DEVELOPMENT OF RODENT CONTROL TECHNOLOGY FOR CONFINED SWINE FACILITIES

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ABSTRACT: This paper discusses the development of site-specific baiting technology for controlling the house mouse (*Mus musculus*) in confined swine facilities utilizing specific rodenticide formulations, bait stations, and baiting strategies. Behavioral research was also conducted to identify primary nesting and travel activities of mice within grower-finishing units. The rodenticide bromadiolone in a block formulation was found to be effective in most baiting trials, and provided resistance to the harsh environment of the swine facility and the necessary versatility for securing baits to minimize hazards to swine. A commercially available tamper resistant bait station was found to be effective for floor baiting procedures in high swine activity areas, and a homemade pvc tube baiter was effective for off-floor baiting efforts. To prevent population resurgences, baiting strategies within grower-finishing units must be responsive to structural and environmental factors affecting the activities of the rodent populations. In the grower-finishing units and other high swine activity areas, both floor and off-floor baiting programs are recommended.

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INTRODUCTION

The house mouse (*Mus musculus*), and the Norway rat (*Rattus norvegicus*), can impact on nearly all production factors affecting a commercial swine facility, and as such they have been determined to be among the most important economic pests to the swine industry. (Corrigan et al. 1987).

Controlling rodents in swine facilities is not a simple task. The presence of relatively unlimited amounts of food, water, warmth, space, and a predator-free shelter leads to artificially high rodent populations. These populations often become established throughout all buildings within the swine facility, as well as within may of the structural components of the buildings resulting in a population which is difficult to control. Additionally, intrinsic factors present restrictions and harsh conditions which impede effective and efficient rodent control programs. For example, the constant movement of pigs about the building, the washing of floor areas with high pressure hoses, equipment storage, and abundant amounts of dirt, dust, moisture, and animal excrement affect rodenticide bait placements. Moreover, unless special precautions are taken, rodenticides can create potential hazards to swine when baits are placed into areas where swine are directly housed, fed, handled and maintained, yet where rodents are abundant. And finally, rodenticide baits used in swine facilities must compete with the copious amounts of swine feed readily available to the rodents.

To date, research is lacking which addresses site-specific rodent control strategies for confined livestock operations. Rodenticide baiting programs currently used in livestock facilities are primarily based upon general directions as provided by rodenticide labels developed for urban rodent control programs (Timm et al. 1983). But these strategies may not necessarily fit the components of the confined swine facility model.

The primary objective of this research project was to develop site-specific rodent IPM technology for confined swine facilities. The house mouse was targeted in this project as it is the most common and serious pest in confined swine facilities and is also the most difficult to control (Timm et al. 1983, Corrigan et al., 1987).

The specific objectives included the following:

1) Identify rodent behavior as it relates specifically to the design of rodent management programs in confined swine facilities. This included identifying nesting locations, feeding areas and behavior, travel pathways, and other high activity areas.
2) Identify methods for censusing mouse populations in the confined livestock environment.
3) Evaluate the rodenticide bromadiolone in a block bait formulation.
4) Identify and develop effective bait delivery systems integrating block bait formulations with swine resistant bait stations.
5) Evaluate site-specific baiting strategies relative to bait placements in high swine activity units (i.e., grower-finishing units).

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MATERIALS AND METHODS

The Baker-Purdue Swine Research Unit in Montmorenci, Indiana and commercial swine producers within central Indiana were used in this project. Swine producers were contacted and interviewed relative to mouse problems. Those producers reporting rodent infestations were solicited for a cooperative research effort. Farrow-to-finish operations having similar structural designs and operational procedures were utilized.

Behavioral Research

The behavioral research was conducted in different swine facilities for approximately 12 evenings over several weeks during the spring and early summer prior to the start of the baiting phases of the project. This involved conducting observations utilizing a general qualitative approach. Observations were conducted between the hours of 6 pm and 12 am using a flashlight. Observations were conducted primarily in the grower-finishing units of each facility.

