ARCHILESTES GRANDIS (GREAT SPREADWING) IN CENTRAL NEW JERSEY, WITH NOTES ON WATER QUALITY[1]

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ABSTRACT

Archilestes grandis has undergone extensive range expansion during this century. *A. grandis* has been documented in a wide variety of aquatic habitats often with varying degrees of degradation or contamination, and biotic indices for this species based on relative water quality tolerances tend to vary widely. Water quality data for *A. grandis* habitats is limited, particularly in the northeast. We evaluated various water quality parameters at three man-made aquatic habitats in central New Jersey that support *A. grandis*. These evaluations and those of others suggest that *A. grandis* is very tolerant of water conditions generally considered "poor" by conventional water quality indices; this apparent tolerance of *A. grandis* to degraded water quality may explain its recent range expansion. The occurrence of this species in habitats generally depauperate in other, less tolerant odonate and other macroinvertebrate species may be a useful indicator of "poor" water quality in biotic "index" systems. Moreover, the facility with which the adult odonate community of an aquatic system can be characterized suggests, as other investigators of odonates have proposed, that "odonate metrics" would be ideal for the rapid biological assessment of such ecosystems.

INTRODUCTION

Archilestes grandis (Rambur), the Great Spreadwing damselfly, has undergone remarkable range expansion during this century. Early in the century, the species was apparently restricted to the southwestern United States, Central America, and northern South America (Needham, 1929; Gloyd, 1980). *A. grandis* was first recorded east of the Mississippi River in Ohio in 1927 (Williamson, 1931). Subsequent sightings included those in western Pennsylvania in 1935 (Ahrens, 1935), Washington, D.C., in 1949 (Donnelly, 1962), and Philadelphia in 1951 (Ferris, 1951). By the mid-1960's, *A. grandis* had been collected in New Jersey, and is now widely, but patchily, distributed in this state, with populations known from seven counties (May, 1996). The first New York record was established in 1992 (Blanchard, 1992) and, apparently, the species has also recently been collected in Vermont (pers. comm., Donnelly, 1996).

Throughout its range, *A. grandis* has been documented in a wide variety of habitats, including slow-moving forested streams with silt substratum (Orr, 1996a), rocky pools of streams or ponds (Tennessen *et al.*, 1995), pristine streams in Costa Rica (pers. comm.; Donnelly, 1996), permanent ponds or impoundments (Westfall and May, 1996), artificial ponds (Ingram, 1976), canals (Orr, 1996b), temporal bodies of water in open areas (pers. comm.; E. Esquivel, 1997), and drainage and irrigation ditches (pers. comm.; Donnelly, 1996). *A. grandis* is also often noted in waterbodies with varying degrees of degradation or contamination, including brooks adjacent to animal pens, open bodies of water with urban and industrial contamination (Ramirez, 1994), ponds subject to fish kills from agricultural runoff (Lasswell *et al.*, 1995), stream pools with high temperatures (pers. comm.; D. Huggins, 1997), and dirty creeks around cities and towns in Costa Rica (pers. comm.; C. Esquivel, 1997). The observations of Williamson (1931) on the habitat of *A. grandis* in Ohio are particularly illustrative:

> "There is a little brook which runs through the west side of the campus at the Western College, and which at its head is merely a draw. One branch of this draw goes back of some houses on the campus, and is apparently little more than a sewer; septic tanks are located on it. Another branch of the draw goes back into the Miami campus, and receives refuse liquids from the chemical laboratory and the power house. [the creek] never froze but "steamed" all winter...[and] the chemicals it carried killed all the goldfish, planted in the pool, several times."

Perhaps as a consequence of the sometimes patchy distribution of this species and its observed occurrence in a wide variety of aquatic habitats, "biotic index"

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systems based on relative water quality tolerances tend to attribute rather widely varying index values to this odonate. The biotic indices for *A. grandis* specifically, the genus *Archilestes*, and the family Lestidae are listed below as assigned by a range of federal and state resource agencies (all indices use a smaller numerical value to designate less tolerance of degraded water quality; the range of the particular index is indicated in parentheses following the index value). In all indices cited, the lower integer values indicate intolerance, and high integer values indicate tolerance.

