

SUMMARY AND OVERVIEW OF PECAN ARTHROPOD PEST MANAGEMENT

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INTRODUCTION

The objectives of this chapter are to briefly summarize the accomplishments of other pecan entomologists and to present the author's contributions to pecan research. Pest management remains especially challenging for the pecan grower. However, management of pecan arthropod pests has made steady progress in the last 20-25 years away from unilateral reliance on chemical pesticides towards biologically-based management systems. Throughout the period pecan scientists in all disciplines have worked cooperatively to develop an understanding of pecan tree physiology and its interactions with culture and management practices and pest management. The addition of new knowledge about tree physiology continues to have dramatic impact on pecan horticulture and pest management. Major advances in monitoring methods for pecan nut casebearer along with the availability of softer chemicals for use in early season now provide practical and economical decision making and management tactics that do not eliminate beneficial insects in early season. Better detection methods for pecan weevil provide similar benefits in late season. The colonization by the exotic ladybird, *Harmonia axyridis* (Pallas), has significantly reduced the need for control of the yellow aphid complex and opened additional opportunities to better manage black pecan aphid. New methods for stinkbug detection appear promising. Similarly, as the role of the red imported fire ant is better understood, this exotic species will be managed more effectively.

SUPPLEMENT REVIEW

Pecans in the Nursery. Pecan budmoth, *Gretchina bolliana* (Slingerland), is the primary pest of pecan seedlings in the nursery and in newly planted orchards during the first years of establishment. Larvae feed in and destroy the terminal buds causing the terminal to branch profusely. Their damage results in poor form and lack of height and diameter growth. Mizell et al. (1988) used a terminal removal technique to pinpoint the critical time of budmoth attack. Budmoth attacks in May and early June in north Florida caused a reduction in tree caliper and height that resulted in a loss at sale of ca. \$1.00-2.00 per attacked seedling. Attacks after 1 July had little or no impact on pecan growth. Therefore, they concluded that an insecticide application in May and June was sufficient to control pecan budmoth in most years. They also reported that it was not necessary to control budmoth larvae attacking first and second year seedlings used as rootstock. Mizell and Schiffhauer (1986) reported that 'Gloria Grande' and 'Stuart' cultivars were more susceptible to budmoth than were 'Elliott', 'Sumner' and 'Desirable'. They suggested that 'Stuart' could be used as an "indicator" cultivar to monitor pecan budmoth populations for management decision making.

Pecan leaf phylloxera, *Phylloxera notabilis* Pergande, is often a pest of nursery or newly planted pecan stock. Leaf phylloxera may also reach significant numbers on orchard trees. Stem mothers emerge from overwintering at budbreak and form galls on the leaves. Occasionally they reach population levels that warrant suppression. Andersen and Mizell (1987) assessed the physiological impact of phylloxera galls on pecan foliage. Galls interfered with leaf nutrient status and photosynthesis and diverted nutrients away from normal leaf metabolic functions.

The Established Orchard. Pecan, *Carya illinoensis* (Wangenh.), is native to the U.S. and presently grown from coast to coast primarily in the Southeast and Southwest (Fig. 1). Wood (2003) characterized the commercial pecan industry as to its three distinct production strategies, four production subsystems, and prominent sub-subsystems relating to water (dry vs. irrigated), nitrogen (moderate vs. high), ground cover (none vs. grasses vs. legumes), livestock (grazing vs. nongrazing), and pest control (biological vs. chemical vs. integrated). The large diversity of management practices and economics associated with the different orchard types presents a huge challenge to scientists trying to address the

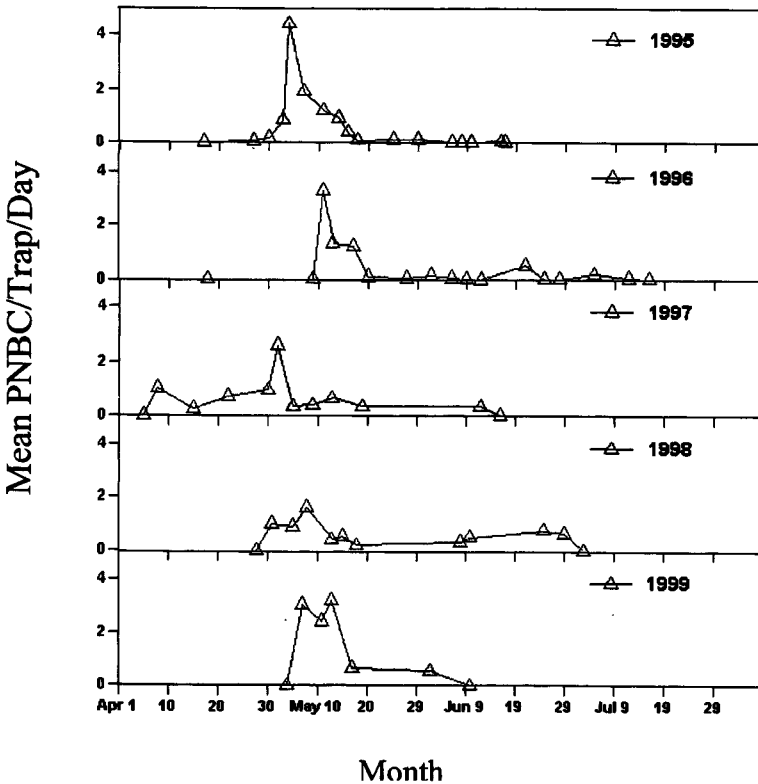


FIG.1: Mean Number of Pecan Nut Casebearer Males/Trap/Day in Delta Traps With Pheromone at Monticello, FL in Years 1995-1999.

problems associated with pest management. Profitability is linked closely to alternate bearing and successful arthropod management practices must contribute to the reduction from the impact of this innate stress physiology phenomena. It is notable credit to pecan scientists that much of the past and present research is multi- and interdisciplinary in recognition of the dominant role played by tree physiology.

