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Kelly M. Micher
Bowling Green State University

C. Lee Rockett
Bowling Green State University

FIELD INVESTIGATIONS ON THE AMERICAN DOG TICK, *DERMACENTOR VARIABILIS*, IN NORTHWEST OHIO (ACARI: IXODIDAE)

Kelly M. Micher[1] and C. Lee Rockett[1]

ABSTRACT

Ecological investigations on the American dog tick, *Dermacentor variabilis*, were conducted in two metroparks located in Lucas County, Ohio. Adult tick surveys were conducted in 1989 and 1990. For both years, adult tick activity began in late April, and adult ticks were most abundant from early May to mid-June. Observed activity had ceased by early August, producing a unimodal pattern of activity. Sunny days with temperatures between 24° and 32°C were most conducive to adult tick activity, and adult ticks were most abundant on grass trails and in meadows. Using nest boxes inhabited by white-footed mice, immature tick surveys were conducted in 1989 and 1990. For both years, larval abundance peaked in early May and nymphal abundance peaked in late June or early July.

The American dog tick, *Dermacentor variabilis* (Say), is established in large areas of eastern and central North America, and in addition, there are several disjunct populations which include populations in the Great Lakes region and Canada (Sonenshine 1979). Ecological investigations of *D. variabilis* have taken place in Virginia (Sonenshine 1979), Tennessee (Zimmerman et al. 1987, 1988), Georgia (Newhouse 1983), Nova Scotia (Campbell 1979) and Ohio (Conlon and Rockett 1982, Harlan 1986). The importance of *D. variabilis* as a vector of Rocky Mountain spotted fever (RMSF) has provided much of the incentive behind such studies (Mount and Haile 1989). Much remains to be learned of the distribution, abundance, seasonal activity, host and vegetative parameters, and environmental aspects of *D. variabilis*.

The American dog tick has a life cycle of egg, larva, nymph, and adult. Campbell and MacKay (1979) reported the importance of the whitefooted mouse, *Peromyscus leucopus* (Rafinesque); the meadow vole, *Microtus pennsylvanicus* Ord; and the red-backed vole, *Clethrionomys gapperi* Vigors, as hosts for larval dog ticks. The meadow vole, *M. pennsylvanicus*, was listed as an important host for nymphal dog ticks. Grey squirrels, *Sciurus carolinensis* Gmelin; raccoons, *Procyon lotor* (L.); eastern chipmunks, *Tamias striatus* (L.); and red squirrels, *Tamiasciurus hudsonicus* Erxleben, also were reported to be important nymphal hosts (Garvie et al. 1978, Campbell and MacKay 1979, Zimmerman et al. 1988). The adult ticks tend to parasitize larger mammals such as raccoons, skunks, *Mephitis mephitis* (Schreber); woodchucks, *Marmota monax* (L.); opossums, *Didelphis virginiana* Kerr; horses, dogs, and man

[1]Department of Biological Sciences, Bowling Green State University, Bowling Green, OH 43403.

(Zimmerman et al. 1988, Fish and Dowler 1989). Tick seasonal activity patterns vary with regional temperature regimes. In the northern part of the dog tick's range such as Canada and Massachusetts, overwintering larvae and adults begin activity in the spring with peak activity occurring in early summer (McEnroe 1978, Campbell 1979). Tick activity in these areas normally ceases by mid-autumn (Campbell 1979).

Ecological studies of *D. variabilis* have provided information on environmental factors that may influence tick seasonal activity and survival. Important controlling factors appear to be ambient temperature, annual temperature regime, solar radiation received at ground level, and moisture (Atwood and Sonenshine 1967, Conlon and Rockett 1982, McEnroe 1978, 1984). Differences in relative abundance and distribution of ticks with respect to vegetation have also been noted.

The purpose of this study was to obtain information on the life cycle, seasonal dynamics, vegetative and host associations, and other environmental parameters of the American dog tick in two heavily used park areas of Lucas County, Ohio. In 1979 and 1980, after extensive surveys, Conlon and Rockett (1982) reported extremely low number of collected dog ticks in one of these two park areas. This low number of collected ticks limited the significance of the overall ecological investigation necessitating additional studies. Despite an apparent low number of ticks, Lucas County, located in northwest Ohio, accounted for more than 21 percent (107/491) of the RMSF cases reported from Ohio between the years 1964 through 1990 (Fontaine 1991).

