Hypopagea: The World of Winter-Active Insects

A Final Report to:

Nova Scotia

Habitat Conservation Fund

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Abstract

In temperate and polar regions, insects are generally thought to go dormant during the winter (save for the few which migrate). Therefore, no one generally thinks to explore the potential for winter activity. It is widely known that few insects can tolerate temperatures below freezing, and for those which can, they can only do so a few degrees below that threshold. However, liquid fresh water cannot get below freezing (by definition!), and so the potential for insect activity in water bodies is much higher than that in terrestrial systems. To discover the diversity of these hypopagic (= under ice) insects, frozen-over ponds around Antigonish County, Nova Scotia were sampled for insects. Data on the environmental conditions of each pond were collected in order to map environmental effects on diversity. The total catch included 319 adult insects from eight families. Among the captures were species which have been rarely found in the ice-free portion of the year.

Introduction

Insects, as a taxonomic group, are poikilothermic (~cold-blooded). The assumption that they are dormant during the winter is therefore not illogical. Preliminary work by RFL and colleague Barry Taylor has shown that at least some insects are active in ponds during the winter, even under complete ice cover. Some literature alludes to the winter activity of these insects (Evans 2008, Holmen 1987, Hungerford et al. 1948, Larson et al. 2000, Scheers 2014, Vahruševs 2009) but mostly as personal observations. Winter dormancy of insects, being the status quo, is so engrained in the minds of biologists, that it is barely mentioned, though it can be found to be reiterated from time to time (Patenaude et al. 2015, Vahruševs, 2009). All of this lends to the belief that no work on hypopagic insects activity has ever been done, ***anywhere***, so this study was initiated to survey the local diversity of pond-dwelling winter active insects and literally introduce the world to this phenomenon.

Materials and Methods

Study Sites and Survey Period

The survey period was from 09 January to 09 March 2015, inclusive. Most of the collection sites were ponds in Antigonish County (Fig. 1, Appendix 1) which either lacked fish, or had a relatively small fish population. Fish are predators of insects and therefore we did not want to trap sites with a small insect community. Additionally, by-catch would be avoided.

Figure 1. Locations of the trapping sites around Antigonish; exact coordinates will be given in the final report.

Physical and Chemical Parameters

The water temperature was taken once at every pond, a thermometer was submerged in the water at one of the holes and stirred around in the water for a minute before reading. Ice thickness was measured to the nearest centimetre, three times around each hole, using a meter stick. Water depth was taken in the center of each hole; depths over 1 m were recorded as > 1 m. One litre of water was collected from each pond and kept cool until arrival at the lab. The pH, dissolved oxygen, and conductivity were all measured.

Traps and trapping regime

Traps were built based on the design of a conventional minnow trap though 2 mm stainless steel mesh was used (Fig. 2). The traps were 18 cm in diameter, 40 cm long with an 8 cm inverted cone in each end. The hole in each cone had a 5 cm diameter. To remove captures from the traps there was a 10 x 15 cm door halfway down the trap wall. There was a 1 cm wide white plastic flange (not shown in the figure) around the circumference of one end of the trap; this flange helped to prevent swimming insects from entering the space between the trap wall and the wall of the bored 20 cm hole in the ice.

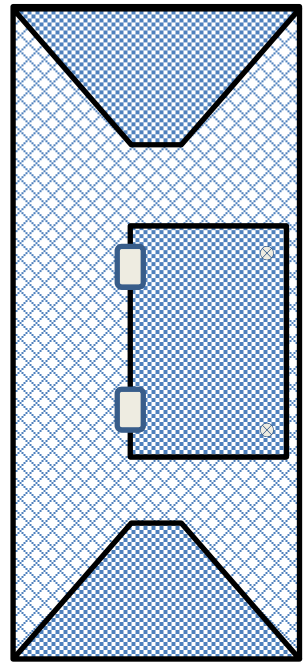

Figure 2 The ice trap.

At each site five holes of 20 cm diameter were made in the ice near the pond edge. Aquatic insects spend most of their time associated with plants (Merritt et al. 2008), so the holes were placed near any emergent vegetation, if present. Either a power auger or a hand axe was used to make holes in the ice. In the case of the latter, the hole at the upper ice surface was often twice the diameter of the 20 cm hole at the lower ice surface. A minimum of 5.0 m spacing was left between each hole.

The traps were seated in the ice vertically such that the lower edge was not below the surface of the ice, if possible. However, the small opening of the lower cone needed to be submerged, and 5 cm below water level was chosen. Traps were then packed into the holes with snow and ice to stabilize them.

Trapping was normally done at one site each week from January through March, 2015.

After 24 hours, each trap was labeled then chopped out of the ice with an axe and transported back to the lab. The traps, which were frozen shut, were placed in a sink where the ice was thawed, typically with a stream of hot water. The specimens from each of the traps were then removed from the bins either by hand or with forceps.

