

BODY TEMPERATURE OF CAPTIVE MOOSE INFESTED WITH WINTER TICKS

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ABSTRACT: Eighteen captive moose calves (*Alces alces*) were divided into 3 groups that represented 3 levels of winter tick (*Dermacentor albipictus*) infestation (0, 21,000, and 42,000 ticks). A total of 321 body temperatures (T_b) were taken on 19 occasions between late November and mid-April. The mean T_b of individuals was 38.2 ± 0.4 °C, ranging from 38.0–38.3 °C, and was not different among the control and infested groups ($P = 0.816$), but varied temporally ($P < 0.001$) with a significant interaction effect between treatment and time ($P = 0.041$); these temporal differences are unexplained. The T_b s measured in this study are some of the lowest reported for moose and presumably represent the resting T_b of free-ranging moose, more so than those measured after pursuit, restraint, and/or immobilization during capture. This was not a definitive test of the effects of tick infestation on wild moose because the captive moose consumed a high quality diet throughout winter and surprisingly low numbers of ticks remained on the animals in mid-April.

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Key words: body temperature, *Alces alces*, *Dermacentor albipictus*, moose, T_b , winter tick.

Premature hair loss by moose (*Alces alces*) in winter that is associated with infestations of winter tick (*Dermacentor albipictus*) is well documented (e.g., Addison et al. 1979, Samuel and Barker 1979, Samuel 1991) including by McLaughlin and Addison (1986) studying the same captive moose reported here. This hair loss might influence body temperature (T_b) that is reflective of increased energetic cost and stress in moose. The typical T_b of moose reported in the literature is usually measured on individuals that were pursued, restrained, and/or immobilized during capture. Many of these values may reflect higher than resting T_b since excitability raises T_b in moose (Franzmann et al. 1984). Objectives of this study were to assess the possible effects of winter tick infestation on T_b of moose, and to obtain

T_b from captive animals that more accurately represent resting T_b of unstressed free-ranging moose. Importantly, animals in this study were young-of-the-year, exceptionally tractable, and readily accepted the measurement procedure. Because technological advances in telemetry now allow T_b to be measured in free-ranging moose, these data are also valuable for related comparisons.

METHODS

The experiments were conducted in Algonquin Provincial Park, Ontario (45° 30' N, 78° 35' W) where 13 of 18 calves were captured at <2 weeks of age in May 1982; 5 calves were from other areas in central and northeastern Ontario (Addison and McLaughlin 1993). Male and female calves were paired in each of 6 adjacent pens

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(29.6 × 16.5 m) located within a mixed forest stand with little undergrowth and a partial canopy (50% in summer) of white pine (*Pinus strobus*), white birch (*Betula papyrifera*), trembling (*Populus tremuloides*) and big tooth aspen (*P. grandidentata*). Calves were weaned as described by Addison et al. (1983) and from late October to the end of the experiment were fed *ad libitum* a ruminant ration containing 16% crude protein, 2.5% crude fat, and 6% crude fiber (United Cooperative of Ontario, Mississauga, Ontario, Canada). Husbandry of moose and experimental design for this study were as described in Addison et al. (1994) with all animals assumed born on 15 May 1982.

The 18 calves were divided into 3 treatment groups: moose with no winter ticks ($n = 5$; 2F:3M), moose infested with 21,000 larval winter ticks ($n = 7$; 3F:4M), and moose infested with 42,000 larval winter ticks ($n = 6$; 3F:3M). Larval ticks were applied between mid-September and mid-October 1982, and all moose were euthanized at the end of the experiment (18–28 April 1983). The hair was dissolved and hides checked for ticks as described by Addison et al. (1979).

For months prior to the application of ticks, the study animals were attracted with food to a monitoring station where they stood quietly while we measured weight and took linear measurements. The T_b was measured by inserting a standard, large animal mercury thermometer into the rectum. For 16 moose, T_b was usually measured every 5–9 days from 24 November 1982 to 14 April 1983, except for a 2-week period from late January to mid-February 1983 (Table 1). Fewer data were available from the 2 other moose that were sacrificed prior to the completion of this study.