Censusing Technique

The mouse populations within test sites were censused via live-capture traps (Corrigan and Williams 1986). Other censusing techniques such as animal counts, tracking patches and food consumption as described by Kaukeinen (1984) were also attempted. However, there was a significant amount of variation in the census data using these techniques (Corrigan and Towell, unpubl. data) due to the unique environment and operational aspects of the grower-finishing units. Thus these techniques were not cost-effective relative to the amount of work required to establish these censuses.

Tin Cat® repeating traps were used for the live trap censusing. Traps were placed on floor areas within the test units spaced at 3 m intervals. Approximately 30 g of hog feed was placed within each trap to provide food, and reduce captivity stress and cannibalism. Traps were run for two consecutive days, and the total number of captured mice over the two day period represented the census figure.

Rodenticide Selection

It was important to the cooperating swine producers that every measure possible was taken to minimize the potential hazard of using baits within swine units. The anticoagulant bromadiolone (.005%) was selected for this project. Of the two leading second generation anticoagulants, it is the less toxic rodenticide to swine (Meehan 1984), and has been used in urban rodent control programs successfully over the last 10 years. Bromadiolone is marketed under several different trade names. Most widely known to swine producers at the start of this project was the product Boothill® manufactured by the Lipha Tech Corporation.

An important objective of this study was to target a rodenticide formulation which would provide the versatility for the site-specific baiting procedures required for the livestock environment. After initial field screening and considerations of the advantages and disadvantages of each formulation (Corrigan 1990), the "wax" block formulation was selected for evaluation.

Bait Station Selection

Currently, there are many varieties of commercial bait stations. However, only a few can be considered for use in a swine facility. The Eaton's TP 906 station is classified by EPA as a tamper-resistant bait station, and was selected to be evaluated for floor baiting strategies. This station is made of highly durable, high-impact plastic, is enclosed and contains a top that is secured by a hex screw. The interior tunnel contains two baffles leading to the bait chamber.

With the objective of developing an effective off-floor baiting container, 12 in. (31cm) sections of common pvc plumbing pipe (2 in. (5cm) diameter) were evaluated as "tube baiters." Within each section the bait blocks could be easily secured using either wire or a nail. When the stations were mounted on top of pen dividers, they were held in place using heavy duty plastic "zip straps." When the stations were mounted on wall ledges, a single nail was driven through predrilled holes in the station to affix the station to the ledge. The nail also served to secure the bait within the station (Figure 1).

Prior to utilizing the bait stations for the baiting program, fifteen of each station were tested for durability and ability to protect bait in the swine environment. Both types of stations were placed among pigs within grower-finishing pens. The

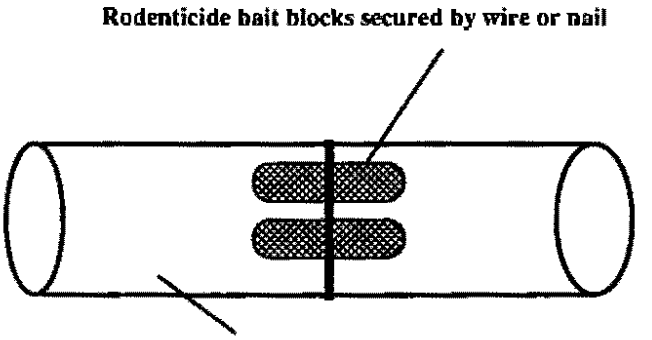

Figure 1. PVC pipe used as a bait station for baiting various off-floor areas in high swine activity areas.

pvc tube baiters were also affixed to the tops of pen dividers and wall ledges commonly traveled by the mice to evaluate their off-floor utility. All stations were filled with hog feed in order to measure durability to persistent hog disturbance. Stations was monitored over a three week period.

Baiting Strategies.

