TICK (DERMACENTOR ALBIPICTUS)-INDUCED WINTER HAIR-LOSS IN CAPTIVE MOOSE (ALCES ALCES)

Authors: McLaughlin, R. F., and Addison, E. M.

TICK (*DERMACENTOR ALBIPICTUS*)-INDUCED WINTER HAIR-LOSS IN CAPTIVE MOOSE (*ALCES ALCES*)

R. F. McLaughlin and E. M. Addison
Ontario Ministry of Natural Resources, Wildlife Research Section,
P.O. Box 50, Maple, Ontario L0J 1E0, Canada

ABSTRACT: Five captive moose calves each infested with 42,000 larval *Dermacentor albipictus*, six calves each infested with 19,000–21,000, and five control moose were observed for changes in hair-loss, body condition and number, stages, and distribution of the tick. Winter hair-loss was observed only in moose infested with ticks and was correlated positively with the total number of adult ticks. Hair-loss associated with ticks was minimal from October to January, but rapidly increased from February to April when up to 44% of hair had been removed. The pattern of hair-loss was similar in all moose with the neck, shoulders, withers, and perianal areas losing the most hair. Moose with extensive premature hair-loss had less pericardial and abdominal visceral fat than moose with little or no hair-loss.

INTRODUCTION

Hair-loss associated with tick infestation in mammals is uncommon. However, premature winter hair-loss associated with the presence of the winter tick, *Dermacentor albipictus*, in moose has been described (Stelfox, 1962; Berg, 1975; Addison et al., 1979; Samuel and Barker, 1979; Glines and Samuel, 1984) and may lead to increased energy expenditure as the hair decreases in length and volume (see Scholander et al., 1950).

The objectives of the present study were to (1) clarify the association of premature hair-loss with the presence of ticks in moose, (2) characterize the location and timing of hair-loss on moose infested with ticks, (3) assess the influence of the intensity and time of infestation on the pattern of hair-loss, and (4) describe any effect premature hair-loss has on the growth and fat reservoirs of moose.

MATERIALS AND METHODS

Sixteen newborn moose were collected during the spring of 1982 and raised in Algonquin Provincial Park, Ontario (45°33'N, 78°35'W) (see Addison et al., 1983).

One male and one female were placed in each of six adjacent pens (29.6 × 16.5 m) and

two males with two females were placed in another pen (29.6 × 35.0 m). All moose were fed ad libitum a pelleted ration containing 16% crude protein, 2.5% crude fat and 16% crude fiber. Fresh feed was supplied daily and the amount consumed from each pen was recorded. Each moose was weighed weekly throughout the experiment.

Larvae of *D. albipictus* were collected during September and October 1982 in Algonquin Provincial Park by dragging white flannelette sheets over questing larval ticks in wild moose habitat. The larvae were evacuated (−40 kPa relative pressure) off sheets into 50-ml test tubes (approximately 5,000 per tube) and sealed in with fine mesh. Larvae were stored outside at ambient air temperature in a shaded location for 1–4 days before being applied at the base of the hair on the dorsal and lateral surfaces of the moose. Moose were tethered on a short lead and fed browse during the application of larvae and for an additional 30 min to allow larvae time to reach the hide without being licked off.

