

## Coleoptera Collected Using Three Trapping Methods at Grass River Natural Area, Antrim County, Michigan

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### Abstract

Overall, 409 Coleoptera species (369 identified to species, 24 to genus only, and 16 to subfamily only), representing 275 genera and 58 beetle families, were collected from late May through late September 2017 at the Grass River Natural Area (GRNA), Antrim County, Michigan, using baited multi-funnel traps (210 species), pitfall traps (104 species), and sweep nets (168 species). All three collecting methods were used in three distinct habitats: a rich conifer swamp (cedar), near the edge of a red pine plantation (pine), and within a mesic northern hardwood forest (hardwoods). Additional collections were made along two trails and in an open field by sweep netting only. Of the 409 species, 322 were collected in one or more of the cedar, hardwoods, and pine habitats, and 152 were collected along the two trails and the grassland site. Of the 322 species collected in the three main habitats, 40 species (36 genera and 14 families) were collected in all three habitats, 105 species (80 genera and 32 families) were collected in the cedar, 176 (131 genera and 38 families) in the hardwoods, and 199 (158 genera and 47 families) in the pine habitats. With respect to adult seasonal activity, 21% of the 409 species were first collected in May, 40% in June, 23% in July, 10% in August, and 6% in September. Of the 210 species collected in funnel traps, 144, 123, and 114 species were collected, respectively, in traps baited with  $\alpha$ -pinene, ethanol, or ipsenol. Diversity indices were calculated for the funnel trap data by site and lure. Overall, 32 of the 409 species were considered exotic to North America, and 18 were considered new state records for Michigan. In addition, 16 species of aquatic beetles (12 genera in 5 families) were identified from GRNA stream samples collected during 2013–2019.

**Keywords:** beetles, diversity index, state records, funnel trap, pitfall trap, sweep net

Interest in insect biodiversity and conservation has grown in recent decades along with recognition of the many important ecosystem services that insects provide (Footitt and Adler 2017, Samways 2019). Moreover, recent reports of global insect declines have heightened public awareness of the threats faced by many insects (van Klink et al. 2020). Just over one million species of insects have been described worldwide (Zhang 2011), including nearly 400,000 species of beetles (Coleoptera) (Bouchard et al. 2017). In North America north of Mexico, over 25,000 beetle species have been described (Marske and Ivie 2003), and in Michigan there are about 4000 beetle species recorded (W. G. Ruesink et al., unpublished data).

Beetle surveys in various parts of Michigan have been published since the late 1800s. Schwarz (1876) published one of the first lists based on beetles collected mostly in the Detroit area. Two years later, Hubbard and Schwarz (1878) published a more extensive list (> 2000 species) based

on collections in both Michigan's Lower and Upper Peninsulas, including Isle Royale in Lake Superior where they recorded 123 beetle species. Townsend (1889) published a list of beetles (161 species) collected in St. Joseph County, MI. Later, Adams (1909) and Wolcott (1909) added several more species to the list of beetles known to occur on Isle Royale, raising the total to 206 species. Andrews (1916) published an extensive list of beetle species (623 species) found on the Charity Islands in Saginaw Bay, Lake Huron. Andrews (1921) published another long list of beetle species (886 species) found at Whitefish Point in the Upper Peninsula of Michigan. One additional early list of Michigan beetles (580 species) was published by Hatch (1925) for Charlevoix County, including Beaver, Garden and Hog Islands in Lake Michigan. More recently, several authoritative lists of Michigan beetles have been published for specific families or subfamilies, such as Buprestidae (Wellso et al. 1976), Cerambycidae (Gosling 1973, 1983;



Figure 1. Map of Grass River Natural Area (GRNA), Antrim County, MI, showing all property as of 2020 except for a few parcels at the north end of Lake Bellaire. The green-colored parcels are open to hunting, while the orange-colored area is closed to hunting. Labels for the 2017 sampling sites are: C = cedar habitat, G = grassland, H = hardwoods, P = pine, RT = Rail Trail, and SMT = Sedge Meadow Trail. The three creeks where sampling occurred are marked (Cold, Finch, and Shanty Creeks). The red star inside the inset map of Michigan is the approximate location of GRNA.

Gosling and Gosling 1977), Ciidae (Grey and Cognato 2019), Cleridae (Gosling 1980), Scolytinae (Cognato et al. 2009), Tenebrionidae (Spilman 1973), and several families of aquatic beetles (Bright 2020).

The Grass River Natural Area (GRNA) is in Antrim County in northwestern Lower Michigan, where it straddles much of the Grass River that connects Lake Bellaire to Clam Lake (Fig. 1). GRNA began in 1969 with a single 62 ac (25 ha) parcel and has now expanded to 1492 ac (603 ha), consisting of 73 discrete and mostly contiguous land parcels (GRNA 2020). The staff at GRNA welcomes and supports on-site field research (GRNA 2020).

The Michigan Natural Features Inventory (MNFI) has identified 77 natural community types in Michigan (Kost et al. 2007, Cohen et al. 2015), of which 9 were identified by MNFI staff at GRNA (Hackett

et al. 2017). Using MNFI terminology the nine natural communities (habitats) found at GRNA, in decreasing order of size as estimated in 2017, were rich conifer swamp (503 ac; 204 ha), mesic northern forest (283 ac; 115 ha), northern fen (185 ac; 75 ha), poor conifer swamp (82 ac; 33 ha), hardwood-conifer swamp (53 ac; 21 ha), northern wet meadow (49 ac; 20 ha), northern shrub thicket (41 ac; 17 ha), dry-mesic northern forest (30 ac; 12 ha), and emergent marsh (6 ac; 2 ha) (Hackett et al. 2017).

Beetles can be collected in a variety of ways with equipment such as sweep nets, beating sheets, light traps, pitfall traps, baited or unbaited flight-intercept traps, Berlese funnels, and Malaise traps (Dillon and Dillon 1972, White 1983, Evans 2014). In the present study, we used sweep nets, pitfall traps, and baited multi-funnel traps to collect beetles at GRNA in 2017. In this paper, we provide a list of the beetle species

collected with details on their habitat associations, seasonality, methods by which they were collected, and status as being native or exotic to the United States as well as a new state record for Michigan. In addition, diversity indices were calculated for the funnel trap data.

### Methods and Materials

**Habitats sampled.** Trapping and sweep netting was conducted in three GRNA habitats, including rich conifer swamp (which we refer to as “cedar”), mesic northern forest (hardwoods), and along the edge of a mature, red pine (*Pinus resinosa* Sol. ex Aiton) plantation (pine) (Fig. 1). The rich conifer swamp was dominated by northern white cedar (*Thuja occidentalis* L.), with other occasional tree species such as tamarack [*Larix laricina* (Du Roi) K. Koch], balsam fir [*Abies balsamea* (L.) Mill], red maple (*Acer rubrum* L.), yellow birch (*Betula alleghaniensis* Britton), and black ash (*Fraxinus nigra* Marshall). The mesic northern forest was dominated by hardwood trees such as sugar maple (*Acer saccharum* Marshall) and American beech (*Fagus grandifolia* Ehrh.), with occasional yellow birch, northern red oak (*Quercus rubra* L.), eastern hemlock [*Tsuga canadensis* (L.) Carrière], and white pine (*Pinus strobus* L.). Along the edge of the red pine plantation were occasional red maple, black cherry (*Prunus serotina* Ehrh.), and white pine. A detailed floristic description of each GRNA habitat is given in Hackett et al. (2017). The Latitude-Longitude coordinates of the three main trapping sites were: N 44.9135° Lat and W 85.2186° Long for the cedar site, N 44.9128° Lat and W 85.2246° Long for the hardwood site, and N 44.9050° Lat and W 85.2223° Long for the pine site.

Sweep netting was also conducted along two GRNA trails (Rail Trail and Sedge Meadow Trail) and in an open field (grassland; N 44.9100° Lat and W 85.2333° Long) (Fig. 1). The Rail Trail occurs along the former Pere-Marquette Railway track bed and typically grades on each side from grasses, forbs and shrubs to trees that reflect the adjacent habitats. The Sedge Meadow Trail traverses three habitats: rich conifer swamp, hardwood-conifer swamp, and northern wet meadow. The hardwood-conifer swamp was dominated by northern white cedar, yellow birch, balsam poplar (*Populus balsamifera* L.), and bigtooth aspen (*Populus grandidentata* Michaux), whereas the northern wet meadow was dominated by sedges, grasses, and occasional small shrubs (Hackett et al. 2017).

**Sampling methods and frequency.** The three main methods of collecting beetles at GRNA involved funnel traps,

pitfall traps, and sweep netting. Sampling with funnel traps occurred from 19 May to 24 September 2017, and similarly from 19 May to 22 September 2017 for pitfall traps, and from 23 May to 20 September 2017 for sweep netting. Starting in June or July, respectively, the pitfall traps and funnel traps were “closed” for two weeks each month, usually the first two weeks of each month. Sweep netting occurred at all sites, starting in May or June, and occurred usually two to three times per month, including the trails and grassland site.

**Funnel traps.** At each of the three main collecting sites, three 12-unit multi-funnel traps (Contech Enterprises Inc., Victoria, British Columbia, Canada) were deployed. The color of the funnels was green as shown in Petrice and Haack (2015). The individual funnels in all traps were coated with Fluon (Northern Products Inc., Woonsocket, RI), a slippery substance that improves trapping efficiency (Graham et al. 2010). The traps were suspended from lower branches of trees so that the bottom of the collection cup was about 1 m above groundline. To make sure the traps were clearly visible to flying insects, any interfering branches were pruned away. The distance between traps at each site ranged from 4–25 m, depending on the location of suitable trees. The collection cup at the bottom of the funnel trap was fitted with a small screen to allow rainwater to drain. Inside each collection cup, a circular piece of window screening was fitted near the bottom that suspended captured insects above any moisture that accumulated at the base of the cup. A few pieces of No-Pest Strip (Spectrum Group, St. Louis, MO), were placed inside each collection cup on top the screen to quickly kill trapped insects. The active ingredient in No-Pest Strips is dichlorvos, an organophosphate insecticide. Three different lures were used at each site, using one lure per trap, including an  $\alpha$ -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), an ethanol UHR pouch with a release rate of about 300 mg per day at 20°C (Contech Enterprises Inc.), and a racemic ipsenol bubble-cap with a release rate of about 0.1–0.2 mg/d at 25°C (Contech Enterprises Inc.). These lures are common attractants to a wide range of bark- and wood-infesting insects and their associates (Miller et al. 2015, Millar and Hanks 2017, Rabaglia et al. 2019). The lures and No-Pest Strips pieces were changed at approximately 6-week intervals. At the end of a sampling period, all insects were removed and placed in a labeled zip-lock plastic bag and frozen until sorted. The collection cup was then cleaned, the screen and No-Pest Strips re-

positioned in the cup, and then the cup was reattached to the trap.

**Pitfall traps.** Two pitfall traps were installed at the three main collection sites. Each trap consisted of an 18 oz (0.5 l) plastic cup with a ca. 10-cm diameter opening that was sunk into the ground so that the top was flush with the soil surface. Two 1-m-long barriers, made from black plastic lawn edging, were partially buried on opposite sides of the cup and positioned flush with the cup's rim at the hardwoods and pine sites, but not the cedar site because the sphagnum surface there was too irregular for the edging to make an effective barrier. Such barriers direct ground invertebrates towards the cup and have been shown to increase trap catch (Durkis and Reeves 1982, Hansen and New 2005, Skvarla et al. 2014). At the start of a sampling period each cup was cleaned and then filled to a depth of ca. 5 cm with 70% ethanol. To reduce dilution from rain, a 25-cm diameter plastic plate was placed ca. 5 cm above each collection cup, supported by large nails. At the end of each sampling period, all beetles were removed and placed in labeled vials with fresh 70% ethanol and then stored until mounted for identification.

**Sweep netting.** A standard 15-inch (38 cm) diameter heavy duty sweep net with a sailcloth bag was used. Typically, 10-30 min was spent sweeping each site when visited. Most sweeping was conducted on non-woody vegetation, but in each habitat about ten percent of all sweeps consisted of strongly beating the net against woody shrubs and lower tree limbs. The number of sweeps taken was not predetermined and varied with each sampling date, depending on conditions and productivity. The number of sweeps varied among habitats. For example, in the hardwoods habitat only 40-50 sweeps would be taken because there was little appropriate vegetation given that most tree branches were too high to reach with the net and relatively little ground vegetation grew in areas of deep shade. By contrast, as many as 500 sweeps were made in the grassland site where there was about 1 ha of open herbaceous vegetation interspersed with a few shrubs available for sweeping. The beetles collected during sweeping were placed in labeled vials with fresh 70% ethanol and stored until mounted for identification.

**Aquatic beetles.** In addition to the beetles collected by the methods described above, the authors also examined vials of stored aquatic macroinvertebrates collected by netting in three GRNA creeks (Cold Creek, Finch Creek, and Shanty Creek; Fig. 1) during the spring and fall sampling efforts during 2013-2019. These collections were made by GRNA staff and volunteers as

part of the MiCorps Volunteer Stream Monitoring Program, sponsored by Michigan's Department of Environment, Great Lakes, and Energy (<https://micorps.net/>). Beetles were removed from the stored vials, pinned, labelled, and later identified.

**Specimen identification and location.** Nearly all beetles were identified by WGR using an AmScope 7X-90X binocular zoom microscope (AmScope, Irvine, CA, USA) and the keys in Downie and Arnett (1996). The identifications were checked against information and photographs on BugGuide (<https://bugguide.net/>). In cases where some doubt existed regarding the identification, literature suggested on BugGuide as well as the keys in Arnett and Thomas (2001) and Arnett et. al. (2002) were consulted. In addition, for some beetle groups, taxonomic advice and assistance were provided by national experts (see Acknowledgments). The specimens discussed in this paper are currently in the authors' private collections but later a few will be retained at GRNA with the vast majority being deposited in the Michigan State University, Department of Entomology, Albert J. Cook Arthropod Research Collection in East Lansing, MI.

**New Michigan state records.** The status of each beetle species as being a potential new state record for Michigan was based on data presented in the several authoritative lists of Michigan beetles mentioned in the introduction plus over 350 other publications that have been reviewed in preparation of a formal list of Michigan Coleoptera by W. G. Ruesink et al. Many of these papers mention only one or a few species, but others cover entire major families for all of North America north of Mexico. Examples of the latter include Beal (2003) [Dermestidae], Bousquet (2012) [Carabidae], Bousquet et al. (2018) [Tenebrionidae], Herman (2001) [Staphylinidae, in part], O'Brien and Wibmer (1982) [Curculionidae], Peck and Newton (2017) [Leiodidae], Pelletier and Hébert (2014) [Cantharidae], and Riley et al. (2003) [Chrysomelidae, excluding Bruchinae]. In addition, the online SCAN database (<https://scan-bugs.org/>) of over 100 North American arthropod collections was consulted to determine if they had Michigan specimens for any of the potential new state records, as well as photographs of identified specimens submitted to BugGuide (<https://bugguide.net/>) and iNaturalist (<https://www.inaturalist.org/>) of beetles collected in Michigan. Gary Parsons, Collection Manager of the A. J. Cook Arthropod Research Collection (ARC) at Michigan State University (MSU), was also consulted to check if specimens of any of the potential new state records had recently been deposited in the ARC-MSU collection.

