Dogwood Borer (Lepidoptera: Sesiidae) Flight Activity and an Attempt to Control Damage in 'Gala' Apples Using Mating Disruption[1]

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Abstract 'Gala' apple trees had a high incidence of burr knots (adventitious root primordia) produced on the trunk. Dogwood borer, *Synanthedon scitula* (Harris), infested many of these growths. Mating disruption using a sex attractant for dogwood borer, (*Z,Z*)-3,13-ODDA, did not control dogwood borer injury. In addition to other variables inherent to mating disruption (dispenser release and application rate, pest density, environmental factors), one potential reason for the failure was an inadequate conception of the dogwood borer sex pheromone composition. Therefore, the composition of dogwood borer pheromone should be reexamined. Traps baited with lilac borer, *Podosesia syringae* (Harris), lures were more sensitive for capturing dogwood borer males than traps baited with lures for dogwood borer. This is difficult to explain because the lures purportedly are identical. This difference in trap response further supports the need for reexamination of the pheromone blend compositions for each species. A complex of seven sesiids was attracted to both dogwood borer and lilac borer traps; captures of all were almost entirely eliminated by permeation with (*Z,Z*)-3,13-ODDA. There was a bimodal pattern of adult activity, with an early peak trap capture in May-June, and a later peak in July-August. The hypothesis of apple producing a later period of dogwood borer emergence than from dogwood was supported. This will complicate control in 'Gala' using current borer insecticides (e.g., chlorpyrifos, endosulfan) because of the proximity of harvest in this early-maturing variety with the ovipositional period of dogwood borer.

Key Words Dogwood borer, *Synanthedon scitula,* apple, pheromone, mating disruption, burr knots.

Dogwood borer, *Synanthedon scitula* (Harris), is a recent addition to the list of indirect pests of apple (Riedl et al. 1985, Warner and Hay 1985). It bores into and develops within burr knots which are primarily adventitious root primordia. 'Gala' is somewhat unique among apple varieties in that the trunk (scion) tends to form burr knots (Pfeiffer et al. 1995). The semi-dwarfing M.26 rootstock to which Gala is often grafted also is among those rootstocks with a tendency to form burr knots (Riedl et al. 1985). Consequently, the problem of burr knot borers becomes amplified.

Engelhardt (1946) reported dogwood borer as having the broadest host range of any member in the family Sesiidae. It is a primary pest of flowering dogwood (Taft et al. 1991) and a secondary pest of many hardwood trees and shrubs including oak,

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beech, birch, hickory, pecan, cherry, mountain ash, and willow. It ranges from southeastern Canada and New England, west to Ohio and Minnesota, and south to Texas. A single protracted generation is thought to occur (Potter and Timmons 1983, Riedl et al. 1985, Warner and Hay 1985). However, some studies show two flight peaks. The phenological significance is unclear (Potter and Timmons 1985). Larvae overwinter in galleries beneath the tree bark (Riedl et al. 1985).

As the popularity of Gala continues to increase, so too will the problem of burr knot borers. Chronic infestations may cause a decline in vigor and yield, occasionally killing the tree (Riedl et al. 1985). Due to difficulties involved in controlling any borer, mating disruption may be the most viable and economical means of control. Mating disruption was shown by Pfeiffer et al. (1991) to be more effective than standard insecticides for control of lesser peachtree borer, *Synanthedon pictipes* (Grote and Robinson). A sex attractant for dogwood borer was reported as (*Z,Z*)-3,13-octadecadienyl acetate (ODDA) by Nielsen et al. (1975). This is the primary component in the pheromone of peachtree borer, *Synanthedon exitiosa* (Say). Barry et al. (1978) listed that component as 92 to 98% of the peachtree borer blend with the remainder as (*E,Z*)-3,13-ODDA (Fig. 1). Because mating disruption dispensers for peachtree borer are commercially available (Pacific Biocontrol, Vancouver, WA), mating disruption of dogwood borer may be an alternative control.

The purpose of this study is to determine the efficacy of currently available pheromone dispensers for mating disruption, to compare alternative pheromone trap lures, and to examine the phenology of dogwood borer flight in apple orchards.

