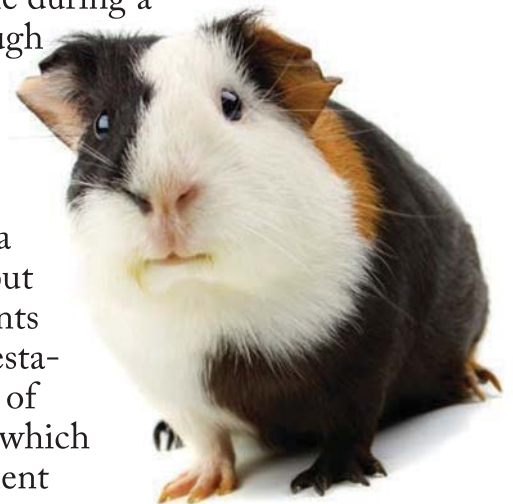


# The Clinical and Environmental Treatment of Pinworms and Their Eggs

By Kevin Lorcheim,  
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Pinworms are like potato chips, you can't have just one. The discovery of a pinworm is never an isolated incident and always the tip of the iceberg. A soiled bedding sentinel does not become infected with pinworms easily, so it's often the sign of a heavy infestation within the colony. Sentinels are usually screened at a quarterly interval, so if a pinworm infection is discovered for the first time during a screening, it could have been spreading through the colony for weeks or even months. While there are rarely clinical signs of a pinworm infection, affected animals can be unsuitable for certain studies due to more subtle effects on their immune system. Therefore, it is not a question of whether treatment is necessary, but only when it should begin and what treatments should be used. Treatment of a pinworm infestation is two-stage: that of the colony and also of the environment. Each has multiple options which must be considered before choosing a treatment plan.



Pinworms are parasites which live in the intestines of their host. There are three main pinworms which affect rodents, *Syphacia obvelata*, *Syphacia muris*, and *Aspiculuris tetraptera*. *Syphacia* females deposit embryonated eggs on the skin of the perianal region which become infective within 5-20 hours. *Aspiculuris* females deposit eggs in the

colon, which are then excreted in the feces and are not infective until 6 days later.<sup>18</sup> Pinworm eggs can persist in the environment for months outside of a host. Infection is spread when eggs are ingested directly from the perianal region of a *Syphacia* infected animal.<sup>18</sup> Transmission of infective eggs can also occur via fomite when embryonated eggs are

## Prepatent Period of Pinworm Infection

Pinworm	Egg Deposition	Infectivity Time	Prepatent Period
<i>Syphacia obvelata</i>	Perianal skin	5-20 hours	11-15 days
<i>Syphacia Muris</i>	Perianal skin	5-20 hours	8 days
<i>Aspiculuris tetraptera</i>	Colon	6 days	23 days

ingested from contaminated materials in the environment, including food and water.<sup>18</sup> Depending on the pinworm species, the prepatent period between infection and the ability to diagnose can be between 8-23 days.

## Diagnosis and Clinical Affect

Rodents infected with pinworms are generally regarded as symptomless, with no clear clinical sign to aid researchers in recognizing the infection. There are reports that describe poor hair coat, rectal prolapse, and weight loss as clinical signs of infection; however none state that definitively. Diagnosis of *Syphacia* infection is primarily accomplished by finding eggs microscopically after a perianal tape test due to the sticky nature of their eggs. *Aspicularis tetraptera* eggs are not adherent to the perianal region of the host, making other diagnostic measures necessary. Fecal flotation, fecal centrifugation concentration, anal swab tests, and more recently, PCR testing are other methods to determine the presence of pinworms including *Syphacia* spp. and *Aspicularis tetraptera*. The gold standard of pinworm diagnosis is necropsy with direct examination of the colonic and cecal contents.

