THE BIOLOGY AND PHENOLOGY OF THE EMERALD ASH BORER

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Abstract

Emergence of adults of the emerald ash borer (EAB), *Agrilus planipennis* Fairmaire, from caged ash logs, at a marshalling yard in Essex Co., Ontario, began during the first week in June in 2003 and peaked in late June. A few adults were observed flying in the marshalling yard on 28 May. Median emergence dates were 25 June for males and 26 June for females. In 2004, median emergence dates were 11 June and 12 June for males and females, respectively. Sex ratio of emerging adults approached unity for 2003, but was skewed towards males (58.5%) in 2004. The logs from which the beetles emerged had an unknown thermal history and may have been exposed to direct sunlight for considerable periods of time. Thus, these emergence data probably reflect emergence comparable to that expected from exposed urban landscape trees. In three mature woodlots, adults captured on TangleTrap™-coated sticky traps, on host trees at ca. 2 m above the ground, demonstrated considerable woodlot-to-woodlot and year-to-year variation in numbers and activity periods. In one heavily-infested plot, 50 traps captured ca. 7000 beetles during the flight period in both years. With the exception of one lightly infested plot in 2003, traps captured a preponderance of females (66.1- 88.9%). For both years, peak activity periods were inversely correlated with crown density of the woodlots. For the three plots trapped in 2003, interpolated median emergence dates were 3, 10 and 13 July, while median dates for the same three plots in 2004 occurred earlier on 21, 27 June and 4 July.

Tangle-trap-coated traps on green ash (*Fraxinus pennsylvanica* Marsh.), basswood (*Tilia americana* L.), silver maple (*Acer saccharinum* L.) and shagbark hickory (*Carya ovata* (Mill.) K. Koch) captured an average of 161.4, 1.6, 3.3, and 2.7 emerald ash borer adults per 0.25 m2 of surface area. This highly significant difference between captures on host trees and non-host trees strongly suggests that the beetles are responding to some cue provided by the host and are not landing on trees at random to determine their suitability for oviposition.

The size distribution of peristoma (sclerotized region around the mouthparts) widths of larvae of EAB dissected from host logs, were determined using an ocular micrometer, This distribution exhibited four well defined modes, indicating four larval instars. Lower size limits of peristoma widths for instars II, III, and IV were 0.325, 0.550 and 0.975 mm. Peristoma widths of prepupae dissected from logs fell within the size limits of IVth instar larvae, but the majority of these widths was skewed towards the upper size limit of the mode. This trend probably reflects the larger sizes of females and their later emergence during the period that we sampled. Temporal distribution of larval instars based on peristoma measurements showed progressive development. Late in the growing season the majority of the population was in the prepupal stage, but a small proportion of the population was in earlier instars. This suggests that some of the population enters winter in the larval stage. A small proportion of the population was also observed in early spring in the larval stage, suggesting that these individuals survived winter as larvae. These observations have implications for the duration of a generation.

EAB-infested green ash bolts were collected in winter and after a storage period at low temperature, bolts were placed in cages at one of six constant temperatures (18-33 °C) in the laboratory. The cages containing the bolts were examined daily for adult emergence. Linear functions were fitted to the median temperature-dependent emergence rates from the logs, independently for male and female adults. For both males and females the estimated developmental threshold was 13.5 °C, and emergence for males and females required 303.0 and 344.8 DD, respectively, above this threshold. For each rearing temperature, emergence was normalized by dividing emergence times by median emergence time. The normalized times for all temperatures were pooled separately for males and females and a weibull functions were fitted to the normalized times to describe the variability around the median emergence

rates. The rate functions and these variability functions were incorporated into a simple phenology model to predict adult emergence. Air temperatures provided by Environment Canada for the Windsor airport for 2003 and 2004 were used as model input. This model adequately predicted the beginning of adult activity in the woodlots for both years, but was unable to predict emergence from the logs in the marshalling yard. Microclimatic temperatures under the bark in these logs exposed to direst solar radiation would be considerably greater than temperatures recorded in a standard weather station. Conversely, temperatures within a closed canopy woodlot would more closely approximate ambient air temperatures.

However, post-winter development of EAB in host trees consists of three distinct processes or phenophases. These are the prepupal period which culminates in pupation, the pupal period that ends at adult eclosion, and a teneral adult period that includes the process of sclerotization and a period of inactivity. Each process may have different developmental rate and threshold parameters, potentially complicating predictions based a models that incorporates all three processes combined, such as the one described above. To examine these individual processes in the laboratory we extracted prepupae from ash trees in winter and after a chilling period, we reared the prepupae at six constant temperatures in the laboratory. Linear functions were fitted to individual rates for the three processes for both males and females. For male and female prepupal periods the developmental thresholds were 12.0 and 11.5 °C and the heat accumulation requirements for development were 118.3 and 121.0 DD above these thresholds, respectively. For pupal periods, the thresholds were 13.6 and 14.7 °C with heat accumulations of 139.2 and 114.6 DD above the thresholds, respectively. Thresholds of 13.6 and 10.1 °C, with DD accumulations of 43.1 and 64.4 described the development of teneral adults. Whether the latter reflects the true behavior of the beetle in the pupal chambers in/under the bark remains to be determined. The pupal period was less variable than the other phenophases as reflected by higher r^2 values for these regressions. Consequently, development is probably more rigorously defined for the pupal stage. For all three phenophases, development thresholds are relatively high and reasonably consistent, thus the use of combined processes in the phenology model described above is probably justified. A rate function and a variability function have also been constructed for egg development of EAB. This stage also had a high development threshold of 13.9 °C with a degree-day requirement of 155.2 above this threshold for completion of development.

To determine the longevity of adults, males and females were housed separately in plastic-cup rearing cages and provided with access to water and fresh foliage. The cages were then placed in one of seven constant temperature chambers (12 to 33 °C). At most temperatures and under these conditions, male and female longevity was comparable. For temperatures of 18°C or greater, longevity was inversely correlated with temperature. At 12 and 15 °C reductions in feeding rates negatively affected longevity. At 18, 21, 24, 27 and 33 °C, median longevities for females were 102.5, 38.0, 22.5, 19.0, and 5.0 days, respectively.

Mating pairs confined in plastic-cup rearing containers at 24 °C, as described above were observed daily for egg production and mating. There was a highly significant linear relationship between the time to first observed mating and the time to first oviposition. No matings or ovipositions were observed until at least 12 days after adult eclosion, with means for both events of ca. 23 days post eclosion.