

A Profile of the Norway rat, *Rattus norvegicus*, in New York City: Its Impact on City Operations and the Need for Collaborative Interagency Rat Management Programs

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ABSTRACT: New York City, New York is a uniquely ideal urban habitat for the Norway rat. There are several reasons for this, but foremost is New York's being one of America's oldest seaport cities and the most densely populated city in the U.S., with a population of at least 8.2 million residents, all living within only a 321-square-mile area. Thus, food resources are readily abundant and easily accessible to rats. So, too, is an abundance of rat harborage resources, ranging from earthen burrows, to a myriad of subterranean harborages within city infrastructures, to the structural harborages associated with the city's buildings numbering in the millions. Such conditions allow the opportunistic brown rat to proliferate, spread, and repeatedly rebound from extermination campaigns that have been directed at it for over a 200-year period. This paper presents a profile of the brown rat as a major urban pest of New York City and its impact within the context of New York's daily operations. An overview is presented of the City of New York's infrastructure and city management agencies of most relevance in rat management programs, and of the city's collaborative interagency approaches.

KEY WORDS: city parks, food and harborage resources, highways, infrastructure, interagency rodent management, New York City, *Rattus norvegicus*, rodent task force, sanitation, subways, urban IPM, urban rats

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INTRODUCTION

Modern day metropolises are subject to a wide range of issues associated with high human densities. Among them are the occurrence, prevalence, and persistence of urban pests. This paper focuses on the Norway (or brown) rat, *Rattus norvegicus*, an urban rodent pest of global scale that is present in many major cities around the world (Jackson 1982, Brooks and Rowe 1987, Lund 1994). It is the only established urban rat species in New York and the northeastern sector of the United States.

As is widely known among pest specialists and mammalogists the world over, the brown rat is among the most successful of all mammals. Sanderson (1956) in his publication *Living Mammals of the World* states, "There is little doubt that some rat, and probably the brown rat (*Rattus norvegicus*), is actually the finest—in every sense of the word, and especially in efficiency—product that Nature has managed to create on this planet."

After centuries of observing rats in many of our cities and towns, humans need little convincing that the brown rat is an adept opportunistic mammal. Barnett (1967) states there are two general reasons for the brown rat's success in coexisting within human habitats: first, its ability to live higger-mugger in crowded underground colonies; and second, its readiness to eat anything man does. In short, it is the brown rat's lack of specificity that enables it to thrive in urban environments.

In addition to these traits, the rat also succeeds and proliferates because as many of the publications have repeatedly emphasized over the years, the city rat benefits as a result of the scope and complexity of a metropolises' structural environments, infrastructures, and of the behavior of the city's urbanites themselves (e.g., Pratt *et al.* 1977, Brooks and Rowe 1987, Jackson 1998).

Consequently, there is an obvious (but often neglected) need for well-designed, comprehensive city rat management programs. Strict implementation of the principles of integrated pest management (IPM) is critical. But so too are the requisites for structured and highly collaborative programs among the different and most relevant agencies that manage a city and the city's large scale infrastructures (Colvin and Jackson 1999).

The purpose of this paper, therefore, is to present a profile on the relationship between the brown rat as a major urban pest of New York City, especially within New York's infrastructures. It also overviews New York's most relevant city agencies regarding urban rat management and the city's collaborative interagency approaches.

THE CITY OF NEW YORK

The City of New York is one of the world's premier cities. According to the U.S. Census Bureau, 8.2 million people live within an area of 321 square miles (830 km²), making New York the largest and most densely populated city in North America. (Unofficial estimates place the population of NYC upwards of 12 million people, as a result of the high numbers of undocumented immigrants arriving during the past decade.) The city is comprised of five boroughs: Manhattan, The Bronx, Brooklyn, Queens, and Staten Island.

New York's operating municipal budget is the largest in the United States, spending approximately \$50 billion a year and employing 250,000 people. About 50 different city departments, with commissioners and directors appointed by the mayor, manage the city and its infrastructures (City of New York 2006).

Since its settlement in 1625, New York has always

been one of the world's most important cities of trade (a point especially pertinent to the vulnerability of New York to rats). Millions of goods in a myriad of variety and packages move in and out of New York's ports and terminals every day via air, ship, rail, and truck. Thus, even if it were somehow possible to exterminate the entire rat population of New York via some magical extermination program, or should New York's rats succumb to some colossal (albeit unlikely) city-wide epizootic event, a relatively rapid reintroduction of rats is highly probable as a result of new rats arriving from some national or international port or city via any one or several modes of trade.

THE BROWN RAT IN NEW YORK CITY

It is not within the scope of this paper to review the biology and behavior of *R. norvegicus*. Many outstanding references address this as well as the management of the brown rat in different urban environments (e.g., Lantz 1909, 1910, 1917; Brown 1960; Calhoun 1963; Brooks 1974; Howard and Marsh 1976; Davis and Jackson 1981; Jackson 1982; Pratt and Brown 1982; Barnett 1988; Timm and Salmon 1988). Some rodent pest management books and book chapters can also provide a gateway to the literature on *R. norvegicus* and its management (e.g., Meehan 1984, Prakash 1988, Frantz and Davis 1991, Buckle and Smith 1994, Corrigan 2004).

In New York City, the brown rat has been a persistent pest for sometime over two centuries. But an accurate date of the brown rat's arrival into New York and via which route (over land or via ships from other eastern American seaports (e.g., Jamestown VA), is not known. Most publications estimate the brown rat's arrival on the eastern shores of America occurring sometime during either the first half (e.g., Lund 1994) or the second half of the 18th century (Brooks 1973).