Infestation of 10 moose took place between 17 September and 12 October as larvae became available. Dosages ranged from 900 to 21,400 larvae per day with each moose receiving over 75% of its final intensity of ticks within 7 days of its initial dose. The day on which a moose had accumulated 50% of its final intensity of ticks was considered "day 0" postinfestation. Five moose, H1 through H5, each received a high intensity of infestation of about 42,000 larvae; five moose, M1 through M5, each received a moderate intensity of infestation of about 21,000 larvae; and five control moose received no ticks. To study the effect of time of infestation on timing of hair-loss the 16th moose,
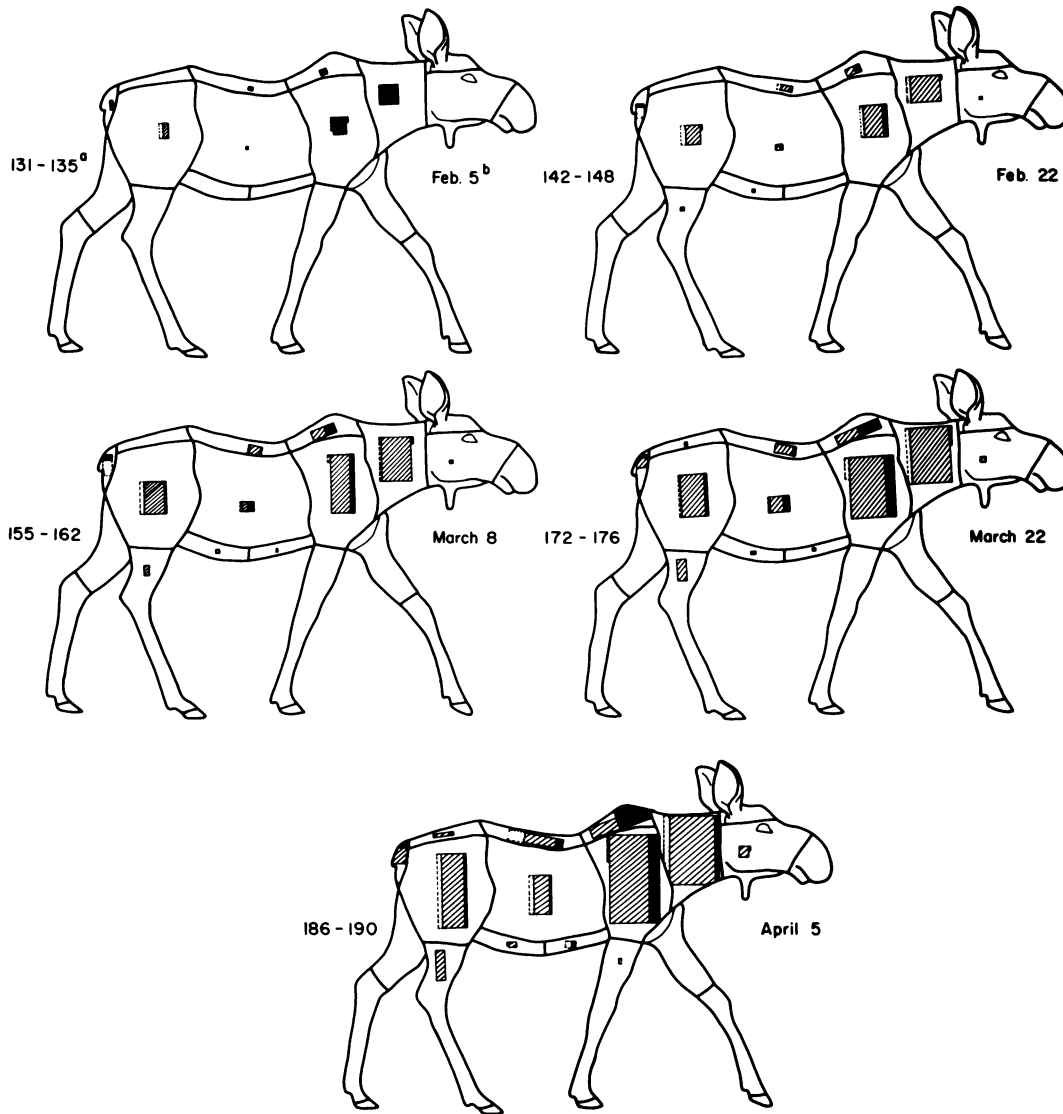
FIGURE 1. Diagrammatic presentation of average surface area and length of damaged hair of nine captive moose infested with between 21,000 and 42,000 larval ticks (*Dermacentor albipictus*). Only animals which experienced greater than 5% total hair loss by April are included. ■ Bare skin; ▨ 66–99% of hair length missing; ▢ 33–60% of hair length missing. [a]Days postinfestation. [b]Approximate dates.

M6, was infested with 19,000 larvae about 1 mo later, on 7 November.

To control natural infestation, pens used to house moose were sprayed with acaricide (Dursban M., Dow Chemical of Canada Ltd., Sarnia, Ontario N7T 7K7, Canada) three times at 2-wk intervals in the spring of 1982 and control moose were sprayed with acaricide twice in November and powdered with rotenone in December, January, and February.

