

Temperature Effects On Host-Seeking By Larval American Dog Ticks, *Dermacentor variabilis* (Say)^{1,2}

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ABSTRACT. Host-seeking activity of larval American dog ticks was measured by determining the proportion of unengorged larvae attached to white-footed mice, *Peromyscus leucopus* (Rafinesque), trapped overnight in Columbus, Ohio, in 1983. A positive linear correlation was found between larval host-seeking activity and evening ambient temperature. No similar correlation was found between this activity and insolation, relative humidity, average daily temperature, or ambient temperatures taken at other times of the day or night.

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INTRODUCTION

Temperature has been reported to influence strongly the activity of immature American dog ticks, *Dermacentor variabilis* (Say), and other tick species (Smith et al. 1946, Hall and McKiel 1961, Lees 1969, Balashov 1972, Dukes and Rodriguez 1976, Rechav 1979). Conversely, Atwood and Sonenshine (1967) reported that air temperature was not related to the host-seeking of immature *D. variabilis* in field studies in Virginia. They reported that average daily solar radiation (insolation) received at ground level was the dominant meteorologic factor correlated with host-seeking by immature forms of this species.

Observations reported here on larval *D. variabilis* host-seeking activity, as reflected by the proportion (percent)

of host-attached larvae that were visibly unengorged, were part of a larger study on the ecology of Rocky Mountain Spotted Fever in Ohio. Absolute numbers of unengorged larvae and average numbers per host were not used to measure activity because the numbers and locations of small mammal traps employed varied greatly on different days, owing to limited availability of traps and investigator's time. Fewer traps will catch lower numbers of animals from which fewer ticks could presumably be collected. Tick density also would be expected to vary with trap site (Smith et al. 1946).

Percentages of unengorged larvae were considered to be a reliable indicator of recent host-seeking activity by these larvae, because the period between attachment and visible blood engorgement is relatively short (<48 h), and because the host collection date and time were accurately known for all specimens.

METHODS AND MATERIALS

White-footed mice, *Peromyscus leucopus* (Rafinesque), were caught alive in Sherman-type traps with peanut butter and corn chips as bait. Traps were set in the late afternoon or early evening and emptied between 0700 and 1200 h the next morning on 21 different days.

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This study was conducted in the American Addition, which is an area (2 km × 3 km) of scattered houses dispersed among untended lots, fields, and woods within northeastern Columbus, Ohio.

Numbers of larval *D. variabilis* collected and the numbers visibly unengorged were recorded for each white-footed mouse taken in the study area in 1983. The percentage of unengorged larvae was compared to published National Oceanic and Atmospheric Administration (NOAA) weather data from the Port Columbus Airport located 6.3 km nearly due east of the study area. Engorgement, as used herein, means ingestion of a substantial amount of food (i.e., to the point of visible detection) and not necessarily absolute repletion. Attention was focused on ambient temperature and insolation (sunshine) data for the trapping period (March-May, 1983).

The raw data for each collection date were combined for each successive 3°C interval of temperature through the observed range of 5°-23°C. The proportion of larvae unengorged (i.e., number unengorged/total number collected) was calculated for each of these temperature intervals, and the resulting percentage was plotted against the median temperature value for each of the respective intervals. Temperatures used were those recorded by the NOAA weather station at 1900 h (EST) on the evening previous to any given larval collection date. A general linear model of the relationship between temperature and the percent of unengorged larvae collected was run with the Statistical Analysis System (Ray 1982).

RESULTS

Temperature apparently influenced the proportion of unengorged larvae of *D. variabilis* that were collected from *P. leucopus* taken in the study area from March-May, 1983. There was a positive correlation between the percent of larvae unengorged and the ambient temperatures recorded at 1900 h (Table 1). For example, collections from 16 March, 1 April, and 16 May yielded among the smallest proportions (58.7, 53.8 and 56.1%, respectively) of unengorged larval *D. variabilis* coupled with ambient temperatures of less than 10°C at 1900 h on each of the respective previous evenings. The collections from 17 March and 2 April were representative of the opposite example. Both yielded notably higher percentages (85.7 and 90.7%, respectively) of unengorged larvae coupled with ambient temperatures above 10°C at 1900 h on each of the two respective previous evenings.

Ambient temperature showed a positive linear relationship to the percentages of larval *D. variabilis* that were unengorged, when data were combined within 3°C intervals (Table 1) and plotted against the median value of each respective temperature interval (Fig. 1). A general linear model of these data indicated a fairly strong linear relationship, with a coefficient of determination (r^2) of 0.82 and $P(r > F) = 0.01$ for this model.

TABLE 1

Proportions of unengorged Larval *D. variabilis* compared to NOAA* temperature data from the previous evening. Collections were grouped by 3°C intervals.

