Odonata Larvae in Urban Retention Ponds in Winnipeg, Manitoba, Canada

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ABSTRACT

We assessed the diversity of Odonata larvae in retention ponds, a prevalent but unexplored aquatic habitat in many cities. Ten storm water retention ponds in Winnipeg were sampled for larval Odonata during the 2001 summer season. Twenty-two species were collected. Six species were common in four or more ponds: *Anax junius*, *Sympetrum costiferum*, *Lestes unguiculatus, Enallagma hageni, E. ebrium* and *E. civile*. Of the other species found, only one specimen each of 10 species was collected. There appeared to be fewer species and fewer individuals of each species in ponds where vegetation control practices had been applied. No juvenile Odonata were found in ponds where carp were present. *Anax junius* was most abundant in ponds with emergent vegetation. However, in one pond where there had been no vegetation control and where there was no emergent vegetation, the greatest number of species was collected.

INTRODUCTION

Man-made water bodies such as ponds, farm dugouts and gravel pits (Benke and Benke 1975; Wissinger1988a; Gribbin and Thompson 1991; Moore 2001; Catling and Brownell 2002) can be important habitats for Odonata, and may include rare and endangered species. Urban storm water retention ponds are thought to be poor habitat for Odonata because they receive polluted avenue waters containing heavy metals, organic debris and chemical residues (Glassey 1991; Pitt *et al*. 1995). They are a conspicuous component of urban landscapes, and in Winnipeg, Manitoba, Canada, 70 retention ponds are managed to optimize storm-water flow rather than for ecological benefit. Submergent vegetation is removed and emergent vegetation is limited by establishing gravel shorelines. For Odonata, these conditions mean poor water quality, removal of oviposition substrate (Lawton 1970; Corbet 1999) and lack of shoreline emergence support structures and visual cues thought to favour oviposition. We did not find any published studies of Odonata under these conditions.

There are published accounts of Odonata for Manitoba (Walker 1912, 1933, 1941; Conroy and Kuhn 1977) and a recent assessment of the provincial fauna (Hughes and Duncan 2003), based entirely on records for adults. No records for larval Odonata within Winnipeg have been compiled. The study of larvae is important because presence of adult Odonata implies, but does not necessarily prove, reproduction at a given site, because some species travel considerable distances from their natal waters (Corbet 1999). We studied storm water retention ponds in Winnipeg over one season, to measure diversity of juvenile Odonata and to record environmental correlates.

MATERIALS AND METHODS

The first storm water retention ponds were constructed in the 1960's, when Winnipeg started to separate avenue water from residential waste flows. All avenue runoff in new suburban areas was directed into these basins which are linked underground and flow into the closest stream or river. Nine of 70 ponds were selected from different areas of the city based on ease of access, vegetation control treatments and inclusion in the Winnipeg Department of Water and Waste water quality monitoring programme. A pond not receiving avenue flow and located in a semi-rural setting was included to compare odonate diversity with city ponds. This pond differed also in that its shoreline was largely overgrown with trees and bushes, and there was little emergent vegetation. Ponds were numbered and a summary of their locations and environmental conditions is provided in Table 1.

Retention ponds were originally engineered so that water levels remain fairly constant throughout the year, with temporary gain following high rainfall or gradual lowering during drought. Ponds were surrounded by a public park, residential housing, or a combination of the two. In winter, retention ponds were covered with ice, possibly creating anaerobic conditions. Summer conditions included high nutrients, high temperatures, heavy runoff and associated pollution. The Winnipeg Water and Waste Department collected data for 13 ponds in 2001, including Ponds 1, 7, 8, 9 and 10, examined by us for odonates. The ponds were shallow (max. depth 1.6 ± 0.25 m), alkaline (pH 9 ±