MATERIALS AND METHODS

Secor and Oak Openings, located in southwestern Lucas County, maintain breeding populations of dog ticks. Secor Park, a 243 ha preserve is located approximately 24 km northeast of the much larger (1,484 ha) Oak Openings Preserve; both parks are open to visitors daily.

From the beginning of March through the middle of October in 1989, Secor Park was surveyed weekly for male and female adult ticks. Sex ratios were noted. Both Secor and Oak Openings were surveyed in 1990 using the same date parameters as used for Secor Park in 1989. Again, sex ratios were noted. Adult dog ticks were collected with a 3 m^2 white flannel drag as described by Smith et al. (1946). Four different vegetative areas of Secor Park and five different vegetative areas of Oak Openings were each "dragged" for a ten-minute period every week during the survey. The flannel cloth was dragged over vegetation for one minute at a time at 50 paces per minute and any attached ticks were removed. At that point, dragging would then continue. Dragging time did not include the time taken to remove ticks from the cloth, and no areas received repetitive drags during any weekly survey. In both parks a grass path and grassy roadside, each approximately 800 m long and containing primarily domestic yard grass, were surveyed for ticks. A meadow with assorted grasses and weeds plus a second growth, mixed, deciduous woodlot with numerous oak trees were also surveyed in each park. In addition, a pine woodlot containing mainly red and white pines, was examined in Oak Openings. All meadows and woodlots were approximately 900–1000 m^2 in area. Comparisons of habitat to number of ticks collected were analyzed using the Kruskal Wallis ANOVA (Zar 1984), which accounted for the unequal variances at each site. The air temperature and the solar radiation condition were recorded each week. The solar radiation condition was rated as being sunny, cloudy, or mixed sun and clouds. A comparison of ticks collected to daily air temperature was accomplished with simple regression analysis (Zar

Table 1. Numbers of adult ticks collected according to park, year, sex, and solar radiation condition on day of capture.

	Number of Ticks Collected					
Park and Year	Male	Female	Ticks/Minute	Sunny	Mixed Sun and Clouds	Cloudy
Secor 1989	503	428	1.45	682	170	79
Secor 1990	113	98	0.31	143	21	47
Oak Openings 1990	17	15	0.04	20	6	6
Total	633	541		845	197	132

1984). The significance of different solar conditions to collected tick numbers was determined with chi-squared analysis (Zar 1984).

Since immature dog ticks are rarely captured by "dragging" the vegetation (Smith et al. 1946), hosts and their nests were examined directly for ticks using mice nest boxes. Sherman-type animal traps were not used due to certain disadvantages such as not having permission to trap in certain areas of the public parks and possible vandalism to traps. In 1989, twenty mouse nest boxes were constructed of plywood, using a modified design described by Mitchell and Micher (1989). Nesting material (polyester fiber filling) was placed inside the boxes and each was baited weekly with a handful of sunflower seeds. The boxes were nailed to trees at a height of 0.5 to 1 m above the ground. Five boxes were attached to trees within each of four areas of Oak Openings Park. These areas consisted of the same deciduous and coniferous woodlots and meadow used for the adult tick survey, plus a different meadow containing a few apple trees. The boxes were checked weekly for ticks and mice from 14 April–13 October and 3 March–13 October for 1989 and 1990, respectively. Collected mice were anesthetized with ether, ticks were removed, and the mice were subsequently released back into their home area. The number of ticks and developmental stage were recorded for each box every week. Comparisons of immature tick number to habitat were analyzed using the Kruskal Wallis ANOVA (Zar 1984), which accounted for unequal variances at each site.

RESULTS

During the two year study period, 1174 adult *Dermacentor variabilis* were collected (Table 1). A marked difference in the number of dog ticks collected was noted between Secor Park (1142 ticks, 97%) and Oak Openings (32 ticks, 3%). In Secor Park, the capture rate decreased from a seasonal average of 1.45 ticks collected per minute in 1989 to a seasonal average of 0.31 ticks collected per minute in 1990. During the 1990 season of adult tick activity in Oak Openings, the average capture rate was 0.04 ticks collected per minute.

