Received: 17 March 2025 | Revised: 20 November 2025 | Accepted: 4 December 2025

DOI: 10.1002/vrc2.70317

Vet Record CaseReports

CASE REPORT

Horses and other equids

Control of *Bovicola equi* infestation in a herd of horses using an environmentally sustainable treatment protocol

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Abstract

In March 2024, a Slovenian warmblood gelding presented with severe pruritus and skin lesions throughout its head, neck and around the base of the tail. The owners had observed increased pruritus in multiple animals within the herd. After careful examination, *Bovicola equi* were found in all five horses, but not the pony. Horse owners requested an environmentally sustainable treatment plan, which consisted of (a) mechanical removal of lice by shaving and/or combing, (b) application of 0.2 g/horse (0.1 g/pony) neem extract, geraniol (0.5 g/horse, 0.25 g/pony) and diatomaceous earth (250 g/horse, 50 g/pony). Clinical signs ceased 1 week after the initial treatment, no lice were found after 3 weeks, and skin lesions resolved within 6 weeks. Although there was no control group to estimate the true efficiency of the described treatment, upon follow-up, all horses remained lice-free for at least 18 months after the last treatment.

KEYWORDS

Bovicola equi, diatomaceous earth, geraniol, horses, natural treatment, neem extract

BACKGROUND

Pruritus in horses can be caused by several factors, with ectoparasites being the most common.[1] During winter and early spring, lice infestations are often the aetiology.[2–4] Lice are obligatory host-specific parasites that cause equine pediculosis. Two louse species are known to infest horses: the sucking louse *Haematopinus asini* and the chewing louse *Bovicola equi* (syn. *Werneckiella equi*, *Damalinia equi*, *Trichodectes parumpilosus*). *B. equi*, from the suborder Ischnocera, is easily distinguished from *H. asini*, from the suborder Anoplura. The sucking louse has a long, pointed head narrower than the prothorax with piercing mouthparts not seen externally, while *B. equi* has a round, broad head wider than the prothorax with chewing mouthparts on the ventral side.[3,4] The latter feeds on the outer layers of the hair shafts and has a worldwide distribution.[4] Although not always clinically noticeable, chewing lice can cause restlessness, severe pruritus and intense rubbing, resulting in patchy alopecia, rough coat, scaling, crusting, secondary skin infections and weight loss.[3–6] The areas affected are typically the head, neck/mane and dorsolateral trunk.[6–8] Combing with a fine-toothed comb is generally effective at revealing subclinical or clinical infestations; however, it is time-consuming and not regularly practised by horse owners. Consequently, lice infestations can easily go unnoticed.[6,8] Several insecticides registered for use on horses and other animal species, such as neonicotinoids (imidacloprid), organophosphates (phoxim) and various pyrethroids, as well as insect growth regulators, have been used for treating lice on horses for many years with good efficacy and safety.[3,5,9–12] However, none are registered for use in horses in Europe; they usually require a veterinary prescription, and the horse needs to be observed for possible side effects. In addition, these compounds can have undesirable effects on the environment.[13–18] Growing concerns about environmental effects are changing treatment decisions toward the use of more sustainable alternatives, such as the use of herbal formulations, neem tree *(Azadirachta indica)* extracts and diatomaceous earth.[8,19–30] However, little efficacy data are available for these alternative treatments.

This case report describes a clinical presentation of *B. equi* infestation in a herd of horses before and after treatment following the use of environmentally sustainable products.

CASE PRESENTATION

In March 2024, an 18-year-old Slovenian warmblood gelding presented with a history of severe pruritus. The horse was part of a herd of five horses and one mini pony that were maintained in an open stable Paddock Paradise track system, with ad libitum wet hay in slow feeder nets.[31] The barn was part

of an environmentally friendly family farm located in central Slovenia. Seven sheep, three ducks, 10 chickens, a cat and a dog were also kept on the farm. The farm owners reported that almost all horses were rubbing more than usual, and the frequency of rubbing in all animals had been increasing over the previous 2 weeks. Horses had no contact with other horses outside their herd for over 1.5 years. The tack and equipment of each horse were not shared between horses within or outside of the herd.

