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THE ODONATA OF PATUXENT WILDLIFE RESEARCH CENTER AND VICINITY

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THE ODONATA OF PATUXENT WILDLIFE RESEARCH CENTER AND VICINITY

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ABSTRACT

A study was conducted between 1990 and 1995 on the dragonflies and damselflies of Patuxent Wildlife Research Center along with few adjacent wetlands of biological interest. One-hundred and five species were cataloged by date, number, and location. Specific observations on migratory dragonflies are provided. In addition, phenograms are provided for all 105 species.

INTRODUCTION

This paper presents the results of a six year study (1990-1995) on the dragonflies and damselflies (Odonata) of Patuxent Wildlife Research Center (PWRC). The purpose of this study was to establish baseline survey data and to provide general information on the Odonata of PWRC.

Patuxent Wildlife Research Center is located in central Maryland in Prince Georges and Anne Arundel Counties approximately half way between Washington D.C. and Baltimore, Maryland (see figure 1). The Research Center is located between the communities of Bowie to the east, and Laurel to the west, and is contiguous with Fort Meade to the north and Beltsville Agricultural Research Center (BARC) to the south. Previous names for PWRC include Patuxent Environmental Science Center and Patuxent Research Refuge.

The 5,160 hectares (12,750 acres) of PWRC is owned by the U.S. Fish and Wildlife Service. The major focus of the Research Center is environmental and wildlife research. Limited hunting, fishing, and other recreational activities are open to the general public under controlled conditions. PWRC also maintains the National Wildlife Visitor Center.

The Research Center is divided into the north, central, and south tracts. The north tract is the largest at 3,430 hectares. The north tract was transferred to PWRC on October 16, 1991, from the U.S. Army where it was used primarily as a

military training location. Prior to 1918 it was largely rural farmland. The central tract at 850 hectares and the south tract at 880 hectares have been managed for wildlife since 1936. When acquired, the central and south tracts were mostly abandon farmland but did contain 2.4 hectares of virgin beech forest along the Patuxent River. At present, PWRC has reclaimed the farmland into a variety of natural and managed wildlife habitats.

The Patuxent Wildlife Research Center and the adjacent Beltsville Agricultural Research Center (BARC) contain the largest contiguous forest in the Piedmont/Coastal Plain of Maryland. This includes what many scientists believe is the finest example of a pristine bottomland beech forest in the eastern United States (FWS, 1988). In addition, the area maintains a diverse and extensive system of pristine and managed wetlands including the Patuxent River, Little Patuxent River, streams, lakes, ponds, marshes, swamps, and bogs. The nearly unbroken natural areas that are contained within PWRC, BARC, and a small number of other government agencies is known collectively as the Green Wedge.

The Green Wedge has been sheltered from urban development by government ownership for over 70 years. It has become an island of native habitat within the Washington D.C./Baltimore metropolitan corridor. The Green Wedge contains geological and biological elements of both the Piedmont and Coastal Plain and is situated at the biological interface (ecotone) of the Upper Austral Zone and Lower Austral Zone. These attributes makes the Green Wedge of national importance because of its wealth in biodiversity (CBPNA, 1976; Hotchkiss & Stewart, 1979). The Green Wedge has not only been recognized as necessary for maintaining native vertebrate populations, but has also been identified as "... the finest preserve for invertebrate fauna still extant in the Washington, D.C. metropolitan area" (CBPNA, 1976).

In addition to PWRC, five smaller locations were

surveyed to provide comprehensive coverage of the Green Wedge. The 120 hectare Bottomland Research Forest, the 70 hectare Wetland Research Forest and the 130 hectare

METHODS

Field excursions were organized to provide maximum coverage of diverse aquatic habitats at different times of the year and under various weather conditions. Field data focused on imagoes and exuviae. Limited larval samples were taken at a number of locations.

Total numbers of exuviae and imagoes of each species identified during a field excursion were recorded along with the date, time, weather conditions, and location. Only those individuals actually seen and identified were counted. There was no attempt to approximate the actual numbers of individuals at a specific site. Each positive identification of an individual odonate was recorded as a data point.

Phenograms were developed by matching maximum numbers of individuals (imagoes and exuviae) observed per day of each species over the 6 year period. Maximum numbers were used because this likely indicated optimal habitat, time, and weather conditions. For species in which the population fluctuated greatly from year to year, data from optimal years were used in making the phenograms.

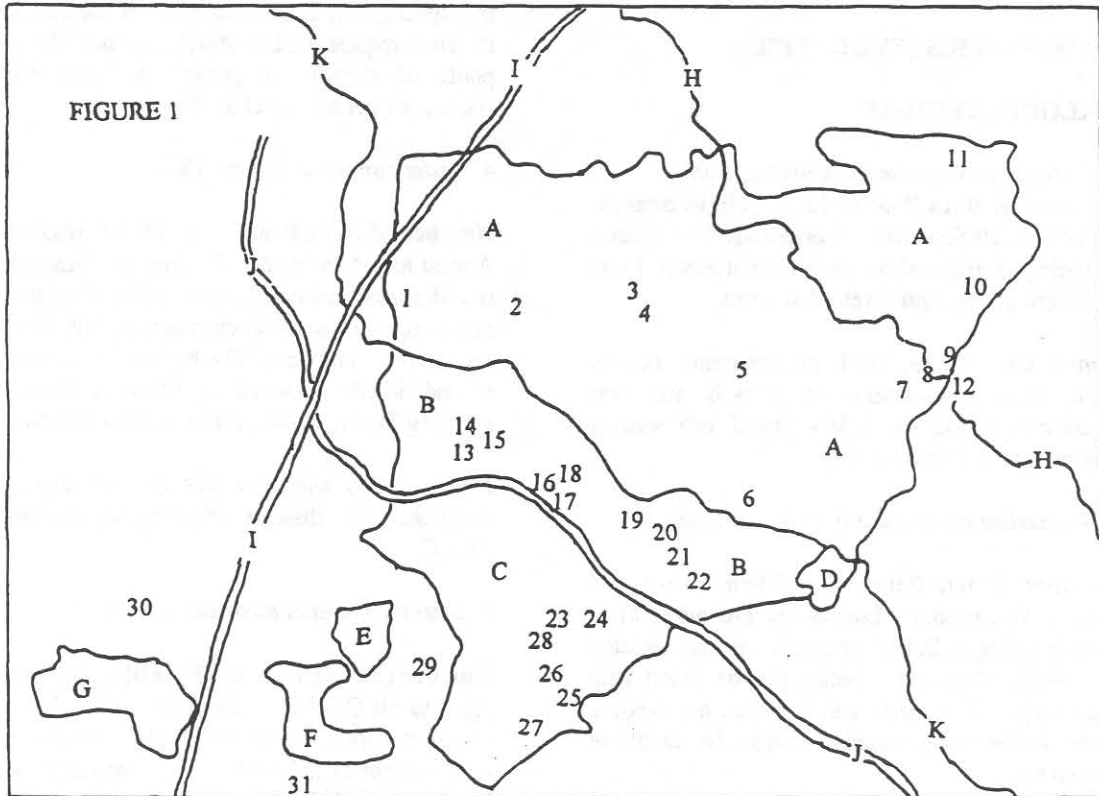
The number of data points recorded for each species is not intended to represent an absolute (statistically valid) measurement of the abundance of that species. However, it does provide a reasonable approximation if the limitations of the data gathering method are taken into consideration. These limitations are:

1) Some species were so abundant that actual numbers seen could not be reasonably counted. In these cases the minimum number that was estimated to be seen was used as the

number of data points entered. Therefore for very abundant species the data points greatly underestimate the number of individuals present (e.g. *Libellula deplanata*, *Pachydiplax longipennis*, *Sympetrum vicinum*).

- 2) For species that were carefully monitored and had small adult populations the data points overestimated the number of individuals in the population. This occurred because the same individual could be counted as a new data point on sequential field days (e.g. *Tachopteryx thoreyi*, *Gomphus rogersi*, *Aeshna mutata*).
- 3) Chance findings of synchronous emergence of some species increased the number of data points compared to similar species in which emergence was missed (e.g. *Progomphus obscurus*).
- 4) Those species which are inconspicuous or small (e.g. *Ischnura posita*) or species which are difficult to separate from other similar species on the wing (e.g. *Aeshna verticalis*, *Epitheca costalis*) are underestimated by the number of data points.
- 5) The preference to examine specific interesting habitats over other, not as interesting, aquatic habitats biased the data points to favor those species which occurred in the most visited habitats (e.g. *Nannothemis bella*, *Somatochlora provocans*).

Because of these limitations the phenograms are a compromise of quantitative and subjective measurements and should be interpreted as general information. The phenograms are not expected to capture minor fluctuations in the adult population but provide enough rigor to provide insight in the general abundance of a species during the course of a year.



Major land divisions, roads, and rivers:

- | | |
|--|--|
| (A) Patuxent Wildlife Research Center -- north tract | (B) Patuxent Wildlife Research Center -- central tract |
| (C) Patuxent Wildlife Research Center -- south tract | (D) Fran Uhler Natural Area |
| (E) BARC-- Wetland Research Forest | (F) BARC -- Upland Deciduous Research Forest |
| (G) BARC -- Bottomland Research Forest | (H) Little Patuxent River |
| (I) Baltimore Washington Parkway -- 295 | (J) Laural Bowie Road -- 197 |
| (K) Patuxent River | |

Locations:

- | | | |
|---------------------------------------|--------------------------------|----------------------------|
| (1) Mitigation Pond (R1) | (2) Elfin Bog | (3) Rieve's Pond |
| (4) Somatochlora Alley | (5) Duck Ponds | (6) Sundew Bog |
| (7) New Marsh Ponds | (8) Bailey Bridge | (9) Bailey Bridge Pond |
| (10) Midway Branch Marsh | (11) Lake Allen | (12) Railroad Bridge |
| (13) Snowden Pond | (14) Uhler Marshes | (15) Hance Ponds |
| (16) Bluegill Pond | (17) Clay Pit Pool | (18) Knowles Marshes |
| (19) Duvall Ponds | (20) Hobbs Ponds | (21) Patuxent Marsh |
| (22) Cash Branch Creek | (23) Goose Pond | (24) Cash Lake |
| (25) Harding Spring Pond | (26) Redington Lake | (27) Mabbott Pond |
| (28) National Wildlife Visitor Center | (29) Mitigation Pond (Airport) | (30) Entomology Road Ponds |
| (31) Alter Pond | | |

SPECIES DISCUSSION

DAMSELFLIES (ZYGOPTERA)

CALOPTERYGIDAE

1. *Calopteryx maculata* (Beauvois, 1805)

Number of Data Points: 1269 **Flight Season:** 14 May to 29 September **Locations:** This species is widely distributed on the Patuxent River, Little Patuxent River, and forested streams.

Notes: On July 13, 1991, an apparently healthy male became entangled in a web and was eventually killed by a long-jawed orb weaver spider (genus *Tetragnatha*).

2. *Hetaerina americana* (Fabricius, 1798)

Number of Data Points: 286 **Flight Season:** 18 June to 19 October **Locations:** The old military tank crossing at Bailey Bridge is the only location at PWRC where this species can be found with regularity. The males can be seen on exposed rocks in the riffles usually towards the middle of the river.

Notes: Since the military tank crossing is no longer used the area will slowly become shaded by the encroaching riparian vegetation and *H. americana* may eventually disappear from PWRC.

Down stream on the Little Patuxent River just outside of PWRC at the railroad bridge another small population exists. This species is very abundant along the fall line of the Potomac River (Donnelly, 1961; Orr, 1995b).

LESTIDAE

3. *Archilestes grandis* (Rambur, 1842)

Number of Data Points: 20 **Flight Season:** 11 September to 16 November **Locations:** *Archilestes grandis* is widespread throughout the area but sporadic and never found in large numbers. The highest number of data points recorded were on sunny days in October along Cash Branch Creek and the small stream entering the east end of Alter Pond.

Notes: The adults are usually found perched on overhanging tree branches along slow moving

forested streams with silt substrate. It appears that this species can utilize a number of habitats since its larval requirements at PWRC are not "the rocky pools of streams or ponds" as reported for Alabama (Tennessee et al, 1995).

4. *Lestes congener* Hagen, 1861

Number of Data Points: 41 **Flight Season:** 20 August to 4 November **Locations:** This species is widespread and occurs in a variety of permanent and temporary pond environments, but is rarely seen in large numbers. The highest concentrations of individuals occurred at Mabbott Pond and Harding Spring Pond during the fall months.