EPA (1989) Rapid Biological Assessment (for family Lestidae) = 9 (scale of 1-10)

State of Illinois Environmental Protection Agency (1987) (genus ***Archilestes***) = 1 (scale of 1-10)

State of Kansas Department of Health and Environment (1985) (for ***A. grandis***, genus ***Archilestes***) = 3 (scale of 1-5)

Kansas Biological Survey (1988) (for ***A. grandis***,
Agricultural Pesticides = 5 (scale of 0-5)
Heavy Metals = 1 (scale of 0-5)
Persistent Organic Compounds = 3 (scale of 0-5)
Salinity = 3 (scale of 0-5)
Suspended Solids and Sediments = 4 (scale of 0-5)
[Average] 3.2 (scale of 0-5)

Based on this array of indices, one might infer **that** ***A. grandis*** might be intolerant, moderately tolerant, or very tolerant of degraded water quality conditions; no consensus is evident in these various indices.

During various field investigations and sampling trips over several years, one of us (D. Moskowitz), noted the occurrence of ***A. grandis*** in a variety of degraded aquatic habitats in central New Jersey. Many of these habitats were artificial aquatic environments created by man for stormwater detention, or degraded natural habitats receiving significant anthropogenic loadings. The occurrence of ***A. grandis*** in such habitats qualitatively attests to a broad tolerance for this species; however, although the above-referenced indices may provide a relative rating of the species with respect to general aquatic conditions, quantitative water quality data from ***A. grandis*** habitats are limited (Bick, 1958; Hart and Fuller, 1974; Lasswell et al., 1995) and are lacking for the northeast. The following discussion provides a quantitative assessment of water quality in three man-made aquatic habitats that support populations of ***A. grandis***.

METHODS AND STUDY AREA

During the summer/fall of 1996, eight adult populations of ***A. grandis*** were located in central New Jersey. Four of the populations were found in Middlesex County, three in Somerset County, and one in Mercer County. The habitats included a small intermittent stream through a horse pasture, a farmland ditch, an irrigation pond, two stormwater detention basins, a small impounded roadside wetland, a large river (North Branch Raritan River), and a small woodland stream.

All of the waterbodies appeared by inspection to possess degraded water quality. The woodland stream, farm pond, roadside wetland, and the stormwater detention basins receive extensive stormwater runoff from roadways and developed areas. The woodland stream also flows through a large automobile junkyard and a scrap metal processing facility and floatable litter was abundant in the stream. Canada goose (*Branta canadensis*) droppings were extensive on the maintained lawns surrounding one of the Somerset County detention basins. This detention basin is treated twice annually with the herbicide Diquat and with a copper-based algicide. The horse pasture stream receives some runoff from roadways, is completely surrounded by maintained equestrian fields and pasture, and is subjected to significant runoff from these areas. The farmland ditch abuts an active cornfield and is fed primarily by agricultural runoff. The large river has been classified by the New Jersey Department of Environmental Protection as an FW2 Non-Trout water (NJDEP, 1994), which reflects water quality appropriate for warm-water fish species, but which is adequate only for temporarily supporting stocked trout.

At most of these sites, fewer than 10 individuals of ***A. grandis*** were observed. The greatest abundance was encountered on October 10, 1996, at the large stormwater detention basin in Somerset County, where more than thirty individuals were found, including numerous pairs in tandem. As a result, this detention basin was selected for an initial analysis of various trophic-state water quality parameters.

On December 2, 1996, surface water samples were collected from the detention basin, and were submitted to a New Jersey-certified laboratory for an analysis of fecal coliforms, chlorophyll *a*, nitrate-nitrogen and five-day biochemical oxygen demand (BOD_5 = a measure of the biodegradable organic loading in a water sample). Meteorological conditions were: air temperature of 50°F, breezy wind, and antecedent rainfall as recent as the preceding night. The water samples were obtained by hand by immersing prepared sample bottles to a depth of approximately eight inches below the water surface.

