SEASON OF DETACHMENT OF WINTER TICKS (*DERMACENTOR ALBIPICTUS*) FROM SOUTHERN ONTARIO MOOSE (*ALCES ALCES*)

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ABSTRACT: Detachment of engorged female winter ticks (*Dermacentor albipictus*) from captive moose (*Alces alces*) was studied in Ontario during March and April, 1981–1984. The earliest detached engorged female was observed on 15 March, and for 9 of 15 moose, on 25–26 March. Detachment increased in early to mid-April with most adult ticks remaining on captive moose in late April. Few ticks were observed on wild cow moose by mid- to late May, 1981–1984, and detachment was considered complete in late May. More ticks dropped from moose at night than during daylight hours. The primary period of detachment was considered mid-April to mid-May during all 4 years of the study. Prediction of relative infestation the following autumn may be possible by considering the drop-off time and ground conditions that influence survival of gravid adult female ticks.

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The winter tick (*Dermacentor albipictus*) has one of the broadest geographic distributions of North American ticks (Gregson 1956) and displays range-wide variation in life history traits including the duration of its parasitic phase. Time from infestation with larvae to detachment of engorged females varied from 22 to 30 days in California (Howell 1939) and Texas (Drummond et al. 1969) to 175 days in Ontario (Addison and McLaughlin 1988). There are innumerable incidental reports of time of winter tick detachment, but only Drew and Samuel (1989) working in Edmonton, Alberta described the complete period when engorged female winter ticks detach from moose. Our study augments their earlier findings by describing this period of detachment from captive moose in Ontario in 1981–1984. Importantly, the portion of an infested moose's home range that is occupied during the period of detachment will become the potential source of infestation with larval winter ticks the following autumn, with overlapping habitat use common in these seasons (Healy et al. 2018). It also delineates the period of greatest energetic demands on calves and gestating females in spring, which are most negatively affected by the amount of blood extracted during severe infestations (see Pekins 2020).

METHODS

Moose were raised in captivity in 1980–1983 in Algonquin Provincial Park (Algonquin Park), Ontario (45° 33'N, 78° 35'W) as described by Addison et al. (1983). They were held in outdoor pens (29.6 × 16.5 m) with ~50% summer canopy cover of white pine (*Pinus strobus*), white birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), and largetooth aspen (*P. grandidentata*). With the exception of red-berried elder (*Sambucus pubens*), ground vegetation in the pens disappeared rapidly during the first summer of occupancy from browsing, grazing, and trampling. Crushed stone (5 cm diameter) was added to the feeding area and perimeter of the pens to increase hoof wear. Straw-lined sheds (2.9 × 2.9 × 2.7 m) were available but moose seldom chose to bed in them.

Larvae for infesting moose were collected by flagging vegetation in the wild in Algonquin Park. In an initial trial in 1980 one moose was infested on 11 November. Subsequently, 14 moose were administered larvae between 17 September and 12 October 1981–1984; the mean date of infestation was 30 September (Table 1).

The 15 captive moose used in this study were part of other tick-related experiments and varied in sex, age, time of infestation, size of the infesting dose, and number of moose per pen. One male calf was infested with 8000 larvae in 1980; two male calves were infested with 21,000–22,500 larvae each in 1981; two male and two female calves were infested with 21,000 larvae each, and two male and two female calves with 42,000 larvae each in 1982; one female and three male yearlings were infested with 21,000 larvae each in 1983. Three of the yearlings infested in 1983 had been infested as calves in 1982 (Table 1).

Beginning in early March each year, the total area of each pen was surveyed for detached ticks by walking parallel 1.0 m wide transects. Some observers changed between years and new staff received training in the established methods. Each pen was checked for ticks for 30–45 min during mornings (0700–0830 h) and evenings (1700–1800 h), with the number of engorged females (EFs) recorded as morning and evening collections. When other behavioral studies occurred, surveys for detached engorged female winter ticks sometimes occurred up to 1 h earlier in the morning and 1 h later in the evening. In 1981–1984, pens were checked for EFs through 22, 18, 17, and 27 April, respectively, when moose were euthanized upon direction from our animal care inspector and/or to prepare pens for introduction of new moose. Hair and hides of moose euthanized in 1982 (n = 2) and 1983 (n = 8) were dissolved and ticks counted as detailed in Addison et al. (1979). Adult ticks collected from hides in 1983 were tallied by sex. In

Table 1. Infestation and first detachment of *Dermacentor albipictus* from captive moose in southern Ontario, Canada, 1981–1984.

