



**Texas Rodent Academy**  
**Resource Manual**  
**December 1 & 2, 2020**

EXTENDING KNOWLEDGE  
*Providing Solutions*

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# **SECTION 1: HEALTH & ECONOMIC SIGNIFICANCE OF RODENTS**



# Roof Rats: Pathogens and Parasites

*For Pest Management Professionals and Environmental Health Professionals*

*Dawn H. Gouge, Paula Rivadeneira and Shujuan (Lucy) Li*

## Introduction

The roof rat (Figures 1 & 4 *Rattus rattus*), also known as the black rat, ship rat, or house rat, is an Old World rodent species originating in southeast Asia. Although it is not native to North America, roof rats are established in most coastal and southern states in the continental United States (U.S.), Hawaii, and small populations exist in Alaska. Information covering the identification, ecology, and signs of roof rats are covered in a separate publication by the same authors (<https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1775-2018.pdf>).

Roof rats pose a significant health and safety hazard as they are implicated in the transmission of a number of diseases to humans and domesticated animals. These diseases include leptospirosis, salmonellosis (food contamination), rat-bite fever, murine typhus, plague, toxoplasmosis, and trichinosis.

Roof rats in Arizona may carry ectoparasites that pose a threat to human health via bites from the ectoparasites; such ectoparasites include the Oriental rat flea (*Xenopsylla cheopis*), the tropical rat mite (*Ornithonyssus bacoti*), spiny rat mite (*Echinolaelaps echidninus*), the spiny rat louse (*Polyplax spinulosa*), and tropical rat louse (*Hoplopleura pacifica*) (Table 1). In most instances, people report skin irritation and itching because of ectoparasite bites, but some of the ectoparasites can have more serious effects, including vectoring disease-causing pathogens to people. Ectoparasites may also be transferred from roof rats to domestic pets, and in the case of the Oriental rat flea, they may be transferred from roof rats onto pet rodents and rabbits.

While the Oriental rat flea is the natural ectoparasitic flea of roof rats, many other species are found. This includes the northern rat flea (*Nosopsyllus fasciatus*), especially where roof rats and Norway rats (*Rattus norvegicus*) occur in the same environment. Additionally, dog fleas (*Ctenocephalides canis*), cat fleas (*Ctenocephalides felis*), and sticktight fleas (Figure 2 *Echidnophaga gallinacea*) are all found on roof rats, sometimes



Figure 1. *Rattus rattus* by Alex O'Neal (CC BY-SA 2.0)



Figure 2. Sticktight flea (*Echidnophaga gallinacea*) on a Norway rat by James Campbell, California State Polytechnic University, Pomona

in larger numbers than Oriental rat fleas. Similarly, a variety of mites may utilize rats as hosts.

**Both the ectoparasites and pathogens carried by a specific roof rat population are influenced by their immediate environment. Very little is known about roof rat populations in Arizona or the health risks they pose.**

## Leptospirosis

*Leptospira* bacteria are one of the most common causes of disease transmitted to people from wild and domestic animals, including cattle, pigs, horses, and dogs. They cause a wide range of symptoms, though some animals and some people may not develop symptoms at all.

Illnesses caused by *Leptospira* are known by many names, including: Weil's syndrome, canicola fever, canefield fever, nanukayami fever, 7-day fever, Rat Catcher's Yellows, Fort Bragg fever, black jaundice, and Pretibial fever. Symptoms in humans may include high fever, severe headache, chills, muscle aches, vomiting, jaundice, red eyes, abdominal pain, diarrhea, and/or a rash. In the absence of treatment, kidney damage, meningitis (inflammation of the membrane around the brain and spinal cord), liver failure, and respiratory distress can be severe, and in rare cases the infection may be fatal.

**Humans most commonly contract an infection through contact with urine or other bodily fluids (except saliva) from infected animals, or contact with water, soil, or food contaminated with the urine of infected animals.** *Leptospira* bacteria in water or soil can survive for weeks to months. The bacteria can enter the body through mucous membranes (eyes, nose, or mouth), and broken skin. Drinking contaminated water can also cause infection. Person-to-person transmission is rare.

## Salmonellosis (food contamination)

Microbial pathogens of the genus *Salmonella* are among the leading causes of foodborne illness in the world. **Consuming food or water that is contaminated by infected rat feces can lead to disease.**

Commensal rodents are reservoirs for human salmonellosis, and *Salmonella enterica* has been isolated from both roof rats and Norway rats. In the 1990s, *Salmonella enterica* Serovar Typhimurium, definitive phage type 104 (DT104) emerged as a significant problem in Europe and the U.S. because the strain has multidrug resistance. DT104 strains are found internationally in many animal reservoirs.

*Salmonella enterica* Serovar Typhimurium is rarely fatal. Symptoms include diarrhea, abdominal cramps, vomiting, and nausea that last for about a week. However, the elderly, very young people, or people with depressed immune systems may develop life-threatening infections if they are not treated with effective antibiotics.

## Rat-bite fever

Rat-bite fever is a systemic bacterial illness caused by *Streptobacillus moniliformis* in the U.S., and other bacteria in other parts of the world. The bacteria are **transferred to a human through the bite or scratch of an infected rodent, or through the ingestion of food or water contaminated with infected rat feces.** When the latter occurs, the disease is often known as Haverhill fever. If not treated, rat-bite fever can become serious and sometimes fatal.

Streptobacillary rat-bite fever symptoms include fever, vomiting, headache, muscle and joint pain, and a rash. Symptoms usually occur 3-10 days after exposure to an infected rodent, but the onset of illness can be delayed as long as 3 weeks, making the link between rodent exposure and illness less obvious since bite or scratch wounds have often healed by then.

Within 2-4 days after fever onset, a rash may appear on the hands and feet. This rash appears as flat, reddened areas with small bumps. Joints may also become swollen, red, and painful.

## Murine typhus

*Rickettsia typhi* are gram negative, intracellular bacteria and the etiologic agent of murine (also called endemic) typhus. The rickettsial pathogen is transmitted primarily by the Oriental rat flea, although ectoparasitic lice and some mites are also vectors. Commensal rodents, including roof rats and Norway rats, are the main pathogen reservoirs, but other vertebrate hosts serve in the same capacity including house mice, shrews, opossums, skunks, and feral and domestic cats.

Symptoms of murine typhus begin within 2 weeks after contact with infected fleas. Signs and symptoms may include fever and chills, body aches and muscle pain, loss of appetite, nausea, vomiting, stomach pain, cough, and rash. Most people will recover without treatment, but some cases may become severe, potentially causing serious organ damage. Rats do not suffer symptoms from *R. typhi* infection, so rat fleas remain infected and are able to vector the pathogen. **Humans are infected through the bite of a rat ectoparasite,** and although humans contracting murine typhus often report contact with a vertebrate host, few recall seeing fleas or other ectoparasites biting them.

## Plague

Plague primarily affects rodents, but can affect other mammals as well, including humans. Plague is caused by *Yersinia pestis*, a non-motile, rod-shaped coccobacillus. It is a facultative anaerobic bacterium. There are around 2,000 human cases of plague globally each year. It is considered a re-emerging disease and remains a serious problem for global public health.

Plague risks increase significantly when people live in close contact with infected rodents that carry high flea numbers. In the U.S., the Centers for Disease Control report that modern day outbreaks of plague usually occur in the southwestern states, including Arizona, California, Colorado, and New Mexico (<https://www.cdc.gov/plague/maps/index.html>).

**Humans most often contract plague through the bite of a rodent flea that is carrying the plague bacterium. But the bacterial pathogen can also be contracted through direct contact with an infected animal or person, e.g., through the consumption of insufficiently cooked meat, or inhalation of aerosolized droplets coughed or sneezed from an infected animal or person with the pneumonic form of the infection.**

Plague symptoms depend on how the patient was exposed to the bacteria. Plague can take different clinical forms, but the most common are bubonic, pneumonic, and septicemic.

**Bubonic plague usually results from the bite of an infected flea.** Patients develop sudden fever, headache, chills, weakness, and swollen, painful lymph nodes called buboes. If the patient is not treated with antibiotics, the bacteria can spread to other parts of the body.

**Septicemic plague can result from bites of infected fleas or from handling an infected animal. It can occur as the first indication of plague, or it may develop from untreated bubonic plague.** Patients develop fever, chills, weakness, abdominal pain, shock, and sometimes bleeding into the skin and other organs. Skin and other tissues may turn black, indicating necrosis.

**Pneumonic plague may develop after inhalation of aerosolized respiratory excreta (droplets coughed or sneezed) of animals or people with the pneumonic form of the infection. It may also develop from untreated bubonic or septicemic plague after the bacteria spread to the lungs.** Patients develop fever, headache, weakness, and pneumonia with chest pain, cough, and sometimes bloody or watery mucous. Respiratory failure and shock may occur. Pneumonic plague can spread from person to person.

