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Dragonfly (Odonata: Corduliidae, Macromiidae, Gomphidae, Aeshnidae) and Damselfly (Odonata: Calopterygidae) Exuviae Observed at Record Heights in Pinus strobus and Picea abies Canopies

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Cover Page Footnote

This project was made possible by a grant from the John C. Bock Foundation, the Morris O. Ristvedt Professorship in the Natural Sciences (JGM), the Sigurd Olson Professorship in the Natural Sciences (ERO), and Northland College Summer Internship in Natural Resources funds. Special thanks to comments of the anonymous reviewer, V Karr, L Williamson, and C Liphart. This work is dedicated to the memory of Parker J Matzinger; he was a burst of bright light.

Dragonfly (Odonata: Corduliidae, Macromiidae, Gomphidae, Aeshnidae) and Damselfly (Odonata: Calopterygidae) Exuviae Observed at Record Heights in *Pinus strobus* and *Picea abies* Canopies

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Abstract

Most odonate species do not typically climb higher than 50 cm when choosing an emergence support. We observed multiple species of odonate nymphs using trees as emergence supports at heights greater than 50 cm and up to 4, 6.9, and 14.6 m for *Calopteryx maculata* (de Beauvois) (Ebony Jewelwing, Odonata: Calopterygidae), *Somatochlora minor* (Calvert) (Ocellated Emerald, Odonata: Corduliidae), and *Didymops transversa* (Say) (Stream Cruiser, Odonata: Corduliidae), respectively. These heights represent the greatest heights ever documented for odonate nymph emergence supports. Our research suggests that some species (*S. minor; D. transversa*) appear to have a greater affinity for climbing to great heights during emergence than others (*Dromogomphus spinosus* Selys (Black-Shouldered Spinyleg, Odonata: Gomphidae)*; Basiaeschna janata* (Say) (Springtime Darner, Odonata: Aeshnidae); *Macromia illinoiensis* Walsh (Swift River Cruiser, Odonata: Corduliidae)). Odonate nymphs appeared to have a strong preference for emergence sites at the underside or base of branches. Researchers have hypothesized that competition for emergence sites drives climbing to such great heights. We propose three alternative hypotheses that could potentially explain these unique behaviors.

Keywords: Emergence, support structures, larvae, nymph, climbing behavior, Wisconsin

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In 2014, we began exploring the habitat potential of *Pinus strobus* L. (White Pine) canopies in northern Wisconsin (Laughlin et al. 2017). While climbing a large and old (>70 cm diameter at breast height, >100 years) *P. strobus* research tree on 6 June 2017 we observed *Didymops transversa* (Say) (Stream Cruiser) exuviae and a few emerging adults at various heights in the canopy (Fig. 1; Table 1; N46.20231, W-91.11506). Exuviae were found at 14.6, 11.1, 9, 8.7, 7.4, 6.8, and 1.3 m; adult dragonflies were found at both 11.1 m and 1.3 m. In total, 8 exuviae and 2 adults were observed. Most exuviae were located on the trunk of the tree underneath and at the base of lateral branches (Fig. 1). All exuviae and adults were observed on the north side of the tree, which faced the nearby lakeshore. The lakeshore of Lake Namekagon, Wisconsin, a warm-water eutrophic lake, was approximately 15 m from the base of the tree (Table 1). The shoreline near this tree is forested with a number of old growth and second growth trees that have been unmanaged since region wide harvests from 1890-1900, and is adjacent to Fairyland State Natural Area near Cable, Wisconsin.

Additional observations of odonate nymphs using trees as emergence structures were noted throughout the summer. On 10 July 2017, *Somatochlora minor* (Calvert) (Ocellated Emerald) exuviae were found on a *Picea abies* (L.) Karst. (Norway Spruce) less than 1 m from Bay City Creek (N46.580401, W-90.876279), a semi-urban creek that flows through Ashland, Wisconsin (Table 1). Exuviae were found at 6.9, 6.4, 6.3, 5.6, 4.7, 3.8, 3.2, and 2 m, and also situated underneath the base of branches. The tree could not be accessed safely beyond 8 m, so any exuviae present beyond that height could not be observed. On 11 July 2017, a *Calopteryx maculata* (de Beauvois) (Ebony Jewelwing) exuvia was observed at 4 m on the stem of a *P. strobus* research tree (N46.494608, W-90.930152) located 1 m from the shore of the White River, a sandy-bottomed stream located six miles south of Ashland, Wisconsin (Table 1). Lastly, on 17 July 2017, exuviae of *Dromogomphus spinosus* Selys (Black-Shoul-

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Table 1. Observations of odonate species using trees as emergence supports.

