October 2003 THE MARYLAND ENTOMOLOGIST Vol. 4, No. 3

Contents

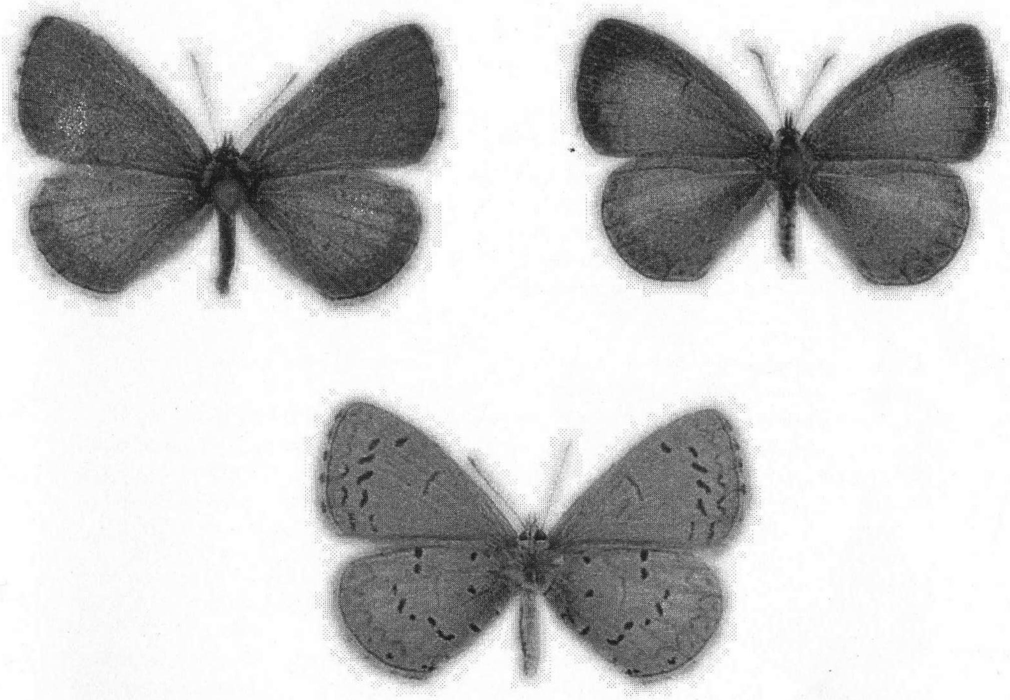
Cover Illustration

The type specimens of the new species,
Celastrina idella Wright & Pavulaan,
the “Holly Azure.”

(Upper left: Holotype Male (dorsal view);
Upper right: Allotype Female (dorsal view)
Below: Holotype Male (ventral view)

(Photographs by Harry Pavulaan.)

THE MARYLAND ENTOMOLOGIST



Maryland Entomological Society • 1971

Volume 4, Number 3 July 2003

MARYLAND ENTOMOLOGICAL SOCIETY

The Maryland Entomological Society (MES) was founded in November, 1971, to promote the science of Entomology in all its sub-disciplines, to provide a common meeting venue for professional and amateur entomologists residing in Maryland, the District of Columbia, and nearby areas; to issue a periodical and other publications dealing with entomology and to facilitate the exchange of ideas and information through its meetings and publications.

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The MES is a non-profit, scientific organization. Meetings are held on the third Friday of October, November, February, March, April and May, at 8:00 p.m., in Room 4, of the Biological Sciences Building, University of Maryland Baltimore County (UMBC), or other announced site.

The *Maryland Entomologist* is published irregularly by the MES. There are four numbers per volume. Original articles or reports on geographic or temporal distribution, particularly pertaining to Maryland or nearby localities; ecology, biology, morphology, genetics, systematics, behavior, etc., are welcome. Book notices or reviews, requests for information, notes on distribution, behavior, occurrence, migration, life history and other biologic topics will be published. All articles are subject to editorial review and acceptance. Sent input to: Harold J. Harlan, (Acting Ed.), 621 Maple Hill Lane, Crownsville, **MD** 21032. Please indicate if you want your submission(s) "peer reviewed."

The MES logo features the Maryland Shield below a drawing of a specimen of ***Euphydryas phaëton*** (Drury), the Baltimore checkerspot [which became the official insect for the state of Maryland through the efforts of many MES members], with its generic name above and its specific epithet below (both in capital letters), all on a pale green field; all these are within a yellow ring double-bordered by red, bearing the message "Maryland Entomological Society . 1971 ."

NOTICE TO CONTRIBUTORS

Celastrina idella (Holly Azure) in Maryland and Delaware

David M. Wright and Harry Pavulaan[1]

ABSTRACT. A new species of *Ilex*-feeding *Celastrina* inhabiting the Atlantic Coastal Plain was recently described by the authors (Wright & Pavulaan, 1999). The type locality of *Celastrina idella* Wright & Pavulaan is Chatsworth, Burlington Co., **NJ**, situated within the biogeographic region known as the New Jersey Pine Barrens. This region serves as the type locality for four other species of lycaenid butterflies: *Epidemia epixanthe* (Boisduval & Le Conte, 1833), *Deciduphagus polios* (Cook & Watson, 1907), *Mitoura hesseli* (Rawson & Ziegler, 1950) and *Deciduphagus irus* (Godart, 1824) by designation of a neotype by Gatrelle (1999). It also serves as the type locality for one satyrid butterfly subspecies: *Neonympha helicta septentrionalis* (Davis, 1924). This paper deals with *C. idella* in Maryland and Delaware, and provides researchers with information necessary to locate and identify this newly recognized taxon. Differentiation of specimens of *C. idella* and *Celastrina ladon* (Cramer, 1780) is the foremost consideration in the descriptions.

BACKGROUND

The familiar Spring Azure, *Celastrina ladon* (Cramer), has long intrigued and puzzled entomologists. Various forms have historically defied precise classification and still do. For over 100 years, taxonomic alignment has shifted back and forth between *C. ladon*, *Celastrina argiolus* (L., 1758), and *Celistrina pseudargiolus* (Boisduval & Le Conte, 1833). Most recent publications have simply listed a single Spring Azure entity, treated as either *C. ladon* or *C. argiolus*. For this paper, we follow the treatment of Clench and Miller (1980) and consider *C. ladon* to be a valid North American species and *C. argiolus* a separate Palaearctic species.

Clench (1972) was the first to fully describe a second North American species, *Celastrina ebenina* Clench, previously thought to be a melanic infrasubspecific form of *C. ladon*. Under current International Code of Zoological Nomenclature (ICZN, 4th ed. 2000) rules, an available senior name, *Celastrina nigra* (Forbes, 1960), superceded *C. ebenina* as the species name (Scott and Wright, 1991). More recently, Opler and Krizek (1984) elevated *Celastrina neglectamajor* Tutt (1908), long misunderstood as a large infrasubspecific form of *C. ladon* and the subject of considerable debate, to full species rank. By 1984, three species: *C. ladon, C. nigra* and *C. neglectamajor* were tentatively recognized in North America. However, *C. ladon*'s status as a unique North American species and the taxonomic status of *C. neglectamajor* continued to be debated for several more years. The latter was eventually confirmed as a full species by the authors (Pavulaan and Wright, 2000). The *C. ladon* issue was subsequently resolved by a close examination of that species' presumed seasonal polymorphism.

In recent years, we questioned whether the seasonal "broods" of the eastern Spring Azure represented a single species or if additional species were involved. A decade and a half of field

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research and extensive laboratory analysis has yielded compelling evidence that establishes nominotypical *C. ladon* as a univoltine spring insect. Under natural conditions, *C. ladon* is subject to obligate pupal diapause and produces only one spring brood per year. One of us (DW), through microscopic analysis, discovered that *C. ladon* males possess a dorsal wing scale structure (Wright, 1995; Wright and Pavulaan, 1999) that is unique among *Celastrina* and is shared only with *C. nigra*. This *C. ladon* scale character is genetically controlled and is transmitted to subsequent annual generations and to "false brood" summer adults induced under laboratory conditions. The naturally-occuring ubiquitous summer flights of the familiar summer "brood" or "form," *neglecta* do not possess the unique wing scale structure and thus represent yet another species: *Celastrina neglecta* (Edwards, 1862). *Celastrina neglecta* is multivoltine, which further distinguishes it from *C. ladon*. Through extensive literature review and interpretation of the earlier works of William Henry Edwards (1862, 1883), we concluded that under ICZN rules the original description of *C. neglecta* is valid and the name is available. Several authors have since adopted this conclusion (Covell, 1999; Glassberg, 1999; Gochfeld and Burger, 1997; Layberry *et al.*, 1998; LeGrand and Howard, 1999; Nielsen, 1999; Opler and Wright, 1999; Wright, 1995), and *C. neglecta* has generally come to be accepted as the fourth species to be recognized in eastern North America. A fifth species, *Celastrina humulus* Scott & Wright, was recently described from the foothills of the Rocky Mountains in Colorado (Scott and Wright, 1998). This species has closer affinity to the eastern complex than it does to western North American taxa.

Through our fieldwork we further learned that the early spring flights of eastern North American *Celastrina* consisted not only of typical *C. ladon* populations, but also other populations with a dorsal scale structure atypical of *C. ladon*. We noticed that along the Atlantic Coastal Plain *C. ladon* specimens were conspicuously absent in many areas, especially in habitats nearer the coast. *Celastrina ladon* appeared to be most common in the Piedmont and Appalachian Mountain region and areas westward to the Ozarks. Coastal Plain specimens lacked the unique *C. ladon* dorsal wing scale character and were therefore something different.

This complex picture was further complicated in New Jersey by the presence of the northern subspecies *Celastrina ladon lucia* (Kirby, 1837) in the Pine Barrens region. The nominotypical subspecies *Celastrina ladon ladon* (Cramer) occupies deciduous forested areas immediately west of the Pine Barrens. The New Jersey Pine Barrens population of *C. l. lucia* is a coastal glacial relict and is more closely related to Canadian *C. l. lucia*, which may yet prove to be another species. It lacks the unique dorsal wing scale structure of nominotypical *C. l. ladon* with which it narrowly intergrades over an area from southern New England to Michigan. In the Pine Barrens, *C. l. lucia* flies several weeks earlier than other *Celastrina* in the mid-Atlantic region. The early flight of *C. l. lucia* begins in March during most years, but fluctuates dramatically depending on the severity of winter or the advance of spring. It usually lasts until mid-late April, but can continue into early May during years of delayed spring warming.

