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Abstract

Horned powder-post beetles (Coleoptera: Bostrichidae) are a geographically widespread family of wood-boring beetles. While members of this family represent important grain pests, are often intercepted in ports, and may play an important role in ecosystem processes, little work has investigated bostrichid life history in their native ranges. This gap limits our ability to assess ecosystem services and invasiveness. Three native species, *Amphicerus bicaudatus* (Say), *Scobicia bidentata* (Horn), and *Xylobiops basilaris* (Say), are commonly found in savannas in Northern Illinois. Although little is currently known about the life history of *S. bidentata, A. bicaudatus* and *X. basilaris* can be minor pests of fruits and wood products. Over two years, we used field and laboratory methods to investigate characteristics of phenology, reproduction, and host use. We found that all three species are attracted to ethanol (stressed plants) in the spring but not in the fall, despite known adult activity. Initial catch of *A. bicaudatus* likely corresponds to an increase in early spring temperature over 18 °C. *S. bidentata* and *X. basilaris* catch occurs in late spring and is not dependent on temperature thresholds, but probably occurs after additional development. Of the 7 common woody plants found in the savanna, female *A. bicaudatus* demonstrated a significant preference for black oak (*Quercus velutina*) twigs in choice assays and *S. bidentata* showed similar preferences. This study is the first to report factors influencing emergence and host choice in native Midwestern Bostrichidae, information that may increase understanding of the life history of this little-studied group.

Keywords: Horned powderpost beetle, Phenology, Host Choice, Eggs, *Amphicerus bicaudatus*, *Scobicia bidentata*, *Xylobiops basilaris*

Bostrichidae (Coleoptera) is a little-studied family of 564 described species of wood-boring beetles with a worldwide distribution (Liu and Schonitzer 2011; Borowski 2020, 2021). Seventy-seven of these species, from twenty-six genera, are native to North America (Edde 2012; Borowski 2020, 2021). Bostrichid adults can cause damage to woody plants due to feeding on live twigs (Solomon 1995). While larvae are typically xylophagous generalists on the dead wood, with eggs laid on a wide range of woody plants (Lesne 1911), some species in the tropics exhibit preferences for bamboo (Lesne 1911).

Little is known about the biology and natural history of most species of Bostrichidae as they are generally considered of little economic importance, despite being a potentially damaging wood borer. Most damage to live trees is caused by adult, not larval, feeding, unlike more well known and destructive wood boring beetle clades (e.g., Cerambycidae, Buprestidae, Scolytinae) (Liu et al. 2008). Two species, the larger grain borer, *Prostephanus truncatus* (Horn), and the lesser grain borer, *Rhyzopertha dominica* (Fabricius), are serious pests of stored cereals outside their native tropical ranges (Scholz et al. 1997, Bashir 2002, Edde and Phillips 2006a, Quellhorst et al. 2021). However, the ecology and life history of even these species are little understood in natural environments in the Midwest (Nansen and Meikle 2002, Edde et al. 2006, Edde 2012). In temperate climates *P. truncatus* and *R. dominica* are dependent upon the artificial environments of grain storage facilities and therefore are of little help in understanding phenology and activity patterns of temperate native species (Fields et al. 1993).

With few studies of native bostrichid biology, our ability to understand the ecological contributions and potential economic impacts of this family is limited. Ecologically, bostrichids likely aid in carbon cycling by causing branch dieback and by accelerating wood decomposition (Lesne 1911, Hesler et al. 2007). Additionally, larval bostrichids may provide food for woodpeckers and vacated tunnels provide nesting sites for bees (Rozen and Go 2015). From an economic perspective, insufficient attention paid to wood boring beetles able to infest lumber and vector plant pathogens (e.g., *Geosmithia morbida*) (Chahal et al. 2019), increases the potential for unforeseen impacts to the silviculture and wood products industries should these insects be introduced outside their native range. Indeed, Haack (2006) reported nearly twice as many Bostrichidae intercepted at US ports of entry than the more well-known and better studied Buprestidae.

