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# Apparent fatal winter tick (*Dermacentor albipictus*) infestation in captive reindeer (*Rangifer tarandus*)

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ABSTRACT

The winter tick, *Dermacentor albipictus* (Ixodidae), commonly infests a wide variety of wild and domestic ungulates throughout North America. This one-host-tick infests animals from October to April, with moose (*Alces alces*) particularly affected. Animals highly infested may present with anemia, tick-induced alopecia, and alterations in thermoregulation, often resulting in death. Mortality from winter tick infestation has been reported in free-ranging woodland caribou (*Rangifer tarandus caribou*) and captive reindeer in Alberta, Canada. This historic report raises concern about mortality due to *D. albipictus* in a wider host range, specifically on translocated caribou. The aim of this report was to describe three cases of winter tick infestation in captive reindeer resulting in severe anemia and mortality likely due to the infestation in New Hampshire, northeastern United States (US). Additionally, ticks were screened molecularly for the detection of tick-borne pathogens. At time of necropsy, all three reindeer showed decreased nutritional status, marked submandibular edema, and had heavy *D. albipictus* infestation. None of the reindeer exhibited alopecia, which is a common clinical manifestation in moose that die from winter tick infestation. No pathogens were detected via qPCR screening. This report highlights the risk that captive cervids face in areas where winter tick is endemic; therefore, the adoption of preventive control measures should be encouraged to reduce the risk of tick infestation and potential death of these animals.

## 1. Introduction

*Dermacentor albipictus* (Acari; Ixodidae), commonly known as the winter tick or moose tick, is a one-host tick with a broad distribution across temperate North America (Calvente et al., 2020; Duncan et al., 2021). There are two distinct morphologic forms of *D. albipictus*, one with an ornate scutum and one that is inornate and commonly referred to as the brown variant, formerly recognized as *D. nigrolineatus*, which is found more commonly in the southern US and Mexico (Ernst and Gladney, 1975). This tick species has low host specificity and infests various wild and domestic ungulates including moose, elk, deer, cattle, and horses (Elliott et al., 2021; Machtinger et al., 2021). Winter tick is known to be strongly associated with moose (*Alces alces*), which are the most severely affected host given their inefficient grooming behavior (Samuel 1989; Welch et al., 1990b). Heavy infestations are commonly observed due to the one-host nature of this tick, and the predisposition for large groups of larvae to quest and attach to a single host (Lindquist et al., 2016). Moose often have the heaviest intensity of *D. albipictus* infestation, reaching hundreds of thousands per moose (Samuel et al., 1991); elk (*Cervus canadensis*) and wild caribou (*Rangifer tarandus* spp.) commonly present moderate infestations; and deer (*Odocoileus virginianus* and *O. hemionus*) harbor the fewest ticks (Welch et al., 1990a).

Clinically, infestation of moose and cattle results in debilitation as a consequence of anemia and excessive rubbing to remove ticks, as moose are not efficient groomers, and this leads to alopecia, and loss of body condition score (Welch et al., 1990b; Musante et al., 2010). In fact, mortality due to winter tick infestation has been reported in two captive reindeer from Alberta, Canada, which presented with alopecia as the main clinical sign (Welch and Samuel 1989). One of these animals was infested by more than 411,661 (25 ticks/cm$^2$) *D. albipictus* (Welch and

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Samuel 1989). Despite the major relevance of *D. albipictus* being due to its direct impacts on hosts, the potential role of this tick species as vector of certain protozoan and rickettsial pathogens cannot be ruled out. There is evidence of transovarial transmission of *Anaplasma phagocytophilum* in winter ticks (Baldridge et al., 2009), and its competence to transmit *Anaplasma marginale* has also been proven (Stiller et al., 1989). More recently, *D. albipictus* has also been suggested as the putative vector of *Babesia duncani*, a zoonotic parasite occurring in the US (Swei et al., 2019).