Over the years, as the spring flight of *C. l. lucia* waned in the Pine Barrens, we noticed a distinct second azure emergence, usually beginning in early May and lasting through the entire month. Though both of these spring emergences occurred in the same general region, we noted that the May flight seemed more common in the vicinity of white cedar swamps, in contrast to the wider variety of damp habitats and bogs used by *C. l. lucia* in New Jersey. It was previously known that *C. l. lucia* utilized *Vaccinium corymbosum* L. (highbush blueberry). Subsequently, it was discovered (by DW) that the May flight used *Ilex glabra* (inkberry) in the Pine Barrens. This situation strongly suggested the presence of two sympatric taxa. After several years of rearing and lab analysis, we were convinced that the two entities, *C. ladon* and *C. idella*, represented separate species (Wright and Pavulaan, 1999).

Broadening our study of *Celastrina* populations on the Atlantic Coastal Plain, we learned that the new species was endemic to wooded habitats containing a dense holly (*Ilex*) component. Several additional *Ilex* hosts were identified and the insect's range was extended south to at least coastal Georgia (Pratt *et al.*, 1994; Wright, 1995). Given the widespread knowledge of our findings, some authors accepted the validity of the *Ilex*-feeding species and published informal descriptions [Gochfeld and Burger, 1997 ("Pine Barren Azure"); LeGrand and Howard, 1999 ("Holly Azure")] based on our work. We decided to properly describe and name the new species *Celastrina idella*, the Holly Azure, making this name available for future research.

DESCRIPTION

The best way to distinguish *C. idella* in our area is by direct comparison with *C. ladon*. Overall, *C. idella* males (fig. 1) are generally similar to *C. ladon* (fig. 2). Size, coloration, and dorsal markings differ only in subtle degrees, and should not be used as the only features to distinguish it from *C. ladon*. While New Jersey Pine Barrens *C. idella* is slightly smaller than *C. ladon*, *C. idella* approaches *C. ladon* in size in the Chesapeake Bay region from Delaware to Virginia's Dismal Swamp. Farther south, a small percentage of *C. idella* individuals are slightly larger than *C. ladon*.

The primary difference between spring males of *C. idella* and *C. ladon* is in their dorsal wing scales. Males of *C. idella* bear androconia scales on their dorsal wing surface; *C. ladon* males lack androconia and, instead, have long, overlapping hoary surface scales. This difference is immediately evident by examination through a dissecting microscope. Most field observers and collectors will not have access to this sort of equipment. However, with practice and the aid of a strong hand-lens, male specimens of *C. ladon* can be identified by the satiny matte appearance of the violet-blue dorsal surface. When held at different angles to a strong light source, this may appear as a milky sheen on *C. ladon* specimens. Males of *C. idella*, on the other hand, are highly reflective blue, lacking the satiny or milky sheen. In *C. ladon*, the hindwing margins are conspicuously "checkered", having alternating white and dark fringes. In *C. idella*, the hindwing margins are solid white, though the forewing margin may contain some checkering.

Females of nominotypical subspecies *C. ladon* are deep violet on the upper surface. Females of *C. ladon* also display strong checkering on the wing margins like their conspecific males. *Celastrina idella* females tend to be lighter violet blue, often with white scaling especially on the hindwing. Like the males, females have solid white hindwing margins.

The ventral surface of *C. idella* (both sexes) differs from *C. ladon*. The light whitish-gray underside of *C. idella* (fig. 1) is considerably lighter than that of *C. ladon* (fig. 2). Some specimens are almost pure white. The *C. ladon* venter (both subspecies) is usually gray. Subspecies *C. l. lucia* is heavily-marked on the ventral surfaces, often showing either a dark margin on the hindwing (form "*marginata*"), a dark hindwing discal patch (form "*lucia*"), or both (form "*lucimargina*"). There are rare *C. l. lucia* individuals lacking both the dark margin and patch (form "*violacea*"), which are still much grayer beneath and with a pattern of larger dots than *C. idella*. The subspecies of *C. ladon* most commonly encountered in our area is typically form "*violacea*" (though a very small percentage of form "*marginata* may be present). The black macules of the hindwing median often are encircled by a thin rim of white. Interestingly, individuals of subspecies *C. l. ladon* from the Chesapeake Bay region, which overlap the range of *C. idella*, are often very white beneath. Some *C. ladon* specimens from the area around Bethel, Delaware, are almost indistinguishable from *C. idella*, except that they always retain the unique *C. ladon* male dorsal wing scales which differentiates specimens. The reason for this convergence of phenotypes is unknown. It might be indicative of a small zone of intergradation, or local variation of *C. ladon*. Conversely, *C. idella* specimens from the western side of the Chesapeake Bay in southern Maryland, south of Annapolis, tend to be slightly grayer beneath and slightly larger than New Jersey and Delmarva specimens. These tend to approach *C. ladon* in overall appearance, however they lack the unique *C. ladon* male dorsal wing scales.

Opler and Malikul (1992, 1998) depicted specimens of *C. idella* as "*Celastrina argiolus* spring form" in the popular Peterson *Field Guide to Eastern Butterflies*. Plate 25 of their 1992 edition and Plate 16 of the 1998 edition both show male and female dorsal views and one female ventral view of *C. idella* from Sussex Co., Delaware. Note the typical solid white hindwing margin in both sexes, plus the whitish venter and tiny dot pattern. These entries need to be revised in future editions to maintain taxonomic accuracy.

An interesting and potentially confusing issue is the presence of sporadic spring individuals of *C. neglecta* (predominantly a summer insect) that occur in many places in our region. These individuals appear in small numbers and tend to fly earlier than *C. idella*. Whether these individuals are aberrant spring *C. neglecta* emergences, regular spring *C. neglecta* emergences, or yet another unidentified univoltine spring taxon is not yet known. The biology of this newly-recognized entity is being studied. Rearing experiments have produced complicated and often inconclusive results. Spring *C. neglecta* males are similar to *C. idella* in appearance, bearing the same type of dorsal wing scale structure that is typical of all *Celastrina* except *C. ladon* and *C. nigra*. Spring *C. neglecta* females are easier to differentiate by their bright metallic pastel blue color above, often with a greenish tint. In order to help find distinguishing characters that differentiate *C. idella* males from spring *C. neglecta* males, one of us (DW) performed microscopic examination of the male genitalia. The results were encouraging, showing that *C. idella* males differ from other *Celastrina* by having a very fine sparse cuticular spinosity on the upper surface of the apical process of the valve which is not present in *C. neglecta* (Wright and Pavulaan, 1999). This characteristic will not be discernable to the average field observer, thus expert analysis should be obtained.

Because of the difficulty of identifying *C. idella* in the field, and differentiating *C. idella* individuals from *C. ladon* and spring *C. neglecta* individuals on the wing, we urge a very conservative approach in reporting this new species. Sight records for new localities, especially west of the Chesapeake Bay, should be considered "unverified" until specimens in hand can be examined. With vouchered specimens, proper species determination is possible.

FLIGHT PERIOD

In New Jersey, *C. idella* may generally be found over a four-week flight within the period from mid-April to the very end of May, though during most years the species emerges in the first week of May. The flight period may be adjusted by several days, depending on the advance of spring during any particular year. Extreme flight dates in the interior of the New Jersey Pine Barrens are April 25 through June 4. An interesting phenomenon is that *C. idella* emerges as much as two weeks earlier in deciduous forest areas immediately south and west of the Pine Barrens (Delaware River and Delaware Bay counties). It is believed that the richer soils in these areas lose heat at a slower rate than the sandy soils of the central Pine Barrens, thus affecting the eclosion of diapausing pupae in the leaf litter. For a considerable time, we had considered the offset *idella* emergences in southern New Jersey may be due to different *C. idella* ecotypes (one feeding on *I. glabra* in the Pine Barrens, and a second feeding on *Ilex opaca* Alt. in Delaware Bay counties), however, this does not seem to be the case. In the laboratory, *C. idella* larvae from each area survive equally well on both *Ilex* species and show the same diapause intensity over the winter.

In our area, on the Delmarva Peninsula, *C. idella* may be found at approximately the same dates as the Delaware Bay counties of southern New Jersey (south of the Pine Barrens), but often it begins flight a few days earlier in the first half of April. On the west side of the Chesapeake Bay in southern Maryland, from Annapolis south, most specimens of *C. idella* that we have examined have been taken in mid-April and were slightly worn, but extreme flight dates have not yet been documented. There the flight may begin in early April. Look for *C. idella* after about a week of warm weather in very early April, and a few days after the first emergence of *C. ladon*.

Extreme flight dates for *C. idella* have not been fully documented to the south. In the Dismal Swamp of southeastern Virginia, and on North Carolina's Outer Banks, *C. idella* has been found as early as March 29, and as late as May 20. In southeastern North Carolina and further south, *C. idella* has been variously reported as early as mid-March, and on some dates as early as late February.

HOSTS

Celastrina idella larvae feed on the male flowers of host hollies (*Ilex* spp.). Females oviposit on the developing flower buds and the larvae feed on buds, flowers, and immature fruit of the hosts. In the New Jersey Pine Barrens, the select host is primarily *I. glabra* (inkberry or gallberry). The original species description of *C. idella* was compiled from an *I. glabra*-feeding population at the type locality (Wright and Pavulaan, 1999). Around the periphery of the Pine Barrens, *I. opaca* (American holly) is the primary host. In general, the earliest emerging *C. idella* in New Jersey feed on *I. opaca*, while those emerging later feed on *I. glabra*. *Ilex laevigata* (smooth winterberry) has also been documented as a host in southern New Jersey, and ovipositions were also observed on *Ilex vomitoria* (yaupon holly) on the North Carolina Outer Banks. The only non-*Ilex* host recorded to date has been *Itea virginica* (Virginia willow) at Virginia Beach, Virginia, possibly selected as a secondary oviposition choice by females that were flying late in the flight period, when *I. opaca* was already in bloom. Females will not oviposit on previously opened flowers.