Adult ticks were collected more often on sunny days than on days with mixed sunny and cloudy days with high air temperatures (i.e., above 25°C). For example, in 1989 with 16 collection dates, one sunny day with the air temperature below 15°C accounted for 5.2% of the total ticks captured, while three cloudy days and two mixed sunny and cloudy days each with air temperatures above 25°C accounted for only 4.5% and 2.3%, respectively, of the total tick captures. During the 1989 season, seven sunny days accounted for 73.3% of the total tick captures within Secor Park. Four mixed sunny and cloudy days accounted for 18.3% of the total tick captures and five cloudy days produced only 8.5% of the ticks. During the 1990 season, ten sunny days

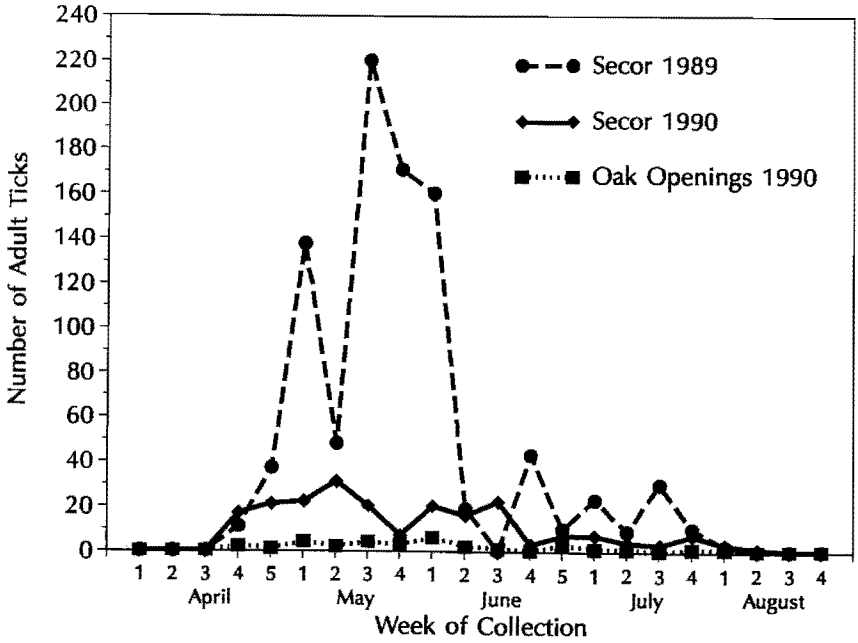

Figure 1. Seasonal distribution of adult *Dermacentor variabilis* in Secor Park and Oak Openings Park, Lucas Co., Ohio.

accounted for 67.1% of the total adult ticks collected within both parks combined, and five cloudy days produced 21.8% of the ticks. The level of adult tick activity increased significantly as the air temperature increased ($P < 0.001$). Adult ticks were most commonly collected (58%) at ambient temperatures between 24°C and 32°C. Adult ticks were not collected at ambient temperatures below 12°C. During this study, no temperatures higher than 32°C were recorded.

Infestation levels were significantly different among habitats within Secor Park ($P \leq 0.0001$). Eight hundred and twenty adult ticks (71.8%) were collected from the grass path habitat. Two hundred thirtyseven ticks (20.8%) were collected from the meadow and 78 ticks (6.8%) were collected from the grassy roadside. Only seven adult ticks (0.6%) were collected from the mixed deciduous woodlot in Secor Park. Infestation levels also were significantly different among habitats within Oak Openings ($P < 0.0003$). As with Secor Park, the majority of adult ticks (17 ticks or 53.1%) were collected from the grass path habitat. Seven (21.9%) and six adult ticks (18.75%) were captured from the meadow and roadside, respectively. Two ticks (6.25%) were collected in the coniferous woodlot and no ticks were collected in the mixed deciduous woodlot within Oak Openings Park.