**Plague is a serious illness. If the disease is suspected, seek immediate medical attention. Prompt treatment with antibiotics effective against *Yersinia pestis* can prevent complications or death.**

### **Cuterebra spp. - rodent and lagomorph (rabbits and hares) bot flies**

Dime and nickel sized warbles (Figure 3) and scars are sometimes found on rodents, made by large bot fly maggots below the skin. The female bot fly lays her eggs in different

locations depending on the species. A typical female will lay one to several thousand eggs, in groups of around 5-15 per site. Some species lay eggs on grass stems, wood chips, and bark along trails and rodent runs near burrows. Eggs hatch in response to increases in temperature when hosts are present. Larvae stick to the host fur and typically enter the host through natural body opening (e.g., mouth, nose, eyes, or anus). First instar maggots migrate through the body and eventually to the subcutaneous positions where the larvae molt to second instar and continue to develop within the developing warble. Third instar larvae back out of the warble and pupate in the soil. Bot flies will lay eggs in pet bedding resulting in infections of dogs and cats, secondary infections commonly follow. The larval stages *Cuterebra* spp. are commonly found in furuncular lesions (small, raised, red, boil-like) in the skin of the rodent host. In cats, the furuncular lesions more commonly show on the cheeks, neck, top of the head, or chest. Larvae have also been reported in the nasal pharynx, pharyngeal area, eye orbits and anterior chamber of the eyes. Intracranial myiasis due to *Cuterebra* has been reported in cats on several occasions, and cats in which larvae migrate through the brain develop neurologic disease. *Cuterebra* spp. have been recovered from humans. Most human cases have occurred in the northeastern U.S. Most larvae are recovered from the head, neck, shoulders and chest. There have been rare cases of bot fly larvae in ocular and upper respiratory areas, but no central nervous system disease has been documented in humans.

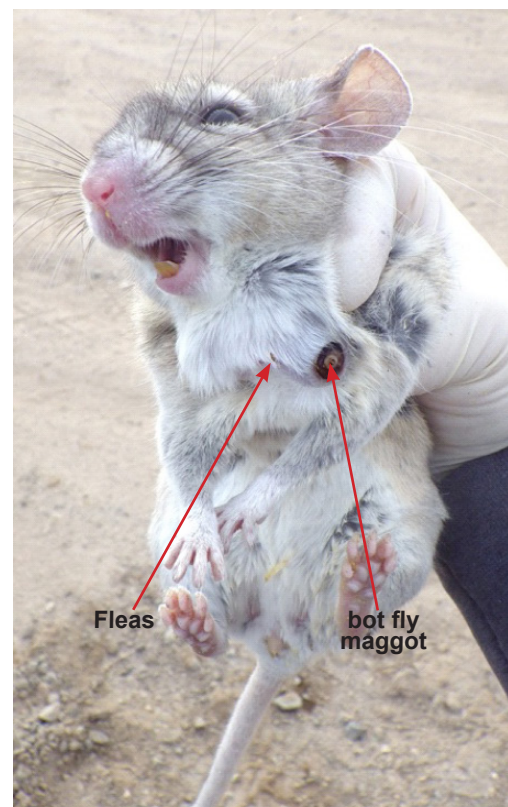


Figure 3. Fleas on and bot fly maggot in a wood rat

## Toxoplasmosis

*Toxoplasma gondii* is an obligate intracellular parasite of warm-blooded animals. Infections usually cause mild flu-like symptoms in adults. Occasionally people may be affected with prolonged illness lasting months that includes muscle aches and tender lymph nodes. Blurred vision develops on rare occasions, and numerous behavioral changes have been associated with human and rat infections. In those with a weak immune system, severe symptoms such as seizures and poor coordination may occur. In infants and those with compromised immunity, the infection may cause a serious and life-threatening illness. If infected during pregnancy, a condition known as congenital toxoplasmosis may affect the infant.

**Humans are infected most commonly through eating undercooked or contaminated meat. They may also be exposed through drinking contaminated water, or by accidentally ingesting the parasite through contact with cat feces that contain *Toxoplasma*.** Cats acquire *Toxoplasma* by eating rats and mice that carry the disease and the bacteria survive in their feces. Therefore, people may be exposed to *Toxoplasma* while cleaning an infected pet cat's litter box, or by coming into contact with contaminated cat feces, soil where cat feces were introduced, or unwashed fruits or vegetables from a garden where cat feces were present.

## Trichinosis

Trichinellosis (trichinosis) is caused by *Trichinella* nematodes. Symptoms in humans initially include nausea, diarrhea, vomiting, fatigue, fever, and abdominal discomfort. Headaches, fevers, chills, cough, swelling of the face and eyes, aching joints and muscle pains, itchy skin, diarrhea, or constipation follow the first symptoms. If the infection is severe, patients may experience difficulty coordinating movements, and have heart and respiratory problems, and in some cases, death can occur. For mild to moderate infections, most symptoms subside within a few months. Fatigue, weakness, muscle pain, and diarrhea may last for months.

Rats and other rodents are responsible for maintaining the infection. Carnivorous and omnivorous animals, such as pigs, wild boar, bears, and cougar that have fed on infected rodents or meat from other animals can develop active infections. **Humans are accidentally infected when eating improperly cooked or processed meat of infected animals (or eating food contaminated with such meat).**

## Nematode infections

There have been rare cases of people contracting rat lungworms. *Angiostrongylus cantonensis* is a parasitic nematode of roof rats that causes angiostrongyliasis. They are the most common cause of human eosinophilic meningitis in Southeast Asia and the Pacific Basin. The nematode resides in the pulmonary arteries of rats, giving it the common name rat lungworm. The parasite has been confirmed in Arizona, California, Colorado, Utah, Texas,

Alabama, New York, and Tennessee, but it is likely to be present elsewhere also.

Humans are typically infected when snails and slugs carrying the infection are inadvertently ingested.

*Capillaria hepatica* is a parasitic nematode that causes hepatic capillariasis in rodents and numerous other mammal species, including humans. Humans are usually infected after ingesting embryonated eggs in fecal-contaminated food, water, or soil. Occasionally in humans, larvae will migrate to the lungs, kidneys, or other organs. The presence of *C. hepatica* eggs in human stool during routine ova-and-parasite examinations indicates passage of ingested eggs through the gut, and not a serious infection of the body.

## Ticks

Ectoparasites found on roof rats belong to four different groups: fleas, lice, mites, and ticks (see table 1). While several species of ticks in the family Ixodidae are found on roof rats in other parts of the world, very little is currently known about urban roof rats' association with ticks in Arizona.

## Rabies

Wild rats of any species have never caused rabies in humans in the U.S., and rarely do so in other countries. Rats are therefore not considered a serious rabies risk, and rabies prophylaxis is not considered necessary after a rat bite.

## Hantavirus Pulmonary Syndrome and Seoul Virus






Roof rats have never been implicated in a human hantavirus incidence, and are not considered a hantavirus reservoir species. However, roof rats have been associated with Seoul virus that is a member of the hantavirus family of rodent-borne viruses (Bunyaviridae family). Most people who contract Seoul virus experience mild or no symptoms, but those developing the severe form of the disease, exhibit hemorrhagic fever with renal syndrome which can be deadly. Seoul virus has been isolated in many states across the U.S. in both 2017 and 2018, and Seoul virus from pet rats to humans has been documented in the U.S.

**Roof rats cause human illness both directly and indirectly and should not be tolerated inside inhabited buildings.**

Over several decades there has been a consistent and significant increase in the geographic host ranges of many vector-borne pathogens and related diseases. Range expansion has been driven by climate change and human encroachment into wild habitats. Relatively little research is focused on rat populations in urban areas, but increasing health risks have been confirmed in some U.S. cities.

Information about controlling roof rats is available in a publication entitled Roof Rats: Integrated Rodent Management by the same authors.

