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Buprestidae, Cerambycidae, and Siricidae Collected in Baited Funnel Traps on Drummond Island, Chippewa County, Michigan

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Abstract

Trapping of bark- and wood-infesting insects in 2015 and 2016 at multiple locations on Drummond Island in northern Lake Huron, using baited multi-funnel traps, yielded 4 species of Buprestidae, 24 Cerambycidae, and 4 Siricidae. In 2015, all funnel traps were baited with the plant volatiles α-pinene, ethanol, and cis-3-hexenol, and were either black or green in color, and placed either at heights similar to the lower canopy of nearby trees (4-5 m) or at 1-2 m above groundline. In 2016, all traps were green, hung at 1-2 m above groundline, and baited with the cerambycid pheromones fuscumol acetate, monochamol, and syn-(2,3)-hexanediol. In 2015, 29 species of Buprestidae, Cerambycidae, and Siricidae were captured, compared with 9 cerambycids in 2016. The original target insect, emerald ash borer, *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), an invasive pest from Asia, was not trapped in either year.

Keywords: Borers, *Agrilus planipennis*, funnel trap, lures, trap height, trap color

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Drummond Island is Michigan's second largest island, covering about 130 square miles (≈ 83,131 ac or 33,642 ha) with 58% being state-owned and managed by the Michigan Department of Natural Resources as part of the Lake Superior State Forest (Karen Rodock, Michigan DNR, personal communication). Drummond Island lies near the northwestern end of Lake Huron and is the easternmost point of Michigan's Upper Peninsula (Fig. 1a). The bedrock on Drummond Island is largely limestone and dolomite (a magnesium rich limestone), and in many areas is exposed at the surface, forming broad, flat expanses known as alvars that are covered with little or no soil and usually dominated by grasses and sedges (Lincoln 2018).

Several tree species occur on Drummond Island and other nearby islands. The most common conifers include balsam fir [*Abies balsamea* (L.) Mill.], tamarack [*Larix laricina* (Du Roi) K. Koch], white spruce [*Picea glauca* (Moench) Voss], black spruce [*Picea mariana* (Mill.) Britton, Sterns & Poggenburg], red pine (*Pinus resinosa* Sol. ex Aiton), white pine (*Pinus strobus* L.), northern white cedar (*Thuja occidentalis* L.), and eastern hemlock [*Tsuga canadensis* (L.) Carrière]. Similarly, the most common hardwood tree species include red maple (*Acer rubrum* L.), sugar maple (*A. saccharum* Marshall), yellow birch (*Betula alleghaniensis* Britton), paper birch (*B. papyrifera* Marshall), American beech (*Fagus grandifolia* Ehrh.), white ash (*Fraxinus americana* L.), black ash (*F. nigra* Marshall). green ash (*F. pennsylvanica* Marshall), American hophornbeam [*Ostrya virginiana* (Mill.) K.Koch], balsam poplar (*Populus balsamifera* L.), bigtooth aspen (*P. grandidentata* Michaux), trembling aspen (*P. tremuloides* Michx.), northern red oak (*Quercus rubra* L.), and American basswood (*Tilia americana* L.) (Scharf and Chamberlin 1978, Weatherbee 2014, MDNR 2015, Reznicek et al. 2016, Lincoln 2018).

In 2015, at the time this study began, the Asian buprestid known as the emerald ash borer (EAB, *Agrilus planipennis* Fairmaire) had not yet been found on Drummond Island, but populations were nearby in both parts of Michigan and Ontario, Canada. EAB was first detected in North America in 2002 near Detroit, Michigan and Windsor, Ontario (Haack et al. 2002, 2015), and has now spread to 35 US states and 5 Canadian provinces as of June 2020 (EAB Info 2020). EAB was first detected in Michigan's Upper Peninsula in 2005 on the shores of Lake Superior in Brimley State Park, Chippewa County (Storer et al. 2009; Fig. 1a). In 2008, EAB was detected in Sault Ste. Marie, Ontario, located near the northern end of the St. Marys River, which connects Lake Superior to Lake Huron (Fig. 1a). In 2009, EAB was detected across the St. Marys River in Sault Ste. Marie, MI. In nearby areas, EAB was next reported on Sugar Island (Michigan) in