Native North American bostrichids are commonly found as bycatch in pheromone baited surveys for *P. truncatus* and *R. dominica,* and in ethanol baited surveys, which simulate stressed trees, for bark and wood-boring beetles (Edde and Phillips 2006b). Three species of bostrichids are often found in ethanol baited traps in Northern Illinois and Indiana where our study occurred; *Amphicerus bicaudatus* (Say)*, Xylobiops basilaris* (Say) and *Scobicia bidentata* (Horn) (Williams and Ginzel 2020, Schnepp et al. 2021; D. Rosenberger pers. obs.). *Amphicerus bicaudatus*, known as the grape cane borer or apple twig borer, is a minor pest of grapes and apples in its native range of eastern and central North America. *Xylobiops basilaris,* the red-shouldered bostrichid, is a pest of trees and wood products, with adults girdling branches during oviposition and larval tunneling compromising wood products (Solomon 1995, Beiriger and Sites 1996, Rozen and Go 2015). Finally, to our knowledge, no studies have focused on *S. bidentata*, although it has been reported infesting a variety of hardwoods, such as oak, hackberry, and sassafras (Schaffner 1953).

Habitat preferences of these insects are not known, however, in Northeastern Illinois, *A. bicaudatus* and *S. bidentata* have been found to be abundant in dry sand savannas (D.W. Rosenberger, unpublished data). Oak savannas are endangered ecosystems in the Midwestern United States that have been reduced to less than 0.02% their original area (Nuzzo 1986). In Northeastern Illinois, dry sand savannas are maintained by frequent fires and dominated by black oaks (*Quercus velutina* Lam.) (Fagales: Fagaceae) sparsely distributed among grasses, forbs, and woody shrubs such as sumacs (*Rhus* spp.) and sassafras (*Sassafras albidum* Nutt.) (Laurales: Lauraceae) (Curtis 1959, Alkazoff 2022). European bostrichids have also been found in savannas (Cardenas et al. 2020).

With so little systematic work done on the life history of these three native bostrichids or other species in this family, we sought to investigate two primary questions. First, when do these beetles emerge or become active in spring in the Midwest, and what stimulates emergence? Previous work suggests *A. bicaudatus* is active in early spring, having overwintered as adults (Beiriger et al. 1988, Williams and Norton 2012). *Xylobiops basilaris* typically overwinter as late instar larvae, suggesting a later emergence period (Solomon 1995). *Scobicia bidentata* overwintering biology and emergence have not been assessed to our knowledge. Second, we asked if adult *A. bicaudatus* and *S. bidentata,* the two most abundant species found at our black oak savanna study sites (D. Rosenberger, unpublished data), display host choice preferences during spring catch. Adult maturation feeding by bostrichids can cause damage to stems of live plants (Hesler et al. 2007). Previous work suggests that *A. bicaudatus* may exhibit host preferences for adult feeding in the fall prior to overwintering (Williams and Norton, 2012). If preferences do occur, this could impact habitat use and abundance.

Methods

Phenology. To determine when adult beetles are attracted to ethanol traps, we used modified bottle traps (Steininger et al. 2015) equipped with ethanol lures (AlphaScents, Inc., Canby, OR, United States) to capture beetles in 2020 and 2022. Sites were located at the Pembroke Savanna Nature Preserve in The Nature Conservancy's Kankakee Sands macro-site (41.076107, –87.639673) near Hopkins Park in Northeastern Illinois, United States. Habitat was black oak sand savanna with limited canopy cover composed of black oak (*Q. velutina*). In 2020, six traps were set approximately 150 m apart along a transect, one meter above the ground on a garden pole. Trap contents were collected weekly from 1 April–1 July. In 2022, ten traps were used, and contents were collected weekly from 5 March–13 October. Beetles were stored in 70% ethanol.

Temperature data was obtained from nearby NOAA database weather stations (NOAA 2022). We used field-based emergence data to estimate cumulative degree day models (Haavik et al. 2013). We created degree-day models beginning at 1 January with a conservative 10 °C lower development threshold (Garcia and Morrell 2009) to determine whether heat accumulation rather than temperature peaks might explain emergence.