Table 1. Roof rat ectoparasites

Ectoparasite		Human disease
<p>Oriental rat flea <i>Xenopsylla cheopis</i></p> <p>Adults are hard-bodied (difficult to crush between fingers), light to dark brown coloration, 1.5 to 4 mm in length with three pairs of legs.</p>	 <p>By Olha Schedrina / The Natural History Museum - <a href="http://data.nhm.ac.uk/object/c11c05ab-189f-4a19-826f-873bbd04b3c6">http://data.nhm.ac.uk/object/c11c05ab-189f-4a19-826f-873bbd04b3c6</a></p>	<p>Primary vector for <i>Yersinia pestis</i> (plague) &amp; <i>Rickettsia typhi</i> (murine typhus)</p> <p>Flea bites can be very itchy and painful. Hives and some swelling near the site of a bite may occur.</p>
<p>Tropical rat mite <i>Ornithonyssus bacoti</i></p> <p>Mean length and breadth of adult female mites 1 mm × 0.6 mm. The body is hairy and has four pairs of legs.</p>	 <p>By Erling Ólafsson Rottumífill &lt;1 mm. ©EÓ</p>	<p>Rat mite dermatitis</p>
<p>Spiny rat mite <i>Echinolaelaps echidninus</i></p> <p>Adult females are oval, and almost covered with a sculptured dorsal shield. The body is about 1 mm long and 0.7 mm wide and has four pairs of legs.</p>	 <p>By Matt Frye, New York State Integrated Pest Management, Cornell University</p>	<p>Rat mite dermatitis</p>
<p>Spiny rat louse <i>Polyplax spinulosa</i></p> <p>Adult females have elongated flattened bodies dorsoventrally 1-1.5 mm in length and have three pairs of legs.</p>	 <p>By Matt Frye, New York State Integrated Pest Management, Cornell University</p>	<p>Do not bite humans but may be intramurid vectors of murine typhus and other zoonoses.</p>
<p>Tropical rat louse <i>Hoplopleura pacifica</i></p> <p>Adult females have elongated flattened bodies dorsoventrally &lt;1 mm in length and have three pairs of legs.</p>	 <p>By K.C. Emerson Entomology Museum, Stillwater Oklahoma</p>	<p>Do not bite humans but may be intramurid vectors of murine typhus and other zoonoses.</p>



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Figure 4. *Rattus rattus* by Alex O'Neal (CC BY-SA 2.0)



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## Annual Rodent Control Issue

# Choking ON Air

New studies show mouse allergens in schools and inner-cities worsen the symptoms of asthmatic children.

By Sandra Kraft and Larry Pinto



*Editor's Note: This article was reprinted with permission from Techletter, a biweekly training letter for professional pest control technicians from Pinto & Associates.*

Asthma is the most common childhood disease in the United States, affecting up to 15 percent of children, mostly in inner-cities. We've known for many years that one of the primary causes of asthma in children is the presence of cockroaches. Cockroach droppings, shed skins, dead bodies and egg cases all shed allergens in the form of protein particles, which become airborne and are then inhaled. Some people have an allergic reaction to cockroaches with sneezing and a runny nose. But cockroach allergens can lead to a more serious asthmatic response in sensitive individuals. For inner-city children and the elderly, German cockroaches cause more cases of asthma than pets or dust mites.

Recently, several researchers have looked more closely at the role of house mice in childhood asthma. What they found was surprising. Mouse infestations cause more serious asthma symptoms than cockroach infestations. Mouse allergens are present at some level in most inner-city and low-income households and are common in high-rise apartments, older homes, mobile homes and inner-city schools. The older the structure, the more likely that mouse allergens are present. The allergens are found primarily in mouse urine and in mouse dander (shed skin flakes). Because mice dribble urine droplets as they travel, allergens can be anywhere.

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ARTICLE CONTINUES AFTER ADVERTISEMENT



RodentStop is an effective product to seal seams, cracks and holes to prevent entry from rodents and other pests.



#### Where?

- Cracks, joints and holes in brickwork.
- Joints and expansion joints.
- Steel, cast-iron and PVC recesses and ducts.
- Settlement cracks.
- Connections between brickwork and drains.
- Sewer connections
- Ducts for (electrical) cables
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In the most recent study, 284 children with asthma in a northeastern U.S. city were followed for one year. Dust samples were taken from their inner-city homes and their schools to analyze for various allergens. In schools, dust mite levels were low and cockroach and rat allergens were almost undetectable. However, mouse allergens were present in almost 100 percent of the school samples and at significantly higher concentrations than in the homes. The children with higher exposure to mouse allergen in schools had increased asthma symptoms and lower lung function. A related study of children in the Bronx, N.Y., found that children allergic to mice were more likely to have had at least one emergency department visit in the past year compared to children not allergic to mice.

**WHAT CAN SCHOOLS DO?** Asthma attributed to pest infestations in schools is a problem for the parents of asthmatic children since they have little control over the school environment where their children spend much of their day. In the home, bedding can be washed to reduce dust mites. Pet dander can be controlled and, presumably, cockroaches and mice can be eliminated. Should schools be routinely tested for allergens, and if so, how would levels be reduced? Because mice are active mostly at night, would most schools even know that they have a mouse problem?

Some national, state, city and non-governmental organizations have developed school-based asthma management programs that primarily rely on education to manage symptoms and reduce asthma-related school absences. The use of classroom HEPA air filters has been studied. What seems to be largely missing is a proactive integrated pest management approach in schools aimed at reducing the pests (now, mice) that are responsible for many asthma symptoms in schoolchildren.

### TakeDown: An Acute Rodenticide in Soft Bait Form

TakeDown, a non-anticoagulant bromethalin soft bait from Liphatech, was introduced to the pest control industry last year; it's since become a valuable tool for PMPs. TakeDown combines the power of bromethalin — a rapidly-absorbed non-anticoagulant neurotoxin — with the palatability of soft bait.

PMPs using TakeDown in commercial and select residential accounts can expect results in as little as 2-3 days (compared to 4-5 days for anticoagulants), making it an efficient means of reducing heavy rodent populations and showing customers faster results, Liphatech reports. Because bromethalin directly attacks the central nervous system instead of causing internal bleeding, TakeDown is ideal for dealing with anticoagulant-resistant rodent populations or as part of a resistance prevention program.

TakeDown soft bait is packaged in 8-gram pouches. Unlike anticoagulant baits that must be bought in quantities of 16 pounds or more, TakeDown pouches are available to PMPs for purchase in 4-pound bags.

Like FirstStrike and Resolv, TakeDown's wax-free soft bait formula won't melt in high temperatures. Food-grade oils and grains make all of Liphatech's soft baits highly attractive to rodents, even when other food is available, Liphatech says. Pouches can be quickly secured with or without paper in bait stations using rods or SoftSecure Technology.

For more information visit [www.liphatech.com](http://www.liphatech.com) (<http://www.liphatech.com>) or call 888-331-7900.

**WHAT CAN PMPs DO?** If you have school accounts, you can understand the importance of thoroughly inspecting for and controlling mice. Too often, mouse management isn't begun until mice are spotted in an account. Schools are prime candidates for preventive measures such as rodent-proofing of doors and openings around utility lines that enter the building.

Don't limit your intensive mouse inspections to school accounts through. Give extra effort to mouse inspections in homes with asthmatic children or adults. Similar inner-city asthma studies in homes have found mouse allergens present in 95 percent of the homes tested. Allergens were found most often in kitchens, but also in children's bedrooms. This means children are exposed to mouse allergens at school during part of the day, and then continue to be exposed at home during the remainder of the day, although generally at lower levels than at school.

**REMOVING ALLERGENS.** Unfortunately, eliminating the pests causing asthma doesn't necessarily eliminate the symptoms for everyone. Allergens accumulate over time and are very difficult to remove from an environment, particularly when they are from pests that live (and die) in hidden places like wall voids or cracks and crevices.

Studies on cockroach allergen deposits in homes found that after successful elimination of the cockroaches, even the most thorough, professional cleaning did not eliminate all the hidden allergens. Enough allergen residue remained to still cause reactions in very sensitive people. This emphasizes the importance of not allowing cockroaches or mice to become problems in the first place. Prevention is key.

## **The Health and Economic Significance of Rats and Mice in NYC**

### **Introduction**

Rats and mice are among the most significant of all pests, not just in New York City, but also on the entire earth. Rodents take advantage of our food and shelters, multiply into populations of millions, and attempt to co-exist with us in our homes, offices, restaurants, hotels, and schools and even in our planes, trains and automobiles.

Rodents are also well designed for carrying and transmitting diseases, and they damage and destroy our buildings, electronic communications and utility systems through their gnawing and burrowing activities. The cost of controlling rodents on a global scale is estimated to be in the billions of dollars.

But rodents are also among the most beneficial of all mammals to humans, because they are so important in health care research. In addition, outside of our cities, they are important for maintaining balance within ecosystems.

### **Rodent Populations in New York**

Many people love to guess the numbers of rats and mice in New York. Statements such as "there is one, or five, or ten, rat for every person in New York City" or, " there are more rats in the world than people" are still prevalent comments.

Notes:

## NYC Rodent Control Academy

### Rodents and Disease Transmission

In the past 100 years, over 10 million people have died from rodent borne diseases. Plague and typhus outbreaks are but two well noted examples that have contributed to this astonishing figure.