Infestation date	Age of moose (months)	Number of moose	Prior infestation with *D. albipictus*	Current infestation with *D. albipictus*	First date of detachment
Nov 11, 1980	4	1	0	8000	March 25
Sept 25, 1981	4	1	0	21,000	March 18
Sept 27, 1981	4	1	0	22,500	March 18
Sept 23–Oct 2, 1982	4	4	0	21,000	March 25
Sept 23–Oct 2, 1982	4	4	0	42,000	March 24
Sept 30, 1983	16	1	19,000	21,000	March 19
Sept 30, 1983	16	1	21,000	21,000	March 16
Sept 30, 1983	16	1	0	21,000	March 21
Sept 30,1983	16	1	42,000	21,000	March 15

1982, the perianal region of one moose was examined for 14 consecutive days and the number, location, and degree of engorgement of each tick was recorded. Additionally, presence of ticks was noted but not quantified on 10 radio-collared wild cows in Algonquin Park during calving behavior studies in late May 1981–1984 (see Addison et al. 1993).

RESULTS

Detachment time of EFs was independent of time and dose of infestation (Table 1). The earliest date of detachment was 15 March, and for 9 of 15 moose occurred on 25 or 26 March. The median date of first detachment for all animals was 25 March. Detachment of EFs in March was similar among years, although in 1982 there were 6 days when the daily count of EFs was ≥ 25% of the maximum daily EF count for that year (Fig. 1). Of winter ticks that were collected as detached EFs and others that remained on hides of moose when euthanized, only 11.8%, 33.4%, 6.7%, and 6.8% had detached as EFs in March

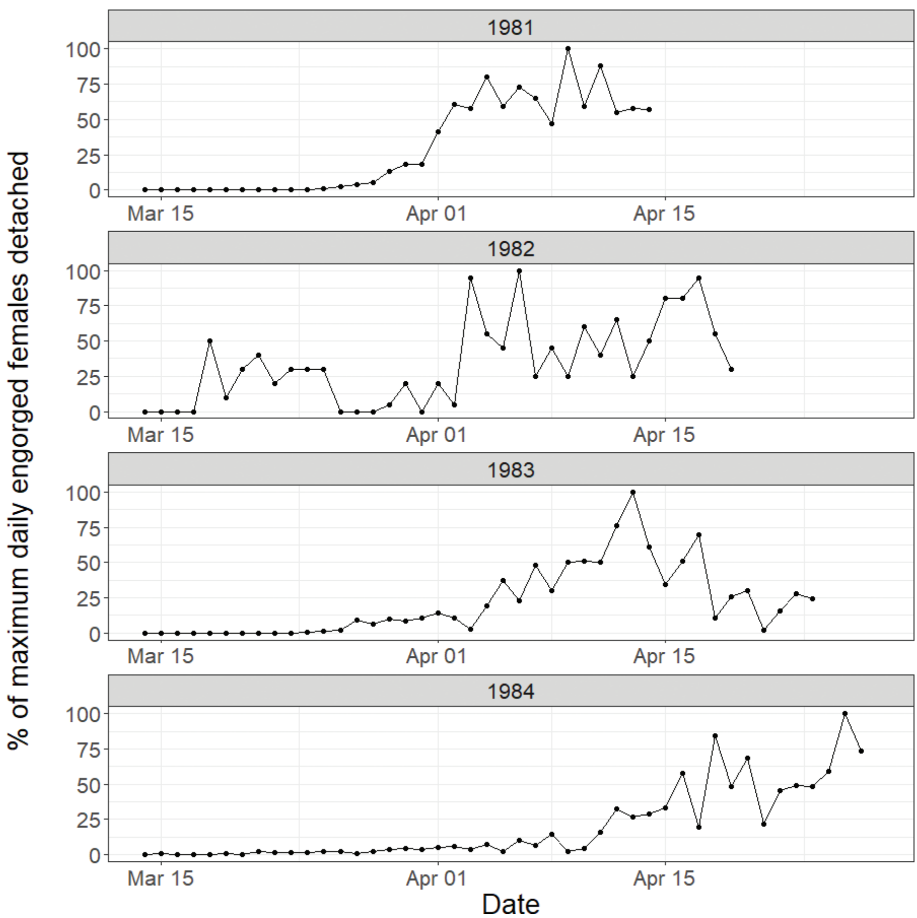

Fig. 1. Early season daily detachment of *Dermacentor albipictus* from captive southern Ontario moose (*Alces alces*), 1981–1984 (expressed as the percentage of a day's detachment relative to the maximum daily number of detached engorged females in that year). The maximum number of detached engorged females collected in one day in each year was: 1981–101, 1982–39, 1983 – 294, and 1984 – 271. The total number of engorged detached females counted each year was: 1981–1489, 1982–230, 1983–2455, and 1984 –2410.

of 1981, 1982, 1983, and 1984, respectively. Generally, the daily counts of detached EFs increased within the first few days of April. The single exception was in 1984 when the daily total count was < 25% of the maximum daily count until well into the second week of April (Fig. 1).