Nevertheless, by the first half of the 19th century, the brown rat was well established and reviled in New York—at least in the southern sections of the Manhattan borough (Silver 1927). Burrows and Wallace (1999) report that rats were so prevalent in New York by the mid 1800s that they were collected in large numbers on a daily basis by professional rat catchers and the city's youth. The rats were then sold to the numerous rat-baiting gambling parlors that, similar to London, had become popular at that time. Apparently New Yorkers, like the Londoners, also enjoyed the satisfaction of watching dogs kill as many rats as possible.

Current Distribution

Now in 2007, some 230 (or so) years later, the rat is fairly entrenched in many areas of the city. It exists in all five boroughs and has successfully infiltrated many of the city's infrastructures. Based on city complaint and extermination data, the brown rat is most problematic in the boroughs of Brooklyn, South Bronx, and Manhattan, and less prevalent in Queens and Staten Island (NYC DOHMH 2006).

Like urbanites in other rat-infested cities, New Yorkers and the New York media seem to have a propensity of wanting to know "how many rats per

person" exists in their city (Ballantine 1967, Jackson 1992, Sullivan 2004). But, in an interesting parallel to the number of New Yorkers themselves, an accurate description of the number of New York rats also remains unknown (and for all practical purposes, this statistic is impossible to accurately determine).

Survey estimates of the rat populations of New York City (Davis 1950) and Baltimore (Davis and Fales 1950) were conducted in the late 1940s. Davis employed neighborhood surveys of rat signs (fecal pellet counts and distribution, tracks, dead and live animals, etc.). Based on this work, he estimated the New York City rat population in the late 1940s at "no more than 250,000 animals."

During 1969-1970, block by block surveys of "urban deteriorated neighborhoods" within two dozen different New York State towns and cities were conducted (Brooks 1974). For New York City, only 11.2% of the surveyed blocks showed rat infestations, which ranked NYC 19th out of the 24 other cities or towns. At that time, the official population of New York City was 7.9 million residents.

Of course, urban rat surveys (Davis *et al.* 1977) and indices can be developed for rat activity and/or infestation severity against which estimates can measure whether or not a population is increasing or decreasing (Brown *et al.* 1955, Davis and Jackson 1981). In fact, relative indices of infestation severity for specific areas and local neighborhoods and boroughs of New York have been recently designed and are currently being piloted in the Bronx and Brooklyn boroughs (Corrigan 2005).

Presently, the NYC Department of Health and Mental Hygiene (DOHMH), the primary rat mitigation agency, employs various complaint and operational statistics to characterize, on a general level, neighborhood rat infestation severity. Rat sighting complaints are received and tracked via a city complaint call-in (311) phone line. The number of annual exterminations* and property inspections performed by the health department's sanitarians and pest control staff are also employed for rat population borough profiles. These operations and data are used to assist in providing general trends and insight to the rat's severity and possible locations on an intra-borough status and possible inter-borough infestation foci. Childs *et al.* (1998) explored the possibility of employing New York's rodent bite data as predictors for neighborhood rat infestations. Ordog *et al.* (1985) discusses rat bite profiles in metropolises in general and their impact on urbanites and attitudes.

Public Perceptions

Regardless of the number of rats or their specific distribution, the citizens of New York City, similar to most other urbanites (Jackson 1980, Childs *et al.* 1991,

* Within the NYC Department of Health, Pest Control Services Division, the pest management professionals are referred to by the civil service job title "exterminators." Within their data base, each site visit involving a corrective action on a rodent infestation using rodenticide baits or traps still employs the antiquated terminology of an "extermination." As the city program progresses, the more contemporary terminology is expected.

Hodgson 1997), strongly dislike the rat and are of the opinion that it is now too common and well-established in their city. In addition, the local media is highly aware of these attitudes and perceptions. New York's newspapers, magazines, and local TV channels regularly report on rat sightings and community outbursts associated with rat infestations. Some of the New York media still employ outrageous headlines by using words to describe the everyday rat as "monster-size", "demon", and "super", while the words "hoards", "invasions", "near-attacks", and similar exaggerations are used to describe sightings of several rats seen at the same time (e.g., Frankel 1994, Jacobs 1996, Alpert 2000, Joseph 2000, McCool 2001, Burke 2004, Epstein 2004). Perhaps these stories are intended to "media-shock" the readers, because of the pervasive human revulsion to rats.

The less melodramatic and better-researched articles (e.g. Chan 2006) are usually published to remind city officials of the importance and complexity of the issue, and consequently the need for sufficient resources to achieve cost-effective management of this industrious kleptoparasite of New Yorkers. In his book *Rats*, Sullivan (2004) describes the relationship between rats and specifically New York City. He also presents some behavioral observations of rats from a lay perspective, based largely upon his nightly vigils of rats in Manhattan alleys and parks.

The Rat Resources of New York

As with most other major cities of high human density in which the brown rat is established, the rat benefits as an opportunist upon a city's complex infrastructure in accessing the essential resources of food, water, and harborage (Glass *et al.*, Farhang-Azad and Southwick 1979). In New York, some infrastructures may provide the rat with only one resource, while others can provide all three— and in abundance.

Relative to the persistence of New York rat's, a few points regarding the rats' utilization of food and harborage within New York's specific environment and infrastructures are worth discussing— at least on a cursory level.