0.75) and nutrient-rich environments (total nitrogen 3 ± 1.3 ppm; phosphorous 0.26 ± 0.17 ppm). The substrate consisted of clay overlain with organic matter. Shorelines were covered with coarse, two-inch gravel from two metres above the waterline and extended into the water from zero to three metres. Filamentous algae were present in all ponds throughout the summer, along with extensive growth of pondweed (*Potamogeton* spp.) and coontail (*Ceratophyllum demersum* Linnaeus). Low rainfall and relatively high water temperatures (>20°C) resulted in the margins of smaller ponds being thick with submergent vegetation. The City controlled vegetation with herbicide (diquat, dichlorophenol) or mechanical removal. This sometimes included removal of emergent vegetation along the shoreline. Thus, some ponds received vegetation treatment and still supported emergent growth in places. Two retention ponds (Ponds 1 and 6) and the rural pond (Pond 2) had no vegetation treatments: the latter two had no gravel shoreline and supported natural growth of emergent vegetation and shrubs. All other ponds received either herbicide treatment or mechanical harvesting. Gravel shorelines were treated yearly with Roundup® (glyphosate) to kill vegetation. Most ponds contained fish, usually mud minnows (*Umbra limi* Kirtland) and sticklebacks (*Culaea inconstans* Kirtland), but bullhead (*Ictaluras melas* Rafinesque) were seen in two (Ponds 7 and 10) and carp (*Cyprinus carpio* Linnaeus) were present in Ponds 8 and 9.

Samples were collected with an aquatic D-net (maximum width, 30 cm; mesh size 1.2 mm). One sweep consisted of three, one-metre passes of substrate or vegetation (Lawton 1970, Johnson 1986) and three sweeps were made on each sampling date. As many microhabitats as possible were sampled, including bare gravel substrate, algae, floating and bottom-rooted aquatic plants, among emergent vegetation, but sampling depth was limited to one metre. Access to shorelines at some ponds was limited to public property, so only that portion of the total margin could be sampled. This was acceptable as each pond appeared to have overall homogenous habitat conditions. All ten ponds were sampled twice a month from June to August, 2001. Specimens were sorted by hand in the field and preserved in 70% ethanol. At each sampling event, emergent vegetation and shorelines were examined for exuviae. Odonate larvae were identified using keys in Walker (1958), Walker & Corbet (1975) and Westfall & May (1996). Voucher specimens were deposited in the J.B. Wallis Museum of Entomology, University of Manitoba, Winnipeg, Manitoba, Canada, R3T 2N2.

RESULTS

Twenty-two species of Odonata were collected from ten ponds during the three months of this study. Great variation was seen among ponds; 10 species (in addition to inseparable specimens of *Enallagma hageni* (Walsh) and *Enallagma ebrium* (Hagen) and early stadia of *Ischnura* spp.) were found in Pond 1 and no specimens were collected in Ponds 8 and 9. Table 2 is a summary of all odonate larvae found during this study. Sufficient numbers of larvae of several species were collected to be able to determine patterns of seasonal abundance in the ponds (Figure 1). For instance, the two species of *Lestes* were found only in late June-early July; they hatch in May, develop rapidly as juveniles, and emerge by mid summer (Corbet 1999). Four *Enallagma* species occurred abundantly as late stadia in early June and emerged by mid to late June.

Juvenile *Enallagma* were not found after early July, but adults were abundant, laying eggs in the floating aquatic plants. Beginning 12 July, 2001 and continuing for the rest of the summer, large numbers of early stadia of larval Coenagrionidae were collected, evidence of their synchronous hatch. These large numbers were not seen in ponds where vegetation control had been undertaken (Ponds 3, 4, and 10) and only moderate populations were seen in the rural Pond 2. *Coenagrion angulatum* (Walker) was the only Coenagrionidae larva identifiable to species in early stadia.

Anax junius (Drury) larvae were not collected until late June and then were collected regularly throughout July until their emergence in August. Adults were seen patrolling shorelines only in early June and not after adult emergence. The entire pattern of juvenile development could not be determined in one season, but *A. junius* appeared to be univoltine, with one cohort present in the ponds. *Sympetrum corruptum* (Hagen) was the only libellulid caught in sufficient numbers to determine its life cycle (Fig. 1). It emerged in August, after which adults were seen laying eggs. There was one cohort that either over-wintered as early instars, or delayed hatching until spring.