Table 1. Summary data by beetle family for Coleoptera collected at Grass River Natural Area (GRNA) in 2017, including common name of the family and number of species in North America north of Mexico from Evans (2014), number of species and genera collected at GRNA, number of species collected and considered exotic to the United States, habitats where the specimens were collected, methods by which the beetles were collected, and months when collected.

| Family         | Common name                 | No. species in |    | No. GRNA species | No. GRNA genera | No. exotic species collected | Habitats where collected <sup>1</sup> | Methods by which collected <sup>2</sup> | Months when collected in 2017 <sup>3</sup> |
|----------------|-----------------------------|----------------|----|------------------|-----------------|------------------------------|---------------------------------------|-----------------------------------------|--------------------------------------------|
|                |                             | North America  |    |                  |                 |                              |                                       |                                         |                                            |
| Aderidae       | Antlike leaf beetles        | 48             | 1  | 1                | 1               |                              | HP                                    | F                                       | VI VII IX                                  |
| Anthicidae     | Antlike flower beetles      | 229            | 1  | 1                | 1               |                              | HP                                    | F                                       | VI VII                                     |
| Anthribidae    | Fungus weevils              | 88             | 3  | 88               | 2               |                              | GPS                                   | FS                                      | V VI VII VIII IX                           |
| Bostrichidae   | Bostrichid beetles          | 77             | 1  | 1                | 1               |                              | P                                     | F                                       | V                                          |
| Brentidae      | Straight-snouted beetles    | 151            | 1  | 1                | 1               | 1                            | G                                     | S                                       | VII                                        |
| Buprestidae    | Jewel beetles               | 788            | 5  | 788              | 4               | 1                            | GPS                                   | FS                                      | VI VII VIII IX                             |
| Byrrhidae      | Moss beetles                | 57             | 1  | 1                | 1               |                              | H                                     | P                                       | V VI                                       |
| Cantharidae    | Soldier beetles             | 473            | 20 | 473              | 7               |                              | CGHPSO                                | FS                                      | V VI VII VIII IX                           |
| Carabidae      | Ground beetles              | 2439           | 41 | 2439             | 21              | 1                            | CGHPSO                                | FPS                                     | V VI VII VIII IX                           |
| Cerambycidae   | Loghorned beetles           | 958            | 17 | 958              | 15              |                              | CGHPO                                 | FS                                      | V VI VII VIII                              |
| Chrysomelidae  | Leaf beetles                | 1869           | 40 | 1869             | 30              | 4                            | CGHPSO                                | FPS                                     | V VI VII VIII IX                           |
| Ciidae         | Minute tree-fungus beetles  | 84             | 1  | 1                | 1               |                              | CP                                    | F                                       | VIII IX                                    |
| Cleridae       | Checkered beetles           | 243            | 7  | 243              | 6               |                              | CHPS                                  | FS                                      | V VI VII VIII IX                           |
| Coccinellidae  | Lady beetles                | 481            | 18 | 481              | 11              | 2                            | CGHPSO                                | FPS                                     | V VI VII VIII IX                           |
| Corylophidae   | Minute hooded beetles       | 61             | 2  | 61               | 2               |                              | CHP                                   | F                                       | VI VIII IX                                 |
| Cryptophagidae | Silken fungus beetles       | 145            | 2  | 145              | 2               |                              | CP                                    | F                                       | V VI                                       |
| Curculionidae  | Weevils                     | 2919           | 47 | 2919             | 38              | 13                           | CGHPSO                                | FPS                                     | V VI VII VIII IX                           |
| Dermestidae    | Skin beetles                | 117            | 1  | 117              | 1               |                              | P                                     | F                                       | VI                                         |
| Elateridae     | Click beetles               | 965            | 21 | 965              | 11              | 1                            | CGHPSO                                | FPS                                     | V VI VII VIII                              |
| Endomychidae   | Handsome fungus beetles     | 45             | 2  | 45               | 2               |                              | CP                                    | FP                                      | VIII IX                                    |
| Erotylidae     | Pleasing fungus beetles     | 82             | 2  | 82               | 2               |                              | PS                                    | FS                                      | VI                                         |
| Eucinetidae    | Plate-thigh beetles         | 11             | 1  | 11               | 1               |                              | H                                     | F                                       | VI                                         |
| Eucnemidae     | False click beetles         | 85             | 7  | 85               | 4               |                              | HPO                                   | FS                                      | VI VII VIII IX                             |
| Geotrupidae    | Earth-boring scarab beetles | 56             | 1  | 56               | 1               |                              | P                                     | P                                       | VI                                         |
| Histeridae     | Clown beetles               | 435            | 3  | 435              | 3               |                              | CHP                                   | FP                                      | VI VII VIII IX                             |
| Hydrophilidae  | Water scavenger beetles     | 258            | 2  | 258              | 2               |                              | HP                                    | P                                       | VII                                        |
| Laemophloeidae | Lined flat bark beetles     | 52             | 1  | 52               | 1               |                              | C                                     | F                                       | VI                                         |

|                           |                                |      |    |    |        |     |                  |
|---------------------------|--------------------------------|------|----|----|--------|-----|------------------|
| Lampyridae                | Fireflies                      | 126  | 7  | 6  | CGHPSO | FPS | V VI VII VIII IX |
| Latridiidae               | Minute brown scavenger beetles | 140  | 5  | 3  | CGHPS  | FS  | V VI VII VIII IX |
| Leiodidae                 | Round fungus beetles           | 381  | 3  | 2  | CP     | FP  | V VI VIII IX     |
| Lucanidae                 | Stag beetles                   | 25   | 1  | 1  | HP     | F   | VI               |
| Lycidae                   | Net-winged beetles             | 76   | 3  | 2  | PO     | FS  | VII VIII IX      |
| Melandryidae              | False darkling beetles         | 50   | 4  | 4  | CHP    | F   | VI VII VIII IX   |
| Meloidae                  | Blister beetles                | 424  | 1  | 1  | O      | S   | VII              |
| Melyridae                 | Soft-winged flower beetles     | 520  | 4  | 3  | GPO    | FS  | VI VII VIII      |
| Monotomidae               | Root-eating beetles            | 56   | 1  | 1  | HP     | F   | VI VII           |
| Mordellidae               | Tumbling flower beetles        | 189  | 9  | 3  | CGHPSO | FS  | V VI VII VIII IX |
| Mycetophagidae            | Hairy fungus beetles           | 26   | 1  | 1  | CGHPS  | FS  | V VI VIII IX     |
| Nemonychidae <sup>4</sup> | Pine flower snout beetles      | 15   | 1  | 1  | P      | F   | V                |
| Nitidulidae               | Sap beetles                    | 173  | 6  | 4  | CHP    | FP  | V VI VII VIII IX |
| Oedemeridae               | False blister beetles          | 87   | 1  | 1  | CP     | F   | V VI             |
| Phalacridae               | Shining flower beetles         | 122  | 4  | 3  | GHSO   | S   | VI VII VIII IX   |
| Ptiliidae                 | Featherwing beetles            | 117  | 1  | 1  | C      | P   | IX               |
| Ptilodactylidae           | Ptilodactylid beetles          | 19   | 1  | 1  | CS     | FPS | VI VII           |
| Primidae                  | Deathwatch & spider beetles    | 471  | 3  | 3  | CHP    | F   | V VI VII VIII IX |
| Pyrochroidae              | Fire-colored beetles           | 50   | 1  | 1  | H      | F   | VI               |
| Scarabaeidae              | Scarab beetles                 | 1700 | 20 | 14 | CGHPO  | FPS | V VI VII VIII IX |
| Scirtidae                 | Marsh beetles                  | 50   | 8  | 5  | CGHPSO | FS  | V VI VII VIII IX |
| Scraptiidae               | False flower beetles           | 46   | 3  | 2  | CHP    | F   | V VI VII         |
| Silphidae                 | Carrion beetles                | 30   | 4  | 3  | CHP    | FP  | VI VII VIII IX   |
| Silvanidae                | Silvanid flat bark beetles     | 32   | 2  | 2  | HP     | F   | VI VII           |
| Sphindidae                | Cryptic slime mold beetles     | 9    | 1  | 1  | H      | F   | VI               |
| Staphylinidae             | Rove beetles                   | 4360 | 43 | 20 | CHPO   | FPS | V VI VII VIII IX |
| Tenebrionidae             | Darkling beetles               | 1184 | 13 | 8  | CGHPSO | FPS | V VI VII VIII IX |
| Tetramoridae              | Polypore fungus beetles        | 26   | 2  | 2  | H      | F   | VII VIII IX      |
| Throscidae                | Throscid beetles               | 20   | 3  | 2  | HP     | F   | V VI VIII        |
| Trogossitidae             | Bark-gnawing beetles           | 59   | 2  | 2  | CP     | F   | VI VII           |
| Zopheridae                | Zopherid beetles               | 109  | 2  | 2  | HP     | F   | V VI             |

<sup>1</sup> Habitats: C = cedar, G = grassland, H = hardwoods, O = other, but primarily the Rail Trail, P = pine, and S = Sedge Meadow Trail. See text for details.

<sup>2</sup> Methods: F = funnel traps, P = pitfall traps, and S = sweeping.

<sup>3</sup> Months: V = May, VI = June, VII = July, VIII = August, and IX = September, X = October.

<sup>4</sup> Some sources have elevated certain subfamilies of Nemonychidae to family status, such as Cimberidinae being elevated to Cimberidae.

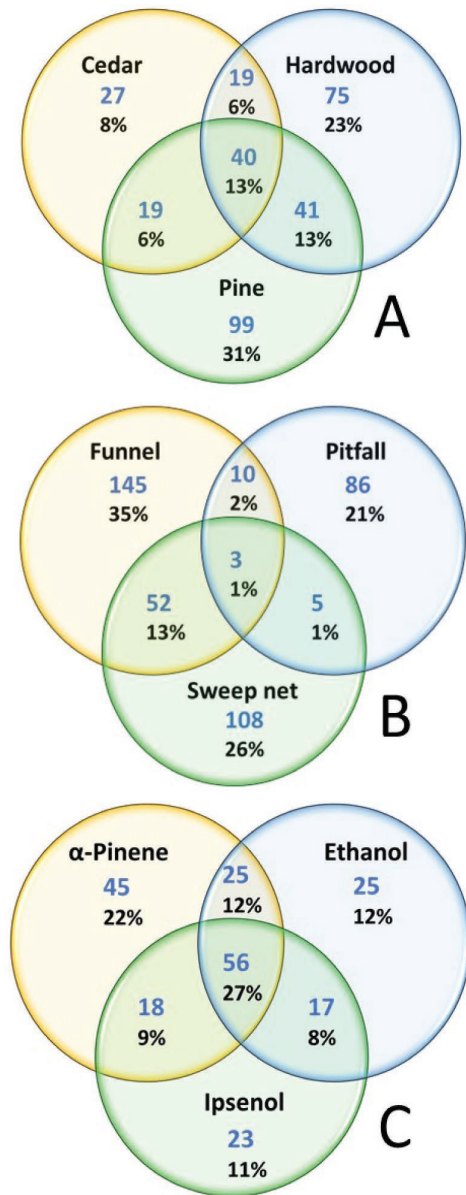


Figure 2. Venn diagrams indicating the number of beetle species and corresponding percent of the total for A: the 322 species that were collected in the cedar, hardwoods, and pine habitats (the label of one specimen was lost so the numbers add to 321); B: the 409 species that were collected in funnel traps, pitfall traps, and by sweep netting; and C: the 210 species that were collected in funnel traps baited with either  $\alpha$ -pinene, ethanol, or ipsenol (values add to 209 due to one lost label).

**Status as native or exotic.** As above, notes were recorded for each species as to whether they were native or exotic to the United States. The main sources of information were again Downie and Arnett (1996) and the internet site BugGuide. The native range of the exotic species was described as Asian, Eurasian, European, or Palearctic (northern portion of Eurasia).

**Diversity indices.** Several diversity indices have been used in ecological studies to characterize community diversity, with some, such as the Shannon index, combining species richness (i.e., the total number of different species) and the proportion of each species into a single value (Washington 1984, Chao et al. 2014). Using EstimateS (Colwell 2013), we calculated the Shannon index ( $H'$ ) and the effective (or equivalent) number of species [ $ENS = \exp(H')$ ] values for the funnel trap data given that the total number of each beetle species collected was recorded from all traps. We computed separate values for each of the three main habitats (cedar, hardwoods, and pine) by combining all funnel trap data (i.e., from the three different lures) within each habitat, and also for each of the three lures ( $\alpha$ -pinene, ethanol, or ipsenol) by combining the funnel trap data by lure type across the three habitats. The ENS value is calculated as the exponential of the Shannon index,  $\exp(H')$ , and is equivalent to the number of equally common species required to produce the same diversity index value (Jost 2006). For example, Shannon index values of 2, 3, 4, and 5 would be equivalent to communities with 7, 20, 55, and 148 equally common species, respectively.

## Results

For all three collecting methods combined, 409 beetle species were identified from the 2017 GRNA samples, including 369 taxa identified to species, 24 to genus only, and 16 to subfamily only (Appendix 1). These 409 species represented 58 families, with the five most speciose being Curculionidae (47 species), Staphylinidae (43), Carabidae (41), Chrysomelidae (40), and Elateridae (21) (Table 1). By contrast, there were 20 families represented by only a single species, and another 22 families represented by only 2–5 species each (Table 1). There was a significant positive linear correlation between the number of species collected per beetle family at GRNA and the corresponding total number of North American species (north of Mexico) recognized in those same families, using the values presented in Table 1 and Evans (2014) ( $r = 0.91$ ,  $R^2 = 0.83$ ,  $N = 58$ ,  $P < 0.0001$ ). The 40 taxa that were not identified to species represented 16 beetle families, 22 of which were Staphylinidae, and 16 of

**Table 2. Number of families, genera, and species of beetles collected at Grass River Natural Area in 2017 in the cedar, hardwoods, and pine habitats by trapping method (funnel traps, pitfall traps, and sweep netting); see text for details.**

| Habitat   | No. families, genera, species by trapping method |               |            |
|-----------|--------------------------------------------------|---------------|------------|
|           | Funnel traps                                     | Pitfall traps | Sweep net  |
| Cedar     | 30, 63, 78                                       | 10, 23, 34    | 11, 18, 24 |
| Hardwoods | 34, 98, 116                                      | 11, 38, 57    | 10, 27, 38 |
| Pine      | 43, 118, 140                                     | 14, 41, 53    | 19, 47, 53 |

the 22 staphylinids were only identified to the subfamily Aleocharinae (Appendix 1).