This portion of the project focused on evaluating two baiting strategies: 1) conventional (i.e., floor) baiting programs (as listed on rodenticide labels for baiting within structures) when used within low swine-active units (e.g., farrowing-nursery units) and high swine-active units (e.g., grower-finishing units) and, 2) site-specific baiting strategies within grower finishing units utilizing both floor and off-floor baiting strategies. For the floor baiting study, a total of 14 houses at the Baker swine facilities were evaluated. The population census value for these trials ranged between 54 and 225 mice. Eatons TP 906 bait stations containing two halves of a 65g bromadiolone bait block were positioned at 3 m intervals around the perimeters of farrowing-nursery and breeding-gestation units.

For the site-specific floor baiting programs within the grower-finishing units (Figure 2), bait stations were placed on both sides of the central aisle way at 2.1 m intervals. The entrance holes of the stations were placed closest to the pen gate. The entire aisle way was baited on both sides in this manner. The total number of floor stations varied between 85 and 98 stations depending on the size of swine unit.

The off-floor baiting strategy was designed to intercept the mice traveling from wall and ceiling areas to the feeder via the perimeter wall ledges and pen divider gates. To accom-plish this, the pvc tube baiters were positioned approximately every 2.1 m along the ledge of the perimeter wall (i.e., the back wall of each pen), and one station on each pen divider gate (Figure 2). The total number of off- floor stations varied from 35 to 127 depending on the the facility and the number of active grower-finishing pens at the time of baiting. A total of 11 grower finishing houses among two different swine facilities were evaluated for the off-floor baiting study. The population census value for these trials ranged between 40 and 137 mice. Five field tests were conducted within grower-finishing units at the MB Swine Complex near Kokomo, Indiana, and six field tests were conducted at the Purdue Baker grower-finishing units.

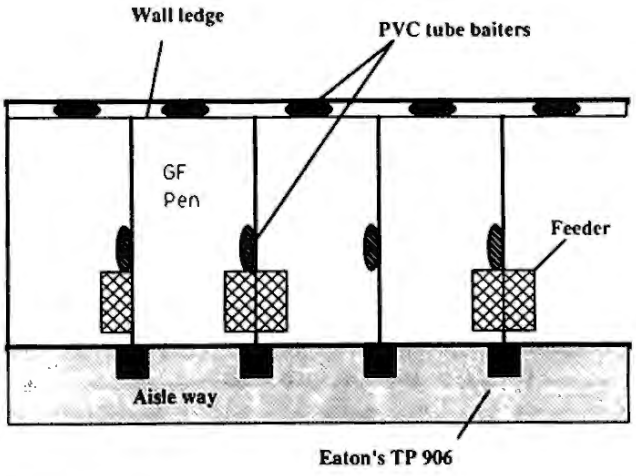

Figure 2. Placement of floor and off-floor bait stations within a grower-finishing unit.

Baiting trials were also conducted among six grower-finishing units to determine any differences in ease of use as well as efficacy between the pvc tube baiters and the Eaton's TP 906 stations for floor baiting. All bait stations were monitored on a 1, 3, 7, 14, and 21 day interval. Any baits consumed before the 21 day period were replaced. Each trial lasted for 35 total days as follows:

- 2 day pre-treatment census
- 3 day lag
- 21 day baiting period
- 7 day lag period
- 2 day post-treatment census

Percent Reduction was calculated as follows:

$$[(T_o - T_i) / T_o] \times 100 = \% \text{ Reduction}$$

where:

T_o = census value prior to treatment, and

T_i = census value post treatment.

RESULTS AND DISCUSSION

Behavioral Observations

Nesting locations—Identifying the behavior and activities of rodents relative to both the swine facility operational aspects and structural aspects are essential for designing effective rodent IPM for swine facilities. Behavioral observations during the evening inspections revealed the mice in the grower finishing to utilize a wide variety of nesting locations. Nesting and suspected nesting locations can be categorized into structural and non-structural areas or items. *Structural* nesting locations (i.e., utilizing the building structure itself), included areas within the insulation of perimeter and interior walls, insulated doors, and ceilings. Mice also made use of various structural nooks and crannies behind utility components, in various corners and spaces at wall-floor junctions, and on top of the building foundation ledges supporting the floor of the grower pens.