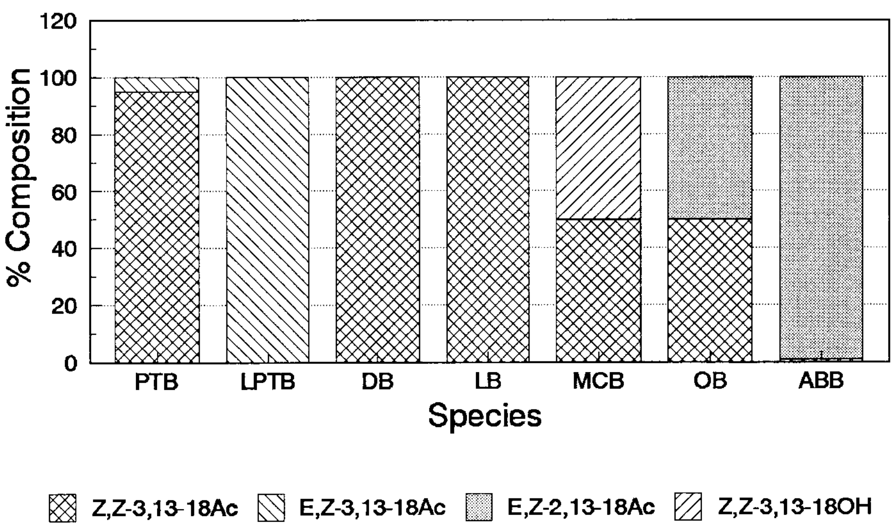

Fig. 1. Sex attractants for selected sesiid species [PTB = peachtree borer (Barry et al. 1978), LPTB = lesser peachtree borer (Tumlinson et al. 1974), DB = dogwood borer (Nielsen et al. 1975), LB = lilac borer (Nielsen et al. 1975), MCB = maple callus borer (Snow et al. 1985), OB = oak borer (Snow et al. 1989), ABB = apple bark borer (Snow et al. 1991)].

Materials and Methods

Research was conducted from 1993-95. Mating disruption was attempted in each of the 3 yr. In each year, the disruption block was unreplicated because of the large block size needed for mating disruption trials, combined with the need for Gala trees of sufficient age to have a significant number of burr knots. Hurlbert (1984) noted that where replication is impractical in ecological field experiments (as in this study), descriptive versus inferential statistics should be employed. Therefore, descriptive statistics are presented here.

The treated area consisted of a 2-ha rectangular block of Gala located in Piney River, VA. It was bordered on the southern and eastern sides by apple orchard and on the northern and western sides by pasture. The orchard was planted in 1987. Two-thirds of the block was planted using 675 trees/ha; the remainder was planted using 1134 trees/ha. Pheromone rope-type dispensers (Isomate-P, Shin-Etsu Fine Chemical Co., Ltd., Japan) containing the sex attractant for dogwood borer [(*Z,Z*)-3,13-ODDA, designed to control peachtree borer] were placed on 21 May 1993 and 22 April 1994 at the rate of 250/ha and on 24 May 1995 at the rate of 500/ha. The loading rate was 37.8 mg/dispenser. Dispensers were placed at a height of approximately 2 m. The control area was another 2-ha, rectangular block of Gala adjacent to the treated block (separated by about 6 m). It was bordered on southern, western and eastern sides by apple and the northern side by pasture. Both blocks were treated with the same conventional spray program of organophosphate insecticides.

1993. As a means for determining disruption, three pheromone traps with septum-type lures (Trécé, Salinas, CA) for dogwood borer were placed in each block on 22 April. Traps were placed in a diagonal line from the northeastern to southwestern corners of each block, at a height of about 1.5 m. Traps were about 50 m apart. Lures were replaced on 6 July. All traps used in this study were Pherocon 1C wing-type traps.

To observe effects of the dogwood borer/peachtree borer blend on related sesiids, 3 pheromone traps with septum-type lures for lilac borer, *Podosesia syringae* (Harris) (which responds to the same sex attractant as dogwood borer, Fig. 1), and two pheromone traps with lures for lesser peachtree borer were placed in each block at the two stations near the block corners on 22 April. Three traps with lures for peachtree borer were placed in each block on 6 July. Peachtree borer lures contained mainly (*Z,Z*)-3,13-ODDA, but also a small amount of (*E,Z*)-3,13-ODDA. Traps were placed in adjacent trees. Septa for lilac borer and lesser peachtree borer were replaced on 6 July. All traps were checked weekly at which time adults removed.