In addition to trap captures, any insects found swimming in the holes either before trap placement or after trap removal were opportunistically captured.

Preservation and Identification

Adults were euthanized with ethyl acetate and pinned; larvae were submerged in 70% isopropanol to both euthanize and preserve them.

Dytiscids were identified to species using Larson et al. (2000). Haliplids were identified to species using Majka et al. (2009). All other insects were identified to genus using the keys within Merritt et al. (2008). The richness and abundance data from each pond were used to calculate a Shannon-Weaver index of diversity for that pond.

Statistical Methods

A correlation between the water depth and the catch for each of the steel mesh traps was calculated. The specific diversity, richness, and abundance were compared to the pond chemistry, water depth at the trap location, and pond location using regression analyses. Significant regression will indicate either a correlation between a parameter and diversity or the effect of a given parameter on diversity with 95% confidence. All calculations were performed in Excel.

Results

Pond Characteristics

All physical and chemical parameters are summarized in Table 1. Average ice thickness in each pond ranged from 7.0 cm to 50 cm; unsurprisingly, the thickness increased as the trapping season progressed. The water depth ranged from 25 cm deep to greater than 100 cm deep. For ponds which we could measure with our tape, sizes ranged from 117 m^2 to 888 m^2; the Beech Hill collection site was too large to measure that way – air photo analysis put it at ~12 000 m^2. The pH values ranged from 4.7 to 5.3. Conductivity readings from the ponds ranged from 35 S/m to 500 S/m with most conductivity values under 100 S/m. Dissolved oxygen values also varied greatly with a range from 1.5 mg/l (almost anoxic) to 17 mg/l (hyper-saturation). The general trend in dissolved oxygen values was a decrease towards the end of the season.

Table 1. Diversity, physical and chemical data collected from the 10 trap sites.

Site	Date	Shannon-Weaver Index	Water Depth (cm)	Ice Thickness (cm)	Size (m^2)	pH	Conductivity (S/m)	dissolved oxygen (mg/l)
Bancroft	9-Jan	0.00	47.4	7.03	171	~	~	~
Silo Pond	13-Jan	1.05	35.6	21.8	416	~	~	~
PBPP	16-Jan	0.00	25.0	20.4	-	~	~	~
The Keppoch	23-Jan	0.59	90.4	26.0	418	~	~	~
Jewkes	31-Jan	1.50	67.8	22.6	572	5.3	91	10.4
Paul	13-Feb	1.65	100.0	34.2	273	5.1	96	4.9
Beech Hill	20-Feb	0.56	67.4	41.1	~	5.3	51	6.4
Cloverville	27-Feb	0.00	86.8	34.0	630	4.7	35	5.0
Frasers Mills	8-Mar	1.68	~	~	~	5.0	70	2.1
Cribbons Point	9-Mar	0.50	~	40.4	~	5.2	209	1.5

Catch counts and Diversity

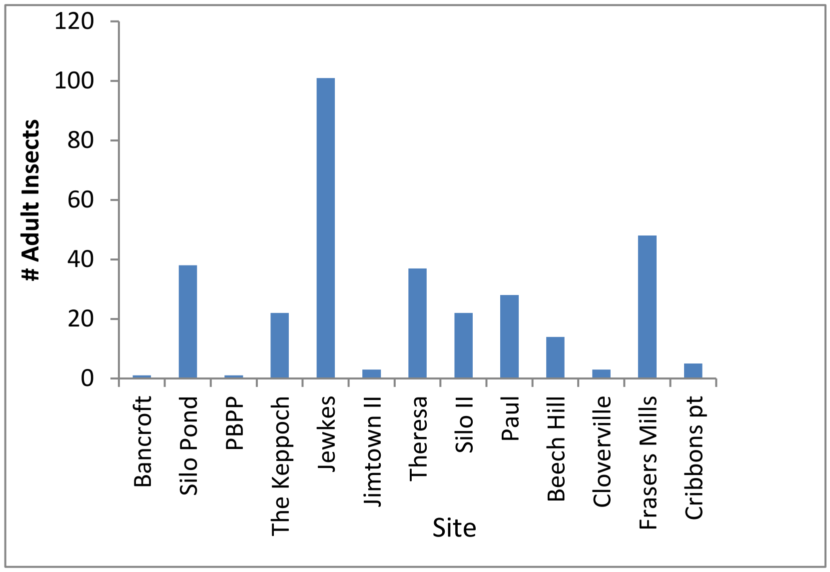

Figure 3. The opportunistic and trap capture totals for all sampled ponds.

The total catch was 319 adult insects caught in traps and opportunistically. The adult insect catch per pond ranged from 1 to 101 insects with an average of 24 insects per collection (Fig. 3). More than 20 species of beetle and bug were caught (Table 2). Larvae were not counted, but came from the following orders Trichoptera, Ephemeroptera, and Megaloptera.

