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Cover Page Footnote

Department of Biological Sciences, Michigan Technological University, 1400 Townsend Drive, Houghton, Michigan 49931, USA Acknowledgements I would like to thank the Huron Mountain Wildlife Foundation for supporting this research (Michigan Tech agreement #1401076), the Michigan Tech Research Excellence Fund (Mentoring Grant 1205026) for funding my meetings with Dr. John Jaenike (University of Rochester, NY), who taught me how to identify drosophilids and who gave valuable comments on this manuscript, and the Walmart store in Houghton, MI, for the generous supply of overripe produce.

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The Drosophilids of a Pristine Old-Growth Northern Hardwood Forest

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Abstract

The current study summarizes the results of a species inventory survey for drosophilid flies (family Drosophilidae, order Diptera) in a primeval forest in northern Michigan. The two main goals of the investigation were to list the species inhabiting the Huron Mountain Club and to collect live specimens for the illustrations of the book "Drosophilids of the Midwest and Northeast". From 2014 to 2016, I found 22 drosophilid species, which belong to the two subfamilies Steganinae and Drosophilinae. Future long-term studies are planned to test how the drosophilid populations respond to climate change.

Keywords: Huron Mountains, Huron Mountain Club, Drosophila, drosophilids, old-growth hardwood forest

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The Huron Mountains, situated about 40 km NW of Marquette in the Upper Peninsula of Michigan, comprise one of the largest old-growth hemlock-hardwood forests in the upper Great Lakes area. The Huron Mountain Club has privately owned a considerable portion of the Huron Mountains since its foundation in 1889 and protected the forest from being logged. Today, the ~6,000 ha club property preserves one of the most extensive tracks of remnant old-growth forest in the Great Lakes area. For a comprehensive review on the history of the region, see (Flaspohler and Meine 2006). The Huron Mountains offer a great variety of habitat types: a total of fifty landscape ecosystem types have been described for the area (Simpson 1990). I had the great privilege to obtain permission to conduct an inventory survey of the drosophilid flies (family Drosophilidae) on the Huron Mountain Club property during the summers of 2014 – 2016. Although most people associate the name *Drosophila* with only one species, "the fruit fly", or more precisely, the genetic model organism *Drosophila melanogaster* Meigen, the genus *Drosophila* alone contains more than 4,100 species worldwide (Markow and O'Grady 2006, Yassin 2013). The many species of the family Drosophilidae are adapted to a broad variety of habitats and diets. While forest-inhabiting species feed on mushrooms (including the most toxic ones), tree sap, acorns, rotten fruit, leaves, or flowers, many other species are habitat and food generalists and can thus be found virtually anywhere. The Huron Mountains offer many highly suitable habitats for drosophilids, both for native and invasive species. In order to investigate the drosophilid fauna, I placed baits and traps at 23 research sites across the Huron Mountain Club property. Over three years, I found a total of 22 drosophilid species, which I will report here. Many of the specimens that I collected in the Huron Mountains were used for the illustrations in the now published book "Drosophilids of the Midwest and Northeast", which is freely available to the public (Werner and Jaenike 2017).

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Materials and Methods

Baits, Traps, and Natural Substrates. Flies were collected with a net from tomato baits, mushroom baits, banana traps, beer traps, and wild mushrooms. Shelf mushroom feeders were aspirated from the underside of shelf mushrooms (*Ganoderma applanatum* (Persoon)). Tomato baits were prepared from large- to medium-sized over-ripe tomatoes that were cut in half and placed on the ground next to fallen logs. Mushroom baits consisted of store-bought white button mushrooms (*Agaricus bisporus* (Lange)) pre-soaked for at least 30 minutes in water to keep them moist for several days. Like tomato baits, the mushroom baits were placed on the ground in groups of ~10 mushrooms. Banana traps were made of mushed over-ripe bananas (without the peel) with a few sprinkles of Baker's yeast added. The banana/yeast mixture was placed into plastic bottles with a few sticks as perching sites and hung in trees to protect them from small mammals. Beer traps consisted of wide-necked glass bottles ("Frappuccino"

bottles) filled with ~80 mL of golden-ale-style beer. Because *Amiota* flies (the target group for beer traps) live in the forest canopy, beer traps were hung in trees. At the time of collection, all flies were immediately transferred into sugar agar vials. I usually collected flies twice from the baits and traps: the first time two days after their installation, and the second time four to five days later. The flies were identified alive at the end of each collection day. For more details about collecting drosophilid flies, see "Drosophilids of the Midwest and Northwest" (Werner and Jaenike 2017).

Collection Periods and Sites. During the summers from 2014–2016, I spent one week in each month of June, July, and August on the Huron Mountain Club property to collect drosophilid flies. (6/23/2014–6/29/2014, 7/22/2014–7/28/2014, 8/25/2014–8/31/2014, 6/15/2015–6/21/2015, 7/6/2015–7/12/2015, 8/10/2016–8/16/2015, 6/27/2016–7/3/2016, 7/25/2016–7/31/2016, and 8/18/2016–8/24/2016). The daytime temperatures usually ranged from 18 to 25°C and rarely reached 30°C or above. Sites 3–25 were established in 2014, while sites 26 and 29 were added in 2015 and 2016, respectively (Fig. 1). Sites 3 and 5–26 received banana, tomato, and mushroom traps/baits. Site 29 received only beer traps. Gaps in site numbers were sites established to study butterflies and moths, which are not reported in the current study, with the exception of site 4, where I collected *Amiota minor* (Malloch) from my arm. Each trap position was recorded with a hand-held GPS. The GPS coordinates and site descriptions are provided in Table 1.