Numbers and stages of ticks were recorded for each region of the moose (see Fig. 1 for regions) except the lower inside of the legs and the belly area. A permanent colored mark was placed in the center of each region on the moose's hide and four transects (1 × 10 cm) were measured out every 90 degrees about this spot. Each transect was examined for numbers and stages of ticks once each month. After each monthly examination, a sample of 100 ticks was

TABLE 1.   Mean volumes of hair lost[a] from various body regions of nine moose[b] infested with *Dermacentor albipictus*.

Body region	%[c]	Days postinfestation (approximate date)									
		81–123 (Jan)	134–140 (15 Feb)	142–148 (22 Feb)	151–153 (28 Feb)	155–162 (8 Mar)	164–170 (15 Mar)	172–176 (22 Mar)	178–184 (30 Mar)	186–190 (5 Apr)	193–203 (13 Apr)
Perianal	2.5	1 (1)	11 (10)	21 (17)	30 (15)	41 (22)	49 (29)	58 (25)	72 (25)	84 (21)	89 (15)
Croup	3.8	0 (0)	0 (0)	0 (1)	0 (1)	1 (1)	1 (1)	1 (2)	3 (3)	9 (9)	21 (29)
Loin	4.0	0 (1)	3 (9)	5 (10)	6 (11)	8 (14)	12 (17)	14 (18)	17 (19)	26 (21)	35 (24)
Withers	2.4	2 (6)	4 (7)	9 (11)	14 (17)	18 (21)	24 (30)	33 (30)	43 (28)	64 (27)	77 (18)
Neck	7.0	1 (3)	12 (13)	19 (21)	23 (21)	28 (22)	34 (23)	49 (21)	58 (19)	71 (20)	79 (17)
Thigh	9.8	0 (0)	2 (2)	5 (5)	7 (6)	8 (7)	9 (7)	13 (9)	18 (9)	22 (11)	31 (12)
Ribs	15.6	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)	2 (1)	3 (3)	4 (4)	7 (5)	12 (7)
Shoulder	9.2	1 (2)	5 (6)	11 (12)	15 (15)	20 (15)	25 (14)	36 (19)	49 (18)	59 (12)	66 (15)
Other[d]	45.7	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	0 (1)	0 (1)

[a] Mean percent of total volume of hair followed in parentheses by 1 SD.
[b] Moose which lost less than 5% of total volume of hair by April are not included.
[c] Percent of total area of hide.
[d] Includes lower and inner legs, belly, sternum, dewlap and head.

removed from each moose to identify developmental stages. Ticks were not sampled from the area of the transects.

To determine the progression of winter hair-loss, tethered moose were examined every 4–10 days (median 8) between 23 January and 15 April 1983. Prior to 23 January, records were made whenever a change in alopecia was observed. The position, shape and dimensions of areas of alopecia, including the length and condition of the damaged hair, were recorded. Observations were recorded on a life-size diagram of each moose. All parts of the hide were checked thoroughly for hair-loss except for areas between the legs and on the belly where the extent of hair-loss was estimated. The resultant diagrams were analyzed on a region by region basis with the left and right sides of the moose combined and averaged. Volume (cm³) of hair lost in alopecic areas was calculated as the product of the surface area and the length of hair removed. The length of hair removed was calculated by comparing the length of damaged hair with the length of undamaged hair from each region as recorded in January and February. Surface area of each alopecic area was determined from the life-size diagrams. Hair density, an important consideration, was not measured as it was beyond the scope of this study.

Photographs of each moose were taken twice a month to compare readily observable hair-loss with actual hair-loss measured during detailed searches of the hide.

Twelve moose were killed at the conclusion of the study. The surface area of each hide was measured immediately after the hide was removed from the animal. A 1-cm² piece of hide not infested with ticks and a piece infested with ticks were removed from each of the perianal, side, withers, neck, shoulder and belly regions and prepared for detailed microscopic examination using routine histological techniques. Sections of hides were checked for ectoparasites during histological examination.

The heart, pericardium and attached fat, and abdominal mesentery and associated visceral fat including renal fat were weighed.

Pearson product moment correlation coefficients were calculated to evaluate the relationship between hair-loss and the stages and total numbers of ticks within body regions. The Student-Newman-Keuls test was used to test differences in the rate of hair-loss between groups of moose infested with high and moderate intensities of ticks. Regression analysis was used to correlate food intake with hair-loss, intensity of infestation, and weight-gain. The Student's t-test was used to test differences in weight-gain and the size of fat reservoirs between moose with little and with extensive hair-loss.