Adult tick seasonal activity, as observed by the authors, is depicted in Figure 1. The first adult ticks were collected on 21 April 1989 and 22 April 1990. In Secor Park, adult ticks were most abundant from early May to mid-June for both years of study. Even during this period, observed tick activity

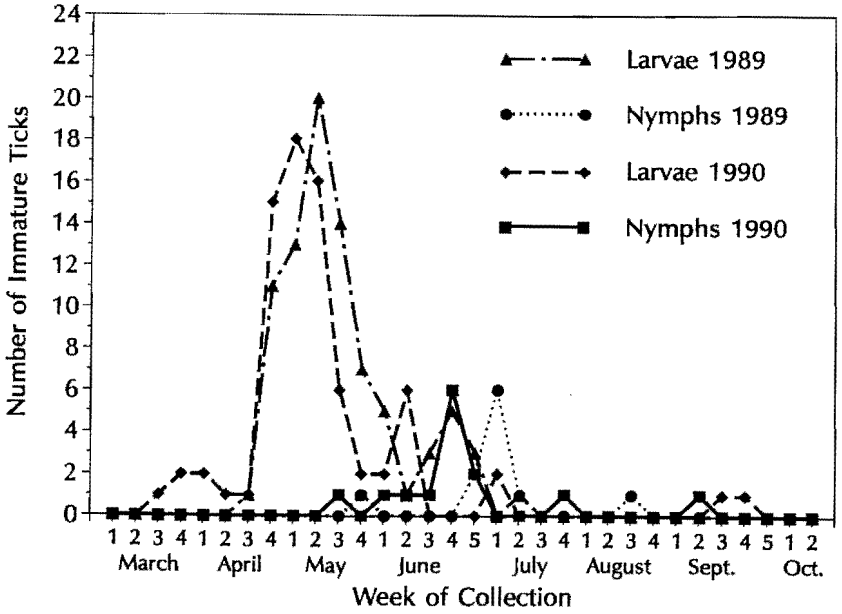

Figure 2. Seasonal distribution of immature *Dermacentor variabilis* in Oak Openings Park, Lucas Co., Ohio.

was decreased and atypical during rainy periods or conditions when air temperatures were below 15°C. This is reflected in Figure 1 (i.e., week 2, May 1989; week 3, June 1989; week 4, May 1990). In Oak Openings, adult ticks maintained a constant low level of observed activity throughout the season. Apparent adult tick activity had ceased by early August for both years and both parks producing a unimodal pattern of distribution. A majority (54%) of ticks collected was male.

A total of 185 immature dog ticks was collected from Oak Openings during the two-year study. One hundred and thirty-six larvae and 24 nymphs were collected from inside the nest boxes and nesting material while 24 larvae and one nymph were collected directly from mice found in the nest boxes. Most (77%) of immature ticks collected were engorged larvae. In 1989, larval collections increased to a peak in May and then decreased thereafter (Figure 2). Similarly, larval activity peaked in May of 1990. No larvae were captured after the first week of July 1989, however, two larvae were collected in late September of 1990. In 1989, the majority of nymphs (64%) was collected in early July and apparent activity ceased by late August. In 1990, peak activity occurred in late June when 78% of the nymphs were collected. Apparent activity ceased by late August.

Immature tick density with respect to nest box location was significantly different for larvae ($P < 0.0008$), but was not significantly different for nymphs. One hundred and two larvae (63.75%) were collected from boxes or mice found in the boxes placed in the first meadow habitat. Thirty-five larvae

(21.88%) were collected from the pine woodlot. Nineteen larvae (11.88%) and four larvae (2.5%) were collected from the mixed deciduous woodlot and second meadow habitat (with a few, scattered apple trees), respectively. Eleven (44%) and nine (30%) nymphs were collected from the mixed deciduous and coniferous woodlots, respectively. Three nymphs (12%) were collected from the first meadow habitat while two (8%) were captured from boxes placed in the second meadow containing apple trees. White-footed mice were the only mammals captured from the nest boxes. Twenty-two and 19 mice were captured from nest boxes in 1989 and 1990, respectively. For both years, the majority of captured mice were from the coniferous woodlot – 1989 (51%) and 1990 (53%).

DISCUSSION

Considerably more ticks were collected from Secor Park than from Oak Openings. This is interesting, given the close proximity of the parks (less than 24 kilometers apart). In a previous study, Conlon and Rockett (1982) reported low population levels of dog ticks in Oak Openings. Unlike Oak Openings, Secor Park is a small metropark that is located in the middle of an urbanized area. Trails or paths in Secor Park are subject to greater and more frequent host traffic, particularly dogs and humans, than Oak Openings. It is tempting to speculate that enhanced host availability would be a factor in increasing tick densities along the path areas in Secor Park. Smith et al. (1946) reported that even in heavily infested regions, abundance of *D. variabilis* is localized and sporadic. Soil surveys have determined that Oak Openings has many more sand dunes, beaches and ridges compared to Secor Park which has more low lying areas (Stone et al. 1980). This should produce a much drier situation in Oak Openings as the sand hills will allow better drainage of water while the low lying areas of Secor Park are subject to ponding. Greater moisture content of the soils in Secor Park may have contributed to the survival success of dog ticks simply because the ticks were not put under as much risk to desiccation. Dodds et al. (1969) reported higher tick abundance in wetter areas of the Tobeatic Game Sanctuary in Nova Scotia when compared to tick surveys in drier areas in the sanctuary. The above authors concluded that the presence of considerable moisture with accompanying grass or sedge is needed to maintain high tick densities.