While the overall consensus is that pinworm infections are symptomless, it is generally recognized that infected animals are not appropriate for critical research. Infected mice have a greater incidence of autoimmune disease<sup>12</sup> and have increased allergic response to nonparasitic antigenic stimuli.<sup>6</sup> They can have abnormal nutritional and blood values<sup>18</sup> and infected nude animals had an increase in lymphoma prevalence.<sup>3</sup> Rats infected with *Syphacia muris* had an impaired transport of water, sodium, and chloride in the intestine.<sup>19</sup>

Researchers must weigh the effect that a pinworm infection might have on their colony and study results. For some, it might be deemed necessary to treat the infected colony as soon as possible to limit the spread of infection and the effect on the study results. For other studies, it might be acceptable to quarantine the infected animals and delay treatment until the end of the study.

## Rodent Treatment

No matter when it occurs, treatment of a pinworm infection is a two-stage process. Infected animals must be treated to ensure that the infection has been stopped in the colony. The environment that the infected animals resided in must also be treated to either remove or decontaminate any infective eggs present so as to eliminate the possibility of reinfection.

Most popular treatments to eradicate pinworms in rodent colonies consist of avermectins and benzimidazoles, represented mainly by ivermectin and fenbendazole, respectively. While both have been clinically proven to rid hosts of the parasite, neither is efficacious against pinworm eggs. For treatment, ivermectin can be added to the water source or administered topically with either a micropipettor or a spray bottle.<sup>14</sup> Topical administration involves the direct handling of every infected animal, which can be both time-consuming and difficult for personnel when dealing with a large number

of infected rodents. Handling of infected animals can also spread the infestation to uninfected areas. While effective, ivermectin does have some clinical drawbacks. Rodents with compromised blood-brain barriers should not be exposed to ivermectin due to an increased mortality rate. This includes CF-1 mice, and *mdr1a* and *mdr1b* knockout mice which are deficient in P-glycoprotein, which acts as a drug transport pump across the blood-brain barrier.<sup>15,16</sup> Young mice and rats are also susceptible to its neurotoxic effects because of the post-natal blood brain barrier closure.<sup>14</sup> Ivermectin has also been shown to increase neonatal mortality<sup>13</sup> and have teratogenic effects.<sup>13,3</sup> Fenbendazole is given to infected animals through their feed. It is a relatively benign drug and has no significant effect on weight, water consumption, size of litter, or birth weight.<sup>8</sup> It has also been shown that fenbendazole does not affect behavioral studies or have teratogenic effects.<sup>8</sup>

## Environmental Treatment

The necessity of environmental treatment for pinworm and pinworm egg inactivation is dependent on several factors. While there have been some studies illustrating the eradication of pinworms from a facility without environmental treatment,<sup>1,6</sup> not all situations lend themselves to that type of treatment plan. The reasoning behind the choice to forego environmental treatment is that the clinical treatments traditionally last longer than the eggs can exist in the environ-



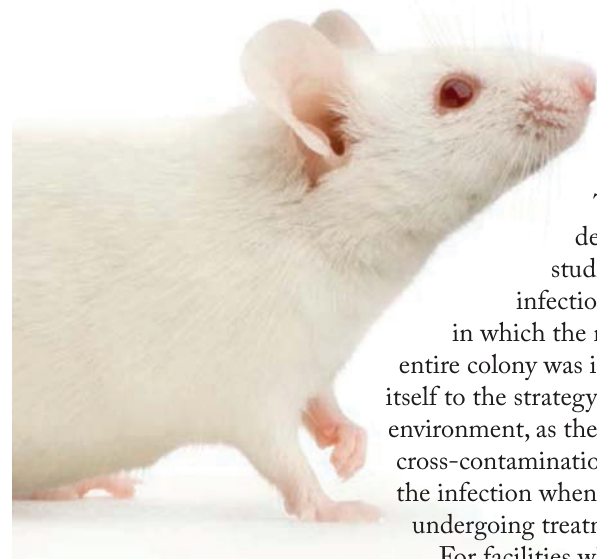
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ment, such that no infective eggs remain after the treatment schedule is complete. The infestations described in those studies were widespread infections of the colonies in which the majority if not the entire colony was infected. This lends itself to the strategy of not treating the environment, as there is no concern for cross-contamination and the spread of the infection when the entire colony is undergoing treatment.

