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**FOUR DECADES OF STABILITY AND CHANGE IN THE ODONATA POPULATIONS  
AT TEN ACRE POND IN CENTRAL PENNSYLVANIA**

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# FOUR DECADES OF STABILITY AND CHANGE IN THE ODONATA POPULATIONS AT TEN ACRE POND IN CENTRAL PENNSYLVANIA

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**ABSTRACT:** Ten Acre Pond, a semipermanent pond near State College, supports a diverse odonate fauna which includes two species (*Aeshna mutata* and *Anax longipes*) that are considered to be vulnerable in Pennsylvania. The perhaps unprecedented monitoring of these species and others at Ten Acre Pond on thirty-eight of the last forty years provides a record dominated by relative stability in species composition and frequent changes in relative abundance of the various species. Many of the changes can be attributed to several droughts and two periods of unusually high water. The year-to-year and seasonal distributions of the 74 species of Odonata known from Ten Acre Pond are reported.

*Libellula auripennis*, *L. axilena*, *L. cyanea*, *L. incesta*, *L. vibrans*, *Erythrodiplax connata minuscula*, *Coenagrion resolutum*, and *Enallagma traviatum* are among the species of interest in central Pennsylvania that are known from Ten Acre Pond.

## INTRODUCTION

Virtually all naturalists have a favorite habitat to which they return when time and circumstances permit. In many cases, these places are remote and sometimes exotic - aspects that often heighten the allure but prevent frequent visitation. For us, Ten Acre Pond, which has similarities to a very large mud puddle, is neither remote nor exotic, but it remains one of our favorite habitats. Due to its accessibility and rich odonate fauna, at least one of us has visited the pond 34 out of the last 36 years, usually multiple times each year. In addition, other odonatologists have visited the pond and

added their observations to ours. As a consequence, the odonate fauna of Ten Acre Pond is among the best documented for any habitat in the United States and may be unrivaled with respect to the almost annual sampling of its fauna for the past four decades.

At a time when urban expansion, air and water pollution, and climate change threaten native species, there is little documentation of long-term changes in odonate populations despite many anecdotal reports of habitat alteration and the disappearance of particular species. In order to provide such baseline information and with the hope that others will share similar documentation for habitats and populations of interest, we describe the seasonal and year-to-year distribution of Odonata at Ten Acre Pond.

## HISTORY OF STUDY

In 1955, George H. Beatty and Stuart W. Frost discovered a thriving population of *Aeshna mutata* at Ten Acre Pond (Beatty and Beatty, 1969). The study of that population was broadened to include a thorough several-year survey of the seasonal distribution and abundance of all Odonata at the pond (White, 1963). Primarily due to the regular occurrence of *A. mutata* and *Anax longipes* (White, 1963; Beatty et al., 1969), both considered vulnerable species in Pennsylvania (Shiffer, 1985), most odonate specialists in eastern North America know about, and many have visited, Ten Acre Pond (Dunkle, 1986). A popular article in *SCIENCE* 82 (Fergus, 1982) also contributed to the awareness and interest in the Odonata of the pond. Despite this interest and perhaps because Ten Acre Pond is not a typical "natural" habitat, no serious efforts have been made to insure its

protection from the suburban expansion of State College nearby.

Ten Acre Pond is located about four miles west of the main campus of the Pennsylvania State University in a region of stunted vegetation known locally as "The Barrens." (See the Julian, PA 7.5' U.S. Geological Survey map; 40° 47' N, 77° 57' W; elev. 1350 ft.) In the 19th century, a combination of clear cutting to produce charcoal, iron mining, and fires caused by the ore trains altered the landscape and depleted the already poor sandy soils (Conklin, 1943). By 1881, the mining town of Scotia consisted of about 400 families, had three stores, and was serviced by a branch of the Lewisburg and Tyrone Railroad. The elevated bed of the former railroad on the outskirts of the ghost town of Scotia forms the linear embankment along the northwest side of Ten Acre Pond (See map in White, 1963). Considering that the deepest parts of the pond are next to the rail bed, excavation for the railroad may have formed Ten Acre Pond or enlarged a preexisting pond.

Numerous shallow depressions in the nearby Barrens support vernal ponds, but none approaches the size or permanence of Ten Acre Pond. That such a pond may have existed in the place of Ten Acre Pond before mining and the railroad disrupted the landscape remains a possibility. However, aerial photographs suggest that those activities had much to do with the extent and character of today's pond whose clay bed in many places lacks the organic sediments and vegetation typical of undisturbed vernal ponds.

#### CLIMATIC INFLUENCES

The sandy soils of the surrounding area do not permit surface streams. Thus, Ten Acre Pond has no inlets or outlet. Its size and depth fluctuate in response to local rainfall and evaporation (White, 1963). In a typical year, the water level starts high in the early spring after the snow melts and falls through the summer, often leaving water in several small separated pools near the railway. The pond dried up completely in 1991 and was practically dry when checked late in the summer in 1960 (White, 1963) and in 1988. These events exterminated most fish species introduced by the Pennsylvania Fish Commission and by local fishermen; however, fathead minnows were still present in 1994. Five days of heavy rain from the

remains of Hurricane Agnes in June 1972 caused the worst flooding state wide in Pennsylvania's history. The more than one foot of rain raised the pond to the highest levels in memory. Its 15 to 20 acres flooded surrounding woodlands, drowned many trees, and changed the character and distribution of aquatic plants for several years. Noticeable changes in the odonate fauna persisted in the following years until the pond returned to its previous size and annual cycle. The water reached the 1972 levels again in 1993 and 1994 when unprecedented winter snow packs melted and were each followed by an unusually wet spring and summer. Once again there were changes in the odonate fauna at the pond.

Other climatic factors affect the vegetation of the Barrens and may influence adult Odonata populations. Due to the topography and sandy soils that do not retain heat well, frosts may occur on any calm clear night after days when the temperature fails to reach 80° F (Clarke, 1946; Butch and Schlegel, 1980). The average minimum temperature throughout the year at a nearby frost pocket is more than 10° F lower than that recorded at the weather station at the Pennsylvania State University. While day-time high temperatures are similar to those at the university, the lower temperatures at night certainly reduce evaporation from the pond and prolong ice cover in the early spring. It is not known whether adult Odonata of certain species are affected by the frequent frosts and the reduced growing season or whether these conditions explain the regular presence of several northern species found sparingly elsewhere in the area.