Drosophilid species identification. To identify the species, I used the characters published in our book "Drosophilids of the Midwest and Northeast" (Werner and Jaenike 2017) and examined external male and female terminalia whenever necessary. I also reared many species from females collected in the field and double-checked the key characters in the F1 generation. In the case of *Drosophila macrospina* Stalker & Spencer, mitochondrial DNA was sequenced to confirm the species. No voucher specimens were stored in ethanol, but many specimens from the Huron Mountain study were digitalized and can be found in our book "Drosophilids of the Midwest and Northeast" (Werner and Jaenike 2017).

Results

Twenty-two Drosophilid Species in the Huron Mountains. The two main objectives of this investigation were to 1) make a species inventory list for the Huron Mountain Club and 2) collect live flies for later breeding and imaging to create the images for the book "Drosophilids of the Midwest and Northeast" (Werner and Jaenike 2017). Hence, the current investigation was of semi-quantitative nature: while I recorded numbers of specimens for rare species, I only recorded rough estimates for the more abundant species. In 2014, I collected 18 drosophilid species in the Huron Mountains: *Amiota humeralis* Loew, *Amiota leucostoma* Loew, *Chymomyza amoena* (Loew), *Hirtodrosophila duncani* (Sturtevant), *D. melanogaster*, *Drosophila suzukii* (Matsumura), *Drosophila algonquin* Sturtevant & Dobzhansky, *Drosophila affinis* Sturtevant, *Drosophila athabasca* Sturtevant & Dobzhansky, *Drosophila busckii* Coquillett, *Scaptomyza sp.*, *Drosophila robusta* Sturtevant, *Drosophila paramelanica* Griffen, *Mycodrosophila claytonae* Wheeler & Takada, *Drosophila immigrans* Sturtevant, *Drosophila neotestacea* Grimaldi, James, & Jaenike, *Drosophila falleni* Wheeler, and *Drosophila recens* Wheeler. In 2015, two more species were attracted to my baits and traps, both of which are quite uncommon in northern Michigan: *Drosophila putrida* Sturtevant and *Drosophila tripunctata* Loew. Finally, I found two additional species in 2016: *A. minor* and *D. macrospina*. In total, I found 22 drosophilid species in the Huron Mountains, including the invasive agricultural pest *D. suzukii*, which originated in Southeast Asia. Table 2 lists the substrates to which the individual species were attracted.

The accompanying figures 2–9 summarize the distribution of each species in time and space. Additional information about the ecology, evolution, and geographical distribution of these species can be found in (Markow and O'Grady 2006, Miller et al. 2017, Werner and Jaenike 2017).

***Amiota humeralis* Loew, subfamily Steganinae.** I encountered this species infrequently and each time in very low numbers (one or two individuals). Most specimens were collected at wooded sites close to Pine Lake and Mountain Lake, usually in July and August (Fig. 1 and 2A). Banana traps were the most efficient to attract this species, although I also collected a few flies from tomato baits, mushroom baits, and wild mushrooms (Table 2). Very little is known about the life history of *Amiota* flies.

***Amiota leucostoma* Loew, subfamily Steganinae.** This species was very rare. I only found three individuals in total, one each year in July (Fig. 2B). The substrates that attracted these flies were diverse: mushrooms, beer, and banana (Table 2). Like *A. humeralis*, *A. leucostoma* visited wooded sites adjacent to Pine Lake and Mountain Lake (Fig. 1 and 2B).

