Ornithonyssus bacoti Infestation and Elimination from a Mouse Colony

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Skin lesions, consisting of nonspecific bites with intense pruritis and excoriation of the skin, were found on personnel working in an animal colony primarily housing mice. The tropical rat mite, *Ornithonyssus bacoti*, was diagnosed from mites trapped on insect-monitoring sticky traps and collected from mouse cages in the colony. Because these mites do not live on mice but only come to feed when the animals are in their nest, an initial attempt was made to eliminate the mites with a thorough cleaning of the facility. Clidox foam was applied to the entire room with a foaming machine. Then the mice were transferred into the sanitized cages in the cleaned room. The numbers of mites were reduced to the point that they were no longer noticed in the colony, but the mites returned within 2 weeks. The mites were successfully eliminated with the use of permethrin-impregnated cotton balls in the mouse cages for 8 weeks and treatment of the premises. Treatment of the premises included spraying floors and walls of all rooms housing mice and adjacent hallways in the colony with pyrethrin spray by a commercial pest control company. To prevent one room of rabbits from maintaining the infestation, they were treated weekly with an organic pyrethrin dust. Insect sticky traps have remained negative for mites for more than 3 years after treatment.

Ornithonyssus bacoti, more commonly known as the tropical rat mite, is endemic in many parts of the United States. *O. bacoti* was first described by Hirst in Australia in 1913 (16). It was found in the United States in 1921 and is common in temperate climates of the world (2). The Arctic and Antarctic are the only two continents with no reports of *O. bacoti* (8). The mite has a rapid life cycle of 7 to 16 days from egg to egg production for each generation. It is also very prolific, with a single female laying as many as 140 eggs during its 60-day lifetime (1, 9-11, 17). One stage of the life cycle, the protonymph, has been shown to survive for 43 days without food (9, 24). The principal host is *Rattus norvegicus*, the common laboratory rat. *O. bacoti* has been found on several different feral rodents on the East Coast, including meadow voles (*Microtus pennsylvanicus*), white-footed mice (*Peromyscus leucopus*), and black rats (*R. rattus*; 6, 7, 9, 10). *O. bacoti* does not live on the host but infests the nest. The mite feeds on blood from the host during the day while the rodent is in its nest, and then the mite returns to the rodent nest area or to cracks and crevices in the immediate area (1, 10, 18). Diagnosis can be a challenge because the mites do not live on the host. Skin scrapings, plucked fur, and pelt examination are often negative for mites. Reports in the literature indicate that *O. bacoti* can produce anemia and reduced production of young mice in research colonies (15, 17).

In addition to the problems with rodent infestation, if this parasite gains entrance into an animal facility, it poses a significant risk for personnel working in the animal colony. Humans are bitten when there is an overabundance of mites (4). The mite is also sometimes found as a nuisance in buildings after an exterminator has removed a nest of rats from a structure (3, 8, 9, 26). To maintain an infestation of *O. bacoti,* the preferred host is required. When that host is not available, the mites will seek another warm-blooded host for a blood meal, biting people and pets such as dogs, cats, and hamsters. The mites will not remain permanently on people or colonize dog or cat fur (9, 20, 26). Besides causing the dermatitis seen in people, *O. bacoti* has been shown experimentally to transmit several human pathogens (1, 8, 10-12, 17, 23).

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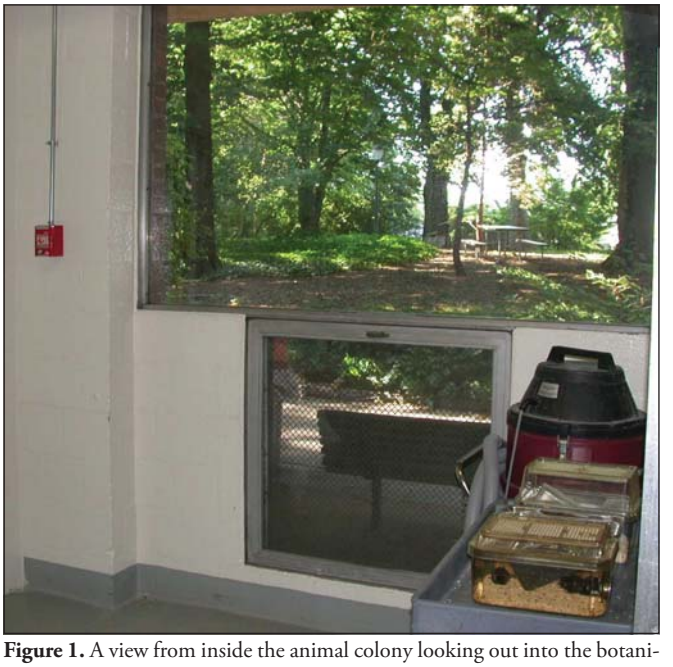

Figure 1. A view from inside the animal colony looking out into the botanical garden.

