CASE REPORT

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Presumptive tick paralysis in 2 American Miniature horses in the United States

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Abstract

Rationale: Tick paralysis has not been reported in horses in North America.

Clinical Findings: Two American Miniature horses were examined for progressive weakness and recumbency. Numerous ticks (*Dermacentor variabilis*) were found on both horses. Horse 1 was recumbent (grade 5/5 gait deficit) on presentation, whereas Horse 2 was standing but ataxic (grade 4/5 gait deficit) and tetraparetic. Both horses had decreased tongue and tail muscle tone, and had normal spinal reflexes. Cerebrospinal fluid cytology was normal. Equine herpesvirus-1 testing was negative.

Pertinent Interventions: Ticks were removed within 24 hours of presentation. Both horses were treated topically with permethrin. Supportive care included fluid therapy, treatment for corneal ulceration, and frequent repositioning during recumbency.

Outcome: Within 48 hours of tick removal, both horses were neurologically normal.

Clinical Relevance: Ours is the first reported case of presumptive tick paralysis in horses in North America. Although rare, tick paralysis should be considered in horses presented with acute-onset weakness progressing to recumbency.

KEYWORDS

horse, recumbency, tetraparesis, tick

1 | CASES

A 3-year-old 93.6-kg American Miniature horse filly (Horse 1) was referred in May 2018 to the Purdue University Veterinary Teaching Hospital (PUVTH) for recumbency. The owner reported the horse had 12 hours of difficulty walking and weakness that progressed to recumbency. The filly had no known vaccination history and was housed with another female American Miniature horse (Horse 2) in a heavily

wooded pasture. Both horses had been purchased from a nonlicensed petting zoo 9 days before the onset of clinical signs, where they had been housed on pasture and fed round bale grass hay. They were evaluated by the referring veterinarian approximately 4 hours before presentation, and did not receive medication at that time. On examination at the PUVTH, Horse 1 was recumbent in the trailer and unable to rise (grade 5/5 gait deficit).[1] The horse was bright, alert, and responsive but anorexic with a body condition score (BCS) of 7/9. Rectal temperature was 37.8°C (reference range, 37.2°C-38.6°C), heart rate was 80 beats/min (reference range, 28-40 beats/min), and respiratory rate was 30 breaths/min (reference range, 8-20 breaths/min). In addition to recumbency, the filly also had decreased tongue and tail muscle tone. Aside from decreased tongue muscle tone, the cranial nerve

examination was unremarkable. Postural reactions and spinal reflexes were intact, but strength and muscle tone were difficult to assess because of recumbency. Superficial corneal ulcers were visible in both eyes and stained positively with fluorescein. Approximately 150 embedded and engorged ticks were found, with the majority concentrated along the base of the mane and tail (Figure 1). These ticks were identified as *Dermacentor variabilis* by a parasitologist. Abnormal results of hematologic and serum biochemical analyses included mature neutrophilia (8.3 K/μL; reference range, 3.0-7.0 K/μL), hyperglycemia (142 mg/dL; reference range, 73-124 mg/dL), hypocalcemia (9.3 mg/dL; reference range, 10.7-13.4 mg/dL), and an increase in creatine kinase activity (2864 IU/L; reference range, 88-453 IU/L).

A 4-year-old 108.6-kg American Miniature horse mare (Horse 2) was referred to the PUVTH with Horse 1 for weakness progressing to recumbency. Similar to Horse 1, Horse 2 was reported first to have shown incoordination and weakness 24 hours before referral and was intermittently recumbent (but able to rise voluntarily) for approximately 12 hours before referral. Otherwise, the history was similar to that of Horse 1. On examination at the PUVTH, Horse 2 was standing and able to walk off the trailer with assistance, but the horse was noted to be tetraparetic and ataxic (grade 4/5 gait deficit in all 4 limbs). The horse was bright, alert, and responsive but anorexic with a BCS of

FIGURE 1 Embedded and engorged *Dermacentor variabilis* ticks concentrated at the base of the tail in a 3-year-old American Miniature horse (Horse 1)

