SEASONAL VARIATION AND EFFECTS OF WINTER TICKS (*DERMACENTOR ALBIPICTUS*) ON CONSUMPTION OF FOOD BY CAPTIVE MOOSE (*ALCES ALCES*) CALVES

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ABSTRACT: Effects of season and level of winter tick (*Dermacentor albipictus*) infestation on food intake by moose (*Alces alces*) were evaluated using 4 heavily infested calves (41,000 larval ticks), 4 moderately infested calves (21,000 larval ticks) and 4 uninfested calves. Food intake for all moose averaged 0.03 kg feed/kg moose/day. Mean daily food intake declined from approximately 0.05 kg feed/kg moose/day in early October, reaching low levels in late February (0.02 kg feed/kg moose/day). Food intake increased during late March and early April. These trends in consumption of food were consistent with trends observed for other northern cervids. The occurrence of ticks (level of infestation) showed no effect on consumption of food ($P = 0.2419$). Similarly, there was no evidence that tick activity (inactive vs. active growth phases) affected food intake ($P = 0.8289$). This experiment does not support the hypothesis that infestation with winter ticks influences food intake in captive moose. However, the possibility of *D. albipictus* affecting consumption of food by moose under other experimental conditions such as higher levels of infestation or under natural conditions with possible increased time and energy spent acquiring food should not be discounted.

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Although some ticks are known to induce anorexia in their hosts (Seebeck *et al.* 1971), Glines and Samuel (1989) reported no difference in food intake by moose (*Alces alces*) infested and not infested with the winter tick (*Dermacentor albipictus* Packard 1869). Similarly, Welch *et al.* (1990) noted no detectable differences in fasting metabolic rates between infested and uninfested captive moose. McLaughlin and Addison (1986) reported that moose with extensive hair loss associated with winter ticks had below average amounts of visceral fat. They attributed some of the lower fat levels to energy costs associated with alopecia and inclement weather. However, some of the reduced weight gain among heavily infested moose could have been due to reduced food consumption and/or increased grooming and restlessness in response to ticks.

Seasonal variation in energy intake or metabolism is a second factor that may influence food intake by moose. Although Welch *et al.* (1990) noted relatively constant fasting metabolic rates from February to early April in infested and uninfested moose, other authors have noted lower dry matter intake or metabolism in winter than in summer for moose and other northern cervids (see Regelin *et al.* 1985, Renecker and Hudson 1985, Schwartz *et al.* 1987).

Moose used in the present study were part of a larger study in which data were also simultaneously collected on growth of ticks (see Addison and McLaughlin 1988), and on effects of winter ticks and season on hair loss (see McLaughlin and Addison 1986), blood parameters, growth, and behaviour of moose. Objectives of the present study were to: 1) establish if level of tick infestation affected food consumption, 2) determine whether tick activity (inactive vs. active growth phases) affected food intake, and 3) determine if temporal trends in consumption observed for other cervids and subspecies of moose also occurred in captive *Alces alces americana*.

METHODS

Moose calves were captured, when less than two weeks old, during the spring of 1982 and were raised in a compound in Algonquin Park, Ontario (45°33'N, 78°35'W).

Techniques for rearing the calves from capture in May through to weaning by mid-August were as described by Addison *et al.* (1983). A ruminant ration (United Cooperative of Ontario, Mississauga, ON L5A 3A4 - 16% protein, 2.5% crude fat, 16% crude fibre) was first added as 10% of the total prepared food on 29 June, and increased in 10% proportions every 5-7 days. Beet pulp was available as 9-18% of the food mixture between 23 August and 23 October after which the ruminant ration was the only prepared food available.

Fresh browse was provided to calves from their first day in captivity through to early November and again on January 27, 28 and 30; on February 7 and 25; and on March 8. Trembling aspen (*Populus tremuloides*) and willow (*Salix* spp.) were most frequently offered but white birch (*Betula papyrifera*), yellow birch (*Betula alleghaniensis*), striped maple (*Acer pensylvanicum*), hard maple (*Acer saccharum*), red maple (*Acer rubrum*), beaked hazel (*Corylus cornuta*), largetooth aspen (*Populus grandidentata*), pin cherry (*Prunus pensylvanica*) and dogwood (*Cornus* spp.) were also provided. The amount of browse consumed was not quantified. The moose also consumed unknown quantities of aspen leaves which fell into the pens in autumn. Moose were allowed free access to food, fresh water or snow, soil and trace mineralized salts in blocks.

In September, two male and two female moose were assigned to each of three tick treatment groups; control (no ticks), moderate (21,000 larval ticks), and high infestations (42,000 larval ticks). Pairs of twins were split among treatment groups. Two moose, one female and one male, were located in each of six adjacent pens. Calves were infested with wild caught, larval *Dermacentor albipictus* beginning on 17 September. Dosing continued until 12 October with most moose receiving half their final infestation by 30 September (infestation date).

