

11. Urban Rodent Control Programs for the 21st Century

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Abstract

Urban rodent control in the 21st century must focus on a program approach that is both strategic and comprehensive (i.e. proactive rather than reactive). This includes an integrated pest management approach that incorporates long-term planning, scheduling, data management and mapping capabilities. It also must include greater partnership among municipal agencies, private pest control companies and community groups. Central to program success will be coordination, communication and accountability among all program participants. Cost-effectiveness will be achievable but predicated on effective administrative management, training, and understanding of the ecological and political complexities of urban environments. Greater focus on sanitation enforcement, infrastructure maintenance and construction will be essential for long-term removal of causal factors.

Keywords

Urban, integrated pest management (IPM), rodent control, commensal rodent, sanitation, infrastructure

INTRODUCTION

THE PRINCIPLES of urban rodent control have been well researched and described in this century.

However, substantial problems continue to persist and grow in many metropolitan areas, as well as in small municipalities. Although the science and technology have been established (Jackson 1982; Frantz and Davis 1991), the failure appears most evident at the point of implementation. Success is not predicated on a control tool, but rather on coordinated efforts supported by technical leadership at the local level.

Telle (1969) in Germany and Myllymäki (1969) in Finland described the principle of establishing a 'rat-free town'. The goal was to have less than 1% of the premises showing signs of active rats. Drummond (1970) in England stressed the idea and importance of a program approach for managing urban rat populations (Drummond et al. 1972, 1977; Drummond 1985). Examples of successful and coordinated programs are few, but include Budapest, Hungary (Gacs et al. 1977; Bajomi and Sasvari 1986), Kuwait (Al Sanei et al. 1986), and Denmark (P. Weile 1998, pers. comm.). All of these have included an emphasis on sanitation and environmental management.

The primary difference between urban and agricultural rodent control is that the urban environment is relatively diverse and stable, requiring consistent application of control measures, since food and structural resources are consistently available. On the other hand, in open agricultural settings, the environment is relatively homogeneous and subject to disruptions, and resources used by

rodents and control efforts tend to be seasonally timed. Habitat manipulation is readily feasible in urban areas for limiting growth of rodent populations and to prevent over-dependency on rodenticide. In contrast, with agricultural situations there may be limited opportunity for habitat manipulation and thus greater emphasis frequently is given to trapping and rodenticide use. The basic ecological and organisational principles of rodent control programs, however, are transferable between urban and agricultural environments.

Urban rodent control in the United States (US) typically is implemented in a limited or disjointed fashion, rather than being comprehensive or coordinated. Programs commonly are reactive rather than proactive. Reasons for this include limited funding, training, political and technical support, and organisation (Howard 1984). The political and scientific interest in urban rodent control in the US currently is low, although the need appears to be great.

Commensal rodents are those described literally as 'feeding at our table'. They include species such as Norway rat (*Rattus norvegicus*), roof rat (*Rattus rattus*), and house mouse (*Mus musculus*). In Asia, they also can include species such as the lesser bandicoot rat (*Bandicota bengalensis*) and Polynesian rat (*Rattus exulans*). Commensal rodents have been associated with a variety of diseases, contamination and destruction of stored foods, structural damage, and other aspects of environmental deterioration (Gratz 1994; Lund 1994). They frequently display remarkable adaptive behaviour in urban environments.

Urban infrastructure is ageing, congestion is increasing, and urban habitat is expanding worldwide. These factors accentuate the growing need for effective rodent control programs, for public health, economic and aesthetic reasons. Additionally, expectations of urban residents and businesses for quality-of-life improvements and effective public health management will continue to grow. The result will be more sanitation problems to be managed in more densely populated urban centres, and these urban environments will increasingly require re-design and construction to support human population levels and business economies.

The purpose of this chapter is to describe strategies and issues for implementing urban rodent control programs, while considering both ecological and administrative components. This includes a historic US perspective with transition to future opportunities worldwide.

HISTORICAL BACKGROUND

The 'modern rodent control era' began with the advent of World War II, as urban destruction and concern for food supplies (both quality and quantity) forced attention to rodent control. This included the need for more effective rodenticides and better understanding of rodent biology. (The term 'ecology' had not yet been applied to this issue.) Federal funds in the US supported related research and development projects.