Massive infestations by *D. albipictus* threaten conservation of various wild ungulates in North America and carry potential risk of exposure to pathogens. Over the last several decades, the northward range expansion of *D. albipictus*, particularly utilizing moose, elk, and woodland caribou has been reported in the Yukon and Northwest Territories of Canada (Kutz et al., 2009, 2012). This represents a threat to wildlife in these regions, with global warming changing the occurrence areas of ticks and therefore increasing potential tick-borne pathogen transmission to wildlife hosts. In this report we describe three cases of *D. albipictus* infestation in captive reindeer apparently resulting in mortality in New Hampshire, northeastern US.

## 2. Materials and methods

### 2.1. Cases

From November 2020 to January 2021 one 5-month-old (case 1), one 6-month-old (case 2), and one 17-years-old (case 3) female reindeer from a New Hampshire farm were submitted for necropsy to the New Hampshire Veterinary Diagnostic Laboratory (NVHDL) at the University of New Hampshire. Case 1 and 2 were found dead in the pasture and no premonitory signs. Case 3 died during ectoparasiticide treatment. All animals were heavily infested by ticks. The animals were part of a herd of roughly 20 animals, that is of decades duration at this New Hampshire location, with good nutritional management, consistent and attentive husbandry, and ongoing veterinary care.

During necropsy, ticks were manually collected for a period of 3–5 min, and then stored in vials containing 70% ethanol until laboratory processing (Kistner et al., 1980). Routine sections of major organs from all reindeer were collected, fixed in 10% buffered formalin, and processed routinely for histopathology.

### 2.2. Morphologic and molecular analysis of ticks

Ticks (n = 84) were quantified, separated by stages, and morphologically identified by standard keys (Strickland 1976). Molecular confirmation via PCR and sequencing a fragment of the 16S rRNA gene (Nadolny et al., 2011) was performed in the four ticks (n = 4; a specimen from each case (3 males) and 1 female was also included to have both tick sexes represented). Ticks were macerated in a solution of lysis buffer plus proteinase K and incubated at 56 °C for 12 h. Afterwards, genomic DNA was extracted using DNeasy Blood & Tissue Kit (Qiagen, CA, USA) according to the manufacturer's recommendations. PCR products were purified using the E.Z.N.A.® Cycle Pure Kit (OMEGA Bio-Tek Inc., Norcross, GA, USA) according to the manufacturer's instructions. Generated sequences were aligned and compared to homologous sequences of *D. albipictus* using the nucleotide Basic Local Alignment Search Tool (BLASTn, National Center for Biotechnology Information, Bethesda, MD, USA). Additionally, ticks (n = 4) were also screened for the presence of several tick-borne pathogens of veterinary and public health importance (*Anaplasma phagocytophilum*, *Borrelia burgdorferi*, *Borrelia hermsii*, *Borrelia parkeri*, *Borrelia turicatae, Babesia gibsoni*, *Babesia canis*, *Babesia caballi, Ehrlichia canis*, *Ehrlichia chaffeensis*, *Ehrlichia ewingii*, and *Rickettsia rickettsia*) by real time PCR at the Texas A&M Veterinary Diagnostic Laboratory (TVMDL) in College Station, TX. All qPCR reactions were performed in a third-party commercial laboratory, for this reason no details have been described for each reaction.

## 3. Results

Animals were in fair (case 1) to good (cases 2 and 3) post-mortem condition, decreased nutritional status (BCS: 1/5) with minimal adiposity, and were heavily infested by ticks, but with no alopecia present. Dark red-brown debris in the fur were associated with these ectoparasites. Ticks were present in at least 85% of the haired skin of all animals and were commonly so densely aggregated that they were oriented perpendicularly to the skin (Fig. 1).

The subcutis in the ventral region of the jaw, neck, brisket and inguinal area was expanded by gelatinous edema (Fig. 2). There was tricavitary effusion with accumulation of transparent pale-yellow transudate within the peritoneal (~700–1700 mL), pleural (~500–1500 mL) and pericardial spaces (~90–220 mL). In case 1, a 20 cm, sharply demarcated segment of the aboral jejunum was deep purple with granular, purple, fluid contents. The heart was mottled pale tan and matte red throughout natural and cut surfaces.