For the *non-structural* nesting locations, mice were opportunistic in their selection, utilizing any type of equipment or debris within the building. This included storage cabinets, desks, discarded boards, conduit pipes, old feed sacks, discarded feeders, boxes, and any other type of debris or garbage. Areas providing good concealment, warmth, and proximity to the food source regularly exhibited high mouse activity. For example, the *weight scales* within the grower-finishing units were constantly infested, as the mice would utilize the void beneath the scales as this area provided a warm and enclosed environment.

The in-pen wooden feeders and the voids created between feeders positioned back to back between two pens, were also used frequently for nesting and harborage. In cases of hollow base wooden feeders, mice utilized the hollow base. Feeders in disrepair providing any type of superficial nooks and crannies (e.g., loose flashing around the base), also provided mouse harborage. Finally, hog manure which was allowed to accumulate and become dry and caked for any length of time in the aisles, between feeders, and in occupied and unoccupied hog pens also provided harborage for mice.

Travel pathways—It is important to identify the travel paths of the mice within livestock facilities to facilitate the most effective placement of bait stations, or other rodent control tools. In the grower finishing units, mice nesting within the structural nesting areas used both floor and off-floor components for traveling and foraging within their home ranges. It is important to note that a significant number of mice utilized the tops of pen divider gates almost exclusively in their foraging, descending to the floor areas only when approaching the feeder. Thus, the travel pathways of these mice were dictated by the structural dimension of the particular pen area. For example, if the dimensions of the pen was 2 x 4 m as delineated by the pen dividers, then the primary travels of the mice were often restricted within these dimensions. Moreover, the total *surface area* traveled by the mice was to a degree dictated by the dimensions of the pen dividers itself (e.g., 3 cm x 2m x 4m).

Mice nesting within the non-structural components within the house utilized both off-floor and floor travel routes depending upon the location of the nesting area. In general, the mice nesting within items stored on the floor, appeared to travel directly across the floor using the shortest routes to the food source. In many cases, mice readily climbed over resting pigs to reach food areas. In fact, mice were often observed feeding within the protection of corners and spaces provided by the resting pig's torso.

Feeding locations—Mice utilizing the floor areas,were generally opportunistic in their foraging behavior as is described in many publications (e.g., Crowcroft 1966) feeding intermittently along various areas where spilled hog feed might occur. Mice utilizing off-floor travel pathways appeared to feed primarily at the feeders, as very little food was available on the tops of wall ledges or pen dividers. In both "floor and off-floor mice", the mice often climb directly within the feeder to feed. This inevitably results in a contamination of the feed.

Bait Block Efficacy

Historically, the block bait formulations was designed for baiting in damp environments. And it is often suggested that block baits are less attractive to rodents than the meal or pelletized grain formulations due to the wax component within the bait. In the majority of the field trials in this study, the bromadiolone block baits produced significant reductions in the mouse populations and were readily accepted by the

rodents even among the copious amount of nutritious hog feed constantly available.

Of the 14 field tests, the population reduction values after three weeks of baiting ranged from –5.0% to 100%. The mean and median values for all treatments was 75.0% and 82.0% respectively. Thus, in only a few cases did the baiting program fail. Failures may have been due to intrinsic operational factors (e.g., baits being moved by swine personnel, floor washing activities, etc.), or related to a constant immigration of rodents from nearby unbaited buildings into the baited area.

There are several important advantages in using the block bait formulation in livestock facilities: 1) block baits provide the durability and bait protection characteristics needed for baiting in harsh conditions; 2) blocks have less spillage potential, and 3) blocks provide the needed versatility for bait securement. The latter two are important advantages as it is important to minimize the hazards associated with baiting in livestock environments. On the other hand, the simple, compact design of block baits may be somewhat too convenient, and lead to hazardous situations. For example, livestock personnel untrained in the proper use of rodenticides commonly place or toss block baits directly into burrows, ceilings, beneath equipment, or around various other areas. These practices result in baits being pushed or knocked out into accessible areas by rodents or people. Furthermore, unsecured blocks may be translocated by the rodents (Lund and Lodal 1990) and become available to pigs, companion animals, or other non-target animals. Thus, block baits provide the needed site-specific formulation for livestock facilities, but they must be secured within bait stations to minimize bait exposure hazards.