To control accidental infestation of moose in the uninfested treatment group, these moose were sprayed with acaricide (Dursban M., Dow Chemical of Canada Ltd., Sarnia, Ontario N7T 7K7) twice in November and powdered with rotenone in December, January and February. Fixed transects were established on each moose to determine the occurrence of ticks on the moose at monthly intervals. The possible transfer of ticks between moose during the experiment was evaluated by examining the occurrence of ticks on a fifth uninfested moose cohabiting a pen with five other infested moose.

Moose were weighed each week using a calibrated platform scale (Canadian Scale Co., Model 7045, accurate to within 250g). Weight was recorded to the nearest 0.5kg. The weight of pelleted ration provided was recorded daily for each pen (i.e. for each pair of moose). The next day the amount of feed remaining was measured and used to calculate actual amount eaten the previous day. Spillage and wastage of food due to trampling was negligible. Consumption of food (kg feed/kg moose/day) was calculated on a per pen basis by averaging daily consumption for the week and dividing the average by the combined whole body weights of the two moose in the pen.

Two tick activity phases were defined for use in data analysis: inactive phase - 22 September to 25 January (weeks 1 through 18); and active phase 26 January to 19 April (weeks 19 through 30). Definition of the activity phases was based on growth of the same winter ticks on the same moose involved in the present study (see Addison and McLaughlin 1988). Addison and McLaughlin (1988) demonstrated that winter ticks grew much more rapidly in February and March than from October to January. February to

April was also the period during which hair loss associated with infestations of ticks on these moose was greatest (McLaughlin and Addison 1986).

Analysis of covariance (ANCOVA) was used to test the effects of tick infestation level (control, moderate, high) and tick activity (inactive vs. active phases) on consumption of food. Time (week) was used as a covariate in the analysis since there was an obvious temporal trend in consumption of food. Since ANCOVA required a simple linear relationship between the response variable and covariate we transformed the food intake/kg moose/day and the time variable. The appropriate transformations were determined using scatter plots. Promising combinations of transformed variables were screened using an evaluation of regression residuals to confirm linearity. We also examined lagged-1 residuals resulting from our regression models to detect serial correlation. There were no strong trends in the resulting residual plots. This suggested that measurements taken from a particular pen were not having a consistent influence on measurements taken through time. For this reason, we considered measurements as independent in our analysis. We used ANOVA to determine if moose weight differed among tick treatment groups at the beginning of the experiment. Normality was assessed using the Kolmogorov-Smirnov test. Hypothesis tests were considered significant at $P < 0.05$.

RESULTS

Body weight was normally distributed within all three treatment groups ($P > 0.05$) at the beginning of the infestation period, and average body weight ($P > 0.250$) and its associated variance ($P > 0.400$), was similar among treatment groups.

Some larval ticks were present on control moose at the outset of the experiment. However, following use of acaricides, fewer than 50 ticks/control moose were present at the end of the experiment. No ticks were observed on the control moose cohabiting a pen with five infested moose.

Food consumption did not differ among tick treatment groups ($P = 0.2419$) or tick activity phases ($P = 0.8289$). The overall adjusted mean feed intake for the transformed data was 1.0229×10^{-3} (kg feed/kg moose/day)^2 (SE = 5.495×10^{-5}, n = 84). Back transformation of this statistic yielded an adjusted mean of 0.03 kg feed/kg moose/day which reflected average food consumption occurring among all moose in early November.

Daily feed consumption per kilogram body weight declined from a high of 0.05 kg feed/kg moose/day in early October to a low of 0.02 kg feed/kg moose/day in late February (Figure 1). Feed intake increased during mid-March and early April (Figure 1). The temporal trend in food consumption was described up to week 25 (March 15) using the following linear model fit to data after transformation of both dependent (Y^2) and independent ($1/(X)^{1/2}$) variables:

$$Y = 0.3024 \times 10^{-3} + 0.1954 \times 10^{-2} X$$

$R^2 = 68.30\%$, $SE_{Y.X} = 2.9618 \times 10^{-4}$, $P < 0.001$

DISCUSSION

Decreased food consumption in mid- to late winter followed by a rapid increase in food intake in early spring for our moose is consistent with trends observed for a variety of cervids from different geographic locations. For example, energy intake or metabolism is lower in winter than in summer for reindeer and caribou (*Rangifer tarandus*) (McEwan and Whitehead 1970), and for moose (Regelin *et al.* 1985, Renecker and Hudson 1985). In more time-specific studies, food intake is lower in late winter as compared to early winter and early spring for captive white-tailed deer (*Odocoileus virginianus*) (Ozoga and Verme 1970, Wheaton and Brown 1983) and in yearling and older moose (Schwartz *et al.* 1984). Re-