Food Resources

Food opportunities for a foraging New York rat are usually not difficult to find and occur across an incredibly wide range of situations. Berdoy and MacDonald (1991) discuss the significance of foods and foraging in wild rats and their impact on management programs. In New York, common examples of the brown rat's specific foraging areas in the New York City environs include: 1) in the gutter zone of the street/ sidewalk area where the food discard litter from the daily pedestrians occurs, 2) around and in any of the street/city park garbage baskets prior to pickup, 3) within each street's storm water catch basins, 4) among the plastic bags of putrescible trash placed out each evening directly onto the sidewalk by the thousands of food serving establishments, 5) in and around commercial refuse dumpsters, 6) at the residential exterior alleys or indoor basement refuse compactor or storage rooms of both small and large multi-family housing complexes, 7) on subway and other rail racks

from discarded food litter (similar to street gutters), 8) in and around parks upon those foods as a result of pigeon feeding, and upon uncollected fresh dog manure, and 9) along the highway medians and embankments from vehicle-discarded food litter.

Nevertheless, human food litter discards and putrescible refuse are the primary food resource for the rats. In this regard, and specific to item 4 above, New York City is unique. Many cities, by practice or by city ordinances, restrict all putrescible refuse to containers. But due in part to New York's human density (i.e., parking, sidewalks needed for pedestrian flow, etc.), the commercial food establishments of New York place their food waste trash directly out on the sidewalk in plastic bags each evening after closing. This trash must be collected the same evening (usually at night, but actual collection may be several hours after its placement onto the street). Of course, plastic bags containing enticing food smells placed in the proximity of the brown rat is all but too obvious an issue for the principles involved in effective rodent management. Moreover, leaking plastic bags or breaking bags during collection are not the responsibility of the collector. Many food fragments and film residues remain behind.

Additional food resource areas for the city's rats include the expected foods as found in sewers (Bentley 1960, Colvin *et al.* 1998) and the natural foods within the environment such as city birds (pigeons, doves, and sparrows), mice, American and Oriental cockroaches, fish and other aquatic animals, and edible flotsam found along the shore areas that are extensive around each of New York City's boroughs.

Harborage Resources: The Role of Infrastructures and Buildings

Equally important as food to the brown rat's proliferation in New York is a similar situation of an abundance of diversified harborages. Harborage, of course, provides rodents with refuge for nesting and rearing of young, protection from predators, and protection from the elements. In New York, the city's infrastructures are an essential component of the rat's harborages. These include the sewers, parks, subways, roadways, shorelines shipping port zones, and the millions of miles of subterranean tubes and tunnels that house electrical, steam, gas, and the linear telecommunication systems and lines.

In addition to the basic protection from the elements and the rats' city predators (e.g., cats, dogs, hawks, humans) that harborage provides, certain infrastructures and situations also provide the resources of food and warmth (i.e., so critical to small mammals during the temperate zone winters). They may also serve as protective travel conduits to facilitate dispersal and colonization, and thus the rat's regional spread.

The subterranean infrastructures of sewers and subways, for example, provide food and protective harborage from the rats' human and animal predators, as well as protection from the extremes of the seasons. Such areas are cooler during summer extremes and warmer during bitter cold Northeastern winters, especially during the time the street surfaces may contain less access to food

scraps due to extended snow. Although research is lacking on the rats' utilization of these areas relative to a seasonal effect, these infrastructure harborages may provide significant advantages for New York rat populations relative to survivability, reproduction, and dispersal (Davis 1953).

A good number of New York's infrastructures are now more than 300 years old. And thus, some systems are in significant states of disrepair. Certainly, city-wide repairs occur on a daily basis to maintain viability to needed systems. For those systems too cost-prohibitive to repair or remove, however, their use has been discontinued (at least by humans) and abandoned. For example, there are 9 abandoned subway stations in New York. Additionally, there exist untold miles of antiquated but unremoved subterranean tubes, sewer lines, utility conduit pipes, and the like below the streets, sidewalks, and train tunnels of New York. How the opportunistic rat takes advantage of "old" New York, in regards to these areas for travel lanes and nest harborages, can only be imagined but will likely never be measured.

Harborage opportunities also exist on the interior and exterior zones of the city's commercial and residential buildings (Bajomi and Sasvári 1986). Around building exteriors, the brown rat establishes harborages within discarded junk that accumulates daily in most large cities, such as discarded furniture, large appliances, equipment, and illegally abandoned vehicles left in alleys, lots, and yards.

An interesting harborage resource that is used by the brown rat in New York (but often unnoticed by the public and even by some pest professionals) is the area within the hollow building facades that flank the doors and provide exterior dressings over old brick exterior walls. Similar voids are created within the signage above the doors. These vertical and horizontal voids exist among thousands of New York City stores and restaurants. Often, rats access these spaces via holes or gaps at ground level. The rats either then nest near the ground behind the facade, or they also commonly climb up and nest above the doors in the sign voids. In this regard, the brown rat behaves much like the roof rat, *Rattus rattus*, in the cityscape—that is, nesting aerially and climbing down (within the protection of the facade void) at night to forage.

Interior building harborages for brown rats include the structural voids of walls, ceilings, cabinets, and floors. Plumbing, heating, and cable chases run vertically from roof to basement within many large apartment houses and commercial buildings of New York. Many of the older buildings have undergone major structural renovations multiple times. Thus, double and triple structural voids exist in many of New York's renovated old structures. In buildings containing concrete hollow block, and/or triple brick foundation walls, these walls typically allow rats protected access to suspended ceilings. The rats travel vertically from ceiling harborages to basement compactor trash rooms and alley trash locations, via the chases and presumably continuous vertical wall voids.