Within the confines of these small man-made ponds, biotic and abiotic factors differed considerably. Substrate varied from coarse gravel and clay to dead vegetation and a black, anoxic organic medium. Vegetation was also varied, with thick stands of *Typha*, floating algae, algae anchored to gravel and pond weeds growing up from clay substrates. Larvae had different affinities for these habitats over the course of sampling. Overwintering larvae were found at depths greater than one metre in preliminary samples taken in May. As the water warmed, larvae were found throughout the pond. *Anax junius* and the early stadia of Coenagrionidae spp. were usually collected among surface portions of submerged vegetation; Libellulidae larvae were mainly sprawled on bottom substrates among dead vegetation; *Lestes* spp. occurred among emergent vegetation. Immediately before their emergence, *A. junius* and *Enallagma* spp. occurred in very shallow water (<10 cm) at the shoreline.

Differences among ponds may have contributed to the observed differences in species assemblages. For instance, *Lestes* spp. were never found in ponds without emergent vegetation (yet were missing at some ponds that supported it). *Anax junius* was generally found in ponds with mud minnows and were more abundant in ponds with abundant emergent vegetation. Six species of Libellulidae were collected in Pond 1, even though it had no emergent vegetation, a factor thought to encourage oviposition in Anisoptera (Corbet 1999). No Odonata were collected in the two ponds where carp were observed. There appeared to be smaller numbers and fewer species of odonate larvae in ponds with vegetation control than in those without.

Arigomphus cornutus (Tough) was only found in Ponds 2 and 6. These ponds were similar in that they had naturally vegetated shorelines and received water from neither non-residential (Pond 2), nor residential avenues (Pond 6).

Almost half of all species were represented by only one individual, but six species occurred in half or more of ponds containing Odonata. No odonates were collected in two of the 10 ponds. The most commonly collected species were *A. junius* and *Enallagma hageni*, which were collected in 60% of the ponds, followed by *Enallagma ebrium*, *Lestes unguiculatus* (Hagen), *Enallagma civile* (Hagen) and *Sympetrum costiferum* (Hagen) in 40% of ponds. The greatest number of species was collected not in the rural pond, but in the smallest retention pond. No vegetation control had been conducted in this latter pond for approximately ten years.

The collection of *Sympetrum rubicundulum* larvae is surprising. Hughes and Duncan (2003) concluded that earlier reports of its presence in Manitoba were erroneous. However, the identification of the specimens has been verified by both authors as well as Lisette Ross (Ducks Unlimited).

Only 100 exuviae were collected over the sampling period (Figure 2). Sampling every two weeks may be too long an interval to assess emergence quantitatively, with most exuviae being lost to the elements. However, the collected exuviae can be used to document the approximate period of emergence for Coenagrionidae from mid June to early July, *A. cornutus* in late June to mid-July, *S. corruptum* and *A. junius* throughout August. Exuviae were found almost exclusively (96%) on emergent vegetation, never on gravel shorelines or in the short grass above the gravel. At ponds without emergent vegetation (Ponds 1 and 5), *Enallagma* spp. were seen climbing onto floating algal mats and emerging. Exuviae of *S. corruptum* were also found on these mats at Pond 1. On hot afternoons in late June, Common Grackles (*Quiscalus quiscula*) were seen at these same ponds feeding on Odonata larvae from the gravel. On one occasion, an *Enallagma* larva was observed crawling among gravel for several minutes until it found the observer's boot, whereupon it climbed five cm up the side and proceeded to emerge.

DISCUSSION

Of the 95 species of Odonata recorded in Manitoba (Hughes and Duncan 2003), almost one quarter were found in the retention ponds during this study. The observed temporal patterns for larvae of species collected were consistent with reported species-specific oviposition, hatching and emergence patterns. Factors which affected species abundance and diversity among ponds may be related to the limited environmental data gathered, but should be interpreted with caution.