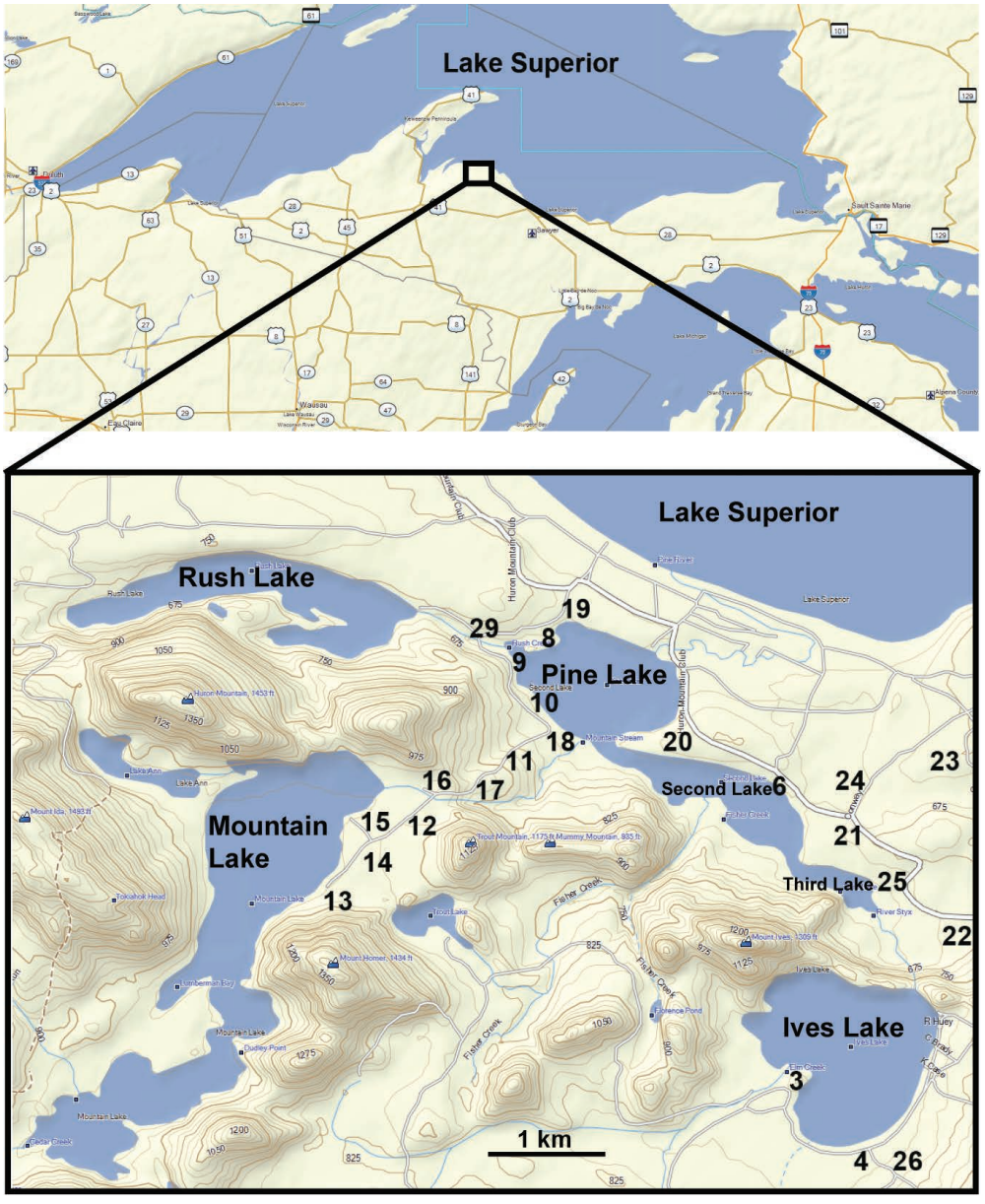

Figure 1. Map of the Huron Mountains and the research sites

***Amiota minor* (Malloch), subfamily Steganinae.** During a butterfly collection walk on a hot day in June 2016, one specimen of *A. minor* landed on my arm at site 4, which is adjacent to Ives Lake. This specimen was apparently attracted to sweat. I have never seen this species come to baits (Fig. 1, 2C, and Table 2).

***Chymomyza amoena* (Loew), subfamily Drosophilinae.** I found this somewhat uncommon species in wooded as well as more open areas (Fig. 1). *Chymomyza amoena* visited mainly tomato baits, but sporadically also wild mushrooms and banana traps (Table 2). I encountered this species throughout the summer months (Fig. 3A).

Table 1. Characteristics of the research sites and GPS coordinates in the Huron Mountains.

Site	Characteristics	GPS Coordinates
3	Ives Lake Field Station, shaded area next to the stone house, former farmland	N46° 50.644' W87° 51.290'
4	Sun-exposed dirt road along south side of Ives Lake, high diversity of deciduous trees/bushes and flowering plants	N46° 50.326' W87° 50.828'
6	Hemlock-dominated forest along north side of Second Lake	N46° 52.309' W87° 51.431'
8	Hemlock-dominated forest northwest of Pine Lake, adjacent to a dirt road	N46° 53.096' W87° 52.922'
9	Hemlock-dominated forest west of Pine Lake, adjacent to dirt road, lots of fallen logs with shelf mushrooms on the ground	N46° 52.956' W87° 53.199'
10	Hemlock/sugar maple forest west of Pine Lake, adjacent to a dirt road	N46° 52.729' W87° 53.049'
11	Mixed hemlock forest, undergrowth dominated by sugar maple saplings, adjacent to a sandy dirt road	N46° 52.454' W87° 53.104'
12	Hemlock-dominated forest, undergrowth dominated by sugar maple saplings, adjacent to a dirt road, large log with shelf mushrooms on the ground	N46° 52.108' W87° 53.799'
13	Hemlock forest east of Mountain Lake	N46° 51.687' W87° 54.377'
14	Hemlock/sugar maple forest, undergrowth dominated by sugar maple saplings, adjacent to a dirt road	N46° 51.946' W87° 54.122'
15	Hemlock/sugar maple forest, undergrowth dominated by sugar maple saplings, east of Mountain Lake	N46° 52.050' W87° 54.160'
16	Hemlock-dominated forest north of Mountain Stream	N46° 52.222' W87° 53.576'
17	Hemlock forest with large logs containing shelf mushrooms on the ground	N46° 52.321' W87° 53.207'
18	Hemlock/sugar maple forest, undergrowth dominated by sugar maple saplings, south of boat landing at Pine Lake	N46° 52.560' W87° 52.905'
19	Hemlock forest bordering the jack pine barren at the northwest corner of Pine Lake, blueberry bushes in the undergrowth	N46° 53.233' W87° 52.782'
20	Hemlock forest adjacent to dirt road	N46° 52.526' W87° 51.916'
21	Hemlock forest adjacent to dirt road	N46° 52.015' W87° 50.888'
22	Hemlock forest	N46° 51.501' W87° 50.148'
23	Hemlock-dominated forest with sugar maple saplings in the undergrowth and a large log with shelf mushrooms on the ground	N46° 52.404' W87° 50.247'
24	Hemlock-dominated forest adjacent to dirt road and a swamp	N46° 52.218' W87° 50.919'
25	Hemlock-dominated forest adjacent to dirt road, sun-exposed during mid-day	N46° 51.731' W87° 50.616'
26	Hemlock/sugar maple forest adjacent to dirt road, often flooded after heavy rain	N46° 50.255' W87° 50.766'
29	Half-shaded area adjacent to Rush Creek and dirt road, swampy character	N46° 53.020' W87° 53.421'