Finally, in addition to the structural elements discussed above, rats that have infiltrated the interiors of apartments will establish harborages within the base voids

of the refrigerators, stoves, and dishwashers, as well as within couches, chairs, and old storage boxes in closets.

The Interconnectedness of Harborages

In New York City, many structural buildings although separated by human property lines, are relative to city rodents and rodent populations, actually interconnected (although this is not readily apparent to the human occupants of these buildings). For example, common basements, attic spaces, and walls may connect several independently owned buildings on the same block.

At the neighborhood level, interconnectedness also exists with different city infrastructures and utility systems via 1) the highly linear aspect of sewers, subway rails, telecommunication tunnels, steam tunnels, vertical elevator shafts, plumbing pipe chases, overhead electrical and computer conduit lines, and street curbs, to list just a few, and 2) proximity that reflects the typical home ranges or dispersal distances (Recht 1988) of the brown rat. The rat is a highly thigmophilic rodent (Barnett 1988, Timm and Salmon 1988). And thus, the various infrastructure lines and linear arrangement of the systems facilitate efficient daily foraging patterns for the rat, or dispersal events.

Proximity examples are common: rats may nest in one property or infrastructure and forage within their normal range (e.g., 75 ft [25m]) (Davis *et al.* 1948) but interact with a different infrastructure or property, and thus affect different property owners or agencies. Consider a restaurant with unkempt commercial trash dumpsters in close proximity to a school, a city park above a major subway line, or major highway embankments bordering residential streets, and so forth.

It is because of the interconnectedness of urban buildings and city systems that possible "sources" of neighborhood rat infestations, especially chronic infestations, are often difficult and even impossible to identify. Repeated rat sightings in a particular street or neighborhood, over the course of months and even years, may easily be interconnected among several different city environments, buildings and/or different infrastructures (Figure 1).

Obviously, then, city rat populations exist as intra- and inter-structural pests, and similarly of course for the infrastructures. And thus, attempts at effective, long-term management of New York's and many other urban rat populations must involve highly coordinated and collaborative programs among all relevant agencies (as well community boards, private pest management companies, citizens, etc.). In other words, rats are interagency pests.

This is nothing new—at least to the rodent control specialists the world over. The need for comprehensive and highly inclusive city rat management programs because of the interconnectedness of city buildings, utility systems and infrastructures has been emphasized and/or discussed by some of the earliest publications, pamphlets, and books addressing urban rat control (e.g., Matthews 1898, Lantz 1910, Nelson 1918, Hartnack 1943, Sherrard 1943), as well as the more recent publications (e.g., Drummond 1970, 1985; Davis and Jackson 1981; Jackson 1984; Kaukeinen 1994; Colvin and Jackson 1999; Lambropoulos *et al.* 1999; Corrigan 2001).