Initial efforts focused at the School of Hygiene and Public Health of the Johns Hopkins University in Baltimore, Maryland. The rodenticide ANTU was brought forth there, and Compound 1080 resulted from a massive synthesis and evaluation program

by the federal government. These rodenticide baits were far more effective than the arsenic and phosphorus baits in use at that time. (It was not until the next decade that warfarin would leap into the marketplace as a 'miracle' rodenticide, following the 'miracle' insecticide, DDT.)

The 1940s and early 1950s at Johns Hopkins University were times of active research on basic elements of rat behaviour, later serving as the foundation of control approaches and future urban programs worldwide. Calhoun (1948, 1963) performed detailed studies of the sociology of the Norway rat, providing new research approaches for studying the social behavior of semi-confined rodent populations. Basic studies of Norway rats in the residential blocks of Baltimore followed by Davis and others (Davis et al. 1948; Emlen et al. 1948, 1949; Davis and Fales 1949, 1950; Davis 1953). Those studies documented for the first time the reproduction, movement, and many other life history components (now referenced as 'ecology') of urban rat populations. Parallel studies on aspects of commensal rodent biology also occurred in the United Kingdom during the same time era (Chitty and Southern 1954).

From the fundamental studies at Johns Hopkins University came the notion of relating a logistical growth curve (sigmoid curve) to changes in rodent populations (Figure 1). Such a mathematical expression could then be used to predict population growth and as a tool for understanding how to strategically manage rodent populations. By lowering the carrying capacity of the environment, the rate of population increase could be dampened and population declines achieved (Davis and Jackson 1981).

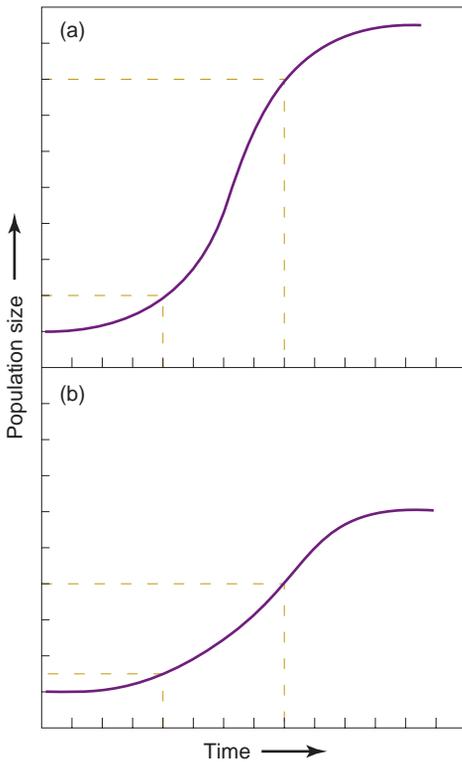


Figure 1. Sigmoid curves depicting the rate of change and growth of rodent populations over time, (a) without environmental (sanitation) management and (b) with environmental management to reduce carrying capacity. The two dashed lines on each graph show the passing of the same amount of time on the horizontal axis, while on the vertical axis there is a dramatic increase in the population size during the second time period. The most economic and effective strategy is to manage populations at the low end of the sigmoid curve under reduced carrying capacity.

Populations then could be more effectively 'managed' at the low end of the population growth curve. Baltimore officials cooperated and set up a demonstration area in which no rodenticides would be used, but intensive enforcement of environmental

standards would be substituted. Specific regulations were passed and sanitation police were hired. Outdoor toilets, board fences, old cars and other rubbish were removed. Proper storage and handling of refuse was enforced. With this regimen, the outside rat population was virtually eliminated from this residential area. However, the program was not maintained because of the need for intensive (i.e. expensive) site management and the lack of political and personal will to maintain environmental standards. Yet, the logistical model as a management tool had been demonstrated successfully and, to one degree or another, became the basis of future management efforts in the US and elsewhere (Figure 2).

During World War II, the US Public Health Service set up programs in the Communicable Disease Center (CDC) in Atlanta, Georgia, for training personnel in the control of various disease vectors met in military activities. In post-war years, such training programs expanded to include state and municipal personnel. Equipment was provided for state agencies as well. Handbooks covering a wide variety of vector and sanitation topics were developed, and many remain as the prime resource documents available today (Pratt and Johnson 1975; Pratt and Brown 1976; Pratt et al. 1976; Scott and Borom 1976; Davis et al. 1977). However, the involvement of CDC in technical support for urban rodent control programs faded by the early 1980s and personnel once active have retired.