Notes: *Lestes congener* has an emergence and flying time later than any other species of *Lestes* at PWRC.

5. *Lestes disjunctus australis* Walker, 1952

Number of Data Points: 830 **Flight Season:** 25 April to 30 October **Locations:** This damselfly occurs at ponds throughout PWRC. An unusually high number of individuals were seen at Mabbott Pond on July 5, 1992.

Notes: This species is unusual in that the first and last records for the flight season were of ovipositing pairs. The earliest oviposition activity observed occurred on April 25, 1993, near Redington Lake and the latest on October 30, 1994, at Rieve's Pond. At least some mature individuals could be found throughout the known flight period at PWRC.

The major emergence at PWRC occurs around the end of May (e.g. mass emergence at Harding Spring Pond on May 26, 1991, and at New Marsh Ponds on May 30, 1994). No adult emergence before mid-May has been observed at PWRC.

Since maturation in *Lestes disjunctus australis* is 10 to 18 days (Dunkle, 1990) it is likely that the mature adults found in early spring emerged unnoticed in mid-April or earlier. Less likely is the possibility that last fall's adults overwintered or that these are spring immigrants from the south.

All oviposition was in tandem on emergent vertical green stems above the waterline. This species has the longest flight period of any Lestidae at PWRC.

6. *Lestes eurinus* Say, 1839

Number of Data Points: 31 **Flight Season:** 23
May to 5 August **Locations:** This species is widely distributed throughout PWRC on ponds and lakes but is never encountered in large numbers.

Notes: An emergence of *L. eurinus* was recorded at Mabbott pond on May 23, 1992. This is a northern species which is nearly at its southern limit for the eastern coastal plain at PWRC.

7. *Lestes forcipatus* Rambur, 1842

Number of Data Points: 644 **Flight Season:** 22
May to 3 September **Locations:** This damselfly is widely distributed throughout PWRC on permanent ponds and temporary pools. At PWRC, habitat differences between *Lestes forcipatus* and *L. disjunctus australis* are subtle since both emerge from the same locations although *L. disjunctus australis* does appear to have a longer flight season. The record highs for numbers of individuals were Clay Pit Pool July 26, 1990, Mabbott Pond June 29, 1991, and the small ponds near Entomology road (BARC) on July 13, 1991. At the later location, newly emerging adults and mature ovipositing adults were both present.

Notes: Tandem pairs were observed ovipositing about midway up the stem of *Sparganium* a few feet landward of shore and on emergent vegetation at Mabbott pond on June 29, 1991. Mass emergences were recorded at the Duck Ponds (temporary ponds) on May 22, 1993, Mabbott Pond (permanent pond) on June 4, 1994, and from small pools located at the power line right-of-way at Wetland Research Forest (BARC) on June 7, 1992.

The discrimination of the male *L. forcipatus* from *Lestes disjunctus australis* can usually be accomplished using the key provided in Walker (1952). However, on occasion, individuals fell in between the measurements provided by Walker and could not be reliably separated into one or the other species. These individuals may represent normal variation within one or the other species, or possibly hybrids.

8. *Lestes inaequalis* Walsh, 1862

Number of Data Points: 177 **Flight Season:** 11

May to 7 August **Locations:** This species is widely distributed at PWRC at permanent ponds and lakes. The highest number of individuals recorded was at Cash Lake on July 6, 1991.

Notes: Mass emergences occurred at Harding Spring Pond and Mabbott Pond on May 26, 1991, and again at Harding Spring Pond on May 23, 1992.

9. *Lestes rectangularis* Say, 1839

Number of Data Points: 284 **Flight Season:** 19
May to 8 October **Locations:** *Lestes rectangularis* is a widespread species found throughout PWRC. The highest concentrations of individuals were recorded at Mabbott Pond, Harding Spring Pond, and Alter Pond.

Notes: A mass emergence occurred at Mabbott Pond on May 30, 1991.

10. *Lestes vigilax* Hagen in Selys, 1862

Number of Data Points: 39 **Flight Season:** 16
July to 29 September **Locations:** This species is widely distributed at PWRC in forested aquatic habitats but is never found in large numbers. One can usually find this species in mid-August through early September at Patuxent Marsh, New Marsh Ponds, Sundew Bog (borrow pits) or along the Patuxent River.

Notes: At PWRC when not ovipositing the adults are usually found in forested areas away from direct sunlight.

COENAGRIONIDAE

11. *Amphiagrion saucium* (Burmeister, 1839)

Number of Data Points: 4 **Flight Season:** 2
June to 30 July **Locations:** Isolated individuals were collected at seepage areas along the edge of Harding Spring Pond, Lake Redington, and Beaverdam Creek at the Bottomland Research Forest. No sustainable population has been found at PWRC but populations of this species are very local in nature and probably exist. **Notes:** Soldier's Delight in Baltimore County, Maryland has high concentrations of *A. saucium*. This serpentine barren has extensive sunlit grassy seeps, which this damselfly prefers.

12. *Argia apicalis* (Say, 1839)

Number of Data Points: 352 **Flight Season:** 13 June to 12 September **Locations:** This damselfly is abundant along sunny sections of the Patuxent River and Little Patuxent River, and less common along sunlit streams. The highest number of individuals recorded was along the Little Patuxent River on July 16, 1993. **Notes:** Males often perch on exposed sunlit logs or branches protruding from the river. Two female color forms exist at PWRC, a brown thorax form and a blue thorax form (male like colors). Stray individuals can be found throughout PWRC including the edge of ponds but adult emergence from ponds at PWRC was not observed.

13. *Argia bipunctulata* (Hagen, 1861)

Number of Data Points: 313 **Flight Season:** 11 June to 20 August **Locations:** This species is locally common at Sundew Bog and Elfin Bog.

Notes: On rare occasions small populations were found at small sunlit grassy seepages at PWRC but these populations generally do not survive from year to year.

14. *Argia fumipennis violacea* (Hagen, 1861)

Number of Data Points: 753 **Flight Season:** 16 May to 19 September **Locations:** The most widespread species of *Argia* at PWRC. This species is often abundant along streams. It is less common along the Patuxent River and Little Patuxent River and at the edges of lakes, ponds, and bogs.

Notes: The females oviposit in horizontal aquatic vegetation (observed at PWRC) and in wet wood (Carpenter, 1991). Large numbers were seen emerging from the outlet stream of Lake Allen on May 16, 1993. Adults prefer sunny spots in which to rest.

15. *Argia moesta* (Hagen, 1861)

Number of Data Points: 1 **Flight Season:** 28 August 93 **Locations:** A single specimen was taken on the Little Patuxent River near the tank crossing at Bailey Bridge on an exposed gravel bar in full sun.

Notes: This species is common along the Potomac

River (Montgomery County) to the southwest and Chimney Branch Creek at Soldiers Delight (Baltimore County) to the northwest. The rarity of this species at PWRC is probably due to the lack of the preferred habitat of extensive sunlit sections of rivers and streams.

16. *Argia sedula* (Hagen, 1861)

Number of Data Points: 1 **Flight Season:** 25 June 94 **Locations:** The only specimen found was at the Little Patuxent River up stream from Bailey Bridge.

Notes: This species is common along the Potomac River corridor in slow moving streams with emergent vegetation (Donnelly, 1961). A possible reason for the rarity of this species along the Little Patuxent River and Patuxent River at PWRC may be due to the lack of exposed river rocks. In the eastern United States this species is normally associated with rivers and streams with extensive rock or boulder environments (May, 1996).

17. *Argia tibialis* (Rambur, 1842)

Number of Data Points: 1730 **Flight Season:** 24 May to 12 September **Locations:** This species occurs along the Patuxent River and Little Patuxent River in large numbers, and to a lesser extent along streams. Lone individuals are often found away from the water or in other aquatic habitats.

Notes: At PWRC, the brown female form is more common than the blue female form. This species and *Enallagma exsulans* are the two dominant river damselflies at PWRC. This species was seen ovipositing in floating vegetation on a number of occasions.

18. *Chromagrion conditum* (Selys, 1876)

Number of Data Points: 83 **Flight Season:** 2 May to 7 June **Locations:** A widespread but local species found in swamps and small ponds. The record high for individuals was recorded at the side ponds across Telephone Road next to Lake Redington.

Notes: The number of individuals fluctuates greatly from year to year.

19. *Enallagma aspersum* (Hagen, 1861)

Number of Data Points: 183 **Flight Season:** 11 May to 7 October **Locations:** This species is widely distributed at ponds throughout PWRC. Healthy populations exist at Patuxent Marsh, Bluegill Pond, Mabbott Pond, and Harding Spring Pond. At BARC this species is common at the ponds off of Entomology Road and the small mitigation pond at the abandoned airport.

20. *Enallagma basidens* Calvert, 1902

Number of Data Points: 39 **Flight Season:** 28 June to 14 October **Locations:** *Enallagma basidens* is a widespread but intermittent species. Most consistent locations are Bluegill Pond, Mabbott Pond, and the various mitigation ponds.

21. *Enallagma civile* (Hagen, 1861)

Number of Data Points: 563 **Flight Season:** 6 May to 8 December **Locations:** This is a widely distributed species. Very common at newly formed mitigation ponds. The highest concentration of individuals was at the Mitigation Pond (R1) on September 12, 1993, where a great variation in the sizes of the adults was noticed.

Notes: This species is the latest flying damselfly at PWRC and appears to survive freezing temperatures better than other damselfly species. Under laboratory conditions adults have been known to submerge when the temperature drops (Currie, 1963). This behavior was looked for at PWRC during cold spells at locations where *E. civile* was common, but no submerged adults could be found.

As a rule *Enallagma civile* preferred open areas toward the middle of the pond over the pond shores which had higher concentrations of emergent vegetation and other damselfly species. This has also been reported by Soltesz (1991). On October 24, 1993, at the Mitigation Pond (R1) a number of males had a bluish pruinescence on the stigmas.

The presence of blue postocular spots versus a blue postocular bar has been used as a characteristic for separating *Enallagma civile* and *E. doubledayi* (Roble, 1994; Dunkle, 1990). Care should be taken in using this characteristic since both occur with regularity on *E. civile* at PWRC.

22. *Enallagma daeckii* (Calvert, 1903)

Number of Data Points: 27 **Flight Season:** 18 June to 11 July **Locations:** This species is reported from Lake Redington, Cash Lake, Mabbott Pond, Rieve's Pond and New Marsh Ponds. The highest concentration of individuals was found at the New Marsh Ponds on July 5, 1993.

Notes: At PWRC this species was nearly always found in the open, confirming observations from New Jersey (Soltesz, 1991) but differing from the shady habitat reported from Alabama (Tennessee et al, 1995) and Florida (Dunkle, 1990). An explanation might be that a different phototactic response is required in the warmer southeastern states than in the cooler locations to the north.

23. *Enallagma divagans* Selys, 1876

Number of Data Points: 198 **Flight Season:** 22 May to 13 July **Locations:** *Enallagma divagans* is a widespread species found on the Patuxent River and Little Patuxent River and the numerous streams at PWRC.

Notes: This species superficially resembles *E. traviatum* and has nearly the same short flight period at PWRC. However, *E. divagans* has a preference for running water while *E. traviatum* favors ponds or at best very slow moving streams.

24. *Enallagma exsulans* (Hagen, 1861)

Number of Data Points: 953 **Flight Season:** 2 June to 7 August **Locations:** This damselfly is very abundant on the Patuxent River and Little Patuxent River, and a little less so on sections of smaller streams which are exposed to the sun.

Notes: This is the most common *Enallagma* at PWRC. It is often observed ovipositing in tandem on floating vegetation in the middle of the river or stream.

25. *Enallagma geminatum* Kelllicott, 1895

Number of Data Points: 291 **Flight Season:** 4 May to 3 September **Locations:** This species is most abundant at ponds but can also be found in fewer numbers at various aquatic habitats throughout PWRC. The high individual counts

were recorded at Mabbott Pond, Hance Ponds, and Hobbs Pond.

Notes: *Enallagma geminatum* can often be seen resting on floating vegetation.

26. *Enallagma signatum* (Hagen, 1861)

Number of Data Points: 113 **Flight Season:** 20 May to 21 September **Locations:** *Enallagma signatum* is a widely distributed species of various still or slow-flowing aquatic habitats. It is easily found along the shaded portions of the Patuxent River, Little Patuxent River, forested ponds, and slow-moving streams.

