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Seasonal Emergence of Neuroptera in Fairfax County, Virginia

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A total of 419 specimens, 25 species, and eight families of Neuroptera were collected from 81 light trap sites in Fairfax County, Virginia, during 2005. Eighty percent of the species (20 of 25) belong to the families Chrysopidae, Coniopterygidae, and Hemerobiidae. The most commonly collected species was the green lacewing, *Chrysoperla rufilabris* (Burmeister), with 29% of the specimens. First records for the state of Virginia are noted for *Hemerobius pinidumus* Fitch and *Hemerobius stigma* Stephens. These data provide a baseline for monitoring future climate change in the metropolitan Washington, D.C. area.

Neuroptera are among our most beneficial insects. Larvae are predators of other insects and can consume a wide variety of insect eggs, nymphs, larvae, and adults (Tjeder 1966) in a variety of habitats and ecological niches. Many move actively over the foliage feeding on almost any insect of the appropriate size. Neuropterans are released in agricultural lands to augment naturally occurring field populations, and are reared for release more than any other group of beneficial insects (Tauber, M.J. et al. 2000). Larvae of antlions are sedentary predators living in tree holes, on the soil surface, and in specialized pits that they create in loose soil (Stange 2004). Larvae of mantis-flies are mostly predators on spider egg sacs (Redborg 1998). Berothid larvae live in termite nests and feed on the termites (Tauber, C.A., and M.J. Tauber 1968). The only aquatic family of neuropterans in North America, the Sisyridae, feed on freshwater sponges as larvae (Parfin and Gurney 1956).

Neuropterans are plentiful in the urban environment. Adults are nocturnal and chrysopids and hemerobiids can frequently be seen at window panes and store fronts at night. In the eastern United States their adult taxonomy, geographical distributions, and diapause mechanisms are fairly well understood (Penny et al. 1997; Tauber, M.J., and C.A. Tauber 1976), yet relatively few studies have been carried out on seasonal activity patterns. With the growing evidence that humans are impacting the environment and are a major contributor to climate change (Hansen and Lacis 1990; Walther et al. 2002), we need to understand baseline patterns of seasonal variation in insect populations. To investigate seasonal patterns of neuropterans in the Mid-Atlantic States, we analyzed collections from a series small light traps set up at 81 sites in Fairfax County, Virginia, in 2005. The light traps were used to monitor mosquito populations and throughout the warmer seasons were also utilized to monitor adult neuropteran presence.

Materials and Methods

Beginning in early May of 2005, one standard Centers for Disease Control and Prevention (CDC) miniature light trap (Sudia and Chamberlain 1962) was set overnight at each of 72 sites once

a week for 24 weeks as part of the mosquito surveillance activities conducted by the Fairfax County Disease Carrying Insects Program. Trap sites were located throughout Fairfax County in areas of varying habitat. In mid-June these trapping efforts were complemented by an additional nine sites (Fig. 1). This technique is useful for the collection of adult Neuroptera, as most species are phototropic insects. However, as the primary purpose of these traps was to collect adult mosquitoes, each trap was also baited with carbon dioxide (CO_2) to increase mosquito numbers and diversity.

The body of the CDC miniature light trap was Plexiglas tubing, which housed a 6.3 volt light bulb, a DC motor, and fan blade. A motorcycle, lead-acid, six-volt battery provided the necessary power. A detachable, flat-topped, plastic lid covered the body of the trap to protect the operating mechanism (Fig. 2). Insects attracted to the light were sucked through the fan blade into a fine mesh collection cup that hung from the bottom of the tubing. Trap sites were typically located a short distance into the margins of wooded areas where cover was good and other sources of artificial light could be avoided. Traps and accompanying plastic thermoses containing dry ice, as a source of CO_2, were hung from trees approximately 1.5 m above the ground.

Throughout the season 1,859 trap samples were examined for neuropterans. All insects were collected alive and killed with triethylamide in the laboratory. Neuropterans observed while sorting trap collections for mosquitoes were removed and assigned specimen identification numbers. Coniopterygidae were preserved in 80% ethanol whereas other neuropterans were dry packed. All specimens in this study are deposited at the California Academy of Sciences. Temporal distribution of these species throughout Fairfax County was determined. The closely related order Megaloptera was not included in this study. A recent study of seasonal populations of the megalopteran family Sialidae in coastal Virginia can be found in Barrows et al. 2005.

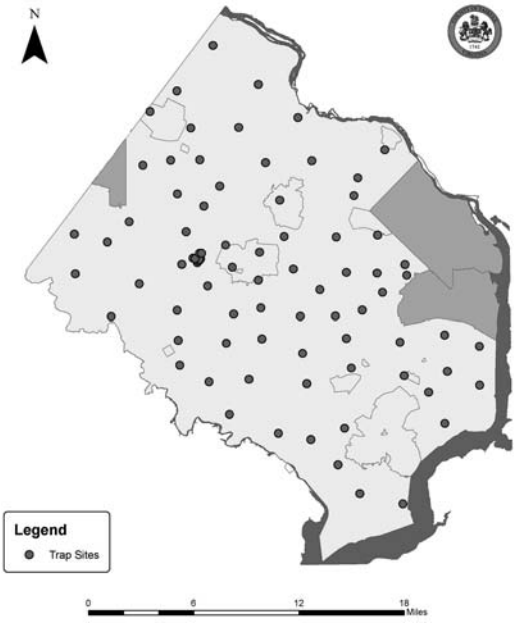


FIGURE 1. Map of collecting localities in Fairfax County, Virginia.

