

Bark- and Wood-Infesting Insects (Coleoptera and Hymenoptera) and Associated Parasitoids Reared from Yellow Birch (*Betula alleghaniensis*) in Ingham County, Michigan

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Abstract

Four species of bark- and wood-infesting borers (two Coleoptera and two Hymenoptera) and six parasitoid species (Hymenoptera) were reared from yellow birch (*Betula alleghaniensis* Britton) one year after the trees were cut and left standing in a woodlot in Ingham County, Michigan in 1986–87. The borers were species of Cerambycidae (Coleoptera) and Xiphydriidae (Hymenoptera), and hymenopteran parasitoid species of Aulacidae, Braconidae, Chalcididae, and Pteromalidae. *Xiphydriophagus meyerinckii* (Ratzeburg) (Pteromalidae) is a new Michigan state record. For the borers, yellow birch is a new host record for the cerambycid *Sternidius alpha* (Say) and the xiphydriid *Xiphydria tibialis* Say. Seasonal emergence data are presented for each insect, as well as sex ratio data for the xiphydriids and aulacid parasitoids. Mean (\pm SE) exit hole density for all borers and parasitoids combined was 2.3 ± 0.7 exit holes/dm² for all branch and trunk samples, but significantly higher (4.7 ± 0.8 exit holes/dm²) on smaller branches (3–5 cm diam) vs. larger branches (0.3 ± 0.1 exit holes/dm², 5–10 cm diam). Dry weight data for the most common borer (*Xiphydria mellipes* Harris) and most common parasitoid [*Aulacus pallipes* Cresson; Aulacidae] demonstrated wide intraspecific variation in adult size.

Keywords: Borers, parasitoids, host range, state records, adult size, yellow birch

Two of the earliest major reports on birch-infesting insects in the United States were those of Packard (1890) and Felt (1905). The bronze birch borer, *Agrilus anxius* Gory (Coleoptera: Buprestidae), was recognized as a major pest of birch since the late 1800s (Chittenden 1898), and still today often reaches outbreak levels especially when trees are stressed by drought and defoliation (Haack and Petrice 2019). Several species of bark- and wood-infesting insects, often called borers, have been associated with various species of birch in North America, including Coleoptera (e.g., Buprestidae, Cerambycidae, and Scolytinae), Hymenoptera (e.g., Siricidae and Xiphydriidae), and Lepidoptera (e.g., Sesiidae) (Smith 1976, Taft et al. 1991, Solomon 1995, Smith and Schiff 2001).

This paper reports on borers and parasitoids reared from yellow birch (*Betula alleghaniensis* Britton) at the same Michigan location where Haack (2020) reported rearing records from shagbark hickory [*Carya ovata* (Mill.) K. Koch] and slippery elm (*Ulmus rubra* Muhl.). The study site was near Dansville in Ingham County, where I lived for about 30 years. This property was over 13 ac (5.3 ha) in size, and along with the neighboring properties contained over 60 ac (24 ha) of contiguous mature forest of the

beech-maple type (Cohen 2008). The most common tree species growing in this Dansville woodlot were listed in Haack (2020). Although these rearing records are decades old, they still provide valuable new information with respect to larval host plants, adult seasonal emergence, and new state records for Michigan insects.

Methods. On 19 April 1986, I cut two stems (12- and 15-cm-diam) of an apparently healthy, multi-stemmed yellow birch tree near ground level in the Dansville woodlot (N 42.5481° Lat, W 84.3189° Long). The two stems were placed upright and left leaning against the trunk of the tree from which they were cut for the next 12 months. On 26 April 1987, I cut the two stems into more than 20 sections, mostly between 40–55 cm long, and down to a final branch diameter of about 3 cm. When examining the cut ends of each section it was clear that the greatest borer activity was in the sections that were 3 to 10 cm in diameter. Therefore, I collected 16 trunk and branch sections that were in this diameter range (about 7 m total length for all 16 sections) and placed them all in a single rearing cage (ca. 60 cm wide, 45 cm deep, and 45 cm tall). The cage had a wood floor, a sliding Plexiglas front panel, and fine screening on the other three side walls and

upper surface. The cage was kept on a counter, inside a covered shed (ca. 8 × 12 ft or 2.4 × 3.7 m), that had double doors at opposite ends that remained open to allow air flow. The shed received direct sunlight during the early morning hours, but later was shaded, and therefore the indoor temperatures of the shed were similar to ambient conditions.