Notes: On warm sunny days this species is semi-crepuscular in activity; however on cloudy or cool days the males may be active throughout the day. An abnormally colored mature male which was bright yellow instead of orange (except on abdominal segment 9 which retained the normal orange color) was collected from Mabbott Pond on August 5, 1995.

27. *Enallagma traviatum traviatum* Selys, 1876

Number of Data Points: 51 **Flight Season:** 20 May to 16 July **Locations:** This species is widely distributed at PWRC at lakes and ponds. Reasonably stable populations can be found at Snowden Pond, Lake Allen, Alter Pond and New Marsh Ponds. The highest concentration of individuals was recorded at New Marsh Ponds on June 27, 1993.

Notes: Tandem pairs were observed ovipositing on floating stems at New Marsh Ponds on July 11, 1993. See notes under *Enallagma divagans*.

28. *Enallagma vesperum* Calvert, 1919

Number of Data Points: 5 **Flight Season:** 19 May to 8 August **Locations:** This damselfly has been recorded from Uhler Marsh 1, Hance Ponds, New Marsh Ponds, and Duvall Ponds. All records are of mature males seen during the day.

Notes: This species is probably more common than the data points suggest because of its crepuscular habits (Dunkle, 1990). A *Pachydiplax longipennis* male was observed trying to capture a male *E. vesperum* unsuccessfully at Hance Ponds on July 14, 1991.

29. *Ischnura hastata* (Say, 1839)

Number of Data Points: 594 **Flight Season:** 25 April to 16 November **Locations:** *Ischnura hastata* is a common but somewhat local species. Resident populations occur at the edges of Clay Pit Pool, Uhler Marsh, and Sundew Bog.

Notes: This species prefers thick emergent sedge, rush, or grassy sunlit areas where the water is shallow and warm. Nearly all their activity is confined below the tops of the emergent vegetation within the dense concentration of stems.

30. *Ischnura kellicotti Williamsoni*, 1898

Number of Data Points: 274 **Flight Season:** 11 May to 19 September **Locations:** A common damselfly on Redington Lake, Cash Lake, Lake Allen, and Alter Pond. It is less common but widespread at PWRC at ponds. Adults are found resting on floating vegetation.

Notes: At PWRC, the larvae occur on the underside of the floating leaves of spatterdock (*Nymphar advena*), water lily (*Nymphaea odorata*), water-shield (*Brasenia schreberi*) floating pondweed (*Potamogeton epihydrus*) and probably others.

31. *Ischnura posita posita* (Hagen, 1861)

Number of Data Points: 3754 **Flight Season:** 6 April to 13 November **Locations:** This is the most abundant and widespread odonate at PWRC. It can be found around still or slow flowing water throughout its long flight season.

Notes: This is the earliest odonate species to emerge in the spring at PWRC. The final instar larvae probably overwinters and emerges when the weather becomes favorable. The observation at PWRC of an early emergence in greenhouses in February supports this hypothesis (Mitchell, 1994).

A female was observed feeding on *N. gracilis* on July 16, 1993, at New Marsh Ponds. A mature female was also seen feeding on a teneral *L. forcipatus* many times her size on June 29, 1990, at the pond near Entomology road (BARC). This is without a doubt the largest prey / predator disparity that I have ever observed between

odonate species. Exuviae were collected at Hobbs Pond on April 9, 1994.

32. *Ischnura ramburii* (Selys, 1850)

Number of Data Points: 3 **Flight Season:** 6 July to 18 August **Locations:** Two individuals were collected from Cash Lake and one from Mabbott Pond.

Notes: This damselfly becomes common further out on the Maryland coastal plain where it appears to replace *I. verticalis* when fresh water mixes with slightly brackish water from the tidal flux. Conversely, *I. verticalis* appears to replace *I. ramburii* in the fresh water at PWRC. Along the Gulf Coast where *I. verticalis* does not occur, *I. ramburii* maintains high densities in fresh water. In New England, *I. verticalis* replaces *I. ramburii* on the coastal plain. In Maryland the separation of habitat between the two species is striking.

33. *Ischnura verticalis* (Say, 1839)

Number of Data Points: 194 **Flight Season:** 21 April to 19 September **Locations:** This damselfly is widely distributed at PWRC on ponds and slow moving streams with abundant emergent vegetation.

Notes: See notes under *I. ramburii*.

34. *Nehalennia gracilis* Morse, 1895

Number of Data Points: 174 **Flight Season:** 11 June to 23 July **Locations:** This species is restricted to sphagnum bogs at PWRC. The best locations are the sphagnum-cranberry bog west of New Marsh Ponds, Sundew Bog, and Elfin Bog.

35. *Nehalennia integricollis* Calvert, 1913

Number of Data Points: 82 **Flight Season:** 30 May to 20 August **Locations:** Isolated individuals were found throughout PWRC at the edges of ponds and bogs with emergent vegetation. The majority of the data points (72 out of the 82) were recorded at New Marsh Ponds on July 5, 1993.

DRAGONFLIES (ANISOPTERA)

PETALURIDAE

36. *Tachopteryx thoreyi* (Hagen in Selys, 1858)

Number of Data Points: 10 **Flight Season:** 26 May to 13 July **Locations:** The small seeps along the forested stream just south of Harding Spring Pond is the only known location at PWRC where *T. thoreyi* can be found with regularity. This population is small with no more than a half dozen adults seen per season. Isolated individuals were reported near New Marsh Ponds on May 30 and again on June 2, 1993 (probably the same individual) and a worn male at Wetlands Research Forest on BARC on July 13, 1991. This last sighting was nearly a month later than any of the other records (next to the last record was June 18th).

GOMPHIDAE

37. *Arigomphus villosipes* (Selys, 1854)

Number of Data Points: 3 **Flight Season:** 16 May to 2 June **Locations:** Two individuals were recorded at the Duck Ponds on June 2, 1993, and a teneral male was netted at Snowden Pond on May 16, 1990.

Notes: In Maryland, the habitat of *Arigomphus villosipes* is ponds and the edges of slow moving coastal plain rivers. This species is widely distributed and not uncommon in Maryland. The reason for its apparent rarity at PWRC is unknown.

38. *Dromogomphus spinosus* Selys, 1854

Number of Data Points: 1 **Flight Season:** 13 June 93 **Locations:** The only confirmed record at PWRC was of a netted mature male at Midway Branch Marsh.

Notes: In Maryland, *D. spinosus* is common on open rivers with mud substrates. This is the most abundant clubtail on the Potomac River at the fall line (Orr, 1995b). It is also common along the Patuxent River once it widens out on the coastal plain a few kilometers downstream from PWRC.

39. *Gomphus exilis* Selys, 1854

Number of Data Points: 123 **Flight Season:** 6 May to 4 July **Locations:** *Gomphus exilis* is a widespread species that is common at ponds, streams, and open areas in the spring.

Notes: Exuviae were collected at Midway Branch Marsh on June 2, 1993, May 30, 1994, and May 14, 1995. Larvae can be vigorous climbers (for a gomphid) with one cast skin found approximately 1 meter up on a cement bridge at Midway Branch Marsh on May 30, 1994. As a rule *G. exilis* larvae prefer quieter waters than the larvae of the similar *G. lividus*.

40. *Gomphus lividus* Selys, 1854

Number of Data Points: 274 **Flight Season:** 25 April to 18 June **Locations:** This species is widely distributed. The highest concentration of individuals was recorded on May 4, 1991, along the Patuxent River.

Notes: This is the most abundant clubtail at PWRC with a flight period earlier than but overlapping that of the less robust *G. exilis*. Mass emergences occurred on the Patuxent River on May 4, 1991, and on the Little Patuxent River on May 24, 1995.

41. *Gomphus rogersi* (Gloyd, 1936)

Number of Data Points: 17 **Flight Season:** 2 June to 15 June, 1991 **Locations:** This species was recorded on June 2, and June 15, 1991, from a section of Beaverdam Creek on the north edge of BARC's Upland Deciduous Research Forest. The failure to find this dragonfly from 1992 through 1995 probably indicates that it has extirpated from this site.

Notes: Sixteen of the 17 data points were recorded between 2:00 and 2:30 PM on June 2, 1991. The stream section where *G. rogersi* occurred was exposed to the sun with the males often landing on the floating leaves of *Sparganium* (asexual form). The substrate was sand with some gravel and silt. The stream was clear and free flowing. A pair in copulation (the only female seen) was collected in tall grass about 2 meters from shore in full sun.

This and one other location in Garrett County are the only known sites of *G. rogersi* in Maryland. At both locations the floating *Sparganium* leaves are the dominant mid-stream vegetation.

42. *Hagenius brevistylus* Selys, 1854

Number of Data Points: 101 **Flight Season:** 15

June to 12 September **Locations:** This is a widely distributed dragonfly found on rivers and streams and to a lesser extent open areas where the adults hunt for food.

Notes: This slow flying giant often feeds on dragonflies including *Libellula vibrans*. At Midway Branch Marsh on May 24, 1995, mid-instar larvae were observed positioning themselves perpendicular to the sun, probably for thermoregulation (Orr, 1995a).

43. *Ophiogomphus incurvatus incurvatus* Carle, 1982

Number of Data Points: 6 **Flight Season:** 24 May to 2 June **Locations:** The larvae appear to be restricted to the little Patuxent River from the Bailey Bridge tank crossing downstream to the railroad bridge just outside the PWRC boundary. The only record of emergence from PWRC was a female taken from the tank crossing on June 2, 1993, in full sun at 2:35 PM. Three out of the six data points were recorded from Midway Branch Marsh on May 30, 1993, and June 2, 1993. These young individuals were sunning on dead branches in a marsh about 100 meters from the river.

Notes: This species emerges in healthy numbers each spring along the fall line of the Little Patuxent River near Savage, Maryland (Howard County). Further downstream at PWRC the required habitat of sunlit rapids occurs only at the tank crossing where the population is small.

44. *Progomphus obscurus* (Rambur, 1842)

Number of Data Points: 401 **Flight Season:** 19 May to 5 July **Locations:** The adults of this species are found predominately on sandy sections of the Patuxent River and Little Patuxent River, but the adults do wander and on occasion are found far from their larval habitat.

Notes: A mass emergence of this species (300 of the 401 data points) occurred on the Little Patuxent River on May 30, 1993, in full sun on mud and sand bars. At 1:05 PM, 1/5 of the adults were still present on or near their cast skins. Although the mass emergence was short lived, a few individuals continued to emerge into late May with the last exuviae collected on June 13. Exuviae were frequently collected from the

Patuxent River and once from a small stream at Midway Branch Marsh. Although common at PWRC this species is relatively rare elsewhere in the Washington D.C. area (Donnelly, 1961).

45. *Stylurus laurae* (Williamson, 1932)

Number of Data Points: 23 **Flight Season:** 15 June to 1 September **Locations:** This species is found with confidence on the Patuxent River and Little Patuxent River only during emergence.

Notes: This mysterious dragonfly seems to disappear after emergence at PWRC. Emergences occurred on the Patuxent River on June 24, 1990, and June 16, 1991, and on the Little Patuxent River on June 26, 1994. These emergences took place in full sun between 11:00 to 4:00 PM. A single late season exuviae was found on July 4, 1995, on the Patuxent River. The only mature adult recorded was a female collected on September 1, 1991, flying just above the surface of a small sandy forested tributary of Beaverdam Creek at the Bottomland Research Forest at 3:15 PM.

One possible explanation for the apparent disappearance of this species after emergence is that the adults leave the river to feed, mature, and mate in the forest canopy. The females after reaching sexual maturity in the fall, oviposit in small forest streams. The developing larvae then move downstream into the rivers to emerge. See notes under *S. plagiatus*.

46. *Stylurus plagiatus* (Selys, 1854)

Number of Data Points: 1 **Flight Season:** 30 June 93 **Locations:** The single sighting was of a mature male flying over the Patuxent River between PWRC and the Fran Uhler Natural Area.

Notes: Along the Patuxent River system, *Stylurus spiniceps* is the predominant species on the Piedmont, *S. laurae* around the fall line, and *S. plagiatus* on the coastal plain.

Stylurus plagiatus is common on the coastal plain rivers. When the Patuxent River widens a few kilometers down stream (e.g. Jug Bay Wetlands Sanctuary and Merkle Wildlife Sanctuary) this species is regularly seen flying low over the surface of the water. The one observation at PWRC was probably of a stray.

