ERADICATION OF A TROPICAL RAT MITE (ORNITHONYSSUS BACOTI) INFESTATION FROM A CAPTIVE COLONY OF ENDANGERED AMARGOSA VOLES (MICROTUS CALIFORNICUS SCIRPENSIS)

Sarah Mantovani, D.V.M., Nora Allan, M.S., Risa Pesapane, M.S., Laurie Brignolo, D.V.M., and Janet Foley, D.V.M., Ph.D.

Abstract: Staff at a university laboratory responsible for management of a captive insurance colony of endangered Amargosa voles (Microtus californicus scirpensis) discovered an outbreak of tropical rat mites (Ornithonyssus bacoti) infesting 106 voles. This bloodsucking mesostigmatid mite typically occurs in laboratory settings and can cause weight loss, wounds, or other negative impacts on health. The source of the infestation was likely feral rodents, and the route was suspected to be straw bedding. Twenty-nine of the 106 (27.4%) infested voles developed ulcerated dorsal skin lesions that resolved when treated with topical selamectin. A triad approach was implemented to eradicate the mites, consisting of environmental management, individual animal treatment, and training. Voles were moved individually into a clean room containing only autoclaved materials (including straw), cages were treated with permethrin-impregnated cotton, treatment order was instituted to avoid transferring mites, and voles coming from outside were quarantined. All animals in an infested room were treated with topical selamectin, and personnel were trained on risks and new procedures. No adverse effects from the use of selamectin were identified, and this efficient protocol does not require the long-term use of acaricides. This report documents infestation of an endangered rodent with an exotic parasite, safe use of permethrin and selamectin in this species, and comprehensive management to manage a large infestation.

Key words: Amargosa vole, captive wildlife, Microtus californicus scirpensis, Ornithonyssus bacoti, selamectin, tropical rat mite.

BRIEF COMMUNICATION

Captive wild animals are at risk for infectious disease not seen in their natural habitat.2,22 An important parasite of rodents in laboratory settings is the tropical rat mite (Ornithonyssus bacoti).16 This bloodsucking mesostigmatid mite will parasitize many species, including humans, and carries numerous pathogens in nature or following experimental infection.1,4,5,7–9,11,13,17,18,20–22,26,27 Control is complicated because of its rapid development, high fecundity, prolonged off-host survival, and ability to travel a 100 m to find a host.14,25

This report describes rat mite infestation in a captive colony of endangered Amargosa voles (Microtus californicus scirpensis) in northern California. This rodent is state and federally listed as endangered24 and found in nature only in marshes in the Mojave Desert.12 The captive breeding program is an insurance colony (against the possibility that the species could go extinct in the wild) and a source for reintroduction into the wild. Sources of mites into the colony were investigated, and the mites eradicated by using a triad approach, incorporating environmental decontamination, acaricides, and personnel training.

The approximately 100 vole captive breeding colony was established with 20 wild-caught voles in 2014 and supplemented with 12 voles in spring 2016. There were 74 voles in captivity at the time the outbreak was detected. Indoor housing in a restricted access building consisted of three rooms designated rooms 2, 3, and 8. Staff entered into a common entryway, where they put on shoe covers, proceeded through a common hallway, and then accessed animal rooms, placing a second pair of shoe covers over the shoes upon entry. Each room had a door to the outside reserved for materials to be autoclaved or trash. A microbiologic barrier cage in each room contained four mice as sentinels for disease or parasites circulating in the room. Outdoor housing consisted of mesocosms in pens in a nearby field. The pens were lined with fine mesh wire cloth to prevent...
wild rodent incursion, although house mice were occasionally detected inside pens. Mesocosms were plastic planters (140 ×102 × 63.5 cm) filled with commercial potting soil and planted with three-square bulrush (Schoenoplectus americanus), the only food item used by voles in the wild.

Voles from the wild were quarantined for 2 wk and then subject to monthly health checks. As weak pathogens were tolerated to allow animals to retain alleles to combat pathogens when released in the wild, protocols did not include routine antiparasite treatment. After quarantine, voles were maintained singly, in sibling groups, or in mated pairs in polycarbonate isolator cages with a wire top or in outside mesocosms. Water was provided in a bowl, and rodent chow was placed loose inside the enclosure. Wheat or rice straw from a local feed store was stored in a bin and used to fill cages 10 cm deep. Cages were spot cleaned daily, soiled straw was replaced, and voles were fed and watered. Cages were washed monthly in an industrial washer, rinsed at 82°C and autoclaved at 121°C for 30 min.