#### SAMPLING PRACTICE AND LIMITATIONS OF THE DATA

The survey of the Odonata of Ten Acre Pond for the past four decades lacks consistency in the frequency of year-to-year and seasonal observations, the observers, the thoroughness of sampling, and the time of daily and seasonal sampling. We have no observations for 1966 and 1967 whereas observations were made on 29 occasions in 1960. In total the authors have visited the pond on nearly 200 occasions; however, records by HBW are infrequent after 1965 while most of the records after 1968 are by CNS. Because Ten Acre Pond includes a number of micro-habitats, certain species are often localized. The apparent absence of these species in particular

years, may simply mean these micro-habitats were not sampled. Similarly, the time of year when most sampling was done will bias the year-to-year record against species with early or late flight seasons.

Some measure of the thoroughness of sampling comes from an intensive two-day survey of the pond by 11 odonate specialists on 21 and 22 June 1986 (Dunkle, 1986). A total of 36 species were recorded of which four were not observed by either of the authors. Particular species, including *Anax longipes*, *Erythemis simplicicollis*, and *Ischnura hastata*, were looked for but not found despite their presence at other times earlier in the month. Several species including *Libellula auripennis*, *Lestes eurinus*, *Coenagrion resolutum*, *Enallagma civile*, *E. cyathigerum*, and *Ischnura posita* were observed on only one of the two days. These anecdotal observations show clearly that surveys by one person, for shorter periods, and under less favorable weather conditions will be incomplete and tend to miss inconspicuous and uncommon species. Given these realities, what can be learned from Tables 1 and 2, and how reliable are the data?

Because *Aeshna mutata* and *Anax longipes* are the main species of interest at Ten Acre Pond and their flight seasons peak in June and July, the year-to-year records and the seasonal distributions for them and those species common at the same time are the most reliable. While *Anax junius*, a large and conspicuous species, is the only species recorded every year, other species undoubtedly should share that distinction. A better indication of sampling practice is the fact that *Ischnura verticalis*, a common but much less conspicuous species, was recorded in all but one of the years we sampled the pond. Nevertheless, it is not clear, for example, whether the apparent multiyear absence of *Lestes congener* from 1973 through 1983 is real or a sampling artifact. In that case, the presence of other species of *Lestes* suggests that the populations of *L. congener* were at least small. The coincidence of this hiatus with a period of very high water and the known biology of *L. congener* (Sawchyn and Gillott, 1974a), also support the observations. Other, but less compelling, arguments could be made for the more than one decade absence of *Gomphus exilis*, *Arigomphus villosipes*, *Tetragoneuria canis*, *Leucorrhinia hudsonica*, *Pantala flavescens*, *L. vigilax*, *L. unguiculatus*, *Enallagma ebrium*, and *E.*

*geminatum*, species that at times have been apparent, if not common.

## IMMIGRATION AND COLONIZATION

Odonata quickly colonize newly created ponds which reflects their tendency to disperse after emergence (Corbet, 1962). The five isolated observations of *Calopteryx maculata* illustrate the dispersal activity of this common stream species in central Pennsylvania. Because it never colonizes ponds and is very conspicuous, it stands out among typical pond species. Most likely, the observed individuals came from a small tributary of Buffalo Run about one mile away. Immigration by other species may be fairly common but can not be recognized in the presence of resident members of the same species. Only when isolated individuals of non-resident species like *C. maculata* appear can immigration be deduced and colonization occur.

Prior to 1963, Ten Acre Pond was thoroughly sampled on more than 50 occasions throughout the flight season. During that period, a single *Libellula cyanea* was observed (White, 1963). Its conspicuousness and its isolated occurrence showed that it was not part of the resident population and that the observed individual was undoubtedly a stray like the isolated occurrence of *Aeshna constricta*, *Libellula axilena*, *Erythrodiplax connata minuscula*, and *Enallagma boreale*, species that are not known to occur regularly anywhere in central Pennsylvania. In 1961 when *L. cyanea* was first seen, it was only known from one previous record within Centre County (White et al., 1968) and it was not seen again at Ten Acre Pond until 1981. Since then, it has been observed in eight years and on many occasions multiple individuals were present. The species has similarly colonized other habitats in the county in recent years.

*Libellula auripennis* first appeared in 1970 and, although observed sporadically since then, the observation of oviposition in 1990 and the presence of multiple individuals in 1990 and 1991 suggest that a transitory breeding population had been established. Similarly, *Epiaeschna heros*, for which there was a doubtful sight record before 1963 (White, 1963), has been observed every year for the past decade and is clearly part of the current resident population. *Aeshna verticalis* also seems to have colonized the pond in recent years. *Lestes*

*dryas*, which had been known from vernal ponds in the Barrens, was first found at Ten Acre Pond in 1965 and, like *E. heros*, seems to have become well established in the past decade.

Among the interesting short-lived colonization events were those by *Enallagma traviatum* in 1973 and *Coenagrion resolutum* from 1984 through 1986. Neither species had been recorded before or since until 1994 when *E. traviatum* reappeared. A pair of *E. traviatum* was collected 15 July 1973 and 5 males and a female were collected a week later on July 22. Colonization in this instance seemed to be associated with periods of high water (see below). Based on the previous colonization, we expect that *E. traviatum* will disappear when water levels drop again. *Coenagrion resolutum* was observed on 12 occasions from its discovery on 3 June 1984 until its last sighting on 21 June 1986. This northern species is not known from other habitats south of the Appalachian Plateau and was rather unexpected at Ten Acre Pond.

The preceding examples probably reflect dispersal from other habitats in central Pennsylvania. One that does not fit this pattern is *Pantala hymenaea*, a migratory species which was observed for the first time in many places transcontinentally in 1988 (White, 1989; Cannings, 1989b; Donnelly, 1992). It appeared at Ten Acre Pond that year, bred at the pond, and has been observed several times since. Although *P. hymenaea* is well known for its dispersal over long distances, its migration into the northeastern United States was an infrequent event in contrast to *Anax junius*, a resident species that migrates annually.