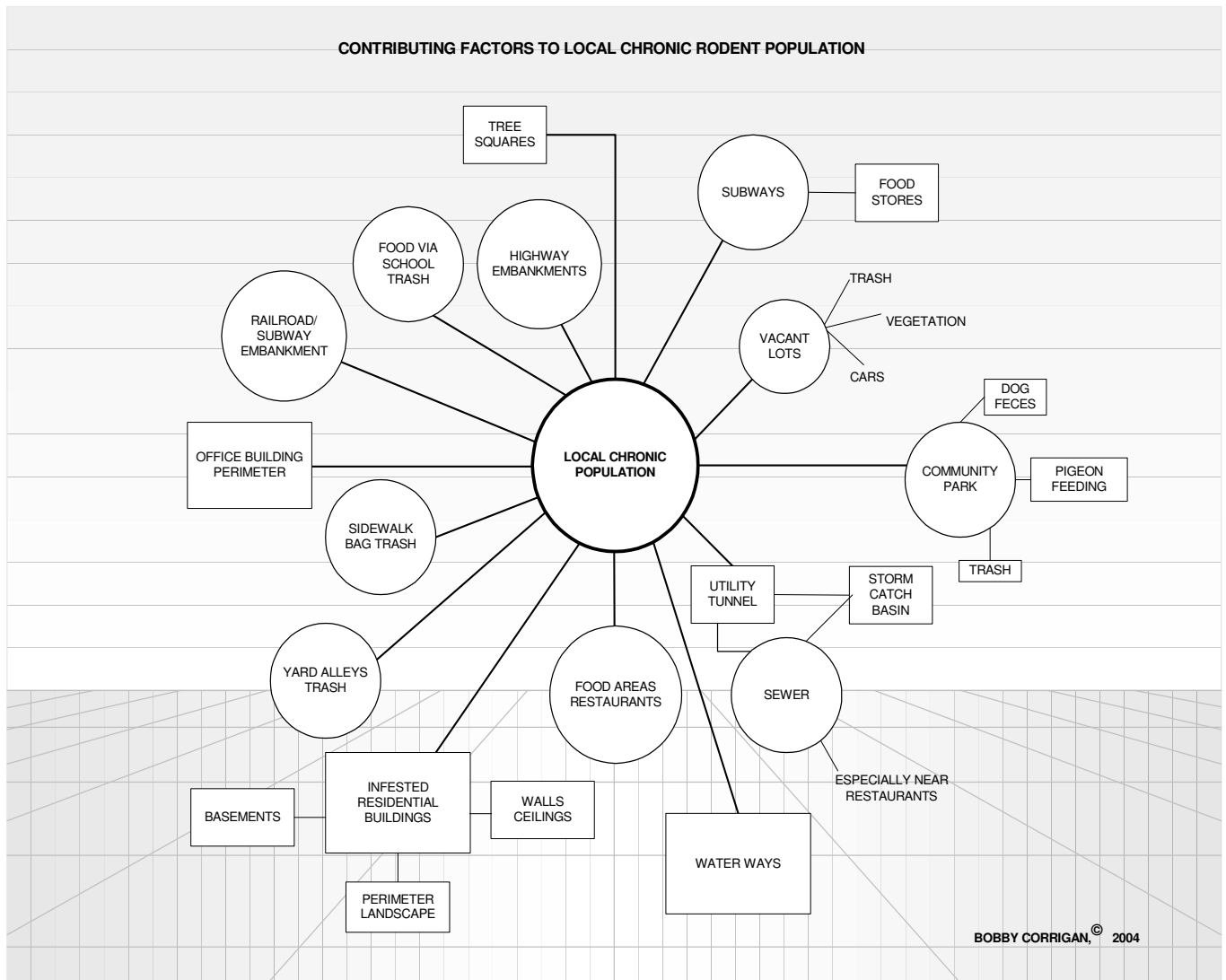


Figure 1. The possible factors contributing to local chronic rodent infestations in a New York City neighborhood. Relative to the foraging and dispersal behavior of the brown rat, many buildings, areas and infrastructures are interconnected via utility or structural systems, or by proximity.

INTERAGENCY RAT MANAGEMENT PROGRAMS

Although city infrastructures are obviously similar in purpose, a fair amount of dissimilarity exists among the world's metropolises in infrastructure dynamics, city management, city boundaries, geographic elements, and human population demographics (e.g., Margulis 1977). Any or all of these factors can affect a specific city's approach to city-wide rodent pest management programs. Just the two obvious variables of human population density levels and a city's age can dramatically impact everyday infrastructure challenges as they relate to rodent control. Consider the impacts of refuse management, sewer system maintenance, and stressed city budgets due to high resident density to effective sanitation programs along highways, streets, subways, parks, and other infrastructures and operations.

Relevant Agencies and Associated Infrastructures

In addition to some of New York's infrastructures

being interconnected, the sewers, power, telecommunications, water, steam, road, surface rail, sub rail, and marine are to a significant degree also piled atop one another in what may be the densest agglomeration of infrastructure anywhere on earth (Ascher 2005). So, the brown rat's ability to fit hugger mugger in secretive tight spaces and harborage, as earlier described by Barnett (1967), is at particular advantage in New York City.

Consequently, a significant portion of New York's infrastructure-related agencies are involved in integrated rodent management efforts. Randy Dupree, a long-time director of New York's rat control program, succinctly summarized during the 2001 NYC Summit on Rat Control that "In New York especially, rat control takes everyone". As discussed below, just the removal of trash that can be used by rats in New York usually involves multiple city agencies (e.g., Department of Sanitation, Department of Transportation, Department of Environmental Protection), all of which are supplemented by an army of private collectors serving the city.

Specific to New York City, about 14 city agencies have direct or indirect responsibilities to address, support, or participate in rat mitigation programs. Certain agencies are primarily responsible for mitigation efforts (e.g., Dept. of Health and Mental Hygiene, Pest Control Services), while others are indirectly involved in prevention as a by-product of their agency responsibilities (e.g., Department of Building Design and Construction).

An overview for these agencies is provided below to illustrate each agency's responsibility to the affected New York infrastructures, and to also show how the brown rat actually impacts these infrastructures and ultimately, the City of New York.

Following the Office of Operations and the lead agency on rodent mitigation and prevention programs (DOHMH), the agencies are simply listed in alphabetical order. Obviously, the magnitude of the impact of a particular agency on rodent pest management may be greater in one agency than another (e.g., street sanitation vs. homeless outreach programs). Nevertheless, for all the reasons discussed throughout this paper, each of the agency's individual efforts is considered *essential* in New York's war on rats. The agency descriptions and statistics discussed here are compiled from Ascher (2005), from New York City's website (www.nyc.gov), and/or from a specific agency's website.

1. Office of Operations

The Office of Operations oversees the daily operations of all of New York's agencies, and provides technical assistance and general guidance. This city department strongly encourages and facilitates inter-agency collaboration on New York's war on the rat.

2. Department of Health and Mental Hygiene (DOHMH)

The Pest Control Services (PCS) Division of DOHMH is the primary lead agency in addressing rat complaints and infestation mitigation efforts at a municipal level. On a broad scale, PCS currently addresses an average of about 26,000 rodent complaints with an annual operating budget that has grown in 40 years from \$1.5 million to \$8 million currently.

PCS performs both property inspections and property rodent exterminations. The inspections address any environmental causes associated with attracting or harboring rats, and fines may be levied against properties creating conducive conditions. The exterminations, where possible, are attempts at eliminating local infestations that affect properties. The DOHMH pest control staff has performed an average of about 8,500 annual rodent exterminations for the past several years.

3. Department of City Administrative Services (DCAS)

The DCAS is responsible for ensuring that New York's agencies have the critical resources and support needed to provide service to the public. The DCAS supports the workforce needs of each agency, and the overall facilities management, for 54 public buildings including maintenance (i.e., pest control) and construction services. Relative to city rat management efforts, DCAS

is responsible for structuring and monitoring all the bid specs for the hiring of private sector pest management companies. Over 500 pest control companies are listed as approved companies to perform work on NYC buildings and grounds.