Tick collections in the morning represented approximately a 13–14 h crepuscular and nocturnal period since the previous evening collection. The evening collection represented ticks dropping in the prior 10–11 h of daylight. Morning and evening collections yielded 4399 and 2051 EFs, respectively, suggestive of a higher rate of detachment during nocturnal and/or crepuscular hours.

Number, location, and degree of engorgement of female ticks in the perianal area of one moose varied daily from 0 to 20 ticks. Between 20 March and 2 April, ≤ 3 female ticks were observed engorging and increasing in size rapidly between consecutive days.

In 1982, 419 detached EFs were collected from the 2 moose prior to euthanasia; 7565 adult ticks were counted on the hides during the post-mortem inspections. In 1983, the 2481 detached EFs collected from the 8 moose prior to death comprised 16.2% of the 15,272 adult female ticks remaining on the hides postmortem. Of the 922–3900 (μ = 1909) adult female ticks/moose on the eight moose euthanized in late April 1983, 0.5–2.8% (μ = 1.8%) per moose were fully engorged or near fully engorged on the day of death. Few engorging winter ticks remained on the 10 radio-collared wild cows in late May (1981–1984) in Algonquin Park (see Addison et al. 1993).

DISCUSSION

In Edmonton, Alberta, detachment of EFs from moose was first observed on 27 February and >50% had detached by the end of March (Drew 1984), with peak detachment occurring in late March in 1982 and 1983 (Drew and Samuel 1989). This was at least 2 and up to 4 weeks earlier than documented in this study in Ontario. Drew and Samuel (1989) referenced the possible influence of photoperiod on synchrony of detachment as proposed by Patrick and Hair (1977) for another ixodid tick, *Amblyomma americanum*. The similar detachment times for engorged female winter ticks, independent of year and time and dose of infestation in the 4 years of our study, is consistent with winter ticks adapting their parasitic phase to local prevailing seasonal conditions.

On captive moose in 1982, 5–22% (μ = 12.4%) of the infesting dose of ticks remained on the hides when moose were euthanized in mid- to late April 1983 (Addison et al. 2019). Presumably, many of the remaining adult female ticks may have engorged and detached during late April into early May. Few engorging winter ticks remained on wild Algonquin moose captured in mid- to late May (E. Addison, pers. comm.). The period of detachment of EFs in our study lasted 4–6 weeks beginning in late March through to mid-May, and the peak period of 2–4 weeks was similar to that observed by Drew and Samuel (1989) and consistent with the variability in engorgement and detachment of some other ixodid ticks (usually 5–21 days). For example, adult female *D. albipictus* have become replete 5–14 d after attaching to the host (Howell 1939), *Amblyomma americanum* in 7–15 days (μ = 9.8 d; Sauer and Hair 1972), and *Dermacentor variabilis* in 7–10 d (μ = 8.7 d; Sonenshine 1967). These times can be extended if mating of females is delayed after their initial period of feeding (Sonenshine 1967).

Although variation exists in the timing of final detachment of winter ticks among studies and areas, detachment is complete by the end of May consistently. In Alberta, Drew (1984) reported all EFs having detached by 1 May, and Glines and Samuel (1989) reported all winter ticks detached from experimentally infested moose by 14 May. Only 32, 52, and 233 ticks were recovered from digested hides of 3 moose killed on 20 May in 1963–1965 in the Chapleau Crown Game Preserve of northern Ontario (Addison et al. 1979). The latest that an EF has been reported on a host was on 31 May, and this was from a horse maintained at 5500 ft above sea level in Pony, Montana (Bishopp and Wood 1913).

Ritcey and Edwards (1958) working with moose in Wells Gray Park, British Columbia, were the first to note the apparent synchrony between presence of EFs on moose and the appearance of bare ground and proposed that presence of snow increased mortality of detached ticks. Drew and Samuel (1986) tested this hypothesis and demonstrated higher mortality of EFs dropped on snow as compared to EFs placed on bare ground.

Edmonton, Alberta has relatively little snowfall with a mean mid-winter snowpack of 18 cm and a mean of 16.9 d in March with at least 5 cm of ground snow (1981–2010; Canadian Climate Normals). In contrast, snow stations near the end of March in Algonquin Park, Ontario (45.58°N, 78.3°W) and Chapleau, Ontario (45.58°N, 83.45°W) in 1961–1986 had mean ground snow depths of 42.6 cm (± 24.9 SD) and 65.2 cm (± 17.76 SD), respectively; near the end of April, mean ground snow depth was 5.1 and 14.6 cm, respectively (Warren et al. 1998, Ontario Ministry of Natural Resources and Forestry 2020). Ticks detaching from moose in Algonquin and in Chapleau at the time of detachment reported for Edmonton would have had lower chance of survival, as well as Chapleau ticks during the early Algonquin detachment period of late March-early April. These data suggest that detachment times of the adult stage of winter ticks are adaptive to local weather conditions and coincident with appearance of bare ground in spring, as proposed by Ritcey and Edwards (1958).