Table 2. Species list for drosophilids found in the Huron Mountains from 2014 to 2016 and the substrates from which they were collected. The species are sorted by their phylogenetic relationships. * = shelf mushroom *Ganoderma applanatum***.**

Species	Banana	Tomato	Mushroom	Beer	Sweat
Amiota humeralis	X	X	X		
Amiota leucostoma	X		X	X	
Amiota minor					X
Chymomyza amoena	X	X	X		
Hirtodrosophila duncani	X		X		
Drosophila melanogaster	X	X			
Drosophila suzukii	X	X	X	X	
Drosophila algonquin	X	X	X		
Drosophila affinis	X	X			
Drosophila athabasca	X	X	X		
Drosophila busckii	X	X	X		
Scaptomyza sp.		X			
Drosophila robusta	X	X	X	X	
Drosophila paramelanica	X	X			
Mycodrosophila claytonae			X*		
Drosophila immigrans	X	X	X		
Drosophila macrospina	X				
Drosophila neotestacea	X	X	X	X	
Drosophila putrida	X		X		
Drosophila falleni	X	X	X		
Drosophila recens	X	X	X		
Drosophila tripunctata		X			

This species is known to breed in acorns and apples (Band 1988), which occur in the area.

***Hirtodrosophila duncani* (Sturtevant), subfamily Drosophilinae.** *Hirtodrosophila duncani* appeared in very low numbers throughout the summer months in wooded areas (Fig. 1 and 3B). Although this species is mycophagous (Lacy 1984), i.e., a mushroom-feeder, banana traps worked best to attract it (Table 2), while I only found one specimen at a mushroom bait. *Hirtodrosophila duncani* breeds more often in various species of shelf mushrooms, which could be why regular store-bought mushrooms are not very attractive to them.

***Drosophila melanogaster* Meigen, subgenus Sophophora.** This cosmopolitan species was surprisingly uncommon in the deep woods of the Huron Mountains. I sparsely encountered this species at only about half of the collection sites in moderate numbers over the three years combined (Fig. 1 and 3C). *Drosophila melanogaster* was most common at the Ives Lake Field Station, where I regularly found this species in somewhat larger numbers on tomato baits and in banana traps (Fig. 3C and Table 2). This species breeds in various decaying fruits and is known to be common around humans settlements and rare quite rare in the woods (Sturtevant 1921).

***Drosophila suzukii* (Matsumura), subgenus Sophophora.** Also known as the "Spotted Wing Drosophila" or "SWD", this species was one of the most abundant species in the Huron Mountains. It was equally common in the woods as in open areas, and it visited all designated fly collection sites (Fig. 1 and 4A). Although I did not encounter a single specimen in June, the numbers of

flies increased as the summers progressed, with few flies in July and dozens of flies per trap in August. Banana traps and tomato baits worked equally well in attracting *D. suzukii*, while I also found a few flies on mushroom baits and wild mushrooms. This species is known to breed in a variety of berries and other small fruits (Lee et al. 2011), of which there are many available in the Huron Mountains, such as raspberries and blueberries. Notably, the beer trap at site 29 contained a few hundred drowned *D. suzukii* flies of both sexes in August of 2016, suggesting that beer traps might provide a useful tool to reduce *D. suzukii* populations on fruit plantations.

***Drosophila algonquin* Sturtevant & Dobzhansky, subgenus Sophophora.** This species was very abundant and mainly attracted to banana traps and tomato baits, although some specimens also visited mushroom baits and wild mushrooms (Table 2). I found it at nearly all research sites from June throughout August (Fig. 1 and 4B). The primary breeding sites of this and the following two species are not known.

***Drosophila affinis* Sturtevant, subgenus Sophophora.** This species was quite rare. I found it both in open and wooded areas (Fig. 1 and 4C). Most specimens came to banana traps, while a few flies visited tomato baits (Table 2). I did not encounter this species in 2016.

***Drosophila athabasca* Sturtevant & Dobzhansky, subgenus Sophophora.** This species was about as common as *D. algonquin*. I found it in open and wooded areas throughout the summer months (Fig. 1 and 5A). Most specimens came to banana traps and tomato baits, while few individuals visited mushroom baits and wild mushrooms (Table 2).