Injury was evaluated between 24 Sep and 15 Oct by searching 100 tree trunks per block (10 groups of 10 trees, the groups spread uniformly in the block) for infested and non-infested burr knots. Infestation was determined by the presence of frass, exuviae, or larvae. All pupal exuviae and larvae were counted and removed. Larval identity was confirmed by inspecting a sample of larvae under a dissecting microscope in Blacksburg using standard sources (Peterson 1962, Mackay 1968).

1994. Based on results obtained in our 1993 study, three pheromone traps with lures for lilac borer were placed in each block on 22 April to monitor dogwood borer and as a means for comparing disruption of olfactory orientation in the two blocks. Additionally, three traps for dogwood borer were placed in the control block in order to repeat the comparison of the dogwood borer and lilac borer lures, i.e., the control block had both dogwood borer and lilac borer traps. Septa were replaced on 23 June. All traps were checked weekly and adults removed. Injury was evaluated between 23 and 24 June and again between 16 Sep and 1 Oct in the manner described for the 1993 test.

To help clarify the phenology of dogwood borer, two lilac borer pheromone traps were placed approximately 90 m apart in each of two non-orchard environments: a residential area and a hardwood forest, both in Fredericksburg, VA. In addition, four traps were placed in Mountain Cove Orchard in Lovingston, VA, in a block containing 'Golden Delicious', 'Fuji', 'Sunrise', 'Red Delicious', and 'Ginger Gold', varieties without unusual burr knot problems.

1995. For determining disruption, three lilac borer pheromone traps were placed in each block. Septa were replaced on 12 July and 1 Sep. All traps were checked weekly and adults removed. Injury was evaluated on 5 Jun, 10 Aug, and between 30 Sep and 7 Oct by searching 100 tree trunks per block (10 groups of 10 trees, the groups spread uniformly in the block) for infested and non-infested burr knots. Infestation was determined by the presence of frass and/or exuviae). Only pupal exuviae (not larvae) were counted and removed.

Data analysis. Lure types were compared for sensitivity in capturing dogwood borer. Data were subjected to a Type 1 generalized linear model analysis, using the GENMOD Procedure (SAS 1996) after testing for model goodness of fit.

Results and Discussion

Flight data. Capture data for male dogwood borer in dogwood borer and lilac borer traps from the control block at Piney River are shown in Fig. 2 for 1993 and 1994. Seasonal trap capture totals of dogwood borer males were significantly greater for traps baited with lilac borer lures than for those baited with dogwood borer lures ($P = 0.0017$ in 1993 and $P = 0.0293$ in 1994). Because the manufacturer maintains that these lures use the same component and loading rate, it is difficult to determine the basis for this difference in captures. This preference by dogwood borer for lilac borer pheromone traps prompted us to use only lilac borer lures in 1995. Capture data for male dogwood borer in lilac borer traps from the control block at Piney River are shown in Fig. 3 for 1993-95. The large peak on 5 Aug 1993 (Figs. 2, 3) is somewhat inflated by including captures from a missed orchard visit on 29 July (moths in traps represented a longer trapping interval). There was, nevertheless, a large amount of activity during this period. In all cases, flight occurred from May to October with peaks in flight activity in late-May to early-June, and again in late-July to mid-August. In Michigan, emergence starts in mid-June, peaking in mid-July, and ending in September (Riedl et al. 1985, Howitt 1993). In Ontario, activity extends from late-June until early-August (Warner and Hay 1985). Snow et al. (1985) reported multiple generations of dogwood borer with the first generation occurrence in April and May in Georgia. However, there are reports of univoltine sesiids exhibiting a bimodal emergence pattern, e.g., grape root borer, *Vitacea polistiformis* (Harris) (Snow et al. 1991).

Captures of lilac borer in lilac borer and dogwood borer traps were 42 versus 26 in 1993, and 21 versus 22 in 1994. While the difference for dogwood borer was especially pronounced in 1993, the difference remained significant in 1994, unlike with lilac borer. This difference in response indicates the need to re-evaluate the blends for dogwood borer and lilac borer, both of which are reported to respond to the same, single component (Fig. 1).