47. *Stylurus spiniceps* ((Walsh, 1862)

Number of Data Points: 1 **Flight Season:** 7 September 95 **Locations:** The only record was of a netted mature male taken from the Patuxent River where it first enters PWRC.

Notes: This is a common species, based on exuviae, on the Piedmont side of the Patuxent River. This species is like *S. laurae* in that the exuviae are easier to find than the adults. Since no exuviae were found at PWRC it is assumed that the one record was of a stray. See notes under *S. plagiatus*.

AESHNIDAE

48. *Aeshna mutata* Hagen, 1861

Number of Data Points: 20 **Flight Season:** 2 June to 29 June **Locations:** In Maryland this species is known only from Mabbott Pond at PWRC and one other site in Garrett County. The Mabbott Pond population was first discovered by Mark Scoville (personal communication) on June 16, 1991, when he observed 3 adults flying low over the surface of the pond. Three adults were again seen on June 26, and five on June 29, of the same year. Five adults were observed on June 19, 1992, and four adults on June 3, 1993.

Notes: At times males appear to actively search out the yellow flowers of *Nuphar advena*. They probably were looking for females which oviposit in the stems.

49. *Aeshna umbrosa umbrosa* Walker, 1908

Number of Data Points: 43 **Flight Season:** 23 September to 16 November **Locations:** This species is widely distributed. The adults can be seen flying low along the shaded portions of the forest edge in the afternoon. The highest number of individuals occurred at the forest edges near Uhler marsh and BARC's Bottomland Research Forest between 2:00 and 4:00 PM during the first half of October.

Notes: At PWRC this species is associated with a variety of pond and stream habitats. In Garrett County, Maryland, where *Aeshna umbrosa* occurs with *Aeshna canadensis*, it becomes restricted to small wooded streams.

Because of its dark coloration and lack of good field marks *Aeshna umbrosa* is difficult to identify on the wing and therefore is more common than the number of data points suggests.

50. *Aeshna verticalis* Hagen, 1861

Number of Data Points: 1 **Flight Season:** 9 October 95 **Locations:** The only positive identification was of a mature male in good condition collected at Bailey Bridge Pond.

Notes: The male was flying between 2:00 to 3:30 (when netted) in full sun over a marshy section of the pond. Although rare, this species is probably more common than the single data point suggests. On a number of occasions isolated individuals of *Aeshna* could be found patrolling sunlit marshes in October at various locations at PWRC. It is difficult to separate this species from other species of *Aeshna* without capture. The possibility of *Aeshna canadensis* and/or *A. tuberculifera* occurring at PWRC precludes recording these other sightings as data points for *A. verticalis*.

51. *Anax junius* (Drury, 1770)

Number of Data Points: 1308 **Flight Season:** 24 March to 4 November **Locations:** This conspicuous species is widespread. The record highs for individuals were mature adults at ponds during early spring and juveniles hawking over open areas during the last weeks in September.

Notes: On May 7, 1991, a female in flight was netted carrying a 1 cm long unharmed Ichneumonid wasp in her legs.

On March 24, 1994, newly arrived migratory males were observed at the edge of ponds at PWRC. They flew short (approximately 1 meter) to moderate distance (variable) then stopped and hovered then quickly moved in and out of the shoreline emergent vegetation in quick jerky movements, after which they again flew directly for a short to moderate distance and repeated the searching pattern. This searching pattern appeared to be more for finding females than food, although one male was seen interrupting his routine to capture a flying insect, which he ate on the wing. These males were not fooled into chasing milkweed seeds blowing over a pond mistaking the seeds for potential prey.

Anax junius exuviae were collected from a newly formed sewage pond near the National Wildlife Visitor Center in 1994. This pond had been created earlier in the year which indicates that larval development was completed during a single season. At Patuxent Wildlife Research Center there are two distinct populations of *Anax junius*, a resident population in which the larvae overwinter and a migratory population in which the larvae complete development during the warmer months. See the section on migration.

52. *Anax longipes* Hagen, 1861

Number of Data Points: 70 **Flight Season:** 7 May to 18 August **Locations:** *Anax longipes* is a widely distributed species often seen over ponds. The highest concentrations of individuals were recorded at Mabbott Pond.

Notes: Exuviae of *Anax longipes* were collected at Mabbott Pond on June 18, 1994, and again on May 23, 1995. Ovipositing females were never observed in tandem or being guarded by males. This species was never abundant at any one location. Preliminary observations at PWRC indicates that this species survives by utilizing numerous ephemeral small larval populations throughout the area.

53. *Basiaeschna janata* (Say, 1839)

Number of Data Points: 6 **Flight Season:** 24 April to 22 May **Locations:** Five out of the six data points for this species were from Midway Branch Creek from the outlet at Lake Allen to Midway Branch Marsh. There is a single record from the Patuxent River on May 4, 1991.

Notes: This is the only Aeshnidae with a restricted early spring flight period at PWRC. This species is common along the Potomac River and the associated C&O canal. *Basiaeschna janata* larvae require well aerated water (Walker, 1958) which limits its numbers at PWRC.

54. *Boyeria vinosa* (Say, 1839)

Number of Data Points: 88 **Flight Season:** 23 June to 3 November **Locations:** This is a widespread species found on rivers and streams. The highest concentrations of individuals were recorded along the Patuxent River during the fall.

Notes: Males are usually seen exploring the edge of the river or stream flying very close to the surface of the water investigating every nook and cranny without ever hovering.

Cast skins of *Boyeria vinosa* were collected about 15 cm above the water surface at the Little Patuxent River on June 30, 1993. A lone female was observed ovipositing in wood approximately 10 cm above the waterline at Cash Branch Creek on August 25, 1991.

55. *Epiaeschna heros* (Fabricius, 1798)

Number of Data Points: 467 **Flight Season:** 27 April to 28 August **Locations:** This large species can be found throughout PWRC. The record high for individuals was May 30, 1993, where swarms had formed over the Little Patuxent River near Bailey Bridge. High numbers of individuals were also observed hawking the open areas of the Fran Uhler Natural Area on June 6, 1993.

Notes: A lone female was observed ovipositing in wet wood at a swamp near the Patuxent River on May 4, 1991. Ovipositing was also observed on June 29, 1990, on top of a half submerged log at a small pond near Entomology Road (BARC). The female's posterior abdominal appendages stick up at a 90 degree angle from the body while ovipositing.

On May 11, 1991, individuals from a feeding swarm were observed diving quickly to the surface of the Patuxent River, dipping their legs briefly into the water before rejoining the swarm. It was done repeatedly, seemingly too often to be drinking. More likely they were washing bits of prey from the legs, cooling off, or picking up dying insects off the surface of the water.

Exuviae were collected on July 18, 1993, from the dried swamp across the road from Rieve's Pond approximately 15 cm up on Bur-Reed stems. Exuviae were also collected from swamps at BARC on August 8, 1990. Although the exuviae were normally seen in swampy environments, a single cast skin was picked up on a log about 12 inches above the waterline on a slow moving section of the Patuxent River on July 14, 1991.

56. *Gomphaeschna antilope* (Hagen, 1874)

Number of Data Points: 1 **Flight Season:** 22 June 95 **Locations:** The only specimen taken at PWRC was a worn male flying slowly over South Road at a steady level approximately 1 to 3 meters above the road, in direct sun, at 12:45 PM, approximately 50 meters from Elfin Bog. **Notes:** Carle (1982) states that the larvae occur in sphagnum borders of bog ponds. If so, Elfin Bog may be the larval habitat for this species.

57. *Gomphaeschna furcillata* (Say, 1839)

Number of Data Points: 49 **Flight Season:** 21 April to 24 May **Locations:** In some years adults can be found throughout PWRC in forest clearings during early May. The high counts of individuals include Elfin Bog, the power line clearing near Clay Pit Pool (look for adults on the power poles) and hawking individuals over Somatochlora Alley.

Notes: The number of individual adults fluctuates greatly from year to year. The females oviposit in wet wood (Dunkle, 1989) probably in swamps at PWRC.

58. *Nasiaeschna pentacantha* (Rambur, 1842)

Number of Data Points: 23 **Flight Season:** 4 May to 22 July **Locations:** *Nasiaeschna pentacantha* is a widely distributed species. The high counts of individuals were on the Patuxent River but isolated individuals were encountered throughout the area.

Notes: In flight this species often bends the tip of the abdomen down. An adult was feeding on winged termites at the Wetland Research Forest (BARC) on June 7, 1992. *Nasiaeschna pentacantha* was not reported until 1957 in the Washington D.C. area (Donnelly, 1961). This species can now be seen with regularity throughout the Washington D.C. area and has become common along the Potomac River corridor.

CORDULEGASTRIDAE

59. *Cordulegaster bilineata* (Carle, 1983)

Number of Data Points: 17 **Flight Season:** 14 May to 7 June **Locations:** The high records for data points include the seepage stream entering Harding Spring Pond on May 23, 1992, the

Bottomland and Wetland Research Forests (BARC), and adults hunting along sunlit portions of the road between Harding Spring Pond and Mabbott Pond on May 30, 1993, and June 4, 1994.

60. *Cordulegaster erronea* Hagen in Selys, 1878

Number of Data Points: 1 **Flight Season:** 15 August 92 **Locations:** The only male recorded was netted and released at the forested edge of a field at the Bottomland Research Forest (BARC).

Notes: This species' flight period is much later than that of other *Cordulegaster* species. The larvae appear to be susceptible to siltation and require small permanent cold water springs with sand substrate with little or no organic matter (Barlow, 1995). This type of habitat is rare at PWRC and therefore the sighting on August 15, 1992, was probably of a dispersing adult.

61. *Cordulegaster maculata* Selys, 1854

Number of Data Points: 27 **Flight Season:** 25 April to 6 May **Locations:** This species is widespread at PWRC along forested streams and the edges of roads but is never found in large numbers.

Notes: On the outlet stream at Hobbs Pond on April 27, 1991, a female was ovipositing in the middle of the creek, in riffles, approximately 1 meter across and 3 cm deep. Her body was moving up and down perpendicular to the stream. Males were actively patrolling the stream.

On May 4, 1991, I captured a female in a sunlit clearing in the forest about 15 feet away from the stream across the road from Hobbs Pond. Before capture she was flying continuously in a 1 ½ meter circle approximately ½ meters off the ground. The reason for this behavior could not be determined.

62. *Cordulegaster obliqua obliqua* (Say, 1839)

Number of Data Points: 6 **Flight Season:** 30 May to 18 June **Locations:** Five of the six data points were recorded at the overflow creek of Mabbott Pond on May 30, 1991, June 15, 1991, and June 18, 1994. The other data point was recorded at Fran Uhler Natural Area on June 1, 1991.

Notes: This species is secretive and inhabits deeply shaded streams and is probably more widespread and common than the data points indicate. Ovipositing was observed in typical *Cordulegaster* fashion on June 15, 1991, at 2:30 PM at the outlet stream of Mabbott Pond where it was approximately 2 mm deep and 30 cm wide and flowing freely. The substrate was pebbles and mud.

MACROMIIDAE

63. *Didymops transversa* (Say, 1839)

Number of Data Points: 60 **Flight Season:** 24 April to 7 June **Locations:** This species is common only along the Patuxent River and Little Patuxent River. It is uncommon, but widely distributed elsewhere at PWRC often patrolling the edges of open ponds or cruising down roads.

Notes: This species usually flies along the edge of the river unlike *Macromia illinoensis* which generally flies down the middle. On May 2, 1992, a male was observed taking a flying insect over Hobbs Pond and ate it on the wing. This species was also observed chasing a male *Ischnura verticalis* without success on May 16, 1993, on Midway Branch Creek. Ovipositing was observed on a number of occasions on the Patuxent River where a lone female, in flight, would dip her abdomen into the water washing off the eggs. This species has a very limited spring flight period which peaks in May.

64. *Macromia illinoensis* (Walsh, 1862)

Number of Data Points: 86 **Flight Season:** 24 May to 2 September **Locations:** This species was most often seen cruising down the middle of the Patuxent River and Little Patuxent River at high speed just above the surface of the water. Individuals can also be found cruising the dirt roads (e.g. Somatochlora Alley) or smaller streams.

Notes: Exuviae were collected from the Patuxent River and Little Patuxent River. The earliest record was May 24, 1995, from a cast skin found 2 meters above the Little Patuxent River on the railroad bridge just outside of the PWRC property. Exuviae were also collected at Midway Branch Creek at Midway Branch Marsh on June 18, 1994,

which indicates that at least some individuals are completing their larval development in the smaller streams. Lone females in flight were observed on a number of occasions ovipositing near the banks of the Patuxent River where they would dip their abdomen into the water.

