Observations on Two Stem-Boring Coleoptera of Prickly-Ash (*Zanthoxylum americanum*) in Michigan: *Micracis suturalis* (Curculionidae: Scolytinae) and *Sternidius alpha* (Cerambycidae)

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Abstract

The xylophagous scolytine *Micracis suturalis* LeConte and the cerambycid beetle *Sternidius alpha* (Say) were reared or collected from trunk sections of prickly-ash, *Zanthoxylum americanum* Mill., in Ingham County, Michigan during 1986 to 1988. Most *M. suturalis* gallery systems were initiated by August in host material cut in late May 1987. *Micracis suturalis* gallery-system density data are presented. No *M. suturalis* were reared from caged host material one-year after cutting. *Sternidius alpha* was univoltine, with adults emerging from mid-May to mid-July from host material cut the previous spring. From 1 to 8 *S. alpha* larvae originated from individual oviposition sites, averaging 3. Larvae tunneled first in the cambial region and then entered the xylem in late summer. Larval and exit hole density data for *S. alpha* are presented.

Keywords: wood borers, seasonal emergence, attack density, parasitoids, voltinism

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Prickly-ash, *Zanthoxylum americanum* Mill. (Rutaceae), is a common woody plant in deciduous forests throughout much of eastern North America (Porter 1976, Little 1979). Prickly-ash grows clonally (Reinartz and Popp 1987), often as a shrub 2–4 m in height (Rosendahl 1955) but can attain heights over 8 m (Ehrle 2006). Plants in the genus *Zanthoxylum* produce a variety of secondary compounds of which some have insecticidal, condiment, and medicinal applications (Fish and Waterman 1973, Su 1984, Ombito 2021).

Relatively few insects have been reported to feed on prickly-ash. Mertins et al. (1973) provided a list of four defoliating and six sap-sucking insects associated with prickly-ash in Wisconsin. The chewing insects included one chrysomelid beetle, *Derospidea brevicollis* (LeConte), and three Lepidoptera: *Agonopterix nigrinotella* (Busck) (Depressariidae), *Dichomeris citrifoliella* (Chambers) (Gelechiidae), and *Papilio cresphontes* Cramer (Papilionidae). The sucking insects (Hemiptera) included *Ceratocapsus incisus* Knight (Miridae), *Lygocoris omnivagus* Knight (Miridae), *Acanthocephala terminalis* (Dallas) (Coreidae), *Metcalfa pruinosa* (Say) (Flatidae), *Aphis rumicis* L. (Aphididae), and *Parthenolecanium corni* (Bouche) (Coccidae). In addition, Blatchley and Leng (1916) reported that the weevil *Catapastus conspersus* LeConte was common on prickly-ash. In Texas, the weevil *Zygobarella xanthoxyli* (Pierce) has been reared from the fruit of *Zanthoxylum clava-herculis* L. (Pierce 1907), and in Louisiana, the weevil *Amercedes subulirostris* Casey has been beaten from *Zanthoxylum* sp. foliage (Pierce 1907). Similarly, two additional diaspidid scale insects (Hemiptera) have been recorded on *Zanthoxylum* species in the southern and western United States (McKenzie 1956): *Parlatoreopsis chinensis* (Marlatt) and *Quadraspidiotus juglansregiae* (Comstock).

Only two wood-boring insects have been recorded from prickly-ash in eastern North America. In Illinois, Shimer (1868) reared the longhorned beetle *Sternidius alpha* (Say) (Coleoptera: Cerambycidae) and the xylophagous scolytine beetle *Micracis suturalis* LeConte (Coleoptera: Curculionidae: Scolytinae). These two species were the only borers listed on prickly-ash in Packard's (1890) tome on "Insects injurious to forest and shade trees" in the continental United States. Both of these beetles occur in Michigan (Gosling and Gosling 1976, Cognato et al. 2009, Ruesink et al. 2023) with first reports made by Hubbard and Schwarz (1878) for *M. suturalis* and by Andrews (1916) for *S. alpha*.

As reported earlier (Haack 2020, 2021), during my career with the U.S.D.A. Forest Service (1986–2015), I reared insects from several species of woody plants growing in a woodlot behind my home near Dansville, Ingham County, MI (42.5481° N, 84.3189° W). The woodlot was part of a 24-ha mature

mesic northern hardwoods stand (Cohen 2008) dominated by sugar maple (*Acer saccharum* Marshall, Sapindaceae) along with many other hardwood tree species as listed in Haack (2020). Prickly-ash was a common shrub in portions of the woodlot, with individual plants commonly growing 2–4 m in height.

The main objective of this study was to identify the bark- and wood-infesting insects associated with prickly-ash in a woodlot in Ingham County, Michigan, record timing of adult emergence, and calculate infestation densities. Although these studies were conducted many years ago, they still offer new life history data for some Michigan insects.