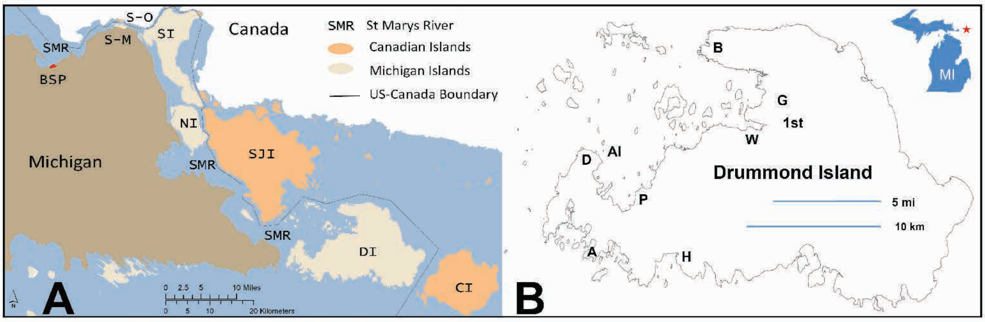

Figure 1. A. Outline map of Drummond Island (DI), surrounding islands and mainland of Michigan and Ontario, Canada. See text for historical spread of emerald ash borer in this area. Codes are: BSP = Brimley State Park; CI = Cockburn Island; NI = Neebish Island; SI = Sugar Island; SJI = St Joseph Island; SMR = St. Marys River; S-M = Sault Ste. Marie, MI; and S-O = Sault Ste. Marie, Ontario. **B**. Outline map of Drummond Island and surrounding islands that comprise Drummond Island Township, Michigan, indicating the 2015 and 2016 trapping locations, which were from north to south, Bruce Point (B), GEMS (Grouse Enhanced Management Systems; G), boat launch site to First Lake (1st), Wa-Wen Resort (W), Arrow Island (AI), Dix Point (D), Township Park (P), Anderson Point (A), and Helen Lake (H). Drummond Island is to the left of the red asterisk in the inset map of Michigan.

2012 and then on St Joseph Island (Ontario) in 2014 (Fig. 1a).

The initial objective of the present study in 2015 was to monitor for presence of EAB on Drummond Island by setting out baited funnel traps at various locations around the island. In 2016 another survey took place, but smaller in scale, using funnel traps with different baits. In this paper a list is presented of the bark- and wood-boring Buprestidae, Cerambycidae, and Siricidae that were collected during the 2-year study.

Methods: 2015 Study. Six trapping sites were selected in 2015, five on Drummond Island itself and one on Arrow Island (AI; N 46.0236° Lat, W 83.8239° Long), a small (2.5 ac, 1 ha), state-owned island near (0.4 km) the west side of Drummond Island (Fig. 1b). The other sites were generally located on the eastern side of Drummond Island, anticipating that if EAB were to fly over water to Drummond Island they would come from infestations to the west in Michigan's Upper Peninsula or from the north on St. Joseph Island (Fig. 1a). The northernmost trapping site was located on Bruce Point (B; N 46.0908°, W 83.7194°) on state land with traps placed in trees near the shoreline (Fig. 1b). Moving southward, traps were placed along the forest edge at Wa-Wen Resort (W; N 46.0332°, W 83.6756°) near the shoreline of Potagannissing Bay. More inland, traps were placed along the forest edge of the Potagannissing River on state land near the parking lot where boats are launched to enter First Lake (1st; N 46.0416°, W 83.6544°). The next trapping site was along the forest edge at Dix Point (D; N 46.0251°, W 83.8419°) on state land. The last trapping site was located on the southwestern side of Drummond Island along the shoreline forest edge of Anderson Point (A; N 45.9576°, W 83.8431°) near Fairview Cove, where the author has a cabin. Ash trees were common at four of the trapping sites (AI, B, 1st, and W) but rare at the other two sites (A and D; Fig. 1b).