Universities were slow to pick up the challenge of urban rodent ecology and control. The Johns Hopkins program faded when the core staff left by the late 1950s.

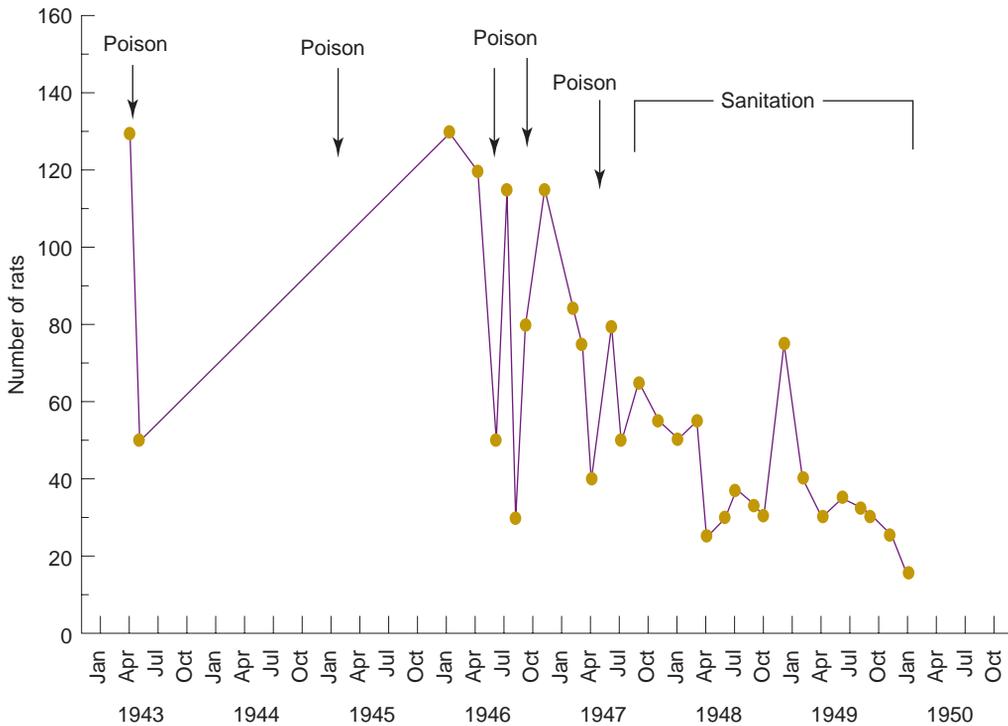


Figure 2. Changes in Norway rat abundance in Baltimore following poisoning and sanitation improvements (Jackson 1998). The population increase during late 1948 was attributable to a strike by garbage collectors that temporarily increased food resources (carrying capacity) for rats.

Most mammalian researchers considered urban pest rodents not 'worthy' of basic research and the urban environment a distasteful setting for studying mammalian ecology. This left entomologists as the source of much information for pest control curricula, and they commonly did not want to bother with rodents or approached them as 'furry cockroaches'.

Two universities, Bowling Green State University in Ohio and the University of California at Davis, developed effective vertebrate pest curricula in the 1960s and 1970s. This included undergraduate and graduate instruction and research

programs. Designations such as 'economic biology' were typical, and research continued the kinds of efforts first begun at Johns Hopkins University. This included basic behaviour but also, by the 1970s and 1980s, a focus on genetic resistance to anticoagulant rodenticide, secondary poisoning hazards, and development of new rodenticides, traps and bait stations. Many personnel currently providing leadership on vertebrate pest management in the US came from these two university programs. However, by the late 1980s these programs also began to fade and ended as faculty retired.

The Federal government, through the US Public Health Service, supported research on genetic resistance to warfarin (first-generation anticoagulant rodenticide) during the 1970s (Jackson et al. 1988). During that same era and into the early 1980s, \$12.8 to \$15.0 million dollars annually were provided for state and local efforts specifically for implementing urban rodent control programs. These programs involved a standardised approach of environmental management, including target areas, systematic surveys, education, sanitation improvements and baiting. The goal was to progressively shift blocks of premises to a maintenance condition with subsequent monitoring for re-infestation. This federal program assisted more than 100 communities (Jackson 1984, 1998). However, in the early 1980s, specific designation of federal funding for urban rodent control ended, and subsequently many local programs were greatly reduced and eventually became less structured.