Materials and Methods

1986–1987 study. I cut three prickly-ash plants near the ground on 19 April 1986. After labelling each plant, I placed them upright and supported by nearby live prickly-ash plants in the same woodlot until the next year. The cut plants were 2–2.5 m tall and 3–4 cm in diameter at the ground. Each had one main trunk with many individual branches. At the time of cutting, which was before leaf flush, the plants appeared healthy based on the presence of buds along all branches and the fresh color of the inner bark (phloem) and sapwood (xylem) at the cut base. Approximately a year later on 24 April 1987, I cut the main stems of the three test plants into several sections, each about 30 cm long, and placed all sections in a single rearing cage as described in Haack (2020). Briefly, the cage measured 60-cm wide by 45-cm deep by 45-cm tall, had a wood floor, a sliding Plexiglas front panel, and very fine screening on the other three side walls and upper surface. The cage was positioned on a counter inside a covered shed that had double doors at opposite ends that remained open throughout spring and summer to allow air flow. The shed was shaded by surrounding trees for most of the day and therefore the air temperatures inside the shed were similar to ambient conditions along the forest edge. The rearing cage was checked every 1–3 days for recently emerged insects through August 1987. I recorded data on only the borers that emerged in 1987, not the parasitoids. After each collection, all specimens were placed in a labeled vial and then frozen. Later, once the borers were identified by experts (see Acknowledgments), they were totaled by emergence date. Specimens were retained by the identifiers in their personal or institutional collections. In September 1987, I collected the trunk samples that had been used for rearing as well as additional trunk and branch samples from the tops of the two test plants that had been left in the woodlot throughout the summer. From these samples, I measured length and diameter of each stem section and counted all exit holes in two size classes: larger and more oval exit holes (ca. 2–4 mm wide) and smaller and more circular exit/entrance holes (ca. 1 mm wide). Several of the smaller exit holes were traced back into the wood to determine if they represented parasitoids or scolytines or some other type of insect.

1987–1988 study. Using methods similar to those described above, five prickly-ash plants were cut on 24 May 1987, labelled, and positioned upright in the woodlot amongst other healthy prickly-ash plants. These plants were similar in size to those cut in 1986 (3 to 5 cm diameter at groundline). One of the five test plants was selected for dissection in July, August, and September 1987 to record activity by bark- and wood-infesting insects. The dissection dates were 10 July, 8 August, and 12 September 1987. On these three occasions, two or three sections (30–69 cm long) were cut from the lower trunk of the selected test plant. For the cerambycid larvae observed under the bark, data were recorded on the number of galleries originating from what appeared to be the same oviposition site and the length of each larval gallery. For the scolytine activity observed, the number of entrance holes were counted and later confirmed as active through dissection. The length and diameter of each stem section was recorded so that infestation densities could be calculated based on bark surface area.

For the other two test plants cut in May 1987, trunk and branch sections were cut on 24 April 1988 and placed in a single rearing cage as described above. Again, the rearing cage was checked for newly emerged insects at 1–3-day intervals through July 1988 to estimate seasonal adult emergence. Both wood borers and parasitoids were collected in 1988. To compare spring and early summer temperatures between 1987 and 1988, I calculated degree-day (DD) accumulations using the max + min method with a start date of 1 March and a 10 °C threshold. These calculations were based on historical weather records from Mason, MI (about 8 km west of the study site).

In addition, several of the adult cerambycids reared in 1987 and 1988 were oven-dried to a constant weight, using an analytical balance (Mettler; Toledo, OH). Only adults with no missing body parts (i.e., having all legs and antennae) were used. Dry weight was used as a proxy for borer size. The intraspecific size variation value, I, was calculated as the ratio of the dry weight of the heaviest individual to the dry weight of the lightest individual in a manner similar to