Site–Specific Bait Stations.

For a bait station to be effective in confined swine facilities, it should meet the following criteria: 1) be highly durable to prevent destruction or access from pigs; 2) protect the bait from environmental contamination; 3) provide excellent bait containment characteristics (reduce bait exposure to swine); 4) be easily serviced, cleaned, and maintained; and, 5) offer an attractive feeding location to rodents.

The two baits stations evaluated in this study proved to be effective for baiting in both high and low swine activity areas. Both the Eatons TP 906 station and the pvc tube station provided excellent protection of the block baits even from direct contact from pigs. In fact, both stations did not show any breakage or signs of pig entry even after being secured directly within grower pens of 113 + kg pigs (although as is discussed below, it is not necessary to bait within the pens).

In the tests comparing the tube baiters for floor baiting with the enclosed TP 906, a mean value of 85.0 % reduction was achieved for the TP 906 enclosed station, while a mean value of only 41.6 % reduction was obtained for the pvc tube baiter (Figure 3). This difference may be partially due to the difference in the design between the two stations. It was noted when checking the baits within the pvc tube baiters, the tube and often the block baits themselves were contaminated with dirt, dust, or moisture, no doubt reducing the attractiveness and palatability of the baits to foraging rodents. Additional protection of the bait can be achieved by placing caps with 3/4 inch holes cut into them over the ends of the stations, but it is probably more cost-efficient to use the enclosed

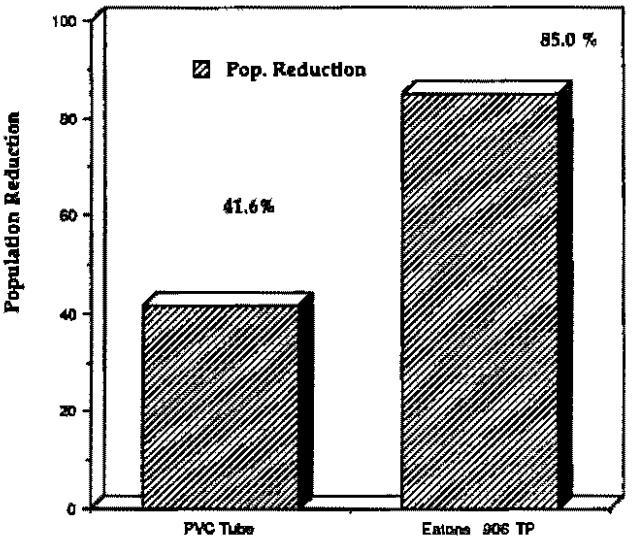

Figure 3. Mean population reduction achieved for two bait stations during floor baiting in high swine activity areas. N = 3

bait stations for floor baiting.

For off-floor baiting, the pvc tube baiters offer good bait protection, economy, and an attractive feeding location to mice. But perhaps most important, they provide the required versatility for baiting on the narrow ledges of pen dividers and perimeter wall ledges which the mice frequently travel to reach the feeders.

Because of the internal baffle system and general design, the TP 906 station is ideal for floor baiting in swine units. Dirt, dust, manure, water, and pig excrement cannot easily contaminate the bait in these stations. However, the design of the TP 906 does not accommodate baiting on the pen dividers or wall ledges.

Baiting Strategies

Conventional floor baiting in low and high swine activity units—Figure 4 illustrates the results of conventional floor baitings between swine units having low, moderate and high swine activity. The highest population reduction among the three types of units was achieved in the farrowing-nursery units and the breeding-gestation units with mean population reduction values of 84.3% and 82.7% respectively. These units typically have the least amount of operational activity (e.g., movement of pigs in aisle ways, feeder carts, floor washing, etc.) relative to rodent control efforts. Pigs are confined to pens, and aisle ways remain clear for prolonged periods allowing for uninterrupted and undisturbed baiting.