Rats and mice have been implicated in about 55 different diseases, representing a diverse range of pathogens from viruses to parasitic worms, as listed here:

<u>Pathogen</u>	<u>Number of rodent-borne diseases</u>
Virus	17
Rickettsial	9
Bacterial	20
Protozoan	3
Cestodes	3
Trematodes	1
Nematodes	3

### Rodent Bites and Attacks

Rodent attacks--especially rats-- on people are a topic that generates concern (and fear) among the public. Both rats and mice bite people regularly, especially in areas where rodent populations are high, and where the rodents live in close proximity to people. Unfortunately, it is babies in cribs, the confined elderly, and the indigent homeless that are most vulnerable to foraging rats and mice.

It is safe to state that in the large, highly populated cities of the world -especially those without formal rodent control programs-- the number of rodent attacks on people is significant. In the USA, it is estimated that up to 14,000 people are bitten each year by rats, the majority being children. Neglected children and homeless people in infested areas may suffer serious wounds from repeated attacks by one or more rats. In many cases, foraging rodents are attracted to the food residues on the hands, fingers or faces of babies or sleeping adults. The rodent may bite when attempting to consume the food completely from the flesh of the person, or the rodent may also consider the flesh itself as food. Rodents also bite children when they attempt to pet or pick up the furry animal that has joined it in bed.

Mouse bites in NYC are not uncommon when people attempt to pick up glue traps containing live mice, and the mouse bites a finger or a hand.

NOTES:

## The House Mouse as a Potential Health Pest in Homes and Apartments

Bobby Corrigan, Ph.D.  
Rodent Control Specialist

The house mouse, *Mus domesticus*, is a ubiquitous urban mammal pest in many cities around the world. It has proven itself particularly adept at infesting multiple unit buildings of all sizes, complexity and operation. Such buildings often contain hundreds and sometimes thousands of structural and equipment voids of varying shapes, sizes and micro-environments. These urban spaces are ideal for allowing the small, highly adaptable house mouse to exist and thrive. Examples of such buildings include hi-rise apartment buildings and condos, hotels, schools, hospitals, office buildings, shopping malls and a host of others. The fact of the matter (and whether we like it or not), the mouse is more the "companion animal" to the human species than is the cat or the dog.

In New York City for example, the mouse is so entrenched that it would be relatively difficult—and I suspect even, rare—to locate a multiple-unit building that does not have at least a few mice. Actually, it is more probable that many New York City multiple unit buildings contain *established* mouse infestations that have been present since the opening of the building itself.

But what is the overall significance of this human-mouse co-existence in buildings? In general, we know that the mouse is an economic and health pest inside buildings. We know from the thousands of case histories that mice inside our buildings attack and contaminate our foods as well as travel across food dishes, utensils and the surfaces we use to prepare food. They also scurry over our work desks, tables chairs, beds and clothes. In only one week, a single mouse can deposit thousands (literally) of micro-droplets of urine and hundreds of fecal pellets in our living spaces and/or onto the furniture and equipment in which we constantly touch with our hands and fingers (the primary human appendages in which we collect and then ingest or absorb microbes that give us colds, flu, and worse). Even though this is a disconcerting image to most of us, it is somewhat a relief to know that most epidemiologists do not classify the mouse as a major health threat because it does not transmit those diseases associated with high mortality rates (at least not yet).

Certainly, this does not mean the mouse is a harmless pest—hardly. We know, as we will see below, that mice have *the potential* to transmit illness to us. And to the point of this article, there is something unique about house mice and diseases in urban areas. Namely, there are several mouse-borne diseases that are overlooked and ignored by people, or misdiagnosed by physicians. Why? because these illnesses closely resemble common everyday ailments. Or, they are ailments that are not severe in their symptoms or duration, so people fail to seek the further medical diagnosis necessary to correctly identify the specific illness.

Additionally, mice, similar to rats and squirrels, gnaw on wires and cables of all types inside buildings, planes, trains, automobiles, computer systems, and a myriad of

mechanicals causing directly, or indirectly, electrical shorts, fires, and /or serious mishaps. But in the scope of trying to pinpoint the cause of these malfunctions or mishaps what inspector is able to discern the typical tiny mouse incisor marks on wiring? Undoubtedly, most times such damage remains hidden.

All in all, society in general under-recognizes and under-emphasizes the health significance of the urban mouse. So, let's examine this issue a bit deeper. Which mouse borne diseases may be going unnoticed because we assume they are something else—something more ordinary?

### Hay Fever or..... Mouse Allergens?

Inside multiple unit buildings, pest professionals servicing for established mouse infestations frequently note the classic "mousey odor". This odor is mostly due to the accumulated mouse urine from the infestations. Up until the late 1990s this odor was dismissed as an unpleasant, but overall mild nuisance. Then research from Johns Hopkins, discovered that the house mouse's urine contains a protein which can trigger asthma in sensitive individuals. The protein is appropriately named *mouse urinary protein (MUP)*. In most cases of MUP sensitivity, the classic symptoms of asthma occur (i.e., watery eyes, shortness of breath, wheezing and coughing). But in severe cases, MUP can cause life threatening and even fatal reactions.

The Johns Hopkins research estimates that about 18% of asthmatic children nationally test positive for mouse allergen sensitivity. In just New York City alone, this equates to about 54,000 asthmatic children being MUP sensitive. But for so many years (and still currently depending on an examining physician), people on a global scale with asthma symptoms are misdiagnosed as allergic to pollen, or dander, or, pending further testing, "something in the air" unless further tests are conducted.

Considering the prevalence of the mouse in our multi-unit buildings and the fact that mice deposit thousands of micro-droplets of urine as discussed earlier, building occupants are exposed to the urinary proteins via inhalation, by skin contact, or by both. And as if the asthma symptoms are not bad enough, skin contact with mouse urine for some people can cause rashes and itching (causing them to imagine they have developed a skin problem, or they are being attacked by fleas, bedbugs, or some mysterious "mite", etc).

The significance of mouse infestations and their role in MUP asthma and other MUP-related ailments should not be under-appreciated.

### The "flu" or..... LCM?

Lymphocytic choriomeningitis (LCM) is an illness caused by a virus (LCMV). This virus becomes established within the feces and body fluids of the house mouse. Similar to mice being overlooked in cases of asthma, recent research has found that LCM is another overlooked and under-diagnosed disease in urban areas where mice are prevalent.

Within multiple unit buildings where LCM-infected mice are established, building occupants become infected by inhaling infectious aerosolized particles of rodent urine, feces or saliva, or by ingesting food contaminated in one form or another by infected mice.

Onset of LCM occurs from one week to two months after exposure to the virus, although about 50% of the people that contract LCM are asymptomatic (no outward signs or symptoms). With other cases, LCM infections include fever, headache, and muscle pains, which as most of us know, this is how you feel when you have come down with a case of "the flu". Most people tend to wait it out by resting in bed, drinking fluids and so forth.

About 20% of the cases produce mild meningitis (i.e., an inflammation of the membranes (meninges) that envelop the brain and spinal cord). In the most severe cases, the fatality rate ranges from 2 to 5 percent. Still, with the exception of the worst cases, most people make a full recovery from LCM within three weeks.

The notable point is that the experts hypothesize LCM is established world-wide and that tens of thousands of people are infected by this virus each year but many of the cases are dismissed as ordinary flu. Considering the ubiquitous distribution of the house mouse in structural environments and the suggestion by researchers that LCMV is an overlooked pathogen, LCM may be among the most significant mouse-borne illness to the general public.

#### *Chicken pox or Rickettsialpox?*

Rickettsialpox is a disease caused by a special group of bacteria, the rickettsia, which are parasitic on cells. Several rickettsial diseases are transmitted to people from fleas, lice, mites, and ticks, and some involve rodents as the reservoirs of these diseases. Notable rickettsial diseases include murine typhus, scrub typhus, and Rickettsialpox. Rickettsialpox is caused by the bacteria *Rickettsia akar* and is associated with house mouse infestations that have become established within multiple unit buildings of several large cities.

The Rickettsialpox bacteria is vectored only by the house mouse mite *Liponyssoides sanguineus*. This mite lives almost exclusively on house mice (although it has also been found on Norway Rats in Arizona and Utah). This mite also causes dermatitis in people. Victims that are bitten by infected house mouse mites in mouse-infested buildings suffer headaches, rashes and fever. But Rickettsialpox often goes undetected or unreported because: (a) it is commonly misdiagnosed as chicken pox (which is not caused by a bacteria, but rather a virus) because of the similarities of the skin rash and the other symptoms; (b) the symptoms of Rickettsialpox are generally not severe and most people fully recover after a week or so. This causes people to not become alarmed, nor seek any further medical attention or testing; and, (c) it is considered an uncommon disease with only about 1000 cases having been reported in the United States.