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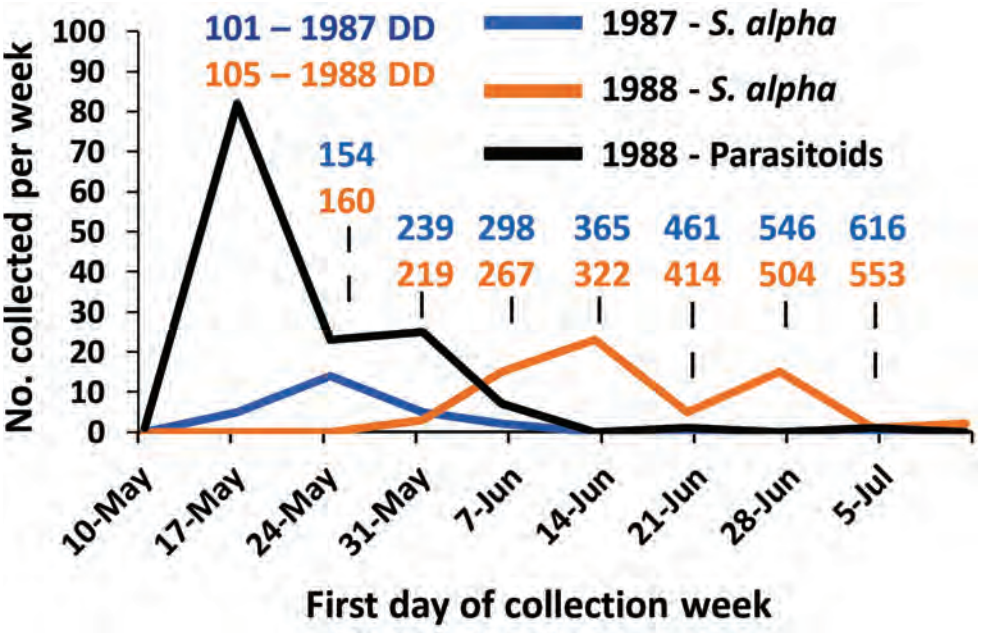

Figure 1. Number of *Sternidius alpha* collected weekly in 1987 and 1988, and number of unidentified braconid parasitoids collected weekly in 1988, from prickly-ash host material cut one year earlier (spring 1986 and 1987) and allowed to undergo natural attack for nearly a year before placement in an outdoor rearing cage. Values above the collection dates from 17 May through 5 July represent the degree-day accumulations in 1987 (top value in blue) and 1988 (bottom value in orange) using the max + min method with a start date of 1 March and a 10° C threshold. See methods for details.

Andersen and Nilssen (1983), who used body length to estimate I in their calculations.

Results

1986–1987 study. The cerambycid beetle *Sternidius alpha* was the only bark- and wood-boring insect that emerged from the caged host material in summer 1987. Overall, 26 adults emerged in 1987, beginning on 17 May, peaking on 24 May, and ending on 6 June (Fig. 1). Based on 19 trunk and branch sections inspected in September 1987, there was an average of 3.1 large exit holes per dm^2 of bark surface area (Table 1). Of the 122 large exit holes counted, all originated from cerambycid galleries that were likely constructed only by *S. alpha* given that was the only cerambycid reared. The average density of small exit or entrance holes on these same 19 trunk and branch samples was 8.5 per dm^2 (Table 1). Of the 325 small exit holes counted, 216 were dissected and of these 19 (9 %) were entrance holes to scolytine galleries and 197 (91 %) appeared as exit holes made by parasitoids of the cerambycids. Unfortunately, the parasitoids in this study were not identified, as was done in Haack (2020, 2021) for other species of woody plants, but notes made during the collections stated that the observed parasitoids were relatively large species of Braconidae (Hymenoptera).

1987–1988 study. For the host material cut in late May 1987, tunneling activity by both *M. suturalis* and *S. alpha* was observed in the July 1987 samples (Table 2). Only one *M. suturalis* gallery system was found in July, located on the middle section of the three trunk sections cut from the test plant. This section represented a portion of the trunk about 40 to 90 cm from groundline. By contrast, *S. alpha* larvae were present in each of the three sampled trunk sections that together represented the lower 1.2 m of trunk. Overall, 55 actively-feeding cerambycid larvae were found in these three sections. All were tunneling in the cambial zone (= phloem + cambium + outer sapwood). The larvae were clearly early instars given that their galleries ranged in length between 0.8 and 4.5 mm. On average, about three cerambycid galleries originated from the same location (range 1-8; Table 2), suggesting that the adult females often laid multiple eggs at the same oviposition site.

Table 1 Mean (±SE) host plant and insect data based on 19 prickly-ash trunk and branch sections from two plants cut in southern Michigan on 19 April 1986 and left in the woodlot to undergo natural attack. Stem sections were examined in September 1987 for larger emergence holes made by the *Sternidius alpha* and smaller holes that were a combination of entrance holes made by the scolytine *Micracis suturalis* and exit holes made by unidentified parasitoids that apparently used *S. alpha* as a host.