The mean T_b of individuals within and between sampling times was calculated using all 18 moose; however, data were missing for certain individuals on particular

dates. All data for 3 moose with missing rectal temperatures for ≥ 3 of the 19 dates were removed from statistical analysis. Further, because measurements were missing from 3 moose on one of the 19 dates, all were removed from the analysis for this date. After removing these data, each treatment group was comprised of 5 moose with measurements from 16 dates, for a total of 80 measurements per treatment. We tested for treatment effect (among groups), temporal effect, and an interaction effect between treatment and time using a two-factor ANOVA with repeated measures of T_b with the AOV function in R (R Core Team 2013).

RESULTS

Female and male calves respectively weighed 161 ± 8 and 178 ± 5 kg in mid-November, and 200 ± 17 and 218 ± 20 kg at the end of the experiment when 11 months old (Addison et al. 1994). The 5 control moose harboured 0, 0, 4, 21, and 85 winter ticks at the conclusion of the experiment; the animal harbouring 85 ticks had limited (5%) hair loss (McLaughlin and Addison 1986). In contrast, 1179–8290 ticks were recovered from the infested moose at the end of the experiment. Hair loss was estimated at 23–44% in 8 of 10 infested animals, and 2 and 4% in the other 2 moderately infested moose (see McLaughlin and Addison 1986).

The mean T_b ($n = 321$) was 38.2 ± 0.4 °C ranging from 36.8–40.7 °C. Individual mean T_b ranged from 38.0–38.3 °C with >99% of individual measurements from 36.8 – 39.4 °C (Fig. 1). Mean T_b was not different among treatment groups ($F_{2,12} = 0.207$, $P = 0.816$), but did vary over time ($F_{15,180} = 6.385$, $P < 0.001$). There was a significant interaction effect between treatment and time ($F_{30,180} = 1.561$, $P = 0.041$) indicating that T_b of treatment groups varied temporally. However, no discernible relationship existed as the mean T_b of groups did not change in similar direction in all periods (Fig. 2).

Table 1. Mean rectal body temperature (T_b , °C) of standing captive calf moose exposed to 3 levels of winter tick loads (0, 21,000, 42,000 larvae) in fall 1982, Algonquin Provincial Park, Ontario; moose sample size is in parentheses.

Date	Winter Tick Infestation Level		
	0	21,000	42,000
24 Nov 1982	38.2 ± 0.2 (5)	38.3 ± 0.4 (6)	37.7 ± 0.5 (6)
30 Nov	38.2 ± 0.1 (5)	38.0 ± 0.4 (7)	37.9 ± 0.5 (6)
5 Dec	38.3 ± 0.2 (5)	38.0 ± 0.3 (6)	38.0 ± 0.6 (6)
12 Dec	37.9 ± 0.4 (5)	37.8 ± 0.2 (7)	38.0 ± 0.3 (6)
19 Dec	38.0 ± 0.3 (5)	38.4 ± 0.5 (6)	38.2 ± 0.7 (6)
26 Dec	37.9 ± 0.1 (5)	38.0 ± 0.1 (7)	37.8 ± 0.1 (6)
3 Jan 1983	38.5 ± 0.6 (4)	38.5 ± 1.0 (7)	38.3 ± 0.3 (6)
12 Jan	38.4 ± 0.2 (5)	38.4 ± 0.3 (7)	38.4 ± 0.1 (6)
17 Jan	37.7 ± 0.7 (4)	37.8 ± 0.6 (7)	38.0 ± 0.4 (6)
25 Jan	38.4 ± 0.3 (5)	38.6 ± 0.1 (7)	38.4 ± 0.2 (6)
31 Jan	37.9 ± 0.2 (5)	38.2 ± 0.5 (7)	38.1 ± 0.2 (6)
15 Feb	38.1 ± 0.2 (5)	38.4 ± 0.1 (7)	38.3 ± 0.2 (6)
1 Mar	38.1 ± 0.3 (5)	37.9 ± 0.3 (5)	38.0 ± 0.4 (5)
7 Mar	38.1 ± 0.1 (5)	38.1 ± 0.3 (6)	38.3 ± 0.3 (5)
15 Mar	38.3 ± 0.2 (5)	38.3 ± 0.4 (6)	38.6 ± 0.2 (5)
23 Mar	38.4 ± 0.2 (5)	38.5 ± 0.3 (6)	38.6 ± 0.3 (5)
28 Mar	38.3 ± 0.4 (5)	38.5 ± 0.2 (6)	38.5 ± 0.3 (5)
5 Apr	38.3 ± 0.3 (5)	38.5 ± 0.4 (6)	38.5 ± 0.3 (5)
14 Apr	38.5 ± 0.5 (5)	38.4 ± 0.5 (6)	38.4 ± 0.5 (5)