FIGURE 2. CDC miniature light trap.

RESULTS

A total of 419 specimens of 25 species in eight families were found in the samples from Fairfax County. Almost 96% of the specimens belonged to three families: Chrysopidae, Coniopterygidae, and Hemerobiidae. No more than seven specimens were encountered of any of the other five families collected.

Family Chrysopidae

Larvae of green lacewings feed on a wide variety of insects that they capture on vegetation, but are best known for feeding on relatively sedentary homopterous pests. Hence, the common name of aphid-lions. Some larvae, such as *Ceraeochrysa lineaticornis*, cover their bodies with debris and the bodies of their prey (Tauber, C.A. et al. 2000). Individuals of this family were the most plentiful, especially during the middle of the summer. In all, six species in four genera were encountered in the light traps.

***Ceraeochrysa lineaticornis* (Fitch, 1855)**

This is a generalist feeder that is found at forest edges and within open forests. Seven specimens were captured, most of them during August and September (Fig. 3).

***Chrysopa oculata* Say, 1839**

This is perhaps the most widespread species of green lacewing in North America. It has a transcontinental distribution and can be found from sea level up to 2576 m (8500 ft.) in elevation. This species is most frequently found in open areas, such as fields and roadside ditches. In Fairfax County its adult population continued to increase throughout the summer and peaked in mid-September (Fig. 4).

***Chrysopa quadripunctata* Burmeister, 1839**

This distinctive species has four bright orange spots on the pronotun that make it easily separable from all other species except *C. slossonae*. Unfortunately, these spots frequently fade after death making recognition more difficult. Although *C. slossonae* is found in Virginia (Penny et al. 1997), it was not encountered during this study. *C. quadripunctata* larvae are generalist predators, while larvae of *C. slossonae* are highly specialized feeders on wooly alder aphids, *Prociphihis tesselatus* (Fitch) (Tauber, C.A. et al. 1995). *C. quadripunctata* adults were found throughout the season, but were more abundant in September (Fig. 5).

***Chrysoperla rufilabris* (Burmeister, 1839)**

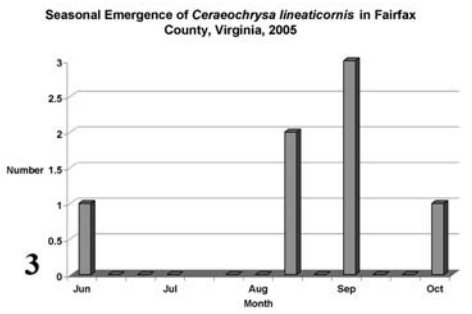
This species prefers trees, especially in open environments such as orchards, parks, and yards. This is the most abundant species in residential areas of the eastern coastal region and was the most commonly encountered species in the survey. It appeared to reach peak abundance in August (Fig. 6)

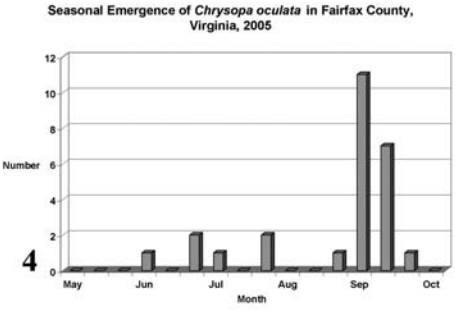
***Leucochrysa* (*Leucochrysa*) *insularis* (Walker, 1853)**

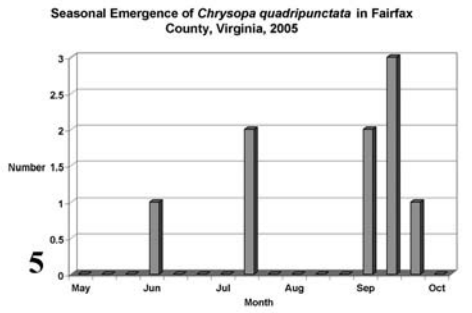
This is the largest species of green lacewing found in the Fairfax County area. It is widespread from Massachusetts to Florida and Iowa to Arkansas (Penny et al. 1997). It is a woodland species that is seldom seen outside of forests. Six individuals were captured on June 23, July 9 [2], July 21, August 5, and September 1. This species appears to be present in low numbers, at least during the period of the survey (Fig. 7).