Parameter	Mean ± SE	Range
Stem section diameter (cm)	2.3 ± 0.1	1.3–3.3
Stem section length (cm)	28.8 ± 0.9	20.2–36.5
Surface area (dm^2)	2.1 ± 0.1	1.4–2.8
S. alpha exit holes/dm^2	3.1 ± 0.5	0.4–8.2
Small exit or entrance holes/ dm^2	8.5 ± 0.6	2.1–12.6

Larvae and parent adults of *M. suturalis* and larvae of *S. alpha* were present in each of the three trunk sections dissected in August 1987, which represented the lower 1.6 m of trunk. Overall, 23 *M. suturalis* entrance holes (gallery systems) and 387 *S. alpha* larvae were counted in August. Both *M. suturalis* entrance hole density and *S. alpha* larval gallery density were considerably higher in August relative to July (Table 2). Because cerambycid larval feeding was so extensive it was possible only to count the number of galleries per oviposition site and measure lengths of individual galleries in a few areas. The August samples, compared to June, indicated similar numbers of larvae originating per oviposition site (2.7 vs 3.2), but much longer average gallery length (19.7 mm vs 3.0 mm) (Table 2). Only one of the 387 larvae had tunneled into the xylem in the August samples. A subset of the adult scolytines recovered during these and other dissections were identified by Thomas H. Atkinson as *M. suturalis*.

The September 1987 observations were made on two trunk sections, representing the lower 69 cm of the test tree. Evidence of both *M. suturalis* and *S. alpha* was found on both trunk sections. Overall, six *M. suturalis* entrance holes and 194 *S. alpha* larvae were counted in the September samples. The average September and August *M. suturalis* entrance hole density and *S. alpha* larval gallery density values were broadly similar (Table 2). Again, given the near complete consumption of the cambial region by the cerambycid larvae, it was not possible to measure individual larval galleries in the September samples. Of the 194 *S. alpha* larvae found in September, 38 had already tunneled into the xylem (Table 2). A few *M. suturalis* gallery systems were excavated, and they appeared similar to those described for other *Micracis* species (Wood 1982, Noguera-Martinez and Atkinson 1990). In the xylophagous *Micracis*, the male adult initiates gallery construction by tunneling directly into the xylem for a short distance (1–2 annual rings of xylem in *M. suturalis*) where he is usually joined by two females that subsequently construct opposing, longitudinal egg galleries. Eggs are deposited in niches along the gallery walls with the larvae feeding outwards. In September, I observed only *M. suturalis* parent adults and larvae in their galleries. In addition, I did not observe any obvious staining of the sapwood around the *M. suturalis* galleries.

Again, *S. alpha* was the only bark- and wood-boring insect collected in the rearing cage in summer 1988. Overall, 64 cerambycid adults were collected in 1988, beginning on 31 May, peaking on 13 June, and ending on 11 July (Fig. 1). Although not identified to species, parasitoids were counted in 1988 on the same inspection days when the cerambycids were collected. Overall, 140 parasitoids were counted in 1988, with the first recorded on 14 May, peaking on 20 May, and ending on 5 July (Fig. 1). Again, based on notes made during the collections, the parasitoids were species of Braconidae.

The average dry weight of 98 *S. alpha* adults was 1.7 ± 0.1 mg with a range of 0.8 to 3.0 mg. Using these values, the intraspecific size variation value, I, was 3.75 (= 3.0 / 0.8) for *S. alpha*.

Discussion

As with Shimer (1868), the only two species of wood borers that I reared or dissected from prickly-ash were the scolytine *M. suturalis* and the cerambycid *S. alpha*. Shimer (1868) conducted his field work in Mount Carroll, IL, about 470 km west of the present study site near Dansville, MI, and at a similar latitude (42.1° N in IL vs 42.5° in MI). He recovered *M. suturalis* adults from the wood of prickly-ash and noted their

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Table 2. Summary data for *Sternidius alpha* larval galleries and *Micracis suturalis* parent-adult entrance holes from sections of three prickly ash plants cut in a Michigan woodlot on 24 May 1987 and left to undergo natural attack. The lower trunk of one plant per month was cut into two or three sections and dissected on 10 July, 8 August, and 12 September 1987.

	Mean ± SE (range; N)		
Parameter	**July**	**August**	**September**
S. alpha larval gallery density per dm^2 of bark surface area	6.9 ± 1.6 (4.2–9.5; 3 ts*)	27.0 ± 3.8 (20.1–33.3; 3 ts)	20.1 ± 0.2 (21.9–22.2; 2 ts)
Mean number of *S. alpha* larval galleries per oviposition site	3.2 ± 0.6 (1–8; 17 os)	2.7 ± 0.2 (1-6; 41 os)	Not discernible**
Length of *S. alpha* larval galleries in phloem (mm)	3.0 ± 0.1 (0.8–4.5; 29 g)	19.7 ± 1.3 (10–32; 26 g)	Not discernible
% of *S. alpha* larvae in xylem	0 ± 0 (0–0; 3 ts)	0.2 ± 0.2 (0–0.5; 3 ts)	19.3 ± 5.2 (14.1–24.5; 2 ts)
M. suturalis entrance hole density per dm^2 of bark surface area	0.1 ± 0.1 (0–3; 3 ts)	1.3 ± 0.7 (0.4–2.7; 3 ts)	0.9 ± 0.4 (0.5–1.3; 2 ts)
Stem section diameter (cm)	2.0 ± 0.3 (1.4–2.6; 3 ts)	3.1 ± 0.5 (2.5–4.1; 3 ts)	4.1 ± 0.3 (3.8–4.4; 2 ts)