The average diversity of insects caught in the traps was 0.75, using the Shannon-Weaver Index, with a range from 0 to 1.68 (Table 1).

Table 2. All adult insects captured from the 10 main ponds sampled; the opportunistically captured insects await identification.

Order	Family	Genus	Species	trap captures
Coleoptera (Beetles)	Dytiscidae	*Acilius*	*semisulcatus*	13
		Agabus	*anthracinus*	3
		Agabus	*erichsoni*	3
		Colymbetes	*paykulli*	5
		Comptotomus	*longulus*	2
		Dytiscus	*fasciventris*	2
		Dytiscus	*verticalis*	7
		Laccophilus	*maculosus*	1
		Nebrioporus	*depressus*	1
		Neoporus	*carolinus*	1
		Rhantus	*binotatus*	2
	Gyrinidae	*Dineutus*	spp.	53
		Gyrinus	spp.	5
	Haliplidae	*Haliplus*	*connexus*	1
		Peltodytes	*litoralis*	1
	Hydrophilidae	*Tropisternus*	spp.	15
Hemiptera (Bugs)	Belostomatidae	*Belostoma*	*flumineum*	1
	Corixidae	*Hesperocorixa*	spp.	15
		Neocorixa	spp.	54
	Nepidae	*Ranatra*	*fusca*	23
	Notonectidae	*Notonecta*	spp.	111

Regression Analyses

No significant linear correlations between pond chemistry and diversity were seen at a confidence level of 95%. Dissolved oxygen was weakly correlated with the abundance of the 10 sampling sites. This correlation was significant at a confidence level of 90% ($p=0.07$, $r^2 = 0.60$). However, this correlation appeared to be driven by Jewkes pond, an outlier with a catch of 96 adults. With the outlier removed the previous trend was lost ($r^2 = 0.02$; Fig. 4).

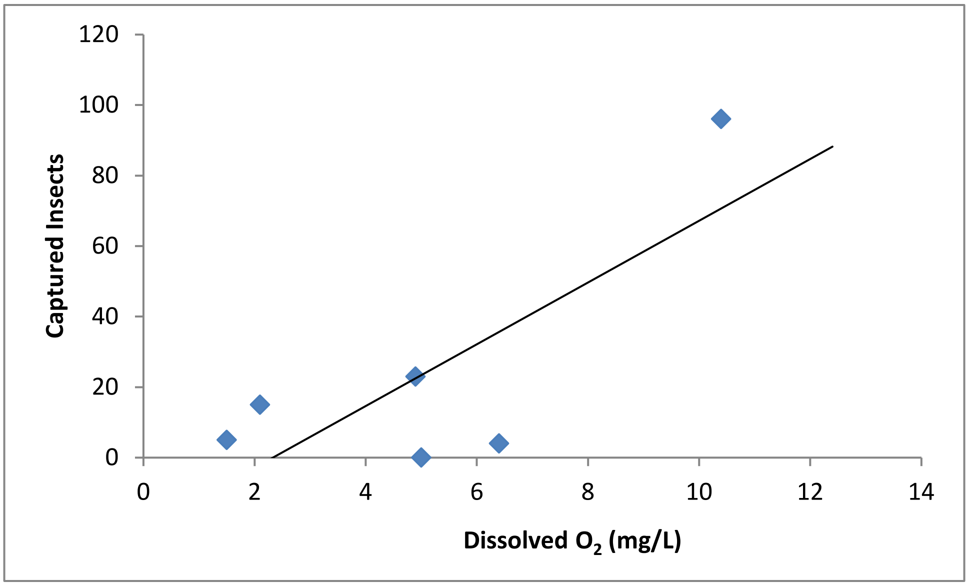

Figure 4. The correlation between dissolved oxygen and insect capture in five of the ten ponds which had dO_2 measured.

Conclusions

The diversity of hypopagic insect activity is far greater than previously understood. This survey is just the tip of the iceberg in terms of comprehending this newly explored habitat. More research is required to tease out the mechanism of attraction of the insects, the physiological coping mechanisms of theses aquatic invertebrates, and the true environmental factors that influence hypopagic diversity. It is expected that after publication of these results (pending species-level identification of the remaining species), many more resar

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Appendix 3. Locations of the trap sites.

Site	coordinates
Bancroft	45.643368, -61.854195
Silo Pond	45.635109, -61.981812
PBPP	45.646118, -61.812107
The Keppoch	45.555397, -62.125835
Jewkes	45.709194, -61.902435
Paul	45.635021, -61.881180
Beech Hill	45.594265, -61.957249
Cloverville	45.666428, -61.992199
Frasers Mills	45.504097, -61.942371
Cribbons Point	45.751682, -61.905800