The specimens collected at PWRC are actually intergrades between the subspecies *Macromia illinoensis illinoensis* and *Macromia illinoensis georgina*. Although certain individuals have the coloration of one or the other subspecies careful morphological examination of PWRC specimens indicate that they could not be assigned to either subspecies. See Donnelly and Tennessen (1994) for details.

CORDULIIDAE

65. *Epitheca (Epicordulia) princeps* (Hagen, 1861)

Number of Data Points: 3 **Flight Season:** 4 June to 26 August **Locations:** All three sightings of *E. princeps* were in 1990. One was seen flying over Alter Pond and another hawking over a field at the north tract. Both of these sightings were in June. The third sighting, which was unusually late for Maryland, was seen over the Patuxent River on August 26.

Notes: This species is common along the C & O canal and on the larger reservoirs in Maryland. Why this species is not more abundant at PWRC is unknown.

66. *Epitheca (Tetragoneuria) costalis* (Selys, 1871)

Number of Data Points: 3 **Flight Season:** 26 June to 30 June **Locations:** One mature male was collected and another one netted and released on June 26, 1994, at Somatochlora Alley where they were hawking 2 to 3 meters above the road. Another male was netted and released on June 30, 1994, at the same location. Rieve's Pond is the only pond close to Somatochlora Alley and is probably the larval location.

Notes: The *E. costalis* that occurs at PWRC are of the *williamsoni* form.

Lake Kittamaquadi in Howard County is the only other location in Maryland where the author has

seen this species. A healthy population of *E. costalis* (males on territory and females with eggs) was observed on the north end of Lake Kittamaquadi from June 15 to June 17, 1992. Including Lake Kittamaquadi data and the PWRC data, the flight season for this species in Maryland ranges from June 15 to June 30 (with 16 data points). Based on these limited observations it appears that at PWRC *E. costalis* and *E. cynosura* flight seasons may not overlap. This is not consistent with *E. costalis* reported from other locations (Dunkle, 1989; Tennessen et al, 1995; Carle, 1982; May, 1996).

67. *Epitheca (Tetragoneuria) cynosura* (Say, 1839)

Number of Data Points: 874 **Flight Season:** 18 April to 30 May **Locations:** This species is widely distributed throughout PWRC in early spring. The record high for individuals was along the edges of dirt roads in the central tract on May 7, 1991.

Notes: Towards the end of April and the first weeks in May, *Epitheca cynosura* and *Libellula deplanata* are the dominant dragonfly species at PWRC. Adults of both species are gone by mid-June.

The larvae of *E. cynosura* were found at PWRC in ponds, swamps, and slow moving sections of streams and rivers. A large number of exuviae were seen at Duvall Ponds on emergent vegetation averaging about 20 cm above the surface of the water on April 24, 1992. Evenly spaced males defending territory can be found throughout the area on ponds (e.g. Hobbs Pond on May 2, 1992) or slow moving sections of the streams and rivers (e.g. Patuxent River on May 4, 1991). Larvae collected from Hobbs pond on April 9, 1994, were of two distinct sizes; mature larvae and mid-sized larvae. This reflects a two year larval development at PWRC. The larvae were photonegative in the laboratory.

Both normal and *simulans* (with enlarged hind wing basal spots) forms occur regular at PWRC. The normal form is more common than the *simulans* form and more females appear as *simulans* than males. Some females have nearly as much dark coloration in the hind wing as *Epitheca semiaquea* which is a bog species found further north in New Jersey. Separation between

these two species (especially the females) should not be based on the size of the hind wing basal spot.

68. *Epitheca* (*Tetragoneuria*) *spinosa* (Hagen in Selys, 1878)

Number of Data Points: 97 **Flight Season:** 8 April to 2 May **Locations:** This species is more abundant in some years than others. Even in years with few adults, the swamp at the eastern finger of Hobbs Pond regularly has territorial males. In some years adults are widespread at PWRC and the Fran Uhler Natural Area. The highest count of individuals was on April 18, 1993, where approximately 30 teneral adults were observed sunning themselves in low shrubs across the road from Patuxent Marsh.

Notes: The larval habitat is permanent swamp with very little flow. Males maintain small but variable size territories (3 - 6 meters) in which they fly slowly back and forth with intermittent hovering often chasing after intruding dragonflies or other large insects. A pair was captured in copulation on April 20, 1992. They were flying in wheel 2-4 meters above the water eventually landing in a tree. For three minutes until capture, the coupled dragonflies maintained the wheel as they flew from tree to tree, while being chased.

Mature larvae were collected at the swamp at the eastern finger of Hobbs Pond on March 2, 1992. Two were successfully reared, emerging on March 24 and 26. The adults upon emergence flew to the sunlit window (phototrophic). A mature larva was also collected on April 11, 1993. On April 17, the larva climbed out of the rearing tank and traveled a couple of meters before emerging 20 cm up the side of a wooden box. Although territorial males were normally observed in swamps, during April 27, 1991, a few male *E. spinosa* established territories on the moderately flowing creek across from Hobbs Pond.

68.5 *Epitheca spinosa* X *cynosura* (hybrid)

Number of Data Points: 3 **Flight Season:** May 2, 1993 **Locations:** The 3 males were collected at Bailey Bridge Marsh on May 2, 1993. **Notes:** These males were on territory when the flight period for *E. spinosa* was over for 1993, and before 1993 *E. cynosura* had been observed on territories (although juvenile *E. cynosura* were

common). They were observed flying back and forth over the waters edge in the sun in typical *Tetragoneuria* fashion. The males had reduced basal spots with the superior appendages and body intermediate between the two species. Two of the three males were also examined by May (1994) who agreed that the most probable explanation is hybridization.

69. *Helocordulia selysii* (Hagen in Selys, 1878)

Number of Data Points: 6 **Flight Season:** 20 April to 7 May **Locations:** All six data points were isolated territorial males in open areas above Mid Branch Creek and Beaverdam Creek.

Notes: Since all observations of this species at PWRC were of mature males, the flight season probably starts a few weeks before April 20. Males were observed patrolling back and forth in full sun in the middle of small streams (less than 1 meter wide) for a distance of approximately 5 meters, approximately 0.2 to 1 meter above the surface of the water. The absence of the more common Maryland species in this genus, *Helocordulia uhleri*, from the PWRC survey was unexpected.

70. *Somatochlora filosa* (Hagen, 1861)

Number of Data Points: 1 **Flight Season:** 11 September 92 **Locations:** The only confirmed record was of a mature male in good condition collected from Fran Uhler Natural Area in a small sunlit forest clearing at 2:48 PM on September 11, 1992.

71. *Somatochlora linearis* (Hagen, 1861)

Number of Data Points: 24 **Flight Season:** 25 June to 21 September **Locations:** This species is widespread, often found hawking in the open above roads or power line right-of-ways. It was also found along the deeply shaded streams where the adults hung vertically from tree branches. The highest record of individuals was along Beaverdam Creek at BARC's Bottomland Research Forest.

Notes: A young female with unusually bright orange-tinged wings was collected at Somatochlora Alley on June 25, 1995.

In an open field at the Bottomland Research forest,

on September 15, 1992, at 1:15 PM, two *S. linearis* were observed flying together in unison. One stayed approximately 2 meters and the other approximately 3 ½ meters off the ground. They maintained their relative position of one right above the other, while flying over the field. The higher of the two was keeping a visual connection with the lower because when I attempted to net the lower one, the dragonfly above precisely mimicked the escape movements of the intended victim. Because this species is so difficult to capture while hawking, the data points probably under represent its abundance.

72. *Somatochlora provocans* Calvert, 1903

Number of Data Points: 93 **Flight Season:** 26 June to 18 July **Locations:** Fifty-seven of the ninety-three data points were of hawking adults recorded over Somatochlora Alley on June 26, 1994 and June 30, 1994.

Notes: The size of the adult population of this species fluctuates greatly from year to year at PWRC. A few hawking adults were seen above Elfin Bog and one female was netted lifting up from a small seepage area in the bog (ovipositing?). Elfin Bog may be a possible larval site. In Alabama the larval habitat is small, spring-fed, sphagnum runs (Tennessen, et al, 1995) like Elfin Bog. However, Carle (1982) states that in Virginia, *S. provocans* probably inhabits the upper reaches of small slow-flowing streams.

Because this species is uncommon elsewhere in Maryland, considerable time was spent observing and monitoring this species at Somatochlora Alley. Therefore the number of data points gives an inflated perception of the abundance of this species at PWRC.

73. *Somatochlora tenebrosa* (Say, 1839)

Number of Data Points: 130 **Flight Season:** 25 June to 21 September **Locations:** This is a widely distributed species, usually observed hawking for insects in open areas near streams. The highest numbers of individuals were recorded at Somatochlora Alley on June 30, 1994 (juveniles) and August 28, 1993 (mature adults).

Notes: Emergences were recorded at Midway Branch Creek at Midway Branch Marsh on June

25, 1994, and Beaverdam Creek July 4, 1990. On a number of occasions, males in flight above Somatochlora Alley exhibited very jerky flight compared to the more steady back and forth flight of the females and most of the other males. The reason is not known.

Both *S. tenebrosa* and *S. provocans* hawk for insects together above Somatochlora Alley. The vertical distance they fly above the road is generally consistent at any one time but their average elevation increases from early morning until around noon; probably reflecting an attempt to maintain their optimal body temperatures while hawking for food.

LIBELLULIDAE

74. *Celithemis elisa* (Hagen, 1861)

Number of Data Points: 761 **Flight Season:** 16 May to 3 September **Locations:** *Celithemis elisa* is a widely distributed species usually found at ponds.

Notes: This small species does not hold a territory and oviposits in tandem with the female touching the surface of the water with the tip of her abdomen while the couple is in flight. A copulating pair was observed on May 30, 1994, at New Marsh Ponds, to undergo the rhythmic jerking motions similar to that used by males of some species to remove sperm from earlier matings (Waage, 1982).

75. *Celithemis eponina* (Drury, 1773)

Number of Data Points: 82 **Flight Season:** 25 June to 19 September **Locations:** This species is widespread but is never abundant at PWRC. The highest records of individuals were from Knowles Marsh 1, Cash Lake, Mabbott Pond, Lake Allen, Alter Pond, and the Wetland Research Forest (Beltsville Bog).

Notes: *Celithemis eponina* are often encountered in fields adjacent to the ponds.

76. *Celithemis fasciata* Kirby, 1889

Number of Data Points: 201 **Flight Season:** 27 May to 3 September **Locations:** This is a widely distributed species. The highest concentrations of individuals occurred at Bluegill

Pond, Mabbott Pond, and New Marsh Ponds.

77. *Celithemis martha* Williamson, 1922

Number of Data Points: 171 **Flight Season:** 27 June to 3 September **Locations:** *Celithemis martha* is a common species at Mabbott Pond and New Marsh Ponds, and uncommon but widespread elsewhere on ponds. The high number of individuals was recorded at Mabbott Pond on Aug 10, 1991.

Notes: See notes under 78.5.

78. *Celithemis ornata* (Rambur, 1842)

Number of Data Points: 2 **Flight Season:** 27 June to 5 July, 1993 **Locations:** Both records of this species were from New Marsh Ponds.

Notes: *Celithemis ornata* is probably more abundant than the number of data points suggest because of the difficulty in separating this species from juvenile *C. martha* in the field. See notes under 78.5.

78.5 *Celithemis martha* X *ornata* ? (possible hybrid)

Number of Data Points: 2 **Flight Season:** 27 June to 5 July, 1993 **Locations:** These possible hybrids were collected at New Marsh Ponds.

Notes: Before male *C. martha* reach maturity, their body and wing marking are nearly identical to the reddish colored of *C. ornata* at PWRC. The majority of the "reddish" individuals were identified as juvenile *C. martha* based on the key provided by Carle (1982). Two individuals keyed to *C. ornata* which were later confirmed by May (1994). Two additional males were somewhat intermediate in characteristics and were not readily separated to either species. One of the two unknowns was examined by May (1994) with the same results.

Too few specimens are available to determine if these apparent intermediates are hybrids or just variants of one or the other species. Considerable time was spent in the field trying to find differences in behavior or habitat requirements between these two species. This was unsuccessful but again it may have been because of the difficulty in making reliable field identifications. It is also

possible that *C. martha* is a northern race of *C. ornata* and that the two races overlap at PWRC (Orr, 1993).