The primary finding in all animals was moderate, chronic, hyperplastic, hyperkeratotic, exudative, lymphoplasmacytic and eosinophilic dermatitis, with intralesional ticks. Cases 1 and 2 had moderate to severe, acute, centrilobular to midzonal hepatic necrosis; mild to moderate nodular lymphocytic to lymphoplasmacytic interstitial nephritis; and lymph node sinusoidal erythrocytosis and histiocytosis. Case 2 had moderate, chronic, focal, eosinophilic and granulomatous peribronchial pneumonia, with intralesional foreign material.

The subset of ticks collected for identification (n = 84) consisted of 9 females, 4 males, and 3 nymphs from case 1; 38 females and 4 males from case 2; and 19 females and 7 males from case 3 many of which engorged or partially engorged. All individuals were morphologically identified as *D. albipictus*. Among the characteristic morphological features were the presence of short mouthparts, rectangular basis capitulum, ornate scutum (adults), and large goblet cells on the spiracular plate (Fig. 2). The identity of tick specimens (Accession number: OQ625481) was confirmed molecularly and presented 99% of identity with *D. albipictus* sequences deposited in the GenBank database (Accession nos: **GU968849.1** and **GU968858.1**). No pathogens were detected via qPCR screening in the tested ticks.

**Fig. 1.** Captive reindeer skin densely infested by *Dermacentor albipictus*.

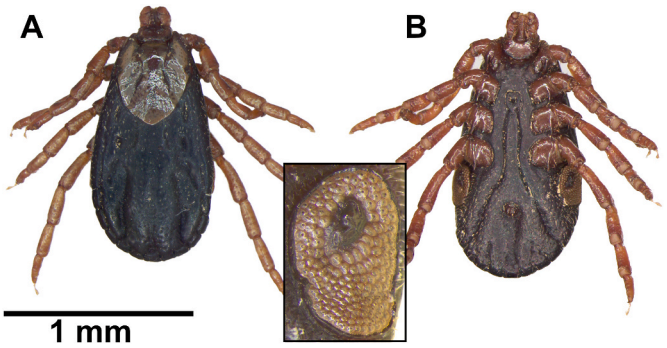


**Fig. 2.** Dorsal (A) and ventral view (B) of an adult female *Dermacentor albipictus* collected from captive reindeer. Inset image shows large goblet cells on the spiracular plate.

## 4. Discussion

This report details three apparently fatal cases of *D. albipictus* infestation in captive reindeer from New Hampshire, northeastern US. Infestation by ticks has been reported in wild animals worldwide, with a significant negative impact on conservation efforts due to the transmission of pathogens (Calvente et al., 2020; Elliott et al., 2021). In the case of *D. albipictus*, severe and fatal infestations have been widely reported in moose across North America, including areas of the northeastern US (Kutz et al., 2012). While *D. albipictus* associated fatalities in other cervids are less common compared to moose, fatal cases associated with heavy *D. albipictus* infestations have been reported in other wild and captive cervids, including reindeer (Welch et al., 1990a), elk (Calvente et al., 2020), and white-tailed deer (Machtinger et al., 2021). While all age classes of moose have been described to be affected by winter tick-related mortality, calves are often overrepresented (Musante et al., 2010). Ungulate calves have fewer nutritional reserves and lower immunity levels, likely contributing to their increased incidence of mortality (Musante et al., 2007). Age-related decline in immune function also contributes to increased disease susceptibility in the geriatric (Weiskopf et al., 2009). These factors likely explain the biphasic age distribution of the affected reindeer in this case series.