In Maryland, *I. opaca* is the primary host. Specimens attributable to *C. idella* have been taken in woodlands with a dense *I. opaca* component in the Annapolis area, around Cedarville, and at Lusby, as well as other locations on the southern peninsula. Populations have also been observed in close association with *I. opaca* at various locations on the Virginia side of the Potomac River and Chesapeake Bay. *Ilex opaca* is suspected by association to be the host on the Delmarva Peninsula, although other *Ilex* spp. could be used. At Nanticoke Wildlife Management Area in Sussex Co., Delaware, *C. idella* ova and larvae have been found only on *I. opaca*.

Around Cedarville and in the Annapolis area, both *C. ladon* and spring *C. neglecta* flights are also found in close association with *I. opaca*, making field identification difficult. *Celastrina ladon* primarily utilizes *Cornus florida* L. (flowering dogwood) in these areas, but it is also associated with *I. opaca* and has been observed ovipositing on male flower buds. In captivity, *C. ladon* females freely oviposit on *I. opaca*. Subsequent rearing experiments prove that *C. ladon* larvae from these areas can successfully utilize *I. opaca* and develop into healthy adults. To what extent *I. opaca* replaces *C. florida* as the *C. ladon* host in the western Chesapeake region is unclear. However, *C. ladon* is generally absent from the outer coastal plain where *I. opaca* is abundant. Interestingly, these populations of *C. ladon* converge on *C.*

idella in appearance, though they retain the unique male dorsal wing scale structure of *C. ladon*. The host of the spring *C. neglecta* individuals remains unknown in these areas (*C. neglecta* do not survive on *Ilex* flowers in the laboratory). Populations of spring *C. neglecta* in extreme southern New Jersey and the Appalachian Mountain region (MD, VA) freely oviposit on the flower buds of *Prunus serotina* Ehrh. (black cherry) in captivity and the larvae will develop into healthy adults. Careful rearing studies from the Chesapeake Bay region should be conducted to answer these questions.

IMMATURE STAGES

Eggs of *C. idella* are white, similar to those of other species of *Celastrina*. Females deposit eggs on the male floral buds of *Ilex* hosts. The first instar larvae are uniformly light green in color. The young larvae bore a hole into the floral buds, extending their head in a telescoping manner to feed on highly nutritious inner contents (mostly pollen). The mature fourth instar larvae are variable in ground color, ranging from light green to creamy white. A few are lightly contrasted with dorsal white chevrons. A maroon-tinted prothoracic shield is present in some individuals, and rarely there is a faint rosy mid-dorsal stripe. The mature larvae are tended by ants, which aggressively defend the larvae from predators (parasitic flies and wasps). The diapausing pupae are light brown.

HABITAT AND HABITS

On the outer Coastal Plain, *C. idella* prefers wet areas such as cedar swamps, cypress swamps, pocosins, rich bottomlands and wet thickets. Closer to the coast, it occurs in dry maritime forests and forested portions of barrier islands. On the inner coastal plain near the Fall Line, the species is found along streams in deciduous forest habitats with a dense *I. opaca* component. The species is rarely recorded in Piedmont habitats (only at a few locations on the west side of the Potomac River in northern Virginia).

Early in the spring flight period, look for *C. idella* along sandy roadways in woodlands containing holly. The adults fly along the wooded road edges, stopping to nectar at clusters of small white flowers of a wide variety of shrubs. Males have been known to engage in "mud puddle parties" at damp spots along sandy roads and at the edges of waterways or ponds. The males have also been observed imbibing minerals (and amino acids?) from animal dung and carcasses. Females do not engage in this behavior, but rather tend to remain close to the wooded edge or within the woodland habitat seeking host plants. Frequent associates in this habitat are Hessel's Hairstreak, *Mitoura hesseli* Rawson & Ziegler) and Henry's Elfin, *Deciduphagus henrici* Grote & Robinson). The latter shares *C. idella*'s holly host plants.

TYPE LOCALITY, RANGE, AND DISTRIBUTION IN MARYLAND AND DELAWARE

The type locality of *Celastrina idella* is Chatsworth, New Jersey; specifically a cedar bog along Risley Branch of Wading River, 2.2 km. south of the village. The holotype male is deposited in the Academy of Natural Sciences in Philadelphia, PA. The original paratype series comes entirely from New Jersey. The species ranges from central New Jersey south across the entire Delmarva Peninsula. It also occurs on the west side of the Chesapeake Bay and is known from the vicinity of Annapolis south to near Point Lookout. Careful search of holly habitats along the entire western shore of Chesapeake Bay to Delaware may turn up additional populations.

In Virginia, it occurs along the immediate western shore of the Potomac River from southern Fairfax County south to the Tidewater region and Great Dismal Swamp. The range continues south into North Carolina along the Coastal Plain from the Outer Banks to the Green Swamp, and inland to approximately where the Piedmont begins. It follows the Coastal Plain into South Carolina, ranging west to the edge of the outer Piedmont. There are several records from extreme eastern Georgia along the coast, marking the southernmost known extent of the range. Future work may find that the species ranges further south, possibly even west along the Gulf Coast.

Specific Maryland distribution (fig. 3) is as follows: Anne Arundel Co. (Annapolis area); Calvert Co. (Lusby area); Caroline Co. (Templeville area); Charles Co. (Cedarville State Forest); Dorchester Co. (Hurlock area); Prince Georges Co. (Cedarville area, esp. Cedarville State Forest); Wicomico Co. (Salisbury area White Cedar Swamps); Worcester Co. (Wango area). Specific Delaware distribution (fig. 3) is as follows: Kent Co. (Mispillion River west of Milford); Sussex Co. (Nanticoke Wildlife Management Area, Bethel and Lincoln areas).

DISCUSSION

Host plant adaptation among the *Celastrina* has clearly played a key role in the evolution of this genus in eastern North America. Their larvae are adapted to feed almost exclusively on the developing flowering parts of their host plants, a short-lived food source. By necessity, local or regional adult flights are phenologically coupled to the flowering period of available hosts, emerging at about the time that the flower buds are forming. Plant-feeding insects, such as the *Celastrina*, seem to be particularly adept at finding vacant ecological niches and exploiting floral opportunities. Since host plants often bloom at different times of the season, host specialization can result in asynchrony of the adult flight times and mating periods. Over many thousands of years, this has resulted in populations with well-defined seasonal isolation and has translated into genetic isolation. Eventually, within isolated *Celastrina* populations, morphological differences emerge which help differentiate them from other host-specific populations. Formal descriptions of these populations are required to delineate them for future studies in molecular systematics, phylogenetics, and possible conservation measures.

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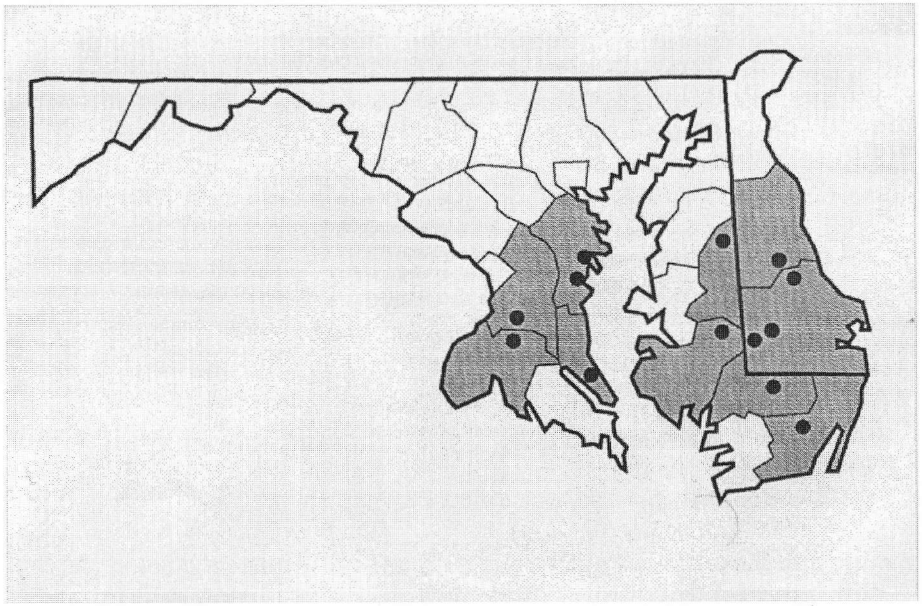
Fig. 3. Map showing *Celastrina idella* distribution in Maryland and Delaware. Counties are shaded. Documented locations shown as dots.



APPENDIX I

Current North American *Celastrina* taxa.

Recent changes and additions to North American *Celastrina* require us to reexamine the nomenclatorial status of named taxa. Until a more thorough work is produced, we maintain a conservative approach in treating the western subspecies.