**Habitats.** Of the 409 species collected at GRNA, 322 were collected at the three main sampled habitats (cedar, hardwoods, and pine) using all three trapping methods, compared with 152 species being collected by sweeping along the two GRNA trails and the grassland site (Appendix 1). Of the 322 species, 105 species (80 genera in 32 families) were collected in the cedar habitat, 176 species (131 genera in 38 families) in the hardwoods habitat, and 199 species (158 genera in 47 families) in the pine habitat (Appendix 1). Similarly, of these 322 species and the three main habitats sampled, 27 species were collected only in the cedar habitat, 76 only in the hardwoods habitat, and 99 only in the pine habitat, whereas 40 species were collected in all three habitats (Fig. 2a). For the three GRNA locations where only sweep netting occurred, 57 beetle species (47 genera in 18 families, including 16 unique species) were collected along the Sedge Meadow Trail, 69 species (56 genera in 18 families, including 18 unique species) along the Rail Trail, and 83 species (67 genera in 19 families, including 36 unique species) in the grassland site (Appendix 1).

**Trapping methods.** Of the 409 species collected in this study, 210 species (165 genera in 51 families) were collected in funnel traps, 104 species (66 genera in 20 families) in pitfall traps, and 168 species (124 genera in 26 families) with sweep nets (Fig. 2b, Appendix 1). Similarly, the greatest number of species were collected in funnel traps when considering the cedar, hardwoods, and pine habitats separately (Table 2). Of the 409 species, 145 species were collected only with funnel traps, 86 species only with pitfall traps, and 108 species only with sweep nets (Fig. 2b). By contrast, only three species were collected with all three methods (Fig. 2b), including the carabid *Calathus gregarius* (Say), the coccinellid *Brachiacantha decempustulata* (Melsheimer), and a ptilodactylid *Ptilodactyla* sp. (Appendix 1).

**Lures.** Of the 210 species collected in funnel traps, 144 species (119 genera in 39 families) were collected in funnel traps baited with  $\alpha$ -pinene, 123 species (97 genera in 36 families) in ethanol-baited traps, and 114 species (97 genera in 38 families) in ipsenol-baited traps (Fig. 2c, Appendix 1). Of these 210 species, 45 species were collected only with  $\alpha$ -pinene, 25 species only with ethanol, and 23 species only with ipsenol (Fig. 2c). By contrast, 56 species were collected with all three lures (Fig. 2c). The label was lost on one specimen and thus the values in Fig. 2c only add to 209, not 210. Considering all collections made from the nine funnel traps used in 2017, 707 individual beetles were collected in the three funnel traps baited with  $\alpha$ -pinene lures, 513 individuals in the three traps with ethanol lures, and 553 individuals in the three traps with ipsenol lures (Appendix 1). When combining the funnel trap data at each site, 79 beetle species were collected at the cedar site, 116 at the hardwoods site, and 143 at the pine site. Several beetle species showed a strong preference for one of the three lures tested. For example,  $\alpha$ -pinene was most attractive to the curculionid *Pissodes affinis* Randall (capturing 96% of 23 individuals) and the histierid *Paromalus bistriatus* Erichson (95% of 20), ethanol was most attractive to the curculionid *Anisandrus sayi* Hopkins (97% of 72) and the nitidulid *Glischrochilus sanguinolentus* (Olivier) (93% of 27), and ipsenol was most attractive to the cerambycid *Monochamus scutellatus* (Say) (61% of 66) and the clerid *Madoniella dislocata* (Say) (73% of 108) (Appendix 1).

**Diversity indices.** The Shannon index values *H*, based on funnel trap data only, were 3.297 for the cedar habitat, 3.971 for the hardwoods habitat, and 4.075 for the pine habitat. The corresponding effective number of equally common species (ENS) for these Shannon index values are 27 for cedar, 53 for hardwoods, and 59 for pine. Similarly, considering the three lures tested, the Shannon Index values *H* were 4.314 for the  $\alpha$ -pinene, 4.005 for ethanol, and 3.764 for

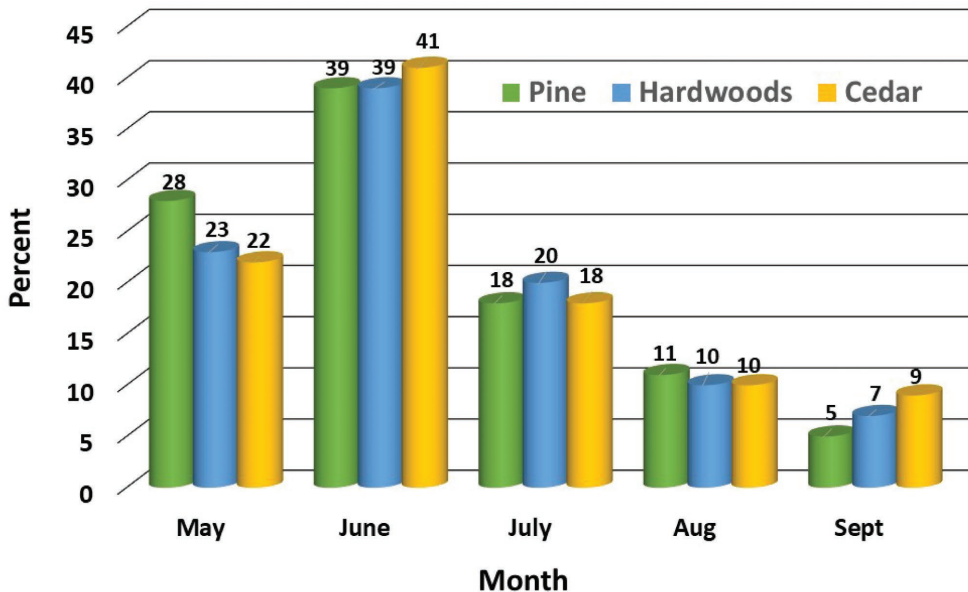


Figure 3. Percentage of beetle species collected by three sampling methods at Grass River Natural Area in 2017 by month of first collection and habitat for the beetle species collected in the cedar (105 species), hardwoods (176 species), and pine (199 species) habitats. Values above each column are percentage values within each habitat.

ipnsenol, which correspond to ENS values of 75, 55, and 43, respectively.

**Seasonality.** Of the 409 beetle species collected at GRNA in 2017, 21% (85 species) were first collected in May, 40% (162) in June, 23% (95) in July, 10% (41) in August, and 6% (26) in September (Appendix 1). A broadly similar pattern emerged for each of the three main habitats sampled, with most species being first collected in May or June (Fig. 3). Moreover, when considering just those beetle species collected in funnel traps, the resulting season-long species accumulation curves for each of the three main habitats were similar in shape with more species consistently being collected at the pine site compared with the hardwoods and cedar sites (Fig. 4). At the family level, 48% (28 families) of the 58 beetle families recorded were first collected in May, 38% (22) in June, 9% (5) in July, 3% (2) in August, and 2% (1) in September (Table 1). The two beetle families first collected in August were Ciidae and Endomychidae, with members of Ptiliidae being first collected in September (Table 1). Considering the number of beetle species collected each month for all 409 species, 21% (85 species) were collected in May, 59% (243) in June, 46% (187) in July, 33% (133) in August, and 27% (111) in September (Appendix 1).

**New Michigan state records.** Of the 369 species that were identified to the species level, we found published, in print, collection records from Michigan for 336 species. For the remaining 33 species, 14 were listed online in SCAN as having been collected in Michigan and deposited in the Albert J. Cook Arthropod Research Collection at Michigan State University (1 of the 14 was also deposited in the C.A. Triplehorn Insect Collection at The Ohio State University), 1 was listed on BugGuide as having been collected in Michigan, and the remaining 18 were considered new state records for Michigan (Appendix 1). These 18 new state records are members of 12 beetle families, including Brentidae (1 species), Cantharidae (2), Chrysomelidae (4), Cryptophagidae (1), Curculionidae (3), Hydrophilidae (1), Laemophloeidae (1), Melyridae (1), Silvanidae (1), Staphylinidae (1), Tenebrionidae (1), and Throscidae (1) (Appendix 1). Four of these 18 species are exotic to the United States, including the brentid *Perapion curtirostre* (Germar), the chrysomelids *Chrysolina hyperici* (Forster) and *Mantura chrysanthemi* (Koch), and the staphylinid *Tasgius melanarius* (Heer).

**Status as native or exotic.** Overall, 32 of the beetle species collected at GRNA were exotic to the United States (Appendix 1). These 32 species represent 9 beetle

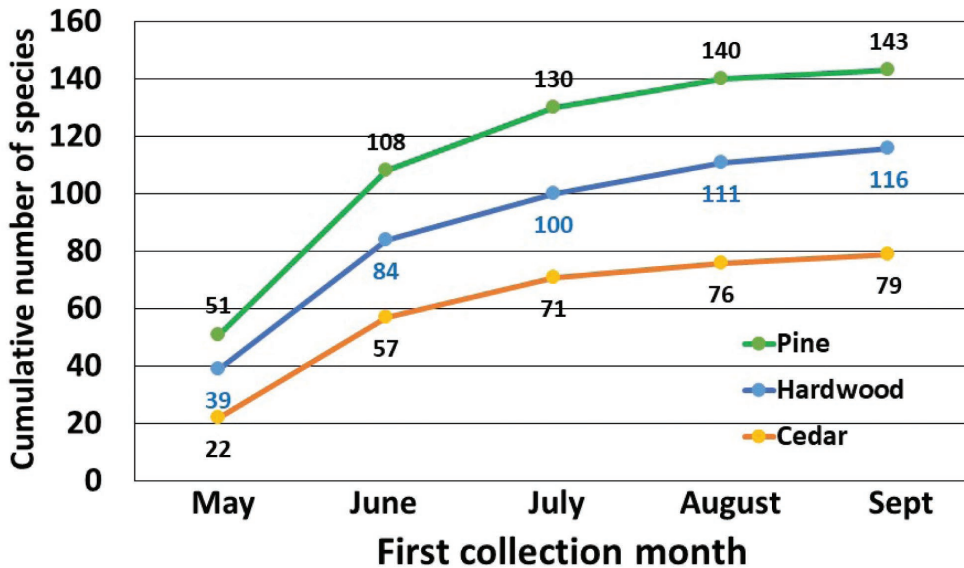


Figure 4. Cumulative number of species collected in funnel traps (all lures combined within sites) by month in three habitats (cedar, hardwoods, and pine) sampled during May to September 2017 at Grass River Natural Area.

families, including Brentidae (1 species), Buprestidae (1), Carabidae (1), Chrysomelidae (4), Coccinellidae (2), Curculionidae (13), Dermestidae (1), Scarabaeidae (4), and Staphylinidae (5). The natural range of these 32 exotics was Asia for 4 species, Europe for 12, Eurasia for 5, and the Palearctic for 11 (Appendix 1).

**Aquatic beetles.** Examination of the invertebrates from the stored GRNA stream samples from 2013–2019 revealed 16 species of adult aquatic beetles, representing 12 genera in 5 families (Table 3). Of these 16 species, 11 were identified to the species level and 5 to genus only (Table 3). Overall, there were 4 species of Dytiscidae, 1 Elmidae, 3 Gyrinidae, 2 Haliplidae, and 6 Hydrophilidae. All taxa identified to species are considered native to the United States and none were new state records for Michigan. Aquatic beetles were collected from each of the three creeks sampled at GRNA, including Cold Creek, Finch Creek, and Shanty Creek (Table 3, Fig. 1).

## Discussion

Although over 400 beetle species were collected at GRNA in 2017, this number undoubtedly represents only a fraction of the total number of beetle species present. Insect diversity tends to increase with sampling intensity in insect surveys (Samways et al. 2010). As an example, consider the work of

Muona (1999), who used large numbers of pitfall traps and flight-intercept traps in three separate studies at Oulanka National Park in Finland, where the beetle fauna is very well known, but reported collecting only 54–61% of the known terrestrial beetle species present in each study. If these same ratios are applied to our GRNA data (409 species), then the total number of terrestrial beetle species at GRNA would be estimated at 670–757 species. Still we would postulate that there would be even more beetle species present at GRNA than these estimates given that sampling intensity in Muona's (1999) studies involved 100–240 pitfall traps and 32–120 flight-intercept traps, depending on the study. Additionally, sampling over successive years typically results in more species being discovered at any site. To demonstrate this point, consider the 10-year study by Martikainen and Kaila (2004) in Finland that focused on saproxylic beetles (those species dependent on dead or decaying wood; Ulyshen and Šobotník 2018) at two forest sites. They reported that only 50% of all 258 saproxylic species collected over the entire 10-year study were collected every single year, that many species showed great year-to-year variation in population size (as reflected in trap catch numbers), and that new species were collected in every year of the study.

Our single-year trapping effort focused on just three habitats, using three

**Table 3. Species of aquatic beetles collected during 2013-2019 in three creeks that cross Grass River Natural Area, including Cold Creek, Finch Creek, and Shanty Creek (see text for details and Fig. 1 for creek locations).**

| <b>FAMILY</b>                           |                                              |
|-----------------------------------------|----------------------------------------------|
| <b>Subfamily</b>                        |                                              |
| <b>Species</b>                          | <b>Creek name (number collected, date)</b>   |
| DYTISCIDAE (Predaceous diving beetles)  |                                              |
| Agabinae                                |                                              |
| <i>Ilybiusoma seriatum</i> (Say)        | Shanty (3, 16 V 2015), Shanty (1, 3 X 2015); |
| <i>Agabus</i> sp.                       | Finch (1, 28 IX 2019)                        |
| Hydroporinae                            |                                              |
| <i>Liodessus crotchii</i> Nilsson       | Finch (1, 27 IX 2014), Cold (1, 17 X 2017)   |
| <i>Neoporus</i> sp.                     | Cold (2, 16 V 2015), (Shanty (1, 16 V 2015)  |
| ELMIDAE (Riffle beetles)                |                                              |
| Elminae                                 |                                              |
| <i>Dubiraphia bivittata</i> (LeConte)   | Shanty (1, 16 V 2015)                        |
| GYRINIDAE (Whirligig beetles)           |                                              |
| Gyrininae                               |                                              |
| <i>Gyrinus maculiventris</i> LeConte    | Cold (1, 27 IX 2014)                         |
| <i>Gyrinus lecontei</i> Fall            | Finch (3, 28 IX 2019)                        |
| <i>Gyrinus</i> sp.                      | Cold (1, 6 V 2017), Shanty (2, 21 V 2014)    |
| HALIPLIDAE (Crawling water beetles)     |                                              |
| <i>Haliphus canadensis</i> (Wallis)     | Cold (1, 16 V 2015)                          |
| <i>Haliphus immaculicollis</i> Harris   | Cold (1, 16 V 2015)                          |
| HYDROPHILIDAE (Water scavenger beetles) |                                              |
| Hydrophilinae                           |                                              |
| <i>Anacaena lutescens</i> (Stephens)    | Cold (2, 16 V 2015)                          |
| <i>Enochrus ochraceus</i> (Melsheimer)  | Shanty (2, 16 V 2015)                        |
| <i>Hydrobius fuscipes</i> (Linnaeus)    | Shanty (1, 16 V 2015)                        |
| <i>Hydrobius melaenus</i> (Germar)      | Shanty (2, 3 X 2015)                         |
| <i>Paracymus</i> sp.                    | Cold (1, 12 X 2013)                          |
| <i>Tropisternus</i> sp.                 | Finch (6, 12 X 2013)                         |

sampling methods and deploying only three funnel traps and two pitfall traps per site. We recognize that many more beetle species would have been collected at GRNA if we had sampled in multiple years, started sampling earlier and ended later in the year, sampled more habitats, deployed more traps per site, used a greater variety of baits in the funnel traps, sampled at different heights within the canopy, and sampled over multiple years. In addition, many more beetle species would have been collected if we had used additional methods, such as flight-intercept window-pane traps, light traps, Malaise traps, and Berlese funnels. Nevertheless, our modest trapping effort did document about 10% of the beetle species known to occur in Michigan, given that Michigan has around 4000 recognized beetle species (W. G. Ruesink et al., unpublished data).