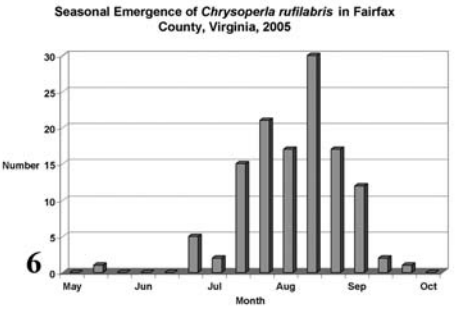
***Leucochrysa* (*Nodita*) *pavida* (Hagen, 1861)**

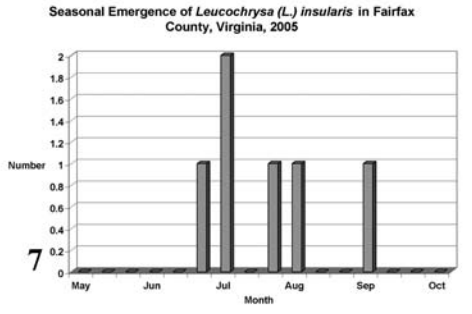
As with the preceding species, this species of *Leucochrysa* is a woodland species and relative-

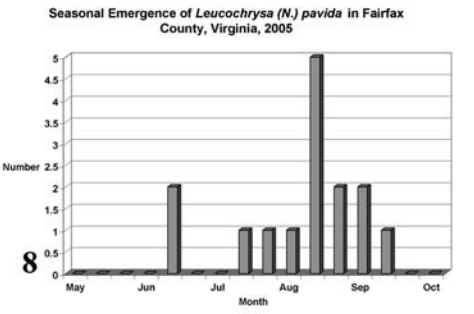












FIGURES 3–8. Seasonal captures of Chrysopidae. Figure 3 – *Ceraeochrysa lineaticornis*; Figure 4 – *Chrysopa oculata*; Figure 5 – *Chrysopa quadripunctata*; Figure 6 – *Chrysoperla rufilabris*; Figure 7 – *Leucochrysa* (*L.*) *insularis*; Figure 8 – *Leucochrysa* (*N.*) *pavida*.

ly large. There appears to be a close relationship between lichens and larvae of this species (Slocum and Lawrey 1976). Larvae occur on the trunks of a wide variety of trees bearing these commensals and cover their bodies with packets of lichens. Adults rest on leaves of a variety of deciduous trees (Tauber, C.A. 2004). They are a more tropical species and Fairfax County is near the northern limit of their distribution. Fifteen individuals were captured between 16 June and 14 September with an apparent peak in late August (Fig. 8).

Family Hemerobiidae

The brown lacewings were the most speciose family in the traps, with eight species in four genera. All of the collected species have ample distributions, being found throughout the eastern U.S. Adults appear to avoid the warmest periods of summer and are most prevalent in September, with a secondary peak in June.

***Hemerobius humulinus* Linnaeus, 1758**

This is the most abundant hemerobiid in eastern North America. It is also found in Western Europe. Adults are frequently encountered on deciduous trees where both larvae and adults feed on slow-moving, soft-bodied insects. In the Fairfax County area, adults have a bimodal emergence in May-June and again in late August and September (Fig. 9).

***Hemerobius pinidumus* Fitch, 1855 (New state record)**

This is a northern species having previously only been recorded as far south as New Jersey (Penny et. al 1997). Thus, this is the first record for this species from Virginia. Only a single individual was captured on September 21. It may be a late-season emergent in the southern part of its distribution.

***Hemerobius stigma* Stevens, 1836 (New state record)**

This species is the counterpart of *H. humulinus* on conifers. It is almost never seen on deciduous trees. It has an ample distribution in Western Europe and throughout the northern and mountainous parts of North America. Only a single specimen was collected before September, perhaps indicating a low population of adults early in the year and a larger fall emergence (Fig. 10). This is the first record for this species from Virginia.

***Megalomus fidelis* (Banks, 1897)**

This was the only species of *Megalomus* encountered during the study, and one of the least collected species of Hemerobiidae. This species was only encountered three times from mid-August to early September (Fig. 26).