- *Celastrina ladon* (Cramer)
  - a. *l. ladon* (Cramer)
    - = *pseudargiolus* (Boisduval & Le Conte)
    - = *violacea* (Edwards)
  - b. *l. lucia* (Kirby)
    - = f. *marginata* (Edwards)
    - = f. *lucimargina* Scott
    - = ab. *fumida* (Scudder)
    - = ab. *pseudora* (Scudder)
    - = ab. *brunnea* Tutt
    - = ab. *subtusjuncta* Tutt
    - = ab. *inequalis* Tutt
  - c. *l. nigrescens* (Fletcher)
    - = *quesnelli* (Cockle)
      - = f. *maculatasuffusa* (Cockle)
  - d. *l. sidara* (Clench)
  - e. *l. echo* (Edwards)
    - = *bakeri* (Clench)
      - = ab. *nunenmacheri* (Strand)
  - f. *l. gozora* (Boisduval)
  - g. *l. cinerea* (Edwards)
    - = f. *arizonensis* (Edwards)
- *Celastrina neglecta* (Edwards)
  - a. *n. neglecta* (Edwards)
  - b. *n. argentata* (Fletcher)
- *Celastrina nigra* (Forbes)
  - = *ebenina* Clench
    - = f. *nig* (Strecker)
    - = f. *intermedia* (Strecker)
    - = f. *nigra* (Edwards) [dimorphic male]
- *Celastrina neglectamajor* Tutt
  - = f. *obsoletalunulata* Tutt
- *Celastrina humulus* Scott & Wright
- *Celastrina idella* Wright & Pavulaan

Red-banded Hairstreak with "Beak Tears" Taken in Baltimore City Beneath Lights at Night

A. P. Platt

Baltimore, **MD**

Upon returning home at 2200 hrs. (10:00 P.M., EDT) on the evening of 25 September, 2002, I found what at first glance I thought was an unusual geometrid moth, with its wings folded over its back, clinging to a glass pane on the storm door of my house, along with several other Noctuid and micro-heterocera, directly beneath the porch light, and about 1.22 m above the ground. The 2.63 m high porch light held a 60W G.E. cool white incandescent bulb that was surrounded by a thick rectangular black metal and clear glass lamp housing. The glass sides and base of the lamp housing had wide tapering beveled edge facets which act as prisms when viewed at right angles to their surfaces. This same light had previously attracted a specimen of the green darner, *Anax junius* (Drury), (Odonata: Anisoptera: Aeschnidae) in late April, 1989 (Platt and Harrison, 1994). [See Ch. 7, No. 5: 169-189, "Collecting at Lights" in Winter (2000) for a further discussion of how to attract Lepidoptera (mainly moths) to light sources of various wave-lengths.]

Closer inspection revealed that the moth-like insect was, in fact, a male red-banded hairstreak, *Calycopis cecrops* (Fab.) (Lepidoptera: Lycaenidae), which had suffered severe "beak tears" to all four of its wings. Except for the sharp triangular "beak tears," the specimen appeared to be quite a fresh one, so that the presumed bird attack likely had occurred earlier in the same day. Pyle (1981) noted that this species hides among leaves until it is disturbed, and that it is often active at dusk.

My home is located in the Ten Hills section of southwestern Baltimore City in a typical suburban setting, with nearby undeveloped woodland patches, small intermittent streams, and lawns. Yew shrubs *Taxus* spp.), forsythias (*Forsythisa* spp.), and azaleas (*Rhododendron* spp.) surround the front of the house, and our front yard contains several large tulip poplars (*Liriodendron* spp.) and a several-hundred year old sycamore (*Platanus* sp.). Hairstreaks of any species are unusual finds in the area. I haave seen only one other red-banded hairstreak during the 33 years I have lived in the neighborhood. D. Flaim informs me (pers. comm.) that lycaenids and other hairstreaks are known to be occasionally attracted to lights. However, Bob Robbins of the USNMNH (pers. comm..) indicates hairstreaks being attracted to light must represent "a very rare phenomenon," and that such attraction would likely occur only if the light was very close to where the insect had chosen to rest for the night.

The specimen has been preserved in the UMBC Collection. Precise outline tracings of the insect's intact wing surfaces, and of the "beak tear" regions first were made for each wing. Estimates of the proportions of each wing's surface area missing as a result of the "beak tears" were measured on enlargements of these paper wing tracings, by summing the areas (in mm^2) of a series of subtriangles within each "beak tear." These results were as follows: right fore wing (= RFW): .483, RHW: .468, LFW: .438, and LHW: .535.

Later, the pinned insect's image was computer scanned, and using the Apple MacIntosh Version 4 of Adobe Photoshop, each wing surface area and its "beak tear" region were calculated in pixils, yielding the following comparable proportions: RFW: .467, RHW: .496, LRF: .433, LHW: .561. The mean proportional differences between the two sets of measurements is only .033. Thus, nearly half of the butterfly's wing area (mean = .489) was missing. Despite this, the insect was quite lively, and was still capable of maneuvering and flying about within the glass jar in which I collected it.

The relative positions of the "beak tears" on each wing are such that they are centered and aligned as a single sharp triangular when the hairstreak's wings were folded into their resting positions over its back. This strongly suggests that the butterfly had alighted prior to being attacked by an avian predator. Other species of hairstreaks are well-known for possessing "false heads" located at the anal angles of their hind wings. Such insects often perch in a head downward position, so that their hind wing tails resemble antennae, with their flaring anal wing protuberances and spots and spots suggesting the insect's head (Robbins, 1980). This mimetic illusion often is enhanced by the small insect's circular hind wing movements.

Resident insectivorous birds common in the area at the time, which may have attacked the hairstreak, include English sparrows (*Passer* spp.), catbirds (*Dumatella* sp.), chickadees and tufted titmice (*Parus* spp.), white-throated sparrows (*Zonotrichia* sp.), mocking birds (*Mimus* sp.), cardinals (*Richmondena* sp.), and blue jays (*Cyanocitta* sp.). Of course, during the fall of the year there are many other migratory passarine species flying through the eastern Atlantic region as well.

The red-banded hairstreak essentially is a southeastern U.S. species belonging to a mainly neotropical genus, but occurring as far north as southern New Jersey and Ohio, and southern Illinois, with occasional "strays" being found farther north. It is considered to be a common species in Maryland and southward to Florida, but its distribution is very local in the northern parts of its range (Klotts 1951, Ehrlich and Ehrlich 1961, Kimball 1965, Irwin and Downey 1973, Opler and Krzek 1984, and Scott 1986). The species is partially triple brooded in the state, and its larvae are reported to feed on sumacs (*Rhus* spp.), wax myrtle (*Myrica* spp.), cruton (Cruton spp.) and oaks (*Quercus* spp.), among other plants. The adults often lay their eggs among leaf litter and duff. They are known to nectar at flowers of milkweed (*Asclepias* spp.), dogbanes (*Apocynum* spp.), sumacs (*Rhus* spp.), and wild cherry (*Prunus* spp.), New Jersey tea (*Ceanothus* sp.), and sweet pepperbush (*Clethra* sp.) , according to Woodbury (1994), and they are quite adept at perching either on horizontal leaves, or on vertical cliff-like surfaces, such as the glass door pane on which this one was found.

Acknowledgements

I wish to thank G. C. (Tim) Ford, Jr., of the Graphics Department in the Biological Sciences, UMBC; for computer scanning the hairstreak and for carrying out the calculations in pixils of the "beak tear" areal proportions on each of the insect's wings.

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Two Recent Interesting Moth Records from the U.M.B.C. Campus

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Record 1. On 16 September, 2001, I collected a male specimen of the cryptic sooty patterned salt-and-pepper geometer, ***Biston betularia cognitaria*** Guenée (Lepidoptera: Geometridae), on the wide stone steps along the east (library) side of the Chemistry Building on my way in to work at the University of Maryland, Baltimore County (UMBC) The campus was undergoing rapid development at the time, with many buildings under construction. It is located in Baltimore County, and its UTM transect is UU44. Although the moth's abdomen had been ruptured, possibly because someone had stepped on it, the specimen was otherwise in good condition. Covell (1984: 356) noted that this insect is the North American equivalent of the famous British peppered moth, much studied by H.D.B. Kettlewell and others in Britain, as an example of evolutionary "industrial melanism." This common species has an holarctic distribution and flies from May through September. Its twig-like larvae are polyphagous and feed on a wide variety of trees and shrubs, including alders and birches (*Alnus* spp. and *Betula* spp.: Betulaceae), blueberries (*Vaccinium* spp.: Ericaceae), cherries (*Prunus* spp.: Rosaceae), walnuts (*Juglans* spp.: Juglandaceae), and willows (*Salix* spp.: Salicaceae).

Record 2. The second moth was a large (54 mm wingspan) noctuid possessing warm tan forewings with darker brown reniform spots and 1-mm angled dark dashes placed subapically. Its hindwings were bright orange-yellow, with single wide marginal black stripes paralleling the hindwing margins, and placed just within thin orange marginal fringes. The specimen had (as had the moth described above) apparently been stepped on and its body flattened. This male specimen was collected on the sidewalk just outside Schwartz Hall, alongside the Library Pond on 19 September, 2001. When I first picked up this specimen, I thought that it might be one of the small orange-colored underwing moths (*Catocala* sp.: Noctuidae). The next day, a hurried search of Holland (1905) and Covell (1984) indicated that this moth was unlike any of the species illustrated in either book, and prompted Stephen Harrison to jokingly remark, "It must be a new species."

Actually, he wasn't too far wrong. A few days later, I received my copy of the August 2001 issue of the *Kentucky Lepidopterist*, which contained an article by L. C. Koehn (2001: 16) complete with color illustrations of this very same moth! The insect was an adult of the invasive European cutworm,

***Noctua pronuba* (L.)** (Lepidoptera: Noctuidae). Koehn stated that this species was first reported from North America in 1979, and that it had spread southwestward through Virginia and Tennessee, reaching the gulf coast and Louisiana by 1996. His first Kentucky records (taken in baited traps) were from early May, 2001. He also reported records from Indiana and Ohio. J. Grehan of the Frost Museum, Pennsylvania State University recently informed me that he has collected this species in Vermont, and that it is spreading very rapidly.

Bryant (1999) estimated that this cutworm moth likely arrived in Maryland sometime between 1988 and 1990, having first been reported at Halifax, Nova Scotia in 1979 by Wright (1983). In the late summer of 1998, Bob Bryant collected nine specimens attracted to a porch light at his home in the Ten Hills section of Baltimore City. He noted further that five of those nine specimens bore "beak marks," probably from previously unsuccessful bird attacks.

South (1907: 232-233) illustrated the eggs and larvae of this species. Hargreaves and Chinery (1981: 181) provided color illustrations of the adult moth, its resting position, and its larva; which is yellowish-brownish gray, with dorsolateral segmental darkened stripes. Their illustration, South's colored Fig. 6, Plate 115, and Koehn's lower specimen all are nearly identical to the one I collected from UMBC. The British common name for this species is the large yellow underwing. The larva is considered to be a pest in flower and vegetable gardens where it feeds on a variety of low herbaceous plants and grasses.