* g = galleries; os = oviposition sites; ts = trunk sections.
** Larval feeding was so extensive and overlapping that it was not possible to discern and measure individual galleries.

galleries were free of frass. In addition, he reported finding both *S. alpha* larvae and pupae in host material in late May, with almost all having transformed to adults and emerged by June, as well as two unidentified species of Ichneumonidae that were associated with *S. alpha* galleries and life stages.

Micracis suturalis is native to much of eastern North America, having been recorded from Texas and Georgia in the south to Michigan, Ontario, and Quebec in the north (Hubbard and Schwarz 1878, MacNay 1957, Atkinson 2023). Although some sources list only eastern redbud (*Cercis canadensis* L., Fabaceae) as a host for *M. suturalis* (Wood 1982, Wood and Bright 1992, Cognato et al. 2009), this species has been reported from many other woody plants in the following families and genera: Annonaceae (*Asemina*), Cornaceae (*Cornus*), Hamamelidaceae (*Liquidambar*), Fabaceae (*Gleditsia* and *Robinia*), Fagaceae (*Quercus*), Juglandaceae (*Carya* and *Juglans*), Lauraceae (*Lindera* and *Sassafras*), Oleaceae (*Fraxinus*), Rutaceae (*Zanthoxylum*), Salicaceae (*Salix*), and Ulmaceae (*Ulmus*) (Shimer 1868; LeConte 1881; Chittenden 1893; Hamilton 1891, 1892; Deyrup 1981; Atkinson 2023).

Micracis suturalis, like many members of the scolytine tribe Micracidini, are considered true xylophages. Both adults and larvae feed directly on the xylem tissues of the host sapwood, but not the heartwood (Kirkendall et al. 2015). These xylophages do not cultivate symbiotic fungi within their galleries, as do true scolytine ambrosia beetles (Hulcr and Stelinski 2017). It is not clear why I did not collect any *M. suturalis* adults in the rearing cages in 1987 and 1988. There are several possibilities. Perhaps there was a hole in the screening of the cages or emerging adults were able to escape directly through

the screening given that *M. suturalis* adults are about 1 mm in width (Wood 1982). However, no holes were ever found, and the mesh aperture was less than 1 mm but not measured exactly. Two, it is possible that the *M. suturalis* adults emerged before I placed the host material in the cage, given that Weber and McPherson (1991) reported capturing *M. suturalis* adults during 20 April to 9 May in window-pane traps in southwestern Illinois. However, I never noticed any scolytine exit holes made by brood adults when the stem sections were first placed in the cage each spring. Three, Chittenden (1893) reported that *M. suturalis* can complete multiple generations in the same host material, so perhaps any *M. suturalis* adults that did emerge soon reinfested the same host material. This could have happened, but again I did not notice any exit holes made by brood adults. And four, possibly *M. suturalis* has a 2-year life cycle, and thus no brood adults were ready to emerge from the host material during the first year after cutting. In the Pennsylvania study by Hamilton (1892), where he caged branches in April 1889 from a hickory (*Carya* sp.) tree that had died the previous year (1888), he reared many specimens of the phloem-feeding (phloeophagous) scolytine *Chramesus hicoriae* LeConte in 1889, but no *M. suturalis* were reared until the following year (May to July 1890). Both *M. suturalis* and *C. hicoriae* are similar in adult size (Wood 1982). Given Hamilton's (1892) observations it is possible that I missed collecting *M. suturalis* brood adults because I did not rear the host material for two years. In addition, I did not dissect the gallery systems completely and look for brood after the first year of rearing, so I cannot comment on whether *M. suturalis* larvae were still feeding in the sapwood. However, during dissections of several prickly-ash branches in September taken from trees cut earlier the same spring, I observed only *M. suturalis* parent adults and larvae in the exposed galleries. Given that sapwood is nutritionally poorer than inner bark (Haack and Slansky 1987, Pallardy 2008), it would not be surprising for *M. suturalis* to have a 2-year life cycle, whereas the phloeophagous scolytine *C. hicoriae* is univoltine. Further study is needed to clarify the generation time of *M. suturalis.*