Host Choice Assays. To determine if *A. bicaudatus* and *S. bidentata* adults displayed host preferences, we added eighteen additional traps baited with ethanol in 2022 to capture live beetles. These traps were placed in a separate section of the preserve from phenology traps. Collecting containers on traps were filled with shredded plastic (Easter grass) to reduce drowning and inter-

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actions with other captured insects. To maximize survivorship, beetles were collected two or three times per week during the trapping season and used immediately in assays. Some assays were conducted simultaneously due to timing of beetle availability.

Each assay was composed of seven twigs, one from each of the seven most abundant woody plant species observed at the Pembroke Savanna Nature Preserve. These included autumn olive (*Elaeagnus umbellate* Thunb.) (Rosales: Elaeagnaceae), black oak (*Q. velutina*), bramble (*Rubus sp.*) (Rosales: Rosaceae), shining sumac (*Rhus copallinum* L.) (Sapindales: Anacardiaceae), smooth sumac (*Rhus glabra* L.)(Sapindales: Anacardiaceae), grape (*Vitis riparia* Michx.) (Rhamnales: Vitaceae), and sassafras (*S. albidum*) (Alkazoff 2022). The twigs were 15–20 cm long and 0.33–1.25 cm diameter and were cut from live stems immediately before use. Twigs were placed upright in a 2.5L glass container covered with a window screen mesh. Between fifteen and twenty live beetles were placed in each container. The container was kept in a greenhouse at nearby Olivet Nazarene University in Bourbonnais, IL. Assays were checked after 12, 24, 48, and 72 hours for number of beetles on each twig species and for number of beetles bored into each species. A search was also performed for eggs anywhere on the stems. Eight separate assays were planned for both *A. bicaudatus* and *S. bidentata*. However, due to fewer beetles than expected during the short flight season, only three assays were completed for *S. bidentata*. No host choice assays were performed for *X. basilaris* due to insufficient abundance.

Sex, size, and egg number. To determine sex of *A. bicaudatus,* we dissected beetles captured in phenology traps each year under a dissecting microscope. Since little is known about the reproductive potential of bostrichids, eggs were counted. We observed a large variation in size between individuals of *A. bicaudatus,* as appears common in bostrichids (Beiriger and Sites 1996). To determine if size relates to fitness, we compared female elytra length (as a proxy for body size) with the number of eggs contained in the female's abdomen. *Amphicerus bicaudatus* was the only species for which eggs were counted, due to insufficient numbers of other species and difficulty in differentiating eggs from other internal structures in those species.

Data Analysis. Data analysis was performed in R version 4.2.1 (R Core Team 2022). The role of plant species on beetle location and feeding was analyzed using a linear mixed effects model (Pinheiro et al. 2022 (R package nlme)). Location analysis used data from 12 and 24 hours, using check time as a fixed effect as beetles appeared to be actively moving during both time points. Our multivariate mixed effects model to assess beetle location choice included stem diameter, check time, and species as fixed effects analyzed sequentially with assay as a random effect and number of beetles on a stem as the response variable. Mixed effects models were similarly used to assess immediate number of beetles feeding at 12 hours. However, stem size was not a significant factor and thus not included in this analysis. These models used only 12–hour boring data in order to assess immediate decisions. Means were compared between host species using Tukey post-hoc tests (Hothorn et al. 2008 (R package multcomp)). Residuals were checked visually for model assumptions of homoscedasticity and normality of errors. To fit these assumptions, models required square root transformation of number of beetles for both models. To analyze size and egg number, simple linear regression was used for each year.

Results

Abundance. Only three species of bostrichids were caught in our ethanol traps: *A. bicaudatus, S. bidentata,* and *X. basilaris.* No known parasites or predators were identified from the traps. In 2020, both *A. bicaudatus* and *S. bidentata* were similarly abundant, with a total of 422 *A. bicaudatus* and 426 *S. bidentata* collected in 6 phenology traps, but no *X. basilaris*. In 2022 however, relative abundance differed between *A. bicaudatus* and *S. bidentata* with 156 *A. bicaudatus*, 24 *S. bidentata*, and 12 *Xylobiops basilaris* captured in 10 traps. Peak abundance also differed between years, with an average of 35.6 *A. bicaudatus* per trap per week in 2020 (Fig.1), but only 11.7 beetles per trap in 2022 (Fig. 2). *Scobicia bidentata* peaked at 22.2 beetles per trap per week in 2020 (Fig.1) and two beetles per trap in 2022 (Fig.2).

