population of 3 male and 3 female mice with natural reproduction and immigration.

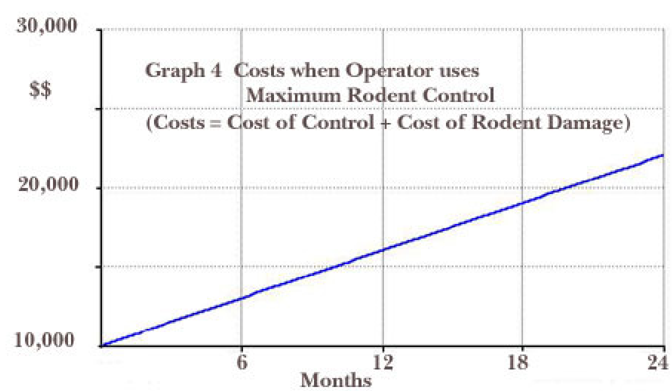

Figure 5. Predicted total costs of damage caused by house mice and costs of control when maximum efforts are applied in a typical farrow-finish swine production facility in the Midwest, with a 20-crate farrowing house, a 200-head nursery, and a finishing barn. The model assumes an initial population of 3 male and 3 female mice with natural reproduction and immigration.

have confirmed direct responsibility and few studies have itemized the economic effects of diseases at the farm level. We were unable to identify any research-based information on the presence of rodents on employee health and morale, product value and quality assurance. We encourage further research in these areas and will continue to develop and fine-tune the model as more research-based information becomes available.

The STELLA model provides cost-benefit analyses and predicts outcomes of various levels of house mouse control. For this presentation, we only included output on mouse population levels and total costs of mouse damage and control for the scenarios of no rodent control and maximum rodent control. Interested parties can access the model through the Internet (http://rodent.swine.unl.edu/) and construct an infinite number of scenarios regarding initial investments in rodent-proof construction and monthly applications of sanitation, trapping, and toxicants. Estimates of mouse population levels, total costs, net costs, and benefit-cost ratios will help users make rational decisions on rodent control options based on economic returns (VerCauteren et al. 2002).

In addition to the model, we created a website on rodent control (http://rodent.swine. unl.edu/) that includes a run-time version of the STELLA model. In the future, the model will be expanded so that producers are able to input information on their own facilities and generate economic analyses that can assist them in site-specific decision-making processes. The website also includes five, two-to six-minute videos and a series of text and still images on rodent control and integrated pest management and links to a series of publications on rodent control. The rodent control website is linked to the NPPC website (http://www.nppc.org) and to the Internet Center for Wildlife Damage Management (http:// wildlifedamage.unl.edu). We will continue to promote the model among swine producers through Cooperative Extension specialists, county agents and educators, and others by means of presentations, media (newsletters, radio programs), and personal contacts. Informational brochures will be developed and distributed as a follow-up to the current project to increase producer awareness of the consequences of rodent infestations, rodent control options, and the availability of the cost-benefit model.

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