Capture of dogwood borer males in dogwood borer pheromone traps was totally suppressed in the treatment block after placement of dogwood borer/peachtree borer

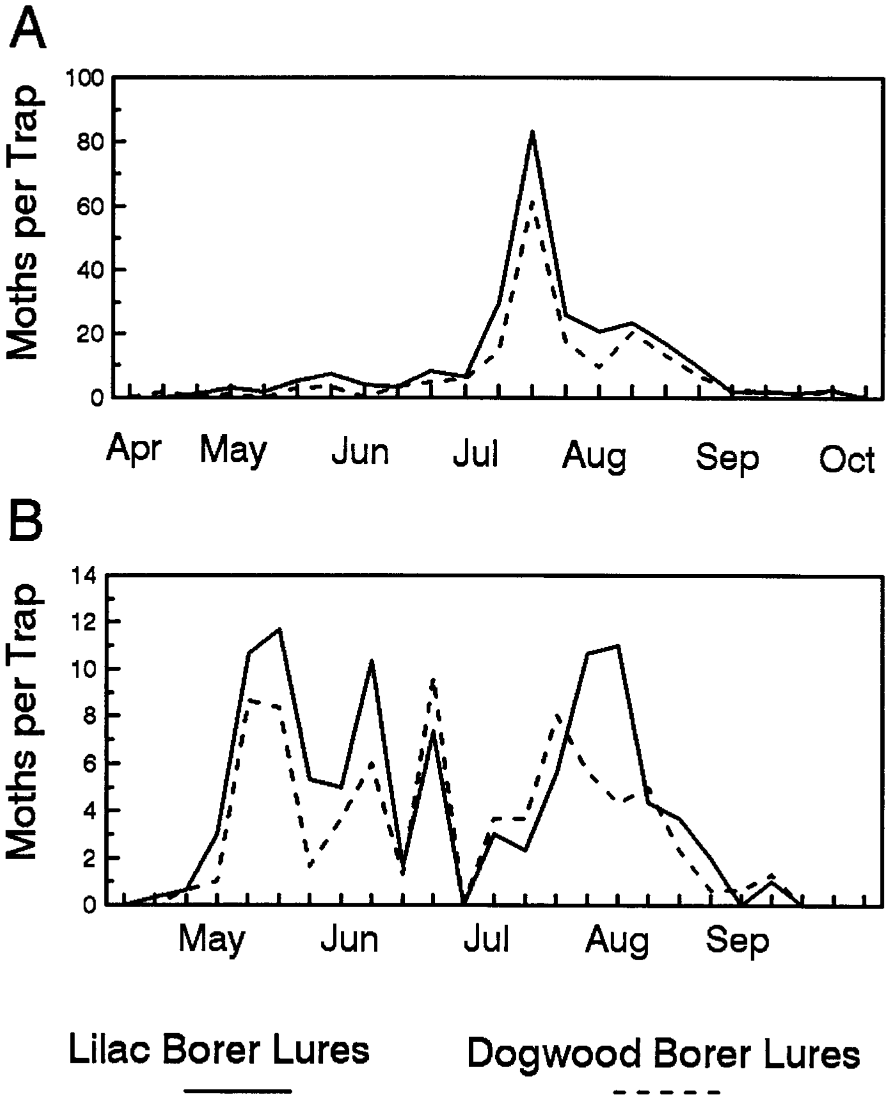

Fig. 2. Dogwood borer captures in pheromone traps baited with dogwood borer lures versus lilac borer lures in 1993 (A) and 1994 (B).

mating disruption dispensers (1993). Suppression of dogwood borer male attraction to lilac borer pheromone traps in the treatment block was 99.4% in 1993, 99.3% in 1994, and 100% in 1995. Sharp et al. (1978) failed to capture dogwood borer in traps baited with *Z,Z*-3,13-ODDA in Florida.