79. *Celithemis verna* Pritchard, 1935

Number of Data Points: 376 **Flight Season:** 19 May to 18 August **Locations:** This is a widely distributed pond species.

Notes: This species differs from the other *Celithemis* species in that the males maintain territories and are very aggressive, often chasing away much larger *Libellula* species. *Celithemis verna* also seems to do well in gravel ponds and other ponds with little emergent vegetation which seem to discourage other *Celithemis* species. Although common at PWRC, this species is uncommon elsewhere in the Washington D.C. area and was not reported for the state of Maryland until the 1980s by Mark Scoville (personal communication).

80. *Erythemis simplicicollis* (Say, 1839)

Number of Data Points: 2674 **Flight Season:** 6 May to 6 October **Locations:** This is one of the most abundant and widespread species of dragonflies at PWRC.

Notes: Their territories are usually associated with floating plants. When males confront one another they demonstrate the unusual ritualistic behavior of each male taking turns flying first under and then up in front of the other. This causes the males to roll across the surface of the pond.

This species is known for its voracity in taking large prey (Dunkle, 1989). Observations at PWRC include capture and consumption by this species of crane flies, deer flies, damselflies (*Lestes rectangularis*) and dragonflies (*Celithemis elisa*).

81. *Libellula auripennis* Burmeister, 1839

Number of Data Points: 19 **Flight Season:** 15 June to 18 August **Locations:** The only records are from the grassy edges of Mabbott Pond and New Marsh Ponds. *Libellula auripennis* is a strong flying dragonfly and is likely to turn up at other ponds.

Notes: *Libellula auripennis* and *L. needhami* are similar in color and size. In Maryland, *L.*

auripennis is never common but can be found on inland fresh water ponds while *L. needhami* is abundant in the slightly brackish water of the coastal plain. Some overlap occurs at PWRC where strays of *L. needhami* can be expected to occur with the resident *L. auripennis*.

82. *Libellula axilena* Westwood, 1837

Number of Data Points: 51 **Flight Season:** 11 June to 25 August **Locations:** This species is widely distributed, but never common. The record high for individuals was Clay Pit Pool on July 15, 1990. Other locations where this species can usually be found are the temporary pools around New Marsh Ponds, Sundew Bog, and the marshy edges of Harding Spring Pond.

83. *Libellula cyanea* Fabricius, 1775

Number of Data Points: 1735 **Flight Season:** 6 May to 12 September **Locations:** This species is abundant and widespread on ponds throughout PWRC. The population peaks in June.

84. *Libellula deplanata* Rambur, 1842

Number of Data Points: 3286 **Flight Season:** 3 April to 4 June **Locations:** This is the most abundant dragonfly in the spring at PWRC.

Notes: Adults are often observed landing on the ground. Hundreds are killed each year by cars at PWRC because the teneral use the dirt roads for sunning.

The male captures the female and completes copulation in flight, the procedure taking less than ½ minute. The female oviposits while being guarded and repeatedly dips her abdomen into the water without tossing the eggs up on shore, as is the general rule for other *Libellula* species. The closely related *Libellula exusta* occurs in Maryland only in a few small isolated bogs just north of PWRC in Anne Arundel County.

85. *Libellula flavida* Rambur, 1842

Number of Data Points: 22 **Flight Season:** 11 June to 30 July **Locations:** Sundew Bog and Elfin Bog are the only locations where this species could be found with regularity. Single individuals were found in widely scattered locations.

Notes: Although this species is not common at PWRC, it is the dominant summer *Libellula* at grassy seepages located at Soldier's Delight (Serpentine Barren) in Baltimore County.

86. *Libellula incesta* Hagen, 1861

Number of Data Points: 1226 **Flight Season:** 19 May to 8 October **Locations:** This species is widespread at PWRC on sunlit ponds.

Notes: A large number of *L. incesta* emerged at Uhler Marsh on May 27, 1990. On a number of occasions this species was seen in copulation low on shoreline or emergent vegetation. An Eastern Kingbird captured, in flight, a tandem pair on June 29, 1990.

A male *L. incesta* was maintaining a territory with a deformed hind wing at Hance Ponds on July 14, 1991. The wing was present but wrinkled and useless for flying except that it may have provided a counter weight for the other healthy hind wing. The three-winged male appeared to fly and defend without trouble.

A male *L. incesta* was observed in wheel with a female *L. vibrans*, in flight over Hobbs Pond on October 7, 1990. The wheel was maintained until they were netted. October 7, is late in the year for both species with few adults still on the wing. This might partly explain this unusual coupling.

87. *Libellula luctuosa* Burmeister, 1839

Number of Data Points: 542 **Flight Season:** 20 May to 6 October **Locations:** This is a widespread and conspicuous pond species.

Notes: Copulation times were observed of 10 seconds on May 26, 1991, and 25 seconds on August 14, 1993.

88. *Libellula lydia* Drury, 1770

Number of Data Points: 2295 **Flight Season:** 21 April to 3 November **Locations:** This is an abundant and widespread dragonfly.

Notes: On June 29, 1990, a male resting on the ground outside a honeybee colony took a honeybee coming out of the hive. An Eastern Phoebe was observed capturing and eating a *L. lydia* on June 30, 1993.

A mature male with only 3 wings (one never formed) was seen at Alter Pond on May 7, 1991; its flight seemed normal. *Libellula lydia* usually oviposits while being guarded, but a lone female was observed pitching water and eggs up onto a stump at New Marsh Ponds on June 2, 1991.

89. *Libellula needhami* Westfall, 1943

Number of Data Points: 1 **Flight Season:** 7 August 94 **Locations:** The only confirmed sighting was a mature male at Hobbs Pond on August 7, 1994.

Notes: This adult was probably a stray. See notes under *L. auripennis*.

90. *Libellula pulchella* Drury, 1773

Number of Data Points: 142 **Flight Season:** 20 May to 19 October **Locations:** This species is widely distributed but never in found in large numbers. The highest number of individuals recorded occurred at ponds which were recently drained and at newly created mitigation ponds.

91. *Libellula semifasciata* Burmeister, 1839

Number of Data Points: 516 **Flight Season:** 21 April to 12 August **Locations:** This is a widespread and common spring species. During the summer and early fall this species becomes local in marshy ditches and bogs. The highest concentration of individuals occurred on May 16, 1993, at the Duck Ponds.

Notes: A mass emergence occurred at Clay Pit Pool on May 19, 1991. This species is one of the earlier emerging dragonflies at PWRC. Its population peaks in mid-May.

92. *Libellula vibrans* Fabricius, 1798

Number of Data Points: 335 **Flight Season:** 19 May to 7 October **Locations:** This dragonfly is widely distributed at PWRC at forest ponds. This species is also common along the shaded portions of the two rivers and larger streams. The high concentrations of individuals were reported from Midway Branch Marsh on May 24, 1995, and along the shaded sections of the Patuxent River during mid-summer.

Notes: This species appears to replace *L. incesta*

in shaded ponds (compared to open ponds) and *L. axilena* in the permanent forested pools or ponds (compared to temporary forested pools and ponds). Also see notes under *L. incesta*.

93. *Nannothemis bella* (Uhler, 1857)

Number of Data Points: 54 **Flight Season:** 11 June to 30 July **Locations:** Sundew Bog has the only known population of *N. bella* at PWRC. Isolated individuals were found at Bluegill Pond in the late 1980's and at Elfin Bog on July 1, 1994. Both of these were collected by Mark Scoville (personal communication). There is also a historical record of this species from Snowden Pond in 1953 (Mitchell, 1994).

Notes: In Maryland, *Nannothemis bella* are found in isolated acidic bogs on the coastal plain. The date of June 11, as the beginning of the flight season is misleading because the males observed on this date were fully mature and defending territories.

94. *Pachydiplax longipennis* (Burmeister, 1839)

Number of Data Points: 4998 **Flight Season:** 25 April to 14 October **Locations:** This is the most widespread and abundant summer dragonfly at PWRC.

Notes: Exuviae were recorded from numerous ponds and on occasion from other aquatic habitats (e.g. Midway Branch Creek on June 13, 1993, on emergent vegetation in moderate flowing water).

At Lake Allen on July 18, 1993, a male *P. longipennis* was observed guarding an ovipositing *Libellula luctuosa*. I assume that the oviposition movements of the female *L. luctuosa* abnormally triggered the guarding behavior in the male *P. longipennis*. On June 29, 1991, a female *P. longipennis* was seen placing eggs into water pooled on top of a lily pad.

On a number of occasions juvenile adults were found infested with large numbers of parasitic mites. These immature water mites were in such high concentrations (under the thorax and abdomen) that the dragonflies could fly only with difficulty. A young male netted on Beaverdam Creek at the Bottomland Research Center on June 15, 1991, had an estimated 750 mites on the abdomen with an additional 300 on the thorax.

95. *Pantala flavescens* (Fabricius, 1798)

Number of Data Points: 240 **Flight Season:** 4 June to 19 October **Locations:** This species is a widely distributed migrant. It is usually encountered flying in loose swarms in open areas in summer and fall.

Notes: At PWRC this species completes its life cycle in shallow sun-exposed permanent ponds which undergo large seasonal fluctuations in size. Mass emergences of this species occurred at Goose Pond on September 21, 1991, and New Marsh Ponds on September 12, 1993. The latest seasonal emergence recorded was at Mabbott Pond on October 14, 1991. An unusually late oviposition was observed at the Mitigation Pond (R1) on September 12, 1993, by a lone female.

Often females are triggered into oviposition behavior on parked cars, apparently mistaking the surface shine for a pool of water. On a few occasions eggs are deposited, but more often eggs are not released and the female's behavior may be directed towards testing or confirming the suitability of the car as a possible oviposition site. See the section on migration.

96. *Pantala hymenaea* (Say, 1839)

Number of Data Points: 76 **Flight Season:** 18 June to 14 October **Locations:** This is a widespread migrant usually seen flying in loose swarms in open areas during summer and fall.

Notes: Mixed swarms of the two *Pantala* species are common. Often females can be seen undergoing oviposition behavior on parked cars, apparently mistaking the surface shine for a pool of water. See the section on migration.

97. *Perithemis tenera* (Say, 1839)

Number of Data Points: 581 **Flight Season:** 19 May to 7 October **Locations:** This species is widely distributed at PWRC on open ponds and bogs.

Notes: Males with unusually deep red, instead of amber, wings were observed at Alter Pond on August 1, 1990.

98. *Sympetrum ambiguum* (Rambur, 1842)

Number of Data Points: 469 **Flight Season:** 30 May to 27 October **Locations:** This species is widespread and common at temporary ponds such as Clay Pit Pool, Duck Ponds and Patuxent Marsh. It is also common at some permanent ponds such as Mabbott Pond and Harding Spring Pond. The record highs for individuals were the Duck Ponds during the last week of September, 1993.

Notes: Mass emergences of *S. ambiguum* were recorded from Mabbott Pond on May 30, 1991, and Harding Spring Pond on June 26, 1991. All observations of oviposition were of females guarded by non-tandem males. The eggs were dropped on the ground at dried ponds or in vegetation on the land side of shore.

On the morning of October 14, 1991, at Mabbott Pond, during the cool of the morning all of the males seen (8 total) had lime-green, and not china-blue, faces. Since only mature males should have been present at this time of year it might be that the cool temperatures triggered a reversal of the face color. If this is the case then the blue face pigment may not be fixed.

99. *Sympetrum obtrusum* (Hagen, 1867)

Number of Data Points: 2 **Flight Season:** 29 September 1990 **Locations:** Both data points were of mature males at a dried up section of Clay Pit Pool.

Notes: This species is rarely seen on the Maryland coastal plain but is common in western Maryland. See notes under *Sympetrum rubicundulum*.

100. *Sympetrum rubicundulum* (Say, 1839)

Number of Data Points: 276 **Flight Season:** 2 June to 6 October **Locations:** This is a widely distributed species. The record high for individuals was at the Duck Ponds on August 28, 1993. Other high concentrations of individuals were recorded at Clay Pit Pool, the small ponds next to Entomology Road (BARC), and the small temporary pools at the Wetland Research Forest (BARC).

Notes: The species called *rubicundulum* in this paper are not completely typical of that species in the eastern United States. It is possible that

extensive hybridization with *S. janeae* Carle (1993) may occur in this region.