The US Fish and Wildlife Service, through regional and state programs in the 1960s–1980s, stimulated and supported efforts at universities as related to vertebrate pests. This included some technical support on urban rodents, although most of their effort was directed at predators, birds and field rodents. In the mid 1980s, these programs were transferred by the US Congress to the US Department of Agriculture (USDA). With that change, control of urban rodents was specifically excluded from the USDA scope of services, although rodent infestation of stored grain and croplands remain within their area of concern.

Today in the US, technical support for urban rodent control is very limited. Active research programs do not exist on the federal, state or university level. Most States and municipalities have limited knowledge and skill in urban rodent control, resulting in limited effectiveness when programs are implemented. Urban (and suburban) rodent control could be described as a composite of work by householders, licensed pest control operators and municipal agencies (Kaukeinen 1994), but without defined coordination. Most efforts by local health departments are reactive, in response to citizen complaints about infestations or rat bites. Their efforts typically involve use of anticoagulant baits within a limited area (e.g. at the site of complaint or perhaps a few city blocks).

THE BOSTON MODEL

The basic research of the 1940s–1950s, the program approaches described in the 1960s–1970s, and the technical advances of the 1970s–1980s were combined in 1990 in Boston, Massachusetts. The unique opportunity to establish a truly comprehensive and properly designed rodent control program had arisen from the start of an 11-billion-dollar highway construction project funded by the Federal Highway Administration (Colvin et al. 1990). This involved reconstruction of the urban infrastructure along a seven-mile route, including utility systems and an 8–10 lane highway to be built underground.

Key to the program design was a centralised approach with well-defined responsibilities and firm accountability. The primary management function was performed by personnel (biologists) skilled

in technical aspects of rodent control, yet also with contract management, public relations, engineering, scheduling, and computer-based mapping and data management skills. The second component of the program was the municipal functions, performed by the Inspectional Services Department, the code enforcement police, the Water and Sewer Commission, and the Public Works Department. The third component involved pest control contractors who performed poison baiting, trapping and monitoring. The fourth component was public participation, championed by community leaders and organisations. These various components were integrated to maximise the skills and participation of each group within the total program.

Work tasks assigned to each municipal agency were based on their existing scope of services. For example, the Inspectional Services Department was assigned standardised surveys of premises, enforcement of State Sanitary Code and public education. The code enforcement police dealt with violations of City sanitation ordinances. The Water and Sewer Commission assisted by cleaning catch basins and providing access to sewer manholes. The Public Works Department helped by making infrastructure repairs and maintaining trash receptacles in public areas. Most of these municipal tasks focused on environmental change to reduce rodent habitat.

The program was an integrated pest management (IPM) approach covering about a seven-square-mile area. It was tailored to the need of each neighborhood based on surveys of sanitary conditions and rodent activity at surface and subsurface

levels. Where problems were chronic, IPM methods and monitoring were applied more intensely. The program included an extensive public outreach and education campaign involving community meetings, diverse literature, videos, door-to-door contact and school presentations. The education campaign recognised cultural differences among neighbourhoods, and literature was prepared in multiple languages.

Sanitation was given heightened attention on more than 10,000 premises in the project area. The code enforcement police performed ticketing daily, and the Inspectional Services Department cited property owners to hearings and court for chronic sanitary code violations. In locations highly susceptible to infestation, residents and businesses were given refuse containers after signing a contract to maintain and use them. Property owners and businesses were held responsible for maintaining their property in an acceptable condition, including hiring their own pest control contractor if needed. City personnel conducted baseline and periodic surveys on private properties, and these surveys helped ensure maintenance of environmental improvements. The objectives were to reduce the environmental carrying capacity for rodents and also to prevent their dispersal.

Trapping and poisoning were performed on both surface and subsurface levels in all public areas, and as a supportive measure on some private properties. Engineering drawings and information were used to 'three-dimensionally' dissect the infrastructure. About 1,500 sewer and other types of utility manholes were baited using

pulsed-baiting methods on a seasonal basis (Colvin et al. 1998). Census and monitoring tools were used extensively to detect and closely monitor for low levels of activity (non-toxic census baits, tracking tiles, night-time visual surveys and tracking with snow cover). Night-time observations were essential for targeting control resources and identifying sanitary problems that only appeared after dark (e.g. plastic rubbish bags left out on sidewalks).