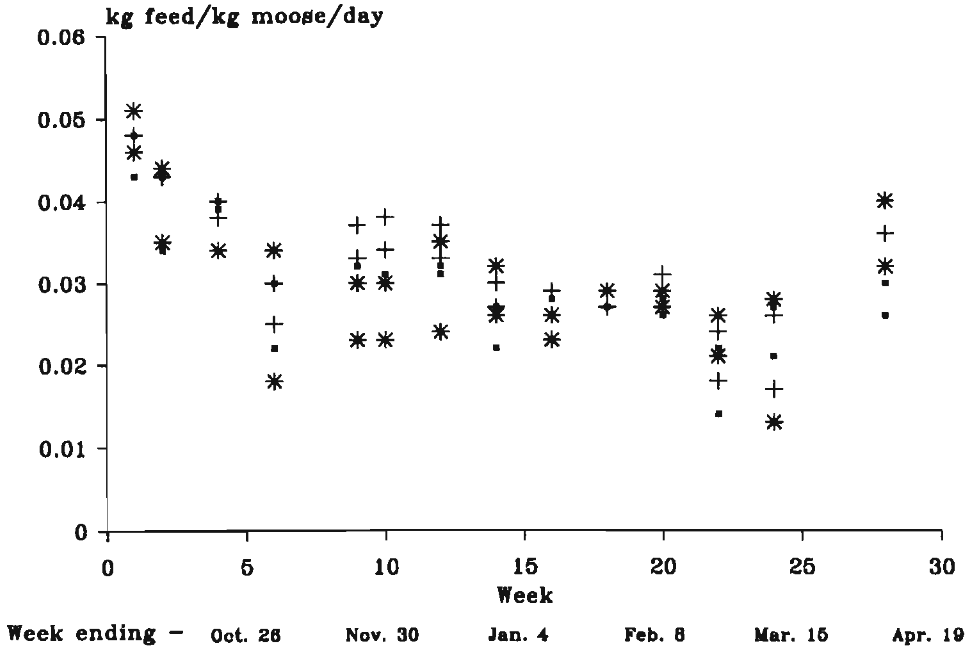

Fig. 1. Mean food intake per pen (kg feed/kg moose/day). Asterisks (*) denote pens with heavily infested moose, plus signs (+) denote pens containing moose moderately infested with winter ticks, and squares (■) denote pens containing control moose not infested with winter ticks.

sults of the present study also confirm the suggestion of Schwartz *et al.* (1984) that these seasonal trends in food intake occur in calf, in addition to older, moose.

Effects of ticks on host appetite have seldom been studied. However, Seebeck *et al.* (1971) did note a pronounced anorectic effect of *Boophilus microplus* on cattle. Absence of significant differences in food intake between infested and uninfested moose in the present study and as observed by Glines and Samuel (1989) suggests that winter ticks do not induce anorexia. Actually, the relationship between food intake by moose and infestation with winter ticks is likely much more complex than has been tested experimentally. Anorexia in moose could occur at some, but not all, levels of infestation with winter ticks. Numbers of larval winter ticks applied in this experiment and by Glines and Samuel (1989) were low when comparing the number of winter ticks recovered from the experimentally infected moose late in the present study (most moose had <5000 ticks) with numbers from dead wild moose in late winter-early spring (most moose had >20,000 ticks)(see Samuel and Barker 1979). By using higher infesting doses, further experiments might more rigorously examine the potential for winter ticks to induce anorexia in moose.

Another compelling reason for using caution in extrapolating results from the experimental studies to free-ranging situations is that moose in this study and in the study of Glines and Samuel (1989) were provided free access to high energy, high protein ration as compared to food available to wild moose in winter. These differences and differences in particle density between food of experimental and wild moose could all significantly affect consumption of food since food intake is strongly correlated with quality and availability of forage (see Regelin *et al.* 1985, Renecker and Hudson 1985).

Variation in tick activity during the infestation is another factor possibly influencing effects of winter ticks on consumption of food by moose. Addison and McLaughlin (1988) demonstrated that winter ticks grow much more rapidly in February and March than from October to January. As with grooming (Samuel 1991) and alopecia (see Glines and Samuel 1984, McLaughlin and Addison 1986), it is possible that other effects of winter ticks on moose are more pronounced during the rapid growth phase of the ticks in late winter than in autumn and early winter. There was no evidence that less food was consumed/body weight/day during the active tick phase of the experiment (i.e. when temporal trend in food consumption is controlled for). Further experiments to address this question should use individually housed rather than pooled moose since there is evidence that individual moose may respond differently to similar levels of infestation (McLaughlin and Addison 1986). This individual variation could not be measured within the present experimental design.

McLaughlin and Addison (1986) described alopecia in the same moose used in the present experiment. Moose with extensive alopecia had lower mean weight gains and visceral fat in late winter than did moose with limited or no alopecia. The absence of a direct effect of winter ticks on consumption of food supports the suggestion of McLaughlin and Addison (1986) that differences in weight and visceral fat reservoirs may be attributable to loss of energy associated with alopecia in combination with weather. However, these differences could alternatively or additionally be associated with increased grooming (see Samuel 1991) and restlessness in infested moose.

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