A period of detachment of winter ticks prolonged over 4–6 weeks has adaptive advantages as compared to a more compressed period. During spring in moose range, remaining ground snow and/or fresh snow varies annually and, in the case of fresh snow, varies daily among habitats within a local area and year, and daily in the case of fresh snow. A prolonged period of detachment of *D. albipictus* increases the probability of some winter ticks detaching onto substrates optimal for survival and egg laying. Additionally, detachment of EFs over a prolonged period may spread their distribution over a larger portion of the spring home range; subsequently, more of the home range would be a source of infesting larvae the next autumn.

Extraction of blood from moose by winter ticks can be extensive and energetically demanding (see Samuel 2004, Musante et al. 2007, Pekins 2020). Extending the period of repletion and detachment of EFs over numerous weeks as compared to a more compressed period may result in increased survival of some infested moose. The rapidity of final engorgement and detachment of individual winter ticks was apparent from the rapid increase in size of engorging EFs on the perianal region of one moose followed for 14 consecutive days. Rapid engorgement of individuals is also observed in the ixodid, *Boophilus microplus*, where partially engorged females doubled in length and increased in weight 5–25 × during their last night of feeding before detaching from the host (Wharton and Utech 1970). The energetic demands of extraction of large amounts of blood just prior to detachment may be ameliorated by asynchronous final engorgement of adult female winter ticks.

The small proportion (0.5–2.8, $\mu = 1.8\%$) of adult female ticks/moose fully or near fully engorged on the day of death on the 8 moose euthanized in late April, 1983 suggests a degree of asynchrony in the final engorgement and detachment of EFs.

Numerous variables made it more likely that a greater proportion of detached EFs were recovered in the Alberta study than in the Ontario study. Drew and Samuel (1989) maintained their moose in smaller pens with concrete floors and solid wood partitions between pens, unlike the forest floor in the Ontario study. During our behavioral studies in March and April, we observed EFs detaching from moose, yet a few hours later, were unable to locate all EFs known to have detached. It was likely more EFs were recovered from our pens before all snow was gone due to the contrasting appearance of ticks and snow and the inability of EFs to rapidly burrow into the duff layer or through snow. It was more difficult to locate recently detached EFs during days of fresh heavy snowfall than on snow-free days. Ravens (*Corvus corax*) and Canada jays (*Perisoreus canadensis*) were observed feeding on detached engorged EFs during the observation periods (Addison et al. 1989). A daily rhythm to the time of detachment has been observed for many species of ixodid ticks (Belozerov 1982), and the EFs detaching at night may be less vulnerable to predation by corvids. Our data are not indicative of absolute numbers, but instead reflect trends over time in early detachment of EFs.

Much current emphasis is placed on the potential impacts of climate change on biotic and abiotic components of ecosystems, including ecosystems with moose. Many die-offs of moose associated with winter ticks occurred in the first half of the 20th century (Seton 1909, Samuel 2004) and again more recently in the northeastern United States (Jones et al. 2017, 2019). The extent to which changes in climate can be attributed as a primary cause of these die-offs both past and relatively current remains conjectural. However, it is clear that unpredictability in weather patterns has increased greatly in recent decades and continues to increase. If climate changes and associated weather patterns lead to increased snow depth during the expected local period of detachment of EFs, production of winter tick larvae will be suppressed and this will be advantageous to moose populations. Conversely, warming weather that decreases the extent of ground snow cover during the period of detachment of EFs may negatively impact moose populations. Summer weather conditions also influence recruitment of the non-parasitic stages of winter ticks and those influences vary among habitats (Addison et al. 2016). Additionally, a longer questing period in autumn may elevate infestations (Pekins 2020).

In summary, the main period of adult feeding and detachment of winter ticks on captive moose in Algonquin Park, Ontario was 4–6 weeks in length between early April and mid-May. Although generally similar, this was approximately one month later than documented in central Alberta. Differences in detachment time of EFs among areas appears consistent with local variation of bare ground in spring. Knowledge of local detachment times of EFs combined with snow cover information in a specific spring might provide insight and predictability of the annual tick burdens on moose the following autumn. Local differences in moose density and weather affecting larval survival and questing will influence the relative accuracy of these predictions.

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