***Micromus posticus* (Walker, 1853)**

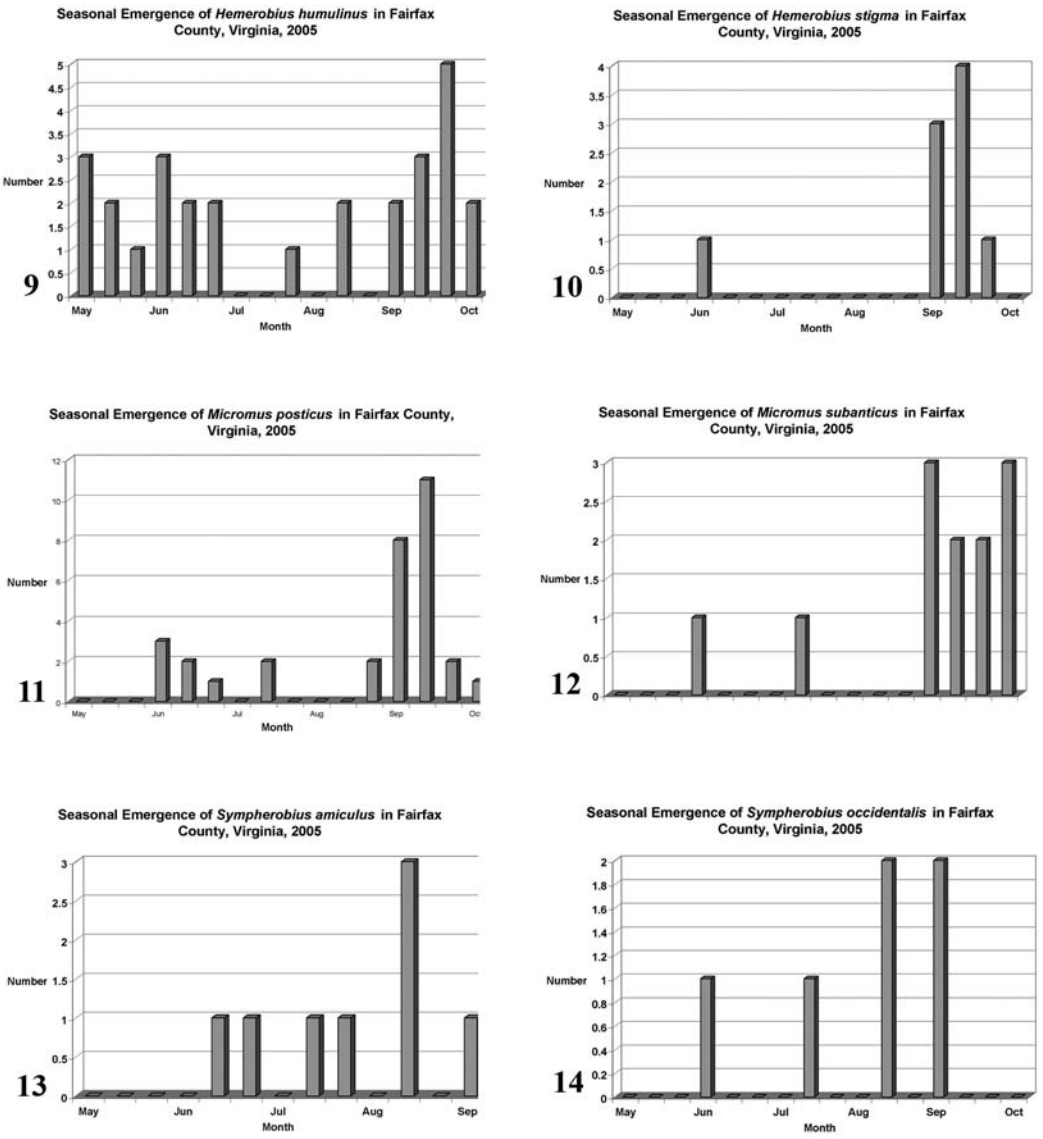
This is the most frequently collected hemerobiid in the survey. It is found in forests in the eastern part of the country. Although collections indicate a typical hemerobiid bimodal emergence, some adults were trapped throughout the season, indicating a continuous (albeit low population level) presence of adults (Fig. 11).

***Micromus subanticus* (Walker, 1853)**

This species is found in open grassland. Numbers were low in traps, probably because of a forest habitat preference for trap locations. As with most hemerobiids, trapping levels were low until September (Fig. 12).

***Sympherobius amiculus* (Fitch, 1855)**

The species of *Sympherobius* are among our smallest brown lacewings. *S. amiculus* is the most common species of *Sympherobius* in southeastern Canada and the eastern U.S.A. west to about the 100th meridian. It has been found associated with various species of pine, oak, apple, and vineyards (Oswald 1988). Adults have been collected from January 15 to November 11 (Oswald *ibid*.) and during this survey were collected from June 15 to September 20, with a gradual increase in numbers until late August and early September (Fig. 13).



FIGURES 9–14. Seasonal captures of Hemerobiidae. Figure 9 – *Hemerobius humulinus*; Figure 10 – *Hemerobius stigma*; Figure 11 – *Micromus posticus*; Figure 12 – *Micromus subanticus*; Figure 13 – *Sympherobius amiculus*; Figure 14 – *Sympherobius occidentalis*.

Sympherobius occidentalis (Fitch, 1855)

This species has been associated with *Pinus* sp. throughout the eastern U.S.A. and collected elsewhere from April 20 to October 25 (Oswald 1988), but our survey found a gradual increase in numbers from June 8 to September 9 (Fig. 14).