Dogwood borer captures from the residential, hardwood forest, and mixed apple environments (1994) are shown in Fig. 4. In both the residential and hardwood forest

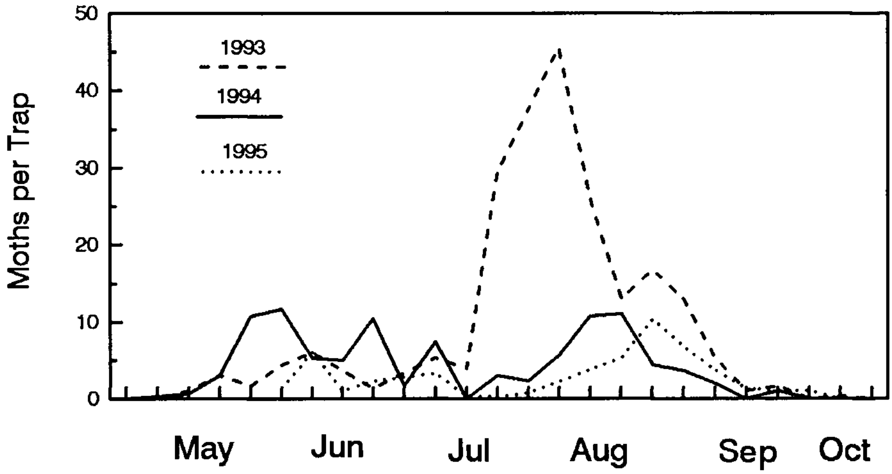

Fig. 3. Dogwood borer captures in pheromone traps baited with lilac borer lures from 1993 through 1995.

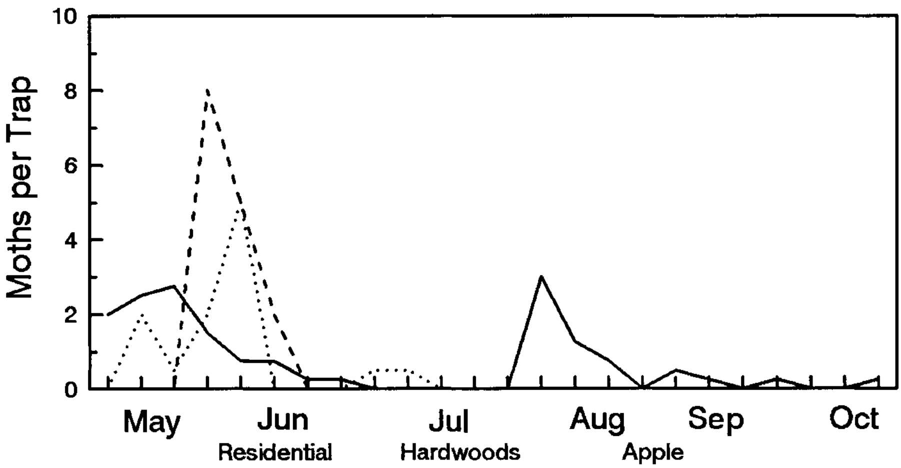

Fig. 4. Dogwood borer captures in pheromone traps placed in a residential area, hardwood forest, and a mixed apple planting.

environments, dogwood borer captures peaked in early-June, then ceased. Dogwood borer captures in the mixed apple environment peaked in mid-May and then again in late-July. These data are consistent with those of Potter and Timmons (1983) who provided evidence suggesting that an early-flight peak was indicative of dogwood borer emergence from dogwood, while the larger, late-summer flight peak reflected infestation of apple (and possibly other hosts). A period of reproductive activity in

August will complicate insecticidal control of dogwood borer in Gala apples which are harvested in August. Chlorpyrifos and endosulfan, two insecticides commonly applied for borers, have respective preharvest intervals of 28 and 21 d.

Injury data. Number of burr knots per 10 trees and % infestation, as indicated by the presence of frass, exuviae, and larvae, for the late-season 1993 count are presented in Table 1. There was an average of 6 or 7 burr knots per tree. About two-thirds of burr knots were infested by dogwood borer.

Number of burr knots per 10 trees, and % infestation as indicated by the presence of frass, exuviae, and larvae for early- and late-season 1994 counts are presented in Table 2. Although overall infestation of burr knots by dogwood borer in 1994 is less than that of 1993, the differences between infestation in the control vs. treatment blocks are insignificant. In the June counts, the number of burr knots per tree averaged 4 or 5. In the September-October count, the mean increased to about 9 per tree (the same trees were sampled).