Dispositions. Both of these specimens have been pinned and placed in the Platt Collection at UMBC.

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FIGURE REFERENCES:

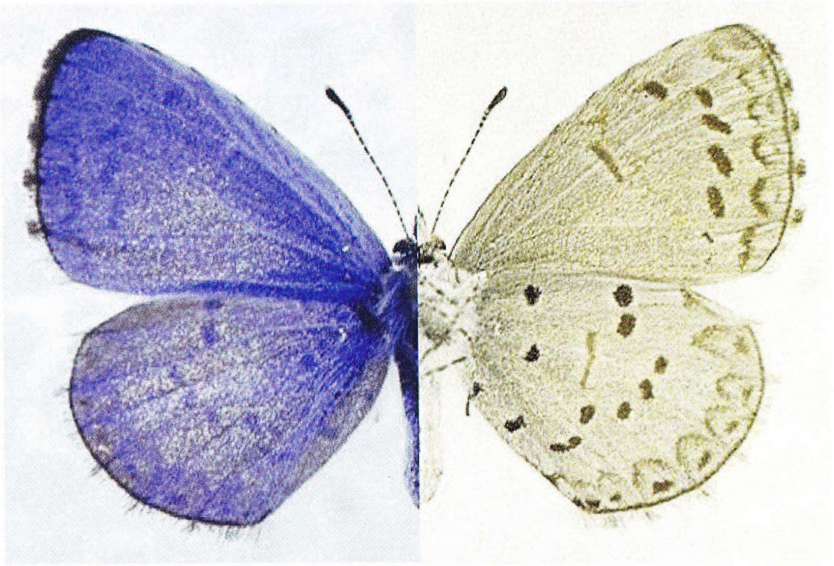

Fig. 1. *Celastrina idella*. Paratype male. 16 April 1995, Bevan WMA, Cumberland Co., N.J. Left (dorsal view), right (ventral view).

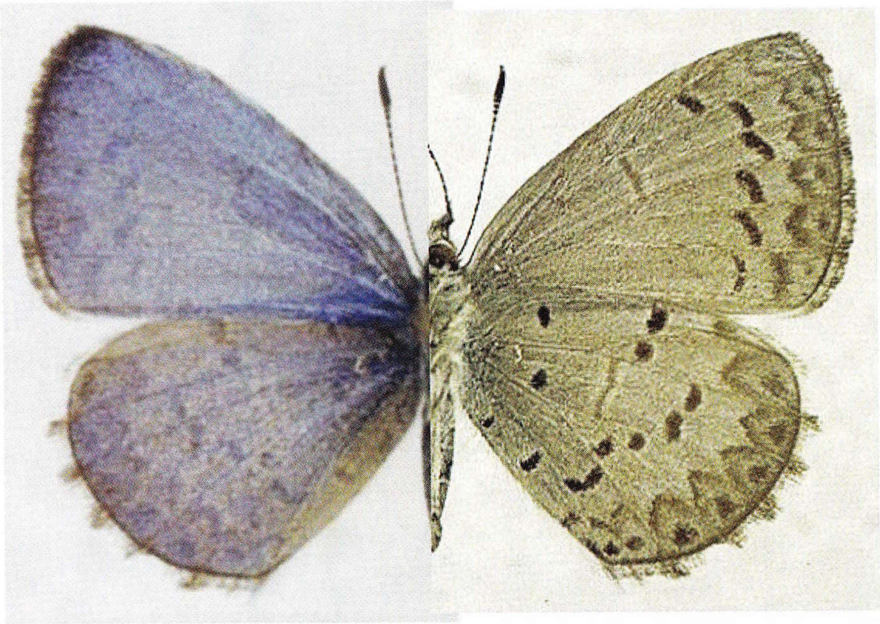

Fig. 2. *Celastrina ladon*. Male. 22 April 1988, nr. Rancocas SP, Burlington Co., N.J. Left (dorsal view), right (ventral view).

FIGURE REFERENCES:

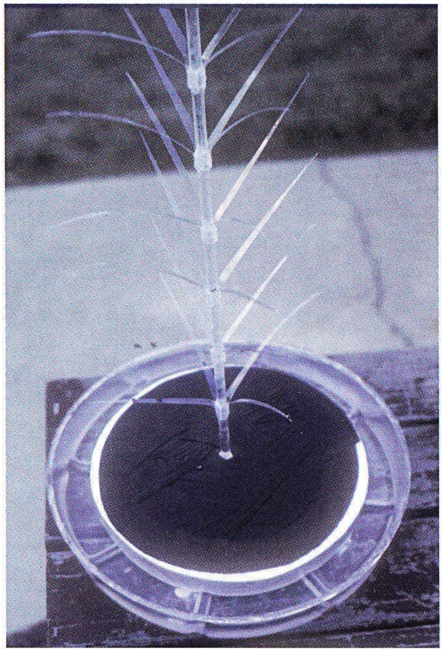

Fig. 1. Artificial "tree" for observing tick behavior.

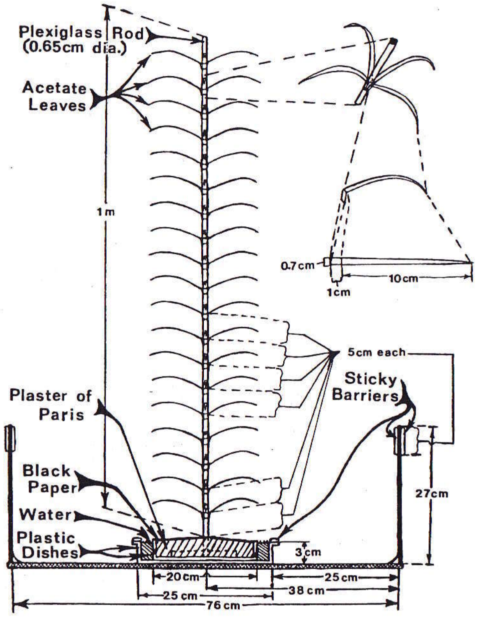

Fig. 2. Sketch of factors affecting tick host-seeking.

FIGURE REFERENCES:

Fig. 3. White-footed mouse with immature ticks attached.

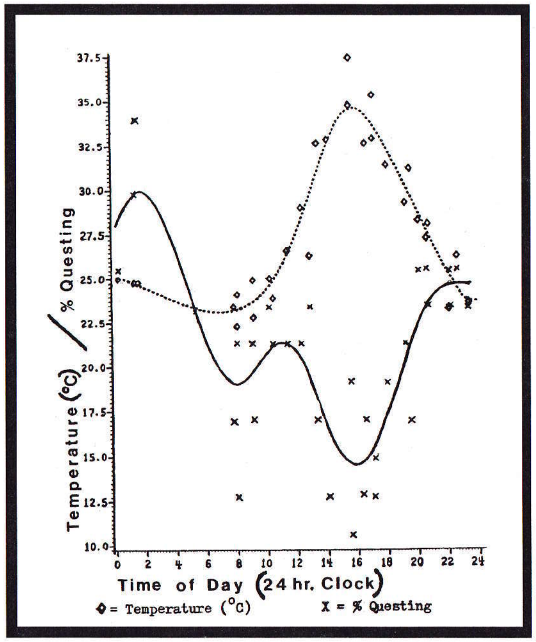

Fig. 4. Computer-generated (by SAS) daily questing "cycle" for adults and nymphs of *D. variabilis* on a plastic "tree" outdoors. Temperature, in degrees **C**, and percent questing are both plotted on a common-scaled ordinate.

FIGURE REFERENCES:

Fig. 5. Adult female *Dermacentor variabilis* (Say).

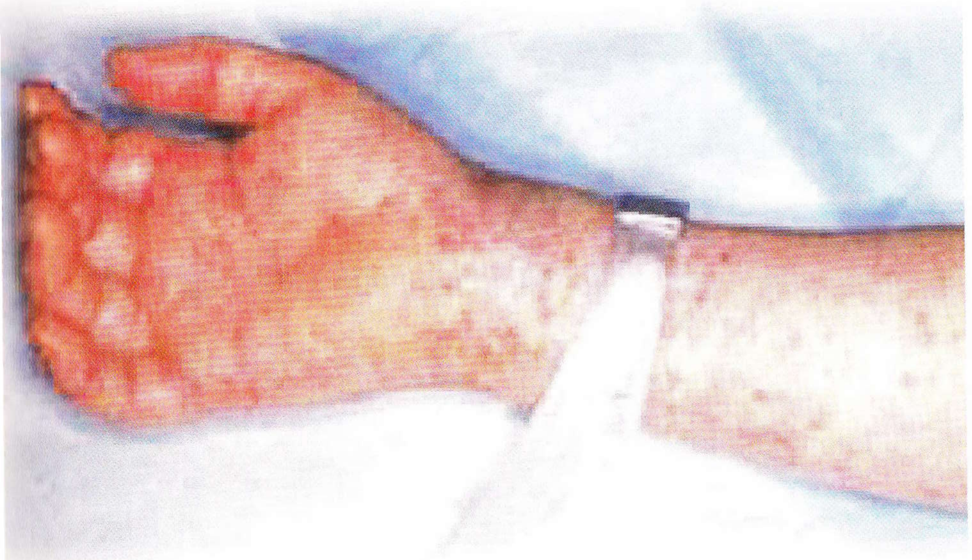

Fig. 6. Classic symptoms of Rocky Mountain spotted fever on a child's arm and hand (image by CDC).

Koehn, L.C. 2001. A Kentucky Record of the European Cutworm, *Noctua pronuba* (L.). *Kentucky Lepidopterist* 27(3): 16.

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Butterfly Food

by

Joy Cohen

Columbia, **MD**

If my terrain you'll surely drench
With urine, I will love the stench.

It's also known that all my species
Make breakfast out of human feces.

As if that's not enough, to boot,
We're known to lunch on rotted fruit.

For appetizers, we're most glad
To dine upon your fish gone bad.