RESULTS

Hair-loss was first observed on some moose by day 20, but involved less than 5% of the total hair volume until 134 days after infestation (mid-February) (Table 1).

Differences between the average amount of hair lost by moose with high intensities

of infestation and that lost by moose with moderate intensities of infestation increased with time. However, a Student-Newman-Keuls test revealed no significant difference between the two treatment groups. Based on their temporal and spatial hair loss patterns, the 16 experimental moose could, however, be separated into three statistically distinct groups. The first group consisted of four moose with moderate intensities of infestation and all five of the moose with high intensities of infestation. These moose experienced a small amount of hair-loss by day 135 (mid-February) followed by a rapid increase in rate of hair-loss through day 195 (mid-April) (Fig. 2) when 23–44% of their hair had been removed (Table 2). Volumes of hair-loss experienced by this group at any given time varied between moose, but the spatial distribution of alopecia was similar. The neck, shoulders, withers and perianal regions lost hair first and on a percentage basis were the regions of greatest hair-loss for most moose throughout the study (Table 1). Loss of hair from the croup and loin increased over time. Other regions showed varying degrees of hair-loss with most of it occurring along edges adjacent to regions of major hair-loss (Fig. 1).

In the second group of animals almost no hair was lost until mid-March and these moose still had 95% of their hair in mid-April (Table 2). This group consisted of one control animal (C2), a moose with a moderate intensity of infestion (M3), and moose M6, which was infested 1 mo later than the other moose. It is interesting to note that M6's spatial hair-loss pattern and rate of hair-loss was the same as the group one animals, but lagged behind by 1 mo.

Moose C2, a female, may have groomed slightly more than other control animals and did carry a small unknown number of ticks from natural infestation, as did its pen mate C1, a male. However, from observations we feel that C2 suffered much of her hair-loss, not from personal grooming or the presence of ticks, but rather
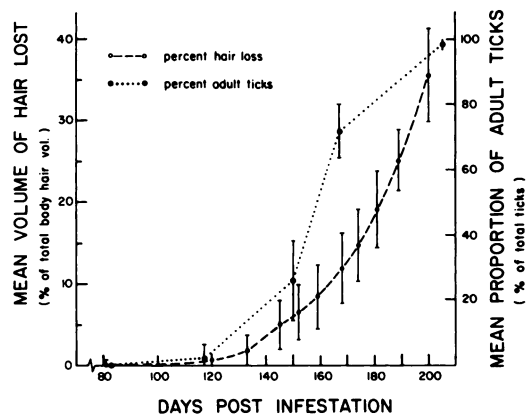

FIGURE 2. Average volume of hair lost by nine captive moose in relation to the proportion of adult to nymphal ticks (*Dermacentor albipictus*) on their hides. Only animals which experienced greater than 5% total hair-loss by April are included.

from C1's unusual habit of biting hair out of C2's rump, back and shoulders.

The third group consisted of the remaining four control animals. These animals experienced no hair-loss until mid- to late April, when the spring molt began. Molted hair was observed on the ground and scattered loosely on the hides. This loss of hair could not be measured as the tick associated alopecia was, since it was an evenly distributed hair-loss with no evidence of shearing or patches of alopecia.

A considerable amount of hair-loss occurred during February (Fig. 1, Table 1), but it was not readily apparent from photographs until after early March (see Fig. 3). The volume of alopecia necessary before becoming readily apparent varied between moose and between regions depending on the degree of spatial scatter and the length of the remaining undamaged hair. Hair-loss localized in one area was easier to observe than the same volume of hair-loss scattered over a wide area since the remaining undamaged hair often obscured the smaller areas of hair-loss. As time progressed, small areas of hair-loss enlarged and coalesced. The most characteristic pattern on infested moose in

TABLE 2.   Total hair-loss, weight changes and amounts of fat in captive moose infested and not infested with winter ticks.