Family Coniopterygidae

Coniopterygidae, or dustywings, are tiny neuropterans that feed on soft-bodied, slow moving insects, especially homopterans. Adults are completely covered with a fine white powder that gives them the appearance of whiteflies (Homoptera: Aleyrodidae). Perhaps it is no accident that whiteflies are among the favorite food items of this family. They are normally nocturnal, and adults can often be seen fluttering among bushes and shrubbery early on warm mornings. Later in the day they rest under leaves and are much harder to find (NP, personal observation). Six species in three genera were collected in Fairfax County during the study. Females cannot be separated from other species of the same genus, so that counts are based on males only, unless females are associated with males in the same trap sample.

***Coniopteryx* (*Coniopteryx*) *simplicior* Meinander, 1972**

This species is found throughout the eastern U.S.A. and has been recorded on peach and *Citrus* trees. Seven specimens of this species were collected, five on July 13 at one trap site. There may have been a temporary colony of host prey near the trap site at this time (Fig. 15).

***Coniopteryx* (*Coniopteryx*) *tineiformis* Curtis, 1834**

This is a widely distributed species, being found in Europe, Asia Minor, and northern North America (Meinander 1972). It is confined to deciduous trees and bushes (Meinander *ibid*.). During the study, it was only collected twice, both late in the season, on September 1 and September 13 (Fig. 16).

***Coniopteryx* (*Coniopteryx*) *westwoodi* (Fitch, 1855)**

This species is found throughout the eastern U.S.A. and is the most common species of dustywing in the Fairfax County area. There appears to be an early summer emergence and then a larger emergence in August and September (Fig. 17).

***Conwentzia pineticola* Enderlein, 1905**

This is the most widely distributed species of coniopterygid in the study. It is found throughout Europe and eastern North America, North Africa, Siberia, and Mongolia (Meinander 1972). It is typical of many species of *Conwentzia* in that its hindwings are reduced to small stubs, and it is functionally two-winged. Both larvae and adults are found primarily on coniferous trees (Meinander 1972). There appears to be a June emergence that tapers off later in the season (Fig. 18).

***Semidalis inconspicua* Meinander, 1972**

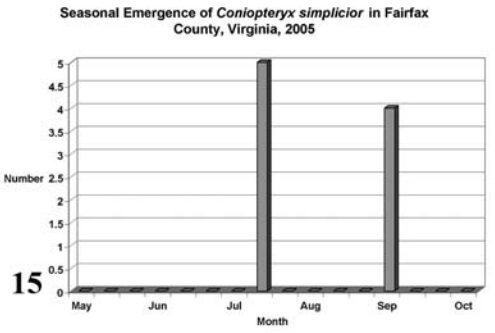
This species has been collected on *Carya*, *Quercus*, and *Juniperus*. Although it is hard to generalize from only two trap captures, both records are for September (Fig. 19).

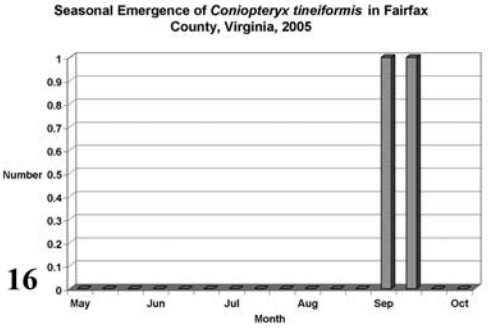
***Semidalis vicina* (Hagen, 1861)**

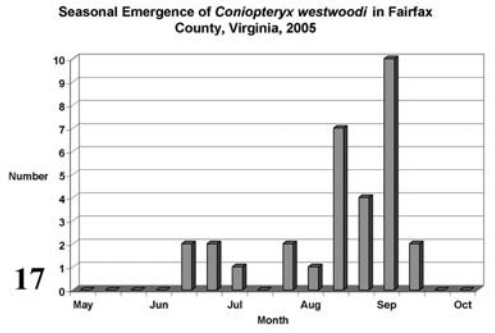
This species is found in Europe, Morocco, and the eastern U.S.A. It has been recorded on deciduous trees such as elm, oak, and peach, as well as orange trees. Muma (1967) records it as feeding on homopterous insects and mites. It appears to emerge as adults in early summer and continues to be present in low numbers throughout the summer and early fall (Fig. 20).

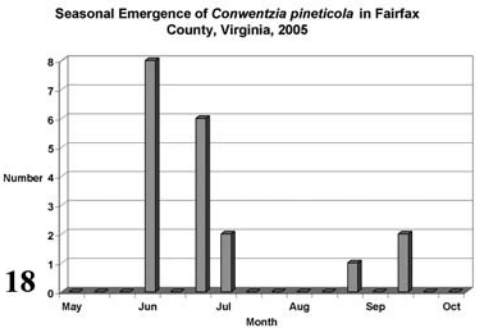
Family Berothidae

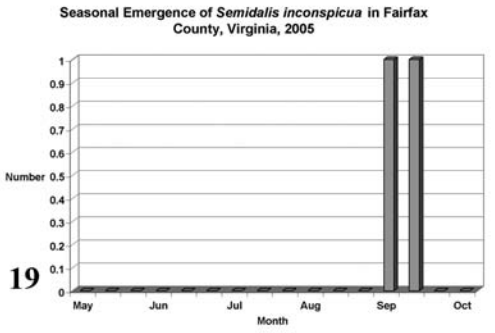
This family, called beaded lacewings, is quite distinctive. The only genus in North America, *Lomamyia*, has adults with falcate (scalloped) wings. Females often have scales on the thorax,