Within the grower-finishing units, however, a mean population reduction value of only 65.0% was achieved. As discussed previously, grower-finishing units present a more complex environment relative to the nesting, traveling, and foraging activities of the mice. Mice in grower-finishing units often traveled directly to feeders via the tops of pen dividers or wall ledges, and did not interact with the floor area to any significant degree. Therefore, these data suggest that conventional baiting needs to be supplemented to address all populations of mice.

From a practical aspect, rodent control efforts are often not properly administered in grower-finishing units by producers due to the various inconveniences associated with

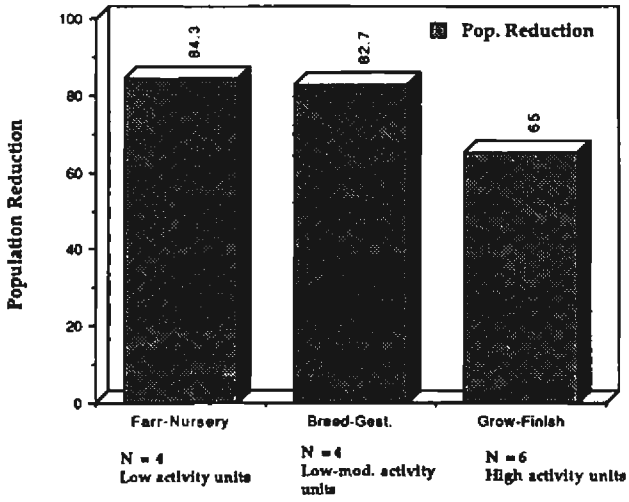

Figure 4. Mean population reduction values for conventional floor baiting using bromadiolone blocks within different swine units relative to the amount of swine activity.

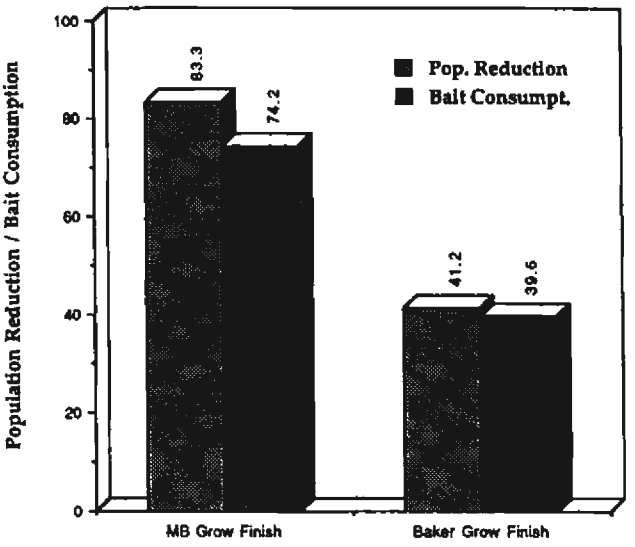

Figure 5. Mean population reduction values and bait consumption for off-floor baiting trials in two different grower-finishing units. The MB facility provided little floor harborage for mice, whereas the Baker facility provided numerous floor harborage sites.

baiting and the daily operational practices within these units.. For example, pigs are constantly being moved within the narrow aisle ways (e.g., 76 cm width) disrupting bait placements, as well as the baiting being interrupted by feed carts, frequent floor cleaning, equipment repairs, etc.

Off floor baiting strategies in growing-finishing units—Among the 11 growing-finishing units evaluated in the off-floor baiting tests, a mean population reduction of 83.3% was achieved for the five MB sites, with only 41.2% attained for the six Baker units (Figure 5). There were operational differences however between these two swine facilities which are important to be noted. The MB facilities were exceptionally well maintained and organized. Thus, there was no floor debris or stored equipment providing floor level harborage to the mice. The evening observations in the MB facility revealed the mice to be nesting in the ceiling, within the walls, and within some nursery equipment several feet off the floor. These mice traveled along the tops of pen dividers to reach the pen feeders; their interactions with floor areas was unnecessary, and thus limited. This is partially reflected in the relatively high level of bait consumption (74.2%) within the MB facility.