Sternidius alpha is commonly reared from dead branches of several hardwood tree genera, including *Acer* (Sapindaceae), *Ampelopsis* (Vitaceae), *Carya*, *Castanea* (Fagaceae), *Celastrus* (Celastraceae), *Celtis* (Cannabaceae), *Diospyros* (Ebenaceae), *Juglans*, *Morus* (Moraceae), *Platanus* (Platanaceae), *Quercus*, *Rhus* (Anacardiaceae) and *Robinia* (Shimer 1868, Craighead 1923, Knull 1946, Gosling and Gosling 1976, Rice and Enns 1981, Gosling 1984, Lewis 1986). Its native range includes most of eastern North America, with some reports from as far west as California (Lewis 1986). Members of *Sternidius* have very high intraspecific variability in coloration, which has led to many taxonomic changes and synonymies (Dillon 1956, Lewis 1986, Linsley and Chemsak 1995). At times, *Sternidius* has been assigned to five other genera: *Amniscus*, *Lamia*, *Leiopus*, *Liopinus*, and *Liopus* (Lewis 1986, Linsley and Chemsak 1995, Bezark 2019). Shimer (1868) named the cerambycids he reared from prickly-ash *Liopus xanthoxyli* Shimer, which Lewis (1986) considered a synonym of *Sternidius fascicularis* (Harris), whereas Bezark (2019) considered it a synonym of *S. alpha*. At the time when the beetles reared in the present study were confirmed (1987-1991), the two experts who viewed several specimens (John A. Chemsak and David C. L Gosling), both acknowledged the taxonomic confusion within the genus but determined the specimens as *S. alpha*.

When comparing emergence of *S. alpha* between the two years in this study, peak emergence occurred a few weeks earlier in 1987 than in 1988 (Fig. 1). This difference could simply reflect that the test trees were cut more than a month earlier in 1986 (19 April) than in 1987 (24 May), and thus oviposition and larval development could have started earlier in 1986. Another possibility is that spring and early summer temperatures were warmer in 1987 than 1988, which would result in earlier pupation and adult emergence in 1987. However, this seems unlikely because historical weather records from nearby Mason, MI, indicated that degree-day accumulations were similar through 24 May in both years (154 DD in 1987 vs 160 DD in 1988), which is the time when peak emergence of *S. alpha* occurred in 1987 (Fig. 1).

Although the parasitoids observed in this study were not identified, two braconid wasps have been reported from *S. alpha*: *Cenocoelius ashmeadii* Dalla Torre and *Heterospilus liopodis* (Brues) (Marsh 1979). In a similar study where I reared borers and parasitoids from yellow birch branches (*Betula alleghaniensis* Britton) in the same woodlot (Haack 2021), both *S. alpha* and an unidentified species of *Cenocoelius* (Braconidae) were reared from the same branches. The only parasitoid listed in Krombein et al. (1979) as using an eastern *Micracis* species as a host was the braconid *Ecphylus pallidus* Ashmead (Marsh 1965). Notes made on the size of the parasitoids reared in the present study and during branch dissections suggest that they were associated with the cerambycid *S. alpha*, not *M. suturalis***.**

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Andersen and Nilssen (1983) reported that intraspecific size variation based on body length (I) was generally greater in Coleoptera that develop in woody tissues compared to those that are free-living. Grouping species at the family or subfamily level, they presented median I values of 1.1 to 1.4 for most free-living groups, with the highest median I value of 2.1 for wood borers of the cerambycid subfamily Spondylidinae. For individual species the highest I value was 3.3 for each of two Cerambycinae cerambycids (Andersen and Nilssen 1983). As for *S. alpha*, an I value of 1.9 can be calculated from the adult length measurements (4.3 to 8.2 mm) given by Lewis (1986), but a much higher I value (3.75) results from the dry weight data presented in the current study (0.8 to 3.0 mg). However, given that length is a one-dimensional measure, whereas body weight reflects a three dimensional form, a fairer comparison would be to use the third root of 3.75, which is 1.55. Nevertheless, such wide variation in adult body size of wood-boring insects likely reflects the large differences in nutritional quality and quantity of hosts tissues encountered as the larvae develop (Andersen and Nilssen 1983, Haack and Slansky 1987, Shibata 1998, Torres-Vila et al. 2018).

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Literature Cited

Andersen, J. and A. C. Nilssen. 1983. Intrapopulation size variation of free-living and tree-boring Coleoptera. The Canadian Entomologist 115: 1453–1464.

Andrews, A. W. 1916. Results of the Mershon Expedition to the Charity Islands, Lake Huron: Coleoptera. p. 65-108 in Miscellaneous Papers on the Zoology of Michigan. Michigan Geological and Biological Survey Publication 20.

Atkinson, T. H. 2023. Bark and ambrosia beetles of the Americas. Available from http://www.barkbeetles.info.