In the present report, all animals exhibited decreased nutritional status (BCS: 1/5) with minimal adiposity. Animals in this herd often have elevated BCS and are well cared for. Most likely, the apparent heavy tick infestation led to severe blood loss resulting in hypoproteinemia insurmountable by forage. It is estimated that a 150 kg moose with a moderate tick burden (30,000 ticks) may lose between 7600 and 13,000 mL of blood over 8 weeks (Musante et al., 2007), and in a 75 kg deer blood loss may reach 6000 mL in the same period (Machtinger et al., 2021). Such intense blood loss may be fatal and is the most likely cause for the three reindeer deaths. Preventive ectoparasiticide treatment with ivermectin was initiated in the herd after the first two fatal cases, but as evidenced by the third case where the animal died during ivermectin treatment was initiated too late for this animal. Additionally, ivermectin is not labeled for the treatment and control of ticks in large animals, and in this case was an off-label use for this host species (Durvet Animal Health Products, Missouri, United States). In regards to the renal lesions present in cases 1 and 2, their etiology is unknown, but this could possibly indicate some degree of antigenic stimulation over the course of the animals' life, potentially with the pathogens that have a particular tropism for the kidney as differential diagnoses (e.g. *Leptospira*), but the lesions were fairly chronic and nonspecific, in addition to being unexpected in animals of this age. All 3 case findings were consistent with severe winter tick infestation.

The excessive rubbing in moose heavily infested by *D. albipictus* induces the appearance of alopecia (Welch et al., 1990b). Alopecia was not observed in animals we present, similarly to reports of heavily infested woodland caribou without alopecia (Welch et al., 1990a). The lack of alopecia in infested *Rangifer* may be related to differences in the hair coat between host species (moose vs. reindeer/caribou), but also to a more rapid course of infestation, possibly resulting in anemia and/or exsanguination in *Rangifer* as compared to moose. It has been demonstrated that moose have a delayed sensory response to adult ticks (Mooring and Samuel 1998), which has also been suggested in caribou (Bondo et al., 2019). The absence of alopecia reported in the present report may be related to increased grooming activity by reindeer as compared to moose, or due to a late response to infestation with adult ticks, coupled with the timing of infestations in early and mid-winter as opposed to late-winter when severe winter tick infestations are more often reported, as animals may succumb to infestations before they have time to develop the alopecia exhibited by moose. The subcutaneous edema and tricavitary effusions are likely due to hypoproteinemia as a result of high tick burden.

Various reports of *D. albipictus* infestation in caribou (Welch et al., 1990a; Bondo et al., 2019; Welch and Samuel, 1989) combined with the current description of apparent death in three captive reindeer due to infestation, raises concerns about the potential deleterious health impacts of *D. albipictus* to *Rangifer*, including both captive reindeer and wild caribou. These infestations may represent a greater concern for captive populations as animals are unable to leave infested pastures as opposed to wild populations. The recent and ongoing expansion of the geographic distribution of *D. albipictus* has been largely associated with climate change and could potentially impact health and population dynamics of various wild North American ungulates, especially in moose and caribou (Kutz et al., 2012). There are some limitations to this report. Namely, lack of tick infestation estimates, absence of pathogen assessment in the animals' carcasses, incomplete pathogen assessment (particularly for *A. marginale* and *B. duncani*) in ticks. However, despite the limitations of the report necropsy findings and sudden death corroborate previous associations between heavy winter tick infestation and death of animals (Welch et al., 1990a; Calvente et al., 2020; Machtinger et al., 2021; Chenery et al., 2023). In addition, none of the ticks tested were positive for specific protozoan and rickettsial tick-borne pathogens via molecular screening.

## 5. Conclusions

Our report highlights that domestic reindeer reared in areas of North America where *D. albipictus* is endemic should be closely monitored for tick infestation and possibly undergo periodic or preventive acaricide treatment to reduce the risk of tick infestation and potential death. Similarly, translocation of caribou for conservation efforts or transportation of domesticated reindeer across areas of the United States and Canada may further contribute to range expansion and establishment of *D. albipictus* into new areas, which has been widely reported in the literature (Chenery et al., 2023). Hence, it is crucial to improve the vigilance regarding ectoparasite infestations in these animals. Additionally, winter tick abundance is influenced by mild seasons and low snowfall (Garner and Wilton, 1993), so changes in climatic conditions could positively contribute to their overabundance. This report emphasizes the importance of evaluating potential risk periods to improve the management tools and avoid heavy tick infestations in these animals.

## Conflicts of interest

The authors declare no conflict of interest.

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