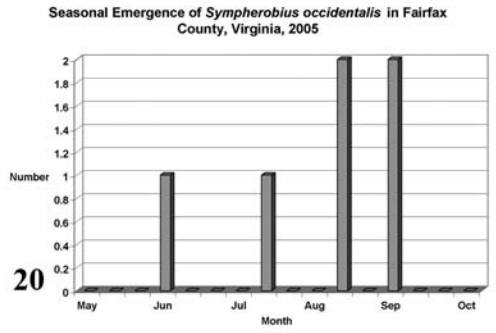










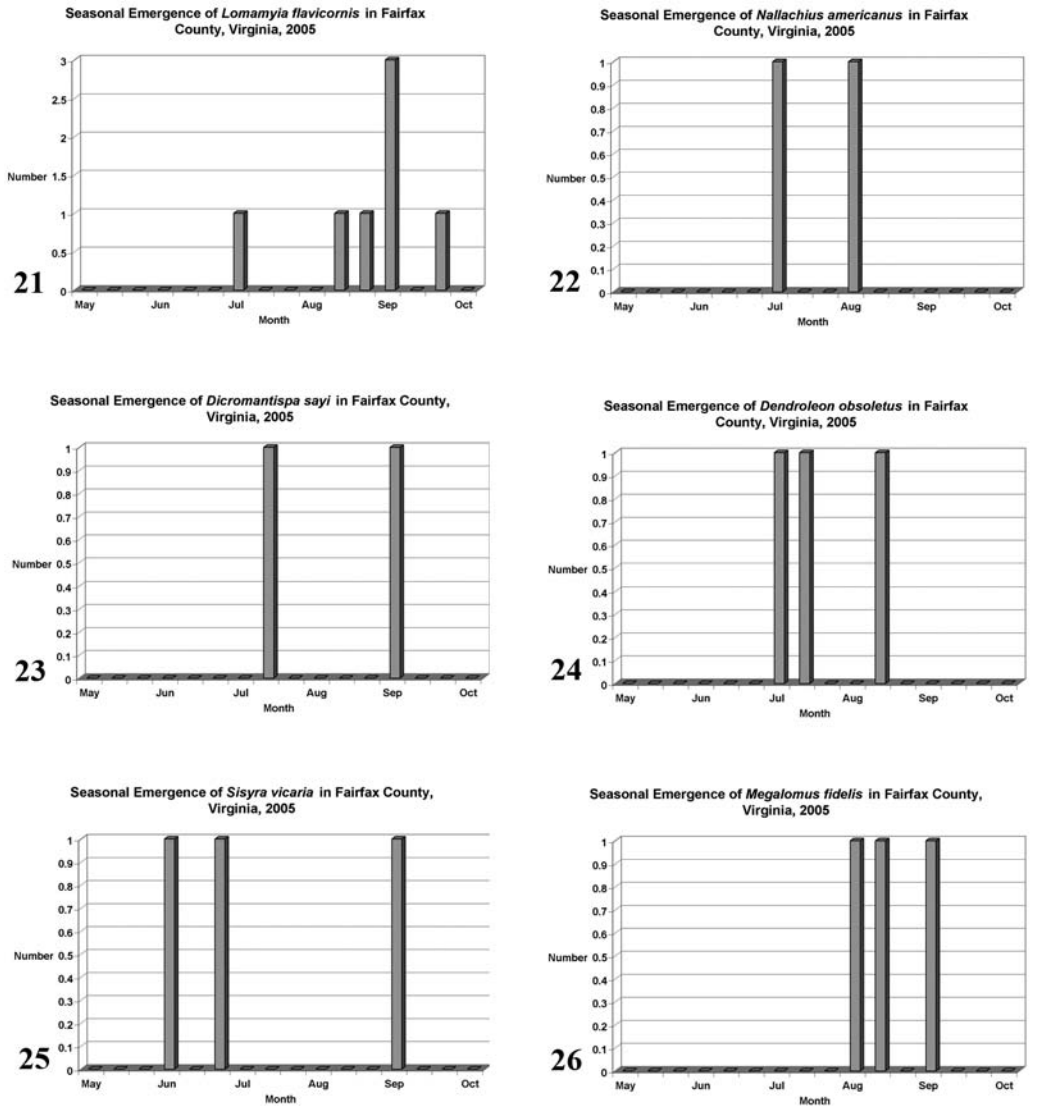


FIGURES 15–20. Seasonal captures of Coniopterygidae. Figure 15 – *Coniopteryx* (*C.*) *simplicior*; Figure 16 – *Coniopteryx* (*C.*) *tineiformis*; Figure 17 – *Coniopteryx westwoodi*; Figure 18 – *Conwentzia pineticola*; Figure 19 – *Semidalis inconspicua*; Figure 20 – *Semidalis vicina*.

coxae, or along the wing veins. When resting on twigs or plant stems, adults weave back and forth, as if being blown in the wind (NP, personal observation). Larvae live in termite nests where they feed on termites and appear to be completely accepted by the colony (Tauber, C.A., and M.J. Tauber 1968; Johnson and Hagen 1981).