Consequently, many physicians are not alert to the possibility of skin pox cases being Rickettsialpox. In turn, maybe this adds to the disease remaining "uncommon". Similar to "asthma" and the "flu" cases discussed earlier, no one knows how many cases of "chicken pox", are in fact mouse-borne Rickettsialpox. But in the cities of New York, Cleveland, Philadelphia, Boston, and West Hartford, where the Rickettsialpox bacteria is established, cases of "chicken pox", especially those originating in mouse infested multiple unit buildings, should be further tested for Rickettsialpox because this has important ramifications for all the other occupants of the building.



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### The Hidden Benefits

So, in urban zones, how many mice does the average pest professional control on just one typical route each month? Dozens? And probably several hundred over the course of a year—right? Moreover, among the 15,000 pest management companies and the thousands of municipal pest professionals in the United States, how many mice as a whole do all pest management professionals combined control?

The next time a pest professional performs a service for mice in any of the multi-unit structures discussed here, remember this: as the professional completes the work and exits the building, no one is following behind them dissecting any of the mouse carcasses that were controlled via their baits or traps to profile them for pathogenic viruses or bacteria. Nor is there a medical entomologist combing the mouse's fur searching for flea mite, or tick vectors.

But my guess is that if we could somehow pass a "pathogen Geiger counter" over any of mice eliminated via control efforts day in, day out, we might all be surprised with what would be present—yet remains hidden. Hidden to us, to physicians, to emergency room doctors, to the average building occupant regardless of the building type.

And so too hidden are the benefits that pest professionals everywhere provide to the occupants of any the types of buildings discussed here. Pest Professionals without knowing it, and depending on the thoroughness of their work may be significantly alleviating or even eliminating the discomfort experienced by the asthmatic children in an apartment building. Or they might be preventing several families within an apartment complex from contracting LCM or Rickettsialpox.

As a species, we humans are tangible-oriented. You know, "what you see is what you get". This is how we make purchasing decisions for cars, houses, clothing and so forth. Well, in urban pest management, what you don't see is what you can get also. It is the job of the pest professional everywhere to actually help prevent people, pets and livestock from "getting things" whether they are seen or unseen.

If the world of rodents and their microbes *were* more readily visible to us, then for sure pest management professionals might (one could only hope) be viewed in a different light of community importance by the persons answering the door, or by the purchasing agents of schools, housing complexes, office buildings and hospitals that bicker for "low bids" on rodent control contract prices.

**Manage refuse, manage pests 1**  
**Bobby Corrigan, Ph.D.**

Ironically, as a species, humans frequently attract pests to the structures we most do not want the pests around. Consider how unwelcome, rats, mice, flies and cockroaches) are restaurants and supermarkets, schools and health care facilities. These are the very environments the public takes food safety for granted. Most people assume the food they are about to eat, or the foods they take home are free from filth or the potential of filth. Yet it is common in these accounts to find through human behavior and practice, it is people's poor behavior that often directly attract rodent and insect pests directly to our food sites, and may even provide them with the conditions to proliferate. Let's examine how this is so.

Commercial establishments that handle and/or serve food generate relatively large amounts of attractive food odors and warmth. As you might expect, these conditions alone are highly attractive to any pests that come foraging nearby the property. But, the exterior refuse areas, depending on how they are maintained, may be the reasons pests are attracted to the building site in the first place. Once on site, the pests gravitate indoors, or they establish themselves close to the food generating refuse containers.

Thus, it should be common sense to most of us that the proper management of our food refuse is also one important approach in which we can pro-actively avoid pests problems. Unfortunately, often times, it is the nature of humans to dispose of their attention and concern for cleanliness when they dispose of their trash. (After all, it is trash, waste, and dirt!). This includes both their handling of the trash, as well as the keeping trash rooms, cans, and dumpsters organized, and cleaned.

Additionally, the proper handling of food waste materials, selecting the appropriate waste collection bags, appropriate dumpster size, and the management of all waste containers are usually overlooked, and/or are not addressed during any employee training programs. Most employees are simply instructed or have the mindset to "take the trash out and throw it in the dumpster". And sadly for preventative pest management efforts, this is exactly what is done. The consequences of this become visible later, and then passed along to pest management professionals to correct.

Consequently, two things are important for us as pest professionals relative to commercial refuse management. First, we should keep in mind the important role exterior refuse areas play in attracting and allowing rodents and other pests to proliferate. Second, we need to communicate to clients the relationship between refuse and pests, and the importance of the client's role in managing their trash and trash receptacle s properly.

Yes, this is easier said than done. Sanitation issues are not a subject easily broached by pest professionals to clients (especially to those clients needing the information the most). Such information has to be delivered via tactful (and skillful) dialog that suggest the PMP and client work together in keeping flies rodents and roaches from ever getting a foothold in the account in the first place. But we can also help them and ourselves by also providing them with a "helpful tips" fact sheet on proper trash management.

In reality, most of our commercial clients, including the supervisors and managers of the employees whom actually may handle the trash, have themselves never had trash management training. A fact sheet from you or your company to help inform custodians, hospital staffs, restaurants, supermarkets, nursing homes, day care centers, and virtually

any other commercial account employee properly handle their food refuse will likely be most welcomed. The following can be listed in the fact sheet:

1. Food wastes should always be placed into plastic bags or in some other container prior to being put into a dumpster (or compactor). Loose food wastes in general should never be placed into dumpster (with the exception of customized dumpsters and programs).
2. High quality, heavy duty plastic bags should be used for food wastes (especially wet food wastes). Cheap bags split, break or leak, defeating the purpose of even using bags.
3. Excessively wet food waste should be wrapped in newspapers or other absorbent materials prior to being placed into garbage bags.
4. Attention should be paid to not overloading the garbage bags or the refuse dumpsters (both of which are commonly done). Overfilled bags stresses the bag seams and causes spillage or leakage while the trash is being carried or while the bag remains inside the dumpster. Not overfilling the bags also allows for space to twist tie and seal off the garbage bag. Heavy loads should be divided into several bags, or the trash should be double-bagged. Overfilling the actual dumpster results in trash on the ground. Gradually, empty dumpster are placed back down on top of trash, and the whole purpose of having a dumpster in the first place is virtually negated. Rodents and pests will feed beneath the trash containers unseen by people.
5. The tops of the garbage bags should be tightly sealed using twist ties or via by tying the bag itself. This will prevent spillage and leakage which in turn will reduce the garbage odors, and thus reduce the pest attraction level. Sealed bags will also deny insect and bird pests direct entry to the bags once they are placed into the dumpster.
6. Perhaps most importantly, filled bags should be carried out to the dumpster and placed into the dumpster. In other words, the bags should not be thrown or tossed into the dumpster. This is important for two reasons:
  - a) Often times, a tossed or thrown heavy bag creates stress on plastic seams, causing them to break or leak, spillage food refuse all around the exterior areas, or within the dumpster itself. Tossed bags often miss their target, hit the side or edges of the dumpster, and break open, causing a mess and a food residual either on the ground, or on and inside the dumpster which might attract, and feed pests for weeks.
  - b) Dumpsters become coated with food residues and spillage as a result of thrown bags. During the late summer and early fall, yellowjackets begin to become numerous around the exterior of the dumpster. Employees afraid of these stinging insects around the dumpster in turn are afraid to get near the dumpster, and thus increase their slinging of the bags towards the dumpster, causing a cycle of more garbage, attracting more yellow jackets, rodents, birds, and roaches.
7. The dumpsters should remain reasonably clean, and should be changed out on a regular basis by the waste management contractor. Dumpsters that have become severely damaged (no rain guards, deteriorating sides, etc), should be replaced.

8. Dumpsters that are used for food refuse must always be kept on a cement pad, or on some equivalent surface that will withstand the weight and allow for proper cleaning. Dumpsters situated on turf or dirt are highly vulnerable to rodents, ants, and other pests burrowing into the ground directly beneath the dumpster. The ground area supporting the dumpster must remain clean via power washing, or via some other acceptable efforts. The areas beneath and behind the dumpster should be kept picked up and orderly.

9. The dumpster should be located away from doors (e.g., especially the kitchen doors) and receiving areas. There is no set distance rule, but 50 yards or more is desirable. The closer the dumpster is to the back doors and receiving areas, the greater the chance for pests to discreetly enter the account. Although, this is unpopular with employees because they must carry the trash for greater distances, it is important for overall food safety and effective pest prevention. (Notice for example, the next time you visit a popular, large chain fast food restaurant, how far their dumpsters are away from the building perimeter. Ideally, carts should be available to enable employees to transfer heavy trash.