Number of burr knots per 10 trees, and % infestation as indicated by the presence of frass and exuviae for early-, mid-, and late-season 1995 counts are presented in Table 3. Mean levels of burr knot infestation in the control and treatment blocks for the early-season counts were 42.5 and 38.2%, respectively. In the control block, the percentage of burr knots infested per 10 trees increased with each of the three counts (42.5, 31.8, and 48.3), as did the percentage of exuviae per group of 10 trees (1.3, 2.7, and 3.7). Although twice the number of dogwood borer/peachtree borer dispensers were used relative to the previous 2 yrs of study, the amount of injury (early-, mid- and late-season) did not support the use of dispensers currently available for peachtree borer as an effective agent for mating disruption of dogwood borer. Further testing using greater dispenser application rates and environmental conditions as well as with dispensers of the appropriate dogwood borer blend appears to be in order.

The number of burr knots per tree in June averaged about 9; in August, 12 to 14; in September-October, 13 to 15. There appears to be an increase in the incidence of aerial burr knots over time, both within years and across years.

Disruption of orientation by other sesiids. In addition to dogwood borer and lilac borer, males of five other sesiid species [*Synanthedon acerni* (Clemens), the maple callus borer; *Paranthrene simulans* (Grote), the oak borer; *Carmenta ithacae* (Beutenmuller); peachtree borer; and grape root borer], were attracted to both lilac borer and dogwood borer pheromone traps. With the exception of one male lilac borer

Table 1. Mean (and standard error) number of burr knots in 2 m of trunk, and % infested burr knots, % burr knots with exuviae, and % burr knots with larvae in Gala orchard blocks with and without treatment with purported peachtree borer pheromone in Piney River, VA, 1993*

Treatment	Burr knots /10 trees	% burr knots Infested	Exuviae	Larvae
Control:	58.0 (12.6)	68.5 (11.4)	4.3 (3.1)	26.2 (12.0)
Pheromone:	68.3 (22.3)	64.1 (4.7)	6.7 (4.1)	18.8 (7.3)

* Counts based on 10 groups of 10 trees each.

Table 2. Mean (and standard error) number of burr knots in 2 m of trunk, % infested burr knots, % burr knots with exuviae, and % burr knots with larvae in Gala orchard blocks with and without treatment with purported peachtree borer pheromone in Piney River, VA, 1993*

Treatment	Burr knots /10 trees	% burr knots		
		Infested	Exuviae	Larvae
Jun 23-24				
Control:	50.5 (13.5)	22.5 (7.0)	3.9 (3.6)	2.4 (2.1)
Pheromone:	42.0 (12.5)	16.0 (6.8)	2.6 (2.3)	0.7 (1.2)
Sep 16-Oct 1				
Control:	91.6 (22.9)	38.0 (17.6)	2.3 (2.0)	14.5 (8.9)
Pheromone:	93.6 (28.0)	37.4 (9.6)	3.2 (2.5)	10.5 (6.3)

* Counts based on 10 groups of 10 trees each.

Table 3. Mean (and standard error) number of burr knots in 2 m of trunk, % burr knots with frass and % burr knots with exuviae in Gala orchard blocks with and without treatment with purported peachtree borer pheromone in Piney River, VA, 1993*

Treatment	Burr knots /10 trees	% infested burr knots	
		Frass	Exuviae
Jun 5			
Control:	86.2 (13.0)	42.5 (5.8)	1.3 (2.0)
Pheromone:	91.9 (22.4)	38.2 (6.3)	0.4 (1.4)
Aug 10			
Control:	115.3 (12.6)	31.8 (4.7)	2.7 (2.0)
Pheromone:	136.3 (36.4)	19.4 (4.6)	5.7 (3.0)
Sep 30-Oct 7			
Control:	132.8 (17.1)	48.3 (11.1)	3.7 (2.0)
Pheromone:	151.6 (44.6)	53.1 (6.9)	1.9 (1.7)

* Counts based on 10 groups of 10 trees each.

captured in the lilac borer pheromone trap on 12 Aug 1993, and the captures of one and two dogwood borer males in lilac borer pheromone traps on 6 July and 20 Aug 1993, respectively, orientation of all sesiid males to both dogwood borer and lilac borer traps was totally suppressed after placement of dogwood borer/peachtree borer dispensers. No peachtree borer males were captured in peachtree borer pheromone traps.