***Drosophila busckii* Coquillett, subgenus Dorsilopha.** I found a total of three individuals of this species: one on a mushroom bait, one on a tomato bait (both at the Ives Lake Field Station), and one in a banana trap in a wooded area near Mountain Lake (Fig. 1 and 5B, Table 2). The sampling results reflect the fact that *D. busckii* breeds in a very large variety of substrates, including garbage and decaying vegetables (Atkinson and Shorrocks 1977). It is possible that this species breeds in the garbage of the field station.

***Scaptomyza sp.*, subgenus Drosophila.** A total of three specimens visited tomato baits: two at the Ives lake Field Station and one near Pine Lake (Fig. 1 and 5C, Table 1). I was unable to identify *Scaptomyza* flies to the species until just recently, and the flies perished before I was able to image them. An identification key can be found in "Drosophilids of the Midwest and Northeast" (Werner and Jaenike 2017). Future collection trips to the Huron Mountain Club are planned to reveal the species identity of the flies of this genus.

***Drosophila robusta* Sturtevant, subgenus Drosophila.** This species was a common sight throughout the summers in banana traps and on tomato baits, while I collected it much less frequently from mushroom baits. *Drosophila robusta* was also attracted to beer at site 29 (Fig. 1 and 6A, Table 2). This species breeds in slime fluxes or various trees (Carson and Stalker 1951).

***Drosophila paramelanica* Griffen, subgenus Drosophila.** I collected this species sporadically at open and wooded sites. *Drosophila paramelanica* showed a preference for banana traps, but it also came a few times to tomato baits (Table 2). I collected it usually in July and August (Fig. 1 and 6B). This species is likely to breed in slime fluxes of trees (Stalker 1960).

***Mycodrosophila claytonae* Wheeler & Takada, subgenus Drosophila.** Unlike most other species, *M. claytonae* never visited traps or baits. I only found it only at three collection sites, where *G. applanatum* shelf mushrooms were abundant on dead logs (Fig. 1 and 6C). The flies of this mycophagous species (Lacy 1984) sat or walked across the mushrooms' white underside, usually on warm, sunny days just after heavy rainfalls (Table 2). The undersides of the mushrooms often steamed off water vapor when flies were present. Flies were present in high numbers (ten individuals) at times on this species. I never encountered this species under dry conditions.

***Drosophila immigrans* Sturtevant, subgenus Drosophila.** This cosmopolitan species (Sturtevant 1921) was absent in June and became increasingly abundant as summer progressed. I found it in banana traps, as well as on tomato and mushroom baits across the study area (Fig. 1 and 7A, Table 2). *Drosophila immigrans* usually breeds in decaying fruits and vegetables (Atkinson and Shorrocks 1977).

***Drosophila macrospina* Stalker & Spencer, subgenus Drosophila.** This very rare species was attracted to banana baits in the woods. I only encountered two specimens on the same day in August 2016 (Fig. 1 and 7B, Table 2). This species has been described as living in the woods near streams and swamps, although its natural breeding substrates are unknown (Mainland 1942).