In addition to being the only species recorded every year that observations have been made and having the longest flight period, *A. junius* appears earlier in the spring than any other species at Ten Acre Pond (White and Raff, 1970). The observation that the first adults at the pond are fully mature and appear weeks before other species, (an observation also made by Butler et al. (1975) in southern Ontario), supports the hypothesis that they had immigrated from the south. While the southward fall migration of *A. junius* is well documented (Bagg, 1958; May, 1992), the inferred northward spring migration has never been observed and its geographic origins remain unknown. Confounding the picture are two exuviae of *A. junius* discovered on 31 March 1963, the earliest date adults have been observed at the Ten Acre Pond (White and

Raff, 1970). Although it would resolve the dilemma to speculate that they came from fall emergences and had survived the winter, the water levels in the preceding fall were very low and far from where the exuviae were found. Thus it seems that early spring emergences also occur in central Pennsylvania. Clearly there is much still to be learned about the migratory biology of the most widely distributed dragonfly in North America (May, 1992; 1993).

#### SPECIES THAT HAVE NOT COLONIZED TEN ACRE POND

With the exception of species associated with streams, very few species found in the surrounding area have not also been observed at Ten Acre Pond. Among those that have never been recorded and whose absence is perhaps surprising are: *Archilestes grandis*, *Argia fumipennis violacea*, and *Enallagma basidens*. In central Pennsylvania, *A. f. violacea* is well established at a number of impoundments with stable water levels. Although very uncommon in Centre County (White et al., 1968), *A. grandis* was collected twice within a mile of Ten Acre Pond on 19 September 1988 (CNS unpublished) and may be expected at the pond if more collecting is done in the late summer and early fall. *Enallagma basidens* has expanded its range strikingly in the recent decades (Raff et al., 1969; Cannings, 1989a) and has been recorded nearby. It also may be expected at Ten Acre Pond with careful surveys in the future. Several species that would have been on this list appeared for the first time in 1994 along with high water levels. They are *Epicordulia p. princeps*, *Libellula incesta*, and *Enallagma exsulans*.

#### IMPACT OF DROUGHT AND FLOOD

At least once (1991) and perhaps two other times (1960 and 1988), Ten Acre Pond has dried completely. While these events do not seem to have major long term effects on the species found at Ten Acre Pond, there are significant short term changes in the total abundance and relative abundance in the following years. In particular, various species of *Lestes* are common. For example, 1990 and 1991 are the only years when all nine species of *Lestes* were recorded. While this may be due to the reduction in competition from drought intolerant species, another important factor is the extermination or reduction of fish that are major insect predators and whose presence is

correlated with the presence or absence of certain species of *Enallagma* (McPeck, 1990), for example.

At the other extreme is 1972 when Hurricane Agnes raised the water to unprecedented levels that did not return to typical levels for two years and noticeably affected aquatic vegetation for up to five years. No doubt the colonization by *E. traviatum* observed in 1973 and again in 1994 was related to the lake-like character the pond had assumed. The high water profoundly reduced or eliminated the population of many species including *Aeshna tuberculifera* and various species of *Lestes*. These species lay their eggs in plant stems when water levels are low (Corbet, 1975; Sawchyn & Gillott, 1974a,b). The eggs hatch when water levels rise in the spring. Without these features, Ten Acre Pond ceases to be a suitable habitat.

While the abundance of species varies from year to year, the observation that many species persist despite drought requires an explanation. Certainly dispersal and colonization from ponds that do not dry up or having eggs that diapause until water returns explains the persistence of some species. However, neither of these strategies satisfactorily explain the persistence of *Aeshna mutata*. Unlike *A. tuberculifera*, its eggs are laid early in the summer in submerged vegetation (Beatty and Beatty, 1969) and should hatch soon thereafter necessitating that the nymphs, rather than the eggs, survive summer droughts. Populations of *A. mutata* are reduced in summers following a drought year (White, 1963); however, the apparent lack of nearby populations in permanent ponds that could serve to repopulate Ten Acre Pond creates a mystery and other strategies of drought tolerance need to be considered to explain the continued presence of *A. mutata* during several recent severe droughts. One possible way to survive drought is used by *Somatochlora semicircularis* in the Rocky Mountains. Its nymphs burrow into the mud and under logs when their habitat dries up (Willey and Eiler, 1972). *Aeshna multicolor*, a common western species closely related to *A. mutata* (Beatty and Beatty, 1969), also has an early flight period but inhabits much more arid environments. This raises the possibility that drought hardiness in both species may be associated with the nymph stage, in contrast to the egg stage, in other species of *Aeshna*.

## CONSERVATION ISSUES

While high species diversity is a regular feature of the Odonata fauna of Ten Acre Pond, populations of individual species fluctuate widely. Species common one year may be hard to find the next. This is certainly the case with *Anax longipes* and *Aeshna mutata*, two of Pennsylvania's vulnerable species (Shiffer, 1985). Stability is not a characteristic of the pond or its inhabitants. Change is the defining attribute. While there are seasonal trends in the patterns of change, consecutive years are frequently quite different. Several times in the forty years the pond has dried up completely or nearly so and within a year or two risen to flood the surrounding woodland. Vegetation, bottom composition, water depth, and exposure to sun vary greatly around the pond at all times. We conclude that the lack of stability in this habitat actually promotes the diversity we observe (Reice, 1994). The conditions in different years favor different species. An equilibrium predictable state that would provide long-term stability will never exist at Ten Acre Pond.

In Ten Acre Pond we have a habitat created by humans but relatively unperturbed by humans for more than four decades except for the introduction of fish. It now lies on the edge of the expanding metropolitan area of State College which in the future threatens the supply of surface water and the level of the water table, if not the pond itself. Although it is adjacent to Pennsylvania State Game Lands (Conklin, 1943), it currently is privately owned. Should efforts be made to conserve Ten Acre Pond? Considering the impact of urbanization, would preservation of the pond site save the pond? While most conserved habitats are managed for stability, can a habitat be managed for unpredictable natural change while avoiding unpredictable human-caused change? These issues and more need to be addressed soon if Ten Acre Pond is to remain a haven for Odonata.