Moose	Intensity of infestation (×1,000)	Hair loss[a] (% vol)	Weight change[b] (kg)	Pericardial fat		Abdominal fat	
				P[c] (g)	P/H[d] (%)	M[e] (g)	M/B[f] (%)
H4	42	44	12.0	270	18.2	2.09	1.07
H3	42	38	10.0	225	14.1	1.68	0.84
H1	42	32	−4.5	186	11.7	2.02	0.93
H2	42	32	−23.0				
M4	21	31	19.5	325	20.3	4.16	1.76
H5	42	28	10.5				
M1	21	24[g]	−11.5	220	15.1	2.25	1.12
M2	21	24[g]	−5.0				
M5	21	23	2.5				
C2	0	5	14.0	408	26.1	4.73	2.19
M6	19	4	12.0				
M3	21	2	24.5	360	21.3	6.68	2.58
C3	0	0	3.5	410	25.6	4.01	1.79
C4	0	0	10.5	540	34.6	6.42	2.97
C5	0	0	11.5				
C1	0	0	24.0	650	36.9		

[a] Total hair lost by 15 April.
[b] Total change in weight between 15 February and 15 April.
[c] Weight of pericardium and attached fat.
[d] Weight of pericardium and attached fat divided by weight of heart.
[e] Weight of abdominal mesentery and visceral fat.
[f] Weight of abdominal mesentery and visceral fat divided by total body weight.
[g] Total hair lost by 5 April.

April was hair-loss posterior to the ears and anterior to a diagonal line between the saddle of the back and the chest (see Fig. 4). The most visible sign of hair-loss was the contrast in color between the dark undamaged hair and the light gray bases of broken guard hair (Fig. 4). Bared skin initially appeared pink and gradually darkened to a shiny black (Fig. 4).

Loss of hair first became apparent in photographs between days 170 and 180 on the neck and shoulders of moose which had lost between 20 and 60% of the hair of these regions (Table 1). Hair-loss on the withers became apparent after day 180 and only when over 50% of the hair in this region had been lost. Other regions were of less value as indicators of hair-loss as hair-loss was generally more scattered and less visible in photographs.

The number of ticks, number of adult ticks and proportion of nymphs to adults varied between regions and over time. We could find no strong correlation between tick population parameters and the extent of alopecia within a region. There was also no strong correlation between amount of alopecia in a region and the number of ticks that were present 1 mo previously. There was a significant positive correlation ($r = 0.74$) between the proportion of adult to nymphal ticks on a moose and the total amount of hair lost over the whole body (see Fig. 2).

All animals showed a reduced weight-gain over the winter months. The animals which experienced extensive hair-loss gained an average 1.2 kg during the period of major hair-loss, 15 February to 15 April (see Table 2), compared to an average 14.3 kg exhibited by all other moose. However, due to the extreme variability in weight-gains within each group, no significant difference in mean weight-gains could be detected between the nine moose with extensive hair-loss and the other sev-
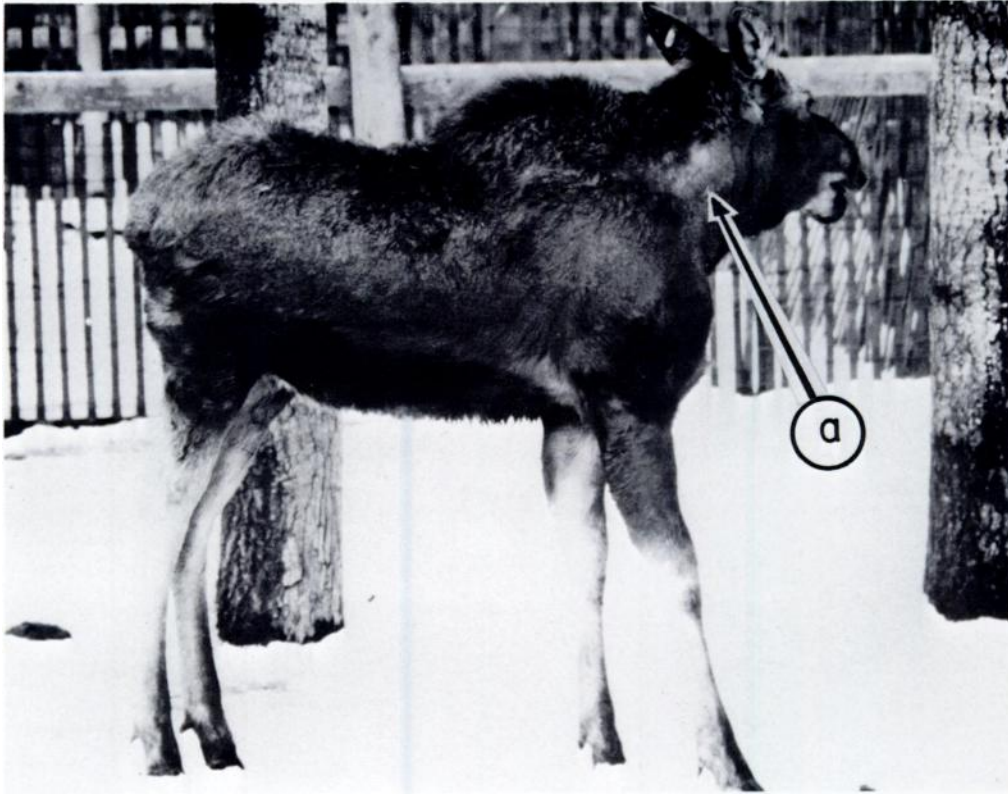
FIGURE 3. A moose calf (M4) on 5 March, 158 days after being infested with 42,000 *Dermacentor albipictus* larvae. Hair-loss of this magnitude (8% of total hair volume) is not readily apparent at a distance. Some hair-loss (a) can be seen on the neck.