Adult dog tick abundance decreased markedly in Secor Park during the second year of the study; over four times as many ticks were captured in 1989 than in 1990. This decrease may be explained partially by differences in known winter weather conditions, particularly December 1988 and 1989. According to the National Oceanic and Atmospheric Administration (NOAA 1988, 1989), the mean temperature in December, 1988, was only slightly below normal (0.2°C below normal), but the mean temperature of December, 1989, was well below normal (6.2°C below normal). The seasonal snowfall was below normal for both winters (NOAA) 1988, 1989). The low tick abundance observed in 1990 may be due partially to lowered overwintering success caused by the harsh December temperature (monthly mean of -8.4°C) of 1989 coupled with inadequate snow cover. McEnroe (1977) reported that when winter temperature means fall below 0°C the overwintering ticks are subject to mortality from desiccation as the water maintenance pump works less adequately under extreme temperatures. Conlon and Rockett (1982) and McEnroe (1984) reported that snow cover might help to insulate ticks from colder winter temperatures within their overwintering microhabitat and help maintain soil and leaf-litter moisture above the ticks' critical humidity equilibrium.

Solar radiation condition data denoted higher adult tick activity on sunny days than on days with mixed sun and clouds or cloudy days. This supports Atwood and Sonenshine's (1967) finding that questing activity in adult ticks is positively correlated to the amount of solar radiation received at ground level. New house (1983) observed that cloudy days negatively affected tick activity, and Conlon and Rockett (1982) reported higher capture rates on sunny days. Temperature data from Secor Park and Oak Openings indicated that adult tick activity also increased as ambient air temperatures increased. Newhouse (1983) reported a positive correlation between tick activity and ambient temperature. Smith et al. (1946) reported the importance of ambient temperature to the incubation period of eggs, molting time for immature ticks, tick activity, and longevity in ticks. In the present study, adult ticks were not captured at air temperatures below 12°C or above 32°C. Hall and McKiel (1961) and McEnroe and McEnroe (1973) reported a lower temperature threshold of 5°C for adult tick questing activity and a curbing of questing at higher temperatures (40°C).

During 1989 and 1990, adult tick activity began in late April, peaked in mid-May to early June, and declined thereafter. Larval activity began in late March and peaked in May. Nymphal activity was most evident in late June to early July. This pattern of seasonal tick activity suggested a two-year life cycle for *D. variabilis*. The spring adults would produce eggs that hatch into larvae in the summer. These larvae would overwinter until the following spring. In the spring, the overwintered larvae would become active and then the engorged larvae would molt into nymphs which quest for hosts in June and July. The engorged nymphs would molt into adults in late summer. Most of these late-summer adults would not actively quest, but instead, would overwinter and become active in late April the following year for a two-year cycle. Some late summer adult ticks will quest, but, McEnroe (1974) and Smith et al. (1946) noted that latesummer, questing adults usually do not contribute to the following generation because eggs cannot successfully overwinter in cold climates.

In Lucas County, the last annual freeze is typically between 10–20 April. Initial adult activity began in both Secor Park and Oak Openings just after these dates (21 April 1989 and 22 April 1990), the same dates reported by Conlon and Rockett (1982). Adults were not collected by "dragging" in late summer of 1989 and 1990. Comparable seasonal activity patterns for *D. variabilis* were reported by Campbell (1979), Garvie et al. (1978), and Smith et al. (1946). In contrast to the present study, Conlon and Rockett (1982) and McEnroe (1974) reported bimodal activity for adult dog ticks with a second small peak of activity observed in late summer. This bimodal activity pattern may be attributed to the maintenance of a few individuals with aberrant behavior (Wilkinson 1979). The individuals may quest for hosts in late summer or fall if environmental conditions are suitable and produce the second small peak of activity sometimes observed.