The cage was generally checked every 1–2 days for recently emerged insects through August 1987, and then less frequently through October 1987. After each collection, all insects were placed in labeled vials and then frozen. Later, once individuals of each morphospecies had been identified by experts (see Table 1 and acknowledgments), the insects were totaled by species and emergence date. Specimens of each species were retained by the identifiers in their personal or institutional collections. All parasitoids were identified by staff at the US Department of Agriculture, Systematic Entomology Laboratory in Beltsville, MD.

In late summer 1987, after all emergence had apparently stopped, the emergence density of all borers and parasitoids was calculated for each branch. The insect emergence values were based simply on a count of all exit holes seen on the bark surface. At first, I attempted to classify the exit holes as large (about 2.5 mm in diameter or larger) or small (less than 2.5 mm), thinking that the larger holes would represent borers and the smaller holes would represent parasitoids. However, this was not possible because there was considerable overlap between some of the larger parasitoids (e.g., female Aulacidae) and the smaller borers (e.g., male Xiphydriidae). The bark surface area of each trunk or branch section was calculated as a cylinder, based on the average diameter of each cut end and the section length. As a proxy for borer size, the adult dry weight of selected borers and parasitoids was determined by drying undamaged (i.e., no missing body parts) insects to a constant weight, using an analytical balance. The intraspecific size variation value, *I*, was calculated for these selected species as the ratio of the dry weight of the heaviest individual to the weight of the lightest individual in a method similar to that computed by Andersen and Nilssen (1983) based on insect length.

Statistical analyses. Mean differences in attack density and adult dry weight were tested for significance using a two-tailed *t*-test. An alpha level of 0.05 was used to test for significance.

Results. In 1987, which was assumed the first year after infestation of the two birch stems that were cut in 1986, 190 individual borers, representing four species were reared, including two species of Ceram-

bycidae [Coleoptera: *Sternidius alpha* (Say) and *Xylotrechus colonus* (Fabricius)] and two species of Xiphydriidae (Hymenoptera: *Xiphydria mellipes* Harris and *Xiphydria tibialis* Say) (Table 1). The xiphydriid *X. mellipes* was the most common borer reared, representing 95% of all borers (Table 1). The sex ratio (male:female) of the reared *X. mellipes* was 1:1.4. Considering all borers, individuals were collected from 17 May to 19 July 1987 (Table 1).

Similarly, 36 individual parasitoids, representing six species (all Hymenoptera), were reared from birch in 1987, including one species of Aulacidae (*Aulacus pallipes* Cresson), three Braconidae (*Atanycolus impressifrons* Shenefelt, *Cenocoelius* sp., and *Coeloides rossicus betulae* Mason), one Chalcididae (*Haltichella* sp.), and one Pteromalidae [*Xiphydriophagus meyerinckii* (Ratzeburg)] (Table 1). The most common parasitoid reared was the aulacid *A. pallipes*, representing 81% of all parasitoids collected (Table 1). The male:female sex ratio of the reared *A. pallipes* was 1:2.6. Considering all parasitoids, individuals were collected from 10 May to 21 July 1987 (Table 1).

Overall, 225 exit holes were counted on the 16 trunk and branch sections, which corresponds closely to the 226 borers and parasitoids that were collected. Considering all exit holes, the mean (\pm SE) density was 2.2 ± 0.7 exit holes/dm² of bark surface area for all 16 sections. However, if the sections were divided into two groups based on average diameter then it was clear that densities were significantly higher (4.7 ± 0.8 exit holes/dm²) on smaller branches (3–5 cm diam; *N* = 7 sections) as compared with larger branch and trunk sections (0.3 ± 0.1 exit holes/dm²; 5–10 cm diam; *N* = 9 sections; *t*-value = 6.35, *P* < 0.0001).