10. Dumpsters should always have rain covers that are in good condition, and are always kept closed. Rain covers help reduce rain water from accumulating in the base of the dumpster which is important in reducing among other sanitary issues, the fly breeding potential. By keeping the covers closed, the garbage will also be less available to birds.

Pest management professionals and health inspectors see mis-managed trash all the time. But certainly not as often as those who service commercial dumpsters for a living. Sometime, take a moment to chat with a waste management employee about the conditions they see everyday around commercial food establishment dumpsters. While you're at it, ask them about the rats, mice or cockroaches they see from time to time, or the thousands of fly maggots that spill out of the compactor crevices during pick ups and "swap-outs". Often times, before these employees reply, they frequently grin and then exclaim, "Oh boy" do I ever see some pests!" Their experience is no coincidence.

Commercial clients must realize that although the exterminator can employ professional level tools, no pesticide or trap can substitute for basic hygiene. The biological premise is simple: when we manage our urban trash, we also manage urban pest populations. But managing human behavior? Well, not so simple.

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## Cover Story

# Public Health Importance of Urban Rodents

A research update addressing the significance of city mice and rats and everyday public health from Dr. Bobby Corrigan.

By Bobby Corrigan, Ph.D.



Bobby Corrigan

FIGURE 1. The house mouse is our most ubiquitous rodent pest. It invades nearly every type of building and lives intimately

among people.

### **“That which can be foreseen can be prevented.” — Will Mayo, 1910**

The purpose of this article is to provide an important research update addressing the significance of city mice and rats and everyday public health. As PMPs likely already know, public health updates are important for the pest management industry. They not only help us better serve our residential and commercial clients (e.g., schools, restaurants, office buildings), but even for our own lives, homes and families.

**VIRUS HUNTERS.** In New York City, the well-respected Center for Infection and Immunity is located at Columbia University’s School of Public Health. The scientists at this center have been studying the microbial pathogens (e.g., viruses, bacteria) associated with various insect and animal vectors (e.g., mosquitoes, rodents, ticks, etc.) for years.

This update also provides important tips for safely working with rodents on your everyday accounts. Moreover, these research findings should serve to emphasize why the integrated portion of Integrated Pest Management (IPM) must continue to be strongly emphasized in urban rodent control.

One group of these scientists is led by Dr. Ian Lipkin, the virus hunter internationally recognized for his work with West Nile virus and SARS. Dr. Lipkin served as the science consultant for the film Contagion — a film that was acclaimed for its scientific accuracy.

Beginning in 2012, Dr. Lipkin’s teams began live-capturing and analyzing everyday city rats and mice from New York. The goal was to study which viruses and bacteria these rodents were carrying, and whether or not they might pose public health threats. Columbia published their important research findings of city rats (*Rattus norvegicus*) in 2014. (*See references on page 46.*)

The more recent rodent research update (and addressed here) discusses Columbia’s second rodent research project, which was conducted similarly to the rat study, except it focused only on wild house mice (*Mus domesticus*). The research findings were published in two separate journal papers earlier this year and received quite a bit of attention from the global press (which no doubt, many of our clients read online and may have had follow-up questions for you out in the field). The following is an overview of the research findings.

**CITY MICE & GERMS.** The city mouse project was led by Simon Williams, a research scientist with Ian Lipkin’s lab at Columbia. Simon was joined by a team of virologists, microbiologists, epidemiologists and rodentologists.

The mouse team live-trapped 416 wild house mice from various residential and multi-functional buildings throughout greater New York. By employing a range of sophisticated laboratory techniques, the droppings, urine and the mice themselves were analyzed, allowing Williams’ team to isolate and identify the bacteria and viruses found on and within the mice.

**DANGEROUS FINDINGS.** Importantly, the collected house mice were found to be carrying several of the bacteria responsible for human gastroenteritis (inflammation of the stomach and intestines, typically resulting from bacterial toxins or viral infection).

Five bacterial pathogens and one protozoan were discovered in the wild house mice with significant frequency:

1. Salmonella (different strains)
2. *Escherichia coli*
3. *Clostridium difficile*

4. *Shigella*

5. *Leptospira* spp.

6. *Toxoplasma gondii* (protozoan)

Depending on the acquired infection level and the specific bacterial pathogen, should a person ingest (directly or indirectly via contact or inhalation), the resultant sicknesses ranges from mild to life-threatening. *Salmonella* bacteria, for example, is a leading cause of bacterial food poisoning in the United States with 1.4 million reported cases annually along with 15,000 hospitalizations and 400 deaths. And if we consider the impact of all foodborne pathogens, the Centers for Disease Control and Prevention in 2010 reported a staggering 76 million cases of foodborne illness and between 3,000-5,000 associated deaths occurring every year in the United States.

Among the millions of less severe cases of foodborne illness infections (and if you are reading this, no doubt you have "been there, done that"), most result in diarrhea, fever and stomach cramps with accompanying and sometimes severe vomiting one or two days after contact or somehow ingesting the bacteria or viruses from fecal or other contact from rodents or other pests (flies, cockroaches) or animals (*see Figures 2 and 3*).

*Toxoplasma gondii* is a protozoan parasite that causes *toxoplasmosis*, of which the cat is the definitive host. Cats become infected by killing and eating house mice infected with *T. gondii*. When the parasite gains a foothold around mouse-infested homes and apartment complexes (via cat feces accumulating in basements, crawlspaces, unkempt apartments, etc.), the house mouse serves as an intermediate host contributing to the parasite's persistence and propagation. If pregnant women contact infected cat feces, they can become infected, resulting in spontaneous abortions or various fetal abnormalities, such as lifelong retinal damage causing partial or complete blindness in one or both eyes.

The *leptospira* bacteria found in the NYC mice (and rats) are probably the most widespread and most prevalent of all zoonotic diseases (i.e., transferable from lower animals to man). The leptospirosis bacteria can be transmitted to people via the urine from rodent pests around buildings. This happens via skin contact with leptospirosis-contaminated water, moist soil and vegetation, or sometimes via the direct ingestion of food contaminated by infected rodents.

Symptoms of leptospirosis often closely mimic the common flu: fevers, headaches, diarrhea, chills and vomiting. As such, many cases are too casually dismissed by both the patients and their physicians as "the flu." In severe cases, however, this bacteria can be deadly as it can cause severe kidney damage, jaundice and hemorrhaging. Just last year (2017) in New York City, rodent-transmitted leptospirosis killed one and hospitalized others in the Bronx. Because leptospirosis is prevalent among rodents in American cities containing high populations of rats and mice, perhaps health departments should undertake more preventive programs with appropriate serology and analyses of local rat populations. (*See the comments of Lieberman.*)

It should be noted that the discovery of these particular germs with the NYC mice isn't revolutionary. During the past several decades, other researchers have recorded rodents carrying various microbial pathogens. What is significant is this was the *first time* a random sample of just a tiny portion of the wild house mice of America's most highly dense and populated city has been profiled — which begs the question: "What might be the profile of any of the other millions of mice not sampled?"

There was an additional interesting and important finding in the study. Columbia also discovered within the NYC mice the evidence of genes widely distributed that can bring about antimicrobial resistance (AMR) to several of our most common antibiotics including the fluoroquinolones and -lactam compounds. Notably, these particular antibiotics are, in fact, among the most commonly used drugs to combat the bacterial gastrointestinal infections caused by the pathogens discovered in the wild mice of this study.

For example, one of the fluoroquinolone antibiotics is ciprofloxacin (trade name: Cipro). This drug is used worldwide for the treatment of gastroenteritis. And, the -lactam drugs include the universally known penicillin derivatives. For many years, more than half of all commercially available antibiotics in use were of the -lactam compounds.

With the Columbia study then, it is yet another example of the axiom “the deeper we look, the more we find.” Finding the AMR association in everyday house mice certainly opens up the door for additional questions regarding one of our most pressing worries — the threat of continual increase of antibiotic resistance.

**NOVEL VIRUSES.** Columbia’s second study on house mice (also published in the journal *Molecular Biology*), investigated the viruses present in mouse droppings. Interestingly, 36 viruses, including six new viruses, were identified. None of the viruses were found to be varieties that cause *human* illness; this was different from what was found in the bacteria study.

This is not to say the wild mouse viruses were cleared of all guilt. The study *did* identify genetic sequences matching important viruses that infect insects, dogs, chickens and pigs, findings which will certainly be of interest to veterinarians and livestock producers everywhere (considering how prevalent mouse infestations are around livestock, animal hospitals, zoological parks and so on).

Nevertheless, the lack of human-pathogenic viruses — at least in the sample of mice collected in this study — is a bit of a relief compared to what we’ve been alerted to with mouse viruses during the past 30 years (e.g., hantavirus and deer mice, LCMV, etc.).