Of the three collection methods used in the present study, baited funnel traps caught the greatest number of beetle species, whereas pitfall traps caught the fewest (Fig. 2b). Multiple collection methods have been compared in many other studies. At forested sites in Finland, Hyvärinen et al. (2006) found that two types of flight-intercept traps caught a greater number of beetle species than did pitfall traps. Similarly, in a forested area of Arkansas, Skvarla and Dowling (2017) compared 12 trapping methods for collecting four groups of beetles (Carabidae, Buprestidae, Cerambycidae, and Curculionioidea excluding Scolytinae) and found that the best trapping method varied by beetle family. For example, the greatest diversity of buprestids was collected in Malaise traps and unbaited green funnel traps; whereas Malaise traps, canopy SLAM traps, and

funnel traps were best for cerambycids; pitfall traps and funnel traps were best for non-scolytine curculionoids; and pitfall traps were best for carabids. In the present study, 33 (80%) of the 41 carabid species collected at GRNA were collected in pitfall traps, compared with only 4 carabid species in funnel traps and 6 species in sweep-net samples (Appendix 1).

The three lures used in the present study are commonly used in surveys for bark- and wood-infesting beetles, especially Cerambycidae and Scolytinae (Brockerhoff et al. 2006, Millar and Hanks 2017, Rabaglia et al. 2019, Rassati et al. 2019). In fact, since 2007 the USDA Forest Service has implemented a nationwide survey for exotic bark and ambrosia beetles, using funnel traps baited with  $\alpha$ -pinene, ethanol and a three-component pheromone lure containing ipsdienol, cis-verbenol, and methyl-butanol (Rabaglia et al. 2019). As noted in the present study, Miller et al. (2015) and Rabaglia et al. (2019) also reported that many cerambycid and scolytine species showed strong preferences for individual lures similar to the lures we tested, either individually or in various combinations.

Volatile compounds such as  $\alpha$ -pinene and ethanol are often produced at increased levels in stressed trees, and thus many bark- and wood-infesting insects have evolved to use these compounds to locate stressed host plants (Mattson and Haack 1987, Millar and Hanks 2017). Besides cerambycids and scolytines, many other beetles use  $\alpha$ -pinene and ethanol, as well as bark beetle pheromones, as kairomones to locate stressed plants (e.g., some Bostrichidae, Buprestidae, and Nitidulidae) or potential prey (e.g., some Cleridae, Histeridae, and Tenebrionidae) (Chénier and Philogène 1989, Schroeder and Lindelöw 1989, Erbilgin and Raffa 2002, Bouget et al. 2009, Millar and Hanks 2017).

Variation in seasonal adult activity among insects reflects their overwintering life stage, overwintering site, and voltinism pattern (Wolda 1988). In temperate areas, many insects overwinter as larvae (Danks 1978), and thus must still complete metamorphosis before adult activity can begin. Many others overwinter as adults and are thus most abundant in late spring or in late summer and autumn. Adults of temperate insects tend to have one of three seasonal patterns: a single peak, multiple peaks (for multivoltine species), or one broad maximum (Wolda 1988). Although we collected new beetle species at GRNA in all months from May to September, June had the greatest number (162 of 409) of new species collected for any single month. Similar seasonal patterns have been reported by others for

Coleoptera. For example, in New Zealand, using Malaise traps, Hutcheson (1990) noted that both insect species richness and abundance increased from spring to summer and then declined into fall. In Arkansas, using multiple trapping methods, Skvarla and Dowling (2017) noted different adult activity patterns among different groups of beetles: Carabidae were active from spring to fall with a slight peak in June, Buprestidae and Cerambycidae were most active in June and July, and Curculionoidea (excluding Scolytinae) were most active in May and June. In the present study, we had similar results for members of these same beetle groups with most species initiating adult activity in June (Appendix 1).

Shannon index (H) values have been reported in dozens of Coleoptera survey studies, but usually with a focus on just one or a few beetle families. However, all Coleoptera families and species were included in the analyses of a few studies and therefore can be compared to our results for the cedar (H = 3.297; ENS = 27), hardwoods (H = 3.971, ENS = 53), and pine sites (H = 4.075, ENS = 59). For example, Coulson et al. (1971), working in North Carolina, reported diversity values for the canopy Coleoptera collected in a monoculture stand of white pine (seasonal range of H = 0.969–2.205, ENS = 3–9) and a mostly oak-hickory (*Quercus-Carya*) forest (seasonal range of H = 1.931–2.941, ENS = 7–19). Trieff (2002), working at multiple sites in Tennessee, collected canopy Coleoptera by fogging northern red oak trees and reported a range in season-long H values of 3.04 to 3.70 (ENS = 21–40) for the various sites. In a third study, working in a mixed-conifer forest in California, Apigian et al. (2006) reported an overall H value of 3.73 (ENS = 42) for all Coleoptera collected in pitfall traps collected over a 3-year period.

Faunistic surveys provide basic knowledge on the occurrence, abundance and distribution of selected species within a given area. To that end, the present study provides information on over 400 beetle species found at the Grass River Natural Area in Antrim County, Michigan, and will serve as a baseline for future surveys of Coleoptera in Michigan.

### Acknowledgments

The authors thank Anthony Cognato (Michigan State University) and Thomas McElrath (Illinois Natural History Survey) for identification assistance on Scolytinae and Latridiidae, respectively; John Epler (independent researcher, Crawfordville, Florida), Frank Etzler (Clemson University), Margaret Thayer (Field Museum, Chicago), and Daniel Young (University of

Wisconsin-Madison), for taxonomic advice regarding several beetle families; Gary Parsons (Michigan State University, MSU) for assistance with beetle collection records at MSU and the SCAN database; and Richard Hannan (GRNA Board), Toby Petrice (USDA Forest Service, Northern Research Station), Michael Ulyshen (USDA Forest Service, Southern Research Station), and two anonymous reviewers for comments on an earlier draft of this paper. This research was supported in part by the USDA Forest Service.

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Appendix 1. Coleoptera collected at Grass River Natural Area in 2017, using funnel traps (F) and pitfall traps (P), and by sweeping (S), with details on habitats where specimens were collected, months when collected, and numbers of individuals collected in funnel traps by bait type. Additional information is presented on whether each species is considered a potential new state record for Michigan (species with an \* after the species name), and if each species is considered native or exotic to the continental USA.

| FAMILY       | Subfamily       | Species <sup>1</sup>                      | Habitats <sup>2</sup> | Months collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     |       | Native to USA <sup>6</sup> |
|--------------|-----------------|-------------------------------------------|-----------------------|-------------------------------|----------------------|--------------------------------------|------|-----|-------|----------------------------|
|              |                 |                                           |                       |                               |                      | a-p                                  | ETOH | Ips | Total |                            |
| ADERIDAE     |                 | <i>Elonus basalis</i> (LeConte)           | HP                    | VI VII IX                     | F                    | 3                                    | 1    | 0   | 4     | Yes                        |
| ANTHICIDAE   |                 |                                           |                       |                               |                      |                                      |      |     |       |                            |
|              | Notoxinae       | <i>Notoxus desertus</i> Casey             | HP                    | VI VII                        | F                    | 7                                    | 4    | 1   | 12    | Yes                        |
| ANTHRIBIDAE  |                 |                                           |                       |                               |                      |                                      |      |     |       |                            |
|              | Anthribinae     | <i>Euparius marmoreus</i> (Olivier)       | P                     | V VI VII VIII                 | F                    | 2                                    | 3    | 0   | 5     | Yes                        |
|              |                 | <i>Trigonorhinus rotundatus</i> (LeConte) | G                     | VII                           | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|              |                 | <i>Trigonorhinus sticticus</i> (Boheman)  | GS                    | VI IX                         | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
| BOSTRICHIDAE |                 |                                           |                       |                               |                      |                                      |      |     |       |                            |
|              | Bostrichinae    | <i>Prostephanus punctatus</i> (Say) ‡     | P                     | V                             | F                    | 1                                    | 0    | 0   | 1     | Yes                        |
| BRENTIDAE    |                 |                                           |                       |                               |                      |                                      |      |     |       |                            |
|              | Apioninae       | <i>Perapion curtirostre</i> (Germar) *    | G                     | VII                           | S                    | 0                                    | 0    | 0   | 0     | Eur                        |
| BUPRESTIDAE  |                 |                                           |                       |                               |                      |                                      |      |     |       |                            |
|              | Agrilinae       | <i>Agrilus cuprescens</i> (Ménétriés)     | GS                    | VII                           | S                    | 0                                    | 0    | 0   | 0     | Pal                        |
|              |                 | <i>Agrilus politus</i> (Say)              | G                     | VI VII                        | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|              |                 | <i>Taphrocerus gracilis</i> (Say)         | GPS                   | VII VIII IX                   | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|              | Buprestinae     | <i>Anthaxia inornata</i> (Randall)        | G                     | VI                            | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|              | Chrysobothrinae | <i>Dicerca divaricata</i> (Say)           | P                     | VI                            | F                    | 2                                    | 0    | 0   | 2     | Yes                        |
| BYRRHIDAE    |                 |                                           |                       |                               |                      |                                      |      |     |       |                            |
|              | Byrrhinae       | <i>Cytillus alternatus</i> (Say)          | H                     | V VI                          | P                    | 0                                    | 0    | 0   | 0     | Yes                        |

(Continued on next page)

Appendix 1. Continued.

| FAMILY                          | Subfamily                                        | Species <sup>1</sup>                          | Habitats <sup>2</sup> | Months collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     | Native to USA <sup>6</sup> |       |
|---------------------------------|--------------------------------------------------|-----------------------------------------------|-----------------------|-------------------------------|----------------------|--------------------------------------|------|-----|----------------------------|-------|
|                                 |                                                  |                                               |                       |                               |                      | a-p                                  | ETOH | Ips |                            | Total |
| CANTHARIDAE                     | Cantharinae                                      | <i>Atalantycha bilineata</i> (Say)            | G                     | V                             | S                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 |                                                  | <i>Atalantycha neglecta</i> (Fall) ‡          | HP                    | V VI                          | F                    | 4                                    | 2    | 1   | 7                          | Yes   |
|                                 | <i>Cantharis tuberculata</i> (LeConte)           | GPS                                           | VI                    | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 |                                                  | <i>Dichelotarsus piniphilus</i> (Eschscholtz) | S                     | VII                           | S                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 | <i>Podabrus brevicollis</i> Fall ‡               | HO                                            | VI                    | FS                            | 1                    | 1                                    | 1    | 3   | Yes                        |       |
|                                 | <i>Podabrus diadema</i> (Fabricius)              | G                                             | VIII                  | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <i>Podabrus frater</i> LeConte                   | GHS                                           | VI VII                | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <i>Podabrus rugosulus</i> LeConte                | G                                             | VI                    | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <i>Podabrus tricosatus</i> (Say)                 | CH                                            | VI                    | FS                            | 1                    | 1                                    | 0    | 2   | Yes                        |       |
|                                 | <i>Rhagonycha fraxini</i> (Say)                  | O                                             | VII                   | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <b><i>Rhagonycha hirticula</i> (Green) *</b>     | SO                                            | VI                    | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <i>Rhagonycha imbecillis</i> (LeConte) ‡         | HSO                                           | VII VIII              | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <i>Rhagonycha nanula</i> (LeConte)               | S                                             | VII                   | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <i>Rhagonycha oriflava</i> (LeConte)             | G                                             | VI                    | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <i>Rhagonycha recta</i> (Melsheimer)             | CHP                                           | VI VII VIII           | FS                            | 3                    | 1                                    | 1    | 5   | Yes                        |       |
|                                 | <i>Rhagonycha scitula</i> (Say)                  | S                                             | VII                   | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <b><i>Rhagonycha septentrionis</i> (Green) *</b> | G                                             | VII                   | S                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | <i>Rhagonycha vilis</i> (LeConte)                | CHP                                           | VI VII VIII IX        | F                             | 25                   | 8                                    | 1    | 34  | Yes                        |       |
|                                 | Chauliognathinae                                 |                                               |                       |                               |                      |                                      |      |     |                            |       |
|                                 |                                                  | <i>Chauliognathus pensylvanicus</i> (DeGeer)  | GO                    | VIII IX                       | S                    | 0                                    | 0    | 0   | 0                          | Yes   |
| Silinae                         |                                                  |                                               |                       |                               |                      |                                      |      |     |                            |       |
| <i>Polemia canadensis</i> Brown | S                                                | VII                                           | S                     | 0                             | 0                    | 0                                    | 0    | Yes |                            |       |
| CARABIDAE                       | Carabinae                                        |                                               |                       |                               |                      |                                      |      |     |                            |       |
|                                 |                                                  | <i>Carabus goryi</i> Dejean                   | P                     | V VIII                        | P                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 | <i>Sphaeroderus stenostomus lecontei</i> Dejean  | CP                                            | V VIII                | P                             | 0                    | 0                                    | 0    | 0   | Yes                        |       |
|                                 | Harpalinae                                       |                                               |                       |                               |                      |                                      |      |     |                            |       |
|                                 |                                                  | <i>Agonum fidele</i> Casey                    | H                     | VI VIII                       | P                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 |                                                  | <i>Agonum gratiosum</i> (Mannerheim)          | S                     | IX                            | S                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 |                                                  | <i>Amara angustata</i> (Say)                  | H                     | VI                            | P                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 |                                                  | <i>Amara ellipsis</i> (Casey)                 | P                     | VII                           | P                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 |                                                  | <i>Amphasia interstitialis</i> (Say)          | H                     | IX                            | P                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 |                                                  | <i>Anisodactylus agricola</i> (Say)           | H                     | VI                            | P                    | 0                                    | 0    | 0   | 0                          | Yes   |
|                                 |                                                  | <i>Anisodactylus kirbyi</i> Lindroth          | P                     | VI                            | P                    | 0                                    | 0    | 0   | 0                          | Yes   |