en moose ($t = 2.10$, $P = 0.055$). Consumption of feed during this same 2-mo period ranged from an average 6.0 kg/day for one pair of moose to 9.0 kg/day for another pair, was not related to intensity of infestation with ticks ($r = 0.26$) and did not appear to be related to hair-loss ($r = 0.23$).

The ratio of pericardial fat-weight to heart-weight and the ratio of abdominal visceral fat-weight to body-weight were both consistently lower in moose with extensive hair-loss than in moose with little or no hair-loss (Table 2) ($t = 3.91$ and 3.85, respectively, $P < 0.01$). The combined weight of the pericardium and associated fat was on average 48% lower in moose with extensive hair-loss than in the other moose ($t = 3.91$, $P < 0.01$), while combined weight of the abdominal mes-

entery and visceral fat was on average 55% lower ($t = 3.85$, $P < 0.01$) (Table 2).

Ticks were the only ectoparasite observed in over 260 skin samples examined histologically.

DISCUSSION

Winter hair-loss was definitely related to the presence of ticks and was independent of the spring molt. This concurs with observations reported by Glines and Samuel (1984). However, the amount of hair-loss varied greatly between infested moose, making the relationship of density of ticks to amount of hair-loss unclear. Mean total volumes of hair lost by the moose with a high intensity of infestation did not differ significantly from similar measures of hair lost by the moderately infested moose ($P > 0.05$). However, progressively increasing
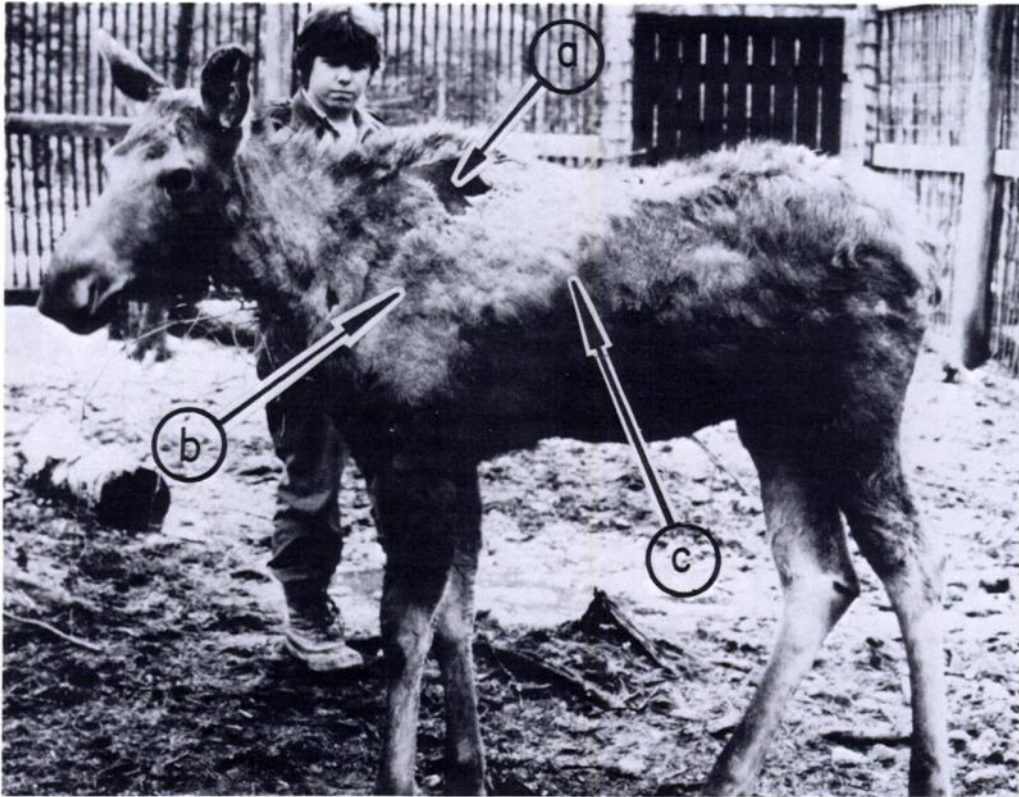
FIGURE 4. A moose calf (M4) on 13 April, 197 days after being infested with 42,000 *Dermacentor albipictus* larvae, with 44% of its normal volume of hair missing. Bare skin is initially pink and gradually darkens to a shiny black color (a). There is a contrast between dark, undamaged hair and the light gray bases (b) of broken guard hairs. The most characteristic pattern of the pelage of infested moose in April is hair-loss anterior from a diagonal line between the saddle and chest (c) to the area of the ears.