INVESTIGATIONS

In addition to a basic clinical examination, the coats of all horses in the herd were examined thoroughly; hair samples, skin scrapings and adhesive tape samples were taken from the five horses with dermatological lesions (Table 1). Skin scrapings were taken from the periphery of several locations where the skin was most affected. Adhesive tape samples were taken from around the perianal area to detect *Oxyuris equi* eggs. Horse 1 (H1) had a rugged coat with broken hair and areas of alopecia and scaling around the head, neck and base of the tail (Figure 1a–c). Horse 2 (H2) had areas of alopecia on both caudal gaskin areas (approximately 10 × 10 cm). Horse 3 (H3) had a large hairless and crusted patch (approximately 15 × 20 cm) on the caudal gaskin of the left hind leg (Figure 1d). Horse 4 (H4) had two hairless spots (2 × 3 cm) under the mane on both sides of the upper third of the neck, while horse 5 (H5) had a 2 × 2 cm hairless spot with scaling on the neck behind the left ear (Figure 1e). The Mini Shetland pony (P) had no dermatological lesions. All horses, except for H5, had a mild to severe pruritus (Table 1). On careful examination of the coat where skin lesions were present, 2 mm long yellow-to-brown moving parasites were noticed. With a fine-toothed comb, several lice and their eggs were collected (Figure 2c). Under light and fluorescence microscopy, eggs and associated parasites were examined (Figure 2b,d,e). Based on morphological differences to *H. asini* (Figure 2a) and clinical features,[4,32] a definitive diagnosis of pediculosis due to the chewing louse *B. equi* was made. *B. equi* were recovered from H1–H5, but not from P. Skin scrapings and adhesive tape samples were all negative for other ectoparasites or pinworms. Clinical observations and areas where most specimens of *B. equi* were recovered for each horse are shown in Table 1.

LEARNING POINTS/TAKE-HOME MESSAGES

- Chewing lice can apparently establish in a herd of horses that do not interact with outside horses or share equipment.
- Depending on national regulations, treatment options are often limited to off-label use of therapeutics.
- Environmentally sustainable treatment options are available, and although labour-intensive, they may be associated with complete resolution of clinical signs.
- Further optimisation of environmentally sustainable protocols to treat ectoparasite infestations in horses is required to determine their true efficacy and sustainability.

TREATMENT

After confirmation of the diagnosis in H1–H5, a treatment plan was designed to clear the herd of the *B. equi* infestations. A sunny, warm day with a daytime temperature of 20°C was chosen for the occasion. Before treatment, all horses were combed over their entire coat with a fine-toothed comb for up to 1 hour each. To allow good contact of compounds with the lice, three horses were shaved (Figure 3a); the most severely affected (H1) and the two horses with the longest and most dense hair coats (H4 and H6). For anti-louse treatment we chose: approximately 50 mL/horse (25 mL/pony) of shampoo containing neem extract (Canina Verminex shampoo, Petvital, Canina Pharma) at a concentration of 5 g/L (0.2 g neem extract/horse, 0.1 g neem extract/pony), sprayed with approximately 100 mL/horse (50 mL/pony) of geraniol (Reudanon Konzentrat, Arthur Schopf Hygiene; concentrate: 30 g geraniol/L in a water/paraffin mixture) diluted 1:5 with tap water and with a resultant concentration of 5 g/L (0.5 g geraniol/horse, 0.25 g geraniol/pony), and approximately 250 g/horse (50 g/pony) of dry powder food grade diatomaceous earth (Diatomea, Agro Support) with 100% amorphous silicon dioxide. Supportive treatment with a horse coat conditioner (The Original Mane 'n Tail Conditioner, Straight Arrow Products) was also applied. The protocol was as follows:

TABLE 1 General information and clinical observations for a *Bovicola equi*-infested herd of horses.