The mean dry weights for *X. mellipes* adults were 7.6 ± 0.5 mg for males (*N* = 20; range 4.8–12.1 mg) and 21.4 ± 0.5 mg for females (*N* = 38; range 13.3–27.2 mg); females were significantly larger than males (*t*-value = 17.8, *P* < 0.0001). Similarly, the mean dry weights for *A. pallipes* adults were 3.8 ± 0.5 mg for males (*N* = 5; range 2.1–4.8 mg) and 6.4 ± 0.5 mg for females (*N* = 12; range 4.0–8.9 mg); females were significantly larger than males (*t*-value = 3.7, *P* < 0.003). Using the range of dry weights for the above species, *I*-ratios were 2.5 and 2.0 for *X. mellipes* males and females, respectively, and similarly 2.3 and 2.2 for *A. pallipes* males and females.

Discussion. There is a succession of borers, parasitoids and other associated insects that colonize the woody tissues of trees as they decline, die and decay (Blackman and Stage 1924, Savely 1939, Haack and Slansky 1987). For the four borers reared

Table 1. Collection data for adult bark- and wood-infesting borers (Coleoptera and Hymenoptera) and parasitoids (Hymenoptera) reared from yellow birch (*Betula alleghaniensis*) trunk and branch sections held outdoors in 1987 in Ingham County, Michigan.

FAMILY Species	Number collected			Range of collection dates		
	Total	Males	Female	Calendar days	Julian days (mean)	Identifier ²
Borers						
CERAMBYCIDAE						
<i>Sternidius alpha</i>	1	n.a. ¹	n.a.	VI 4	155 (155)	DCLG
<i>Xylotrechus colonus</i>	4	n.a.	n.a.	VI 28–VII 11	179–192 (185)	DCLG
XIPHYDRIIDAE						
<i>Xiphydria mellipes</i>	181	76	105	V 17–VII 19	137–199 (167)	DRS
<i>Xiphydria tibialis</i>	4	1	3	VI 17–VII 3	169–184 (176)	DRS
Parasitoids						
AULACIDAE						
<i>Aulacus pallipes</i>	29	8	21	V 28–VII 21	148–202 (168)	DRS
BRACONIDAE						
<i>Atanycolus impressifrons</i>	3	0	3	V 10–V 21	130–141 (136)	PMM
<i>Cenocoelius</i> sp.	2	1	1	V 10–V 21	130–141 (136)	PMM
<i>Coeloides rossicus betulae</i>	2	1	1	VI 22–VI 28	173–178 (176)	PMM
CHALCIDIDAE						
<i>Haltichella</i> sp.	1	0	1	V 28	148 (148)	EEG
PTEROMALIDAE						
<i>Xiphydriophagus meyerinckii</i>	1	0	1	V 28	148 (148)	EEG

¹ Cerambycid adults were not sexed.

² Identifiers: DCLG = David C. L. Gosling, DRS = David R. Smith, EEG = Eric E. Grissell, and PMM = Paul M. Marsh.

in the present study, yellow birch is a new host record for the cerambycid *S. alpha* and the xiphydriid *X. tibialis*, although both have been reared from other *Betula* species, e.g., river birch (*Betula nigra* L.) (Patton 1879, Smith 1976, MacRae and Rice 2007). For the other two borers, Gosling (1986) reared *X. colonus* from yellow birch in Michigan, and Smith (1976) reports that *X. mellipes* is a birch specialist, having been reared from at least five birch species including yellow birch. Of the four parasitoids that were identified to the species level, only the braconid *C. rossicus betulae* has been reared from yellow birch (Mason 1978); however, the aulacid *A. pallipes* has been reared from other birch species (Townes 1950, Smith 2001), and the pteromalid *X. meyerinckii*, which is a European species, has been reared from birch in Europe as well as other hardwoods (Ferrière 1951).

