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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.

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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, Odonata: Corduliidae) 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-Shouldered Spinyleg, Odonata: Gomphidae) and *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.
Table 1. Observations of odonate species using trees as emergence supports.

<table>
<thead>
<tr>
<th>Location</th>
<th>Species</th>
<th>Height range observed</th>
<th>Distance from water source</th>
<th>Tree species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Namekagon</td>
<td>Epitheca princips</td>
<td>1 m – 8 m*</td>
<td>15 m</td>
<td>Pinus strobus</td>
</tr>
<tr>
<td>Lake Namekagon</td>
<td>Didymops transversa</td>
<td>1 m – 14.6 m</td>
<td>15 m</td>
<td>Pinus strobus</td>
</tr>
<tr>
<td>Lake Namekagon</td>
<td>Macromia illinoensis</td>
<td>1 m – 1.5 m</td>
<td>15 m</td>
<td>Pinus strobus</td>
</tr>
<tr>
<td>Lake Namekagon</td>
<td>Dromogomphus spinosus</td>
<td>1 m – 1.5 m</td>
<td>10 m</td>
<td>Tsuga canadensis</td>
</tr>
<tr>
<td>Lake Namekagon</td>
<td>Basiaeschna janata</td>
<td>1 m – 1.5 m</td>
<td>10 m</td>
<td>Tsuga canadensis</td>
</tr>
<tr>
<td>White River</td>
<td>Calopteryx maculata</td>
<td>4 m</td>
<td>1 m</td>
<td>Pinus strobus</td>
</tr>
<tr>
<td>Bay City Creek</td>
<td>Somatochlora minor</td>
<td>2 m – 6.9 m</td>
<td>&lt;1 m</td>
<td>Picea abies</td>
</tr>
</tbody>
</table>

*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.

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,
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.

**Acknowledgments**

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.

**Literature Cited**