Enallagma spp. and *A. junius* were commonly collected species. Their development and aggregation near the shore before emergence were similar to that reported by others (Trottier 1966; Lawton 1970; Benke and Benke 1975). These species were found together in floating vegetation; *A. junius* may prey upon early instar *Enallagma* (McPeek 1990). Growth and emergence of *A. junius* corresponded to the migratory cohort described by Trottier (1966), where adults migrating from the south in spring lay eggs that hatch and quickly develop to emerge by late summer, the adults then migrate south (Wissinger 1988b). Resident *A. junius* hatched in July, overwintered as late stadia, and emerged in June having spent 11 months as larvae (Trottier 1966). More frequent sampling and arrangement of specimens into discreet instars are required to verify to which population these Winnipeg specimens belong. Ponds 4 and 6, with extensive emergent vegetation, had considerable numbers of *A. junius*. The extent and nature of vegetation is an important factor during oviposition for this species, as its eggs are inserted into stems of emergent plants. It may be for this reason that there were few *A.*

junius found in ponds with little or no emergent vegetation. On the other hand, many species of Libellulidae lay their eggs directly into the water. Libellulids were abundant in Pond 1, where there was little emergent vegetation and few *A. junius*.

Carp are omnivorous, their diets including plants, macroinvertebrates and even mollusks (Marsden 1997). They are also credited with destruction of aquatic macrophytes during their aggressive, bottom-feeding habit (Dr. Gordon Goldsborough, Dept. of Botany, University of Manitoba, pers. comm.). We do not know whether carp may have impacted the Odonata as a result of habitat modification and disruption, or if they consume the larval stages as well. The presence of carp, coupled with shoreline treatments with glyphosate resulted in an absence of vascular plants at these ponds, eliminating oviposition sites in and around the pond for species requiring plants for egg-laying. No species of odonates that are directly or indirectly dependent upon these plants were collected. It may be that ponds experiencing vegetation disruption have less diverse overall invertebrate populations and this may affect colonization success and survival in Odonata with specific prey requirements. Libellulidae may be examples of this phenomenon, as they were found almost exclusively in ponds without vegetation control. Determination of prey populations and Odonata in a controlled vegetation experiment would be needed to test this hypothesis.

In ponds where there was no emergent vegetation, few Lestidae were collected, although there was still a wide diversity of other Odonata. A lack of emergent vegetation may affect overall success when emerging larvae become more openly exposed to bird predation. No exuviae were found at ponds without emergent shoreline vegetation and the presence of avian predators at these ponds may constitute a significant mortality factor during this susceptible stage in the life cycle. Wissinger (1988a) observed that up to 50% of emerging damselflies were consumed by birds. Avian predation appears to be greatly facilitated where there are gravel shorelines.

Reduced diversity has been related to shaded, man-made ponds in England (Moore 2001). Because the rural pond (Pond 2) was surrounded with shrubs, the margins were shaded much of the day. This, in combination with its lack of emergent vegetation may have affected the diversity of odonates found in the pond.

Links among odonate species diversity and environmental factors have not been conclusively demonstrated (Carchini *et al*. 2002). In just one season, it was not possible to determine the most important factors that affect distribution and abundance of each species in Winnipeg retention ponds. Almost half of all species collected during this study were represented by only one specimen. Pond habitats may be marginal for these species, or perhaps these species were not particularly abundant in 2001. Retention ponds have become an important component of the urban landscape, and additional study in future years is needed to gain a better understanding of the ecology of the odonates in them.

In conclusion, storm water retention ponds supported a diverse community of Odonata. It appears that pond habitat could be improved and odonate diversity increased by encouraging vegetation and eliminating carp. If these changes could be accomplished while meeting the intended functions of the retention ponds, improved Odonata habitat would add to the aesthetic appeal and ecological diversity of suburban neighbourhoods.