And if from me the truth is wrung,
We make dessert of cattle dung.

What we call food, humans call waste,
Be it liquid, or be it paste.

Thus, think I'm filthy, only meant
To serve as pretty ornament?

The truth is this, by God I'm sent
To help clean our environment.

Observations of Host Seeking Behavior in American Dog Ticks, *Dermacentor variabilis* (Say) (Acari: Ixodidae) in Ohio.

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ABSTRACT. This note reports observations of host seeking behavior by larvae, nymphs and adults of the American Dog Tick, *Dermacentor variabilis* (Say), outdoors, with lateral physical barriers restricting specimens to an artificial arena which enabled the investigator to make periodic observations of the known captive populations observed. Several micro-meteorologic factors (ambient air temperature, relative humidity, insolation, and air movement speeds when applicable) were recorded at the local site of the arena, using precise hand-held or local sensor devices, at the time of each set of behavioral observations. Statistical analyses of resultant data showed correlations between air temperature, time of day, and tick host seeking activities. Most nymphs remained at vertical heights on an artificial (plastic) "tree" of 10 cm or less above the substrate most of the time (54.6 % of observations). Most adults remained at vertical heights on an artificial (plastic) "tree" of 30 cm or less above the substrate most of the time (92.6% of observations). The host seeking activity of nymphs was strongly negatively correlated with ambient temperature. Adults showed a generally similar but more variable (not statistically significant) vertical distribution and negative correlation to ambient temperature.

INTRODUCTION

Previously published reports of *Dermacentor variabilis* (Say) host seeking behavior have been based primarily upon either drag collections of adults or collections of adults and immatures from live-trapped hosts (Smith *et al.*, 1946; Sonenshine *et al.*, 1966; McEnroe, 1971, 1978). These methods provide approximations of the numbers of a given instar questing at a given place and time. However, they provide little information about the proportion of the possible number or three dimensional location of any given questing instar. Dragging provides only spot information of the time of day when adult ticks are questing and few reports have related tick samples to concurrent local environmental conditions. Collections of ticks from live-trapped hosts are even less directly relatable to tick questing locations or concurrent local environmental conditions.

In this study, the term "questing" is defined as the combination of all actions an individual tick performs in its efforts to detect, contact, and gain access to a potential blood-meal host. That includes all activities from the time it leaves the (presumed) hydration/ re-hydration zone in the ground-level substrate, to the time it begins to feed on a host. While it is up on a plant or other elevated structure, there are three distinctly different actions a tick may perform. These are: waiting stationary at some elevated, expose point (often near a leaf tip); resting in an "alerted" posture, oriented toward a perceived host with its forelegs raised; and actively moving around on the substrate. When a host is near, this last action is often actively directional toward that host when that is possible.

Several authors have reported on field observations of tick questing behavior. Larval ticks have been reported crawling up on low grass blades and other vegetation at the edges of small rodent runs (Smith *et al.*, 1946; Wilkinson, 1968; Vail and Smith, 1998). Each tick instar (larva, nymph or adult) has been reported to quest within a certain vertical height range on vegetation in its natural habitat (Dodds *et al.*, 1969; Lees, 1969; Balashov, 1972) and immatures of this species move laterally for only very short distances, tending to stay on (or by) one plant stem or other questing support (Lees and Milne, 1951; Conlon, 1981; Conlon and Rockett, 1982). Adults begin active questing only after a post-eclosion delay of two weeks or longer (Lees and Milne, 1951; Lees, 1969; Sonenshine, 1993), and they have been reported to have diurnal questing cycles which are strongly influenced by meso- and microenvironmental temperature and humidity regimes (Lees and Milne, 1951; Atwood and Sonenshine, 1967; Balashov, 1972; McEnroe, 1971; McEnroe and McEnroe, 1973; Harlan and Foster, 1986; Randolph and Storey, 1999). Several of these studies (*e.g.* Smith *et al.*, 1946; Sonenshine *et al.*, 1966; Dodds *et al.*, 1969; McEnroe and McEnroe, 1973; and Conlon, 1981) dealt mainly with *D. variabilis*.

This study was undertaken to try to determine how high above a substrate each *D. variabilis* instar would await a host (quest) as well as relative frequencies of questing with regard to vertical or lateral location on an artificial "plant" in an outdoor "arena," as related to microenvironmental conditions. Field observations and mammal tick host live trapping were done in mainly at sites in five Ohio counties; Clermont, Delaware, Franklin, Lucas, and Muskingum.

MATERIALS AND METHODS

Field-collected adult *D. variabilis* and laboratory reared (F_1) nymphs were placed (during separate tests) on the upper surface of a layer of moist black construction paper and near the rachis of a clear plastic "tree" (Figure 1.). This tree had whorls of four clear acetate plastic leaves (attached to the rachis by clear silicone rubber sealant) projecting at about a 60° angle from the rachis every 90° around its circumference at regular 5 cm vertical intervals from the substrate up to 95 cm above that surface. The rachis was a clear 0.65 cm diameter round plastic rod 1 m long set vertically in a plastic dish filled with plaster-of-Paris, overlaid by 1 or 2 sheets of black construction paper, and ringed by a 2.5 cm moat of water within a larger plastic dish. This moat was ringed with a 0.75 cm band of a 1:1 (v:v) mixture of mineral oil and petroleum jelly. A pasteboard barrier about 27 cm high, coated on both sides near its top edge with a 5 cm (or wider) sticky barrier, was sealed to a base platform with silicone sealant and formed into a roughly circular shape with a 76 cm diameter. This whole structure was placed approximately half-way under a set of open steps so that it had a western exposure to ambient weather. The artificial tree was oriented so its acetate "leaves" projected in vertical rows, roughly due north, east, south and west.

Temperature, relative humidity, solar radiation (during daylight), and air movement (wind speed) were recorded at 1 m above ground level (called "ambient" readings)and within 1 cm of the ground (substrate) surface at the beginning of each set of behavioral observations. Temperature and relative humidity were measured using a Cole Parmer$^{\text{TM}}$ LCD portable hygrometer, model # FP-3308-00, with a filtered probe (model # FP-3308-10). Solar radiation was measured as a single, "spot" reading at the start of each set of observations using a Dodge Products$^{\text{TM}}$ solar meter, model # 776. Wind speed was measured with a Taylor$^{\text{TM}}$ 15-cm dia. anemometer, model 13B-2040.

Before each test, a group of ticks was placed in the arena and allowed 4-24 hrs to acclimate. The number of ticks on each leaf and each tick's proximity to the leaf tip or rachis were recorded as well as concurrent meteorologic data (taken always at the start, and sometimes also at the end, of any reading period). Temperature, relative humidity, solar radiation (during daylight) and air movement readings were taken at various intervals throughout several subsequent days and nights (Figure 2.).

In this study, substrate = the ground level atop the upper layer(s) of black construction paper, stationary = sitting still, quiescent, questing = generally, either actively seeking a host or stationary on any structure above the substrate (and physically in position to quickly respond to any potential host which may pass by), and alerted = the state in which a tick is waving its front legs about in the air and standing or crawling or turning around with its idiosome held well clear of the surface upon which it is standing.

Adult Questing. In adult tick questing tests, one group of 20 adults (10 males, 10 females) was observed in 28 separate readings and another group of 100 adults (50 males, 50 females) was observed in 18 separate readings. A separate group of 20 field-collected adult *D. variabilis* (10 males, 10 females) were individually marked with acrylic paint spots using a previously chosen coding scheme. Each individual tick's location and movements were recorded during 11 different 20-45 min periods at irregular intervals throughout several successive days and nights.

Nymphal Questing. Nymphal questing observations were performed in exactly the same manner and in the same arena as for the adult observations (above). One group of 47 nymphs was observed in 32 separate readings in this test.

Larval Questing. Larvae were very hard to observe and quantify. They were not tested on the same arena used for nymphs and adults. The arena used for larval observations was a 9.0 cm diameter clear plastic dish, 2.5 cm deep, filled with paster-of-Paris, covered with a very thin layer of fine peat moss; and having nine plastic stems (2 mm in diameter) inserted vertically so that each stem protruded 12.3 cm above the surface of the plaster. Eight of the stems were arranged at approximately equally-spaced points 2.0 cm apart around a 5.0 cm diameter circle and the ninth was in the center of this circle. The rest of the test arena was exactly the same as for adult and nymphal tests above, except that the plastic dish containing the water moat was only 20.0 cm in diameter.

Approximately 1,000 *D. variabilis* larvae of the F_1 generation produced by field-collected adults (engorged on laboratory rats) were placed on the arena, within the outer 76 cm diameter arena, allowed 24 hrs to acclimate, and were then observed at eight irregular intervals. The maximum heights any larvae were observed on the plastic stems were recorded at the time of any given reading, as well as concurrent meteorologic data (collected as described above). Counting the number of larvae at any given height on the bottom 2-3 cm of the stems was a near impossibility. Even detecting movement by them was difficult. These factors forced these readings to be slightly subjective.

RESULTS

Vertical Distribution of adults and nymphs on the artificial "tree."
Both adults and nymphs of *D. variabilis* were found most frequently questing (awaiting hosts) at relatively low levels on the plastic tree. A total of 56.4% of questing adults were on leaves or rachis at ≤ 10 cm above the substrate and 92.6% were at ≤ 30 cm. Only one individual male was observed to climb to the top of the 1-m rachis. He crawled back down to the whorl at 20 cm above the substrate before he came to rest. Only one other observation included any adult at a level higher than the 50 cm whorl. One male was stationary on a leaf tip at the 80 cm whorl at the time of one observation. A total of 72.9% of the nymphs were questing on leaves or the rachis at ≤ 5 cm and 92.5% were at ≤ 10 cm above the substrate (Table 1.).

Lateral Distribution of adults and nymphs on the artificial "tree."
Adult *D. variabilis* showed a distinct tendency to await hosts near the plastic leaves' tips. More than 92% of all questing adults were located within 2.0 cm of a "leaf" tip, whereas only 7% were elsewhere on leaves and 1.5% were on the rachis at the time of each initial reading. Nymphs showed much less clumping near leaf tips with slightly larger percentages elsewhere on leaves or on the rachis (Table 2.).