4. Department of Design and Construction (DDC)

The DDC currently manages a design and construction portfolio of over \$4.6 billion of New York's capital construction projects. Projects range from streets, highways, sewers and water mains to public safety and health and human service facilities, as well as cultural institutions and libraries. Of course, pest exclusion designs on the front end of building construction is paramount in integrated rodent management efforts.

5. Department of Environmental Protection (DEP)

New York's water supply provides over 1 billion gallons of drinking water daily, and nearly 1 million sewer accounts are managed. This operation is managed by the DEP. New York's sewer system is comprised of 6,000 miles of sewer pipes. But contrary to the popular urban myth of "cities of rats living in the sewers", the entire system is not vulnerable to rat infestations. Bentley (1960), Kaukeinen (1992), and Colvin *et al.* (1998) provide discussion regarding the characteristics of rat-vulnerable sewer systems and the management of sewer rats. One factor is that the older systems, comprised of brick linings, are more vulnerable to rats. In New York, some of the neighborhoods with high numbers of complaints also contain some of the oldest sewer systems, dating back to 1821. However, a formal study of New York City sewer rat populations has not been conducted.

Relative to the city's rat population, perhaps more important than the sewers themselves is the formidable 145,000 street storm water catch basins. As they are designed to do, the catch basins channel water off of the street and also filter (i.e., "catch") a wide variety of the larger street litter items and packaging materials to prevent them from entering, and possibly clogging, sewer pipes and laterals.

A fair amount of the materials that ends up in these catch basins are food fragments (e.g., fried chicken discards, partially-eaten sandwiches, partial packages of food, etc.). These food items may be wind-blown, carried by rain runoff, or tossed by pedestrians into the basin instead of into a trash can. Periodically, restaurant workers also illegally pour grease into these basins late at night— a highly attractive and nutritious food for rats. Food resources may remain in the catch basins for days, weeks, and even months (with fresh new foods usually arriving daily) before the basins are cleaned out. When members of the lay public notice rats coming or going from the street catch basins, their interpretation is that rats are associated with the sewers below (which in some cases could also be true).

6. Department of Education (DOE)

The DOE provides primary and secondary education to over 1 million students in over 1,400 schools. Because of the food waste generated among this many dispersed buildings, rats are occasional pests in and around school

buildings and grounds. The house mouse (*Mus musculus*), however, is the primary rodent pest for most NYC schools. To address the constant rodent pressure on schools, the DOE maintains dedicated staff for school pest management operations.

7. Office of Emergency Management (OEM)

The OEM coordinates and supports multi-agency responses to, and regularly monitors, emergency conditions and other potential incidents that affect public health and safety in the City, including natural hazards and disasters, power outages, transportation incidents, labor disruptions, aviation disasters, and acts of terrorism. OEM educates residents and businesses on the need for preparedness and supports the efforts of City and other government agencies and private and non-profit entities in emergency planning, interagency training, and collaboration on critical issues (e.g., rat management programs).

8. Department of Homeless Services (DHS)

The DHS provides temporary emergency shelter for eligible homeless people. DHS manages 15 city-run and 206 privately-run shelter facilities consisting of 51 adult facilities and 170 family facilities. DHS also provides outreach services available 24 hours a day, 7 days a week, as well as homeless prevention services through community-based programs.

It is not uncommon for rats to become established in or around any of the street encampments of homeless persons or groups. Some of these encampments may remain undiscovered and last for years. And, of course, encampments often occur in the out-of-sight areas around the city's subways, alleyway nooks and crannies, bridge underpasses, beneath dense shrubbery in low-frequented park areas and so forth— all of which are also attractive harborage sites for rats. Thus, with humans “moving into” these areas, food and food discards will also arrive, promoting the occurrence of rat infestations in these areas.

9. New York City Housing Authority (NYCHA)

The Housing Authority provides affordable housing to nearly 420,000 low- and moderate-income city residents in 345 housing developments, containing an overall 180,000 apartments in the five boroughs. In addition, the Authority provides social services for its residents through 112 community centers and 42 senior centers.

Obviously, rodents (rats and mice) are major vertebrate pests of the NYCHA. Inside most apartment complexes, the house mouse is the primary rodent pest, especially within the apartments themselves. But the rat is the most common pest in basements, crawl spaces of apartment complexes, and landscaped portions of the yards of some complexes. Rats present an ongoing challenge among the NYCHA pest management staff. In fact, NYCHA employs more exterminators for their agency than does the DOHMH Pest Control Division.

10. Department of Housing Preservation and Development (HPD)

The HPD is the nation's largest municipal housing

agency, and it works to strengthen neighborhoods and enable more New Yorkers to become homeowners or to rent well-maintained, affordable housing. As properties and their associated yards and lots are being maintained or prepared for occupants, rats must be monitored on a constant basis.

11. Metro-Transit Authority (MTA)

Technically, the New York City Transit Authority, which runs the city's subways, commuter railroads, buses, and some ferries, is not a city agency, but rather a separate public corporation. Nevertheless, it is discussed here for continuity.

New York's subway is one of the largest subway systems in the world. It employs 47,000 people, involving 25 unions, and it transports 4.5 million passengers every day— a staggering 1.4 billion passengers every year (Ascher 2005). The subway system is comprised of 25 lines, which are all interconnected among 468 subway stations. More than half of the stations are underground. Nine of the stations are no longer in use and have been abandoned.

The entire system runs along 842 miles of track (which is enough to connect New York to Chicago). Of relevance to rats, 435 miles of this system is underground. This equates to 2.3 million liner feet of darkened tunnels or shadowy rail zones.