Animal	Breed	Age (years)	Sex	*B. equi* recovered	Predilection sites of *B. equi*	Dermatological lesions	Pruritus
H1	Slovenian warmblood	18	Gelding	Yes	Head, neck, shoulders	Head, neck, shoulders, buttocks, base of tail	Severe
H2	Arabian	22	Gelding	Yes	Back	Left and right gaskin	Moderate
H3	Crossbreed	18	Mare	Yes	Mane, neck, back	Left gaskin	Moderate to severe
H4	Islandic horse	18	Mare	Yes	Rump	Upper neck, both sides	Mild
H5	Oldenburg	9	Mare	Yes	Mane, behind the ears	Behind left ear	None
P1	Mini Shetland pony	14	Mare	No	/	None	Mild

FIGURE 1 Mild to severe dermatological lesions in a herd of horses infested with *Bovicola equi*: (a) base of neck (Horse 1), (b) buttock and base of the tail (Horse 1), (c) around the base of the left ear (Horse 1), (d) left caudal gaskin (Horse 3), and (e) behind the left ear (Horse 5).

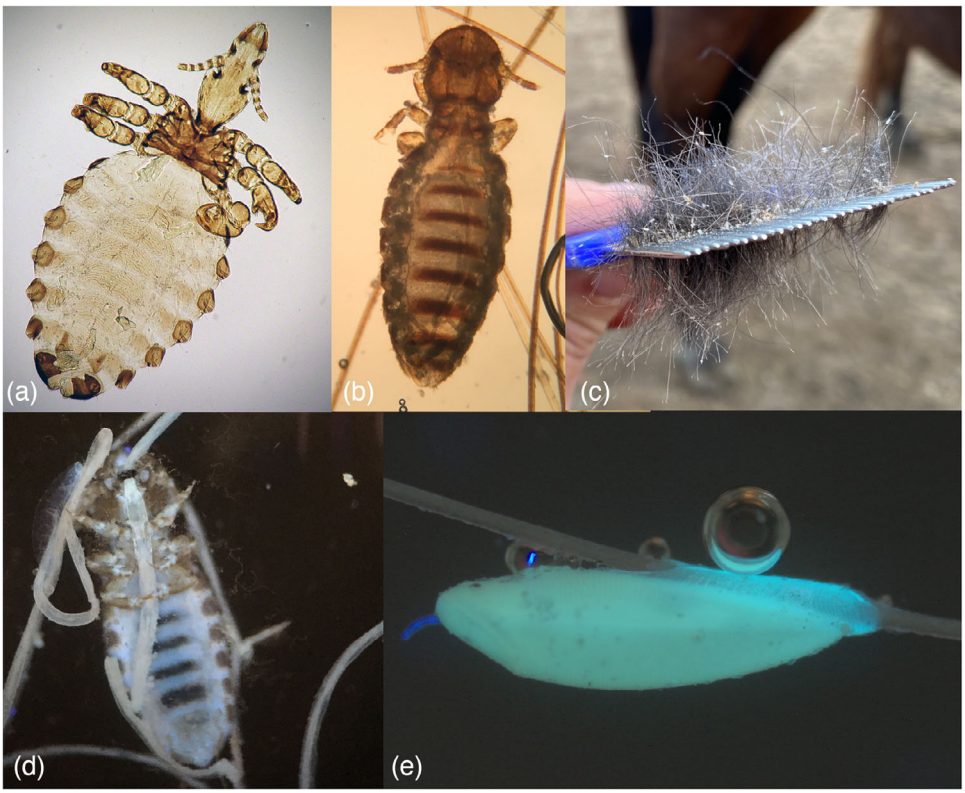

FIGURE 2 Horse lice. (a) A mounted *Haematopinus asini* (size 3.5 mm) with a head narrower than the prothorax under light microscopy (photo courtesy of Araceli Lucio-Forster). (b–e) *Bovicola equi* from present report: (b) dorsal aspect of an adult louse (size 2 mm) with the broad, round head wider than the prothorax under light microscopy; (c) collection of adult lice and eggs with a louse comb; (d) ventral aspect of an adult louse with chewing mouthparts under fluorescent microscopy; (e) louse egg glued on a horsehair under fluorescence microscopy.