Carle states in his 1993 paper that *S. janeae* prefers temporary marsh pools while *S. rubicundulum* prefers stands of emergent vegetation along permanent ponds and streams. At PWRC, *Sympetrum rubicundulum* is mainly associated with temporary pools but is occasionally found with emergent vegetation along permanent ponds. Habitat differences between *Sympetrum rubicundulum* and those individuals which had characteristics of *S. janeae* could not be detected at PWRC.

Based upon the specimens collected, it is certain that *S. rubicundulum* and *S. obtrusum* occur at PWRC. It is also possible that *S. janeae* also occurs, but hybridizes readily with *S. rubicundulum*.

101. *Sympetrum semicinctorum* (Say, 1839)

Number of Data Points: 51 **Flight Season:** 13 June to 8 September **Locations:** Except for a single male found at Alter Pond on September 8, 1990, all records were from Midway Branch Marsh on June 13, and June 27, 1993.

Notes: The population fluctuates greatly from year to year. The adults of this species did not appear to be present at Midway Branch Marsh in 1994 and 1995. On June 27, 1993, females were ovipositing in tandem by repeatedly dipping their abdomen into the water at the shoreline in Midway Branch Creek at Midway Branch Marsh.

102. *Sympetrum vicinum* (Hagen, 1861)

Number of Data Points: 3562 **Flight Season:** 5 July to 7 December **Locations:** *Sympetrum vicinum* is a widespread species found at permanent ponds. It is the most abundant fall dragonfly at PWRC.

Notes: *Sympetrum vicinum* and *Enallagma civile* are the most cold hardy of any of the Odonata at PWRC. Both species can be found in protected micro-habitats into December during warm years.

Mass emergences of *S. vicinum* occurred at Patuxent Marsh on August 4, 1990, and at Goose Pond on August 10, 1991. When Harding Spring

Pond was drained on October 12, 1992, tandem pairs of *S. vicinum* used the water remaining in deer foot prints for their egg laying.

On October 14, 1991, at Mabbott Pond, six or seven *S. vicinum* were flying together much higher (approximately 3 meters) than the other adults. Their flight was slow, moving back and forth in wide swaths at the edge of a field next to the forests. A late Eastern Phoebe (most had migrated south by this time) sitting at the edge of the forest had little difficulty capturing the slow flying *S. vicinum* one at a time, returning to his perch after each capture. After this observation, on various dates and locations, other high flying individuals moving slowly back and forth in the open (while the majority of the normal adult activity was kept relatively low in the vegetation) were repeatedly observed. Dumont and Hinneking (1973, as cited in Corbet 1980) provided a scenario for *Libellula quadrimaculata* in which trematode parasitism causes a change in the flight behavior of that species. Since trematodes use dragonflies as intermediate hosts to reach birds, the change in flight behavior of *S. vicinum*, due to parasitism, to become easier to capture by birds is speculative, but not beyond reason. This change in the flight behavior of *S. vicinum* may also shed light on the scattered reports that this species sometimes immigrates in large numbers (May, 1992), a phenomenon not yet observed at PWRC.

103. *Tamea carolina* (Linnaeus, 1763)

Number of Data Points: 338 **Flight Season:** 6 May to 14 October **Locations:** This is a widely distributed species often seen hawking in open areas or ovipositing at ponds. The record high of individuals was at Mabbott Pond on August 18, 1991. **Notes:** Sexually mature *T. carolina* first start arriving in the spring where they can be seen actively ovipositing throughout the area. See the section on migration.

104. *Tamea lacerata* Hagen, 1861

Number of Data Points: 278 **Flight Season:** 16 May to 9 October **Locations:** *Tamea lacerata* is a widespread species seen either hawking in open areas or ovipositing in permanent ponds. This species is most abundant at new mitigation ponds.

Notes: Mature adults were observed on a number

of occasions to have their abdomen pointed down while hawking over open areas. This behavior is probably thermoregulatory where the over-heated dragonfly is removing the abdomen from direct sunlight (May, 1996). See the section on migration.

105. *Tramea onusta* Hagen, 1861

Number of Data Points: 1 **Flight Season:** 30 May 91 **Locations:** A single mature male was observed at Mabbott Pond on May 30, 1991. **Notes:** This species was first collected in Maryland from Mabbott Pond by Mark Scoville (personal communication) in the late 1980s. This is a southern species with great dispersal capabilities and probably occurs only as a stray at PWRC.

MIGRATION

Mass movements of dragonflies are well documented (Corbet, 1962; Corbet, 1980; May, 1992; Soltész, et al, 1995). In addition to true migration, many of these mass movements may be due to periodic or eruptive dispersal behavior or to pathological nervous excitation of dragonflies due to internal parasitism (Corbet, 1980).

For the purpose of this paper only those species or populations of dragonflies are considered to be migratory in which 1) distinct northern movement of sexually mature adults into an area occurs, resulting in an establishment of a larval population, 2) larval development occurs within a single season and 3) subsequent emergence in the fall results in a mass movement southward of juvenile adults. Therefore, a migratory species or population under this definition would not reside over winter (as larvae) and would maintain its

population solely by movements of the adults north in spring or summer, and south in the fall. Three species, *Anax junius*, *Pantala flavescens*, and *Tramea lacerata* meet this definition of migration at PWRC. *Pantala hymenaea* and *Tramea carolina* are also discussed since they may be migratory even though evidence for a southern fall movement of juvenile individuals could not be found.

What happens to the southward movement of juvenile adults is still speculative. The simplest explanation would be that the juvenile adults overwintered in the south and returned the next spring to continue the cycle. However, the sexually mature adults arriving in the spring show little wear on the body and wings, which indicates that they are probably not the same individuals that left the previous fall, and that a southern larval cycle is likely involved.

Migration of *Anax junius* -- Spring and fall movements of *Anax junius* at PWRC were closely monitored from 1991 to 1995. Great variation in the influx of migrants between years was observed. During 1994 a very early wave of migrants arrived in March and the adults could be seen flying over the snow drifts. However, in 1993 there was little or no influx of spring migrants until April 25.

Table 1 contains the *Anax junius* spring migration data from 1991 to 1995. All observations were conducted on sunny, relatively warm days with little or no wind. In table 1, all records of the migrant population were of mature adults and all records of the residence population were of teneral adults or exuviae.

TABLE 1

	1991	1992	1993	1994	1995
February		17: none			
March	2: none 28:50+migrants	1: none 9: none 30:none	9: none	24: 15 migrants 26: none	15: none
April	6: 6 migrants 30: 10 migrants	7: none 11:50+migrant s 24: 12 migrants	11: none 8: none 25:25+migrant s	9: 70+ migrants 24:50+migrant s	21: 2 migrants 8:100+migrants *21: 2 migrants 25: 6 migrants
May	4: 1 migrant 7: 30+most residents few migrants	2: 15 migrants 17: none 23: 25 residents	2: 12 migrants 16: 8 migrants 22: 2 a migrant and a resident	14:30+migrant s 30: 2 migrants	6: 3 migrants 24: none
June				4: 5 residents	11: 1 resident

*In New Jersey, the first migrants were observed on April 13 (Allen Barlow, personal communication) and April 15 (Soltesz et al, 1995) which could be the same wave of individuals recorded at PWRC on April 8.

Despite the irregularities in data, the following hypotheses is presented on the movement of *Anax junius*. Both migratory and the resident *Anax junius* populations occur together at PWRC. It is realistic to assume that the two populations exchange genetic material, but the extent of the interactions between these populations is

unknown. A few isolated late spring migrants are probably still around when the resident spring population reaches maturity, but data show that this would be the exception and not the rule. Mixing of the populations in the fall is even less likely since the migratory population leaves before they are sexually mature. For purposes of simplifying the following discussion I will treat the resident and migratory populations as physiologically separate.

Migratory population -- The spring migrants start to arrive with warm frontal systems coming up from the south in late March or April. It is likely that they move as individuals since their distribution is relatively random throughout the area after they arrive, and the spring adults show no tendency to cluster. This movement of

individuals, versus groups of individuals, and the correlation of movement with fronts associated with poor weather, could explain the lack of observations associated with spring migration.

The yearly migration was not confined to a single front but moved in successional fronts for at least a couple of weeks. Not all fronts moving northward through PWRC during the spring migratory period brought adults. On a number of occasions when a front went through, it would acquire earlier PWRC migrants but failed to leave new individuals, only to be followed in a couple of days by another front which, once again, left adults at the Research Center. On the warm days between the frontal systems the migrants remain at PWRC feeding and ovipositing until the next front stimulates them to move further northward. It is likely that this northward trend continues until cold weather kills the north bound dragonflies. The migrants are sexually mature adults in good condition and males greatly out-number females. Oviposition was always observed in tandem (23 records).

The immature stages of the migrants probably develop quickly without completing a winter diapause and emerge in, and around, September. These fall juveniles have a tendency to form large feeding swarms over the open areas. This tendency to swarm was not observed in the spring migrants. Mass fall migrations through PWRC were not observed. This probably indicates that the main fall migration route or routes do not cross over

PWRC (as does the wide front of the spring migration). Local fall migrants probably move towards defined routes providing better landmarks for moving south. Mass fall movements elsewhere have been observed following shorelines or mountain ranges (May, 1992; Soltesz, 1991).

Resident population -- The major emergence of the resident population begins in mid to late May and peaks in early June. Emergence continues on a lesser scale with scattered exuviae found into July. It is likely that the larvae are annual and undergo winter diapause. Oviposition is done either in tandem (6 records) or alone (5 records). Trotter (1971) in Canada, reported that resident females complete their egg laying before the fall emergence of the migratory population begins. At PWRC this appeared to be generally true but the observation of a resident pair ovipositing in tandem on November 3, 1990, at Duvall Pond indicates that there is, on occasion, overlap.

Migration of *Pantala flavescens* -- The influx of mature *P. flavescens* during summer and a corresponding late fall emergence of this species does occur at PWRC. However, this trend is not as consistent or as obvious as for *Anax junius*. The movement of mature adults into PWRC appears to take place throughout the summer and perhaps into fall. Oviposition has been observed from June 4 to as late as September 12.

Emergence of adults were recorded from September 21 to October 14. All of these were from shallow sun-exposed permanent ponds which undergo large seasonal fluctuations in size. The literature (Dunkle, 1982; Walker and Corbet, 1978) indicates that *P. flavescens* is a temporary pond or rain pool breeder in the Southern United States. Significant temporary ponds exist at PWRC but no emergence of *P. flavescens* has ever been observed. Because the development of *P. flavescens* larvae have a high thermal coefficient requirement (Corbet, 1962), it is reasonable to assume that the temporary ponds at PWRC do not provide enough time for complete larval development.

Fall juvenile swarms hawking in open areas were observed from mid-September through mid-October. Soltesz (1991) reports that this species mixes with *Anax junius* aggregations along the New Jersey coast in the fall. Since the number of mature adults arriving at PWRC in the summer

appears to far outnumber the juveniles observed in the fall, it is likely that PWRC is too far north to maintain a stable population of this southern dragonfly.

Possible migration of *Pantala hymenaea* -- The influx of mature *P. hymenaea*, like *P. flavescens*, during the summer at PWRC is dramatic. Oviposition has also been observed. However at present, evidence has not been found for southbound fall-flying juveniles at PWRC. This species is considered migratory and has completed development as far north as southern Canada (Walker and Corbet, 1978). A few *Pantala hymenaea* have also been reported moving south in fall swarms of *Anax junius* at Cape May, New Jersey (Soltesz, 1991). Therefore, it is likely that, at least a few individuals complete their larval development at PWRC. PWRC is probably too far north to maintain a stable population of this species.

Migration of *Tramea lacerata* -- Mature ovipositing pairs of *T. lacerata* generally appear in mid-May and immigration may continue throughout the spring and summer. Mass emergence of this species occurred on September 8, 1990 at Alter pond, and large feeding swarms of juvenile adults were seen over the open areas of the north tract on Sept 12, 1993. Mass fall movements of *T. lacerata*, often with *Anax junius* have been reported moving south along the eastern seaboard (Walker and Corbet, 1978; Soltesz, 1991).

Possible migration of *Tramea carolina*: The spring immigration of sexually mature *T. carolina* into PWRC is more dramatic than that of *Tramea lacerata*. However at present, evidence has not been found for southbound fall-flying juveniles at PWRC. What is interesting is that the data points when converted into the phenogram for this species shows an increase of adults during the first half of August (see phenogram for *T. carolina*). It is not known whether this is an artifact of the data, or represents a second wave of immigrants, or the emergence of the offspring from the spring adults.