Phenology. Ethanol traps captured beetles only in spring, with no beetles captured July-October. *Amphicerus bicaudatus* was first to be captured in both years, followed by both *S. bidentata* and *X. basilaris* (Fig. 1). *Amphicerus bicaudatus* catch began in early April in 2020 (Fig. 1) but in late April in 2022 (Fig. 2). Peak *A. bicaudatus* catch in both years was in early May (Fig. 1). *Scobicia bidentata* catch began in late May in 2020 and mid-May in 2022 (Fig. 1). In 2020, peak catch occurred in early June, two weeks after first catch (Fig. 1). In 2022, peak catch occurred in late May, only one week after initial catch (Fig. 2). *Xylobiops basilaris* was not caught in 2020 but was

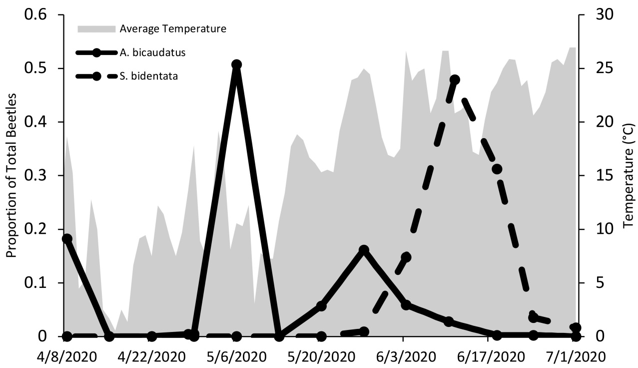

Figure 1. Proportion of total number of individuals caught per date in spring and early summer in 2020.

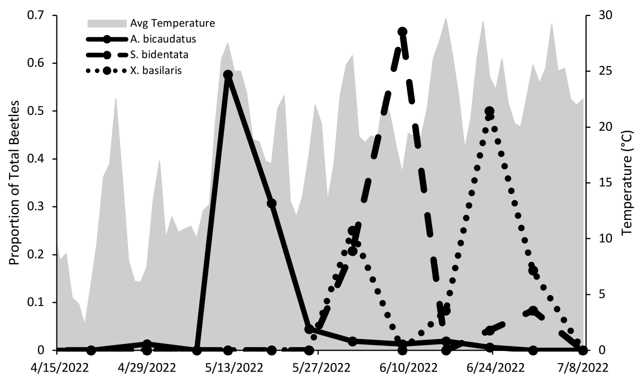

Figure 2. Proportion of total number of individuals caught per date in spring and early summer in 2022.

caught in 2022. Catch began in late May and peaked in mid-June (Fig. 1).

Phenology and Temperature. We compared weekly beetle catch peaks with average daily temperature to determine if temperature peaks might explain beetle emergence. *Amphicerus bicaudatus* catch correspond with early spikes in average daily temperature above 18 °C, with termination of activity during intermediate cooler periods (Fig. 1). However, *S. bidentata* and *X. basilaris* catch did not correspond with any daily temperature peaks that had not already occurred (Fig. 1). In 2020, initial catch of *A. bicaudatus* corresponded to the first daily average daily temperature of 18 °C (Fig. 1). Additional catches during the year correspond only to sampling periods that include at least one day with an average daily temperature above 18 °C (Fig. 1). Similarly, the first *A. bicaudatus* catch in 2022 corresponded with a temperature spike reaching 22.5 °C (Fig. 2) during the sampling period and no catches occurred in weeks with temperatures below 18 °C (Fig. 2).

While development degree-day models are most accurately determined in controlled experiments, field estimates can be obtained by observing overlapping ranges of accumulated degree-days to emergence across multiple locations or years. Degree-day models did not contain overlapping ranges for initial catch or 50% emergence between years for *A. bicaudatus* but did for *S. bidentata* (Fig. 3). *Scobicia bidentata* were first attracted to ethanol between 110 and 190 degree-days in 2020 and between 190 and 230 degree-days in 2022. In 2020, 50% emergence of *S. bidentata* occurred between 260 and 370 degree-days and between 230 and 305 degree-days in 2022 (Fig. 3).