Traps were deployed during 4–6 June 2015 and taken down on 3 October 2015 (≈ 120 trapping days). The traps were checked irregularly, usually every 3–4 weeks. A kayak was used to reach the traps on Arrow Island. At each site, four 12-unit funnel traps (Contech Enterprises Inc., Victoria, British Columbia, Canada) were deployed. Two of the traps had black funnels and two had green funnels like those pictured in Petrice and Haack (2015). The funnels of all traps were coated with Fluon (Northern Products Inc., Woonsocket, RI), a slippery substance that improves trapping efficiency (Graham et al. 2010). Two traps, one of each color, were suspended from branches in the lower canopy of dominant trees so that the bottom of the collection cup was about 4-5 m above groundline. The other two traps, one of each color, were suspended in the understory, using lower branches of trees so that the collection cup was about 1 m above groundline. Typically, the two traps of the same color were suspended from the same tree or two trees within 5 m of each other. The two other traps were suspended from one or two trees that were at least 10 m away from the first pair. Traps were suspended from ash trees at four sites (1st, AI, B, and W), but not the other two sites (A and

D) where no ash trees were nearby. Most of the selected ash trees had some branch dieback, but none had signs of EAB infestation (e.g., EAB adult exit holes or EAB larval galleries; Haack et al. 2015). In all cases, traps were suspended so that they were clearly visible, and any interfering branches were pruned. The base of the collection cups had a small screen funnel to allow rainwater to drain. A circular piece of window screening was fitted snugly near the bottom of each cup to suspend captured insects above any moisture that accumulated. Pieces of No-Pest Strip (Spectrum Group, St. Louis, MO) were placed inside each collection cup to quickly kill trapped insects. Dichlorvos, an organophosphate insecticide, is the active ingredient in No-Pest Strips.

Three different attractant lures were attached to the inside of each funnel trap and changed every 6–7 weeks. The lures included one α-pinene UHR (ultra-high release) pouch with a release rate of 2.3 g per day at 26 °C (Alpha Scents, Inc., West Linn, OR), one ethanol UHR pouch with a release rate of about 300 mg per day at 20 °C (Contech Enterprises Inc., Delta, BC), and two cis-3-hexenol bubble caps with a combined release rate of 7.4 mg per day at 20 °C (Contech Enterprises Inc). The α-pinene and ethanol lures are common attractants for a wide range of bark- and wood-infesting insects (Millar and Hanks 2017, Rabaglia et al. 2019). The volatile leaf alcohol *cis*-3-hexenol serves as a host attractant for EAB adults (Poland et al. 2019). In addition, at Anderson Point (A), a single unbaited black funnel trap was deployed in the lower canopy near the other traps as a blank control.

2016 Study. Six trapping sites were used in 2016, including three of the original sites (A, D, and W; Fig. 1b). The three new sites, from north to south, were along the forest edge at the GEMS (Grouse Enhanced Management Systems) site on state land (G; N 46.0580°, W 83.6622°), a forested area of the Drummond Island Township Park that had recently been selectively logged (P; N 45.9884°, W 83.7850°), and in a forest opening near Helen Lake on state land (H; N 45.9547°, W 83.7514°; Fig. 1b). A single Fluon-coated, green, 12-unit funnel trap was deployed at each site. The 2016 study was not focused on EAB and therefore sites with a different tree mixture were used: *Abies* and *Populus* dominated the GEMS site, *Acer* and *Fagus* the Township Park, and *Pinus* the Helen Lake site.