***Lomamyia flavicornis* (Walker, 1853)**

This species is found throughout the eastern U.S.A. as far west as Kansas wherever termites are found. In Fairfax County, most adults were collected in late August and early September (Fig. 21)



FIGURES 21– 26. Seasonal captures of various Neuroptera. Figure 21 – *Lomamyia flavicornis* (Berothidae); Figure 22 – *Nallachius americanus* (Dilaridae); Figure 23 – *Dicromantispa sayi* (Mantispidae); Figure 24 – *Dendroleon obsoletus* (Myrmeleontidae); Figure 25 – *Sisyra vicaria* (Sisyridae); Figure 26 – *Megalomus fidelis* (Hemerobiidae).

Family Dilaridae

Dilaridae are known as pleasing lacewings. Adults are relatively small, hairy, and broad-winged. Usually there are dark bands across the wings. Females have elongate ovipositors and males have plumose antennae, making them look much like small moths. Larvae are predators of insects living in rotting logs (MacLeod and Spiegler 1961). Only two species are known from the U.S.A., one living in the East and the other in the Southwest (Penny et al. 1997).

***Nallachius americanus* (McLachlan, 1881)**

This species is found in the eastern U.S.A. from Indiana to Georgia. Two males were collected on 6 July and 3 August (Fig. 22).

Family Mantispidae

Mantispids are called mantis-flies because of their close resemblance to small praying mantids. Larvae are generally known as spider egg case predators, but some larvae feed on solitary wasps, colonial wasps, and even scarab pupae in the soil (MacLeod and Redborg 1982). One female will lay thousands of eggs, often in clusters on the bark of trees. The first instar larvae are elongate and active, seeking to board a female spider before she forms her egg sac. Because the chances of success are so small, the number of eggs laid must be great (Redborg and MacLeod 1985). The second and third instar larvae are scarabaeiform and sedentary inside the egg sac of the host. Because the food source for larvae is fixed and finite, mantispids are one of the few groups of insects that can survive food shortages by producing a much smaller adult.

This is a small family with only 15 species known from the U.S.A., most of them confined to the southwestern part of the country.

***Dicromantispa sayi* (Banks, 1897)**

This species is widespread in the southern U.S.A. from Georgia and Florida to Arizona and as far north as Illinois. Two individuals were captured during the study, on July 12 and September 7 (Fig. 23).

Family Myrmeleontidae

Myrmeleontidae, or ant-lions, is the largest family of Neuroptera worldwide with more than 1200 described species (Stange 2004). Ninty-four species are known from the United States (Penny et al. 1997) with most of them distributed in the desert Southwest.

Dendroleon is a colorful genus with two species, one eastern and one western, both bearing numerous dark maculations on the wings. The eastern species, *Dendroleon obsoletus*, was captured during the study in Fairfax County.

***Dendroleon obsoletus* (Say, 1839)**

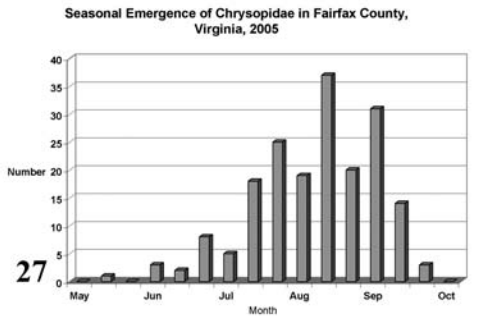
This species is widespread over the eastern U.S.A. as far west as Kansas (Penny et al. 1997). It is known to live in tree holes as larvae (Stange 1980). Two adults were captured on July 14 and August 11 (Fig. 24).

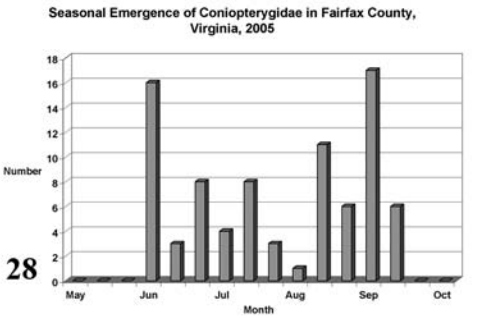
Family Sisyridae

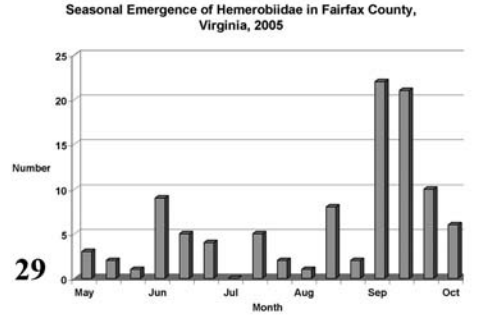
This is the only truly aquatic family of Neuroptera in North America. Larvae live in fresh or brackish water and feed on freshwater sponges. When mature, larvae climb out of the water and pupate at the top of rushes or on the bark of trees. Larvae often weave an inner cocoon and a loose outer webbing (Parfin and Gurney 1956). Although associated with water, adults can often be captured several hundred feet in the air or more than a kilometer from the nearest water course (NP, pers. obser.).