Diurnal Questing Frequency. Both adults and nymphs of this species exhibited a roughly bimodal diurnal distribution of peak questing frequency (activity) levels (Figure 4.). The peaks for both adults and nymphs appeared to be at approximately Noon - 1 P.M. and 7 - 8 P.M. daily during these observations. There was a questing activity depression for both of these instars at approximately 3 - 4 P.M. daily. The observed depression of mid-afternoon activity levels here seemed to be inversely related to the peak daily ambient temperature. It also seemed to lag an hour or so behind that peak.

Adult Time Budget. The adult time budget study showed that, for the population sampled, 80% of the overall observed time was spent in stationary questing (at locations up on structures above the substrate waiting for a host), and roughly 19% was spent sitting on the substrate (presumably re-hydrating). Less than 2% of all observed time was spent in crawling around (Table 3.). Males spent a total of more than four times as much time walking and nearly three times as much time stationary on the substrate (presumably re-hydrating) as females.

Larval Questing. None of the approximately 1,000 larvae observed in the arena was ever seen higher than 12.0 cm above the substrate. The vast majority remained below 7.5 cm and the bulk of these were never observed to crawl higher than 4.0 cm above the substrate.

DISCUSSION

Three-Dimensional Distribution of Ticks. The questing heights observed here agree well with field observations of adult *D. variabilis* reported by Dodds *et al.* (1969). They also reinforce the validity of questing height limits observed for other tick species by Lees (1969), Wilkinson (1953), and Balashov (1972). These observed questing locations (*i.e.* roughly 50% of questing ticks at vegetation tips between 5 and 30 cm above the substrate) should provide adult *D. variabilis* an optimal probability of encountering a suitable host. A wide variety of mammal species could readily be encountered at these heights (*e.g.* raccoon, opossum, dogs, and even browsing deer). Questing at much higher or lower levels (*e.g.* more than 50 cm or less than 5 cm above the substrate) might preclude effective contact with many medium-sized mammals such as raccoon, a very frequent wild host of adults of this species throughout its range (Sonenshine *et al.*, 1966; Magnarelli *et al.*, 1983). Although not as obvious from these results, the questing distribution of both nymphs and larvae, in physical space and time, probably also helps insure adequate contact with their respective normal hosts (Figure 3.).

Diurnal Activity Cycle. The amplitude of the daily questing cycle activity peaks, shown in Figure 4., is relative and depends upon tick populations, as well as overall weather conditions (Lees, 1969; Sonenshine, 1993). Extremes of heat, wind, or very low humidity may depress the peaks. Sudden fluctuations of such conditions (as when a weather front moves into the area suddenly) may shift the locations of these activity peaks to earlier or later in the day (Balashov, 1972). The bimodal diurnal cycle observed in this study, may be the result of several interacting environmental influences. Temperature has a very strong influence on activity in ticks (Smith *et al.*, 1946; Harlan and Foster, 1986; 1990), and as daily temperatures increase, so might the general activity levels of these ticks. The activity depression in mid-afternoon may be a delayed response to temperature exceeding some critical level, as reported for *Hyalomma* spp. (Balashov, 1972); or to accelerated dehydration rates due to peak daily temperatures which (after a delay) usually trigger a behavioral response causing the ticks to return to the litter layer for re-hydration (McEnroe and McEnroe, 1973). These activities may be superimposed on an innate diurnal cycle of *D. variabilis* in late evening through early night. It is reasonable to assume the existence of such a cycle, since most of the natural hosts of all active instars of this tick are well known to have a parallel activity cycle throughout its distribution (*i.e.* small rodents which are the main hosts for immatures; raccoon, opossum, rabbits, and skunks, which are the main adult hosts are mainly nocturnal).

Time Budget. Adult *D. variabilis* spent most of their time questing ("sitting" up on an elevated site) during this study. These test ticks were field-collected while they had been in the act of questing. Thus, they may not have been truly representative of the overall population from which they were collected. Apparently, *D. variabilis* adults are not very active physically during most of their host seeking, unless (until) alerted by stimuli from a nearby host (Lees, 1969). This may help conserve their limited energy resources. Males may have dehydrated faster and, therefore, spent some time crawling down to the substrate, or back up, as well as more time on the substrate re-hydrating than females. This difference may be due to the ability of female *D. variabilis* to maintain a fairly constant "hemolymph volume percent" even under very dry (30% RH) conditions, apparently independent of total body weight loss (McEnroe, 1971; Sonenshine, 1993; Sonenshine *et al.*, 2002).

CONCLUSIONS

Field live-trapping and sampling showed that the white-footed mouse, *Peromyscus leucopus* (Rafinesque), was the most important species for supporting immature *D. variabilis* in all five of the counties studied. Meadow voles, *Microtus pennsylvanicus* (Ord), appeared to play a less important role, despite having higher average nymphal infestations. This was most obvious in Clermont, Franklin and Lucas Counties, those with the highest human RMSF case incidence in Ohio at the time of this study.

Larval *D. variabilis* infested male *P. leucopus* in significantly greater average numbers than they did females. Domestic dogs were probably one of the main blood meal sources for adult *D. variabilis* in all these study areas, but opossums were the wild mammals most frequently and most heavily infested with adults of this tick species in the American Addition area.

The very high relative humidity, high water table and lake effects (especially the damping of extreme temperature and humidity fluctuations and the lengthening of the annual frost-free-period), within an approximate 80 km radius of the shore around the western end of Lake Erie, combine to provide ample microhabitats which are adequate for successful overwintering of *D. variabilis* populations. Lack of such adequate microhabitats (especially inadequate humidity levels) appear to prevent these ticks from surviving overwinter in most of the areas between Lucas and Delaware Counties (*i.e.* above the -1°C January average temperature isotherm).

In Alum Creek study sites, temperatures (especially ambient temperature) and their squares were the most important of all of 15 measured micrometeorological parameters in explaining observed questing adult *D. variabilis* data variability. Moisture factors (relative humidities and soil moisture) were of secondary importance in four of five study sites. Solar radiation was of tertiary importance, at best, and seemed to be covariant with ambient temperature (Harlan and Foster, 1990).

During this study, large differences were often noted between macrometeorologic data collected by NOAA stations and the micro-meteorologic data collected in any given meso- or microhabitat. Therefore, great care must be taken in interpreting microhabitat level observations on the basis of weather data from NOAA stations.

Adult and nymphal *D. variabilis* both showed a roughly bimodal diurnal questing cycle with activity peaks at about 1 P.M. and 7 P.M. and a depression at about 3 P.M. This activity depression lagged behind, but may have been effected by, the daily ambient temperature peak. Adult American dog ticks remained inactive for most of the time they were questing. Males were more active and spent more time on the substrate (presumably re-hydrating) and less time in the good locations for contacting a host than did females.

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Table 1. Vertical Stratification of *D. variabilis* on Plastic "Tree"

Height above Substrate (cm.)[a]	Average % at each height on tree Adults	Nymphs
0-5	38.2	72.9[b]
5-10	18.2[b]	19.6[c]
10-15	14.7	4.1
15-20	10.3	3.1
20-25	8.4	0.3
25-30	2.8[c]	
30-35	1.2	
35-40	1.6	
above 40	4.6	
Mean % Questing[d]	23.4	21.3

[a] Includes ticks on any leaf attached to rachis at the top of this node.

[b] Cumulative total No. of ticks questing at this level or lower > 50%.

[c] Cumulative total No. of ticks questing at this level or lower > 90%.

[d] This value was derived as follows:

$$\text{Mean} = \frac{\text{Composite Total No. of Ticks Observed Questing}}{\begin{matrix}\text{\% Total Potential No.} \\ \text{of Ticks Questing}\end{matrix} \;\mathbf{X}\; \begin{matrix}\text{Total No. of Observed} \\ \text{Questing Opportunities}\end{matrix} \;\mathbf{X}\; 100}$$

Table 2. Distribution of Questing D. variabilis[a] on Plastic "Tree".

Location	Average % at each location[b]	
	Adults	Nymphs
Within 2.0 cm of leaf tips	92.4	31.2
Elsewhere on leaves	6.0	35.1
On rachis	1.5	33.8

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[a] No larvae were observed on this experimental setup.

[b] Based upon a total of 100 adults (50 males; 50 females) over 18 observations and 47 nymphs over 32 observations.

Table 3. Results of Time Budget Observations of 20 Adult Field-Collected *D. variabilis* on an Artificial Outdoor Arena.

Tick No.[b]	Time Spent/Activity[a]			
	A	B	C	D
M-1	50.11	3.74	45.96	0
M-2	91.43	0	8.57	0
M-3	93.14	1.79	2.15	2.91
M-4	70.32	0.34	28.88	0.46
M-5	86.73	11.77	0.37	1.13
M-6	81.68	0	18.32	0
M-7	32.41	0	67.59	0
M-8	100.00	0	0	0
M-9	0	0	100.0	0
M-10	100.00	0	0	0
F-1	100.00	0	0	0
F-2	100.00	0	0	0
F-3	100.00	0	0	0
F-4	100.00	0	0	0
F-5	100.00	0	0	0
F-6	8.37	0.20	91.43	0
F-7	99.05	0.95	0	0
F-8	100.00	0	0	0
F-9	89.37	2.34	8.26	0.14
F-10	100.00	0	0	0
Overall M	70.60	1.76	27.19	0.45
Proportions F	89.67	0.35	9.97	0.01
Both	80.13	1.06	18.58	0.23

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[a] Percent of total observation time spent by each tick in each activity based on 11 observation periods (410 total min); **A** = stationary somewhere on the tree (*i.e* above the substrate), **B** = crawling somewhere on the tree (above the substrate), **C** = stationary on substrate, **D** = crawling about on substrate.

[b] **M** = males, **F** = females; individuals of each sex numbered 1 through 10.