All four borers reared in this study have previously been reported from Michigan (Gosling 1973, Smith 1976, Gosling and Gosling 1977). Similarly, using the online SCAN database (<https://scan-bugs.org/>)

in March 2021, which contains collection records of insects from over 100 North American arthropod collections, Michigan specimens of all four borers currently reside in various collections throughout the United States. With respect to the four parasitoids identified to species, Michigan records have been published for *A. pallipes* (Townes 1950, Smith 2001), *A. impressifrons* (Shenefelt 1943), and *C. rossicus betulae* (Mason 1978). Of these three species, Michigan specimens are reported in SCAN for only *A. pallipes*.

In the case of *X. meyerinckii*, no published papers or SCAN records have been found stating that this insect has been previously collected in Michigan, and it is therefore considered a new state record. This pteromalid has been reported in Indiana, parasitizing *Xiphydria maculata* Say in maple (*Acer*) (Deyrup 1984), and reared from larch (*Larix*) in Newfoundland that were infested by the bark beetle *Dendroctonus simplex* LeConte (Coleoptera: Curculionidae: Scolytinae) (Langor 1991). In Europe, *X. meyerinckii* has been reared from at least two species of *Xiphydria* (Schimitschek 1974).

I did not attempt to associate the parasitoids reared in this study with their insect hosts; however, Deyrup (1984) did make such associations through detailed dissections of infested branches. For the braconid *A. impressifrons*, Marsh (1979) reports that it has been reared from cerambycids. Similarly, the *Cenocoelius* species reared in the present study likely had a cerambycid host. In fact, the braconid *Cenocoelius ashmeadii* Dalla Torre has been reared from the cerambycid *S. alpha*, as well as other cerambycids (Marsh 1979), and has been previously collected in Michigan based on SCAN records. Members of the chalcidid genus *Haltichella* are known to be primary parasitoids of Lepidoptera as well as hyperparasitoids of Braconidae and Tachinidae (Diptera) (Halstead 1990). The only species of *Haltichella* reported in SCAN to be from Michigan is *Haltichella xanticles* (Walker), which is recognized as both a primary parasitoid and hyperparasitoid (Halstead 1990).

Life history studies have been conducted on a few species of *Xiphydria*. Deyrup (1984) studied *X. maculata* and its parasitoids on maple in Indiana, and reported two of the same parasitoids as found in this study (*C. rossicus betulae* and *X. meyerinckii*), as well as two other distinct *Aulacus* species, one Braconidae, one Ichneumonidae, and one Orussidae (Hymenoptera). In addition, Deyrup (1984) reported univoltine life cycles for the borers and parasitoids in his study, adult flight for most species between late May and early August, and that *X. maculata* mostly infested maple branches and stems that were 2.5 to 9 cm in diameter. Working in New York, Blackman and Stage (1924) reported that *Xiphydria hicoloriae* Rohwer, which infests hickory (*Carya*), was univoltine, had adult emergence mostly during July and early August, favored host material 5–9 cm in diameter, and would reinfest the same host material at least once. Smith and Schiff (2001) reported that *Xiphydria decem* Smith and Schiff was reared from a recently dead branch (2.8–4.1 cm diam) of river birch in southern Illinois in April and May. In studies of *Xiphydria picta* Konow on alder (*Alnus*) in the North Caucasus region of southern Russia, Kravchenko (1972) noted that infestation occurs soon after tree death, oviposition is primarily on stems and branches 4–40 cm in diameter, borer densities are highest on smaller diameter trunk and branch sections, the flight season extends from July to early September, and the sex ratio is female biased.

Deyrup (1984) noted that the *Aulacus* females in his study oviposited on *Xiphydria* eggs. Worldwide, several *Aulacus* species use xiphydriids as hosts, especially in the northern hemisphere, as well wood-boring

Coleoptera, especially in the southern hemisphere (Evenhuis and Vlug 1975, Smith 2001, Jennings and Austin 2004).