Regardless of the urban myths associated with rats and the subway's (and sewers), “dark, mysterious” tunnels, the population dynamics of New York's subway system rats thus far are not well understood. But, as with street-level rats, any particular station or tunnel area providing enough food and harborage is likely to be a potential local source of a chronic rat infestation. In some stations, rats are rarely seen. Foods for foraging rats in the subway tunnels and or the stations occur in two formats: 1) food scraps discarded onto the rails from the waiting passengers on the station platforms, and 2) from within any of the refuse holding/transfer rooms of each station (although these rooms are currently all being rat-proofed).

Harborages for the rats in subway systems are likely to be among any of the hundreds of structural nooks and crannies associated with the elevated platform voids, or in areas of deteriorating tunnel walls, floors, and ceilings. Inspection programs are currently scheduled for 2007 for various subway stations and tunnels for 2007 to better profile subway rat activity.

12. Department of Parks and Recreation (DPR)

New York's DPR maintains a municipal park system that includes more than 28,800 acres, comprised of nearly 1,700 parks, about 2,100 Greenstreet sites, 990 playgrounds, 800 athletic fields, 15 nature centers, and 4 zoos. The DPR is also responsible for more than 500,000 street trees and 2 million park trees.

Despite diligent rodent control efforts, parks are especially prone to brown rat infestations because parks offer rats their natural earthen harborage sites (i.e., soil burrow systems) and dependable sources of food (from park visitors and from nearby street gutters). Thus, if not monitored on an on-going basis, rat infestations can

become severe in a city park. And thus, some of these rats can affect neighborhoods in the proximity of the park (which is also true of highways and city-owned properties). Due to the scope of New York's park area and the rat-vulnerability of parks, the DPR employs their own pest control staff.

In some neighborhoods, residents landscape and garden with ground ivy and flowers around their street trees (utilizing the tree's soil space, usually measuring about 12 to 16 ft²). In neighborhoods under high rat pressure, it is not uncommon for rats to establish burrows below these street trees. With such cover, pliable soil, and the tidbits of gutter food discards or dog fecal waste, rats invade these green spaces and burrow down among the tree roots to establish their nests (Pisano and Storer 1948).

13. Department of Sanitation (DSNY)

Approximately 25,000 tons of trash are produced every day in New York. About half of this is from household and institutional waste. The Department of Sanitation attempts to remove the trash as frequently as possible, operating out of 59 district garages and employing a fleet of about 2,000 collection trucks. The department also clears the food discard litter and all other curb litter from approximately 6,000 city street miles by mobilizing 450 "street sweeper" vehicles. Additionally, sanitation teams are designated to remove debris from vacant lots as well collect abandoned vehicles. The DSNY also employs area-specific sanitation "police" (with badges) who patrol their neighborhoods (similar to a beat cop). The sanitation police identify issues requiring immediate action and possess the authority to issue and levy fines for egregious sanitation violations.

According to educational websites that address the behavior of human littering, 25% of urbanites litter repeatedly during any given day (Washington State Dept. of Ecology 2006). Considering a New York population that may extend up to 4 million people beyond official census counts, the daily food discards and the accumulating potential rat harborage (junk piles, abandoned vehicles, etc.), must be kept to a minimum to impact rat populations— to whatever level that may be.

Thus, because sanitation is in fact rodent control, New York's sanitation department, like in any metropolis, is one of the most essential agencies relative to helping suppress urban rat populations to acceptable aesthetic injury levels (Pratt and Johnson 1975). Although, for cities as complex as New York, the impact would be difficult to measure.

14. Department of Transportation (DOT)

The DOT is responsible for approximately 20,000 miles of streets and highways, of which 11,000 miles comprises the local streets. Highways comprise about 2,000 miles, and the remaining 7,000 miles are made up by the primary and secondary roads. New York also contains 790 bridge structures and 6 tunnels that, along with highways, connect the five boroughs.

Relative to the presence and management of New York's rats, these staggering DOT statistics provide an interesting profile. First, the streets provide the covering

and/or a foundation for a world of other infrastructures and utilities such as steam, water, sewage, telecommunications, and other utility systems, positioned in horizontal and vertical lines and layers below the streets. Second, the street structure itself, particularly where the street interfaces with the elevated sidewalks (i.e., elevated soil resource), and the corner storm water catch basins are often exploited by rats for burrow locations. And third, (and in some ways most important), the streets and highways are a major source of food for the New York rat (and also for pigeons and house sparrows). Along the 11,000 miles of local streets, rats often have little trouble locating highly diversified (i.e., nutritionally balanced) food fragments discarded both from vehicles and more so by the pedestrians on the street (see related DSNY discussion below). Moreover, along residential streets, cars are often parked for entire blocks bumper to bumper. Below the cars, rats can forage on food scraps in a predator-free environment along an entire block. Further, the warm engines of some of the cars also provide an additional beneficial resource for foraging street rats on cold nights and mornings.

On the highways, hundreds of thousands of food fragments are discarded from vehicles every day and dispersed along the length of a highway. And because many of New York's highways contain miles and miles of earthen embankments and medians, rats often infiltrate those portions of the highways where food discards are constant and where sufficient cover or protection of their earthen burrows exist (nearby overpasses and, bridge foundations, and particularly nearby and among established trees, shrubs, and or among highway beautification projects suitable protective landscaping).

Because this describes thousands of locales among New York's roads and highways, connecting the five boroughs, it accentuates a significant understanding of the rat's dispersal throughout the five boroughs over the several decades.