Case Report

The University of Pennsylvania Biology Department's animal research colony consists of eight rooms off a single corridor. One room houses the cage washer and is used to store caging supplies. Two small rooms are used to store food and other supplies. The remaining five rooms house animals; one small room has four rabbits, and the remaining four rooms have approximately 1200 cages of mice in total. The facility was built in 1986. Windows in the corridor look onto the botanical garden on campus (Fig. 1). All animals in the facility are on studies with protocols approved by the University of Pennsylvania's Institutional Animal Care and Use Committee. Mice are maintained in ventilated cages or static isolator cages on Betachip bedding (Northeastern Products Corp., Warrensburg, N.Y.). The colony has numerous strains of mice, including many transgenic lines. Breeding mice comprise approximately half the colony, with the other half used in experimental studies. Although there was no sentinel program at

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the time of the mite infestation, the general health of the colony was good. The mice produced healthy pups to weaning. Some of the studies included aging mice, and many cages contained mice older than 2 years. None of the strains are known to be immunodeficient. Water is provided in water bottles that are changed a minimum of once a week. Static isolator cages are changed twice a week, and ventilated cages are changed once a week. The cages are changed on an open cart by using forceps or gloved hands, which are dipped in Clidox (Pharmacal Research Labs, Naugatuck, Conn.) between each cage. All personnel entering the facility wear shoe covers, masks, head covers, and gloves. The animal care technicians wear dedicated scrubs in the facility; all others put on a disposable lab coat over their street clothes. The food is standard rodent chow provided ad libitum. The diets include Purina mouse diet 5010 and Purina mouse diet 5015 supplied by Animal Specialties and Provisions, LLC (Quakertown, Pa.). None of the personnel entering the facility were known to have pet rodents at home. The University's training program advises all personnel entering rodent colonies about the risk of transmitting rodent pathogens to the colony from rodents at home. Personnel are encouraged not to keep pet rodents at home.

In the fall of 2001, pruritic red papules developed on the skin of all three animal care technicians and on > 50% of the research personnel entering the facility. Bites from this mite are described as nonspecific, with pruritis being the most consistent feature (4, 11). The bites resemble flea or mosquito bites (11). Fall is the time of year when many arthropods are at their highest numbers. In August, when the pruritis was first noticed, there could have been many causes of skin irritation. Differential diagnoses included fleas, scabies, chigger bites, several species of mites, human lice, bedbugs, viruses such as chicken pox, neurodermatitis, and drug allergies (5). Originally the dermatitis was attributed to allergens contacted from sources other than the university, and the animal colony was not considered a source for the dermatitis.

Six weeks after the initial case of skin irritation, an animal care technician noticed small mites moving on the mouse cage racks. Insect sticky traps were put on the racks, and mites were collected. When cages were examined closely, the mites were found crawling on the filter tops of at least one cage on every rack. It was assumed that the mites had infested the entire colony. In two cases, family members of personnel that had either been in the animal colony or to the break area just outside of the colony developed pruritic dermatitis, which led to excoriation of the skin. The mice and rabbits in the colony did not show any indication of skin problems. No mites were found when a few select, culled mice were examined under a dissecting microscope.

A definitive diagnosis of *O. bacoti* was made by the United States Department of Agriculture (USDA) Systematic Entomology Lab (27; Fig. 2). Mites sent to the USDA lab for identification were collected from the filter tops of mouse cages and preserved in 90% ethanol. It is difficult to definitively identify mites because of the subtle differences between common zoonotic mites, which include the house mouse mite (*Liponyssoides sanguineus*), tropical rat mite (*O. bacoti*), northern fowl mite (*O. sylviarum*), and tropical fowl mite (*O. bursa*). Identification usually is accomplished by sending specimens to a mite taxonomist at a governmental or academic entomologic laboratory (26). Identification is made by microscopic examination. *O. bacoti* ranges in length from 0.55 mm in immature stages to 1.4 mm for engorged adult females (3, 9, 14). The mite is identified taxonomically by a narrow dorsal plate with long, serrate setae (hair-like structures); three pairs of setae on the sternal plate, and a genital shield that narrows to a point posteriorly (14, 26).

A number of the mice in the colony were in the middle of a long-term learning study that would last at least another year. The

Figure 2. *Ornithonyssus bacoti* collected from filter tops in the colony. The engorged female mites are 1 to 1.4 mm in length.

investigators were very reluctant to use any type of insecticide on the mice because of the possibility that insecticide use could alter experimental results. Following the advice of an exterminator, the facility decided to try to eliminate the mites with a thorough cleaning, in view of the fact that the mites do not live on the mice but only come to feed when the animals are in their nest. A foaming machine with Clidox was used to clean the facility and racks. Everything, including racks of mice in their cages, was removed from the room. The entire room including the floor, walls, and ceiling was coated with Clidox foam. An empty rack then was put into the room and foamed. A person outside the room used forceps to remove mice from their cage and deposited them in a clean cage on a cart (which had been foamed) inside the cleaned room. A second person, who was in the room, put the cage on the rack. All cages, wire bars, filter tops, and water bottles were cleaned in a cage washer with a sanitization cycle before mice were transferred into them in the cleaned room. The same procedures were followed for the single room housing the four rabbits in the colony.