FIGURE 3 Treatment and follow-up of the horse most infested with *Bovicola equi* with an environmentally friendly protocol: (a) complete body shaving, (b) washing a horse with a neem-based shampoo, (c) application of diatomaceous earth, (d) 1 month after the start of treatment.

1. Use a water hose to wet the horse entirely.
2. Apply the shampoo with neem extract and let it stay in situ for 5–10 minutes (Figure 3b).
3. Rinse the shampoo off the animal with the water hose.
4. Apply the coat conditioner for 5 minutes.
5. Rinse the conditioner off the horse with the water hose and let the coat dry.
6. Spray a 1:5 dilution of geraniol all over the animal with a hand spray and let the coat dry completely.
7. Apply diatomaceous earth all over the animal by hand, especially at predilection sites where most lice were found (Table 1), avoiding eyes and nostrils (Figure 3c).

Throughout the treatment, all people handling the horses wore gloves. During the application of diatomaceous earth, a face mask was worn. Following the initial treatment day, combing the mane and coat with the application of diatomaceous earth on louse predilection sites for each horse (Table 1) was repeated at 3–4-day intervals for the first 2 weeks, and thereafter at weekly intervals until no lice (live or dead) were found for three consecutive weekly combings. After the initial treatment, the application of diatomaceous earth was facilitated with a saltshaker. For the mane, diatomaceous earth was applied meticulously on the skin and hairline. When treatment started, all the brushes for self-scratching placed throughout the barn were removed and replaced 3 weeks later with new easy-to-clean rubber scratching pads (Equine Bovine Massage Brush Kit, Tefola). Grooming equipment of each animal was washed and treated once with 20 mL of neem extract shampoo (Canina Verminex shampoo Petvital) per litre of water in 5–10 L buckets for 30 minutes before rinsing with a water hose and air dried.

OUTCOME AND FOLLOW-UP

The pruritus resolved in all affected animals within the first few days following initiation of treatment, while dermatological lesions took 3–4 weeks to resolve. The treatment finished 3–6 weeks (mean 4.3 weeks, median 4 weeks) after the initial treatment (Figure 3d). No clinical signs of pruritus or alopecia were noticed for 18 months following treatment.

DISCUSSION

During the grazing season, hypersensitivity skin lesions and increased itchiness in response to bites from various families of the order Diptera (e.g., Cerapopogonidae, Tabanidae, Culicidae) are common in horses.[1,33] During winter and early spring, sucking or chewing lice infestations are typically the most common ectoparasite issue.[2–4] However, treatment options for lice infestations in horses are scarce and challenging. In the case described here, infestation of a small herd of horses with *B. equi* was controlled using an environmentally sustainable treatment protocol, applying shampoos and biocides instead of off-label use of veterinary products registered for other animal species, such as neonicotinoids, fiproles or pyrethroids.[3,5,9–12] Clinical observations after repeated treatment were of complete and long-term resolution of the clinical signs and absence of lice.

The infestation described was diagnosed in early March, towards the end of the winter season. Horses were boarded in an open stable and free to go in and out all day, all year round. However, in autumn and winter, they preferred to be inside the stall during the long, cold nights, spending more time inside than in spring and summer. The reduced exposure to UV light, the higher humidity in the stable and the increased direct contact between the animals likely favoured the occurrence of heavier infestation with clinical signs during the winter.[3,4] The herd infestation appeared to be unevenly distributed, as has been previously described.[5,9,34] The origin of this infestation is unclear. Lice are wingless insects, and their transfer between individuals primarily takes place by direct contact or by shared equipment.[4,35] Some flies, such as *Haematobia irritans* or hippoboscid flies, may serve as transport hosts and could play a

role in the dispersion of chewing lice.[4,35–37] In our case, no horse had left or entered the barn for at least 18 months before the initial diagnosis. The last two horses that were introduced to the herd were the Arabian gelding (H2), 18 months earlier, and the Oldenburg mare (H5), 3 years earlier; neither showed signs that suggested a louse infestation at the time of their introduction to the herd. However, at the previous location of H5, a severe *B. equi* infestation occurred in another horse within a month following relocation of H5 to the property described here. Consequently, H5 was checked for lice at that time, but none were found.