5/9. Rectal temperature was 38.4°C (reference range, 37.2°C-38.6°C), heart rate was 100 beats/min (reference range, 28-40 beats/min), and respiratory rate was 52 breaths/min (reference range, 8-20 breaths/min). Approximately 100 embedded and engorged ticks (*D. variabilis*) were observed, primarily concentrated at the base of the mane and tail. Horse 2 demonstrated a grade 4/5 gait deficit in all 4 limbs (ie, stumbling, tripping, and falling spontaneously), as well as decreased tongue and tail muscle tone. Postural reactions and spinal reflexes were normal. Abnormal results of hematologic and serum biochemical analyses included leukocytosis (12.7 K/μL; reference range, 6.0-12.0 K/μL), mature neutrophilia (7.9 K/μL; reference range, 3.0-7.0 K/μL), hypocalcemia (9.5 mg/dL; reference range, 10.7-13.4 mg/dL), and an increase in creatine kinase activity (5382 IU/L; reference range, 88-453 IU/L).

For both horses, plasma fibrinogen concentration and serum triglyceride concentrations were normal. Ultrasound-guided atlantoaxial cerebrospinal fluid (CSF) was obtained and cytology results were normal in both horses. The CSF WBC count was 2/μL and 5/μL (reference range, 0-6/μL), and the total protein concentration was 20 and 49 mg/dL (reference range, 5-100 mg/dL) for Horses 1 and 2, respectively. Equine herpesvirus-1 (EHV-1) nasal swab quantitative polymerase chain reaction (qPCR) and EHV-1 whole blood qPCR were negative. Botulism testing was not performed. Initial treatment of both horses included manual tick removal, IV fluid support (2.2 mL/kg/h; PLASMA-LYTE A Injection pH 7.4, Zoetis, Inc, Parsippany, New Jersey) because the horses were not eating or drinking, a single dose of trivalent equine botulinum antitoxin (2.5 mL/kg IV; Lake Immunogenics, Inc, Ab Select - BOTABC [Botulism A, B, & C Toxins] Equine HI Plasma, Ontario, New York) considering the possibility of botulism, ceftiofur crystalline free acid (6.6 mg/kg IM q72h; Excede, Zoetis, Inc) for pneumonia prophylaxis, and flunixin meglumine (1.1 mg/kg IV q12h; Banamine Injectable Solution, Merck Animal Health, Madison, New Jersey) for potential central nervous system (CNS) inflammation and muscle pain associated with recumbency. Horse 1 also was treated for bilateral corneal ulcers that likely were a consequence of recumbency-associated trauma. Triple antibiotic ophthalmic ointment (Perrigo Neo-Polycin [bacitracin, neomycin, polymyxin B], Minneapolis, Minnesota) was applied to both eyes q6h. Horse 1 also was manually repositioned on a foam mattress alternating between right and left lateral recumbency q6-8h to minimize muscle damage and prevent decubital ulcer formation.

On the morning of Day 2, anorexia persisted in both horses, and dextrose was added to the IV fluids in an effort to blunt lipid catabolism and prevent hypertriglyceridemia. To provide approximately 20% of the daily resting energy requirement of approximately 3000 kcal/d for each horse, 1.5% dextrose (3.4 kcal/g) was administered at twice the maintenance fluid rate (4.4 mL/kg/h). Additional ticks were discovered on both horses and immediately removed. Topical 45% permethrin (Equi-Spot Spot On Protection for Horses, Farnam Companies, Inc, Phoenix, Arizona) was applied on multiple body sites in both horses. For Horse 1, the foam mattress was replaced with a waterbed (New World Manufacturing, Cloverdale, California) to further protect against muscle necrosis and decubital ulcer formation,[2] in the event that long-term management of recumbency was needed (eg, botulism). Warm water was used to fill the waterbed so that the horse's dependent tuber coxa

was approximately 12″ off the ground (Figure 2). By the evening of Day 2, both horses showed improvement of 1 grade in their neurologic gait deficits; Horse 1 was able to stand with assistance, and Horse 2 had clinically relevant improvement in strength. Tongue and tail muscle tone was subjectively improved in both horses. Whole blood glucose concentrations were obtained q4-6h and remained within the reference range.