The water samples were placed on ice in a cooler in the field, and were delivered to the laboratory within three hours of the sampling. Field measurements of surface temperature and dissolved oxygen were also obtained using a YSI Model 55 Dissolved Oxygen Meter. The transparency of the water was measured using a Secchi disk.

On October 28, 1997, additional water quality measurements and samples were taken from a detention basin and an irrigation pond located in Middlesex County, New Jersey. At both sites adult ***A. grandis*** were observed in tandem and larvae have been found in a short drainage ditch feeding the irrigation pond (pers. comm., M. May, 1997). The sample methodology and water quality parameters were the same as in 1996. Meteorological conditions were: air temperature of 55°F, and breezy wind.

The analytical values for DO saturation, nitrate-nitrogen and total phosphorus concentration, BOD_5, and fecal coliforms can be used to generate water quality subindex values according to charts prepared by the National Sanitation Foundation (Brown *et al.*, 1970). This index was first proposed by Brown *et al.* as a method of facilitating the interpretation of water quality data sets. For the full index computation, nine water quality parameters quantified are converted to subindex values according to curves relating the value of a particular water quality variable with the sense of that value in terms of water quality. The curves were the result of Delphi polling of 142 water quality experts by the NSF. The nine parameters measured as the basis for the full NSF-WQI are: temperature (as deviation from ambient), dissolved oxygen saturation, pH, biochemical oxygen demand (BOD_5), total phosphorus, nitrate, turbidity, total solids, and fecal coliforms. In this case, because the full set of nine parameters were not run on the water samples, the subindex values are evaluated without aggregation. Additionally, for nitrate-nitrogen and total phosphorus, the inner limiting curve for the subindex was used because the range of nutrient concentrations evaluated in the NSF subindex curves extends to very high concentrations of these ions not often found in non-process waters.

The analytical or field values for chlorophyll *a*, total phosphorus and Secchi disk depth can be used to generate Trophic State Indices (TSI's) according to formulae presented by Carleson (1977). Carleson evaluated the relationships between the trophic state of lakes and three important water quality parameters: summer surface orthophosphate concentration [P], summer Secchi disk depth (Z), and summer chlorophyll concentration [B], and found that lake trophic status had a pronounced relationship to the logarithm of each of these values. Carleson established a Trophic State Index that varied from 0 to 100 (with the state of eutrophy increasing as the index increased), and was related to these three parameters by the following equations:

$I(P) = 4.2+33.2 \log[P]$,
where [P] is the orthophosphate concentration in milligrams per cubic meter (ppb)

$I(T) = 60-33.2 \log Z$,
where Z is the Secchi disk transparency in meters

$I(B) = 30.6+22.6 \log [B]$,
where [B] is the chlorophyll *a* concentration in milligrams per cubic meter (ppb)

The NSF-WQI subindices (as interpolated from the NSF curves) and Carleson's TSI's are summarized for the three surface water samples in Table 2.

RESULTS AND DISCUSSION

Table 1 presents the results of the field and laboratory water quality measurements in the three surface waters sampled.

Inspection of the water quality data from Table 1 indicates that aquatic habitats in which ***A. grandis*** were found generally had dissolved oxygen concentrations well below saturation (28 - 58%), reduced transparency (0.25 - 0.91 m), high five-day biochemical oxygen demand (5.0 - 7.0 mg/l), and high concentrations of

WATER QUALITY PARAMETER	Somerset County basin (12/2/96)	Middlesex County basin (10/28/97)	Middlesex County Irrigation Pond (10/28/97)
Temperature (°C)	9.7	11.0	11.1
Dissolved Oxygen (mg/l)	6.80	4.13	6.7
Dissolved Oxygen Saturation (%)	60.2	37.3	61.3
Nitrate-Nitrogen (mg/l)	<0.50	<0.50	0.88
Five-day Biochemical Oxygen	5.0	5.0	7.0
Fecal coliforms (MPN/100 ml)	>2400	900	>2400
Chlorophyll a (mg/m^3)	3.74	2.17	3.74
Secchi disk depth (m)	0.25	0.61	0.91
Total Phosphorus (mg/l)	ND	0.051	0.233
Alkalinity (mg/l as $CaCO_3$)	ND	9.2	43.5

Table 1 Water Quality Analysis at selected *A. grandis* habitats

fecal coliforms (900 - >2400 MPN/100 ml). These are general properties expected in degraded surface waters. Biogenic nutrients were variable, with only the irrigation pond showing elevated phosphorus concentrations. Chlorophyll *a* concentrations were not excessive at any of the sample locations.