Andersen and Nilssen (1983) reported that intraspecific size variation (I) was generally lower for free-living groups (usually families) of beetles (family medians of 1.1 to 1.4) compared with those that developed in woody tissues [medians of 1.2 for ambrosia beetles (Platypodinae and some Scolytinae) to 2.1 for wood-borers of the cerambycid subfamily Spondylidinae (= Aseminae)]. The highest I value for individual species was 3.3 for two Cerambycinae cerambycids. Haack and Slansky (1987) calculated mean I values of 2.8 for 12 Siricidae and 2.8 for 9 Xiphydriidae, all of which are wood-infesting Hymenoptera. The I index value for *X. mellipes*, combining data for males and females, is 2.7 based on length data given in Smith (1976) and 5.9 based on dry weights from the present study. For the *A. pallipes* parasitoids reared in the present study, the I index value for males and females combined is 4.2 based on dry weight. Such wide variation in intraspecific size in wood-boring insects likely reflects, in part, differences in nutritional quality and water content of the woody tissues (Andersen and Nilssen 1983, Haack and Slansky 1987, Shibata 1998, Torres-Vila et al. 2018). Similarly, the broad size variation noted in the borer *X. mellipes* is likely the main reason for size variation in the parasitoid *A. pallipes*. Others have found that parasitoid size tends to increase with the size of the larval host in various buprestid and cerambycid borers (Urano and Hijii 1995, Paine et al. 2004, Wang et al. 2008).

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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.

- Blackman, M. W. and H. H. Stage. 1924.** On the succession of insects living in the bark and wood of dead, dying, and decaying hickory. New York State College of Forestry, Technical Bulletin 17: 3–269.
- Chittenden, F. H. 1898.** A destructive borer enemy of birch trees, with notes on related species. USDA Division of Entomology Bulletin New Series 18: 44–51.
- Cohen, J. G. 2008.** Natural community abstract for mesic southern forest. Michigan Natural Features Inventory, Lansing, MI. 12 pp. https://web.archive.org/web/20090105155916/http://web4.msue.msu.edu/mnfi/abstracts/ecology/Mesic_southern_forest.pdf
- Deyrup, M. A. 1984.** A maple wood wasp, *Xiphydria maculata*, and its insect enemies (Hymenoptera: Xiphydriidae). The Great Lakes Entomologist 17: 17–28.
- Evenhuis, H. H. and H. J. Vlug. 1975.** *Aulacus striatus* parasiet van *Xiphydria camelus*. Entomologische Berichten 35(4): 58. (in German)
- Felt, E. P. 1905.** Insects affecting park and woodland trees. New York State Museum Memoir 8: Vol 1. The University of the State of New York, Albany, NY. 459 pp.
- Ferrière, C. 1951.** A new genus of Pteromalidae (Hym.), parasitic on the alder wood-wasp, *Xiphydria camelus* L., found in Norfolk, England. Entomologist's Monthly Magazine 87: 322–324.
- Gosling, D. C. L. 1973.** An annotated list of the Cerambycidae of Michigan (Coleoptera) Part I, Introduction and the subfamilies Parandrinae, Prioninae, Spondylinae, Aseminae, and Cerambycinae. The Great Lakes Entomologist 6: 65–84.
- Gosling, D. C. L. 1986.** Ecology of the Cerambycidae (Coleoptera) of the Huron Mountains in northern Michigan. The Great Lakes Entomologist 19: 153–162.
- Gosling, D. C. L., and N. M. Gosling. 1977.** An annotated list of the Cerambycidae of Michigan (Coleoptera). 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. and T. R. Petrice. 2019.** Historical population increases and related inciting factors of *Agrilus anxius*, *Agrilus bilineatus*, and *Agrilus granulatus liragus* (Coleoptera: Buprestidae) in the Lake States (Michigan, Minnesota, and Wisconsin). The Great Lakes Entomologist 52: 21–33.
- 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.
- Halstead, J. A. 1990.** Review of *Haltichella* Spinola in the Nearctic Region (Hymenoptera: Chalcididae). Proceedings of the Entomological Society of Washington 92: 153–159.
- Jennings, J. T. and A. D. Austin. 2004.** Biology and host relationships of aulacid and gasteruptiid wasps (Hymenoptera: Evaniodea): a review, pp. 187–215. In: K. Rajmohana, K. Sudheer Girish, P. Kumar, and S. Santhosh (eds.), Perspectives on Biosystematics and Biodiversity. University of Calicut, Kerala, India.
- Kravchenko, M. A. 1972.** Ecology of the variegated wood wasp *Xiphydria picta* Knw. in North Caucasia. Soviet Journal of Ecology 3: 77–79.
- Langor, D. W. 1991.** Arthropods and nematodes co-occurring with the eastern larch beetle, *Dendroctonus simplex* [Col.: Scolytidae], in Newfoundland. Entomophaga 36: 303–313.
- MacRae, T. C. and M. E. Rice. 2007.** Biological and distributional observations on North American Cerambycidae (Coleoptera). The Coleopterists Bulletin 61: 227–263.
- 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.
- Mason, W. R. M. 1978.** A synopsis of the Nearctic Braconini, with revisions of Nearctic species of *Coeloides* and *Myosoma* (Hymenoptera: Braconidae). The Canadian Entomologist 110: 721–768.
- Packard, A. S. 1890.** 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, DC. 957 pp.
- Paine, T. D., A. L. Joyce, J. G. Millar and L. M. Hanks. 2004.** Effect of variation in host size on sex ratio, size, and survival of *Syngaster lepidus*, a parasitoid of eucalyptus longhorned beetles (*Phoracantha* spp.): II. Biological Control 30: 374–381.
- Patton W. H. 1879.** A rare *Xiphydria* and its parasite. The Canadian Entomologist 11: 12–15.
- Savely, H. E. 1939.** Ecological relations of certain animals in dead pine and oak logs. Ecological Monographs 9: 321–385.