Host Choice Assays. In adult host choice assays, location of *A. bicaudatus* in the enclosure was significantly affected by twig species ($F = 5.98$; df = 6, 94; $P < 0.0001$) and diameter ($F = 16.55$; df = 1, 94; $P < 0.0001$), but not by check time ($F = 0.445$; df = 1, 94; $P = 0.51$) in a multivariate mixed effects model. Black oak was the most attractive species and bramble the least (Fig. 4a). Similarly, in the feeding assay after 12 hours, twig species had a significant effect on boring ($F = 3.42$; df = 6, 41; $P = 0.0078$), with black oak being most preferred (Fig. 4b).

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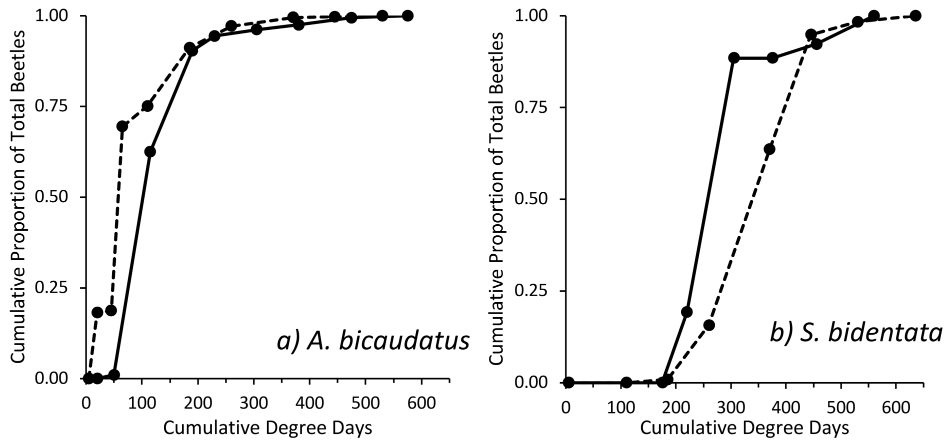

Figure 3. Cumulative proportion of total *A. bicaudatus* and *S. bidentata* collected from ethanol traps by degree days accumulated above a 10 °C threshold. Collections were made once a week over the course of emergence. 2020 totals are denoted in dashed lines, and 2022 with solid lines.

Due to low abundance of *S. bidentata*, with 45 total live beetles collected, only three of the eight intended host choice assays with *S. bidentata* were completed. Statistical analysis was not completed due to low replication, but these initial observations suggest *S. bidentata* may also demonstrate a preference for black oak in free-choice assays for location and feeding (Table 1).

Sex, size, and egg number. Dissection of 595 *A. bicaudatus* collected in 2020 and 2022 showed that 98.8% of *A. bicaudatus* captured in our ethanol traps were females. Total eggs per female ranged from 0–65, with the average number remaining stable until declining at the end of the trapping season (Table 2). There was a significant positive correlation between elytra length and number of eggs contained in the abdomen in both 2020 ($F = 130.66$; df = 1, 476; $P < 0.0001$) (Residual mean-squared error = 9.41) and 2022 ($F = 43.92$; df = 1, 108; $P < 0.0001$) (Residual mean-squared error = 8.85) (Fig. 5).

Discussion

This study provides a foundation for better understanding activity patterns and host use of both common (*A. bicaudatus* and *X. basilaris)* and uncommon *(S. bidentata)* species of Bostrichidae found in central and eastern North America. Our primary find-