The NSF-WQI subindices (Table 2) confirm the occurrence of generally poor water quality in these *A. grandis* habitats, although the range of these subindices is pronounced, from 15 (very poor) for fecal coliforms to >92 (very good) for nitrate-nitrogen. The Carleson's Trophic State Index values are also variable, with the chlorophyll *a* indices indicating mesotrophy, but the Secchi disk and total phosphorus indices indicating eutrophy. These apparently disparate results are likely the result of reduction in water clarity due to the presence of elevated suspended solids, both organic and inorganic, rather than a reduction of clarity due to elevated primary production. Such a condition would likely yield an elevated BOD_5 value and undersaturation of dissolved oxygen, both of which were documented in the field or laboratory determinations of water quality. Such conditions would also be anticipated in surface waters that receive runoff from developed or farmed areas, where suspended sediment and BOD_5 loadings are commonly elevated.

These evaluations of the water quality in man-made or degraded aquatic habitats supporting substantial numbers of *A. grandis* in New Jersey indicate that this odonate species is very tolerant of water conditions generally considered "poor" by conventional water quality indices. These specific observations, when combined with the observations and biotic indices reported by others, portray *A. grandis* as an odonate species with broad tolerances and the ability to flourish in a wide variety of degraded aquatic habitats. This apparent adaptability may explain the rapid range expansion *A. grandis* has undergone this century. As the anthropogenic influences on aquatic environments increased through most of the century, *A. grandis* may have been able to utilize habitats that proved intolerable to other odonate species, possibly diminishing competitive interactions and promoting range expansion in this species.

The proportion of tolerant species to the total number of species in a particular community is often used as an ecological or biotic metric - a value that can be used, generally with other independently-derived metrics, to evaluate the general "health" of a particular ecosystem. Based on the observations detailed herein, *A. grandis* would clearly be assigned to the "tolerant" category as used in several biotic metrics, e.g., EPA's Rapid Bioassessment Protocols, or RBP's (EPA, 1989), or Pennsylvania's Fish Metrics Development Project (Smith et al.; 1997). Interestingly, because the odonates have relatively long-lived, conspicuous adult stages that can be recognized, and even censused, by visual observation, the derivation and/or refinement of odonate metrics for surface waters could provide a mechanism for "rapid biological assessment" of such

NSF-WQI SUBINDICES[1]	Somerset County basin (12/2/96)	Middlesex County basin (10/28/97)	Middlesex County Irrigation Pond (10/28/97)
Dissolved Oxygen Saturation	56	28	58
Nitrate-Nitrogen	>92	>92	84
Total Phosphorus	ND	91	57
BOD_5	55	55	44
Fecal coliforms	15	21	15
CARLESON'S TSI[2]			
Chlorophyll a	43.5	38.2	43.5
Total Phosphorus	ND	60.9	82.8
Secchi disk depth	80.0	67.1	61.4

[1] NSF-WQI values range from 0-100, with higher values indicating better water quality.
[2] Carleson's TSI's range from 0-100, with lower values indicating more oligotrophic conditions

Table 2 . Water Quality and Trophic State Indices for Selected *A. grandis* Habitats

waters without the need for extensive underwater sampling or detailed taxonomic experience in the identification of benthic macroinvertebrates. In essence, odonate assemblages could be surveyed in a manner similar to that used by experienced "birders," and the survey information could be used in the derivation of an odonate metric for a particular water body. We support the efforts of those authors (Carle, 1979; Minter and May, 1996; Sprandel, 1996; Daigle, 1998) who have proposed such metrics, and advise that, to this end, the collection of quantitative water quality data should be an integral component in the description of distributions of various odonate species.

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