- Schimitschek, E. 1974.** Contributions to the ecology of coniferous and leaf wood Siricidae in Europe. *Journal of Applied Entomology* 75: 225–247. (in German)
- Shenefelt, R. D. 1943.** The genus *Atanycolus* Foerster in America north of Mexico. *Research Studies of the State College of Washington* 11: 51–163.
- Shibata, E. 1998.** Effects of Japanese cedar inner bark nutritional quality on development of *Semanotus japonicus* (Coleoptera: Cerambycidae). *Environmental Entomology* 27: 1431–1436.
- Smith, D. R. 1976.** The xiphydriid woodwasps of North America (Hymenoptera: Xiphydriidae). *Transactions of the American Entomological Society* 102: 101–131.
- Smith, D. R. 2001.** World catalog of the family Aulacidae (Hymenoptera). *Contributions on Entomology, International*. 4: 263–319.
- Smith, D. R. and N. M. Schiff. 2001.** A new species of *Xiphydria* Latreille (Hymenoptera: Xiphydriidae) reared from river birch, *Betula nigra* L., in North America. *Proceedings of the Entomological Society of Washington*. 103: 962–967.
- Solomon, J. D. 1995.** Guide to insect borers in North American broadleaf trees and shrubs. U.S. Department of Agriculture, Forest Service, *Agriculture Handbook*, AH-706. Washington, D.C. 735 pp.
- Taft, W. H., D. Smitley and J. W. Snow. 1991.** A guide to the clearwing borers (Sesiidae) of the north central United States. Michigan State University, North Central Regional Extension Publication 394. East Lansing, MI.
- Torres-Vila, L., F. J. Mendiola-Díaz, 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.
- Townes, H. 1950.** The Nearctic species of Gasteruptiidae (Hymenoptera). *Proceedings of the United States National Museum*. 100: 85–145.
- Urano, T. and N. Hijii. 1995.** Resource utilization and sex allocation in response to host size in two ectoparasitoid wasps on subcortical beetles. *Entomologia Experimentalis et Applicata* 74: 23–35.
- Wang, X. Y., Z. Q. Yang, H. Wu and J. R. Gould. 2008.** Effects of host size on the sex ratio, clutch size, and size of adult *Spathius agrili*, an ectoparasitoid of emerald ash borer. *Biological Control* 44: 7–12.