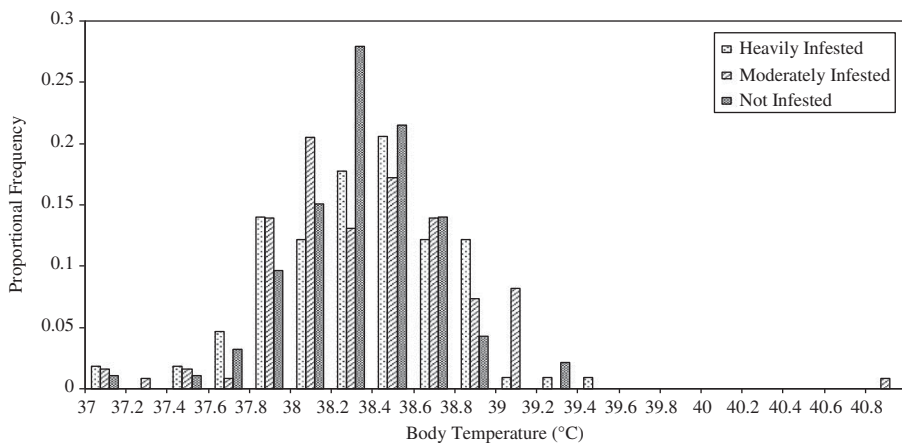


Figure 1. The frequency distribution of body temperature as measured in captive calf moose in Ontario, 1982–1983.

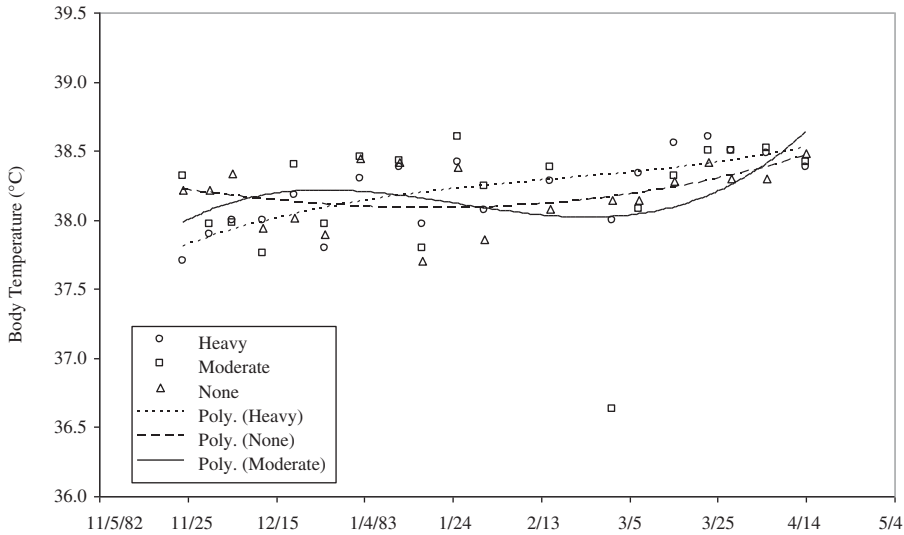


Figure 2. The relationship between time and body temperature (rectal) of captive calf moose in 3 treatment groups of winter tick infestation: heavy (42,000), moderate (21,000), none. Although treatment and time were statistically related, the temporal trend differed among treatment groups; Ontario, 1982–1983.