Traps were deployed on 23 May 2016 and taken down on 20 October 2016 (148 trapping days). The traps were checked irregularly, every 3–6 weeks. Traps were suspended from lower tree branches so that the collection cup was about 1 m above groundline. The collection cups were prepared as in 2015. The lures used on each trap included one fuscumol acetate bubble cap with a release rate of 2 mg/day at 20 °C (Synergy Semiochemicals Corporation, Delta, BC), one monochamol bubble cap with a release rate of ~750 ug/day at 20 °C (Synergy), and one syn-(2,3)-hexanediol (a racemic mix of six-carbon diols) bubble cap with an undetermined release rate (Synergy). These compounds are known pheromones or attractants for several cerambycid species in multiple cerambycid subfamilies that infest both conifers and hardwoods (Millar and Hanks 2017), and they can be suspended from the same traps with no apparent antagonistic effects on attraction to cerambycids (Fan et al. 2019). In addition, at the Anderson Point (A) site, a single unbaited green funnel trap was deployed in the lower canopy near the other trap as a blank control.

Insect sorting and identification. In both years, all insects in the collection cups were emptied into labeled plastic zip-lock bags and kept frozen until sorted. Insects were later removed from one bag at a time and placed in a Petri dish and viewed under a dissecting microscope. All specimens of Buprestidae, Cerambycidae, and Siricidae were removed and placed in labelled vials or pinned. These insects were identified using various reference books and keys, including Wellso et al. (1976) and Paiero et al. (2012) for Buprestidae; Yanega (1996) and Lingafelter (2007) for Cerambycidae, and Schiff et al. (2006, 2012) for Siricidae. Identifications were later confirmed by comparing specimens with previously identified insects in the Michigan State University (MSU), Department of Entomology, Albert J. Cook Arthropod Research Collection in East Lansing, MI. Currently, the borers identified in this paper reside in the author's personal collection but later will be placed in the MSU collection.

Results: 2015 Study. Overall, 129 borers (4.5 borers per 100 trap-days) were collected in the 24 baited traps in 2015, including 7 buprestids (4 species, but no EAB), 115 cerambycids (21 species), and 7 siricids (4 species) (Table 1). No borers were collected in the single unbaited control trap. Of the 21 cerambycid species, five were members of the subfamily Cerambycinae, six were Lamiinae, eight were Lepturinae, and two were Spondylidinae (Table 1). Nine of the 21 cerambycid species develop primarily in conifers (softwoods), 11 mostly in broadleafed trees (hardwoods), and the larval hosts of one cerambycid species are still unknown: *Idiopidonia pedalis* (LeConte) (Table 1). Similarly, one of the buprestid species de-

Table 1. Details on the bark- and wood-infesting Buprestidae, Cerambycidae, and Siricidae collected in baited funnel traps on Drummond Island in 2015 and 2016.