On Day 3, Horse 1 was able to stand voluntarily and had only mild weakness. The waterbed was removed from the stall and replaced with deep wood shavings. Both horses continued to improve and were neurologically normal with no apparent gait deficits by Day 4. Reevaluation serum biochemical analyses on Day 4 for Horse 1 identified further increased aspartate aminotransferase activity (4258 IU/L; reference range, 206-810 IU/L) and creatine kinase activity (4489 IU/L; reference range, 88-453 IU/L) compared to results at presentation. For Horse 2, reevaluation serum biochemical analyses on Day 4 identified further increased aspartate aminotransferase activity (1146 IU/L; reference range, 206-810 IU/L) compared to presentation, and slightly decreased (albeit higher than the reference range) creatine kinase activity (1284 IU/L; reference range, 88-453 IU/L) compared to presentation. Hyperbilirubinemia was present in both horses (total bilirubin concentration 5.00 and 5.50 mg/dL for Horses 1 and 2, respectively; reference

FIGURE 2 Implementation of a waterbed for a 3-year-old recumbent American Miniature horse presumptively diagnosed with tick paralysis (Horse 1)

range, 0.10-2.60 mg/dL). Antimicrobial and anti-inflammatory drugs were discontinued in both horses by Day 4. The corneal ulcers of Horse 1 were resolved by Day 6. Horse 1 continued to have a poor appetite, whereas Horse 2's appetite returned to normal by Day 5. Intravenous fluids were discontinued in Horses 1 and 2 on Days 9 and 4, respectively.

Reevaluation hematologic and serum biochemical analyses on Day 8 for Horse 1 identified hypertriglyceridemia (359 mg/dL; reference range, 11-65 mg/dL), increased alkaline phosphatase activity (400 IU/L; reference range, 109-331 IU/L), increased gamma-glutamyl transferase activity (171 IU/L; reference range, 12-46 IU/L), increased aspartate aminotransferase activity (2207 IU/L; reference range, 206-810 IU/L), and increased total bilirubin concentration (3.50 mg/dL; reference range, 0.10-2.60 mg/dL). Given these indicators of negative energy balance likely leading to hepatic lipidosis, fluid therapy at 4.4 mL/kg/h containing 2.5% dextrose was continued. These test results normalized and appetite returned to normal by Day 9; therefore, fluid therapy was discontinued. Horse 1 was discharged from the hospital on Day 15.

For Horse 2, reevaluation hematologic and serum biochemical analyses performed on Day 7 showed expected increases in muscle enzyme activity (aspartate aminotransferase, 1146 IU/L; reference range, 206-810 IU/L; and creatine kinase, 1284 IU/L; reference range, 88-435 IU/L). Horse 2 was discharged on Day 10.

Both horses were discharged with instructions to remove them from the wooded area at home and to implement tick control measures. Both horses were reported to be normal 1 week and 8 months after discharge from the hospital.

2 | DISCUSSION

Tick paralysis most frequently is reported in dogs, but can cause disease in humans, cats, cattle, sheep, and horses.[3-8] Tick paralysis in dogs occurs when an adult female tick attaches to the host and produces salivary neurotoxins that then are introduced into the circulatory system of the host. These neurotoxins act on presynaptic membranes at the neuromuscular junction and prevent the release of acetylcholine, most commonly resulting in ascending flaccid motor paralysis.[4,9,10] The primary tick species implicated in cases of tick paralysis of dogs and cats in North America are *Dermacentor andersoni* (the Rocky Mountain Wood tick) and *D. variabilis* (the American Dog tick), whereas tick paralysis in Australia most commonly is caused by *Ixodes holocyclus*.[4] In small animals, this disease typically is characterized by rapidly progressive symmetrical lower motor neuron (LMN) tetraparesis to tetraplegia with decreased spinal reflexes. Additional clinical abnormalities can include facial paresis or paralysis, dysphonia, dysphagia, regurgitation, and in severe cases, progression to recumbency and eventual respiratory muscle failure.[4,11,12] Sensory function remains normal. Other abnormalities only reported in the Australian form of tick paralysis can include cardio-pulmonary dysfunction such as left-sided congestive heart failure, pulmonary hypertension, cardiac arrhythmias, and long Q-T syndrome, which are secondary to autonomic dysfunction and sympathetic over-drive.[11,13,14] Tick paralysis in small animals in Australia typically causes more severe and prolonged clinical disease that can progress even after