|                                                |     |                |     |   |   |   |   |     |
|------------------------------------------------|-----|----------------|-----|---|---|---|---|-----|
| <i>Calathus gregarius</i> (Say)                | PO  | VI VII VIII IX | FPS | 1 | 0 | 2 | 3 | Yes |
| <i>Calleida punctata</i> LeConte               | G   | VI             | S   | 0 | 0 | 0 | 0 | Yes |
| <i>Cyclotrachelus sodalis</i> (LeConte)        | P   | VI VII         | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Cymindis americana</i> Dejean               | P   | VIII           | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Cymindis limbata</i> Dejean                 | CHP | V VI VII VIII  | F   | 2 | 3 | 4 | 9 | Yes |
| <i>Cymindis platicollis</i> (Say)              | P   | VI             | F   | 2 | 1 | 0 | 3 | Yes |
| <i>Dromius piceus</i> Dejean                   | CHP | V VI           | F   | 3 | 4 | 2 | 9 | Yes |
| <i>Harpalus erythropus</i> Dejean              | P   | V              | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Harpalus providens</i> Casey                | P   | VII            | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Harpalus somnulentus</i> Dejean             | HP  | VI VII VIII IX | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Lebia fuscata</i> Dejean                    | P   | VII            | S   | 0 | 0 | 0 | 0 | Yes |
| <i>Lebia viridis</i> Say                       | GO  | VI VIII        | S   | 0 | 0 | 0 | 0 | Yes |
| <i>Myas cyanescens</i> Dejean                  | P   | VI VII         | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Platynus decentis</i> (Say)                 | H   | VI             | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Poecilus lucublandus</i> (Say)              | H   | VI VIII IX     | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Pterostichus adstrictus</i> Eschscholtz     | H   | VI             | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Pterostichus commutabilis</i> (Motschulsky) | H   | VI             | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Pterostichus coracinus</i> (Newman)         | C   | VII VIII       | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Pterostichus corvinus</i> (Dejean)          | CH  | VI             | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Pterostichus luctuosus</i> (Dejean)         | H   | IX             | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Pterostichus melanarius</i> (Illiger)       | H   | VI VII IX      | P   | 0 | 0 | 0 | 0 | Eur |
| <i>Pterostichus mutus</i> (Say)                | CP  | VIII           | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Pterostichus stygicus</i> (Say)             | CHP | VIII IX        | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Pterostichus tristis</i> (Dejean)           | O   | VI             | S   | 0 | 0 | 0 | 0 | Yes |
| <i>Selenophorus opalinus</i> (LeConte)         | P   | VI             | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Synuchus impunctatus</i> (Say)              | HP  | VII VIII IX    | P   | 0 | 0 | 0 | 0 | Yes |
| Trechinae                                      |     |                |     |   |   |   |   |     |
| <i>Bembidion affine</i> Say                    | H   | V              | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Bembidion fortetrium</i> (Motschulsky)      | H   | IX             | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Bembidion minus</i> Hayward                 | H   | IX             | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Bembidion semicinctum</i> Notman            | H   | VII VIII       | P   | 0 | 0 | 0 | 0 | Yes |
| <i>Bembidion</i> sp.                           | H   | VII            | P   | 0 | 0 | 0 | 0 | NA  |
| <i>Trechus apicalis</i> Motschulsky            | HP  | VII VIII IX    | P   | 0 | 0 | 0 | 0 | Yes |
| CERAMBYCIDAE                                   |     |                |     |   |   |   |   |     |
| Cerambycinae                                   |     |                |     |   |   |   |   |     |
| <i>Neoclytus acuminatus</i> (Fabricius)        | C   | VII            | F   | 0 | 1 | 0 | 1 | Yes |
| <i>Xylotrechus sagittatus</i> (Germar)         | H   | VII            | F   | 0 | 1 | 0 | 1 | Yes |
| <i>Xylotrechus undulatus</i> (Say)             | CHP | VI VII         | F   | 6 | 2 | 1 | 9 | Yes |
| Laminae                                        |     |                |     |   |   |   |   |     |
| <i>Astylopsis sexguttata</i> (Say)             | CG  | VI VII         | FS  | 1 | 0 | 0 | 1 | Yes |

(Continued on next page)

Appendix 1. Continued.

| FAMILY           | Subfamily                                | Species <sup>1</sup>                     | Habitats <sup>2</sup> | Months collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     |       | Native to USA <sup>6</sup> |
|------------------|------------------------------------------|------------------------------------------|-----------------------|-------------------------------|----------------------|--------------------------------------|------|-----|-------|----------------------------|
|                  |                                          |                                          |                       |                               |                      | a-p                                  | ETOH | Ips | Total |                            |
| Lepturinae       |                                          | <i>Monochamus scutellatus</i> (Say)      | CHP                   | VI VII                        | F                    | 21                                   | 5    | 40  | 66    | Yes                        |
|                  |                                          | <i>Oberea tripunctata</i> (Swederus)     | G                     | VII                           | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  |                                          | <i>Pogonocherus mixtus</i> Haldeman      | P                     | VIII                          | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  |                                          | <i>Saperda mutica</i> Say                | G                     | VI                            | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  |                                          | <i>Tetropes melanurus</i> Schoenherr     | G                     | VII                           | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  |                                          | <i>Tetropes tetrophthalmus</i> (Forster) | G                     | VIII                          | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  |                                          | <i>Analeptura lineola</i> (Say)          | O                     | VI                            | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  |                                          | <i>Brachyleptura champlaini</i> Casey    | G                     | VIII                          | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  |                                          | <i>Grammoptera haematites</i> (Newman)   | P                     | VI                            | F                    | 1                                    | 0    | 0   | 1     | Yes                        |
|                  |                                          | <i>Strangalepta abbreviata</i> (Germar)  | O                     | VI                            | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  |                                          | <i>Typocerus velutinus</i> (Olivier)     | PO                    | VII                           | FS                   | 1                                    | 0    | 0   | 1     | Yes                        |
|                  | Spondyliinae                             |                                          |                       |                               |                      |                                      |      |     |       |                            |
|                  |                                          | <i>Asemum striatum</i> (Linnaeus)        | CHP                   | V VI                          | F                    | 4                                    | 0    | 1   | 5     | Yes                        |
|                  |                                          | <i>Tetropium cinnamopterum</i> Kirby     | H                     | V                             | F                    | 1                                    | 0    | 0   | 1     | Yes                        |
|                  | CHRYSOMELIDAE                            |                                          |                       |                               |                      |                                      |      |     |       |                            |
| Bruchinae        |                                          |                                          |                       |                               |                      |                                      |      |     |       |                            |
|                  | <i>Bruchus brachialis</i> Fähræus        | G                                        | VI VIII               | S                             | 0                    | 0                                    | 0    | 0   | 0     | Pal                        |
| Cassidinae       |                                          |                                          |                       |                               |                      |                                      |      |     |       |                            |
|                  | <i>Chalepus walshii</i> (Crotch)         | G                                        | VI VII VIII IX        | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Microhophala vittata</i> (Fabricius)  | O                                        | VI VIII               | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Sumitrosis inaequalis</i> (Webar)     | O                                        | IX                    | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
| Chrysomelinae    |                                          |                                          |                       |                               |                      |                                      |      |     |       |                            |
|                  | <i>Calligrapha multipunctata</i> (Say)   | GO                                       | VI VIII               | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Chrysolina hyperici</i> (Forster) #   | GPS                                      | VI                    | S                             | 0                    | 0                                    | 0    | 0   | 0     | EurAs                      |
|                  | <i>Chrysomela knabi</i> Brown            | O                                        | VII                   | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Chrysomela mainensis</i> Bechyne      | S                                        | V                     | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Gonioctena americana</i> (Schaeffer)  | PO                                       | V VI VII              | FS                            | 0                    | 1                                    | 3    | 4   | 4     | Yes                        |
|                  | <i>Labidomera clivicollis</i> (Kirby)    | GS                                       | VII                   | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
| Cryptocephalinae |                                          |                                          |                       |                               |                      |                                      |      |     |       |                            |
|                  | <i>Bassareus mammifer</i> (Newman)       | CPO                                      | VI VIII               | FS                            | 0                    | 6                                    | 0    | 6   | 6     | Yes                        |
|                  | <i>Cryptocephalus quadripex</i> Newman   | P                                        | VI                    | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Cryptocephalus venustus</i> Fabricius | G                                        | VIII                  | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Diachus auratus</i> (Fabricius)       | GS                                       | VII VIII              | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Exema canadensis</i> Pierce           | GO                                       | VII VIII IX           | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                  | <i>Lexiphanes saponatus</i> (Fabricius)  | S                                        | VII VIII              | S                             | 0                    | 0                                    | 0    | 0   | 0     | Yes                        |

|                                                  |     |                  |    |    |    |    |     |   |   |     |
|--------------------------------------------------|-----|------------------|----|----|----|----|-----|---|---|-----|
| <i>Neochlamisus comptoniae</i> (Brown)           | G   | VIII             | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Neochlamisus eubati</i> (Brown)               | GSO | VII VIII IX      | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Pachybrachis othonus</i> (Say)                | G   | VII              | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Pachybrachis trinitatus</i> (Melsheimer)      | G   | VII VIII         | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| Donaciinae                                       |     |                  |    |    |    |    |     |   |   |     |
| <i>Donacia tuberculifrons</i> Schaeffer          | SO  | VI               | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Plateumaris rufa</i> (Say)                    | CHO | V VI             | FS | 1  | 2  | 0  | 0   | 0 | 3 | Yes |
| Eumolpinae                                       |     |                  |    |    |    |    |     |   |   |     |
| <i>Paria fragariae</i> Wilcox ‡                  | GHO | VI VII VIII IX   | PS | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Paria pratensis</i> Balsbaugh                 | HO  | VIII IX          | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Paria thoracica</i> (Melsheimer) ‡            | HO  | IX               | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Xanthonia decemnotata</i> (Say)               | HP  | V VI VII         | FS | 6  | 5  | 58 | 69  | 0 | 0 | Yes |
| <i>Xanthonia villosula</i> (Melsheimer)          | GPO | VIII XI          | FS | 0  | 0  | 1  | 1   | 0 | 0 | Yes |
| Galerucinae                                      |     |                  |    |    |    |    |     |   |   |     |
| <i>Altica gloriosa</i> Blatchley *               | S   | VI IX            | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Capraita subvittata</i> (Horn)                | S   | VI               | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Crepidodera longula</i> Horn *                | GPS | VI VII           | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Crepidodera nana</i> (Say)                    | GPS | V VI VII VIII    | FS | 4  | 1  | 4  | 9   | 0 | 0 | Yes |
| <i>Crepidodera populivora</i> Parry              | P   | VI               | F  | 0  | 1  | 0  | 1   | 0 | 0 | Yes |
| <i>Crepidodera violacea</i> Melsheimer           | P   | V                | F  | 7  | 2  | 0  | 9   | 0 | 0 | Yes |
| <i>Diabrotica undecimpunctata howardi</i> Barber | G   | IX               | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Luperaltica nigripalpis</i> (LeConte) *       | GPO | VII VIII IX      | FS | 1  | 0  | 0  | 1   | 0 | 0 | Yes |
| <i>Mantura chrysanthemi</i> (Koch) *             | G   | VI               | S  | 0  | 0  | 0  | 0   | 0 | 0 | Eur |
| <i>Neogalerucella</i> sp.                        | S   | VI VII           | S  | 0  | 0  | 0  | 0   | 0 | 0 | Pal |
| <i>Ophraella conferta</i> (LeConte)              | GHO | VI VIII IX       | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Tricholochmaea decora</i> (Say)               | G   | VI               | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| <i>Trirhabda borealis</i> Blake                  | G   | VII              | S  | 0  | 0  | 0  | 0   | 0 | 0 | Yes |
| CIIDAE                                           |     |                  |    |    |    |    |     |   |   |     |
| Ciinae                                           |     |                  |    |    |    |    |     |   |   |     |
| <i>Cis fuscipes</i> Mellié                       | CP  | VIII IX          | F  | 1  | 0  | 1  | 2   | 0 | 0 | Yes |
| CLERIDAE                                         |     |                  |    |    |    |    |     |   |   |     |
| Clerinae                                         |     |                  |    |    |    |    |     |   |   |     |
| <i>Enoclerus nigrifrons</i> (Say)                | CH  | VI VII IX        | F  | 7  | 1  | 0  | 8   | 0 | 0 | Yes |
| <i>Enoclerus nigripes rufiventris</i> (Spinola)  | CHP | V VI VII IX      | F  | 17 | 9  | 3  | 29  | 0 | 0 | Yes |
| <i>Thanasimus dubius</i> (Fabricius)             | CHP | V VI VII VIII IX | F  | 20 | 10 | 20 | 50  | 0 | 0 | Yes |
| Epiphloeinae                                     |     |                  |    |    |    |    |     |   |   |     |
| <i>Madoniella dislocata</i> (Say)                | CHP | VII VIII IX      | F  | 7  | 22 | 79 | 108 | 0 | 0 | Yes |
| Hydnocerinae                                     |     |                  |    |    |    |    |     |   |   |     |
| <i>Phyllobaenus pallipennis</i> (Say)            | P   | VIII IX          | FS | 6  | 0  | 0  | 6   | 0 | 0 | Yes |

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Appendix 1. Continued.

