INTERNAL GROSS PATHOLOGY OF MOOSE EXPERIMENTALLY INFESTED WITH WINTER TICKS

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ABSTRACT: Captive moose (*Alces alces*) infested with 21,000 and 42,000 larval winter ticks (*Dermacentor albipictus*) in September-October, and unifested moose were studied to assess impact of winter ticks on moose. Study animals were euthanized the following April near the end of the parasitic phase of winter ticks. Major organs and selected superficial lymph nodes were examined and compared among treatment groups. No visible lesions were evident in spleen, lung, liver, thyroid, heart, adrenal, and kidney of most moose. Several foci of necrosis in the liver of 1 moose were considered minor and unrelated to tick infestation. Prescapular and prefemoral lymph nodes, but not popliteal nodes, were significantly heavier and reddened in infested than uninfested moose. Hyperactive, hypertrophied lymph nodes may compromise the immune defense of moose and may predispose infested moose to increased risk of bacterial infection. While not a proximate cause of death in heavily infested moose, bacterial infections may contribute as a secondary cause of death.

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Since the early 1900s winter ticks (*Dermacentor albipictus*) have been associated with numerous die-offs of moose (*Alces alces*) in the Canadian provinces (Samuel and Barker 1979, Samuel 2004), and most recently, annual epizootics (>50% calf mortality) are occurring with unprecedented frequency in the northeastern United States (Jones et al. 2017, 2019). Experimental studies with captive moose infested with winter ticks have demonstrated that the amount of grooming, rubbing, and hair loss are related directly with the level of infestation (McLaughlin and Addison 1986, Addison et al. 2019). Captive studies further revealed that shivering by infested calves in winter is seldom observed in uninfested animals (Addison and McLaughlin 2014), infested moose have less pericardial fat and abdominal visceral fat than uninfested animals (McLaughlin and Addison 1986), and infested calves grow more slowly than uninfested calves (Addison et al. 1994). In addition, Glines and Samuel (1989) reported transitory anemia in a captive calf, and the concentrated blood loss associated with feeding by adult female winter ticks is directly related to mortality of wild calves (Samuel 2004, Musante et al. 2007).

The first record of the bacterium *Erysipelothrix rhusiopathiae* in lymph nodes and other tissues collected from dead wild moose with high infestation of winter ticks was by Campbell et al. (1994). A common route of infection for *E. rhusiopathiae* is from contamination of wounds (Leighton 2001). Because extensive grooming and rubbing induced by winter ticks (Addison et al. 2019) can cause extensive dermal wounds on moose (authors' personal observation), high infestations of winter ticks may predispose moose to bacterial and fungal infections. Here we present data and observations from internal gross pathology of uninfested captive moose and those experimentally infested with winter ticks to identify any differences in physiological response possibly associated with tick infestations.

METHODS

Twelve moose captive-reared in 1982 in Algonquin Provincial Park, Ontario (45° 33'N, 78° 35'W) were used in this experiment which was part of a larger study (see Addison et al. 1983). These animals were divided into 3 treatment groups: 4 uninfested (control) moose that were administered no winter ticks, 4 infested with 21,000 larvae, and 4 infested with 42,000 larvae; infestations occurred from 17 September to 12 October 1982. Control moose were sprayed with an acaricide (Dursban M., Dow Chemical of Canada Ltd., Sarnia, Ontario, Canada) twice in November, and powdered with rotenone in December, January, and February in an attempt to prevent accidental infestation.

Moose were euthanized by initially immobilizing them with 300 mg of xylazine hydrochloride (Rompun, Haver-Lockhart Laboratories, Mississauga, Ontario, Canada) followed with a lethal dose of T-61 (N-[2-(methoxyphenyl)-2-ethylbutyl-(1)]-g- hydroxy-butyramide and 4,4'–methylene-bis- (cyclohexyl-triemthylammonium iodide)) (Hoechst Canada Inc., Montreal, Quebec, Canada). Necropsies were performed on 18–29 April 1983.

Heart, lungs, liver, kidney, spleen, and thyroid and adrenal glands were extracted and examined for visible lesions. In addition, the prefemoral, prescapular, and popliteal superficial lymph nodes were extracted, trimmed, weighed (0.01 g), and photographed. The prescapular and prefemoral lymph nodes are bifurcated into distinct upper and lower portions in moose. An analysis of variance (ANOVA) and Tukey's test were used to examine for difference in weight of the prescapular, prefemoral, and popliteal lymph nodes among the 3 treatment groups; significance was set at $P = 0.05$. All studies were approved under an animal care protocol and with close scrutiny by a provincial veterinarian who set the April termination date of the experiment.

RESULTS AND DISCUSSION

The numbers of ticks in the treatment groups should be considered in a relative rather than absolute sense. For example, although ticks were not applied to the control moose, and despite our preventative exercises, there were 0, 4, 21, and 85 ticks recovered from their hides at the termination of the experiment. For all practical purposes, however, they served as control animals given the infestation levels of the other groups. Further, the infested moose successfully removed a measurable number of ticks by the end of the experiment (Addison et al. 2019). The treatments are best considered as uninfested, low infestation, and moderate infestation because infestation is typically >35,000 ticks at death (Jones et al. 2019).