ticks are removed compared to that caused by *Dermacentor* spp. in North America.[4] Tick paralysis generally occurs in the spring and summer months when ticks are actively seeking hosts, which is consistent with the cases described here. A single tick can cause clinical signs of tick paralysis in dogs, and increasing numbers of ticks are associated with increased severity of clinical signs.[15]

Cases of tick paralysis in large animals have also been reported, but only in Australia. The typical presentation of large animals with tick paralysis is similar to that in small animals and consists of paresis progressing to recumbency over hours to days after tick attachment, as well as abnormal phonation and cranial nerve dysfunction.[16] In a retrospective study of 103 horses in Australia with presumptive tick paralysis secondary to *I. holocyclus*, 88% of the horses were recumbent and unable to stand on presentation.[17] Recumbency for >120 hours increased the odds of nonsurvival, which is not surprising given that recumbency in large animals can exacerbate morbidity secondary to decubital ulceration, intertrigo, corneal ulceration, and rhabdomyolysis.[17-20] Seventy-six percent of horses were <1 year of age with over half <6 months of age, and 39% were Miniature horses or ponies. Other studies also have found that affected animals tend to be young and have relatively low body weight (eg, calves, foals, and sheep), suggesting that a high tick burden to body mass ratio might be important in whether or not clinical signs develop.[3,6,8] However, no association has been identified between the number of ticks (range, 1-100 ticks) found on a horse and survival.[17] This observation suggests that whereas body size might be important, other factors such as immune status (eg, naive immunity in younger animals) and tick virulence factors are also likely important in determining susceptibility to disease. In fact, only 1 to 2 ticks were identified on 63% of horses with presumptive tick paralysis.[17]

Here, we report the first 2 cases of presumptive tick paralysis in horses outside of Australia. Both horses initially showed generalized ataxia progressing to profound weakness and recumbency. Although ataxia typically occurs with upper motor neuron (UMN) weakness secondary to CNS disease, these horses had profound weakness with intact postural reactions supporting diffuse LMN disease. Both horses had intact spinal reflexes (consistent with UMN dysfunction), but decreased tongue and tail muscle tone with normal mentation also was suggestive of LMN weakness. Overall, profound weakness with normal proprioception is most consistent with LMN weakness despite the fact that other classic signs of neuromuscular dysfunction such as muscle trembling while standing or neurogenic muscle atrophy were not apparent in these horses. Although clinical signs of tick paralysis caused by both *Dermacentor* spp. and *Ixodes* spp. in small animals are caused by presynaptic neuromuscular dysfunction and likely a consequence of the same mechanism in the cases presented here, the neuroanatomical site of toxin activity of *Dermacentor* spp. neurotoxins in horses is unknown. It is possible that UMN, LMN, neuromuscular junction, or some combination of these might be targeted, resulting in a different constellation of clinical signs in affected horses.