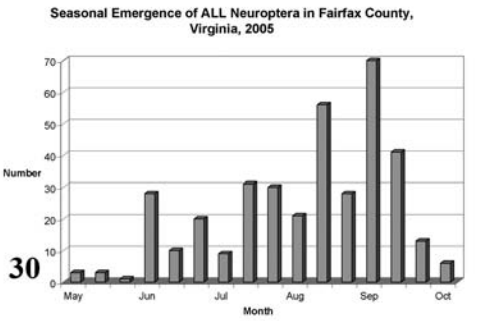
***Sisyra vicaria* (Walker, 1853)**

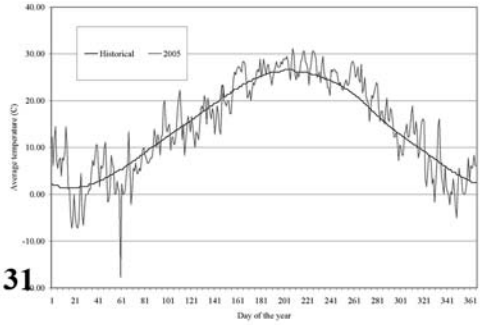
This species is found throughout North America. During the study three individuals were captured on June 8, June 28, and September 1 (Fig. 25).

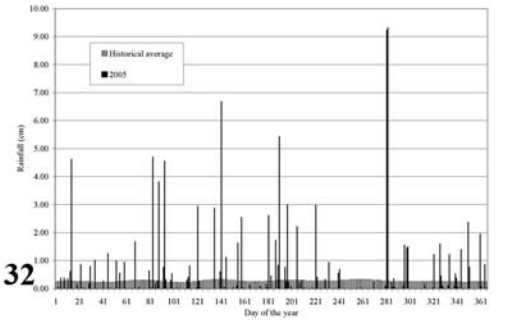












FIGURES 27–32. Total seasonal captures of all Chrysopidae (Figure 27); all Coniopterygidae (Figure 28); all Hemerobiidae (Figure 29); and all Neuroptera (Figure 30). Figure 31: Seasonal temperature pattern in Fairfax County. Figure 32: Seasonal rainfall pattern in Fairfax County.

DISCUSSION

The seasonal life cycle of predatory neuropterans is controlled by both climatic factors such as photoperiod and temperature and biotic factors such as abundance of food. Whether a second generation per year is produced, or not, is based on a balance of these factors and is constantly adjusted through environmental cues (Canard 2005). Most North American green lacewings overwinter as prepupae in the cocoon, although *Chrysoperla* species overwinter as adults (Canard *ibid.*). Several species of North American Hemerobiidae are found overwintering in cocoons within conifer cones (Deyrup and Deyrup 1978). Springtime rising temperatures and longer photoperiods trigger a break of diapause and a renewal of feeding and reproductive activity (Canard 2005). Most

chrysopids are facultatively multivoltine and by early summer the longer day length, as well as biotic factors, such as the abundance of aphids determine whether the species undergoes multiple generations, or not (Canard *ibid*). As the days get shorter in the fall, the shorter photoperiod and lower temperatures work differentially on the larvae to stop development. This helps synchronize the renewed development and adult emergence the following spring (Canard *ibid*.).

The overall abundance of adult neuropterans increased throughout the summer months until the colder, shorter days of late September and early October (Fig. 30). However, the various families behaved differently. In Fairfax County, Chrysopidae reached maximum population levels in August (Fig. 27), while Hemerobiidae reached their highest levels in mid to late September (Fig. 29). Coniopterygidae appeared to be more balanced, with emergence occurring throughout the warmer months (Fig. 28). This separation of emergences may be one way of partitioning similar food prey, as most species of all three families glean various stages of soft-bodied insects from plant surfaces. The interplay among food specialization, habitat selection, and emergence partitioning may provide the niche breadth needed for survival in the suburban Virginia environment. It is unknown what impact changing temperature (Fig. 31) and rainfall patterns (Fig. 32) will have on development and emergence patterns of these insects in the future.

A more extensive survey should be conducted not only to verify but to enhance the baseline data provided here inasmuch as altering patterns of Neuroptera emergence and population densities seem to be closely tied to pertubations in local climates, especially in densely populated metropolitan areas such as Washington, D.C. and adjacent communities.

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