Adult chewing lice live for approximately 1 month, and females typically lay one egg per day, which is individually attached to hair shafts.[4] The eggs, glued firmly with a cement-like cylinder on the base of hair shafts,[38] hatch within 5–10 days to release a nymph.[6,39] The nymph then moults three times in 2 weeks before becoming an adult. Thus, the egg-to-egg cycle is approximately 3–4 weeks.[4–6] As a *B. equi* population is commonly comprised of 99% female lice, adult females are conveniently parthenogenic.[4,6–8] Thus, one remaining louse would be sufficient to establish an infestation. And although a louse infestation can go undetected for a long time,[3] 3 years as indicated in the present case appears unlikely, but possible. Another possibility, although rare and highly unlikely, is the introduction of chewing lice from spatially more distant animals by phoretic flies,[4,35–37] as there was an open barn with horses reared for meat production less than 100 m away from the herd described here.

Irrespective of the source of *B. equi*, a treatment plan was required for the affected farm. The lack of registered therapeutics for horses in the European Union makes it difficult for equine veterinarians to put effective control measures into place.[40] Previous studies have described several effective chemical insecticides for the treatment of *B. equi* infestation[40]: phoxim, an organophosphate[5]; carbaryl, a carbamate[39]; the synthetic pyrethroids permethrin,[39] alphacypermethrin and deltamethrin[11,12]; imidacloprid, a neonicotinoid[5,9]; and the insect growth regulators diflubenzuron and triflumuron.[10,41] However, many of these compounds are not available in Slovenia, and none are registered for use in horses.[42] Furthermore, these products can have undesirable effects on non-target insects, such as pollinators or aquatic organisms when released into the environment during application or excreted by treated animals.[13–18]

As mentioned, the infested horses described here were stabled on an eco-friendly family farm. Thus, no ectoparasiticides were used for any of the other animals at the farm at the time of this study. The agreement with the owners was to first try natural treatments. Based on successful treatment studies with neem seed extract when applied to horses, dogs, goats, sheep, chickens and people infested with mites and lice,[8,21–23,25,42,43], we elected to use a neem shampoo. Neem oil (also known as margosa oil) is a bitter and inedible oil extracted from the seed of the tree *Azadirachta indica*, native to south-east Asia. It is widely used in herbal medicine and contains numerous bioactive compounds, including the insecticide azadirachtin.[27,44] Although found to be effective and safe to use topically in concentrations of up to 2 g/animal,[45] its ingestion can be toxic, especially for cats, rats and rabbits.[45,46] A topical application of 0.2 g neem/horse, therefore, is well within the safety levels. This was then supplemented by spraying the entire coat of the animals using a diluted solution of geraniol, which is the essential oil from geranium rose oil (*Pelargonium graveolens*). Geraniol was found to be highly effective as a repellent against several mosquitoes,[28] flies and ticks,[20,26] as well as insecticidal for head lice on people and acaricidal for *Dermanyssus gallinae*,[19,24] *Psoroptes cuniculi* and *Sarcoptes scabiei*.[29,30] Geraniol is safe to be consumed via feed up to 5 mg/kg for all animal species, but should be considered as a skin and respiratory sensitiser.[47] After the horses' coats dried, following application of geraniol, the treatment ended with topical application of diatomaceous earth, which has been used as a physical method for insect and mite control, especially in the control of the poultry red mite with up to 100% efficacy.[48,49] Diatomaceous earth is a silica-rich mineral product that adheres to the arthropod body, causing death by desiccation.[48] Food-grade diatomaceous earth is considered safe to ingest for all terrestrial animal species and for the environment. However, it should be considered as a skin sensitiser, and its inhalation has been linked to respiratory disease in horses and people.[50–52] Side effects should be minimised by using face masks and avoiding application around the eyes and nostrils.