		Number of adults collected						
Family, Subfamily, Species	**Year(s) when collected**	**2015 B / G[1]**	**2015 U / C[2]**	**Total for 2015**	**Total for 2016**	**Sites where collected in 2015–16[3]**	**Primary months collected in 2015–16[4]**	**Common larval hosts[5]**
CERAMBYCIDAE		67 / 48	58 / 57	115	53			
Cerambycinae								
Clytus ruricola (Olivier)	2015	0 / 3	2 / 1	3	0	1st W	VII-VIII	Hardwoods
Cyrtophorus verrucosus (Olivier)	2015	1 / 1	0 / 2	2	0	B W	VI-VII	Hardwoods
Microclytus gazellula (Haldeman)	2015	1 / 2	1 / 2	3	0	D W	VI	Hardwoods
Neoclytus acuminatus (Fab.)	2016	-	-	0	1	W	VI-VII	Hardwoods
Pronocera collaris (Kirby)	2015	1 / 0	0 / 1	1	0	W	VI-VII	Conifers
Xylotrechus undulatus (Say)	2015	12 / 12	9 / 15	24	0	1st A AI D W	VI-VIII	Conifers
Lamiinae								
Acanthocinus pusillus Kirby	2015-16	2 / 2	2 / 2	4	1	1st D P	VI-VIII	Conifers
Aegomorphus modestus (Gyllenhal)	2015-16	1 / 0	0 / 1	1	1	H W	VI-VIII	Hardwoods
Astylopsis collaris (Haldeman)	2015-16	2 / 2	2 / 2	6	2	D G W	VI-VIII	Hardwoods
Graphisurus fasciatus (DeGeer)	2016	-	-	0	6	P	VII-VIII	Hardwoods
Monochamus marmorator Kirby	2015-16	0 / 1	0 / 1	2	1	A G	VII-VIII	Conifers
Monochamus notatus (Drury)	2015-16	2 / 0	2 / 0	3	1	A H	VIII-IX	Conifers
Monochamus scutellatus (Say)	2015-16	10 / 10	10 / 10	59	39	1st A G H P W	VI-IX	Conifers
Lepturinae								
Bellamira scalaris (Say)	2015	2 / 0	0 / 2	2	0	1st W	VII-VIII	Hardwoods
Evodinus monticola (Randall)	2016	-	-	0	1	A	V-VI	Conifers
Grammoptera subargentata (Kirby)	2015	1 / 0	1 / 0	1	0	B	IX	Hardwoods
Hyperplatys aspersa (Say)	2015	1 / 0	1 / 0	1	0	AI	VII-VIII	Hardwoods
Idiopidonia pedalis (LeConte)	2015	1 / 0	1 / 0	1	0	W	VI-VII	Unknown
Pidonia ruficollis (Say)	2015	0 / 2	1 / 1	2	0	W	VI	Hardwoods
Rhagium inquisitor (L.)	2015	2 / 1	2 / 1	3	0	1st A W	VI-VIII	Conifers
Trachysida mutabilis (Newman)	2015	1 / 3	4 / 0	4	0	1st D W	VI-VIII	Hardwoods
Trigonarthris minnesotana (Casey)	2015	20 / 0	12 / 8	20	0	1st AI B W	VI-VIII	Hardwoods

Table 1. Continued.

Family, Subfamily, Species	Year(s) when collected	Number of adults collected: 2015 B / G[1]	2015 U / C[2]	Total for 2015	Total for 2016	Sites where collected in 2015–16[3]	Primary months collected in 2015–16[4]	Common larval hosts[5]
Spondylidinae								
Asemum striatum (L.)	2015	6 / 8	7 / 7	14	0	D, W	VI-VII	Conifers
Tetropium cinnamopterum Kirby	2015	1 / 1	1 / 1	2	0	D W	VI-VII	Conifers
BUPRESTIDAE		4 / 3	3 / 4	7	0			
Agrilus anxius Gory	2015	0 / 1	1 / 0	1	0	W	VII-VIII	*Betula*
Buprestis maculativentris Say	2015	1 / 0	1 / 0	1	0	1st	VIII	Conifers
Dicerca tenebrica (Kirby)	2015	2 / 1	0 / 3	3	0	W	VI-VII	*Populus*
Poecilonota cyanipes (Say)	2015	1 / 1	1 / 1	2	0	W	VIII-IX	*Populus*
SIRICIDAE		7 / 0	4 / 3	7	0			
Sirex nigricornis Fabricius	2015	1 / 0	1 / 0	1	0	A	IX	Conifers
Urocerus albicornis (Fabricius)	2015	3 / 0	2 / 1	3	0	1st D	VII-VIII	Conifers
Urocerus cressoni Norton	2015	1 / 0	0 / 1	1	0	1st	VIII	Conifers
Xeris melancholicus (Westwood)	2015	2 / 0	1 / 1	2	0	B	VII-IX	Conifers

[1]Trap color: B = black, G = green.
[2]Trap location: U = understory, C = canopy.
[3]Trapping site codes given in Fig. 1b.
[4]Months: V = May, VI = June, VII = July, VIII = August, IX = September.
[5]Common hosts are based on Gosling 1973, 1983, 1984, 1986; Gosling and Gosling 1977; Heffern et al. 2015; Lingafelter 2007; Paiero et al. 2012; Schiff et al. 2006, 2012; Wellso et al. 1976; Yanega 1996.

veloped in conifers and three in hardwoods (Table 1). All four siricid species developed in conifers (Table 1).