Temp. range (°C)	Median temp. (°C)	No. larvae unengorged/ No. of larvae collected	% Unengorged
5-8	6.5	236/356	66.3
8-11	9.5	62/96	64.6
11-14	12.5	267/375	71.2
14-17	15.5	62/83	74.7
17-20	18.5	205/275	74.5
20-23	21.5	423/559	75.7

*NOAA = National Oceanic and Atmospheric Administration.

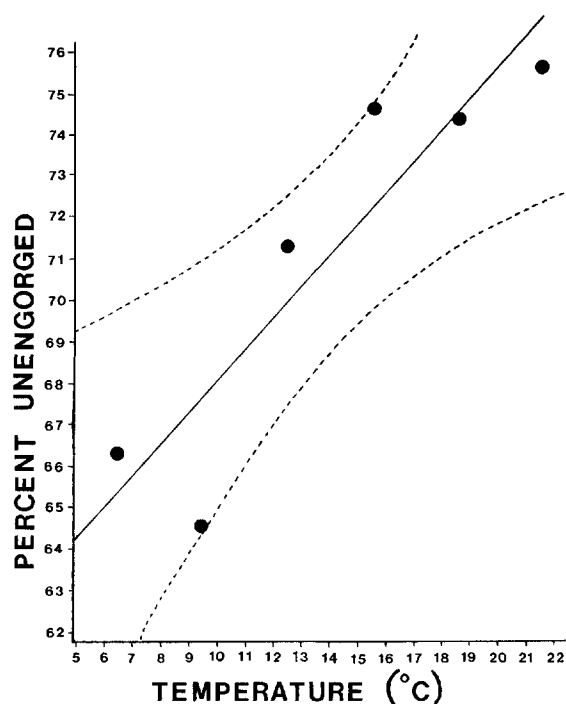


FIGURE 1. Computer-generated plot of percentage of larval *D. variabilis* collected unengorged from *P. leucopus* vs. ambient temperature (°C) at 1900 h the previous evening. Dotted lines show 95% confidence limits.

Identical treatment of data for insolation showed almost no correlation with the percentages of unengorged *D. variabilis* larvae collected from the white-footed mice. The NOAA data for average daily temperatures, for relative humidity, and for temperatures taken at other times of day showed only very weak correlations with these same percentages of unengorged larvae.

DISCUSSION

The choice of the 1900 h NOAA readings used in this study was based upon the primary food-seeking activity period (dusk to 2200 h) reported for *P. leucopus* (Amin 1974, Falls 1968, Mineau and Madison 1977). Live traps were most likely entered by mice during their normal foraging period, and the chance of contacting larval ticks was probably minimal after they entered the traps. Trap entry and its timing, therefore, probably constituted a cut-off of further increase in the numerical tick burden of any given mouse.

Larval *D. variabilis* require 3-5 days to fully engorge (Smith et al. 1946, Atwood and Sonenshine 1967). However, the vast majority of larval *D. variabilis* (i.e. F₁ larvae hatched from the eggs of field-collected adults) fed on white rats in our laboratory showed visible distention with blood within 36 to 48 h after placement on a host. This time was relatively independent of ambient temperature because the larvae were placed in direct contact with the hosts. Based on these observations, any larvae taken from field-collected hosts and not yet engorged must have been picked up by their host no more than 36 h earlier. The live traps were emptied each morning, so that each mouse was restricted from exposure to larval ticks for less than 24 h. Any larvae picked up the previous evening (i.e. just before their host's capture, since

these mice are most active in late evening) could not have become visibly engorged by the time the host was processed the next morning. These larvae would have been recorded as "unengorged". On the other hand, larvae picked up more than 24 h earlier, and very likely at least 36 to 48 h earlier (i.e. during the peak activity period of the host two evenings previous to the morning the host was processed), would almost certainly have become visibly engorged.

Accepting the above, it follows that, when relative proportions of unengorged larvae increased noticeably, relative rates of host-seeking activity by larval *D. variabilis* in the study area must have increased similarly. On some days few hosts were collected, or few larval ticks per host were found, resulting in small samples that were subject to sampling error in the proportions of larvae unengorged. Also, a few larger samples deviated widely from expected values, but are probably explained by rapid weather changes recorded the previous afternoons causing subsequent substantial decreases or increases in the temperatures recorded by NOAA at 1900 h. Changes in actual microclimates where larval ticks sought hosts may have preceded or lagged behind these recorded changes. Any such distortions were minimized by pooling the data into successive 3°C temperature intervals.

These data support the premise that there was an effect of temperature on larval *D. variabilis* host-seeking activity in the area and time period examined in the present study. The best explanation for these observations is that an increase in the ambient evening temperature led to increased host-seeking activity by the larval ticks. These

observations also suggest that, at least for larval *D. variabilis* in Columbus, Ohio, insolation should be rejected and evening temperature accepted as the main determinant of host-seeking activity.

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