The initial treatment described was not 100% effective, as several live lice were found on all horses 7–21 days after treatment started. However, after systematic examination of the entire skin of all animals for lice, only a few were found and on louse predilection sites, which made it easier to look for them during follow-up treatments. Nevertheless, to go through the mane of one horse systematically with a louse comb and apply diatomaceous earth with a saltshaker, the owner had to spend over an hour. After the third week of treatment, no live or dead lice were found on any of the animals. Although several compounds were used for the treatment, we observed that shaving and combing of the most severely infested horse, and the horse and pony with the most dense hair coats, were essential for the successful elimination of lice. Larsen et al.[6] noted a reduction of lice infestations following clipping a horse's winter coat on both sides along the mane. In our case, it also allowed for better application of the other treatment compounds and therefore a more direct effect on lice and their eggs. The approaching spring weather with day temperatures above 20°C, longer UV exposure, less time spent indoors[4] and good coordinated teamwork between horse owners were likely also helpful for the successful resolution of the infestation.

In conclusion, this report indicates that chewing lice can establish in a herd of horses that do not interact with outside horses, either in association with a lengthy subclinical period or by phoretic transportation by flies. Depending on national regulations, treatment options are often limited to off-label use of therapeutics, or more environmentally sustainable biocides, such as neem extracts, geraniol and diatomaceous earth.[8,27,40,48] However, use of the latter is labour-intensive and time-consuming. One of our study limitations was the absence of a control group due to the small size of the herd. For this reason, the true efficacy of the described control measures could not be evaluated. We also did not evaluate the applied protocol with the quantification of lice in infested horses before and after treatment, as clinical presentation does not always correlate with lice burden.[6,8] The effectiveness in our study was evaluated based on the clinical resolution of infested horses and the absence of lice after

combing. The described treatment was associated with complete resolution of clinical signs, with no lice found for at least 18 months after treatment. Due to its long-term success, the protocol described should be considered as a starting point for more complex studies evaluating the effectiveness and safety of environmentally sustainable compounds used separately or in combination against common wingless ectoparasites in horses.

AUTHOR CONTRIBUTIONS

Petra Bandelj conceived and designed the project and acquired the data. **Petra Bandelj**, **Andrew Peregrine** and **Anja Joachim** analysed and interpreted the data and wrote the paper.

ACKNOWLEDGEMENTS

The authors would like to thank veterinary students for their help in the clinical examination of the horses. We thank all the horse and pony owners, as well as Katarina Vengušt, Ana Dečman and Neža Petelin, for their help and collaboration in the identification of predilection sites and treatment of the horses. Our gratitude also goes to Dr. Araceli Lucio-Forster for her valuable contribution of the *H. asini* photo and her final revision of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

FUNDING INFORMATION

The authors declare that financial support was received for the research, authorship and/or publication of this article. This research was funded by the Slovenian Research and Innovation Agency (research core funding No. P4-0092 'Animal health, environment and food safety') and the Administration of the Republic of Slovenia for Food Safety, Veterinary Service and Plant Protection.

ETHICS STATEMENT

Owners gave explicit consent to include their animals in the report. An ethical statement was not required.

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How to cite this article: Bandelj P, Peregrine A, Joachim A. Control of *Bovicola equi* infestation in a herd of horses using an environmentally sustainable treatment protocol. Vet Rec Case Rep. 2026;14:e70317. https://doi.org/10.1002/vrc2.70317

OWNER'S PERSPECTIVE

Although the treatment was initially labour-intensive and time-consuming, the clinical signs resolved quickly, and the follow-up treatments were much easier. Following the infestation, the barn owners are much more aware of the pruritus status within the herd and are prepared to act quickly. Having an environmentally friendly treatment option at hand makes them feel more in control of the situation and happy for keeping their food and land healthier.

IMAGE QUIZ

Mild to severe dermatological lesions following intense pruritus in a herd of horses during late winter/early spring (Figure 1).

MULTIPLE-CHOICE QUESTION

What is the most likely diagnosis?

POSSIBLE ANSWERS TO MULTIPLE-CHOICE QUESTION

A. *Bovicola equi*
B. Haematopinus asini
C. Chorioptes bovis
D. Sarcoptes scabiei
E. Leishmania infantum
F. Culicoides hypersensitivity

CORRECT ANSWER

A.) *Bovicola equi* is a common cause of pediculosis in horses, where dermatological lesions and pruritus usually occur in late winter or early spring.