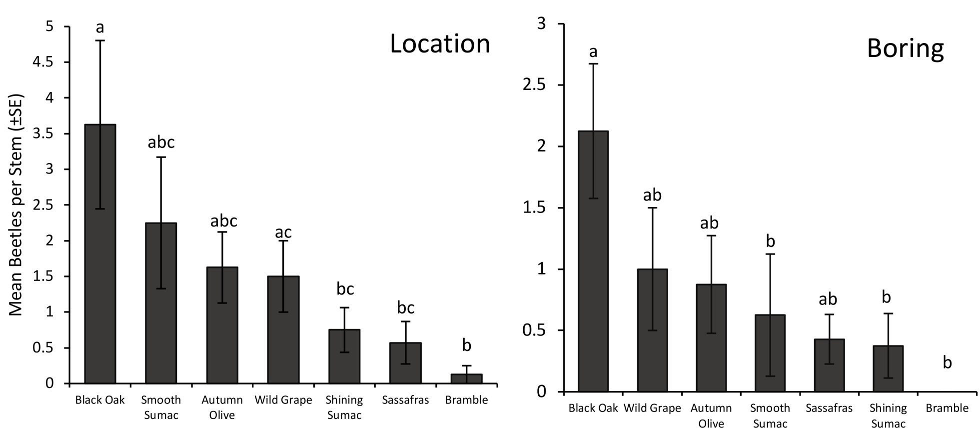

Figure 4. Mean beetles (±SE) located on (a) and bored into (b) each stem in free-choice assays. Categories with the same letter label were not significantly different (P > 0.05) in Tukey post-hoc tests. All bars are from stems checked after 12 and 24 hours since there was no effect of check time on location. Standard error bars are included.

Table 1. Mean number of *S. bidentata* per stem for both location and boring.

	Location			Boring		
Species	**12hr**	**24hr**	**48hr**	**12hr**	**24hr**	**48hr**
Autumn Olive	1.00	1.67	1.00	0.00	1.00	0.33
Black Oak	2.00	2.00	2.00	0.33	1.67	1.67
Bramble	1.67	0.67	1.00	0.33	0.33	0.00
Sassafras	0.00	0.67	0.00	0.00	0.33	0.00
Shining Sumac	0.33	0.00	0.33	0.00	0.00	0.00
Smooth Sumac	0.00	0.67	1.00	0.00	0.67	0.33
Wild Grape	0.67	0.33	0.00	0.00	0.00	0.00

Table 2. Eggs per *A. bicaudatus* through the trapping season.

Date	N	Avg. (SD) Eggs per female	Min-Max
2020			
April–early	112	21.3 (7.5)	3–41
May–early	234	25.1 (10.6)	3–65
May–mid	23	22.0 (9.2)	3–43
May–late	71	23.4 (12.3)	3–49
June–early	34	14.0 (11.4)	0–43
2022			
May–mid	96	16.0 (10.3)	0–58
May–late	10	15.8 (12.4)	1–38
June–early	4	4.0 (6.1)	0–13

ings suggest that the period when beetles are attracted to ethanol lures, which may indicate attraction to stressed trees, occurs only in spring and differs among species, and that bostrichids can demonstrate host preferences during spring flight when damage to live plants generally occurs. Knowledge of flight time and host preferences provide a foundation for understanding ecological interactions and economic concerns. Additionally, the location of this study in a Midwestern black oak savanna, an ecosystem of conservation concern with little previous entomological investigation, further enhances the value of this work.

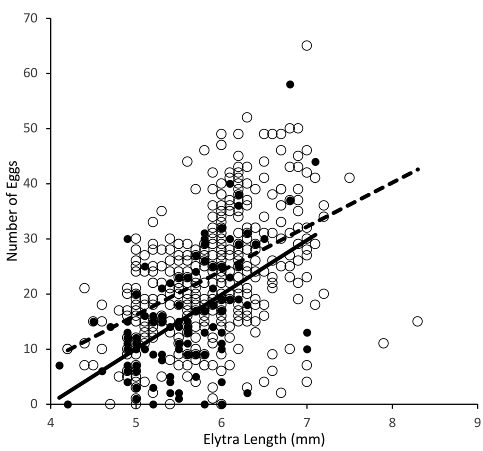

Figure 5. Relationship between elytra length and number of eggs in the abdomen in 2020 (open circles, dashed line) (y = 8.004x–23.831) and 2022 (solid circles, solid line) (y = 9.854x–39.224).