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References Cited

Barry, M. W., D. G. Nielsen, F. F. Purrington and J. H. Tumlinson. 1978. Attractivity of pheromone blends to male peachtree borer, *Synanthedon exitiosa.* Environ. Entomol. 7: 1-3.

Engelhardt, G. D. 1946. The North American clear-wing moths of the family Aegeriidae. Smithsonian Instit., U.S. Nat. Mus. Bull. 190: 1-122.

Howitt, A. H. 1993. Common tree fruit pests. Michigan State University. North Central Regional Publication No. 63.

Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecol. Monogr. 54: 187-211.

Mackay, M. R. 1968. The North American Aegeriidae (Lepidoptera): A revision based on late-instar larvae. Mem. Entomol. Soc. Canada. 58: 1-112.

Nielsen, D. G., F. F. Purrington, J. H. Tumlinson, R. E. Doolittle and C. E. Yonce. 1975. Response of male clearwing moths to caged virgin females, female extracts, and synthetic sex attractants. Environ. Entomol. 4: 451-454.

Peterson, A. 1962. Larvae of insects: Part 1. Lepidoptera and Hymenoptera. Edwards Bros., Ann Arbor, MI.

Pfeiffer, D. G., L. A. Hull, D. J. Biddinger and J. C. Killian. 1995. Apple-indirect pests. *In* H. W. Hegmire (ed.), Mid-Atlantic orchard monitoring guide. Northeast Reg. Agric. Engin. Serv. Publ. 75.

Pfeiffer, D. G., J. C. Killian, E. G. Rajotte, L. A. Hull and J. W. Snow. 1991. Mating disruption for reduction of damage by lesser peachtree borer (Lepidoptera: Sesiidae) in Virginia and Pennsylvania peach orchards. J. Econ. Entomol. 84: 218-223.

Potter, D. A. and G. M. Timmons. 1983. Flight phenology of the dogwood borer (Lepidoptera: Sesiidae) and implications for control in *Cornus florida* L. J. Econ. Entomol. 76: 1069-1074.

Riedl, H., R. W. Weires, A. Seaman and S. A. Hoying. 1985. Seasonal biology and control of the dogwood borer, *Synanthedon scitula* (Lepidoptera: Sesiidae) on clonal apple rootstocks in New York. Can. Entomol. 117: 1367-1377.

SAS. 1996. SAS/STAT Software Changes and Enhancements. SAS Inst., Cary NC.

Sharp, J. L., J. R. McLaughlin, J. James, T. D. Eichlin and J. H. Tumlinson. 1978. Seasonal occurrence of male Sesiidae in north central Florida determined with pheromone trapping methods. Florida Entomol. 61: 245-250.

Snow, J. W., T. D. Eichlin, and J. H. Tumlinson. 1985. Seasonal captures of clearwing moths (Sesiidae) in traps baited with various formulations of 3,13-Octadecadienyl acetate and alcohol. J. Agric. Entomol. 2: 73-84.

Snow, J. W., M. Schwarz and T. D. Eichlin. 1989. Captures of clearwing moths (Lepidoptera: Sesiidae) with various octadecadienyl acetates and alcohols in central Georgia during 1983-1985. Environ. Entomol. 18: 216-222.

Snow, W. J. [sic], D. T. Johnson and J. R. Meyer. 1991. The seasonal occurrence of the grape root borer, (Lepidoptera: Sesiidae) in the eastern United States. J. Entomol. Sci. 26: 157-168.

Taft, W. H., D. S. Smitley and J. W. Snow. 1991. A guide to the clearwing borers (Sesiidae) of the North Central United States. North Central Regional Publication No. 394.

Tumlinson, J. H., C. E. Yonce, R. E. Doolittle, R. R. Heath, C. R. Gentry and E. R. Mitchell. 1974. Sex pheromones and reproductive isolation of the lesser peachtree borer and the peachtree borer. Science 185: 614-616.

Warner, J. and S. Hay. 1985. Observation, monitoring, and control of clearwing borers (Lepidoptera: Sesiidae) on apple in central Ontario. Can. Entomol. 117: 1471-1478.