***Drosophila neotestacea* Grimaldi, James, & Jaenike, subgenus Drosophila.** *Drosophila neotestacea* is a mycophagous

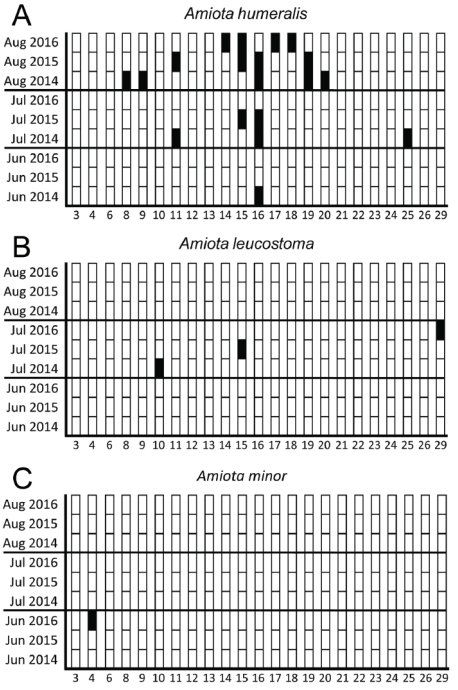

FIGURE 2

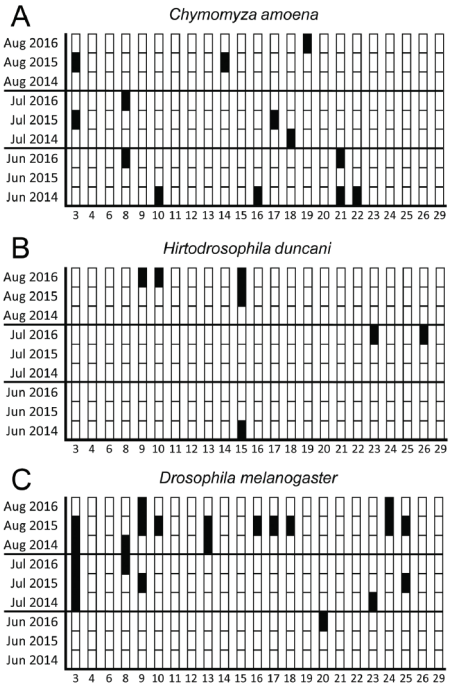

FIGURE 3

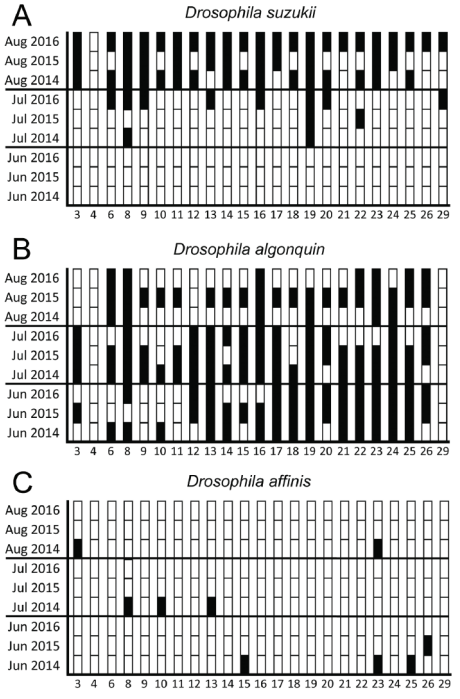

FIGURE 4

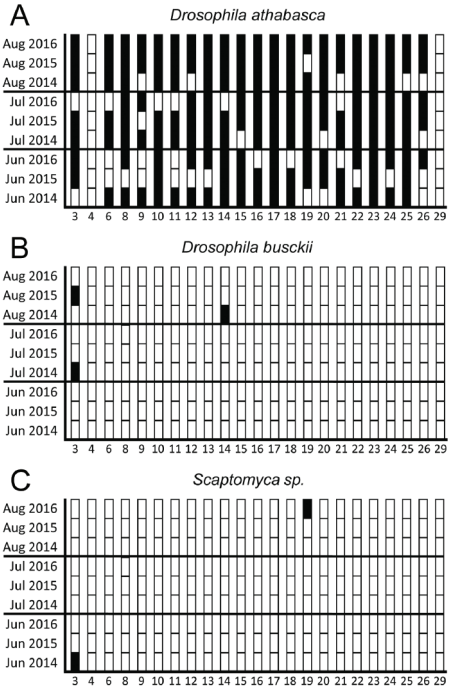

FIGURE 5

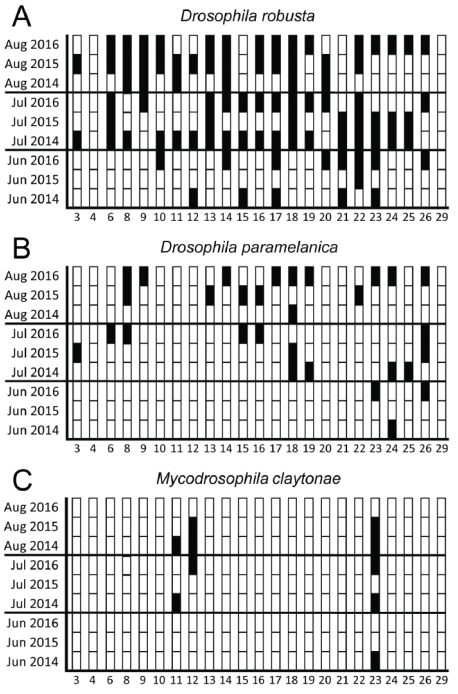

FIGURE 6

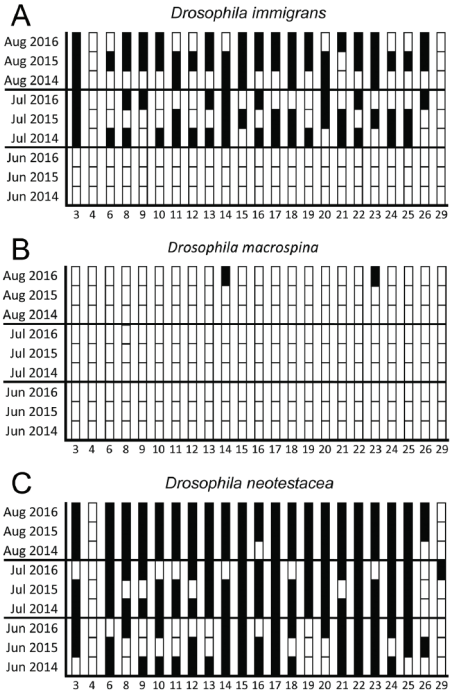

FIGURE 7

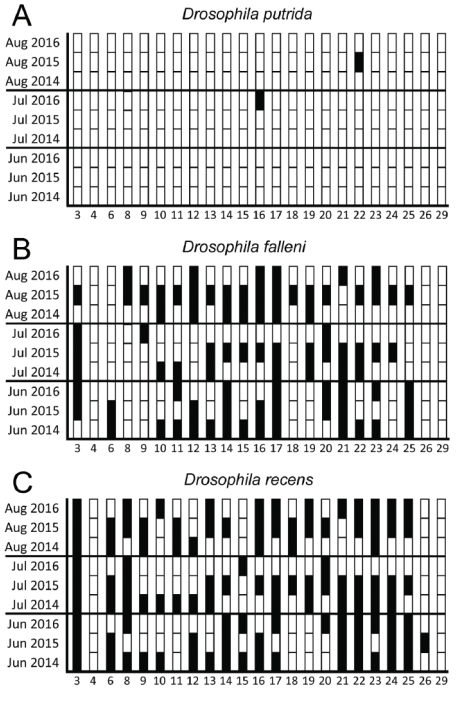

FIGURE 8

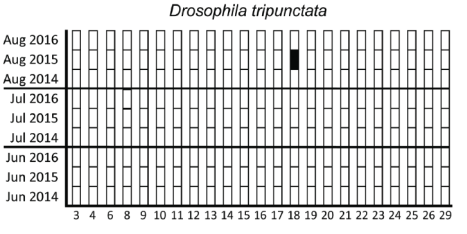

FIGURE 9

Figures 2–9. Plots of spatio-temperal distributions of the 22 drosophilid species. The y-axis shows the months and years during which I collected flies. The actual dates can be found in the Materials and Methods section. The research sites are listed on the x-axis.

species (Grimaldi 1985) and was the most abundant drosophilid species in the Huron Mountains. It was very common at all sites and times (Fig. 1 and 7C). Although it strongly preferred mushroom baits and wild mushrooms, I also found it on tomato baits and far less often in banana and beer traps (Table 2).

***Drosophila putrida* Sturtevant, subgenus Drosophila.** I encountered only two specimens of this mycophagous species (Grimaldi 1985): one fly came to a mushroom bait and one to a banana trap. Both research sites 16 and 22 were positioned in the woods, a bit further away from the lakes (Table 2, Fig. 1 and 8A).

***Drosophila falleni* Wheeler, subgenus Drosophila.** This mycophagous species (Jaenike 1978, Lacy 1984) was a regular visitor of mushroom baits, wild mushrooms, tomato baits, and banana traps (Table 2). I found it at virtually all collection sites with nearly equal abundance throughout the summer months (Fig. 1 and 8B).

***Drosophila recens* Wheeler, subgenus Drosophila.** Like *D. falleni*, *D. recens* is mycophagous (Grimaldi 1985) and was a common visitor of mushroom baits, wild mushrooms, tomato baits, and sometimes banana traps (Table 2). I found it at all fly collection sites (except the beer trap) with nearly equal abundance throughout the summer months (Fig. 1 and 8C).

***Drosophila tripunctata* Loew, subgenus Drosophila.** This is perhaps the rarest drosophilid species in the Huron Mountains. I found a single specimen of *D. tripunctata* at site 18 near Pine Lake on a tomato bait (Fig. 1 and 8C, Table 2). The diet of this species includes mushrooms and fruits (Carson and Stalker 1951, Collins 1956, Lacy 1984).

Discussion