Despite the colony cleaning, animal care staff showed new signs of dermatitis in 2 weeks. In addition, mites were seen on the racks 2 weeks after the Clidox cleaning. When the pruritis returned, the animal care staff understandably was reluctant to enter the animal colony.

Many insecticides were considered to eliminate the mites. Insecticides that interrupt neurotransmission in insects such as pyrethrins, pyrethroids, and ivermectin, which have been used for many years, as well as more recent products, including fipronil and imidacloprid (19, 25, 28), were explored. Cholinesterase inhibitors including organophosphates as well as carbamates were considered too toxic to use on the mice. Growth regulators, such as methoprene and lufenuron, also were considered as possible treatments.

After considering the options for insecticide control, the investigators and laboratory animal veterinary staff decided that permethrin-impregnated cotton balls (7.4% permethrin by weight; Mite Arrest, EcoHealth, Inc., Boston, Mass.) were the safest option for use on experimental mice. Permethrin has a long history of use in mammals to control insect and arachnid pests, and it has a very wide margin of safety (28). No mites were observed in the rabbit room, but to prevent the rabbits from maintaining the infestation, they were treated weekly with an organic pyrethrin dust, which consisted of a powdered preparation of *Chrysanthemum* sp. flowers.

When the permethrin cotton balls were first put into the mouse cages, they appeared to repel the mites from the mouse cages, and large numbers of mites were seen crawling the walls in the facility. A

commercial exterminator was contacted immediately, and he sprayed the facility with a pyrethrin spray (Microcare CS, Controlled Release; pyrethrin concentration, 1.1%; Whitmire Micro-Gen Research Laboratories, Inc., St. Louis, Mo.) over the course of two evenings. On the first night, the racks of mice were moved into the hallways while the rooms were sprayed. The next night, the remaining rooms and hallways were emptied and sprayed. After the spraying, no more mites were noticed in the colony. The permethrin cotton balls were kept in the cages for 8 weeks. Each time a cage was changed, a new treated cotton ball was put into it. The rabbits were dusted weekly for the entire 8 weeks. Because *O. bacoti* has a developmental stage that can survive 6 to 7 weeks without feeding, an 8-week treatment was considered essential to make sure no mites would be viable afterwards (9, 24). The 8-week treatment appears to have eliminated *O. bacoti* from the colony. The colony has not been treated again, no tropical rat mites have been found, and personnel have not had any pruritis during the past 3 years.

The animal colony did not have a sentinel rodent program at the time of the outbreak. After this infestation, a sentinel program was instituted in which every quarter, a sentinel mouse from each side of a mouse cage rack is examined for evidence of pathogens. A cage with two sentinel mice is present on each side of a rack; the mice have dirty bedding added to their cage from all cages on that side of a rack during the cage change cycle each week. In addition, insect sticky boards are maintained on the mouse cage racks to monitor arthropod activity in the colony. The boards are examined visually on the racks once a month. The mites are obvious in the traps where they stick to the edges of the glue line. They can be seen without any magnification when they are engorged with blood. When the mites initially were discovered on the traps, only two or three were seen on a trap. Once a year live mice are sent to a commercial testing laboratory for a comprehensive diagnostic evaluation, including serologic, bacteriologic, parasitologic, and pathologic screens for mouse pathogens. For each of the remaining three quarters, blood is collected and sent to a commercial laboratory for an expanded serology panel to determine whether the mice have been exposed to the more-common mouse viruses. Laboratory animal diagnostic division staff members examine the pelt and cecum under a dissecting microscope to check for external and internal parasites.

Discussion

Published manuscripts from 1946 through 1987 indicate that a tropical rat mite infestation in a rodent facility can create health problems for the rodents as well as the personnel entering the colony (11, 13, 15, 17, 22). In mice, *O. bacoti* infestations have been shown to cause anemia, deaths due to chronic blood loss, and reduced production of litters (13, 15, 17, 22). In our experience, the mite was much more of a pest for the people entering the colony than for the rodents. Approximately half of the mice in the colony are used for breeding, and there was no noticeable reduction in the number of pups weaned during the infestation or treatment. Animal care technicians suffered from severe dermatitis caused from the bites of the mites, without a visible effect on the mice in the colony. There are many reports in the literature describing the dermatitis in people caused by the mite (3, 4, 8, 9, 11, 23, 26). The bites are nonspecific, with pruritis as the most consistent feature. Lesions may be vesicular, urticarial, eczematous or a combination (4). Bites are often grouped together, frequently in a linear pattern (3, 11, 23). Bites occur on the extremeties, neck, and trunk, particularly around the waist (3, 4, 8, 9, 11, 23, 26). Secondary lesions in this infestation were due to excoriation.