FIGURE REFERENCES:

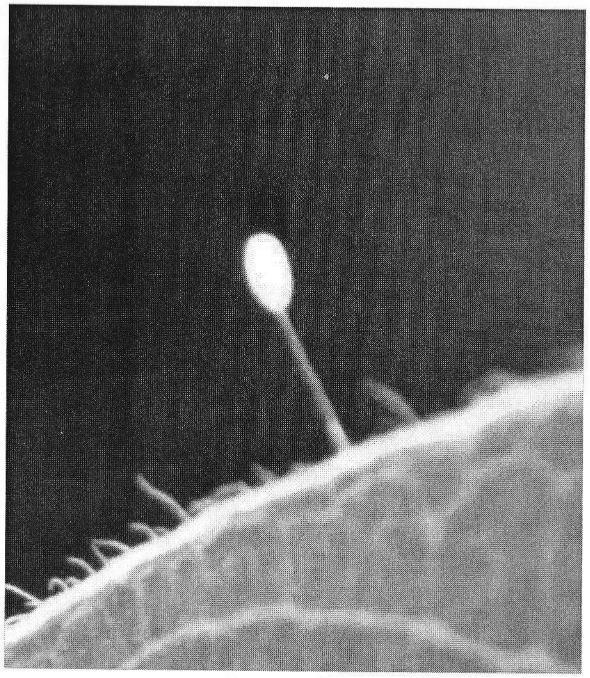

Fig. 1. Lacewing egg (1 mm long).

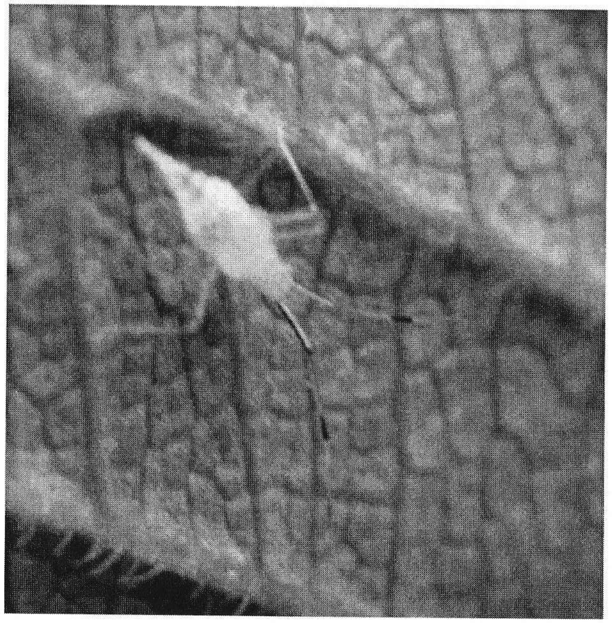

Fig. 2. Lacewing larva 1st Instar (1 mm long).

FIGURE REFERENCES:

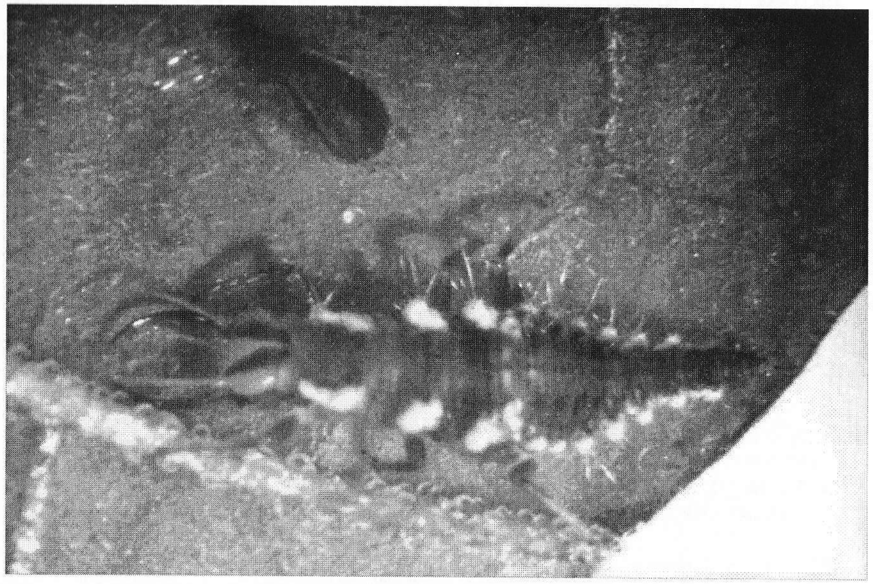

Fig. 3. Lacewing larva 4th Instar (5 mm long).

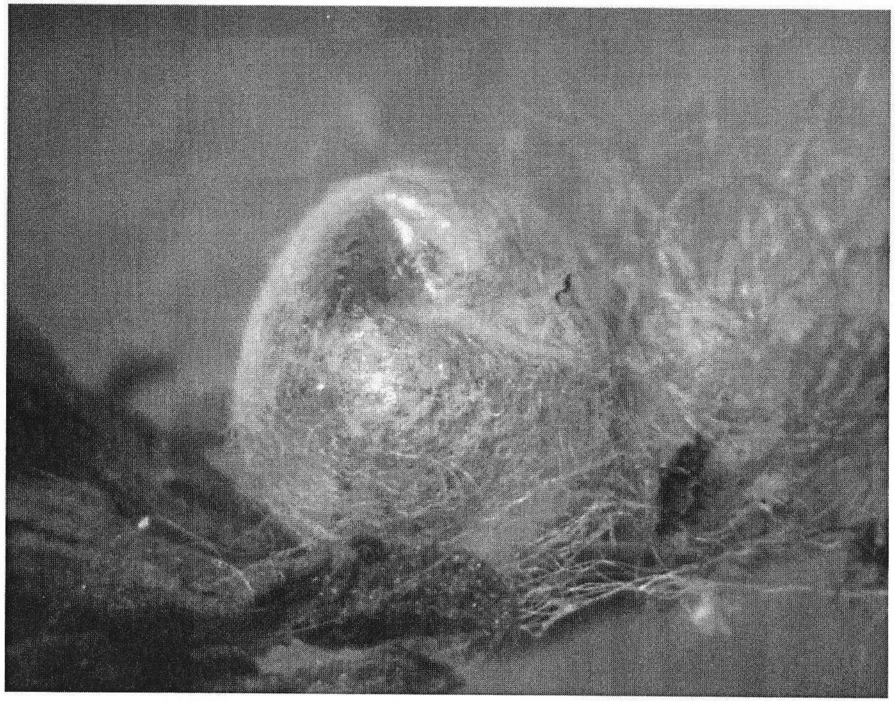

Fig. 4. Lacewing pupal case (4 mm diameter).

FIGURE REFERENCES:

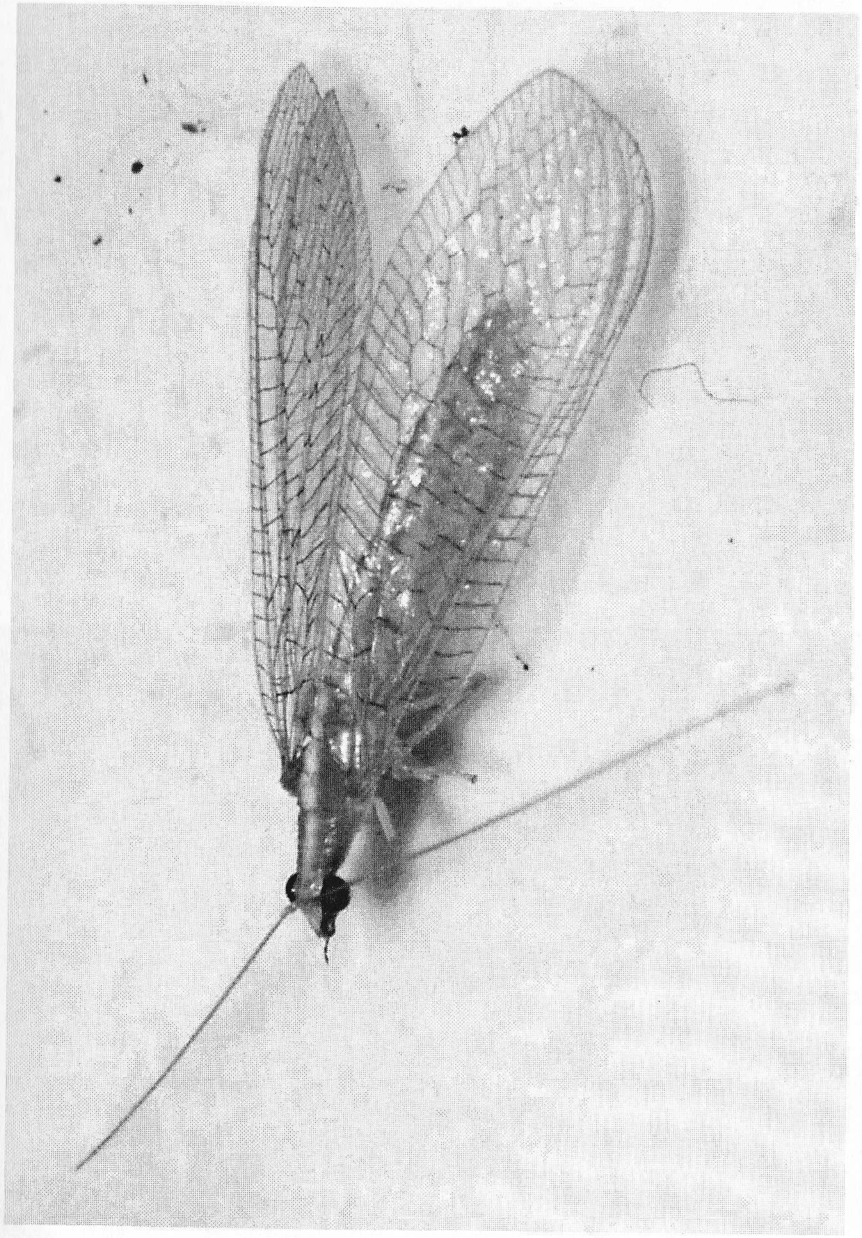

Fig. 5. Green Lacewing adult (2.5 cm long).

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