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Table 1. Environmental variables for storm retention ponds in Winnipeg in which dragonfly larva were sampled in 2001. Some variables are indicated as presence (1) and absence (0).

				Vegetation Controls				
Pond	Location	Dept.* code	Area** (m^2)	Harvest	Herbicide	Gravel shore	Carp	% shore with emerg veg.
1	Isbister & Hamilton	2-2	3,000	0	0	1	0	0
2	Little Mountain Park	-	6,000	0	0	0	0	10
3	Burrows & Benbow	3-3	15,000	1	0	1	0	<10
4	Burrows & Albina	3-2	15,000	1	0	1	0	50
5	Springfield Rd. east of Gateway	4-2	37,500	1	1	1	0	<10
6+	Paquin & Debaets	5-2	15,000	0	0	0	0	100
7	Markham & Lakeland	6-8	7,500	1	0	1	0	<10
8	Dalhousie & Baylor	6-10	15,000	0	0	1	1	0
9	Baldy Creek Park	6-11	11,250	0	0	1	1	0
10	Grandmont Park	6-12	7,500	0	1	1	0	<10

* Winnipeg Department of Water and Waste identification code.

** Estimated values

+Pond 6 is in a sparsely developed industrial park; however, no water quality data were available for this pond in 2001.

Table 2. Total numbers of Odonata larvae and exuviae collected at ten Winnipeg ponds during June to August, 2001. Taxa are listed from most prevalent to least.

Species	Pond 1 (6)[4]	Pond 2 (5)	Pond 3 (5)	Pond 4 (4)	Pond 5 (4)	Pond 6 (5)	Pond 7 (5)	Pond 8 (4)	Pond 9 (4)	Pond 10 (5)	Total Individuals	# of Ponds Where Found
Coenagrionidae spp. imm. [1]	515	88	27	3	830	1429	313	0	0	0	3205	7
Anax junius	2	1	8	31	0	27	5	0	0	0	74	6
Enallagma hageni	0	6	3	2	14	2	0	0	0	4	31	6
Enallagma spp. mature[2]	3	17	0	1	7	5	0	0	0	0	33	5
E. ebrium/hageni[3]	3	5	0	2	16	0	0	0	0	3	29	5
Lestes unguiculatus	0	0	1	7	0	11	2	0	0	0	21	4
Enallagma ebrium	0	2	0	3	4	0	0	0	0	1	10	4
Enallagma civile	1	2	0	2	4	0	0	0	0	0	9	4
Sympetrum costiferum	1	1	1	1	0	0	0	0	0	0	4	4
Enallagma cyathigerum	4	10	0	0	4	0	0	0	0	0	18	3
Coenagrion angulatum	7	0	1	0	1	0	0	0	0	0	9	3
Lestes spp.	0	0	0	6	0	1	1	0	0	0	8	3
Sympetrum rubicundulum[5]	0	0	1	1	0	0	0	0	0	0	2	3
Arigomphus cornutus	0	14	0	0	0	2	0	0	0	0	16	2
Sympetrum corruptum	8	0	0	0	0	8	0	0	0	0	16	2
Sympetrum spp.	11	0	0	0	0	4	0	0	0	0	15	2
Ischnura spp.	10	0	0	0	2	0	0	0	0	0	12	2
Leucorrhinia spp.	12	0	0	0	0	0	0	0	0	0	12	1
Lestes dryas	0	0	0	0	0	1	0	0	0	0	1	1
Nehalennia irene	0	1	0	0	0	0	0	0	0	0	1	1
Aeshna sp.	0	1	0	0	0	0	0	0	0	0	1	1
Epitheca canis	0	0	0	0	0	0	1	0	0	0	1	1
Leucorrhinia intacta	1	0	0	0	0	0	0	0	0	0	1	1
L. frigida	1	0	0	0	0	0	0	0	0	0	1	1
L. proxima	1	0	0	0	0	0	0	0	0	0	1	1
Sympetrum danae	0	1	0	0	0	0	0	0	0	0	1	1
Cordulia shurtleffi	0	1	0	0	0	0	0	0	0	0	1	1
Sympetrum internum	1	0	0	0	0	0	0	0	0	0	1	1
Total species	10	10	6	7	5	6	3	0	0	2		