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PHENOGRAMS FOR THE ODONATA OF PATUXENT WILDLIFE RESEARCH CENTER

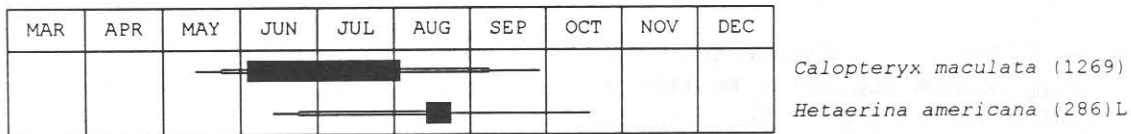
Key: Numbers expected to be seen daily at optimal year, location and weather conditions. Based on 1990 to 1995 field observations.

- 0 - 5 =  = rare to common
- 6 - 50 =  = common
- 51 + =  = abundant

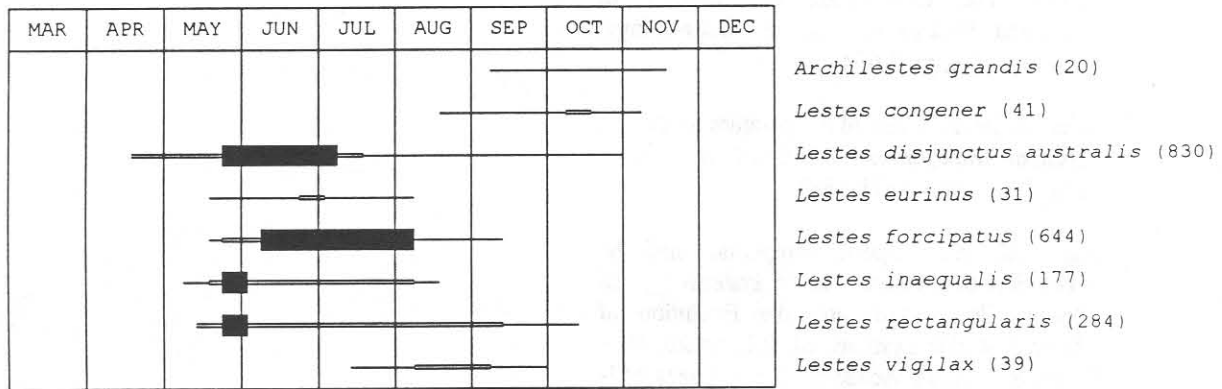
Other notations:

- C = Most records based on cast skins (exuviae)
- F = Populations fluctuate greatly from year to year
- L = Populations are very localized
- S = Stray adults -- probably no viable larval population in area
- () = Number of data points used in making the phenogram

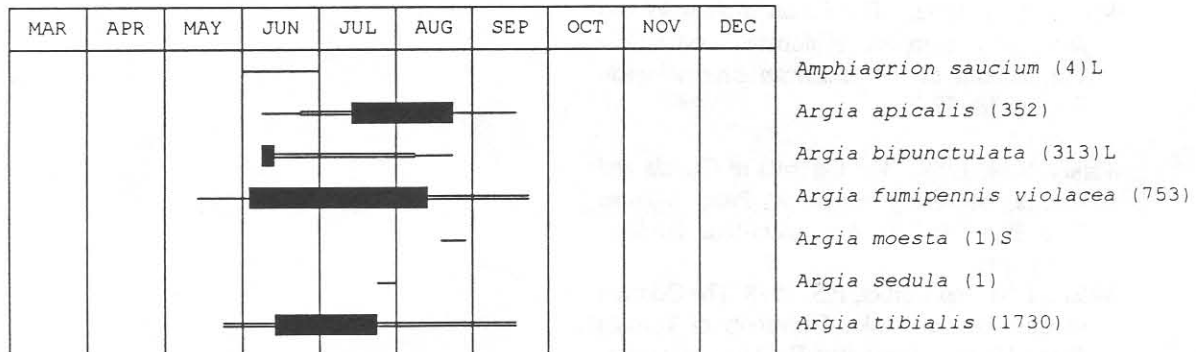
CALOPTERYGIDAE



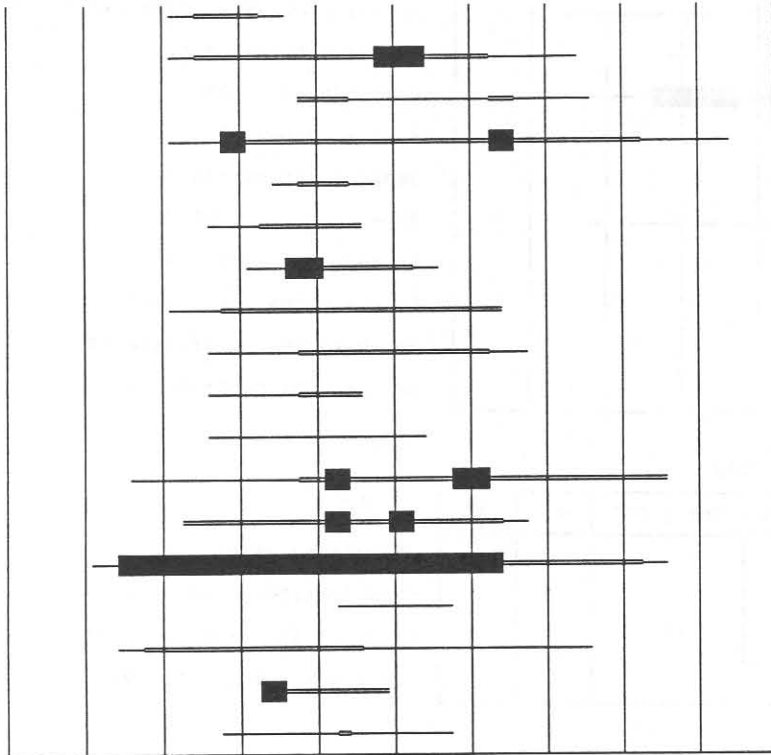
LESTIDAE



COENAGRIONIDAE



Orr: Odonata of Patuxent Wildlife Research Center



- Chromagrion conditum* (83)L,F
- Enallagma aspersum* (183)
- Enallagma basidens* (39)
- Enallagma civile* (563)
- Enallagma daeckii* (27)
- Enallagma divagans* (198)
- Enallagma exsulans* (953)
- Enallagma geminatum* (291)
- Enallagma signatum* (113)
- Enallagma t. traviatum* (51)
- Enallagma vesperum* (5)
- Ischnura hastata* (594)
- Ischnura kellicotti* (274)
- Ischnura posita posita* (3754)
- Ischnura ramburii* (3)
- Ischnura verticalis* (194)
- Nehalennia gracilis* (174)L
- Nehalennia integricolis* (82)

PETALURIDAE

MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Tachopteryx thoreyi (10)L

GOMPHIDAE

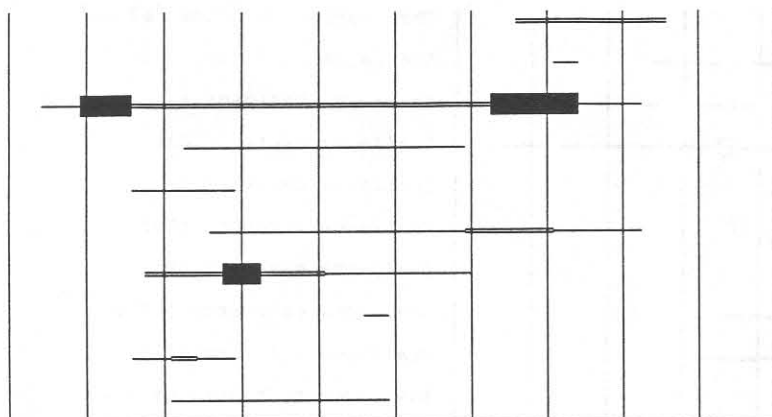
MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

- Arigomphus villosipes* (3)
- Dromogomphus spinosa* (1)
- Gomphus exilus* (123)
- Gomphus lividus* (274)
- Gomphus rogersi* (17)L
- Hagenius brevistylus* (101)
- Ophiogomphus i. incurvatus* (6)C
- Progomphus obscurus* (401)
- Stylurus laurae* (23)C
- Stylurus plagiatus* (1)S
- Stylurus spiniceps* (1)S

AESHNIDAE

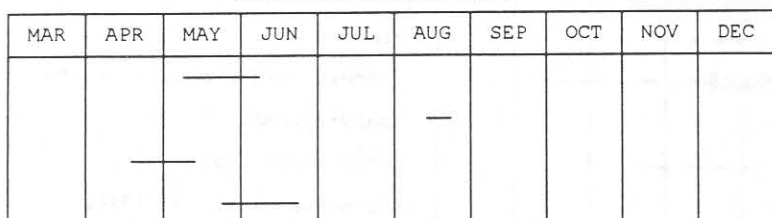
MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

Aeshna mutata (20)L



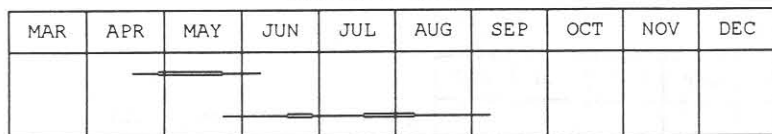
- Aeshna umbrosa umbrosa* (43)
- Aeshna verticalis* (1)
- Anax junius* (1308)
- Anax longipes* (70)
- Basiaeschna janata* (6)
- Boyeria vinosa* (88)
- Epiaeschna heros* (467)
- Gomphaeschna antilope* (1)
- Gomphaeschna furcillata* (49)F
- Nasiaeschna pentacantha* (23)

CORDULEGASTRIDAE



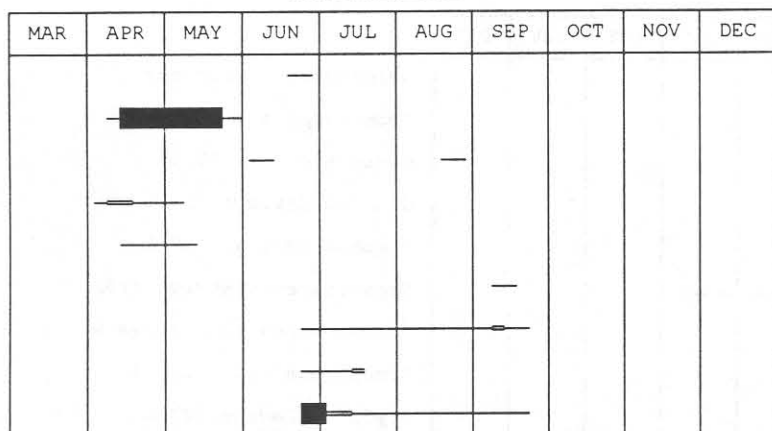
- Cordulegaster bilineata* (17)
- Cordulegaster erronea* (1)S
- Cordulegaster maculata* (27)
- Cordulegaster o. obliqua* (6)L

MACROMIINAE



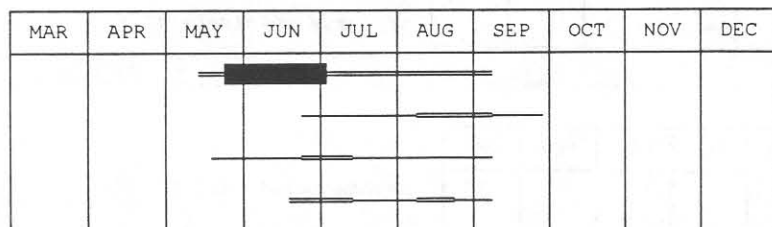
- Didymops transversa* (60)
- Macromia illinoiensis* (86)

CORDULIIDAE



- Epitheca costalis* (3)L
- Epitheca cynosura* (874)
- Epitheca princeps* (3)
- Epitheca spinosa* (97)F
- Helocordulia selysis* (6)
- Somatochlora filosa* (1)
- Somatochlora linearis* (24)
- Somatochlora provocans* (93)F
- Somatochlora tenebrosa* (130)

LIBELLULIDAE



- Celithemis elisa* (761)
- Celithemis eponina* (82)
- Celithemis fasciata* (201)
- Celithemis martha* (171)L

Orr: Odonata of Patuxent Wildlife Research Center