| FAMILY                           | Subfamily                               | Species <sup>1</sup>                           | Habitats <sup>2</sup>                            | Months collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     |       | Native to USA <sup>6</sup> |       |
|----------------------------------|-----------------------------------------|------------------------------------------------|--------------------------------------------------|-------------------------------|----------------------|--------------------------------------|------|-----|-------|----------------------------|-------|
|                                  |                                         |                                                |                                                  |                               |                      | a-p                                  | ETOH | Ips | Total |                            |       |
| Thanerocerinae                   | Tillinae                                | <i>Zenodorus sanguineus</i> (Say)              | C                                                | VIII                          | F                    | 0                                    | 1    | 0   | 1     | Yes                        |       |
|                                  |                                         | <i>Cymatodera bicolor</i> (Say)                | S                                                | VII                           | S                    | 0                                    | 0    | 0   | 0     | Yes                        |       |
|                                  |                                         |                                                |                                                  |                               |                      |                                      |      |     |       |                            |       |
|                                  | COCCINELLIDAE                           | Chilocorinae                                   | <i>Chilocorus stigma</i> (Say)                   | PS                            | V                    | FS                                   | 0    | 0   | 1     | 1                          | Yes   |
|                                  |                                         |                                                |                                                  |                               |                      |                                      |      |     |       |                            |       |
|                                  |                                         | Coccinellinae                                  | <i>Anatis labiculata</i> (Say)                   | P                             | VI                   | F                                    | 1    | 0   | 0     | 1                          | Yes   |
|                                  |                                         |                                                | <i>Anatis mali</i> (Say)                         | O                             | VIII                 | S                                    | 0    | 0   | 0     | 0                          | Yes   |
|                                  |                                         |                                                | <i>Anisosticta bitriangularis</i> (Say)          | S                             | VII VIII             | S                                    | 0    | 0   | 0     | 0                          | Yes   |
|                                  |                                         |                                                | <i>Coccinella monticola</i> Mulsant              | O                             | VI                   | S                                    | 0    | 0   | 0     | 0                          | Yes   |
|                                  |                                         |                                                | <i>Coccinella septempunctata</i> Linnaeus        | G                             | VI VII VIII          | S                                    | 0    | 0   | 0     | 0                          | EurAs |
| Scymninae                        | Coccinella trifasciata perplexa Mulsant | <i>Coccinella trifasciata perplexa</i> Mulsant | GPO                                              | V VI VII VIII IX              | FS                   | 4                                    | 0    | 5   | 9     | Yes                        |       |
|                                  |                                         | <i>Cycloneda munda</i> (Say)                   | GS                                               | VI VII VIII IX                | S                    | 0                                    | 0    | 0   | 0     | Yes                        |       |
|                                  |                                         | <i>Harmonia axyridis</i> (Pallas)              | GPS                                              | V VI VII VIII                 | FS                   | 15                                   | 1    | 3   | 19    | Asian                      |       |
|                                  |                                         | <i>Hippodamia parenthesis</i> (Say)            | G                                                | VI VII VIII IX                | S                    | 0                                    | 0    | 0   | 0     | Yes                        |       |
|                                  |                                         | <i>Psyllobora vigintimaculata</i> (Say)        | PO                                               | VI IX                         | FS                   | 1                                    | 0    | 0   | 1     | Yes                        |       |
|                                  |                                         | Scymninae                                      | <i>Brachiacantha decempustulata</i> (Melsheimer) | GPO                           | VI VII VIII          | FPS                                  | 2    | 0   | 1     | 3                          | Yes   |
|                                  |                                         |                                                | <i>Brachiacantha quadripunctata</i> Melsheimer ‡ | G                             | VIII                 | S                                    | 0    | 0   | 0     | 0                          | Yes   |
|                                  |                                         |                                                | <i>Hyperaspis binotata</i> (Say)                 | CGPSO                         | V VI VII VIII IX     | FS                                   | 15   | 2   | 4     | 21                         | Yes   |
|                                  |                                         |                                                | <i>Hyperaspis proba</i> (Say)                    | GP                            | VII VIII IX          | FS                                   | 0    | 1   | 0     | 1                          | Yes   |
|                                  |                                         |                                                | <i>Hyperaspis undulata</i> (Say)                 | G                             | VIII                 | S                                    | 0    | 0   | 0     | 0                          | Yes   |
| <i>Scymnus rubricaudus</i> Casey | P                                       | VII                                            | S                                                | 0                             | 0                    | 0                                    | 0    | Yes |       |                            |       |
| <i>Scymnus</i> sp.               | H                                       | V                                              | F                                                | 1                             | 0                    | 0                                    | 1    | NA  |       |                            |       |
| CORYLOPHIDAE                     |                                         |                                                |                                                  |                               |                      |                                      |      |     |       |                            |       |
| Corylophinae                     | Corylophinae                            | <i>Clypastraea lunata</i> (LeConte)            | CH                                               | VI VIII IX                    | F                    | 2                                    | 2    | 0   | 4     | Yes                        |       |
|                                  |                                         | <i>Sericoderus lateralis</i> (Gyllenhal)       | HP                                               | VI VIII                       | F                    | 1                                    | 1    | 0   | 2     | Yes                        |       |
|                                  |                                         |                                                |                                                  |                               |                      |                                      |      |     |       |                            |       |
| CRYPTOPHAGIDAE                   |                                         |                                                |                                                  |                               |                      |                                      |      |     |       |                            |       |
| Cryptophaginae                   | Cryptophaginae                          | <i>Atomaria</i> sp.                            | P                                                | VI                            | F                    | 1                                    | 0    | 0   | 1     | NA                         |       |
|                                  |                                         | <i>Henoticus mycetoeus</i> (Park) *            | C                                                | V                             | F                    | 0                                    | 1    | 0   | 1     | Yes                        |       |
|                                  |                                         |                                                |                                                  |                               |                      |                                      |      |     |       |                            |       |

|                                                 |      |                  |    |   |   |   |    |    |        |
|-------------------------------------------------|------|------------------|----|---|---|---|----|----|--------|
| CURCULIONIDAE                                   |      |                  |    |   |   |   |    |    |        |
| Baridinae                                       |      |                  |    |   |   |   |    |    |        |
| <i>Dirabius rectirostris</i> (LeConte)          | GO   | VII              | S  | 0 | 0 | 0 | 0  | 0  | Yes    |
| <i>Odontocorynus salebrosus</i> (Casey)         | GO   | VI VIII          | S  | 0 | 0 | 0 | 0  | 0  | Yes    |
| <i>Odontocorynus umbellae</i> (Fabricius)       | G    | VIII             | S  | 0 | 0 | 0 | 0  | 0  | Yes    |
| <b><i>Sibariops sector Casey *</i></b>          | O    | V                | S  | 0 | 0 | 0 | 0  | 0  | Yes    |
| <i>Stethobaris ovata</i> (LeConte)              | H    | VIII             | F  | 1 | 0 | 0 | 0  | 1  | Yes    |
| Ceutorhynchinae                                 |      |                  |    |   |   |   |    |    |        |
| <i>Rhinocerus castor</i> (Fabricius)            | G    | VI               | S  | 0 | 0 | 0 | 0  | 0  | Pal    |
| Conoderinae                                     |      |                  |    |   |   |   |    |    |        |
| <i>Acoptus suturalis</i> LeConte                | HP   | V VI             | F  | 1 | 1 | 0 | 0  | 2  | Yes    |
| Cossoninae                                      |      |                  |    |   |   |   |    |    |        |
| <b><i>Trichacorynus protractus</i> (Horn) *</b> | C    | VI               | P  | 0 | 0 | 0 | 0  | 0  | Yes    |
| Curculioninae                                   |      |                  |    |   |   |   |    |    |        |
| <i>Anthrenomus subfasciatus</i> LeConte         | P    | VI               | F  | 1 | 0 | 0 | 0  | 1  | Yes    |
| <i>Orchestes pallicornis</i> (Say)              | P    | V                | F  | 0 | 1 | 0 | 0  | 1  | Yes    |
| <i>Rhinusa tetra</i> (Fabricius)                | G    | VI               | S  | 0 | 0 | 0 | 0  | 0  | Eur    |
| <i>Tachyerges ephippiatus</i> Say               | GPS  | VI IX            | FS | 0 | 1 | 0 | 0  | 1  | Yes    |
| <i>Tachyerges salicis</i> (Linnaeus)            | P    | VI               | F  | 0 | 0 | 1 | 0  | 1  | Yes    |
| <i>Tychius picirostris</i> (Fabricius)          | C    | VI               | F  | 1 | 0 | 0 | 0  | 1  | Eur    |
| Dryophthorinae                                  |      |                  |    |   |   |   |    |    |        |
| <i>Dryophthorus americanus</i> Bedel            | C    | VII              | FP | 1 | 0 | 0 | 0  | 1  | Yes    |
| <b><i>Sphenophorus scoparius</i> Horn *</b>     | H    | VI               | P  | 0 | 0 | 0 | 0  | 0  | Yes    |
| Entiminae                                       |      |                  |    |   |   |   |    |    |        |
| <i>Barypeithes pellucidus</i> (Boheman)         | CHP  | VI VII           | P  | 0 | 0 | 0 | 0  | 0  | Eur    |
| <i>Mesagroicus minor</i> Buchanan               | P    | VIII             | P  | 0 | 0 | 0 | 0  | 0  | Yes    |
| <i>Otiorhynchus ovatus</i> (Linnaeus)           | HPO  | VI VII           | PS | 0 | 0 | 0 | 0  | 0  | Eur/As |
| <i>Otiorhynchus rugosostriatus</i> (Goeze)      | HO   | VII VIII         | PS | 0 | 0 | 0 | 0  | 0  | Eur    |
| <i>Otiorhynchus sulcatus</i> (Fabricius)        | HO   | VII VIII IX      | PS | 0 | 0 | 0 | 0  | 0  | Eur    |
| <i>Phyllobius oblongus</i> (Linnaeus)           | GHP  | V VI VII         | FS | 4 | 5 | 2 | 11 | 11 | Pal    |
| <i>Polydrusus formosus</i> (Mayer)              | GHPO | V VI VII VIII IX | FS | 7 | 1 | 1 | 9  | 9  | Eur    |
| <i>Sciaphilus asperatus</i> (Bonsdorff)         | GHSO | VII VIII IX      | S  | 0 | 0 | 0 | 0  | 0  | Eur    |
| <i>Sitona cylindricollis</i> (Fähræus)          | O    | VII              | S  | 0 | 0 | 0 | 0  | 0  | Pal    |
| <i>Sitona lineellus</i> (Bonsdorff)             | G    | VI               | S  | 0 | 0 | 0 | 0  | 0  | Yes    |
| Mesoptilinae                                    |      |                  |    |   |   |   |    |    |        |
| <i>Magdalis gentilis</i> LeConte                | GP   | VI               | FS | 1 | 0 | 0 | 0  | 1  | Yes    |
| Molytinae                                       |      |                  |    |   |   |   |    |    |        |
| <i>Conotrachelus nenuphar</i> (Herbst)          | H    | VI               | F  | 0 | 2 | 0 | 0  | 2  | Yes    |
| <i>Conotrachelus posticatus</i> Boheman         | HP   | VIII IX          | P  | 0 | 0 | 0 | 0  | 0  | Yes    |
| <i>Hylobius congener</i> Dalla Torre et al.     | CHP  | VI VII           | FP | 5 | 0 | 2 | 7  | 7  | Yes    |

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Appendix 1. Continued.

| FAMILY         | Subfamily | Species <sup>1</sup>                          | Habitats <sup>2</sup> | Months collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     |       | Native to USA <sup>6</sup> |
|----------------|-----------|-----------------------------------------------|-----------------------|-------------------------------|----------------------|--------------------------------------|------|-----|-------|----------------------------|
|                |           |                                               |                       |                               |                      | a-p                                  | ETOH | Ips | Total |                            |
| Scolytinae     |           | <i>Pissodes affinis</i> Randall               | HP                    | V VI VII                      | F                    | 22                                   | 1    | 0   | 23    | Yes                        |
|                |           | <i>Pissodes approximatus</i> Hopkins          | CHP                   | V VI                          | F                    | 5                                    | 0    | 0   | 5     | Yes                        |
|                |           | <i>Rhyssomatus lineaticollis</i> (Say)        | GP                    | VI                            | FS                   | 0                                    | 0    | 1   | 1     | Yes                        |
|                |           | <i>Anisandrus obesus</i> (LeConte)            | H                     | VI VII                        | F                    | 0                                    | 17   | 0   | 17    | Yes                        |
|                |           | <i>Anisandrus sayi</i> Hopkins                | CHP                   | V VI VII IX                   | F                    | 1                                    | 70   | 1   | 72    | Yes                        |
|                |           | <i>Corthylius punctatissimus</i> (Zimmermann) | P                     | VI VII IX                     | FP                   | 0                                    | 2    | 0   | 2     | Yes                        |
|                |           | <i>Crypturgus borealis</i> Swaine             | CH                    | V VI VII VIII                 | F                    | 7                                    | 2    | 8   | 17    | Yes                        |
|                |           | <i>Dryocoetes autographus</i> (Ratzeburg)     | CHP                   | VI VII VIII IX                | F                    | 2                                    | 5    | 0   | 7     | Yes                        |
|                |           | <i>Gnathotrichus materiarius</i> (Fitch)      | CHP                   | V VI VII VIII IX              | F                    | 3                                    | 1    | 4   | 8     | Yes                        |
|                |           | <i>Ips grandicollis</i> (Eichhoff)            | HP                    | V VI                          | F                    | 14                                   | 1    | 2   | 17    | Yes                        |
|                |           | <i>Ips pini</i> (Say)                         | CH                    | V VI VII VIII IX              | F                    | 6                                    | 2    | 6   | 14    | Yes                        |
|                |           | <i>Lymanitor decipiens</i> (LeConte)          | HP                    | VIII IX                       | F                    | 0                                    | 0    | 2   | 2     | Yes                        |
|                |           | <i>Monarthrum mali</i> (Fitch)                | HP                    | V VI                          | F                    | 2                                    | 2    | 0   | 4     | Yes                        |
|                |           | <i>Orthotomicus caelatus</i> (Eichhoff)       | CP                    | V VI VII                      | F                    | 2                                    | 3    | 4   | 9     | Yes                        |
|                |           | <i>Phloeotribus liminaris</i> (Harris)        | HP                    | V VI VII                      | F                    | 2                                    | 41   | 1   | 44    | Yes                        |
|                |           | <i>Xyleborinus saxeseni</i> (Ratzeburg)       | CHP                   | VI VII VIII                   | F                    | 1                                    | 5    | 0   | 6     | EurAs                      |
|                |           | <i>Xylosandrus germanus</i> (Blandford)       | CHP                   | V VI VII IX                   | FP                   | 4                                    | 11   | 3   | 18    | Asian                      |
| DERMESTIDAE    |           |                                               |                       |                               |                      |                                      |      |     |       |                            |
| Megatominae    |           |                                               |                       |                               |                      |                                      |      |     |       |                            |
|                |           | <i>Anthrenus verbasci</i> (Linnaeus)          | P                     | VI                            | F                    | 1                                    | 0    | 1   | 2     | Eur                        |
| ELATERIDAE     |           |                                               |                       |                               |                      |                                      |      |     |       |                            |
| Cardiophorinae |           |                                               |                       |                               |                      |                                      |      |     |       |                            |
|                |           | <i>Cardiophorus convexulus</i> LeConte        | HP                    | V VI                          | F                    | 15                                   | 6    | 1   | 22    | Yes                        |
|                |           | <i>Cardiophorus convexus</i> (Say)            | CHP                   | V VI VII                      | FP                   | 31                                   | 14   | 12  | 57    | Yes                        |
|                |           | <i>Cardiophorus gagates</i> Erichson          | CHPO                  | V VI VII                      | FS                   | 21                                   | 4    | 0   | 25    | Yes                        |
| Dendrometrinae |           |                                               |                       |                               |                      |                                      |      |     |       |                            |
|                |           | <i>Athous acanthus</i> (Say)                  | PO                    | VII VIII                      | FS                   | 1                                    | 0    | 0   | 1     | Yes                        |
|                |           | <i>Athous brightwelli</i> (Kirby)             | P                     | V VII                         | F                    | 3                                    | 0    | 0   | 3     | Yes                        |
|                |           | <i>Elathous discalceatus</i> (Say)            | CHP                   | VII VIII                      | F                    | 0                                    | 1    | 3   | 4     | Yes                        |
|                |           | <i>Gambrius plebejus</i> (Say)                | CHP                   | V VI                          | F                    | 3                                    | 11   | 6   | 20    | Yes                        |
|                |           | <i>Hemicrepidius memnonius</i> (Herbst)       | P                     | V VII                         | F                    | 0                                    | 1    | 1   | 2     | Yes                        |
|                |           | <i>Limonijs basilaris</i> (Say)               | O                     | VI                            | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                |           | <i>Pseudanostirus hieroglyphicus</i> (Say)    | CP                    | V VI                          | F                    | 5                                    | 1    | 2   | 8     | Yes                        |
|                |           | <i>Pseudanostirus propolus</i> (LeConte)      | P                     | VII                           | S                    | 0                                    | 0    | 0   | 0     | Yes                        |