This three-year study from 2014 to 2016 has shown that the Huron Mountain Club property is home to at least 22 drosophilid species, which represent ~40% of the species that inhabit the Midwest and Northeast of the USA (Miller et al. 2017, Werner and Jaenike 2017). The current study is the most comprehensive investigation of wild drosophilid populations performed in the Upper Peninsula of Michigan thus far, and it is the first study describing these insects in the Huron Mountains. According to the distribution maps in (Miller et al. 2017), no one has collected drosophilids in the Upper Peninsula before. Therefore, most, if not all, species encounters are new records for this area.

The diverse trap and bait types used here attracted different sets of species, although there was also substantial overlap (Table 2). Banana traps attracted larger numbers of drosophilid flies that feed on fruit and also tree sap and mushroom feeders in lower numbers. Tomatoes attracted a wide range of species, but none in large numbers. Mushroom baits attracted large numbers of mostly mushroom-feeding species, except the shelf mushroom feeder *M. claytonae*, which I was only able to collect from *G. applanatum* shelf mushrooms. It is worth noting that omitting mushroom baits in this study would have resulted in an identical species list because all species that were attracted to mushroom baits also visited other substrates.

Although I was unable to find any remarkable correlations between particular habitats and overall species occurrence, I note that the sites in the valley between Mountain Lake and Pine Lake (sites 11 – 18) were my favorite ones because of the highest abundance of *Amiota* flies. This genus is poorly studied because of the elusive lifestyle of the flies and may contain cryptic species to be discovered in the future. Also, I encountered nearly all drosophliid species there, except *Scaptomyza sp*. and *A. minor*.

Amiota and *Scaptomyza* species are not easily attracted to commonly used fruit fly baits and traps. In addition to that, *Amiota* flies live high up in the canopy of forests (Beppu 1984). It is therefore likely that my sparse encounters with flies of these genera are an underestimate of the true abundance *Amiota* and *Scaptomyza* species in the area. I consider the Huron Mountains a superb study ground for *Amiota* flies because three species are present and likely well established. Future studies in the Huron Mountains will include improved beer and wine traps, to which some *Amiota* species are attracted (Bächli et al. 2004). The trap designs will have to be modified from the current standard though, so that the flies can be collected alive for imaging purposes.