Collaborative Interagency Rat Management Programs: The Mayor's Rodent Task Force

As discussed earlier, the primary agency responsible for the city's rat management efforts is the Department of Health and Mental Hygiene (DOHMH), Pest Control Services (PCS). However, each agency is responsible for controlling pests under their assigned purview. For example, a rat in the park is addressed by parks; in subways, by MTA; rats emerging from a storm basin, by the DEP; and so forth. As is obvious to any vertebrate pest specialist, virtually every city agency can be considered to be important under the obvious goal of controlling rats on broad scale and across all the agency boundaries (Figure 1). So along with the interconnectedness of buildings, infrastructures and utility systems discussed above, each of The City of New York's agencies, relative to the ubiquitous, opportunistic, and wily rat, are also interconnected.

Part of the City of New York's effort to address the importance of interagency corroboration and collaboration is the establishment in 2001 of a Rodent Task Force (RTF) by the Office of the Mayor. One of the primary goals of the RTF is to facilitate all city agencies that may

have any role—minor or major—in helping to manage, directly or indirectly, an area, neighborhood, or building’s rat infestation. Specific rat infestations and their association with environmental deficiencies (e.g., an empty lot being used for dumping) are constantly recorded and acted upon by not only the pertinent city health and sanitation agencies, but usually other city agencies as well, acting within the Mayor’s Task Force on Rodent Control, under a directive from the Office of the Mayor.

A rat complaint in a small NYC park near a highway or a shoreline, and with a subway station beneath or nearby, can require the concurrent attention of different agencies to ensure long-term management and possible elimination of the rat infestation. For example, this seemingly simple situation may involve 5 different agencies: DOP, DOT, MTA, DSNY, and the DOHMH.

The rodent task force currently meets on a weekly basis to analyze these types of situations and to mobilize as many of the pertinent agencies as necessary to address a city rat infestation.

SUMMARY

Because of New York City’s age, human population density, infrastructure agglomerations, interconnectedness of buildings and associated systems, its seaport trading center, and other characteristics, it has a long history of providing the brown rat with a unique and highly suitable urban habitat in which it has proliferated and spread. Of course, it is relatively simple to kill individual rats or eliminate infestation pockets in small areas via municipality program complaint baiting. But as stressed throughout this paper, to significantly suppress neighborhood-level rat populations, comprehensive interagency programs are necessary. City administrators must acknowledge such programs are sophisticated undertakings requiring not only well-coordinated efforts, but also sufficient budgets. For without appropriate financial resources to support the necessary staff, city-level rat control campaigns are vulnerable to degrading to “rat farming” (Davis and Jackson 1981, Jackson 1984). That is, hundreds of rats may be “harvested” via the quick and “inexpensive” local poisoning programs, but hundreds “grow back” over time after the local complaints have subsided, following the harvesting of the rats most easily accessed in the more superficial portions of a neighborhood.

And, of course, this premise applies to the City of New York as well as to many of America’s cities containing rat populations. When collaborative interagency efforts and proper rodent population monitoring have been implemented, significant infestations have been eliminated in neighborhoods throughout New York. When these areas are diligently monitored via inspections, neighborhood rat population indexing (Corrigan 2005), and continuing emphasis on community IPM programs, rat populations can remain significantly suppressed for extended periods, lasting years. Conversely, of course, if mere spot and area baiting efforts are the primary thrust to resolve neighborhood rat complaints, then surviving rats, or those rats that existed in the regions peripheral to the baiting programs (and thus less visible,

and less subject to call in complaints) (e.g., within sewer systems, along waterfront rip-rap, overgrown highway vegetation, etc.), will re-infiltrate and repopulate the area (Davis 1953), resulting in highly inefficient and costly programs.

Within local New York City neighborhoods and/or areas (e.g., an area encompassing several streets, a local park, a subway station), rats can be managed to levels that do not exceed aesthetic injury levels (AILs) (after Sawyer and Casagrande 1983, and other urban ecologists). In urban pest management, and particularly relative to rats, AILs vary significantly depending on specific individuals, their spatial separation from the rat or rats, neighborhoods, infrastructures, and obviously specific buildings or areas (e.g., a schoolyard vs. a shipyard, alleys, a subway passenger platform vs. a sewer lateral, an old warehouse vs. a popular restaurant).

Like urbanites in perhaps all global metropolises, New Yorkers undoubtedly would prefer to not share any part of their daily lives with any wild rats. But considering the rat has been a part of New York’s complex and massive urban environment now for over two centuries, most New Yorkers aren’t shocked upon seeing a rat. Most of the city’s residents probably understand that zero rats in modern-day metropolises the likes and pace of New York City is not possible, and they seem inclined to accept realistic (albeit, vaguely defined) “Big Apple” aesthetic injury levels. Most accept an occasional sighting of a rat in a street, or trash alley, or someplace off in the distance—as long as the rat or rats are not on their street, or the trash alley behind their favorite neighborhood restaurant, or on their child’s school playground.

All in all, after more than 200 years of New York’s war on the brown rat, the current status is still perhaps best reflected by McLoughlin’s (1978) writings of the rat in his urban inquilines book, *The Animals Among Us*. He states that “...all the ingenious traps, all the virulent poisons, all the cunning predators domesticated by offended humanity have served to cause only momentary fluctuations in localized populations of rats. The world rat population rises in direct proportion to the world’s human population, and neither species shows any sign of faltering in its struggle toward whatever biological limit will slap it back to a healthy level.”

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