**NO GUARANTEED TRANSMISSION.** It is important to keep in mind, not only for this study, but for any research addressing pest-species vectors, that just because animals are found to be *harboring* germs, it doesn’t guarantee those germs will be *transmitted* to other animals around them. Such is the case with this house mouse study as well. More research is needed to measure, if possible, the likelihood of transmission of microbial pathogens found on mice and rats, or even cockroaches and flies, for that matter, under typical everyday conditions.

Still, it’s sobering that in only the space of a period at the end of a sentence several million viruses can fit. And, only one mouse in a restaurant can produce upwards of 125 fecal pellets and upwards of thousands of microdroplets of urine in 24 hours (*see Figure 3*).

What’s more, we know mice constantly dart about in thousands of “spots” throughout the rooms where they are active day-in and day-out and that they tend to investigate many of the everyday objects they encounter during those forays. So, it seems an obvious likelihood that sooner or later an infected dropping or microdroplet of urine will find its way into “our world.”





(Photo: Bobby Corrigan)

Figure 2. When mice are active in kitchens (commercial or residential), they constantly defecate and urinate on and into dishes, pots and cooking containers — it is not uncommon for small droppings or fragments of such to go unnoticed when the containers are used.

One example of this would be the all-too-common mouse infestations that occur in the ceilings above the kitchens in our commercial accounts (e.g., restaurants, bakeries, delis, grocery convenience stores, etc.). For these infestations, there is a decent possibility of pieces and parts of feces, hair, urine fragments and so on routinely falling down (partly by the daily vibrations that occur from all the moving of objects and activity below busy commercial ceilings) onto foods, food boxes, preparation areas, utensils, plates, pots and pans and the like. Similarly, droppings and urine can be deposited within food containers stored within the mouse-attracting dark, quiet drawers and closets of common household pantries of residences everywhere (see Figure 2).

The bottom line: transmission of bacteria and viruses from interior mice can happen at any time and in any number of ways. This also includes when we are actually trying to clean up the presence of germs and dirt via sweeping and vacuuming — which can then render microbes airborne and inhaled by those doing the cleaning.

**WHAT'S IN YOUR WALLET?** Perhaps you are thinking, "Well, the rats and mice collected in these studies were from New York City, a very crowded, old seaport city with more than 900,000 buildings and lots and lots of garbage, litter and the like. It doesn't mean the rodents in *my* city, town or area are carrying the same pathogens." Well, maybe. But until a city rodent/pathogen profile is conducted in *your* city, the question truly is, "What's in your wallet?" Maybe it's less? But maybe it's more.

This then leads us back to the Will Mayo quote at the beginning of this article about being preventive (in part, via effective, well-designed and well-implemented pest management programs at the ground level). Because in all cities around the entire globe, the fact of the matter is millions of cases of unexplained febrile illnesses year after year are not *actually* diagnosed.

When it comes to being preventive around any city where mice and rat infestations occur, Jay M. Lieberman, M.D., an infectious diseases specialist and former professor of clinical pediatrics at the University of California, Irvine, suggested in an important 2009 publication salient advice for all: namely, that when any ill person is brought in for medical attention with an unexplained fever-related (i.e., febrile) illness or infectious disease, *clinicians should routinely ask about any potential exposures to animal pests such as mice and rats that have been active around the domicile or workplace.*

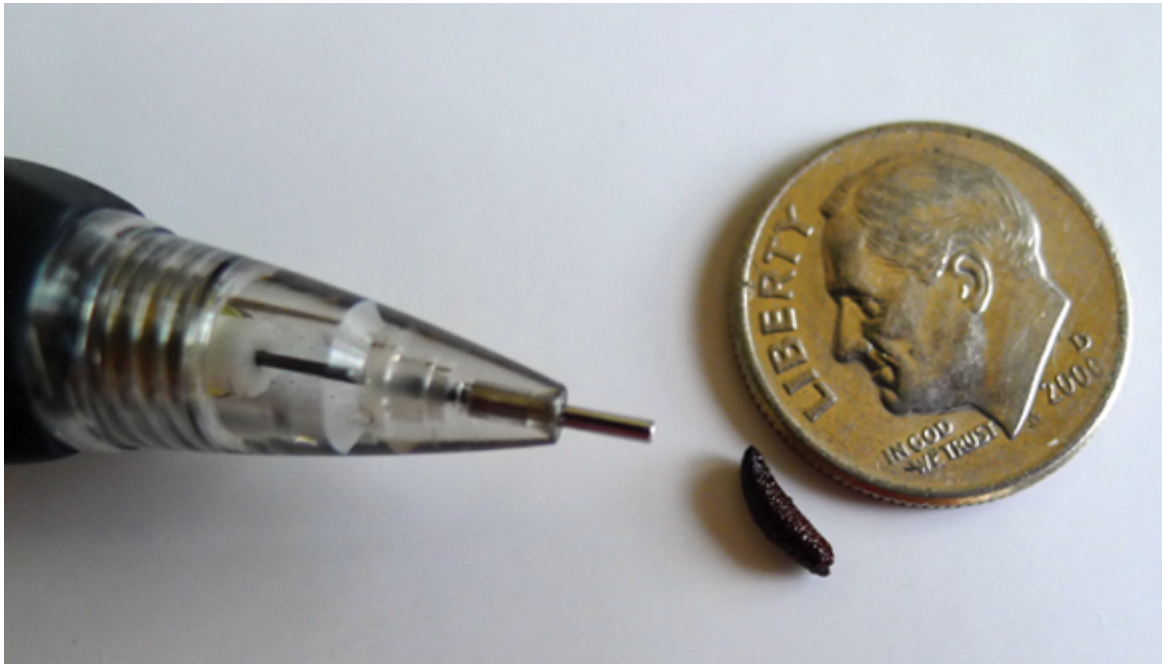
**TAKE-AWAY TIPS.** Rodent control is among our industry's highest revenue-generating services, as well as one of our primary identities as to why we truly do help protect the health and lives of humans. So how can we use this important research update in what we do and what we offer in our services, not to mention in our own daily work?

Here are some tips:

- The Columbia research further substantiates the importance of the basic tenets of *exclusion and sanitation* within the urban IPM model. If rodents can't get into the buildings in which we eat, sleep and work in the first place, they can't deposit fecal matter of any sort containing pathogens and/or the genes for facilitating anti-biotic resistance that we may later contact, ingest or inhale.
- Ensuring rodent-proof doors, sealed holes and detailed/cleaned floors in shadowy, hard-to-reach spots (i.e., the favorites of house mice) is not, as the saying goes, rocket science. Updates in the public health risks of rodent pests can help our clients be aware of the importance of the *essential partnership* in any IPM program between them and us. Company fact sheets, website blogs and simple handouts with highlighted points recapping such research can go a long way in your role in promoting public health to schools, homes, apartment and office buildings, restaurants and so on.
- Any client with a current rodent infestation and/or who has called upon you to provide the service to eliminate such rodent infestations should be *reminded* as to the importance of personal hygiene (e.g., frequent washing of hands) — especially until the rodent infestation is corrected.
- Services to address rodent infestations must be sold with an attitude of achieving high control on an ASAP basis. Inexpensive services can hardly input the up-front labor necessary to get the population eliminated fast. (Consider all the fecal material that can be laid down by a few mice in just a few days.)
- Rodents in our commercial accounts tend to favor nesting and reproducing and being most active in those structural areas that are often hard-to-reach (and thus often prone to being skipped over during service visits). Employing any of the electronic remote sensors now available on the market serve as important food safety and public health monitors in this regard.
- Cleaning up any excrement and associated rodent filth is the client's responsibility. Clients should clean and disinfect all areas in which rodents have been traveling and/or have left fecal material (advise clients to refer to the [www.cdc.gov](http://www.cdc.gov) for proper methods of disinfecting small and large amounts of animal excrement).
- All on-the-job pest professionals must always wear issued PPE (gloves, respirators when inside enclosed spaces) while performing inspections, and/or laying down indoor rodent control equipment within infested areas.
- Always wash any coveralls or discard any Tyvek-style suits in the proper donning and doffing procedures after using them in crawlspaces, attics or other areas/surfaces where rodent infestations occurred. (Check the [cdc.gov](http://www.cdc.gov) (<http://www.cdc.gov>) site for donning and doffing in these scenarios.)

- Even after wearing your disposable gloves during rodent control work, wash your hands after removing the gloves each and every time.
- Never, ever, clean out rodent-visited exterior bait stations or traps by sweeping the station's contents (feces, dirt, hairs, etc.) onto any client's property.
- To dispose of dead rodents found on the job (including contaminated glue traps) always double-bag and remove the contents from the premises and discard in an appropriate trash receptacle.