Administrative elements were emphasised as part of the IPM program. Contract specifications for both pest control contractors and municipal agencies were developed (Colvin et al. 1992). This provided a basis for accountability and performance. Program elements were centrally scheduled, to maximise timing and geographical distribution of resources. Data management and mapping using a geographic information system was important for efficiency of operations (Von Wahlde and Colvin 1994); this included tracking of events over the entire project area, historic patterns of problems and poison placements in utility systems. Standardised data sheets were used to collect information for program planning and analysis. Data sheets also helped ensure that personnel were performing their assigned tasks. Cost containment was predicated on maintaining a proactive rather than haphazard or reactive approach.

An important administrative element that characterised the dynamics of the program was a referral system. All members of the program team were cross-trained to identify program issues, even though the particular issue might involve a task assigned to another team member (agency or

contractor). If a pest control contractor observed a sanitary problem on private property, the contractor could refer that observation through the centralised program office to the city agency responsible for enforcement. Similarly, observations by a city agency of a rat infestation needing treatment could be referred to a pest control contractor assigned to the particular geographic region. All referrals were tracked on a database to ensure they were followed through.

The program also entailed habitat modification beyond basic rodent-proofing of structures (i.e. sealing of holes and entry points). Landscaping within the project area was evaluated and factors conducive to rodent activity were identified (Colvin et al. 1996). Rodent-proofing principles were then incorporated into design specifications for final surface restoration and landscaping. For example, rat abundance in landscaped areas was associated with the amount of coverage by shrubbery. Plots with massed needed evergreens were most susceptible to infestation, in contrast to plots with broad-leaved evergreens and deciduous shrubs. Numerous property owners and businesses re-designed their existing landscaping, reducing densely planted needed-evergreens and giving greater emphasis to stone mulch, shrubbery spacing, refuse containers, maintenance, and trees and shrubs that did not produce excessive fruit. Varieties that grow in vase-like, rather than mounded, shapes provided more openness within landscaped areas.

Results of the control program can be characterised in several ways. Brick sewers with pipe diameter <61 cm in residential areas had the highest subsurface rat activity;

up to 38% of those manholes were active at the program start (baseline). Bait consumption and the number of active sewer holes were 96% and 87% below baseline, respectively, when seasonal baiting was last initiated in 1997. The code enforcement police in 1996 were issuing 67% fewer tickets for sanitation violations than in 1991, even with intensified efforts. About 375 properties were identified with rat activity during baseline surveys; by 1997, control efforts were needed on about ten of those properties (<4% of those originally identified). Another 25–30 properties required close monitoring to detect potential re-infestation. Referrals by the program's pest control contractors to the City for resolution of sanitary problems and rat activity on private property declined from a high of 153 in 1993 to 13 in 1995 and 20 in 1996 (87% reduction). Visual night-time surveys for rat activity declined from a localised average event of 104 sightings per hour (range 19–500) to incidental observations within the project area (>99% reduction). These 'real world' statistics collectively demonstrated that the program approach was effective.

Throughout the program, phone calls from the public concerning complaints about rodents and sanitation remained relatively constant, independent of the obviously positive environmental changes that were occurring. However, the magnitude of problems identified by the public grew less as the program continued. The relatively constant input from the public was a positive event, since it demonstrated sustained participation by the communities. This was achieved through the consistent presence of program staff in the

neighbourhoods, timely and effective response to public concerns, involvement of community leaders, and repetitive positive feedback to political entities by program managers and the public. Neighbourhood 'cleanup days' evolved with the participation of residents and businesses, and awards and recognition were given. The pattern of success, involvement, and commitment broke the public scepticism that commonly degrades the opportunity to sustain an urban rodent control program.

The Boston model had several elements that proved crucial for success. Foremost was a true partnership among City agencies, community groups, and contracted management and pest control firms. The model demonstrated that a blend of municipal and privatised functions worked well and could succeed, but only with technical leadership, open sharing of information, consistent communication among team members, and trust. It had to be one team focused on an IPM strategy, with excellent diversity of skills and accountability on the part of each team member. Weekly meetings within various program groups and quarterly team meetings enhanced training and communication.