In experimental studies in the laboratory, the mite is implicated as vector for several human diseases, including murine typhus, scrub typhus, endemic typhus, plague, Q fever, rickettsial pox, tularemia, Coxsackie virus, Eastern and Western equine encephalitides, and Langat virus. These agents have been shown to be transmitted during experimental infection, but there has been no evidence to indicate that this occurs naturally (1, 5, 8, 10-12, 17, 23). Even though there has been no proven natural disease transmission by *O. bacoti*, it is important to eliminate this parasite as quickly as possible. It caused extreme discomfort to the personnel working in the vivarium as well as a few people associated with the personnel. When ectoparasites enter an animal colony, it is important to consider the health of the personnel working in the vivarium along with the welfare of the animals.

Investigators initially were opposed to insecticide use on the mice in the colony. Cleaning the facility was unsuccessful in removing parasitic mites. Even though the mites do not live on their host, when 1200 cages containing as many as 10 mice per cage are transferred, it is reasonable to expect that enough mites are transferred on mice to maintain the infestation. The University does have an Occupational Health Program, although they were not consulted in this infestation. The investigators and University Laboratory Animal Resources wanted to permanently eliminate the mite as quickly as possible. As soon as it was determined that the cleaning did not eliminate the mite, the investigators and animal resources veterinarian determined that an insecticide treatment would be necessary.

The selection of an insecticide to use during an infestation of mites must be made in conjunction with the investigators using the research animals. In this case, pyrethrin, a botanical-based insecticide with a large margin of safety in mammals, was used (28). Whereas pyrethrins break down quickly in the environment with exposure to air and sunlight, the synthetic analogs (e.g., permethrin) are stable for long periods of time. Pyrethrins are a natural product that slow the closing of the sodium activation gate. This prevents repolarization, leading to disruption of normal nerve conduction (28). The mechanism of toxicity is the same for insects and mammals, but the insect's nervous system is 1000 times more sensitive to this effect (28). The margin of safety is much greater for pyrethrins, which have a selectivity ratio of 1000, versus other classes of insecticides, which typically have ratios of < 100 and sometimes as low as 10 (28). A discussion with investigators indicated that the insecticide treatment did not alter the reproduction of the mice or significantly alter experimental results during the 8-week treatment.

There are 50 species of mites capable of causing lesions in people (5). The entomologist from the USDA Systematic Entomology Lab indicated that there are records of *O. bacoti* on *Peromyscus* from Maryland and West Virginia, although he was not aware of any published reports of this mite in the Philadelphia area. In an urban setting, commensal rats (*Rattus*) are the most common hosts (21). There are two probable sources of this infestation. The first is research mice brought into the facility that had been left in open cages on a loading dock on campus, and the second source is wild rodents entering the building from the surrounding botanical garden. Commercial exterminators have increased the use of traps to keep the rat population as low as possible around the vivarium. Almost no rats are caught in the traps, although dead rats occasionally are seen in the botanical garden, which surrounds the animal colony wing on three sides. No wild rats from the vicinity have been examined for the presence of mites. Open cages of mice are no longer left on loading docks. There has been no change in the protective wear that personnel put on when they enter the facility. Lab coats still are used, and do allow exposure of pant legs, but the mites have not returned in more than 3 years.

Animal colonies need to be protected from feral rodents in the surrounding area, which may carry pathogens. Possible mechanisms

to prevent entry include transporting rodents between buildings on campus in cages or shipping boxes with filters to prevent the entry of pathogens. Containers with rodents should not be left unattended on loading docks; they need to be kept in a protected area until the carrier arrives to pick up the transport containers. Good pest control in the animal colony and the area surrounding buildings is essential to maintain clean rodent colonies.

Despite reports in August of skin irritation in a graduate student and in one animal care technician 6 weeks later, the cause of the dermatitis was not determined until the beginning of November. By that time, the remaining two animal care technicians had developed dermatitis, and one of them noticed the mites on the mouse cage racks in the research animal colony. It is possible that even a sentinel program might not have detected an infestation in the rodent colony. Examination of the pelts of representative mice from the colony, under a dissecting microscope, did not reveal any mites. Insect monitoring sticky traps can be a useful adjunct for monitoring the environment in an animal facility. The animal care technicians are the first line of detection in many types of disease outbreaks. As such these staff members should be an integral part of the team for maintaining the health of experimental animals.

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