In January 2015, the care team first detected skin lesions in room 2 on voles’ cervical and scapular regions, followed by lesions in room 3 in March, and in outside housing in September 2016. A total of 106 voles were documented infested with rat mites, with 187 separate mite detections (with some animals being diagnosed more than once, Fig. 1). The last case was the single-known infested outdoor vole and detected more than once, Fig. 1). The last case was the single-known infested outdoor vole and detected months after eradication had occurred indoors. This vole was placed outside in February 2016, showed no disease during monthly health checks, and was found dead with heavy tropical rat mite infestation. Necropsy revealed mild pneumonia, cardiomyopathy, and a possible portosystemic shunt.

Indoors, mites were seen frequently in cages. No mites were seen in quarantine or on sentinel mice, except after straw from contaminated vole cages was placed into the sentinel cage; infested mice did not develop skin lesions. Twenty-nine of the 106 (27.4%) infested voles had gross skin lesions that typically were round, 0.5 to 1 cm in diameter, with raised, reddened edges and central ulceration. A tissue biopsy was obtained from a characteristic lesion and revealed focal erosive and mild, diffuse ulcerative pleocellular dermatitis with lymphocytes, plasma cells and neutrophils, and mites extending into hair follicles. The lesion extended minimally into the dermis. It was not known if the mites or self-trauma caused the lesions. Voles with ulcerated lesions typically had dozens of mobile mites present along lesion edges; nevertheless, all lesions resolved within 1–2 wk of topical application of approximately 0.1 ml of 60 mg/ml selamectin (Zoetis, Parsippany, New Jersey 07005, USA). One staff person noted occasional small 1–2 mm, raised, reddened, and pruritic arthropod bites on herself but did not report them at the time (and only associated the bites with the voles after the mite was identified).

Under compound light microscopy, mites were characteristic of O. bacoti, with eight legs on an unsegmented, weakly sclerotized body, three setal pairs on the sternal shield, an anal shield with a cranially positioned anus, anteroventral keel on trochanter of pedipalp, gnathosoma with four pairs of setae, and a tritosternum. DNA from four mites was extracted by using a Qiagen blood and tissue kit (Valencia, California 91354, USA) following manufacturer’s instructions for 18S PCR and a 16S fragment by using primers 16S−1 and 16S−2. DNA sequences were searched with the Basic Local Alignment Search Tool by using the National Center for Biotechnology Information GenBank database (https://www.ncbi.nlm.nih.gov/genbank/). All 18S samples from voles were 100% the same and had 96% query coverage, with 99% homology with Ornithonyssus bursa (there were no 18S O. bacoti accessions in GenBank). The 16S fragments were also identical among vole mites and were 95% homologous over the full amplicon with O. bacoti. Representative sequences were deposited in GenBank as MF872606 for 16S and MF741975 for 18S.

Prior to May 2016, cases were managed with topical selamectin on affected animals and cage mates, bedding was replaced, and caging and other fomites washed and autoclaved. Large-scale eradication was performed after a year because of ongoing cases, bites on humans, and reports of the same species of mite in a mouse colony on the other side of the campus (approximately 5 km away).

Possible sources of mites included the original field source, movement among facilities on personnel, introduction on fomites (most plausibly the straw from the feed store), infestation of outdoor mesocosms by wild rodents, and feral mice within the animal building. Despite a perceived population increase in local feral house mice, mesocosms were considered unlikely because lesions were detected inside 2 mo prior to any voles being brought in from mesocosms. On-personnel transport was unlikely: staff denied having pet rodents or any exposure to rodents that
could be sources of infection. The only staff individuals who had visited both infested colonies were campus veterinary staff, and they were scrupulous about protocols to avoid disease transport. Mites from original field sites could not be ruled out, although tropical rat mites have never been detected during extensive trapping of Amargosa voles in the field. Feral mice occur in the animal building but have never been seen in vole rooms and mouse feces has not been detected.