FUTURE OPPORTUNITIES

The future of urban rodent control is not limited by science and technology; it is limited by politics and bureaucracies. Personnel management, budgets, contracts, news media, legal proceedings and political agendas were not factored together when Davis and others performed the original ecological research in Baltimore, but they

must be today for the science of rodent control to be implemented. When Davis (1972) summarised rodent control in context of future strategies, he expressed frustration with the political impedance of urban rat control and use of short-term solutions. He reaffirmed the need to focus on basic biological principles (i.e. reducing carrying capacity) and the need for competent administrators.

Urban programs need to be consistently and strategically managed rather than politically cyclic in their implementation and focus. Lethal measures need to be intensive rather than simply cropping populations and spurring higher reproductive rates that occur with lower competition. In other words, many urban programs function today on the steep slope of the sigmoid growth curve (Figure 1). A temporary lowering of the number of animals is achieved by a punctuated control effort, but subsequently a sudden population rebound occurs. This sudden perturbation of rodents often is misinterpreted as a 'new' population of colonists. Whereas in reality, the population may never have been effectively controlled to start with and has simply responded reproductively as the sigmoid curve predicts.

There must be a commitment to long-term management of the urban environment and an organisational structure to achieve closure of issues day-by-day. This type of preventative approach is actually a more cost-effective (economical) approach long-term than chronically reacting to crises and public complaints. Of course, any program also must have the capability to respond quickly to sudden problems and

emergencies (e.g. disease, rat bites or localised outbreaks).

Rats need to be viewed as an 'indicator species' of environmental quality (or degradation), and programs need to focus on causal factors for species success rather than simply being reactive and poison dependent. The goal must be to manage populations at the low end of the sigmoid growth curve by reducing carrying capacity and giving greater emphasis to surveillance monitoring and sanitation controls. A behavioural shift from rat hunting to environmental management and monitoring is needed. This represents an ecologically-based strategy.

The kind of organisational management and IPM methods demonstrated in the 1990s in Boston should become the foundation of program implementation in the 21st century. An effective program will include centralised leadership, partnerships among participants, sound definition of work scope, assigned responsibilities, mapping and data management capabilities, and education of policy makers. A program approach should be comprehensive in scope and structure, and inclusive in terms of participants (Figure 3).

An emphasis on the engineering and structural maintenance of urban environments, to reduce pest habitat and permanently lower carrying capacity, is critically needed as part of public health management. Rodent control should be incorporated into both urban planning (design) and urban maintenance if a truly proactive program is desired. Municipalities also should require rodent control for major construction projects, since by their nature they create rodent habitat during the

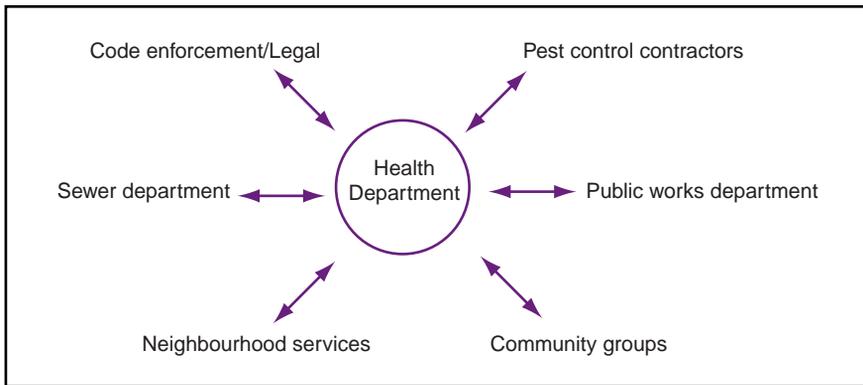


Figure 3.

A flow chart that illustrates a centralised, inclusive and organised approach to managing an urban rodent control program.

construction phase. Biologists need to become more familiar with design engineering and urban infrastructure, and work with engineers and architects.

Basic research and stewardship on the use of refuse containers, recycling programs, and refuse management and containment should be a priority. A shift from focusing primarily on rodenticide and traps (reactive approach) to sanitation management (proactive approach) is needed in urban environments. This includes use of rodent-proof containers (rubbish bins, dumpsters, refuse compactors and grease containers), public education campaigns, reduction of refuse volume, and uniform refuse containers and pickup times. Foremost, there must be effective and enforceable sanitation laws and practices established. For example, keeping lids securely closed on containers, not using plastic bags alone for refuse storage, avoiding placement of refuse outside overnight the day before collection, and timing necessary night-time collections to minimise the number of hours that refuse is exposed.