Xylobiops basilaris. *Xylobiops basilaris* is the most well documented of the three species observed, being commonly found as bycatch or a nontarget species (Werle et al. 2012, Miller et al. 2020, Williams and Ginzel 2020). This beetle is widespread in the Midwest, being found at all 6 sites investigated by Schnepp et al. (2021) across Indiana (by comparison, *A. bicaudatus* and *S. bidentata* were found at just 2 and 1 sites, respectively). Why it was not abundant in our study is unclear. However, most other studies are done in woodland areas rather than savanna, suggesting differences in habitat preference among these species. More detailed phenology and life history information is needed however, particularly in light of its destructive capacity (St. George 1941). While low numbers were captured in our study, we observed adult catch in late rather than early spring (Fig. 2), but not after June. This supports previous observations of overwintering as larvae, which would then require additional development in spring prior to emergence (Solomon 1995). Others however have reported abundant captures of *X. basilaris* in both spring and summer (after 24 June) in Indiana (Williams and Ginzel, 2020) and even in late summer and fall in Tennessee (Chahal et al. 2019), supporting a more complex life cycle, perhaps influenced by climate and in need of further investigation.

Attraction to ethanol lures is consistent with seeking stressed host material. A variety of studies have found *X. basilaris* in ethanol traps set for scolytines (Chahal et al. 2019, Miller et al. 2020, Williams and Ginzel 2020). Since *X. basilaris* is known to girdle live stems while laying eggs in the sapwood, attraction to ethanol traps in this species may occur at a time of female host seeking (St. George 1941). While we were not able to investigate host attraction, according to Fisher (1950), *X. basilaris* has been reared from a wide range of hosts, including oak (*Quercus* sp.) and grape (*Vitis* sp.), two species prevalent in our study area.

Catch periods. Amphicerus bicaudatus. The adult flight period of *A. bicaudatus* has been reported previously by Beiriger et al. (1988) in Texas and Hesler et al. (2007) in New York. These authors report a univoltine life cycle (differing from that of *P. truncatus* and *R. dominica*) with fall emergence of adult *A. bicaudatus* from stems of larval host material. *Amphicerus bicaudatus* has not been reported to lay eggs in the fall, but instead finds a new location to overwinter as an adult, individually or in pairs, often in live twigs, although some larvae may overwinter in more northern areas (Solomon 1995, Hesler et al. 2007, Williams and Norton 2012). Despite Williams and Norton (2012) only observing overwintering adults in live tamarisk stems in the Great Plains, we did not observe *A. bicaudatus* in ethanol baited traps during the fall in Illinois, suggesting that the insects may not use host stress cues (ethanol) to identify hosts for overwintering.

What stimulates spring emergence is unclear, but Beiriger et al. (1988) suggested that when 25–30 growing degree days accumulate over base 10 °C for 3–4 days, a flush of emergence occurs. It is unknown whether attraction to stressed hosts occurs immediately upon emergence. Our ethanol trap data did not demonstrate consistent trends in a field based cumulative degree-days model (Fig. 3), but found that, across two years, trapping consistently required a warm spring day with an average temperature over 18 °C (Fig. 1, 2). Emergence during early warm spring days were similarly observed by Hesler et al. (2007).

Why *A. bicaudatus* are attracted to ethanol in the spring, but not as new adults in the fall is unclear, but may have to do with differences in preferred overwintering versus maturation feeding or oviposition material. Stressed host material may be more suitable for feeding (Lesne 1911, Liu et al. 2008) or egg laying (Beiriger et al. 1988, Hesler et al. 2007), whereas healthy material may serve as suitable overwintering hosts (Williams and Norton 2012). Ethanol attraction as part of reproductive behaviors may further explain why 98.8% of all captured beetles were female and indicate that males are not attracted to stressed material.

Scobicia bidentata. This study is the first to report a trapping period for the little-known *S. bidentata*. There have previously been very few observations of this insect in bycatch or reported as a pest species. Our results suggest that unlike *A. bicaudatus*, *S. bidentata* catch does not correlate with a spike in daily temperature (Fig. 1, 2). Later emergence in June, similar to *X. basilaris*, which generally overwinters as larvae (Solomon 1995), combined with an overlapping range of degree-days between years (Fig. 3), suggests that further development is needed to reach adulthood from a cold-tolerant immature stage. Since ethanol baited traps and not emergence traps were used, it is possible that adult beetles emerged earlier but are not immediately attracted to ethanol upon emergence, although the advantage of that is unclear. From our field-collected catch data, we estimate that attraction to ethanol began around 190 accumulated degree-days and reached 50% collection between 260–305 accumulated degree-days (Fig. 3). Since traps were collected weekly, the level of precision in our degree-days model is limited. Further studies with more frequent trapping may increase model precision.