Relative to these concerns, it is significant that Ten Acre Pond and some of its odonate inhabitants are important elements within a large Gatesburg Sand Barrens Megasite targeted for priority protection efforts by the Western Pennsylvania Conservancy. Headquartered in Pittsburgh, the Conservancy operates throughout the western half of Pennsylvania. They completed a Natural Areas Inventory for Centre County and designated the Gatesburg Sand Barrens Megasite as a priority area

for future conservation concern. Further, the Conservancy serves, under a contract arrangement, as the western office of the Pennsylvania Natural Diversity Inventory administered by the Pennsylvania Department of Environmental Resources/ Bureau of Forestry. (The Nature Conservancy, under similar contract, is also linked to the PNDI effort as the eastern office.)

Altogether, the Gatesburg Sand Barrens Megasite contains nearly 50 elements of special concern, including vascular plants, invertebrates, and wetlands, which have been compiled by the Western Pennsylvania Conservancy. The Centre County Natural Areas Inventory (and similar inventories conducted throughout the state) and the larger PNDI provide local, county, and state agencies with the information needed to make pertinent conservation decisions which result in the protection and perpetuation of important natural elements threatened by various forms of development.

Humans created Ten Acre Pond during an enterprise that mined and profited from a reservoir of mineral wealth. Now a new amalgam of public and private enterprises need to act in order to ensure the perpetuation of this habitat with its biological riches, so that humans can continue to profit from them. The tools to make this possible are already in place.

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**NOTE ADDED IN PROOF:** In Pennsylvania, Centre County is the most studied county for Odonata and, within Centre County, Ten Acre Pond is the most thoroughly studied habitat. While one might expect that any habitat, that has been studied as long and as frequently as Ten Acre Pond has, would produce notable records, this locality seems to get more than its share. Not included in Tables 1 and 2 are records from the 1995 season. On 31 May, one of us (CNS) discovered *Libellula vibrans*, a species never before found at the pond. A day later he found *L. axilena*, previously known from one record.

#### REFERENCES

- Bagg, A. M., 1959, Fall emigration of the dragon-fly *Anax junius*. Maine Fld. Nat. 14:2-13.
- Beatty, G. H. and Beatty, A. F., 1969, Evolution and speciation in the subgenus *Schizuraeschna*, with observations on *Aeshna (Schizuraeschna) mutata* Hagen (Odonata). Penna Acad. Sci. Proc. 43:147-152.
- Beatty, G. H., Beatty, A. F., and Shiffer, C. N., 1969, A survey of the Odonata of central Pennsylvania. Penna. Acad. Sci. Proc. 43:127-136.
- Butler, T., Peterson, J. E., and Corbet, P. S., 1975, An exceptionally early and informative arrival of adult *Anax junius* in Ontario. Can. Entomol. 107:1253-1254.
- Cannings, R. A., 1989a, *Pantala hymenaea* (Say) new to British Columbia, Canada with notes on its status in the northwestern United States (Anisoptera: Libellulidae). Notul. Odonatol. 3(2):31-32.
- Cannings, R. A., 1989b, *Enallagma basidens* Calvert, a dragonfly new to Canada, with notes on the expansion of its range in North America (Zygoptera: Coenagrionidae). Notul. Odonatol. 3(4):53-55.
- Carle, F. L., 1982, A Contribution to the Knowledge of the Odonata of Virginia. Ph.D Thesis Virginia Polytechnic Institute and State University, Blacksburg, VA, 1095 pp.



- Carle, F. L., 1993, *Sympetrum janeae* spec. nov. from eastern North America, with a key to nearctic *Sympetrum* (Anisoptera: Libellulidae). *Odonatologica* 22(1): 1 - 16.
- Clarke, W. S., Jr., 1946, Effect of low temperatures on the vegetation of the Barrens in Central Pennsylvania. *Ecology* 27:188-189.
- Conklin, W. G., 1943, Portion of famous "Barren" in Centre County acquired by State Game Lands. *Penna. Game News* April, 6-7, 24-25.
- Corbet, P. S., 1962, *A Biology of Dragonflies*. Witherby LTD, London, 247 pp.
- Donnelly, T. W., 1992, The Odonata of New York. *Bull. Am. Odonatol.* 1(1):1-27.
- Dunkle, S. W., 1986, North American Odonatologists' Meeting. *Selysia* 15:23-24.
- Fergus, C., 1982, Lord & master of June. *Science* 82 June p.54-59.  
[Reprinted with slightly modified text and with different illustrations in, *Penna. Game News* 54(6):49-54 (1983)]
- May, M. L., 1992, Migrating dragonflies in North America. *Argia* 4(2):4-8.
- May, M. L., 1993, Interim report on DSA dragonfly migration project. *Argia* 5(1):12-13.
- McPeck, M. A., 1990, Determination of species composition in the *Enallagma* damselfly assemblages of permanent lakes. *Ecology* 71:83-98.
- Raff, R. A., Raff, E. C., Beatty, G. H., and Beatty, A. F., 1969, Odonata of the Potomac River drainage in Pennsylvania. *Penna. Acad. Sci. Proc.* 43:114-118.
- Reice, S. R., 1994, Nonequilibrium determinants of biological community structure. *Am. Scientist* 82:424-435.
- Sawchyn, W. W. and Gillott, C., 1974a, The life history of *Lestes congener* (Odonata: Zygoptera) on the Canadian prairies. *Can. Entomol.* 106:367-376.
- Sawchyn, W. W. and Gillott, C., 1974b, The life histories of three species of *Lestes* (Odonata: Zygoptera) in Saskatchewan. *Can. Entomol.* 106:1283-1293.
- Schlegel, J. and Butch, G., 1980, The Barrens: Central Pennsylvania's year-round deep freeze. *Bull. Am. Meteorol. Soc.* 61:1368-1373.
- Shiffer, C. N., 1985, "Spring Blue Darner" and "Long-Legged Green Darner" p. 93-97 in *Invertebrates* (P. A. Opler, ed.) in "Species of Special Concern in Pennsylvania" (H. H. Genoways and F. J. Brenner, eds.), Carnegie Museum of Natural History, Special Publication No. 11, Pittsburgh, PA.
- White, H. B., 1963, Seasonal distribution and relative abundance of Odonata at a large pond in central Pennsylvania. *N. Cent. Br. Ent. Soc. Am. Proc.* 18:120-124.
- White, H. B., 1989, The dragonflies and damselflies (Odonata) of Acadia National Park and vicinity. *Ent. News* 100:89:103.
- White, H. B., Beatty, G. H., and Beatty, A. F., 1968, The Odonata fauna of Bear Meadows, a boreal bog in central Pennsylvania. *Penna. Acad. Sci. Proc.* 42:130-137.
- White, H. B. and Raff, R. A., 1970, Early spring emergence of *Anax junius* (Odonata: Aeschnidae) in central Pennsylvania. *Can. Entomol.* 102:498-499.
- Willey, R. and Eiler, H. O., 1972, Drought resistance in subalpine nymphs of *Somatochlora semicircularis* Selys (Odonata: Corduliidae). *Am. Midland Nat.* 87:215-221.
- Wright, M., 1943, The effect of certain ecological factors on dragonfly nymphs. *J. Tenn. Acad. Sci.* 18:172-196.