Ten of the 29 borer species were each represented by only a single individual, and six others by only two individuals each (Table 1). By contrast, only four of the 29 borer species were collected in numbers of 10 individuals or greater, all of which were cerambycids, including *Asemum striatum* (L.) (14 individuals), *Monochamus scutellatus* (Say) (20), *Trigonarthris minnesotana* (Casey) (20), and *Xylotrechus undulatus* (Say) (24; Table 1). Of the six trapping sites, Arrow Island had the fewest with only 3 borer species collected (all cerambycids), whereas Wa-Wen Resort had the most, with 19 species collected (3 buprestids and 16 cerambycids).

There were no striking differences between the diversity of borers collected in traps placed in the understory (catching 22 of the 29 species) compared with those placed in the lower canopy (catching 21 of the 29 species). For the four cerambycid species that were captured most frequently, they were captured at equal or nearly equal numbers in traps placed at the two height positions: 7 of 14 *A. striatum* were captured at the lower position ($\chi 2$ test, $P = 1$), and similarly, 10 of 20 *M. scutellatus* ($P = 1$), 11 of 20 *T. minnesotana* ($P = 0.655$), and 13 of 24 *X. undulatus* ($P = 0.683$).

Considering trap color, the buprestids and cerambycids were captured in both black and green traps, whereas all siricids were captured in black traps. Overall, three of the four buprestid species and 18 of the 21 cerambycid species were captured in black traps, compared with three buprestid and 13 cerambycid species being collected in green traps. Of the four most frequently collected cerambycids, only *T. minnesotana* showed a strong color preference with all 20 individuals collected in black traps ($\chi 2$ test, $P < 0.0001$). By contrast, the others were captured at equal or nearly equal numbers in black and green traps: *A. striatum* ($P = 0.593$), *M. scutellatus* ($P = 1$), and *X. undulatus* ($P = 1$).

Borers were captured during each of the five trapping periods. Overall, 25 individual borers (9 species) were collected during the first collecting period that ended on 23 June 2015, 41 (16 species) on 12 July, 45 (13 species) on 15 August, 14 (7 species) on 1 September, and 4 (4 species) on 3 October. Of the 29 borer species collected, the cerambycid *Microclytus gazellula* (Haldeman) was only captured during the first sampling period in June, whereas the cerambycid *Grammoptera subargentata* (Kirby) and siricid *Sirex nigricornis* Fabricius were only captured in the last sampling period that occurred mostly in September and ended in early October (Table 1).

2016 Study. Overall, 53 borers (6.0 borers per 100 trap-days), representing 9 cerambycid species, were collected in the six baited traps used in 2016 (Table 1). No buprestids or siricids were trapped in 2016, and no borers were collected in the single unbaited control trap. Moreover, of the nine cerambycid species, one was a member of the subfamily Cerambycinae, seven were Lamiinae, and one was a Lepturinae (Table 1). Six of the nine cerambycid species collected in 2016 had been captured in 2015 and three were new (Table 1). Four of the nine 2016 cerambycid species developed primarily in hardwoods and five in conifers (Table 1).

Six of the nine 2016 cerambycid species were represented by only a single individual, one was collected twice, another six times, and one (*M. scutellatus*) 39 times. No borers were collected at Dix Point (D) in 2016. At the other five 2016 sites, usually only two or three cerambycid species were captured throughout the entire trapping season, and only *M. scutellatus* was collected at all five sites (Table 1).

From 6 to 19 borers were captured during each of the first five trapping periods, but none were collected during the last period (12 September to 20 October 2016). Overall, 6 individual borers (2 species) were collected during the first collecting period that ended on 4 June 2016, 10 (3 species) on 4 July, 7 (4 species) on 20 July, 19 (4 species) on 21 August, and 11 (2 species) on 12 September. Besides *M. scutellatus*, the only other cerambycid collected during the first collection period that ended on 4 June was *Evodinus monticola* (Randall), and similarly *Monochamus notatus* (Drury) was the only other borer trapped during 21 August to 12 September (Table 1).