Host Use. Bostrichids are commonly thought to be host generalists as dead wood is the preferred substrate for larval development (Lesne 1911, Liu et al. 2008). However, host selection assays with *P. truncatus* and *R. dominica* suggest both primary and secondary attraction can play a role in host selection, with some hosts preferred for egg laying over others and some being non-hosts (Nansen and Meikle 2002, Edde 2012, Quellhorst et al. 2021). Both *A. bicaudatus* and *S. bidentata* have been previously reported utilizing a wide variety of woody plants (Fisher 1950, Schaffner 1953, Baker 1972, Williams and Norton 2012), but hosts could be used for a variety of needs at different life stages, including overwintering, maturation feeding, and larval development. Williams and Norton (2012) observed very clear overwintering host preferences by *A. bicaudatus,* with nearly nine times more exotic tamarisk chosen as hosts than native eastern cottonwoods, and no beetles found overwintering in cottonwood.

Bud and limb dieback due to maturation feeding is the most significant cause of damage by *A. bicaudatus* in viticulture (Beiriger et al. 1988, Solomon 1995). However, host preferences have never been assessed to our knowledge. Our study assessed host use in spring, when female beetles were selecting hosts for maturation feeding and oviposition. Our results show that both *A. bicaudatus* and likely *S. bidentata* are most attracted to and likely to bore into black oak out of seven potential host species in free-choice assays (Table 1; Fig. 4a, b). Wild grape in this study was not as preferred as black oak, although the difference in preference between them was not statistically significant (Fig. 5). Larger twigs were also more attractive to beetles, although not necessarily more likely to be accepted as hosts. Further studies with *S. bidentata* individuals may help verify our findings with this species, which were limited by unexpected low abundance during the study period. High annual variation in abundance is a common phenomenon in Bostrichidae (Edde et al. 2006, Kasambala and Chinwada 2011, Edde 2012).

Reproduction in A. bicaudatus. Greater attraction to certain hosts suggests that ideal free distribution may be at play in bostrichid abundance on a landscape, with beetles able to disperse to areas of more suitable resources. Edde and Phillips (2006b) showed that *R. dominica* is attracted to and preferentially feeds upon the most suitable host for larval growth. Adult size in bostrichids and other beetles can be influenced by food quality during development, which may differ in moisture and nutritional content (Shafiei et al. 2001, Edde and Phillips 2006a, Rosenberger et al. 2018). We did not determine host quality in this study as we did not observe any oviposition or subsequent development on different hosts, although at least two (*Quercus* and *Vitis*) are known to support larval growth (Beiriger et al. 1988, Hesler et al. 2007). However, we did observe high variation in size (Fig. 5), suggesting that *A. bicaudatus* may be influenced by host quality at our sites. Further, the positive correlation we observed in size and egg number (Fig. 5) suggests a fitness benefit to larger size, and in turn, reproductive host preference. However, more work is necessary to establish this relationship since it is unclear whether our assays demonstrate reproductive host choice or simply adult maturation feeding (Fig. 4b).

Conclusion

Little is known about organisms of unrealized economic or ecological importance. This is especially true for woodborers in the family Bostrichidae (Liu et al. 2008), despite known pathways for introduction to new ranges, ability to damage plants and wood products in their native ranges, and a role in ecosystem functioning (Haack 2006, Hesler et al. 2007, Rozen and Go 2015, Chahal et al. 2019). Much work remains to develop even a basic understanding of the life history of such beetles (Liu et al. 2008), which includes those in this study, despite their status as minor pests in North America. Here we report findings on activity in spring, host preferences and correlations between beetle size and fitness, thus laying a foundation for further work on these little understood wood borers.

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