Table 1 Yearly Distribution of Odonata Species at Ten Acre Pond from 1955 to 1994<sup>1</sup>

Species	1950's					1960's					1970's					1980's					1990's					Years								
	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	Obs'd			
<i>Epiaschna heros</i>																																	17	
<i>Aeshna canadensis</i>																																	4	
<i>constricta</i>																																	3	
<i>mutata</i>																																	30	
<i>tuberculifera</i>																																	20	
<i>umbrosa</i>																																	7	
<i>verticalis</i>																																	8	
<i>Anax junius</i>																																	38	
<i>longipes</i>																																	19	
<i>Gomphus exilis</i>																																	5	
<i>spicatus</i>																																	12	
<i>Arigomphus villosipes</i>																																	24	
<i>Epicordulia p. princeps</i>																																	1	
<i>Tetragoneuria canis</i>																																	14	
<i>cynosura</i>																																	31	
<i>Cordulia shurtleffi</i>																																	30	
<i>Dorcordulia libera</i>																																	25	
<i>Libellula auripennis</i>																																	6	
<i>axilena</i>																																	1	
<i>cyanea</i>																																	9	
<i>incesta</i>																																	1	
<i>julia</i>																																	34	
<i>luctuosa</i>																																	28	
<i>lydia</i>																																	34	
<i>pulchella</i>																																	31	
<i>quadrinaculata</i>																																	16	
<i>semifasciata</i>																																	20	
<i>Perithemis tenera</i>																																	11	
<i>Erythrodiplax c. minuscule</i>																																	1	
<i>Erythemis simplicicollis</i>																																	23	
<i>Sympetrum internum<sup>2</sup> faneae</i>																																	(35)	
<i>&amp; rubicundulum<sup>2</sup></i>																																	2	
<i>obtrusum</i>																																	4	
<i>semicinctum</i>																																	21	
<i>vicinum</i>																																	27	
<i>Pachydiplax longipennis</i>																																	24	
<i>Leucorrhinia frigida</i>																																	24	
<i>glacialis</i>																																	13	
<i>hudsonica</i>																																	34	
<i>intacta</i>																																	34	





<i>Celithemis elisa</i>																						5/19-9/9	
<i>Pantala flavescens</i>																						6/3 -9/21	
<i>hymenaea</i>																						6/3 -9/27	
<i>Tramea carolina</i>																						4/19-9/10	
<i>lacerata</i>																						4/19-9/21	
<i>Calopteryx maculata</i>																						6/24-7/16	
<i>Lestes congener</i>																						6/10-11/2	
<i>d. australis</i>																						5/2 -9/27	
<i>dryas</i>																						5/21-7/29	
<i>eurinus</i>																						5/18-8/17	
<i>forcipatus</i>																						5/31-9/27	
<i>inaequalis</i>																						5/17-8/8	
<i>rectangularis</i>																						5/31-10/15	
<i>unguiculatus</i>																						6/6 -10/3	
<i>vigilax</i>																						5/31-9/3	
<i>Nehalennia gracilis</i>																						6/27-7/15	
<i>irene</i>																						5/17-8/25	
<i>Chromagrion conditum</i>																						5/11-7/8	
<i>Coenagrion resolutum</i>																						5/11-6/21	
<i>Enallagma aspersum</i>																						5/18-10/1	
<i>boreale</i>																						6/16	
<i>civile</i>																						5/23-11/2	
<i>cyathigerum</i>																						5/12-7/10	
<i>ebrium</i>																						5/25-7/18	
<i>exsulans</i>																						7/29	
<i>geminatum</i>																						5/27-10/7	
<i>hogeni</i>																						5/17-9/7	
<i>signatum</i>																						6/1 -10/7	
<i>triviatum</i>																						7/15-7/22	
<i>vesperum</i>																						6/18-9/15	
<i>Ischnura hastata</i>																						5/3 -10/15	
<i>posita</i>																						5/11-10/7	
<i>verticalis</i>																						4/29-10/17	
Number of Species <sup>3</sup>	1	1	1	3	3	8	0	6	4	3	9	4	2	5	5	4	4	5	5	4	4	2	1
																							3
																							2
																							8
																							2

<sup>1</sup> Records from White (1963) that fill in gaps or extend the distributions are indicated by a "+".

<sup>2</sup> Quarters of the month: 1st to 8th (1), 9th to 15th (2), 16th to 23rd (3), and 24th to the end of the month (4).

<sup>3</sup> As is now apparent to those familiar with the Odonata of the northeastern United States, there are taxonomic problems within *Sympetrum*. Among the specimens taken before 1963 and recorded as *S. rubicundulum* (White, 1963), T.W. Donnelly (personal communication) and Carle, 1993 recognize two species. The less abundant species is *S. rubicundulum*. The common species was described as *S. janeae* (Carle, 1982, 1993) but is considered by some as a geographic form of *S. interrum*. The above table does not include sight records and thus does not represent the full seasonal distribution. Sight records for one or the other of the two species range from 6/6 to 10/17. Because these sight records are not included above, the species totals for some monthly quarters do not tally.