Discussion. The original impetus for this study was to sample for EAB on Drummond Island. However, no EAB adults were collected in either 2015 or 2016. Moreover, as of June 2020, EAB has still not been reported on Drummond Island, nor on nearby Neebish Island (Michigan) to the northwest or Cockburn Island (Ontario) to the southeast (Fig. 1a). Nevertheless, EAB is becoming more common on the mainland of Michigan's eastern Upper Peninsula, as well as on the mainland of Ontario between Sault Ste. Marie and Manitoulin Island, which is directly east of Cockburn Island. EAB was first detected on Manitoulin Island in 2011. Given that EAB-infested areas generally surround Drummond Island, EAB will likely arrive someday, either by active flight or being assisted by humans, such as by transporting infested firewood (Haack et al. 2010). In 2018, Michigan's internal EAB quarantine was repealed given that EAB was known to occur in all but four of Michigan's 83 counties at that time (MDARD 2018). As a result, movement of ash trees, ash logs, and ash firewood was no longer regulated within Michigan, although the public was still encouraged not to move firewood long distances. Therefore, inadvertent movement of EAB-infested ash trees, logs, or firewood could easily bring EAB to Drummond Island as well as other nearby islands.

All 32 species of borers collected in this study (4 buprestids, 24 cerambycids, and 4 siricids) were already reported to occur in Michigan (Gosling 1973, Wellso et al. 1976, Gosling and Gosling 1977, Schiff et al. 2012). Of these borers, county occurrence data in Michigan have only been published for the cerambycids (Gosling 1973, 1983, 1984; Gosling and Gosling 1977). In these four papers, county-level data are presented for 228 cerambycid species, of which 104 species were recorded in Michigan's Upper Peninsula. Using the above four papers as the baseline, seven of the 24 cerambycid species reported in this paper [*Aegomorphus modestus* (Gyllenhal), *Astylopsis collaris* (Haldeman), *Grammoptera subargentata* (Kirby), *Hyperplatys aspersa* (Say), *Microclytus gazellula* (Haldeman), *Monochamus marmorator* Kirby, and *Pidonia ruficollis* (Say)] are new county records for Chippewa County, MI, and two of these species are recorded for the first time in Michigan's Upper Peninsula (*A. collaris* and *M. gazellula*). Undoubtedly many more borer species occur on Drummond Island than were collected in this study, considering that Michigan has at least 120 species of buprestids (Wellso et al. 1976; Haack et al. 2002, 2009; Maier 2012; MacRae and Basham 2013), 228 species of cerambycids (Gosling 1973, 1983, 1984; Gosling and Gosling 1977), and 10 species of siricids (Schiff et al. 2012).

Although no striking differences in borer diversity were found between understory and canopy traps in the present 2015 study, other researchers have found significant differences relative to trapping height (Dodds 2014, Rassati et al. 2019, Ulyshen and Sheehan 2019). Similarly, there were few striking differences in buprestid and cerambycid attraction to traps of different colors in the present study (black vs. green), although others have reported that trap color did affect borer diversity and abundance. For example, many adult buprestids show a preference for green traps over black traps (Petrice and Haack 2015, Skvarla and Dowling 2017) as well as green over purple traps (Rassati et al. 2019). For cerambycids, Rassati et al. (2019) found that trap color (green vs. purple) significantly affected diversity and abundance at the cerambycid subfamily level and for certain individual cerambycid species. This was true in present study as well, with black traps preferred by the lepturine cerambycid *T. minnesotana*, and similarly by the cerambycine *Xylotrechus colonus* (Fabricius) (Skvarla and Dowling 2017). In other studies, black traps were shown to be superior to clear traps or white traps in catching various buprestids, cerambycids, and siricids (de Groot and Nott 2001, Hurley et al. 2015, Allison and Redak 2017). In a study in South Africa, where six traps of each color were used, more *Sirex noctilio* F. adults were captured in black intercept panel traps (33 individuals; Alpha Scents, West Linn, OR) and black 12-unit funnel traps (28), compared with either light blue (6) or dark blue (2) funnel traps (Brett P. Hurley, University of Pretoria, South Africa, unpublished data).