**SUMMARY.** Perhaps the most succinct way to summarize this important Columbia University research would be to consider two things. First, what if the mice collected from this study targeted only the mice of restaurants, or schools, or office buildings? Would less, or more pathogens have been found?



(Photo: Bobby Corrigan)

Figure 3. In the space only the size of a period at the end of a sentence, several million viruses can fit. So how many viruses (or bacteria) can fit on only one mouse dropping in only one restaurant (or in your own kitchen)?

And second, I'd like to repeat the answer to a question I had posed to the famous food microbiologist Dr. Michael Doyle, of the University of Georgia, at a food safety symposium awhile back: "Would you, Dr. Doyle, eat in a restaurant if you knew it had only one mouse positive for *Salmonella enteritidis* hiding somewhere in the kitchen?"

"Dr. Doyle's answer: "I would not. Would you?"

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#### References (Free via open access [OA])

Firth C., Bhat M., Firth M.A., Williams S.H., Frye M.J., Simmonds P., Conte J.M., Ng J., Garcia J., Bhuvu N.P., Lee B., Che X., Quan P-L, Lipkin W.I. 2014. Detection of zoonotic pathogens and characterization of novel viruses carried by commensal *Rattus norvegicus* in New York City. *mBio* 5(5):e01933-14. doi:10.1128/mBio.01933-14.

Simon H. Williams, Xiaoyu Che, Ashley Pawulick, Cheng Guo, Bohyun Lee, Dorothy Muller, Anne-Catrin Uhlemann, Franklin D. Lowy, Robert M. Corrigan, W. Ian Lipkin. New York City house mice (*Mus musculus*) as potential reservoirs for pathogenic bacteria and antimicrobial resistance determinants. *mBio*, 2018; 9 (2): e00624-18 DOI: 10.1128/mBio.00624-18

Simon H. Williams, Xiaoyu Che, Joel A. Garcia, John D. Klena, Bohyun Lee, Dorothy Muller, Werner Ulrich, Robert M. Corrigan, Stuart T. Nichol, Kormal Jain, W. Ian Lipkin. 2018. Viral diversity of house mice in New York City. *mBio* 9:e01354-17doi: 10.1128/mBio.01354-1717 April 2018 *mBio* vol. 9 no. 2 e01354-17

Lieberman, J.M. 2009. North American Zoonoses. *Pediatr Ann.* 2009 Apr;38(4):193-8

Original Contribution

## Rodent-Borne *Bartonella* Infection Varies According to Host Species Within and Among Cities

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**Abstract:** It is becoming increasingly likely that rodents will drive future disease epidemics with the continued expansion of cities worldwide. Though transmission risk is a growing concern, relatively little is known about pathogens carried by urban rats. Here, we assess whether the diversity and prevalence of *Bartonella* bacteria differ according to the (co)occurrence of rat hosts across New Orleans, LA (NO), where both Norway (*Rattus norvegicus*) and roof rats (*Rattus rattus*) are found, relative to New York City (NYC) which only harbors Norway rats. We detected human pathogenic *Bartonella* species in both NYC and New Orleans rodents. We found that Norway rats in New Orleans harbored a more diverse assemblage of *Bartonella* than Norway rats in NYC and that Norway rats harbored a more diverse and distinct assemblage of *Bartonella* compared to roof rats in New Orleans. Additionally, Norway rats were more likely to be infected with *Bartonella* than roof rats in New Orleans. Flea infestation appears to be an important predictor of *Bartonella* infection in Norway rats across both cities. These findings illustrate that pathogen infections can be heterogeneous in urban rodents and indicate that further study of host species interactions could clarify variation in spillover risk across cities.

**Keywords:** Fleas, *Rattus norvegicus*, *Rattus rattus*, Rodent-borne pathogens, Zoonoses

## INTRODUCTION

Zoonotic pathogens are an emerging threat to human health and well-being (Jones et al. 2008), especially in areas where humans and wildlife frequently come in contact (Despommier et al. 2007; Jones et al. 2008; Lloyd-Smith et al. 2009). Rodent-borne pathogen transmission is of

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particular concern in cities, where rodents can be widely distributed and hyper-abundant (Bradley and Altizer 2007; Rael et al. 2016). Commensal rodents like Norway rats (*Rattus norvegicus*) and roof rats (*Rattus rattus*) can carry bacterial and viral assemblages, including pathogens of concern (Ellis et al. 1999, Himsworth et al. 2013a, b; Firth et al. 2014). With rodents likely to drive future epidemics as cities continue to expand worldwide (Bordes et al. 2013; Han et al. 2015), determining the diversity and prevalence of rodent-borne pathogens in cities represents a vital step toward understanding how disease risk will progress with global demographic trends.

Many bacteria within the genus *Bartonella* are rodent-borne pathogens of concern (Andersson and Neuman 1997). *Bartonella* are gram-negative bacteria that can infect erythrocytes and endothelial cells in mammals (Anderson and Neuman 1997). At present, over 40 *Bartonella* species have been described, with most having been detected in bats and rodents (Jiyipong et al. 2012). Though *Bartonella* infections are thought to be relatively benign in rodents, several rodent-borne *Bartonella* species cause disease in humans, including febrile illness and endocarditis (Buffet et al. 2013). Humans can indirectly acquire pathogenic *Bartonella* from blood-feeding arthropods such as fleas (Bai et al. 2009; Billeter et al. 2011; Morick et al. 2011; Gutiérrez et al. 2015), or through biting or scratching by an infected mammalian host (Tsai et al. 2010; Billeter et al. 2011; Harms and Dehio 2012, Kosoy et al. 2012).

Despite potential public health risks, little work has been done to assess the diversity and prevalence of *Bartonella* in urban rodents. So far, studies have primarily surveyed Norway rats at small geographical scales, such as in a neighborhood within a city (Easterbrook et al. 2007, Gundi et al. 2012; Himsworth et al. 2013a, 2015). Yet infection in rodents appears to be heterogeneous, suggesting that ecological factors like host population size and movement might determine the diversity and prevalence of *Bartonella* in cities (Firth et al. 2014; Himsworth et al. 2015). Thus, it is possible that patterns of *Bartonella* infection may vary across and among cities, especially cities that harbor different rodent assemblages (Kosoy et al. 2015).

In this study, we examined the incidence of *Bartonella* in rats from two cities: New Orleans, Louisiana (NO), and New York City, New York (NYC). Several species of rats, including Norway rats and roof rats, occur in NO (Rael et al. 2016), whereas only Norway rats occur in NYC (Childs et al. 1998). Prior surveys of rats in NO have de-

tected *Bartonella* (Ellis et al. 1999) among a suite of other zoonotic pathogens (Campbell and Little 1988; Cross et al. 2014). A recent survey in NYC also found that *Bartonella* was the most prevalent bacterial agent infecting Norway rats (Firth et al. 2014). We characterized the diversity and distribution of *Bartonella* in NO and NYC to assess whether the prevalence of *Bartonella* differs according to the (co)occurrence of host species within and among cities (Keesing et al. 2006, 2010). This enabled us to identify factors that might influence spillover risk (i.e., transmission from wildlife hosts to humans) and thus provide practical guidance for improving pathogen surveillance programs.

## METHODS

### Sample Collection

In NO, we collected a total of 342 rats from May 2014 to March 2015 (Table 1) following Tulane University IACUC-approved protocol #0451. A subset of 272 rats was collected during a quantitative population survey across 78 residential city blocks in eight neighborhoods (Fig. 1) (Gulachenski et al. 2016; Rael et al. 2016). Each block was visited twice, once during May–August 2014, and a second time during November 2014–February 2015. During each trapping period, we set 30 Tomahawk traps (Tomahawk Live Trap Company, Tomahawk, WI) in areas with potential or evident rodent activity for a minimum of three consecutive nights. Trapping efforts were sustained at each site until no additional rodents were captured. We trapped the remaining 70 rats opportunistically as part of control efforts conducted by the City of New Orleans Mosquito, Termite, Rodent Control Board (NOMTRCB) between May 2014 and March 2015. Rats were collected using the same methods reported above, but the number of trapping days varied by location.

We necropsied all NO rats at NOMTRB's facility following a standard protocol. We euthanized NO rats using isoflurane anesthesia followed by cardiac puncture. Blood samples were spun down to separate serum from coagulates. We took standard weight and length measurements and determined the species, sex, and sexual maturity as well as parity in females. We combed each individual for ectoparasites, which we later identified using standard keys (Furman and Catts 1970). We also collected lung, liver, spleen, kidney, urine, and tail tissue samples, which we archived in  $-80^{\circ}\text{C}$  freezers.