DESCRIPCION E HISTORIA NATURAL DE LAS LARVAS DE ODONATOS DE COSTA RICA.  
IV: *MECISTOGASTER ORNATA* (RAMBUR, 1842) (ZYGOPTERA, PSEUDOSTIGMATIDAE).

Alonso Ramírez

Apdo 1643-3000, HEREDIA, COSTA RICA.

SUMMARY

Three genera of Pseudostigmatidae occur in Costa Rica. Of those *Mecistogaster* has three species, the larvae of two of which are known: *M. modesta* (Calvert, 1911) and *M. ornata* (this paper).

Larvae of *M. ornata* were found living in a tree hole full of water. The larvae were living together with *Orthemis ferruginea*, *Megaloprepus caerulatus* (Odonata), and with Chironomidae (Diptera).

*M. ornata* differs from *M. modesta* in the shape of the caudal gills and in having no setae in the tarsal claw. Both species vary considerably in size. They differ from *Pseudostigma aberrans* in the lack of antennal setae and in size.

Key to Central American Pseudostigmatid larvae:

1. Caudal gills with a pale area; pulveriform swelling present ..... 2
- 1'. Caudal gills lacking pale areas; no pulveriform swelling ..... 3
2. Total length, without gills, of the ultimate stage about 30 mm; pale area at the apex of the gills only slightly evident ..... *Pseudostigma aberrans*
- 2'. Total length, without gills, of the ultimate stage about 25 mm; pale area at the apex of the gills clearly evident ..... *Megaloprepus caerulatus*
3. Antennae bare, gills slightly petiolate .....  
..... *Mecistogaster ornata*
- 3'. Antennae with fine hairs near the articulations, gills markedly petiolate .. *Mecistogaster modesta*

Larvae unknown: *M. linearis*, *P. accedens*.

RESUMEN

En el presente trabajo se describe e ilustra la larva de *Mecistogaster ornata*. De las tres especies de *Mecistogaster* registradas en Costa Rica, solo dos,

*M. modesta* (Calvert, 1911) y *M. ornata* (aquí descrita), cuentan con su larva descrita. Ambas se diferencian en especial por que la primera presenta: sedas en el ápice de algunos de los artejos antenales, además en la forma de las branquias. *M. ornata* se separa de *Pseudostigma aberrans* por la falta de sedas en las antenas y por el tamaño. Se discute brevemente algunas características del hábitat.

INTRODUCCION

La familia Pseudostigmatidae posee en Costa Rica tres géneros y seis especies (Paulson, 1982). A pesar de ser un grupo llamativo, por tener adultos vistosos, previo a este trabajo solo se conocían las larvas de dos especies, *Mecistogaster modesta* (Calvert, 1911) y *Pseudostigma aberrans* (Novelo, 1993).

Fincke (1992) describe brevemente como diferenciar las especies: *Mecistogaster linearis*, *M. ornata* y *Megaloprepus caerulatus*. Dando a entender que a pesar de no existir una descripción oficial, las larvas se conocen debido a que han sido objeto de estudios ecológicos y de comportamiento, como en el caso anterior.

Las larvas utilizadas para la elaboración del presente fueron, también, colectadas con el fin de realizar estudios ecológicos (de la Rosa y Ramírez, en prensa).

HISTORIA NATURAL:

Los pseudostigmatidos habitan en pequeños cuerpos de agua, como los formados en los huecos de árboles, bromelias y otros, donde se desarrollan sus larvas. Su distribución se extiende desde los 0 a los 1200 m.s.n.m. (Fincke, 1984) y en Costa Rica se les encuentra en ambas vertientes.

Las larvas de *M. ornata* colectadas se encontraban habitando en huecos llenos de agua en árboles caídos. El tronco se hallaba a pocos metros del

suelo. Los huecos los compartían con otras libélulas como *M. caerulatus* y *Orthemis ferruginea* además de larvas de Chironomidae y otros dípteros.

Las larvas tenían una cubierta de algas en toda la superficie dorsal del cuerpo, incluso en una de las caras de las branquias. Además se encontraron quironómidos foréticos, adheridos a las algas de las branquias y las cubiertas alares. Los detalles de estas relaciones los describen y discuten de la Rosa y Ramírez (en prensa).

#### **MECISTOGASTER ORNATA RAMBUR, 1842** (Figs. 1 - 5)

**Material estudiado:** una larva, hembra, último estadio. Una exuvia, macho, último estadio. Estación Biológica Maritza, Area de Conservación Guanacaste, prov. de Guanacaste, Costa Rica. 15 Jul 91. A. Ramírez y B. Sweeney, colectores.

**Coloración:** exuvia y larva, totalmente castaña oscuro, presenta algunas líneas en el margen posterior de los segmentos abdominales como en la figura 1. Los especímenes estudiados estaban cubiertos de algas lo que hizo difícil definir el patrón de coloración.

**Cabeza:** más ancha que larga, los lóbulos cefálicos presentan sedas gruesas y fuertes cerca del margen posterior. El occipucio fuertemente cóncavo (fig.1). Antenas, completamente glabras, de 7 artejos, el tercero antenómero el más largo (fig.4). Los ojos prominentes y rodeados de una hilera de sedas, en vista ventral. Mandíbulas unirrámicas, ambas con cuatro dientes, el ventral con uno pequeño en la base, los dientes de la mandíbula izquierda son todos del mismo tamaño. Maxilas con dos hileras de dientes, tres en la dorsal y dos en la ventral, ambas hileras continúan en una hilera de sedas basales. Palpos maxilares con sedas esparcidas. Labio, con la articulación del prementón - postmentón a nivel de las procoxas. Prementón (fig.2) con sedas fuertes en los márgenes laterales, en vista ventral. Lígula muy convexa y ligeramente aserrada. Los palpos (fig.3) con seis sedas largas formando una hilera, presenta dos dientes terminales del mismo tamaño, los márgenes laterales lisos y el gancho móvil relativamente corto.

**Tórax:** sin marcas sobresalientes, ambos pares de cubiertas alares llegan hasta el quinto segmento abdominal (fig.1). Fémures con una hilera de espinitas dorsal y otra ventral, las tibias lisas dorsalmente y con dos hileras de espinitas, una en cada margen alcanzando los 0.5 basales, en vista ventral; tarsos con una hilera de espinitas en cada margen ventral.