The species of most economic interest is *D. suzukii*, the spotted wing Drosophila (SWD), which was introduced to the North American mainland in California in 2008 and quickly spread to the east coast (Lee et al. 2011). I found *D. suzukii* in high abundance in the Huron Mountains, especially during late summer, when it became one of the most frequently encountered species. Notably, the beer trap at site 29 contained hundreds of drowned *D. suzukii* flies of both sexes. It would be worthwhile testing if beer traps can be used as a feasible way to reduce crop losses on SWD-infested fruit farms.

The three most rarely encountered bait-visiting species were *D. macrospina*, *D. putrida*, and *D. tripunctata*. All three species reach their northwestern distribution range in northern Michigan (Miller et al. 2017). Although *D. macrospina* has been found earlier in Michigan (Stalker and Spencer 1939), the Huron Mountain location is the northern-most site for this species on record in the Northeast (Miller et al. 2017). The geographical distribution range of *D. putrida* is concentrated around the eastern part of the USA, where this species is the most commonly encountered mushroom-feeding species (Miller et al. 2017, Werner and Jaenike 2017). Similarly, *D. tripunctata* is rarely seen in the North, but it has spread northward over the past few decades (Patterson and Wagner 1943, Spiess 1949, Lacy 1984).

The Huron Mountain Club is home of one of the largest old-growth forests of the Great Lakes region and provides an invaluable ground for future long-term studies, particularly to test how climate change affects the species community in the area. Will we see rare southern species become more common in the Huron Mountains, and will they perhaps replace northern species in the coming decades? Future long-term studies will be able to shed light on this question.

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Literature Cited

Atkinson, W. and B. Shorrocks. 1977. Breeding site specificity in the domestic species of *Drosophila*. Oecologia 29: 223–232.

Bächli, G., C. R. Vilela, S. A. Escher, and A. Saura. 2004. The Drosophilidae (Diptera) of Fennoscandia and Denmark, Brill Academic Publishers, Boston.

Band, H. 1988. Host shifts of *Chymomyza amoena* (Diptera: Drosophilidae). American Midland Naturalist 120: 163–182.

Beppu, K. 1984. Vertical microdistribution of Drosophilidae (Diptera) in a beech forest. Kontyu, Tokyo 52: 58–64.

Carson, H. L., and H. D. Stalker. 1951. Natural breeding sites for some wild species of *Drosophila* in the eastern United States. Ecology 32: 317–330.

Collins, W. E. 1956. On the biology and control of *Drosophila* on tomatoes for processing. Journal of Economic Entomology 49: 607–610.

Flaspohler, D. J., and C. Meine. 2006. Planning for wildness: Aldo Leopold's report on Huron Mountain Club. Journal of Forestry 104: 32–42.

Grimaldi, D. A. 1985. Niche separation and competitive coexistence in mycophagous *Drosophila* (Diptera: Drosophilidae). Proceedings of Entomological Society of Washington 87: 498–511.

Jaenike, J. 1978. Resource predictability and niche breadth in the *Drosophila quinaria* species group. Evolution 32: 676–678.

Lacy, R. C. 1984. Predictability, toxicity, and trophic niche breadth in fungus-feeding Drosophilidae (Diptera). Ecological Entomology 9: 43–54.

Lee, J. C., D. J. Bruck, H. Curry, D. Edwards, D. R. Haviland, R. A. Van Steenwyk, and B. M. Yorgey. 2011. The susceptibility of small fruits and cherries to the spotted-wing drosophila, *Drosophila suzukii*. Pest Management Science 67: 1358–67.

Mainland, G. B. 1942. VI. Genetic relationships in the *Drosophila funebris* group. Studies in the genetics of Drosophila 2: 74.

Markow, T. A., and P. M. O'Grady. 2006. Drosophila. A guide to species identification and use, Elsevier Inc., Amsterdam.

Miller, M. E., S. A. Marshall, and D. A. Grimaldi. 2017. A review of the species of *Drosophila* (Diptera: Drosophilidae) and genera of Drosophilidae of northeastern North America. Canadian Journal of Arthropod Identification 31: 1–282.

Patterson, J. T., and R. P. Wagner. 1943. Geographical distribution of species of the genus *Drosophila* in the United States and Mexico. University of Texas Publications 4313: 217–281.

Simpson, T. B. 1990. Landscape ecosystem and cover types of the reserve area and adjacent lands of the Huron Mountain Club, Marquette County, Upper Michigan (Doctoral dissertation). Retrieved from University of Michigan. (Accession No. (UMI)AAI9034516).

Spiess, E. B. 1949. Drosophila in New England. Journal of the New York Entomological Society 57: 117–131.

Stalker, H. D. 1960. Chromosomal polymorphism in *Drosophila paramelanica* Patterson. Genetics 45: 95–114.

Stalker, H. D., and W. P. Spencer. 1939. Four new species of *Drosophila*, with notes on the

funebris group. Annals of the Entomological Society of America 32: 105–112.

Sturtevant, A. H. 1921. The North American species of *Drosophila*, Carnegie Institution of Washington.

Werner, T., and J. Jaenike. 2017. Drosophilids of the Midwest and Northeast, River Campus Libraries, University of Rochester, Rochester, NY, USA.

Yassin, A. 2013. Phylogenetic classification of the Drosophilidae Rondani (Diptera): the role of morphology in the postgenomic era. Systematic Entomology 38: 349–364.