Given that both horses presented with nearly identical and acute clinical signs within the same time period, toxicosis was suspected. Detection of numerous embedded and engorged ticks made tick paralysis likely, although botulism could not be ruled out as a cause of decreased muscle tone, weakness, and recumbency. The horses had been fed with round bale grass hay, which is a known risk factor for botulism.[19] Given the insensitivity of available antemortem diagnostic tests for botulism and the importance of rapid treatment, trivalent equine botulinum antitoxin was given to both horses within hours of presentation.[21] However, the rapid improvement in neurologic status observed in these 2 horses made botulism unlikely because recovery requires regeneration of new motor end plates, which can take up to 3 weeks.[22] Neurotoxicity associated with ingestion of locoweed, yellow star thistle (*Centaurea solstitialis*), moldy corn, or Bermuda or rye grass ("grass staggers") was not considered because of the absence of forebrain signs. Although equine motor neuron disease causes LMN dysfunction, the history in these horses (ie, access to pasture) did not support vitamin E deficiency, and classic signs of LMN weakness were not observed. Additionally, some of the clinical signs were consistent with equine herpes myeloencephalitis (EHM) and were present in more than 1 animal, making it important to test for EHV-1. Normal CSF cytology and negative EHV-1 PCR ruled out EHM and allowed the horses to remain in the main hospital without quarantine. Although testing for West Nile Virus was not performed given the unlikely possibility that both horses would develop signs simultaneously, doing so would have been appropriate given the unknown vaccination history and compatible clinical signs.[23] Finally, diagnosis of tick paralysis was confirmed by the observation of rapid improvement after removal of the ticks in the absence of other disease-specific treatments.

Hematologic and serum biochemical results in small animals with tick paralysis are typically normal.[4,15] The laboratory abnormalities observed in the 2 horses described here were likely a result of anorexia, stress, and recumbency. Hypertriglyceridemia and subsequent hepatic lipidosis are common complications of prolonged anorexia in overconditioned horses and in certain breeds, including the American Miniature horse.

Treatment consisted of manual tick removal, supportive care, and topical administration of an insecticide. Although hyperimmune tick antiserum derived from dogs often is administered to horses with tick paralysis in Australia, it is specific for *Ixodes* spp. and is not commercially available in North America. Even if *Dermacentor* spp. antiserum is developed in the future, it might be unnecessary given the shorter clinical course of disease after removal of *Dermacentor* spp. ticks as compared to *Ixodes* spp. ticks.[17]

Both horses reported here showed rapid improvement upon tick removal and survived. Neither horse had residual neurologic deficits. Given the lack of published reports on tick paralysis in horses in North America, it is likely that horses are relatively resistant to the development of clinical signs. Because the prognosis for tick paralysis associated with *Dermacentor* spp. generally is better than that associated with *Ixodes* spp. in small animals, it is likely that prognosis also is favorable in horses, even with a heavy infestation. The survival rate for horses with tick paralysis caused by *I. holocyclus* was found to be 74% in a large retrospective study, and if host factors that play a role in the pathophysiology of tick paralysis are shared among mammalian species, it is reasonable to expect an even better prognosis for tick paralysis associated with *Dermacentor* spp.[17]

To summarize, tick paralysis in horses has not been recognized previously in North America. However, a thorough physical examination with a focus on the integument to identify the presence of ticks should be performed in horses presented with acute-onset ataxia or tetraparesis progressing to recumbency. Further research is needed to elucidate the mechanism of action and neuroanatomical target or targets of the *Dermacentor* spp. neurotoxins in horses with tick paralysis. Additional reporting of presumptive tick paralysis in horses would better clarify the clinical course and confirm the assumption that prognosis is favorable in affected horses.

CONFLICT OF INTEREST DECLARATION

Authors declare no conflict of interest.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Authors declare no IACUC or other approval was needed.

HUMAN ETHICS APPROVAL DECLARATION

Authors declare human ethics approval was not needed for this study.