|                                                    |      |               |    |    |    |    |    |     |
|----------------------------------------------------|------|---------------|----|----|----|----|----|-----|
| <i>Pseudanostirus triundulatus</i> (Randall)       | CH   | V VI          | F  | 1  | 2  | 2  | 5  | Yes |
| Elaterinae                                         |      |               |    |    |    |    |    |     |
| <i>Ampedus mixtus</i> (Herbst)                     | CHPS | V VI VII      | FS | 3  | 10 | 6  | 19 | Yes |
| <i>Ampedus pedalis</i> Germar                      | CHS  | V VI VII      | FS | 3  | 10 | 10 | 23 | Yes |
| <i>Dalopius vagus</i> Brown ‡                      | HPSO | V VI VII VIII | FS | 0  | 2  | 1  | 3  | Yes |
| <i>Dalopius vernus</i> Brown ‡                     | S    | V             | S  | 0  | 0  | 0  | 0  | Yes |
| <i>Elater abruptus</i> Say                         | HP   | VI VII        | F  | 4  | 1  | 0  | 5  | Yes |
| <i>Melanotus castanipes</i> (Paykull)              | CHP  | V VI VII VIII | F  | 20 | 6  | 22 | 48 | Yes |
| <i>Melanotus communis</i> -complex                 | CHP  | V VI VII      | FS | 7  | 6  | 3  | 16 | Yes |
| <i>Melanotus hyslopi</i> Van Zwaluwenberg          | CHPO | VI VII VIII   | FS | 1  | 1  | 2  | 4  | Yes |
| <i>Melanotus</i> sp.                               | G    | VI            | S  | 0  | 0  | 0  | 0  | NA  |
| ENDOMYCHIDAE                                       |      |               |    |    |    |    |    |     |
| Leiestinae                                         |      |               |    |    |    |    |    |     |
| <i>Phymaphora pulchella</i> Newman                 | C    | VIII IX       | F  | 1  | 0  | 2  | 3  | Yes |
| Lycoperdinae                                       |      |               |    |    |    |    |    |     |
| <i>Lycoperdina ferruginea</i> LeConte              | P    | IX            | P  | 0  | 0  | 0  | 0  | Yes |
| EROTYLIDAE                                         |      |               |    |    |    |    |    |     |
| Languriinae                                        |      |               |    |    |    |    |    |     |
| <i>Acropteroxys gracilis</i> (Newman)              | S    | VI            | S  | 0  | 0  | 0  | 0  | Yes |
| Erotylinae                                         |      |               |    |    |    |    |    |     |
| <i>Triplax frosti</i> Casey                        | P    | VI            | F  | 0  | 1  | 0  | 1  | Yes |
| EUCINETIDAE                                        |      |               |    |    |    |    |    |     |
| <i>Eucinetus strigosus</i> LeConte                 | H    | VI            | F  | 1  | 0  | 0  | 1  | Yes |
| EUCNEMIDAE                                         |      |               |    |    |    |    |    |     |
| Macraulacinae                                      |      |               |    |    |    |    |    |     |
| <i>Onichodon canadensis</i> (Brown)                | H    | VII VIII IX   | F  | 0  | 0  | 3  | 3  | Yes |
| Melasiinae                                         |      |               |    |    |    |    |    |     |
| <i>Dirrhagofarsus ernae</i> Otto, Muona & McClarin | H    | VI            | F  | 3  | 2  | 1  | 6  | Yes |
| <i>Entomophthalmus rufiolus</i> (LeConte)          | HP   | VII VIII IX   | F  | 0  | 2  | 2  | 4  | Yes |
| <i>Microhagrus carinicolis</i> Otto                | H    | VI            | F  | 2  | 1  | 0  | 3  | Yes |
| <i>Microhagrus pectinatus</i> LeConte              | H    | VI VII        | F  | 1  | 0  | 0  | 1  | Yes |
| <i>Microhagrus subsinuatus</i> LeConte             | HP   | VI            | F  | 1  | 3  | 1  | 5  | Yes |
| <i>Microhagrus triangularis</i> (Say)              | PO   | VII VIII IX   | FS | 0  | 0  | 2  | 2  | Yes |
| GEOTRUPIDAE                                        |      |               |    |    |    |    |    |     |
| Bolboceratinae                                     |      |               |    |    |    |    |    |     |
| <i>Odonteus</i> sp.                                | P    | VI            | P  | 0  | 0  | 0  | 0  | NA  |

(Continued on next page)

Appendix 1. Continued.

| FAMILY         | Subfamily | Species <sup>1</sup>                         | Habitats <sup>2</sup> | Months collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     |       | Native to USA <sup>6</sup> |
|----------------|-----------|----------------------------------------------|-----------------------|-------------------------------|----------------------|--------------------------------------|------|-----|-------|----------------------------|
|                |           |                                              |                       |                               |                      | a-p                                  | ETOH | Ips | Total |                            |
| HISTERIDAE     |           |                                              |                       |                               |                      |                                      |      |     |       |                            |
| Dendrophilinae |           | <i>Paromaltus bistriatus</i> Erichson        | CH                    | VI VII VIII IX                | F                    | 19                                   | 0    | 1   | 20    | Yes                        |
|                |           | Histerinae                                   | H                     | IX                            | F                    | 0                                    | 0    | 1   | 1     | Yes                        |
| Saprininae     |           | <i>Euspilotus assimilis</i> (Paykull)        | P                     | VIII                          | P                    | 0                                    | 0    | 0   | 0     | Yes                        |
| HYDROPHILIDAE  |           |                                              |                       |                               |                      |                                      |      |     |       |                            |
| Hydrophilinae  |           | <i>Chaetarthria atra</i> (LeConte) *         | H                     | VII                           | P                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                |           | <i>Helocombus bifidus</i> (LeConte)          | P                     | VII                           | P                    | 0                                    | 0    | 0   | 0     | Yes                        |
| LAEMOPHLOEIDAE |           |                                              |                       |                               |                      |                                      |      |     |       |                            |
|                |           | <i>Laemophloeus fervidus</i> Casey *         | C                     | VI                            | F                    | 0                                    | 0    | 1   | 1     | Yes                        |
| LAMPYRIDAE     |           |                                              |                       |                               |                      |                                      |      |     |       |                            |
| Lampyrinae     |           | <i>Ellychnia corrusca</i> (Linnaeus)         | CGHPSO                | V VI VIII IX                  | FS                   | 13                                   | 10   | 30  | 53    | Yes                        |
|                |           | <i>Lucidota atra</i> (Olivier)               | HSO                   | VI                            | FS                   | 1                                    | 0    | 0   | 1     | Yes                        |
|                |           | <i>Photinus indictus</i> (LeConte)           | G                     | VI                            | S                    | 0                                    | 0    | 0   | 0     | NA                         |
|                |           | <i>Photinus</i> sp.                          | CGHPO                 | VI VII                        | FS                   | 5                                    | 2    | 2   | 10    | Yes                        |
|                |           | <i>Pyrractomena angulata</i> (Say)           | S                     | VI                            | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                |           | <i>Pyropyga decipiens</i> (Harris)           | CGHSO                 | VI VII VIII                   | PS                   | 0                                    | 0    | 0   | 0     | Yes                        |
| Photurinae     |           | <i>Photuris</i> sp.                          | HSO                   | VI                            | S                    | 0                                    | 0    | 0   | 0     | NA                         |
| LATRIDIIDAE    |           |                                              |                       |                               |                      |                                      |      |     |       |                            |
| Corticariinae  |           | <i>Corticaria</i> sp.                        | CP                    | VI                            | F                    | 2                                    | 1    | 1   | 4     | NA                         |
|                |           | <i>Melanophthalma americana</i> (Mannerheim) | GPS                   | VIII IX                       | FS                   | 2                                    | 0    | 0   | 2     | Yes                        |
|                |           | <i>Melanophthalma distinguenda</i> (Comolli) | CHP                   | V VI VII VIII                 | F                    | 19                                   | 15   | 20  | 54    | Yes                        |
|                |           | <i>Melanophthalma pumila</i> (LeConte)       | C                     | V                             | F                    | 0                                    | 0    | 1   | 1     | Yes                        |
| Latridiinae    |           | <i>Stephostethus liratus</i> (LeConte)       | HPS                   | V VI VIII IX                  | FS                   | 3                                    | 0    | 7   | 10    | Yes                        |
| LEIODIDAE      |           |                                              |                       |                               |                      |                                      |      |     |       |                            |
| Cholevininae   |           | <i>Catops basilaris</i> Say                  | P                     | V                             | P                    | 0                                    | 0    | 0   | 0     | Yes                        |



Appendix 1. Continued.

| FAMILY                    | Subfamily      | Species <sup>1</sup>                           | Habitats <sup>2</sup> | Months collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     |       | Native to USA <sup>6</sup> |
|---------------------------|----------------|------------------------------------------------|-----------------------|-------------------------------|----------------------|--------------------------------------|------|-----|-------|----------------------------|
|                           |                |                                                |                       |                               |                      | a-p                                  | ETOH | Ips | Total |                            |
|                           |                | <i>Mordellistena pulchra</i> Liljeblad         | CP                    | VI VII                        | F                    | 0                                    | 1    | 1   | 2     | Yes                        |
|                           |                | <i>Mordellistena tosta</i> LeConte             | H                     | VII                           | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                           |                | <i>Mordellistena trifasciata</i> (Say)         | CP                    | VII                           | F                    | 2                                    | 1    | 0   | 3     | Yes                        |
|                           |                | <i>Mordellistena vera</i> Liljeblad            | CS                    | VII                           | FS                   | 0                                    | 1    | 0   | 1     | Yes                        |
|                           |                | <i>Mordellochroa scapularis</i> (Say)          | P                     | V                             | F                    | 0                                    | 0    | 1   | 1     | Yes                        |
| MYCETOPHAGIDAE            |                |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           | Mycetophaginae |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Litargus tetraspilotus</i> LeConte          | CGHPS                 | V VI VIII IX                  | FS                   | 17                                   | 3    | 7   | 27    | Yes                        |
| NEMONYCHIDAE <sup>7</sup> |                |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           | Cimberidinae   |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Cimberis elongata</i> (LeConte)             | P                     | V                             | F                    | 0                                    | 0    | 1   | 1     | Yes                        |
| NITIDULIDAE               |                |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           | Carpophilinae  |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Carpophilus brachypterus</i> (Say)          | P                     | V                             | F                    | 2                                    | 1    | 0   | 3     | Yes                        |
|                           |                | <i>Carpophilus lugubris</i> Murray ‡           | CHP                   | IX                            | P                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                           | Cryptarchinae  |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Glischrochilus sanguinolentus</i> (Olivier) | CHP                   | V VI VII VIII IX              | FP                   | 1                                    | 25   | 1   | 27    | Yes                        |
|                           |                | <i>Glischrochilus siepmanni</i> W. J. Brown    | C                     | IX                            | P                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                           | Nitidulinae    |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Stelidota geminata</i> (Say) ‡              | CHP                   | VII VIII IX                   | P                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                           |                | <i>Thalycra concolor</i> (LeConte)             | CHP                   | VI VII VIII IX                | FP                   | 1                                    | 0    | 6   | 7     | Yes                        |
| OEDEMERIDAE               |                |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           | Oedemerinae    |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Asclera ruficollis</i> (Say)                | CP                    | V VI                          | F                    | 3                                    | 2    | 1   | 6     | Yes                        |
| PHALACRIDAE               |                |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           | Eustilbinae    |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Acylopus ergoti</i> Casey                   | H                     | VIII                          | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                           | Olibrinae      |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Olibrus semistriatus</i> LeConte            | G                     | VII                           | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                           | Phalacrinae    |                                                |                       |                               |                      |                                      |      |     |       |                            |
|                           |                | <i>Phalacrus politus</i> Melsheimer            | SO                    | VI VII VIII IX                | S                    | 0                                    | 0    | 0   | 0     | Yes                        |
|                           |                | <i>Phalacrus</i> sp.                           | S                     | VII                           | S                    | 0                                    | 0    | 0   | 0     | NA                         |



Appendix 1. Continued.