differences (Student's *t* values) in hair-loss between treatment groups as the experiment progressed suggested a trend which may have led to statistically significant differences in hair-loss had greater differences in intensity of infestation been used or if the experiment had not been terminated so early. Moose were killed in mid-April during a period of continuing rapid hair-loss (Fig. 2).

Winter hair-loss may be used as an indicator of tick infestation, but presence of ticks may be of less importance to the progression of winter hair-loss than is the developmental stage of the ticks on the moose. The rapid increase in the proportion of adult ticks on the moose between mid-February and mid-April correspond-

ed to an equally rapid increase in the amount of hair lost during this period (Fig. 2). This parallels observations on wild and captive moose from Alberta (Glines and Samuel, 1984). The positive association between proportion of adult ticks in a specific region and the hair lost in that region as found by Glines and Samuel (1984) was not evident in this study. Ticks may have emigrated prior to or as a result of grooming as postulated by Samuel and Barker (1979). However, the amount of hair lost from a region was not entirely dependent on tick density. The similarity of hair-loss patterns on moose given markedly different numbers of ticks supports this conjecture.

We recommend that hair-loss as deter-

mined by aerial census using helicopters be used to assess the extent of infestation of moose herds with ticks. However, tick-induced hair-loss on moose observed from a distance or from photographs (Mech, 1966; Samuel and Barker, 1979; Glines and Samuel, 1984) is related to but does not always indicate actual volumes of hair lost. The proportion of actual hair removed before it becomes readily apparent from a distance varies considerably between moose and between regions on the moose. Depending on the spatial distribution of the hair-loss, moose may lose up to 60% of the hair from a region before it begins to show and that may not occur until mid- to late March. This has obvious implications to the timing and subsequent analysis of winter hair-loss surveys done in the wild. We recommend that such surveys be conducted in late March or early April, even in areas where snow conditions are not ideal for locating moose. Prior to this time, hair-loss patterns on infested moose are highly variable and would not provide an accurate assessment of the degree of infestation with ticks.

The effect of a high intensity of infestation with ticks on the health and productivity of a moose herd is open to conjecture. Numerous reports of moose infested with ticks exist in the literature (see Anderson and Lankester, 1974) and often they include observations of alopecia, emaciation, weakness and death (see Samuel and Barker, 1979).

The possibility of D. albipictus causing a disease condition other than that associated with hair-loss is a consideration since other ticks are known vectors of disease. However, one of our infested moose, M3, did not seem to be affected in any way by the presence of ticks. This moose lost very little hair and gained more weight than any other moose (Table 2). The critical factor seems to have been the extent of hair-loss.

The nine moose with extensive hair-loss in this study had much lower average weight-gains and amounts of fat than the other moose. This suggests that these moose had an increased energy expenditure or reduced energy utilization capability because of alopecia.