In the Baker facility, the mouse populations had available to them several different areas in which to nest. These included walls and ceilings as well as various items at floor level. For example, the voids beneath the weighing scales within the aisle way provided constant harborage for the mice. Empty grower pens in this facility were used to store old equipment, and various assorted debris, and the mice utilized these areas for harborage. These "floor level mice" would travel along floor paths to the pen feeders and thus only occasionally intercept the off-floor bait stations. This is also reflected in the low bait consumption of 39.6%.

SUMMARY AND RECOMMENDATIONS

In conventional baiting recommendations for mouse control in structures, rodenticide labels suggest baits be placed at 3-4 m spacing in areas where mice are active. However for rodent control programs for livestock facilities, this project emphasizes the importance of baiting programs being site-specific, and responsive to possible structural and environmental factors affecting the activities of the rodents. Considerations for site-specific strategies include bait formulations, bait stations, and the location, and spacing of the baits. This is especially important for high livestock activity areas such as the growing-finishing units. In these units, some mice may utilize an area only as defined by the dimensions of the tops of pen dividers, e.g., a 2.5cm path measuring 2x4 m.

Therefore, the following are conclusions and recommendations for rodenticide applications in confined swine facilities:

1. Because there is an abundance of food available to the mice in swine facilities, a primary objective must be to attempt to maximize the chances of poisoning rodents as quickly as possible should they encounter a bait within their environment. Thus, the low-dosage/single feed action of the second generation rodenticides are recommended.

2. The block bait formulation is efficacious, provides resistance to the harsh environment of the swine facility and provides the important versatility for securing baits to minimize hazards to livestock.

3. The population reduction values obtained in this study reflect only three weeks of continuous baiting. Significantly greater control levels could be expected if baiting was conducted for extended periods assuming the correct placements of baits as described in this report.

4. Certain areas with a swine facility will be high activity areas of the mice and should be identified via evening inspections. For example, wall and ceiling areas, and weighing scales were high activity areas in the sites studied in this project. Whenever possible, baits should be located so as to intercept rodents traveling between these high activity areas and their food source (e.g., pig feeders).

5. In the grower-finishing units and other swine high activity areas, both floor and off-floor baiting programs are recommended. In facilities with good sanitation, offering rodents little floor harborage, sufficient control may be achieved

via off-floor baiting programs alone. This would facilitate less labor, and maintenance of the rodent control program by swine producers.

6. Baiting programs should encompass the entire facility, and attempt to reach all rodent populations. This is important as swine producers tend to apply baits to only those areas where rodents are commonly observed, and not to the entire facility. This results in immigrating rodents replacing those eliminated by the baiting programs.

7. The Eaton's TP 906 tamper-resistant mouse stations provides excellent protection of rodenticide bait blocks for floor baiting programs. These stations protect the baits from animal excrement, moisture, dirt, and dust, as well as the occasional contact from pigs. It also minimizes baiting hazards by providing good bait containment characteristics. Other commercial stations of similar quality would likewise be expected to be suitable for baiting in swine facilities.

8. The homemade pvc tube station also provides excellent bait containment capabilities, and the required versatility for off-floor baiting. Its spherical shape is particularly well suited for ledges, pen dividers and similar types of structural elements which are used by rodents. And as rodents tend to respond positively to tunnel-shaped objects, they readily enter the tube stations. However, as used in this study, the pvc tube stations are not well suited for floor baiting programs due to potential for bait contamination from water, excrement, dirt, or dust. Caps can be placed over the ends of the pvc pipes to provide additional bait protection as well as serve to secure the baits within the station, thereby eliminating the need to secure the bait with wire or a nail.

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