Adult dog ticks were most often captured on grassy paths. This conformed with the results of other authors such as Newhouse (1983) who observed high tick abundance on grass paths and trails in Georgia. Sonenshine et al. (1972) reported that *D. variabilis* is often associated with edges of trails, roads, meadows and other clearings. The scent of hosts may be more concentrated on grass paths and trails in Georgia. Sonenshine et al. (1972) reported that *D. variabilis* is often associated with edges of trails, roads, meadows and other clearings. The scent of hosts may be more concentrated on grass paths and thus in turn could attract more dog ticks to an area. Dukes and Rodriguez (1976) reported that nymphal dog ticks were more attracted to dog and rabbit hair than sterile cotton. Dog hair was preferred over rabbit hair. Many (244) adult ticks were collected from the meadow habitats in the

parks. Smith et al. (1946) noted that tick infestations were usually associated with an abundance of grassy cover in which meadow mice could thrive. In this study, trees were scattered throughout the meadows and the meadow habitat bordered second growth woodlots. The majority of the meadow captured ticks were collected from the borders and around trees in the meadow. As stated previously, a majority of ticks were caught on sunny days. Presumably, the trees would provide shade from direct sunlight, therefore ticks could quest for longer periods and not risk quick desiccation (Conlon and Rockett 1982). In addition to the benefit of shade, the dog ticks may have aggregated near trees in the meadows because host scent may have been concentrated there, as many mammal burrows were seen in these areas. A considerable number (78) of adult ticks were collected from grassy roadsides within the parks. Smith et al. (1946) partially attributed the high density of dog ticks observed on roadsides to the possible concentrated scent of their hosts. Furthermore, carbon dioxide has been determined to be an attractant to dog ticks (Garcia 1962) and some carbon dioxide is released from automobile traffic in the parks. Very few adult ticks (9) were encountered within the mixed deciduous and coniferous woodlands of Secor and Oak Openings Parks. This finding was not unexpected as this trend was observed by Conlon and Rockett (1982), Dodds et al. (1969), and Sonenshine and Levy (1972). Dodds et al. (1969) suggested that a well-developed canopy prevents the growth of adequate understory needed to maintain large numbers of small mammal hosts for the dog ticks.

Interestingly, more male dog ticks (54%) were collected than females. Conlon and Rockett (1982) also captured more male ticks by dragging. Sonenshine et al. (1966) found that males tend to appear earlier than females. It is unknown whether this is a reflection of a more vigorous questing behavior in males or more rapid acclimation to spring weather conditions after overwintering. In contrast to the above, Garvie et al. (1978) found female ticks outnumbered male ticks on a study site in Nova Scotia, but did not speculate as to why females were more numerous.

Moderate numbers of larvae (160) and low numbers of nymphs (25) were collected from mice nesting boxes placed throughout Oak Openings in 1989 and 1990. Mitchell and Micher (1989) reported the capture of 143 larvae and 8 nymphs from Secor Park in one season of study utilizing 24 nest boxes. Jackson and DeFoliart (1976) collected 7706 immatures in four seasons of study from 337 of 851 nests of white-footed mice in Wisconsin. However, a direct comparison cannot be made with the present study because Jackson and DeFoliart (1976) used both natural nest and nest boxes and did not distinguish between numbers of each. The natural nests may be more attractive to mice than wooden boxes. Interestingly, Jackson and DeFoliart (1976) also reported low numbers of nymphs in nests were at least partially the result of sampling without replacement, i.e., removal of engorged larvae. This could help to explain the low numbers of nymphs captured from nest boxes in the present study. Also, if medium-sized mammals were serving as major nymphal hosts, the population would certainly be much larger than the nymphal capture rate reported from the relatively small nest boxes. In a previous unpublished study, we noted the presence of potential nymphal hosts such as chipmunks, ground squirrels, red squirrels, raccoons and woodchucks, in Secor and Oak Openings.

The American dog tick remains an important pest and vector of disease (RMSF) in Lucas County. Much remains to be learned of the bionomics of *D. variabilis*. Studies are in progress to further detail the seasonal dynamics, host-specific aspects, and vegetative parameters of *D. variabilis* in northwest Ohio.

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