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REFERENCES

1. Mayhew IG, deLahunta A, Whitlock RH, et al. Spinal cord disease in the horse. *Cornell Vet*. 1978;68(Suppl 6):1-207.
2. Lindsay WA, Pascoe PJ, McDonell WN, Burgess ML. Effect of protective padding on forelimb intracompartmental muscle pressures in anesthetized horses. *Am J Vet Res*. 1985;46:688-691.
3. Doube BM. Cattle and the paralysis tick *Ixodes holocyclus*. *Aust Vet J*. 1975;51:511-515.
4. Malik R, Farrow BR. Tick paralysis in North America and Australia. *Vet Clin North Am Small Anim Pract*. 1991;21:157-171.
5. Schull DN, Litster AL, Atwell RB. Tick toxicity in cats caused by Ixodes species in Australia: a review of published literature. *J Feline Med Surg*. 2007;9:487-493.
6. Sloan CA. Mortality in sheep due to Ixodes species. *Aust Vet J*. 1968;44:527.
7. Grattan-Smith PJ, Morris JG, Johnston HM, et al. Clinical and neurophysiological features of tick paralysis. *Brain*. 1997;120(Pt 11):1975-1987.
8. Bootes BW. A fatal paralysis in foals from *Ixodes holocyclus* Neumann infestation. *Aust Vet J*. 1962;38:68-69.
9. Atwell RB, Campbell FE. Reactions to tick antitoxin serum and the role of atropine in treatment of dogs and cats with tick paralysis caused by *Ixodes holocyclus*: a pilot survey. *Aust Vet J*. 2001;79:394-397.
10. Cooper BJ, Spence I. Temperature-dependent inhibition of evoked acetylcholine release in tick paralysis. *Nature*. 1976;263:693-695.
11. Holland CT. Asymmetrical focal neurological deficits in dogs and cats with naturally occurring tick paralysis (*Ixodes holocyclus*): 27 cases (1999-2006). *Aust Vet J*. 2008;86:377-384.
12. Ilkiw JE, Turner DM. Infestation in the dog by the paralysis tick *Ixodes holocyclus*. 3. Respiratory effects. *Aust Vet J*. 1987;64:142-144.
13. Campbell FE, Atwell RB. Long QT syndrome in dogs with tick toxicity (*Ixodes holocyclus*). *Aust Vet J*. 2002;80:611-616.
14. Campbell FE, Atwell RB, Smart L. Effects of the paralysis tick, *Ixodes holocyclus*, on the electrocardiogram of the Spectacled Flying Fox, *Pteropus conspicillatus*. *Aust Vet J*. 2003;81:328-331.
15. Atwell RB, Campbell FE, Evans EA. Prospective survey of tick paralysis in dogs. *Aust Vet J*. 2001;79:412-418.
16. Tee SY, Feary DJ. Suspected tick paralysis (*Ixodes holocyclus*) in a Miniature Horse. *Aust Vet J*. 2012;90:181-185.
17. Ruppin M, Sullivan S, Condon F, et al. Retrospective study of 103 presumed cases of tick (*Ixodes holocyclus*) envenomation in the horse. *Aust Vet J*. 2012;90:175-180.
18. Taylor SD, Toth B, Townsend WM, Bentley RT. Mechanical ventilation and management of an adult horse with presumptive botulism. *J Vet Emerg Crit Care (San Antonio)*. 2014;24:594-601.
19. Johnson AL, McAdams-Gallagher SC, Aceto H. Outcome of adult horses with botulism treated at a veterinary hospital: 92 cases (1989-2013). *J Vet Intern Med*. 2015;29:311-319.
20. White NA, Suarez M. Change in triceps muscle intracompartmental pressure with repositioning and padding of the lowermost thoracic limb of the horse. *Am J Vet Res*. 1986;47:2257-2260.
21. Johnson AL, McAdams-Gallagher SC, Aceto H. Accuracy of a mouse bioassay for the diagnosis of botulism in horses. *J Vet Intern Med*. 2016;30:1293-1299.
22. de Paiva A, Meunier FA, Molgo J, Aoki KR, Dolly JO. Functional repair of motor endplates after botulinum neurotoxin type A poisoning: biphasic switch of synaptic activity between nerve sprouts and their parent terminals. *Proc Natl Acad Sci U S A*. 1999;96:3200-3205.
23. Schuler LA, Khaitsa ML, Dyer NW, Stoltenow CL. Evaluation of an outbreak of West Nile virus infection in horses: 569 cases (2002). *J Am Vet Med Assoc*. 2004;225:1084-1089.