The lures used in the present study were dramatically different between years, with plant volatiles (α-pinene, ethanol, and cis-3-hexenol) used in 2015 and cerambycid pheromones (fuscumol acetate, monochamol, and syn-(2,3)-hexanediol) used in 2016. Many borers use plant volatiles to locate their host plants, especially those that infest trees stressed by environmental factors such as drought (Mattson and Haack 1987, Haack and Petrice 2019). Environmental stress often increases ethanol production in plant tissues in both hardwoods and conifers, and similarly the production of the resin monoterpene α-pinene in stressed conifers (Kimmerer and Kozlowski 1982, Mattson and Haack 1987, Turtola et al. 2003). Ethanol and α-pinene, especially when combined, are well known attractants to many bark- and wood-infesting insects, including many cerambycids and siricids (Miller 2006, Johnson et al. 2013, Millar and Hanks 2017, Hanks et al. 2018). The ethanol and α-pinene lures used in 2015 were likely responsible for attracting most of the wood borers collected that year. By contrast, the cis-3-hexenol lures were specifically used to attract EAB, given that this alcohol is released from hardwood trees, including ash foliage, and is known to be attractive to EAB adults (Poland et al. 2019). Nevertheless, no EAB were collected in 2015, suggesting that EAB had not yet invaded Drummond Island, or if present, was not near any of the six 2015 trapping sites.

Of the nine cerambycid species collected in 2016, when cerambycid pheromones were used as lures, two species are known to use fuscumol acetate as a pheromone component [*Aegomorphus modestus* and *Graphisurus fasciatus* (DeGeer)]; three use monochamol (*Monochamus marmorator*, *M.*

notatus and *M. scutellatus*); and one uses syn-(2,3)-hexanediol [*Neoclytus acuminatus* (Fab)], (Millar and Hanks 2017, Hanks et al. 2018, Meier et al. 2020). No pheromone information was found for the three other cerambycids collected in 2016 (*Acanthocinus pusillus* Kirby, *Astylopsis collaris*, and *Evodinus monticola*).

There are likely many additional borer species on Drummond Island than were collected in this study, given that relatively few lures and trapping techniques were employed as well as relatively few habitats were sampled. In addition to the genera of the tree species listed in the introduction of this paper, many other trees and large shrubs occur on Drummond Island and nearby islands, including native species of *Alnus, Amelanchier, Celastrus, Corylus, Cornus, Crataegus, Dirca, Ilex, Juniperus, Lonicera, Malus, Myrica, Prunus, Rhus, Rhamnus, Ribes, Rosa, Rubus, Salix, Sambucus, Shepherdia, Sorbus, Symphoricarpos, Taxus,* and *Ulmus* (Scharf and Chamberlin 1978, Weatherbee 2014, Reznicek et al. 2016, Lincoln 2018). Borers may also use some of the island's smaller shrubs and woody vines as larval hosts, such as species of *Arctostaphylos*, *Diervilla, Gaultheria*, *Hypericum*, *Rhododendron* (formerly *Ledum*), *Spiraea, Vaccinium* and *Vitis*. For example, the Cerambycinae *Cyrtophorus verrucosus* (Olivier), two of which were collected in this study (Table 1), are 7–11 mm long and have been reared from many species of hardwood trees (Yanega 1996, Lingafelter 2007), and also woody shrubs in the genera *Cornus, Shepherdia*, and *Vaccinium* (Heffern et al. 2018), all of which grow on Drummond Island.

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