**Abdomen:** De coloración uniforme, sin ningún tipo de marca sobresaliente, a excepción de un patrón rayado en el margen distal de cada segmento abdominal. No presenta protuberancias dorsales ni espinas laterales, posee sedas escamiformes esparcidas por toda la superficie. Gonapófisis de la hembra alcanza los 0.5 del segmento 10. Branquias delgadas y pecioladas con forma de hoja (fig.5).

**Dimensiones de la larva, hembra (en mm):** longitud total (sin las branquias) 17, abdomen 11, branquias 4.5, metafémur 3, cabeza: anchura 3.5, largo 2, prementón: anchura 2, largo 3.

#### **DISCUSION**

Calvert fue el primero en describir una larva para el género, *M. modesta*, las larvas de esta especie se encuentra habitando en bromelias que sean capaces de retener agua entre las bases de sus hojas.

Al comparar la larva de *M. ornata* con la de *M. modesta* descrita por Calvert (1911), se encuentran pocas diferencias. La longitud del cuerpo varía grandemente entre individuos de una misma especie, probablemente relacionado con el tamaño del cuerpo de agua en el que la larva se desarrolló y la disponibilidad de alimento. Así pues, Calvert encontró larvas de 11 a 21 mm de longitud, excluyendo las branquias, mientras que las del presente estudio miden 11 mm. A pesar que los adultos de *M. modesta* suelen ser más pequeños, ninguna de las especies presenta un ámbito de tamaño fijo y probablemente su tamaño varíe de acuerdo con el tamaño de la larva.

El hábitat parece ser una característica útil para separar las especies, ya que hasta el momento se ha encontrado a *M. modesta* habitando en bromelias únicamente y a *M. ornata*, *Megaloprepus caerulatus* y *Pseudostigma aberrans* en huecos de árboles. Fincke (1992) encontró que las especies que se desarrollan en huecos de árboles no utilizan

las bromelias aún cuando estas se encuentren disponibles.

Las pocas diferencias morfológicas que se encuentran entre *M. ornata* y *M. modesta* se detallan a continuación, *M. modesta* se diferencia por tener:

- a) tarsos con sedas en la parte dorsal.
- b) antenas con sedas cercanas a la articulación distal, en los segmentos apicales.
- c) branquias con la base más pedunculada (fig.6)

Por su parte *M. ornata* se separa de *Pseudostigma aberrans* fácilmente por el tamaño, ya que la larva de la última mide alrededor de 29 mm (Novelo, 1993). Las antenas de *P. aberrans* poseen algunas sedas cercanas al margen distal de cada antenonero. Las branquias de ambas especies son similares en forma, pero las de *M. ornata* no presentan la mancha blanca en el ápice, caracter que la separa también de *M. caerulatus*.

#### CLAVE PARA LAS ESPECIES DE PSEUDOSTIGMATIDAE EN COSTA RICA:

- 1- Punta de las branquias caudales con una área pálida, empodio pulviforme presente ..... 2
- 1'- Puntas de las branquias sin marcas pálidas, empodio pulviforme ausente ..... 3
- 2- Longitud total, sin branquias, del último estadio de alrededor de 30 mm, área pálida del ápice de las branquias poco evidente .....  
..... *Pseudostigma aberrans*
- 2'- Longitud total, sin branquias, del último estadio de alrededor de 25 mm, área pálida del ápice de las branquias bien evidente .....  
..... *Megaloprepus caerulatus*
- 3- Antenas glabras, branquias poco pecioladas .....  
..... *Mecistogaster ornata*
- 3'- Antenas con sedas cerca de las articulaciones, branquias marcadamente pecioladas .....  
..... *Mecistogaster modesta*

Las larvas de dos especies no se conocen al tiempo presente: *M. linearis* y *P. accedens*.

#### AGRADECIMIENTOS

Mis más sincero agradecimiento al Dr. Carlos de la Rosa y al Area de Conservación Guanacaste por las

facilidades proveídas para la realización del estudio. Al M en C Rodolfo Novelo Gutierrez por facilitarme una copia de su trabajo sobre *P. aberrans*, aún antes de ser publicado.

#### REFERENCIAS

Calvert, P.P. 1911. Studies on Costa Rican Odonata. III. Structure and Transformation of the Larva of *Mecistogaster modestus*. Entomol. News 22 (10): 449-460.

de la Rosa C. & Ramírez, A.. Observations on Phototactic Behavior and Phoretic Associates of Larvae of *Mecistogaster ornata* (Pseudostigmatidae, Zygoptera) from Northern Costa Rica. Notulae Odonatologicae, en revisión.