| FAMILY<br>Subfamily<br>Species <sup>1</sup>     | Habitats <sup>2</sup> | Months<br>collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     |       | Native to<br>USA <sup>6</sup> |
|-------------------------------------------------|-----------------------|----------------------------------|----------------------|--------------------------------------|------|-----|-------|-------------------------------|
|                                                 |                       |                                  |                      | a-p                                  | ETOH | Ips | Total |                               |
| <i>Melanocanthon nigricornis</i> (Say)          | P                     | VI                               | P                    | 0                                    | 0    | 0   | 0     | Yes                           |
| <i>Onthophagus hecate</i> (Panzer)              | CP                    | VI VIII                          | P                    | 0                                    | 0    | 0   | 0     | Yes                           |
| SCIRTIDAE                                       |                       |                                  |                      |                                      |      |     |       |                               |
| Scirtinae                                       |                       |                                  |                      |                                      |      |     |       |                               |
| <i>Contactyphon neopadi</i> (Klausnitzer) ‡     | SO                    | VII                              | S                    | 0                                    | 0    | 0   | 0     | Yes                           |
| <i>Contactyphon obscurus</i> (Guérin-Ménéville) | CHPS                  | V VI VII VIII                    | FS                   | 13                                   | 4    | 7   | 24    | Yes                           |
| <i>Contactyphon variabilis</i> (Thunberg)       | CHPSO                 | V VI VII VIII IX                 | FS                   | 42                                   | 3    | 20  | 65    | NA                            |
| <i>Contactyphon</i> unnamed nr. <i>obscurus</i> | CHS                   | V VI VII                         | FS                   | 9                                    | 4    | 4   | 17    | Yes                           |
| <i>Nyholmia confusa</i> (Brown)                 | GS                    | VII                              | S                    | 0                                    | 0    | 0   | 0     | Yes                           |
| <i>Prionocyphon limbatus</i> LeConte ‡          | GHO                   | VI VII VIII IX                   | FS                   | 8                                    | 4    | 6   | 18    | Yes                           |
| <i>Sacodes thoracica</i> (Guérin-Ménéville)     | HP                    | V VI VIII                        | F                    | 0                                    | 1    | 2   | 3     | Yes                           |
| <i>Scirtes tibialis</i> Guérin-Ménéville        | HSO                   | VII IX                           | FS                   | 0                                    | 1    | 1   | 2     | Yes                           |
| SCRAPTIDAE                                      |                       |                                  |                      |                                      |      |     |       |                               |
| Anaspidinae                                     |                       |                                  |                      |                                      |      |     |       |                               |
| <i>Anaspis flavipennis</i> Haldeman             | HP                    | V VI                             | F                    | 4                                    | 0    | 1   | 5     | Yes                           |
| <i>Anaspis rufa</i> Say                         | C                     | VI                               | F                    | 0                                    | 0    | 1   | 1     | Yes                           |
| Scraptiinae                                     |                       |                                  |                      |                                      |      |     |       |                               |
| <i>Canifa pallipes</i> (Melsheimer)             | CHP                   | VI VII                           | F                    | 1                                    | 3    | 3   | 7     | Yes                           |
| SILPHIDAE                                       |                       |                                  |                      |                                      |      |     |       |                               |
| Nicrophorinae                                   |                       |                                  |                      |                                      |      |     |       |                               |
| <i>Nicrophorus orbicollis</i> Say               | HP                    | VI IX                            | FP                   | 0                                    | 1    | 3   | 4     | Yes                           |
| <i>Nicrophorus sayi</i> Laporte                 | C                     | VI                               | F                    | 0                                    | 0    | 1   | 1     | Yes                           |
| Silphinae                                       |                       |                                  |                      |                                      |      |     |       |                               |
| <i>Necrophila americana</i> (Linnaeus)          | HP                    | VI VII VIII                      | P                    | 0                                    | 0    | 0   | 0     | Yes                           |
| <i>Oiceoptoma noveboracense</i> (Forster)       | HP                    | VII                              | P                    | 0                                    | 0    | 0   | 0     | Yes                           |
| SILVANIDAE                                      |                       |                                  |                      |                                      |      |     |       |                               |
| Brontinae                                       |                       |                                  |                      |                                      |      |     |       |                               |
| <i>Telephanus velox</i> (Haldeman)              | P                     | VI                               | F                    | 1                                    | 0    | 0   | 1     | Yes                           |
| Silvaninae                                      |                       |                                  |                      |                                      |      |     |       |                               |
| <i>Silbanus muticus</i> Sharp *                 | H                     | VII                              | F                    | 0                                    | 1    | 0   | 1     | Yes                           |
| SPHINDIDAE                                      |                       |                                  |                      |                                      |      |     |       |                               |
| Sphindinae                                      |                       |                                  |                      |                                      |      |     |       |                               |
| <i>Sphindus americanus</i> LeConte              | H                     | VI                               | F                    | 1                                    | 0    | 0   | 1     | Yes                           |

|                                               |            |                |   |   |   |   |   |   |     |
|-----------------------------------------------|------------|----------------|---|---|---|---|---|---|-----|
| STAPHYLINIDAE                                 |            |                |   |   |   |   |   |   |     |
| Aleocharinae                                  |            |                |   |   |   |   |   |   |     |
| <i>Aleochara lata</i> Gravenhorst             |            |                |   |   |   |   |   |   |     |
| <i>Aleochara</i> sp. 1                        | H          | IX             | F | 0 | 0 | 0 | 1 | 1 | Pal |
| Unknown sp. 2                                 | H          | VI             | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 3                                 | P          | VIII           | F | 1 | 0 | 0 | 0 | 1 | NA  |
| Unknown sp. 4                                 | P          | VIII IX        | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 5                                 | O          | IX             | S | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 6                                 | P          | IX             | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 7                                 | CH         | VII            | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 8                                 | H          | VII IX         | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 9                                 | H          | VII            | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 10                                | C          | VIII IX        | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 11                                | HP         | IX             | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 12                                | H          | VII            | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 13                                | CP         | IX             | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 14                                | CH         | VII IX         | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 15                                | C          | VIII           | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Unknown sp. 16                                | H          | VII            | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Omaliinae                                     |            |                |   |   |   |   |   |   |     |
| <i>Eusphalerum orientale</i> (Bernhauer)      | P          | V VI           | F | 1 | 2 | 1 | 1 | 4 | Yes |
| <i>Phloeostiba lapponicus</i> (Zetterstedt)   | HP         | VII IX         | F | 5 | 1 | 0 | 0 | 6 | Yes |
| Oxytelinae                                    |            |                |   |   |   |   |   |   |     |
| <i>Oxytelus laqueatus</i> (Marsham)           | label lost | VI             | F | 0 | 0 | 0 | 0 | 1 | Pal |
| Paederinae                                    |            |                |   |   |   |   |   |   |     |
| <i>Paederus littorarius</i> Gravenhorst       | H          | VII            | P | 0 | 0 | 0 | 0 | 0 | Pal |
| <i>Palaminus</i> sp.                          | C          | VII            | F | 1 | 0 | 0 | 0 | 1 | NA  |
| Pselaphinae                                   |            |                |   |   |   |   |   |   |     |
| <i>Batrissodes</i> sp.                        | C          | IX             | P | 0 | 0 | 0 | 0 | 0 | NA  |
| Scaphidiinae                                  |            |                |   |   |   |   |   |   |     |
| <i>Baeocera</i> sp.                           | HP         | VI VII         | F | 1 | 1 | 0 | 0 | 2 | NA  |
| Staphylininae                                 |            |                |   |   |   |   |   |   |     |
| <i>Belonuchus rufipennis</i> (Fabricius)      | H          | VI             | F | 1 | 0 | 0 | 0 | 1 | Yes |
| <i>Bisnius blandus</i> (Gravenhorst)          | CH         | VII IX         | P | 0 | 0 | 0 | 0 | 0 | Yes |
| <i>Dinothenarus badipes</i> (LeConte)         | CH         | VI VII VIII IX | P | 0 | 0 | 0 | 0 | 0 | Yes |
| <i>Nudobius cephalus</i> (Say)                | P          | VI             | F | 1 | 0 | 0 | 0 | 1 | Yes |
| <i>Ontholestes cingulatus</i> (Gravenhorst)   | H          | VIII           | P | 0 | 0 | 0 | 0 | 0 | Yes |
| <i>Philonthus caeruleipennis</i> (Mannerheim) | C          | VII            | P | 0 | 0 | 0 | 0 | 0 | Yes |
| <i>Quedius fulgidus</i> (Fabricius)           | C          | IX             | P | 0 | 0 | 0 | 0 | 0 | Yes |

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Appendix 1. Continued.

| FAMILY        | Subfamily    | Species <sup>1</sup>                      | Habitats <sup>2</sup>                | Months collected <sup>3</sup> | Methods <sup>4</sup> | Funnel trap collections <sup>5</sup> |      |     |       | Native to USA <sup>6</sup> |     |
|---------------|--------------|-------------------------------------------|--------------------------------------|-------------------------------|----------------------|--------------------------------------|------|-----|-------|----------------------------|-----|
|               |              |                                           |                                      |                               |                      | a-p                                  | ETOH | Ips | Total |                            |     |
| Tachyporinae  |              | <i>Quedius fulvicollis</i> (Stephens)     | P                                    | VIII                          | P                    | 0                                    | 0    | 0   | 0     | Yes                        |     |
|               |              | <i>Quedius laticollis</i> (Gravenhorst)   | HP                                   | VIII IX                       | P                    | 0                                    | 0    | 0   | 0     | Yes                        |     |
|               |              | <i>Quedius peregrinus</i> (Gravenhorst)   | CP                                   | VIII IX                       | P                    | 0                                    | 0    | 0   | 0     | Yes                        |     |
|               |              | <i>Quedius plagiatus</i> Mannerheim       | H                                    | VIII                          | F                    | 0                                    | 1    | 0   | 1     | Yes                        |     |
|               |              | <i>Quedius</i> sp.                        | P                                    | VII                           | P                    | 0                                    | 0    | 0   | 0     | NA                         |     |
|               |              | <i>Tasgius melanarius</i> (Heer) *        | H                                    | IX                            | P                    | 0                                    | 0    | 0   | 0     | EurAs                      |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
| Tenebrionidae | Alleculinae  | <i>Capnochora fuliginosa</i> (Melsheimer) | H                                    | VI VII                        | F                    | 0                                    | 0    | 2   | 2     | Yes                        |     |
|               |              | <i>Hymenorus obesus</i> Casey             | P                                    | VI                            | FS                   | 1                                    | 0    | 0   | 1     | Yes                        |     |
|               |              | <i>Hymenorus</i> sp.                      | H                                    | VII VIII                      | F                    | 1                                    | 0    | 0   | 1     | NA                         |     |
|               |              | <i>Isomira oblongula</i> Casey            | CH                                   | VI VIII IX                    | F                    | 1                                    | 2    | 0   | 3     | Yes                        |     |
|               |              | <i>Isonira pulla</i> (Melsheimer)         | C                                    | VII                           | F                    | 0                                    | 1    | 0   | 1     | Yes                        |     |
|               |              | <i>Isonira quadristriata</i> (Couper)     | CO                                   | VI VII VIII                   | FS                   | 0                                    | 2    | 0   | 2     | Yes                        |     |
|               |              | <i>Isonira sericea</i> (Say)              | CHP                                  | VII VIII IX                   | FS                   | 1                                    | 2    | 1   | 4     | Yes                        |     |
|               |              | <i>Mycetochara bicolor</i> (Couper)       | HP                                   | VI VII                        | F                    | 1                                    | 0    | 1   | 2     | Yes                        |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
| Lagriinae     |              | <i>Corticeus parallelus</i> (Melsheimer)  | HP                                   | V VI VIII IX                  | F                    | 4                                    | 0    | 0   | 4     | Yes                        |     |
|               |              | <i>Corticeus praetermissus</i> (Fall)     | H                                    | V VI IX                       | F                    | 7                                    | 0    | 0   | 7     | Yes                        |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               | Stenochiinae |                                           | <i>Anaeetus brunneus</i> (Ziegler) * | P                             | VI VII               | P                                    | 0    | 0   | 0     | 0                          | Yes |
|               |              | <i>Arthromacra aenea</i> (Say)            | GPS                                  | VI VII                        | FS                   | 1                                    | 0    | 0   | 1     | Yes                        |     |
|               |              |                                           |                                      |                               |                      |                                      |      |     |       |                            |     |
|               |              | <i>Strongylium tenuicollis</i> (Say)      | H                                    | VI                            | F                    | 0                                    | 0    | 1   | 1     | Yes                        |     |

|                                                 |    |             |   |   |   |   |   |   |     |
|-------------------------------------------------|----|-------------|---|---|---|---|---|---|-----|
| TETRATOMIDAE                                    |    |             |   |   |   |   |   |   |     |
| Eustrophinae                                    |    |             |   |   |   |   |   |   |     |
| <i>Eustrophus tomentosus</i> Say                | H  | VII VIII IX | F | 0 | 4 | 0 | 4 | 0 | Yes |
| <i>Synstrophus repandus</i> (Horn)              | H  | VIII IX     | F | 0 | 4 | 0 | 4 | 0 | Yes |
| THROSCIDAE                                      |    |             |   |   |   |   |   |   |     |
| Throscinae                                      |    |             |   |   |   |   |   |   |     |
| <i>Autonothoscus constrictor</i> (Say)          | H  | VI VIII     | F | 1 | 2 | 0 |   |   | Yes |
| <b><i>Autonothoscus distans</i> Blanchard *</b> | P  | V VI        | F | 1 | 0 | 1 |   |   | Yes |
| <i>Trixagus carinicollis</i> (Schaeffer)        | H  | VIII        | F | 0 | 1 | 0 |   |   | Yes |
| TROGOSSITIDAE                                   |    |             |   |   |   |   |   |   |     |
| Peltinae                                        |    |             |   |   |   |   |   |   |     |
| <i>Thymalus marginicollis</i> Chevrolat         | CP | VI VII      | F | 2 | 0 | 0 |   |   | Yes |
| Trogossitinae                                   |    |             |   |   |   |   |   |   |     |
| <i>Airora cylindrica</i> (Audinet-Serville)     | CP | VI VII      | F | 2 | 0 | 0 |   |   | Yes |
| ZOPHERIDAE                                      |    |             |   |   |   |   |   |   |     |
| Colydiinae                                      |    |             |   |   |   |   |   |   |     |
| <i>Bitoma quadriguttata</i> (Say)               | P  | V           | F | 0 | 0 | 1 |   |   | Yes |
| <i>Synchita fuliginosa</i> Melsheimer           | H  | VI          | F | 0 | 1 | 0 |   |   | Yes |

<sup>1</sup> A species typed in bold and followed by the symbol \* is considered a new state record for Michigan (N = 18), i.e., we are not aware of any published mention of it occurring in Michigan, either in print or online. A species name followed by ‡ (N = 14) indicates species for which Michigan specimens have been deposited in the Albert J. Cook Arthropod Research Collection (ARC) at Michigan State University (MSU) prior to our study and published on SCAN, but with no published records in print. Similarly, a species name followed by # (N = 1) indicates a species for which photographs of Michigan specimens have been posted on BugGuide, but with no specimens in the ARC-MSU collection, nor any published records in print. Species names not followed by a symbol (N = 336) already have a published in-print record of occurring in Michigan.

<sup>2</sup> Habitats: C = cedar, G = grassland, H = hardwoods, O = other but primarily the Raul Trail, P = pine, and S = Sedge Meadow Trail. See text for details.

<sup>3</sup> Months: V = May, VI = June, VII = July, VIII = August, and IX = September.

<sup>4</sup> Methods: F = funnel traps, P = pitfall traps, and S = sweeping.

<sup>5</sup> Funnel traps were baited with one of three lures: a-p = alpha-pinene, ETOH = ethanol, and Ips = ipsenol. See text for details. Numbers represent season-long totals of individuals collected by lure type and the total for all funnel traps combined. If no values are listed, then these species were not collected in the funnel traps.

<sup>6</sup> Species listed as "Yes" are considered native to the continental USA, and for those considered exotic to the USA, their native ranges are given as follows: Eur = European, EurAs = Eurasian, and Pal = Palearctic. NA = not applicable.

<sup>7</sup> Some sources have elevated certain subfamilies of Nemonychidae to family status, such as Cimberidinae being elevated to Cimberidae.