Inclusion of subsurface environments (sewers), currently ignored by most municipalities, must become a fundamental part of urban rodent control programs (Figure 4). Subsurface populations function as reservoirs that can chronically re-infest surface areas and ‘elevate’ disease organisms. Effective training on subsurface baiting and control is needed worldwide and will have to be incorporated into comprehensive training necessary for the success of any program.

Use of rodenticide in the future will have to be more carefully planned and implemented than typically occurs in most cities today. The spread of genetic resistance, including the recent involvement of second-generation anticoagulant compounds (MacNicoll et al. 1996), presents a significant concern for the future of urban rodent control and public health management. Rodenticide, rather than habitat management, too often is the primary approach used today by municipalities. This provides short-term resolution but may result in long-term problems.

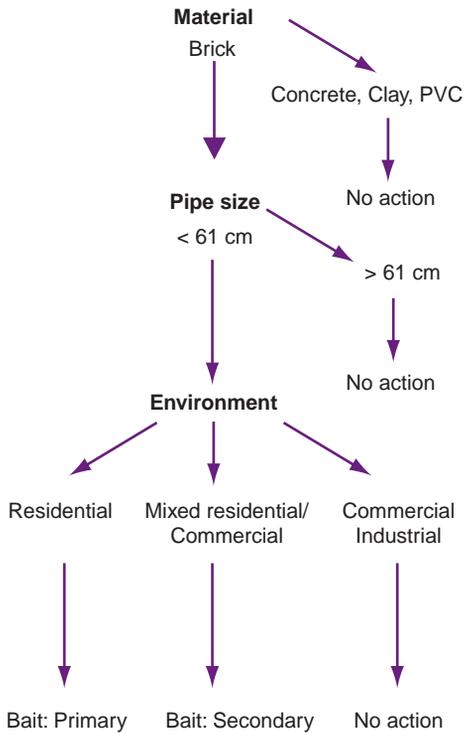


Figure 4.
An example of how to strategically implement and prioritise a sewer baiting campaign (Colvin et al. 1998).

Excessive use of rodenticide, while allowing sanitary problems to remain, presents a condition for rapid reproduction by survivors and the perpetuation of genetic qualities favourable to resistance. The strategy for lowering the potential for resistance must be to focus on environmental management and the wise use of rodenticide.

Diversity of skills should be sought when establishing a rodent control team. For example, a creative approach for public education may require the involvement of public relations and marketing experts. Teachers, lawyers, engineers, contract

administrators, computer scientists, property managers, architects and social workers must be made part of the immediate or extended team to maximise program effectiveness.

A rodent control program should have an 'action plan' that defines program elements and implementation. The action plan should describe: program organisation, staff responsibilities, training, legal requirements and enforcement capabilities, contracted services, schedules, sanitation management, infrastructure design and maintenance, mapping and data management, lethal measures (including subsurface), public education and outreach, community organising, surveys and monitoring, and administrative elements.

Whether in a developed or developing nation, the ecological and organisational principles associated with urban rodent control are largely the same. The difference may be the extent of program resources available; however, it can not be assumed today that a developed nation automatically has an advantage regarding program implementation. Large, developed cities can provide more habitat, have greater bureaucracy, but have no better technical knowledge than found in smaller cities or cities in developing nations. The beginning point for all is the establishment of qualified staffing and training, political and budgetary commitment, enforceable sanitation laws, and defined responsibilities and program goals. Implementation of the IPM plan follows, encompassing surveys, public education, sanitation programs, baiting/trapping, structural improvements, community involvement, scheduling and monitoring.

Technical leadership is a serious constraint for urban rodent control today, and this needs to be overcome through involvement of universities and federal and state agencies. Field personnel on the municipal level need to base their efforts on facts rather than myths. To assist them, they need technical support that is accessible, knowledgeable and practical. In that regard, research biologists must help resolve any technical gaps concerning control methods and local ecological factors. They also must learn to partner directly with municipal personnel and translate the science of rodent control for the 'real world', so programs can be better designed, implemented and sustained.

The history of urban rodent control and the 'lessons learned' in recent years present a 'road map' for future success. However, without political support and effective administration, implementation of urban rodent control programs will continue to be limited and public health and economic impacts will result. The ecological and political arenas of the urban environment are complex and interrelated, and urban rodent control programs can only be implemented effectively when both of those subjects are mastered.

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