Bezark, L. G. 2019. New World Cerambycidae catalog. Available from http://bezbycids.com

Blatchley, W. S., and C. W. Leng. 1916.Rhynchophora or weevils of north eastern America. Nature Publishing Company, Indianapolis, IN.

Chittenden, F. H. 1893. Biologic notes on some species of Scolytidae. Proceedings of the Entomological Society of Washington 2: 391–395.

Cognato, A. I., N. Barc, M. Philip, R. Mech, A. D. Smith, E. Galbraith, A. J. Storer, and L. R. Kirkendall. 2009. The native and introduced bark and ambrosia beetles of Michigan (Coleoptera: Curculionidae, Scolytinae). The Great Lakes Entomologist 42: 101–120.

Cohen, J. G. 2008. Natural community abstract for mesic southern forest. Michigan Natural Features Inventory, Lansing, MI. 12 pp. Available from https://web.archive.org/web/20090105155916/http://web4.msue.msu.edu/mnfi/abstracts/ecology/Mesic_southern_forest.pdf

Craighead, F. C. 1923. North American cerambycid larvae. A classification and the biology of North American cerambycid larvae. Canadian Department of Agriculture, Bulletin 27 (new series), Ottawa.

Deyrup, M. A. 1981. Annotated list of Indiana Scolytidae (Coleoptera). The Great Lakes Entomologist 14: 1–9.

Dillon, L. S. 1956. The Nearctic components of the tribe Acanthocinini (Coleoptera: Cerambycidae). Part II. Annals of the Entomological Society of America 49: 207–235.

Ehrle, E. B. 2006. The big trees and shrubs of Michigan. The Michigan Botanist 45: 65–152.

Fish, F., and P. G. Waterman. 1973. Chemosystematics in the Rutaceae II. The chemosystematics of the *Zanthoxylum/Fagara* complex. Taxon 22: 177–203.

Gosling, D. C. L. 1984. Cerambycid host plants in a southwestern Michigan woodland (Coleoptera: Cerambycidae). The Great Lakes Entomologist 17: 69–78.

Gosling, D. C. L., and N. M. Gosling. 1976. An annotated list of the Cerambycidae of Michigan. Part II, the subfamilies Lepturinae and Lamiinae. The Great Lakes Entomologist 10: 1–37.

Haack, R. A. 2020. Bark- and wood-infesting Coleoptera and associated parasitoids reared from shagbark hickory (*Carya ovata*) and slippery elm (*Ulmus rubra*) in Ingham County, Michigan. The Great Lakes Entomologist 53: 185–191.

Haack, R. A. 2021. Bark- and wood-infesting insects (Coleoptera and Hymenoptera) and associated parasitoids reared from yellow

birch (*Betula alleghaniensis*) in Ingham County, Michigan. The Great Lakes Entomologist 54: 58–63.

Haack, R. A. and F. Slansky. 1987. Nutritional ecology of wood-feeding Coleoptera, Lepidoptera, and Hymenoptera, pp. 449-486. In: F. Slansky and J. G. Rodriguez (eds.), Nutritional ecology of insects, mites, spiders and related invertebrates. John Wiley, New York.

Hamilton, J. 1891. Notes on Coleoptera–No. 7. The Canadian Entomologist 23: 60–65.

Hamilton, J. 1892. Biological notes on *Micracis*, *Chramesus*, and *Coscinoptera*. Insect Life 4: 268.

Hubbard, H. G. and E. A. Schwarz. 1878. The Coleoptera of Michigan. Proceedings of the American Philosophical Society 17: 593–669.

Hulcr, J., and L. L. Stelinski. 2017. The ambrosia symbiosis: from evolutionary ecology to practical management. Annual Review of Entomology 62: 285–303.

Kirkendall, L. R., P. H. W. Biedermann, and B. H. Jordal. 2015. Evolution and diversity of bark and ambrosia beetles, pp. 85–156. In: F. E. Vega and R. W. Hofstetter (eds.), Bark beetles: biology and ecology of native and invasive species. Academic Press, London.

Knull, J. N. 1946. The long-horned beetles of Ohio (Coleoptera: Cerambycidae). Ohio Biological Survey Bulletin 39: 133–354.

Krombein, K. V., P. V. Hurd, Jr., D. R. Smith, and B. D. Burks. 1979. Catalog of the Hymenoptera in America North of Mexico. Smithsonian Institution Press, Washington, D.C.

LeConte, J. L. 1881. Notes of synonyms and habits of Coleoptera. Proceedings of the Monthly Meetings of the Entomological Section of the Academy of Natural Sciences, Philadelphia. 9: xxi–xxii.

Lewis, A. E. 1986. The *Sternidius* of America north of Mexico (Coleoptera: Cerambycidae). The Pan-Pacific Entomologist 62: 171–202.