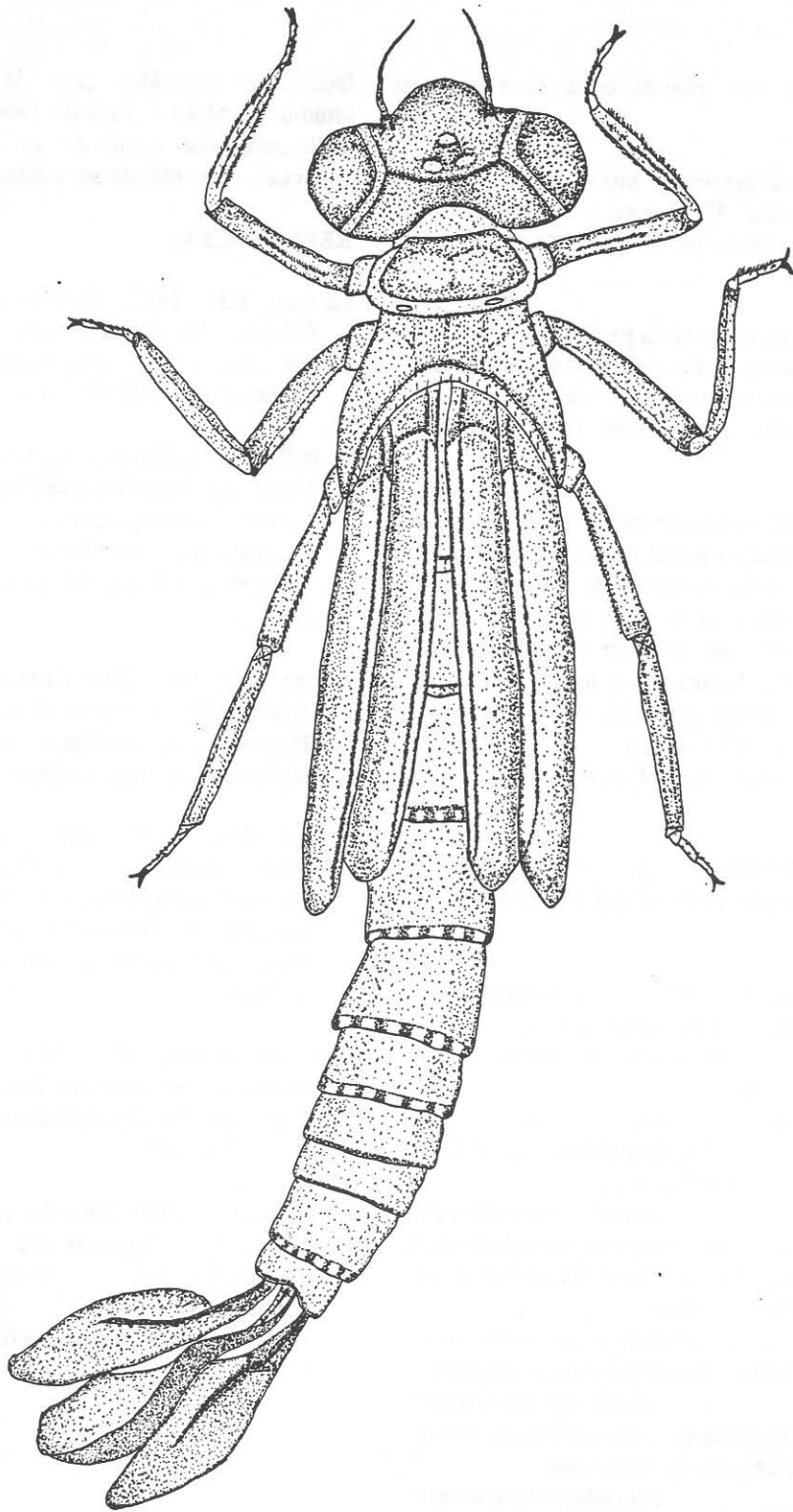
Fincke, O.M. 1984. Giant Damselflies in a Tropical Forest: Reproductive Biology of *Megaloprepus caerulatus* with notes on *Mecistogaster*. Adv. Odonatol. 2:13-27.

Fincke, O.M., 1992. Behavioral ecology fo the giant damselflies (Odonata: Zygoptera: Pseudostigmatidae) of Barro Colorado Island, Panama. In: D.Quintero and A.Aiello, Eds. Insects of Panama and Mesoamerica. Oxford U. Press.

Novelo-Gutierrez, R. 1993. La náyade de *Pseudostigma aberrans* Selys, 1860 (Odonata: Zygoptera: Pseudostigmatidae). Folia Entomol. Mex. 87: en prensa.

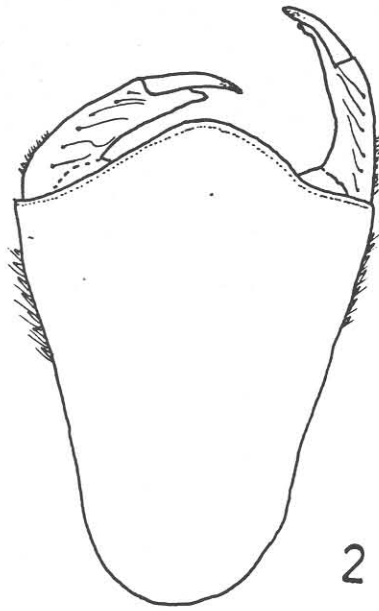
Paulson, D.R., 1982. Odonata. In: S.H. Hulbert & A. Villalobos-Figueroa [Eds], Aquatic Biota of Mexico, Central America and the West Indies, PP 249-277, San Diego State University, San Diego. California.





**LAMINA 1:**

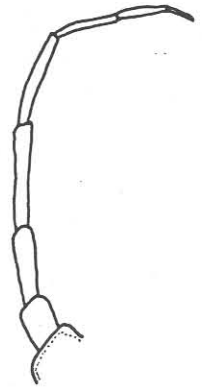
Fig. 1: *Mecistogaster ornata*, larva último estadio, hembra, vista dorsal.



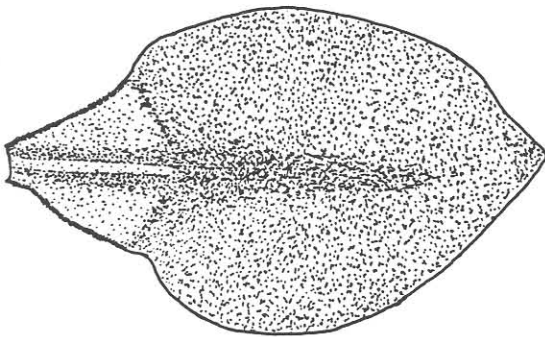
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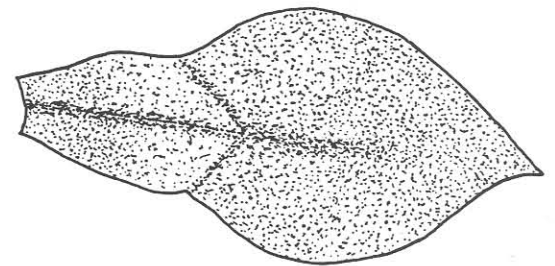
3



4



5



6

**LAMINA 2:**

Fig. 2- 5. Detalles de la morfología de *Mecistogaster ornata*. Fig. 2. Prementón, vista dorsal. Fig.3. Palpo labial, vista dorsal. Fig.4. Antena, vista dorsal. Fig. 5. Branquia lateral, vista lateral. Fig. 6. Branquia lateral de *M. modesta*, vista lateral.

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