For facilities where there is a concern of spreading the pinworm infection, treating the infected rodents is not enough as pinworm eggs have been found on equipment, shelving, in dust, and in ventilation air intake ducts.<sup>4,5</sup> This makes them easily transferable and makes their removal and inactivation that much more important. Pinworm eggs are resistant to most chemical disinfectants and some facilities resort to a physical removal step instead of inactivation. This can be done by wiping or vacuuming the area in hope of removing them all. As pinworm eggs are microscopic and get into difficult to reach areas, spot cleaning is not ideal as it would be very difficult to prove that all have been removed. Treating the entire space with a proven method of inactivation becomes the only way to ensure that all eggs have been inactivated.

There are three methods currently proven to eliminate pinworms and pinworm eggs, and that is dry heat, ethylene

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oxide, and chlorine dioxide gas fumigation. Temperatures of 212°F for 30 minutes have been shown to eliminate 100% of *Syphacia muris* eggs.<sup>2</sup> The same study showed that 1,200 mg/L of ethylene oxide gas held for 12 hours also resulted in a 100% elimination of *Syphacia muris* eggs.<sup>2</sup> A 2012 study from the University of Tennessee—Knoxville has shown that

1 mg/L of chlorine dioxide gas held for 4 hours resulted in a 100% elimination of *Syphacia* spp. eggs.<sup>20</sup> While all three methods of treating the environment are proven to work, it is hard to safely and effectively perform the dry heat and ethylene oxide methods. In order for the dry heat method to work, all materials within a room contaminated with

pinworm eggs must be brought up to 212°F and held at that temperature for 30 minutes. This can be extremely difficult due to the many materials, densities, organic materials, air currents, and other heat sinks within the room which would prevent a uniform temperature of 212°F throughout a space. That high heat can also affect various components within a room, meaning some temperature sensitive materials and items would need to be removed and treated separately. Ethylene oxide is an effective fumigant which is able to penetrate into and through many materials due to its small particle size. It is registered as a sterilant with the US EPA, able to kill all viruses, bacteria, fungi, and spores. It is rarely used for space fumigation due to its risk of explosion, its carcinogenicity, and its difficulty to contain. Chlorine dioxide gas is a common space fumigant within the life science industry. It is registered as a sterilant with the US EPA, able to kill all viruses, bacteria, fungi, and spores. It has also been shown to be effective against protozoa<sup>9,17,21,11</sup> and inactivate beta lactams.<sup>10</sup> Chlorine dioxide gas does not have the explosion risk or carcinogenicity that ethylene oxide does, and is easier to contain. This makes fumigation of an animal holding room for the environmental treatment of pinworms possible.

## Conclusion

Pinworm infestations are common within the life science industry due to the heartiness and transferability of their eggs. The infection's effect on rodents is limited but substantial enough that treatment is warranted in most cases as it can compromise their immune system and affect study results. Due to the prevalence of the pinworm infection, treatment options for rodents are readily available and well documented for both their efficacy and their effect on rodents. Their efficacy falls short of inactivating pinworm eggs, and the eggs ability to survive for weeks outside of a host makes environmental treatment a necessity for some facilities. As eggs have been found in a multitude of locations within a facility and are too small to see, methods of removal are not viable. As such, methods which treat the entire space must be used in order to ensure that all pinworm eggs have been inactivated such that the infection cannot spread further. As of now, that includes dry heat, ethylene oxide, and chlorine dioxide gas. Chlorine dioxide gas is in the best position to effectively and fully treat a space, as dry heat and ethylene oxide both have drawbacks which limit their use and efficacy in a room setting. By adding an environmental treatment plan to an existing rodent treatment plan, it ensures the complete eradication of the problem and eliminates the possibility of the infestation manifesting itself in other areas of the facility from transfer of the eggs.

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