Linsley, E. G., and J. A. Chemsak. 1995. The Cerambycidae of North America, Part VII, No. 2. Taxonomy and classification of the subfamily Lamiinae, tribes Acanthocinini through Hemilophini. University of California Publications in Entomology 114: 1–292.

Little, E. L. 1979. Checklist of United States trees (native and naturalized). USDA Forest Service, Agriculture Handbook AH-541.

MacNay, C. G. 1957. Insects of potential economic importance new to Canada, 1954: a review. The Canadian Entomologist 89: 140–144.

Marsh, P. M. 1965. The Nearctic Doryctinae. I. A review of the subfamily with a taxonomic revision of the tribe Hecabolini (Hymenoptera: Braconidae). Annals of the Entomological Society of America 58: 668–699.

Marsh, P. M. 1979. Braconidae, pp. 144–215. In: K. V. Krombein, P. D. Hurd, D. R. Smith, and B. D. Burks (eds). Catalog of the Hymenoptera in America North of Mexico. Vol. 1. Smithsonian Institution Press, Washington, D.C.

McKenzie, H. L. 1956. The armored scale insects of California. Bulletin of the California Insect Survey 5: 1–209.

Mertins, J. W., H. C. Coppel, and L. J. Bayer. 1973. A preliminary list of the chewing and sucking insects attacking prickly-ash in Wisconsin. University of Wisconsin Forestry Research Notes 167. 6 pp.

Noguera-Martinez, F. A., and T. H. Atkinson. 1990. Biogeography and biology of bark and ambrosia beetles (Coleoptera: Scolytidae and Platypodidae) of a mesic montane forest in Mexico, with an annotated checklist of species. Annals of the Entomological Society of America 83: 453–466.

Ombito, J. O. 2021. Phytochemistry and pharmacology of the Genus *Zanthoxylum* (Rutaceae): A Review. The Natural Products Journal 11: 21–43.

Packard, A. S. 1890. Insects injurious to the prickly ash, *Zanthoxylum americanum,* pp. 659–663. in: Fifth report of the United States Entomological Commission: being a revised and enlarged edition of Bulletin No. 7, on insects injurious to forest and shade trees. US Department of Agriculture, Washington, D.C.

Pallardy, S. G. 2008. Physiology of woody plants, 3rd ed. Academic Press, San Diego, CA.

Pierce, W. D. 1907. Contributions to the knowledge of Rhynchophora. Entomological News 18: 379–385.

Porter, D. M. 1976. *Zanthoxylum* (Rutaceae) in North America north of Mexico. Brittonia 28: 443–447.

Reinartz, J. A., and J. W. Popp. 1987. Structure of clones of northern prickly ash (*Xanthoxylum americanum*). American Journal of Botany 74: 415–428.

Rice, M. E. and W. R. Enns. 1981. The longhorn beetle subfamily Lamiinae (Coleoptera: Cerambycidae) in Missouri. Transactions of the Missouri Academy of Science 15: 89–109.

Rosendahl, C. O. 1955. Trees and shrubs of the upper Midwest. University of Minnesota Press, Minneapolis, MN.

Ruesink, W. G., G. L. Parsons, and R. A. Haack. 2023. Beetles of Michigan. Available from http://beetlesofmichigan.org/

Shibata, E. I. 1998. Effects of Japanese cedar inner bark nutritional quality on development of *Semanotus japonicus* (Coleoptera: Cerambycidae). Environmental Entomology 27*:* 1431–1436.

Shimer, H. 1868. Notes on insects bred from prickly ash, (*Xanthoxylum americanum*). Transactions of the American Entomological Society. 2: vii-viii.

Su, H. C. F. 1984. Biological activity of *Zanthoxylum alatum* to four species of stored-product insects. Journal of the Georgia Entomological Society 19: 462–469.

Torres-Vila, L. M., F. J. Mendiola-Díazand, and Á. Sánchez-González. 2018. Adult size and sex ratio variation of *Cerambyx welensii* (Coleoptera: Cerambycidae) in Mediterranean oak (Fagaceae) woodlands. The Canadian Entomologist 150: 334–346.

Weber, B. C., and J. E. McPherson. 1991. Seasonal flight patterns of Scolytidae (Coleoptera) in black-walnut plantations in North-Carolina and Illinois. Coleopterists Bulletin 45: 45–56.

Wood, S. L. 1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs 6: 1–1359.

Wood, S. L. and D. E. Bright. 1992. Hosts of Scolytidae and Platypodidae, pp. 1241–1348. In: A catalog of the Scolytidae and Platypodidae (Coleoptera). Part 2: Taxonomic index. Great Basin Naturalist Memoirs 13.