Mite eradication was initiated in May 2016 in room 3 (29 voles). Surfaces of a new room were scrubbed weekly for 2 wk with germicidal detergent (Sani-Plex 128, Quip Laboratories, Wilmington, Delaware 19801, USA). The room was fogged for 10 min by using hydrogen peroxide (HaloSpray, Quip Laboratories). Materials were autoclaved at 120°C for 30 min and then not shared between rooms thereafter. Voles were treated with approximately 2.5 mg of topical selamectin once 4 days prior to moving. Two days before the move, they were placed into fresh cages with autoclaved straw inside the original room.

During the move into the clean room, staff were stationed in the building to handle cages to avoid contact with fomites. At no time did hallway or original room personnel have direct contact with the clean room. Fipronil (Merial, Duluth, Georgia 30026, USA) was sprayed on gloves, the bottom of each cage, and countertops between cages.

For the second room (30 voles), mite eradication was performed beginning 19 July 2016 by using 7.4% permethrin-impregnated cotton balls (MiteArrest, Ecohealth, Boston, Massachusetts 01841, USA) and systematic decontamination of cages and room surfaces. This method was attempted to avoid destroying commensal arthropod fauna and because of safety concerns regarding selamectin on neonatal voles. Treatment voles were placed into autoclaved cages and given 2–3 permethrin-impregnated cotton balls (that rodents should incorporate into nests), which were replaced once weekly for 8 wk. Trained staff performed animal care in cages containing permethrin before untreated, contaminated cages every day to prevent movement of mites. Treated cages were transferred to a clean room after 2.5 wk of treatment and edges of shelving dusted with 0.1% pyrethrin and 1% piperonyl butoxide (Zodiac flea powder, Wellmark, Schaumburg, Illinois 60007, USA). Success of the treatments was confirmed by thoroughly examining bedding and cage surfaces for mites and animals for mites and lesions.

Subsequent routine monitoring consisted of monthly examination of every individual for mites or lesions and indefinite quarterly submission of four voles for comprehensive necropsy (all with concurrent medical conditions warranting euthanasia). No rat mites have been found on animals since eradication, leading to the conclusion that the procedures were effective.

Staff training was conducted to ensure that any further infestations would be prevented, if possible, and detected early, if they occurred. All personnel who had contact with voles were contacted individually to review proper vole care, including room...
cleaning order and procedures for introducing supplies or voles into a room, to decrease the opportunity for future outbreaks in the colony.

A triad approach successfully eradicated *O. bacoti* from a captive population of Amargosa voles, in contrast to reports of eradication requiring multiple attempts,⁴ possibly because the mite can survive 6 mo in the environment.³ Sticky traps to monitor for off-host mites have low sensitivity³,⁵ and were not used for Amargosa voles. Lesions were unusual in their severity, possibly associated with self-trauma. Additionally, it was suspected that Amargosa voles may be inherently susceptible to severe clinical outcomes when exposed to mites, on the basis of observations that chiggers could essentially obliterate the pinnal tissue of infested wild individuals.⁴³

Both selamectin and permethrin appeared effective. Selamectin has a wide margin of safety for rodents⁴⁴ but may eradicate endoparasites and lice that was undesirable in this colony. In prior studies using permethrin, mites were observed leaving treated cages,⁴⁰,⁴² which is why this study used flea powder on the caging. Permethrin on cotton works optimally if the rodent brings the cotton into their nest, although not all voles create nests.

Tropical rat mites could be reintroduced into the colony, but straw as a fomite is now mitigated through autoclaving. Voles coming from outside mesocosms are subject to quarantine and now treated with permethrin. The triad approach (environmental decontamination, treating the animals, and personnel training) allowed for successful eradication of a serious pest in an important captive-breeding colony of endangered Amargosa voles.

**Acknowledgments:** The authors thank student care volunteers and staff of the University of California Davis Teaching and Research Animal Care Service, Dr. Deana Clifford at California Department of Fish and Wildlife as coprincipal investigator of the Amargosa vole research work, and Dr. Leslie Woods and California Animal Health and Food Safety for interpreting skin biopsies. Funding for support of the colony was provided by the Bureau of Land Management, US Fish and Wildlife Service Cooperative Endangered Species Conservation Fund Grant, and California Department of Fish and Wildlife.

**LITERATURE CITED**


Accepted for publication 13 March 2018