DISCUSSION

Although one could postulate that hair loss is one factor influencing T_b , the lack of difference in T_b among the treatment groups was not surprising. The number of recovered ticks was relatively low in contrast with tick loads measured on heavily infested wild moose (Samuel and Barker 1979, Samuel 2004). The number of larval winter ticks applied was an *a priori* estimate of the maximum numbers of ticks that would allow for the parasitic phases of the tick-moose cycle to be completed, while maintaining acceptable standards for the humane treatment of experimental animals, an objective that was achieved. For example, although reduced pericardial and abdominal fat reservoirs occurred in the infested versus control moose (McLaughlin and Addison 1986), we presume that all moose retained sufficient tissue reservoirs for adequate thermoregulation. Further, given the wide range in volume of hair loss reported within a single treatment group (i.e., 2–24% in moderately infested moose; McLaughlin and Addison 1986)

and the limited number of moose per treatment group, it would be difficult to detect treatment differences.

The negligible to limited seasonal variation in T_b is consistent with previous reports of seasonal variation in T_b in moose (Franzmann et al. 1984) and wapiti (*Cervus elaphus*) (Parker and Robbins 1984). On a cautionary note, the T_b s measured in this study should not be considered representative of those of heavily infested wild moose with extensive hair loss. The captive moose received higher quality, more accessible food throughout winter compared to free-ranging moose, and seldom experienced ambient temperatures considered thermally stressful (Renecker and Hudson 1986, Addison and McLaughlin 2014).

The significant interaction effect between treatment and time indicated that T_b of treatment groups varied over time, but did so in different directions. Environmental factors that might influence temporal differences remain unclear, but could include effects of handling during measurements as

higher T_b occurs with increased excitability in immobilized moose (Franzmann et al. 1984). However, we recognized no overt excitability in the study animals during measurements and the differences may simply reflect normal variation. The T_b s measured in this study were lower than any reported from healthy moose, and likely reflect the psychical state of our calm tractable moose, or conversely, the more stressful conditions associated with measurements of free-ranging moose.

The upper end of the range of T_b was consistent with data from prior studies (e.g., Franzmann et al. 1984) and most similar to those of captive moose (38.0–39.7 °C) that were not immobilized (Renecker and Hudson 1986). Seal et al. (1985) reported a mean T_b of 38.6 °C for free-ranging moose immobilized from the ground as they approached mineral licks. In contrast, higher T_b was reported for wild moose pursued and restrained (\bar{X} = 39.3 °C, range = 38.0–40.4 °C), or pursued and immobilized (\bar{X} = 40.5 °C, range = 38.0–42.8 °C, Roussel and Patenaude 1975; \bar{X} = 39.1–39.7 °C, Delvaux et al. 1999). Most T_b s of moose have been measured in adults and not young-of-the-year as reported here. Differences in size and age likely have little if any influence on T_b since in most ungulates T_b varies little relative to body mass, and if variable, young animals generally have higher T_b than adults (Parker and Robbins 1985).

In summary, there was no evidence that presence of winter ticks as applied in this experiment had any direct influence on T_b of moose. The T_b s measured in our highly tractable animals were the lowest reported for healthy moose, and consistent with the view that level of excitability influences T_b . Importantly, they provide the baseline T_b for resting moose that is important for metabolic modeling and comparison with T_b

measured via telemetry of free-ranging moose.

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