In 11 moose (all groups) there were no gross lesions in the heart, lungs, liver, kidney, spleen, and thyroid and adrenal glands. The other (12th) animal had several foci of necrosis in its liver that were considered minor and unrelated to tick infestation. The popliteal lymph nodes were of similar size in all 3 groups ($P = 0.79$) (Table 1), and the prescapular ($P = 0.17$) and prefemoral ($P = 0.45$) lymph nodes were of similar size in the 2 infested groups (Fig. 1). Conversely, the prescapular and prefemoral nodes in infested moose were hyperplastic, and 3–4 × heavier

Table 1. Mean weight (g) and range of superficial lymph nodes collected from 3 groups of euthanized moose that received different infestation treatments of winter ticks (4 animals per treatment) the previous autumn, Ontario, Canada. Samples were collected and weighed (0.01 g) on 18–29 April 1983 when adult ticks typically drop from moose.

Lymph node	Body side	Treatment level (# ticks)		
		0	21,000	42,000
Prescapular	Right	10.25 (7–14)	40.75 (34–50)	38.50 (21–57)
	Left	11.25 (7–16)	35.75 (32–46)	34.00 (27–40)
Prefemoral	Right	9.00 (6–12)	30.75 (23–46)	29.50 (24–34)
	Left	8.75 (3–15)	28.50 (23–37)	29.00 (19–34)
Popliteal	Right	5.25 (4–6)	5.25 (4–6)	6.25 (4–11)
	Left	5.25 (4–7)	6.00 (5–7)	5.25 (4–7)

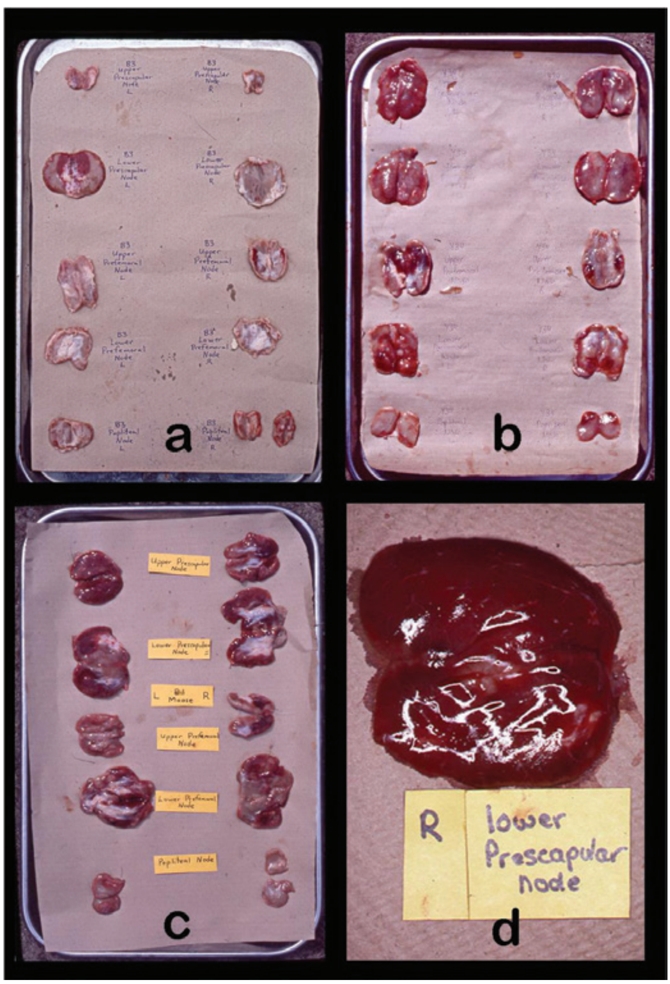

Fig. 1. Superficial lymph nodes from moose not infested with winter ticks (a), infested with 21,000 ticks (b), and infested with 42,000 ticks (c). Lymph nodes in (a) to (c) from top to bottom are upper prescapular (left and right), lower prescapular, upper prefemoral, lower prefemoral and popliteal nodes; (d) is a right lower prescapular lymph node of a year-old wild moose found dead.

(P < 0.001) than those in control moose (Table 1, Fig. 1). Among the control moose, the heaviest prescapular and prefemoral lymph nodes were in the animal that harboured the most ticks (85; Fig. 1a) and groomed and rubbed most, suggesting that even a light infestation may initiate a physiological response in the host.

The apparent response of the prescapular and prefemoral nodes in infested captive moose has also been noted in heavily infested wild moose with hyperplastic and completely red lymph nodes (Fig. 1d). An emaciated year-old wild moose also had hyperplastic and completely red prefemoral and prescapular lymph nodes with *Erysipelothrix rhusiopathiae* also recovered from this animal (Campbell et al. 1994). It follows that infested wild moose are immunocompromised and more susceptible to infection, and that the relative degree of such is probably related directly to infestation level. That grooming behaviour to reduce infestation may simultaneously increase the probability of secondary infection is somewhat ironic. Although high infestations are clearly linked to mortal blood loss and epizootics (Musante et al. 2007, Jones et al. 2019), further pathology of infested moose might identify the relative influence of secondary bacterial infections.

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