[1] These are early stadia Coenagrionidae, individuals that were not identified to species or genus.
[2] Late stadia *Enallagma* with missing caudal gills, preventing further identification.
[3] Females of *E. ebrium* and *E. hageni* were not distinguishable and are labeled as *E. ebrium/hageni.*
[4] Sample events during season.
[5] The occurrence of this species in Manitoba needs to be confirmed (Hughes and Duncan 2003) with collections of

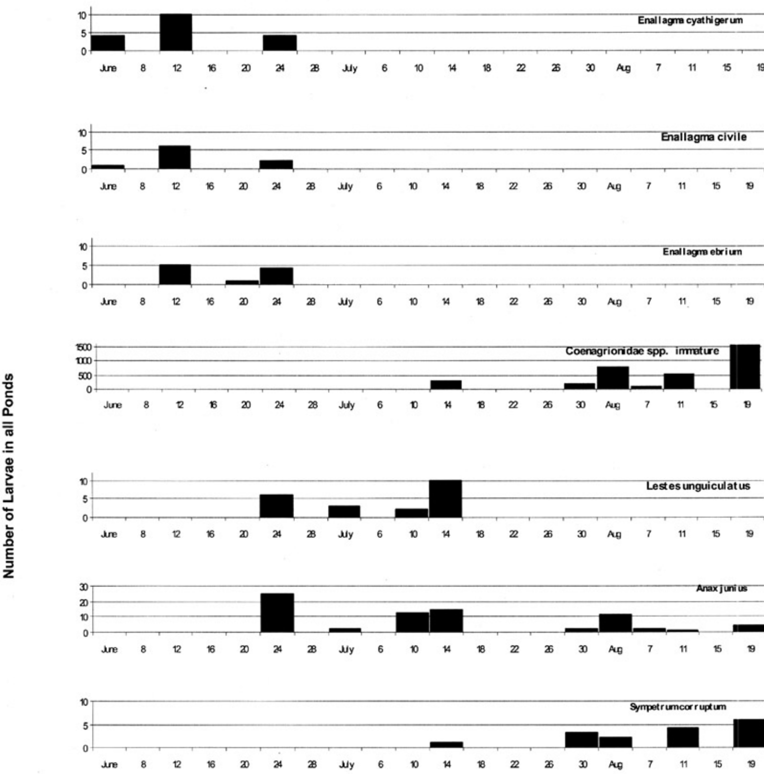

Figure 1. Temporal distribution of Odonata larvae found in retention ponds in Winnipeg in 2001. Note: Most Coenagrionidae are not distinguishable in early stadia, so all were combined into the single category, "Coenagrionidae spp. imm."

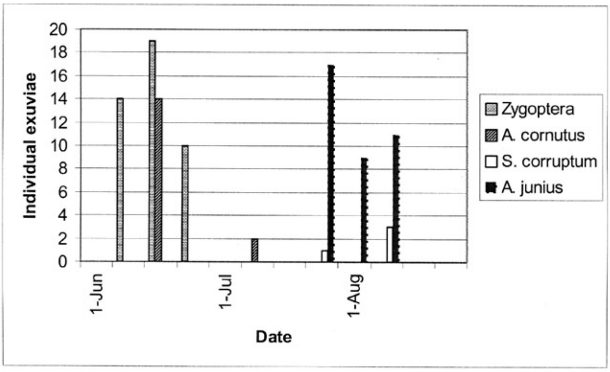

Figure 2. Exuviae of *Arigomphus cornutus*, *Sympetrum corruptum* and *Anax junius* found at retention pond sites in Winnipeg in summer, 2001. Zygoptera include two Lestidae and 41 Coenagrionidae.