Scholander et al. (1950) found that the insulative properties of moose hair is as high or higher than that of any arctic mammal, providing an energy savings of 199–302 $kJ \cdot day^{-1} \cdot dm^{-2}$ at a 37 C temperature differential, and that these values are closely correlated to hair length. A normal 291-dm^2 coat of a yearling moose has the theoretical potential of conserving 57,910–87,882 $kJ \cdot day^{-1}$ at 0 C ambient. Using the formula of Regelin et al. (1985) for basal metabolic rate (BMR = 565 $kJ \cdot kg^{-0.75} \cdot day^{-1}$) we find that the basic daily energy requirements of a normal 230-kg yearling moose is about 33,369 $kJ \cdot day^{-1}$. It can be readily calculated, while ignoring metabolic and behavioral adaptations, that the basic daily energy requirements of this moose could double theoretically if it lost 30% of its hair in a winter environment of −20 C. This high cost in metabolic energy of maintaining a constant body temperature while partially alopecic may well explain the relatively poor condition of moose with extensive hair-loss. In wild moose during the winter, the digestible dry matter intake is low and does not meet normal maintenance requirements (Renecker and Hudson, 1985). Therefore the increased energy expenditure related to hair-loss would necessarily come from the catabolism of body tissues. Depending on the amount of hair lost and environmental conditions, the increased rate of catabolism would weaken the moose, making it more susceptible to predation and disease and, in severe cases, could result in catabolic shock and death.

ACKNOWLEDGMENTS

by C. Pirie, M. A. McLaughlin, D. Carlson, D. Joachim, and P. Methner. L. Smith, K. Paterson, K. Long, A. Jones, S. Gadawski, S. Fraser, D. Fraser, and L. Berejikian assisted in the early care of calves. We appreciate the assistance of C. D. MacInnes and G. Smith and staff for their administrative support and to D. Baggley and A. Chui for their assistance with the manuscript preparation. Histological sections were prepared and examined by I. K. Barker. We would also like to thank our families and colleagues for the moral and intellectual stimuli they provided throughout. This is Ontario Ministry of Natural Resources, Wildlife Research Section Contribution Number 85-18.

LITERATURE CITED

ADDISON, E. M., F. J. JOHNSON, AND A. FYVIE. 1979. Dermacentor albipictus on moose (Alces alces) in Ontario. J. Wildl. Dis. 15: 281–284.

————, R. F. McLAUGHLIN, AND D. J. H. FRASER. 1983. Raising moose calves in Ontario. Alces 19: 246–270.

ANDERSON, R. C., AND M. W. LANKESTER. 1974. Infectious and parasitic diseases and arthropod pests of moose in North America. Nat. Can. 101: 23–50.

BERG, W. E. 1975. Management implications of natural mortality of moose in northwestern Minnesota. Proc. N. Am. Moose Conf. Workshop 11: 332–342.

GLINES, M. V., AND W. M. SAMUEL. 1984. The development of the winter tick, Dermacentor albipictus, and its effect on the hair coat of moose, Alces alces, of central Alberta, Canada. In Acarology VI, Vol. 2, D. A. Griffiths and C. E. Bowman (eds.). Ellis Horwood Ltd., Chichester, England, pp. 1208–1214.

MECH, L. D. 1966. The wolves of Isle Royale. U.S. National Park Services Fauna Series No. 7, 210 pp.

REGELIN, W. L., C. C. SCHWARTZ, AND A. W. FRANZMANN. 1985. Seasonal energy metabolism of adult moose. J. Wildl. Manage. 49: 388–393.

RENECKER, L. A., AND R. J. HUDSON. 1985. Estimation of dry matter intake of free-ranging moose. J. Wildl. Manage. 49: 785–792.

SAMUEL, W. M., AND M. J. BARKER. 1979. The winter tick, Dermacentor albipictus (Packard, 1869) on moose, Alces alces (L.), of central Alberta. Proc. N. Am. Moose Conf. Workshop 15: 303–348.

SCHOLANDER, P. F., V. WALTERS, R. HOCK, AND L. IRVING. 1950. Body insulation of some arctic and tropical mammals and birds. Biol. Bull. 99: 225–236.

STELFOX, J. G. 1962. Liver, lungs and larvae: Parasites and diseases in moose, deer, and elk in Alberta. Alberta Land-Forest-Wildlife 5: 5–12.