Location	Species	Height range observed	Distance from water source	Tree species
Lake Namekagon	*Epitheca princips*	1 m – 8 m?*	15 m	*Pinus strobus*
Lake Namekagon	*Didymops transversa*	1 m – 14.6 m	15 m	*Pinus strobus*
Lake Namekagon	*Macromia illinoiensis*	1 m – 1.5 m	15 m	*Pinus strobus*
Lake Namekagon	*Dromogomphus spinosus*	1 m – 1.5 m	10 m	*Tsuga canadensis*
Lake Namekagon	*Basiaeschna janata*	1 m – 1.5 m	10 m	*Tsuga canadensis*
White River	*Calopteryx maculata*	4 m	1 m	*Pinus strobus*
Bay City Creek	*Somatochlora minor*	2 m – 6.9 m	<1 m	*Picea abies*

*An exuvia of *Epitheca princips* was found in a *Didymops transversa* sample bag collected between 1 m and 8 m on a research tree. We cannot be certain of the height the *E. princips* exuvia was collected.

dered Spinyleg), *Basiaeschna janata* (Say) (Springtime Darner), and *Macromia illinoiensis* Walsh (Swift River Cruiser) were observed between 1 m and 1.5 m on the stem of *Tsuga canadensis* (L.) Carrière (Western Hemlock) and *P. strobus* trees near one of our research trees on Lake Namekagon (N46.20231, W-91.11506) (Table 1).

To support our observations, exuviae were collected and identified using the keys in Needham et al. (2000) and Westfall and May (2006). Specimens from the Hilsenhoff Aquatic Insect Collection at the Wisconsin Insect Research Collection (Madison, WI) were also examined for comparison.

The regular nature of our observations (multiple observations at multiple heights) on an individual tree for *D. transversa* and *S. minor* suggest that these species may regularly climb to great heights in adjacent forest canopies during emergence. In fact, Hill and Hill (2008) documented *D. transversa* nymphs migrating long distances (as far as 50.3 m) and climbing structures to heights up to 5 m during emergence in the upper peninsula of Michigan. At our Lake Namekagon study site it is notable that *D. transversa, D. spinosus*, *B. janata*, and *M. illinoiensis* were all present, yet only *D. transversa* was observed above 1.5 m; further indicating that certain species are more likely to climb to greater heights during emergence than others.

Climbing to such great heights is a seemingly atypical behavior, as most odonate species do not typically climb higher than 50 cm when choosing an emergence support (Corbet 2004). Corbet documents the greatest distances traveled and heights climbed by odonate nymphs during emergence—of 20 species listed, only two have been documented to climb above 5 m. These two species—*Brachythemis contaminata* (Fabricius) (Ditch Jewel, Odonata: Libellulidae) and *Pantala flavescens* (Fabricius) (Globe Skimmer, Odonata: Libellulidae)—were documented at 12.5 m in India (Mathavan and Pandian 1977). To our knowledge, our observation of *D. transversa* at 14.6 meters is the highest documented climb of any odonate nymphs.

Intense competition for emergence structures may drive such atypical climbing behaviors (Mathavan and Pandian 1977, Corbet 2004). However, our observations of *D. transversa* and *S. minor* do not appear to support the intraspecific competition hypothesis, in part, because of the high availability of vertical structures nearby at all of our study sites. Corbet (2004) hypothesizes that predator avoidance could also explain odonate climbing behavior during emergence. Failure to molt, failure to expand and harden wings (sclerotinization), and predation are the top three causes of mortality for odonate nymphs during emergence (Corbet 2004). Most of the exuviae we observed for both *D. transversa* and *S. minor* were at the base and undersides of branches (though not all). We speculate that odonate nymphs may select such habitats for emergence a) to avoid possible detection and predation from birds (i.e., protection provided by branch), b) to exploit gravitational forces which may play an important role in allowing for uniform wing expansion (Andrew and Patankar 2010), or alternatively, c) odonate nymphs likely have a fixed energy supply that restricts the maximum distance traveled for terrestrial movements during the first stage of emergence, and that they may stop once they encounter one of the first obstacles. In the case of the research tree surveyed near Lake Namekagon, there were scattered, small, senesced branches (branch diameter less than 10 cm,

Figure 1. (a) Author MML ascending a *Pinus strobus* research tree; (b) *Didymops transversa* exuviae underneath the branch of a *P. strobus* research tree and (c) adult *D. transversa* observed in a *P. strobus* research tree.

with a trunk diameter of 60 cm) beginning at 8 m above ground, while live branches with larger diameters began at approximately 13 m above ground. Therefore, in this situation, the potential habitat (large branches) begins a considerable distance above ground and coincides with observations of exuviae. While our data does not allow us to fully test these hypotheses, we suggest that preferential selection for slightly overhanging emergence sites and the relative availability of branches at various heights above ground could explain the emergence heights we observed for *D. transversa* and *S. minor*. We recommend further research on this topic to better understand the factors influencing the selection of emergence structures in climbing odonate species.

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