Reid and Mulder (2003) discussed the unique aspects of pest management in low input culture of "natives" pecans. They used the analogy of old world chestnut, hazelnut and walnut production to describe the practices in native orchards. Pecan nut casebearer and pecan weevil are usually the major pests while defoliating Lepidoptera are of minor importance. Inputs are limited to tree thinning, fertilization and <5 insecticide applications. The Circle trap used for pecan weevil detection and placed directly on the tree trunk was a major improvement for monitoring weevils because cattle are usually grazed in native orchards. The use of tebufenozide (Confirm 2F, DowAgroSciences, Indianapolis, IN) insecticide for pecan nut casebearer is a critical tool as it is not toxic to beneficial insects.

Pecan Nut Casebearer. Stevenson et al. (2003) discussed the identification of the sex pheromone of the nut casebearer, *Acrobasis nuxvorella* Neunzig (Millar et al. 1996, Knutson 1998), as a major breakthrough in pecan pest management. They described a day degree model developed in the western states to predict nut casebearer emergence. A sequential sampling plan (Ring et al. 1989) was coupled to the day degree model. In conjunction with the nut casebearer project, a regional effort to determine the emergence patterns and population dynamics of this key early-season pest was completed (Harris et al. 1997). Male emergence times are quite variable from year to year across the pecan belt and populations can vary dramatically from orchard to orchard within a local area. Five years of data using pheromone traps by the author in North Florida pecan (Fig. 1) indicates the degree of variability in male emergence and points out the need and benefit from using this new monitoring tool for decision making relative to nut casebearer management.

Stink bugs. Stink bugs and leaffooted bugs, commonly referred to as kernel-feeding Hemiptera, can be important direct pests of pecan. Several species inhabit pecans and others enter orchards in times of drought or late season. Those that feed on the nuts before shell hardening cause injury termed black pit that causes fruit abscission. In nuts with black pit, the interior decays and turns black. Species that feed on nuts after shell hardening damage the kernel, rarely cause abscission and this damage is termed kernel spot. These spots are variable in size, sunken and bitter to taste (Moznette et al. 1931). Kernel spot lowers nut quality and is undetectable until shelling. Yates et al. (1991) characterized the damage from stink bugs to pecan shells and kernels.

Dutcher and Todd (1983) used D-vac, blacklight and malaise traps to capture stink bugs and leaffooted bugs in pecan as follows: *Euschistus servus* (Say), *E. tristigmus* (Say), *Oebalus pugnax* (F.), *Acrosternum hilare* (Say), *Nezara viridula* (L.), *Acanthocephala femorata* (F.), *Anasa armigera* (Say), *Leptoglossus phyllopus* (L.), *L. oppositus* (Say), and *Brochymena* sp. They reported that *N. viridula* and *E. servus* were the most important species occurring in Georgia pecan orchards all season. Adult *N. viridula* caused 34-53% fruit drop and *E. servus* caused 73% fruit drop when feeding prior to shell hardening. Polles (1979) reported that all nuts with black pit dropped prematurely. Polles et al. (1973) reported that cultivars with thin-shelled nuts such as 'Schley', 'Curtis' and 'Wichita' were preferred by stink bugs.

Stink bugs and leaffooted bugs have similar life cycles. The nymphs feed on herbaceous weeds such as *Crotalaria* spp., *Yucca* spp., Jimson weed, grasses, vegetables and agronomic crops including soybean, peas, cotton and corn (Bissell 1929, Dutcher 1989). Four or five generations may occur in a single year. As the season progresses the adults move from crop to crop. As other crop and weed hosts mature in fall, stink bugs

move into pecan orchards looking for food and overwintering sites (Polles 1979). Some stink bug species overwinter under pecan bark (Mizell and Schiffhauer 1987a).

Stink bug control is difficult. Row crops of cowpeas or soybeans and other legumes in large acreages that harbor stink bugs should not be planted adjacent to pecan orchards. However, Ree discussed the use of legumes as a trap crop for management of plant bugs and stink bugs (M. Hall and W. Ree, unpublished data). They indicated that trap crop management could be difficult because of weather extremes. However, where plant bugs and stink bugs are a chronic problem the technique appears biologically and economically effective.

Efficient and reliable sampling methods are available for some stink bug species (e.g., *Euschistus* spp.) (Mizell and Tedders 1995, Mizell et al. 1996, Mizell et al. 1997). Calibration of trap counts to nut damage has not been completed. The problem is further complicated by the variations in stink bug species diversity across the pecan belt and the determinant impact of climate and weather (i.e., drought) on bug movement into pecan orchards at unpredictable times of the year.

Pecan Aphids. The yellow pecan aphid complex, *Monelliopsis pecanis* Bissell and *Monellia caryella* (Fitch), prior to the introduction of the exotic ladybird, *Harmonia axyridis* Pallas, were very important pests because they removed critical nutrients from leaves, reduced photosynthesis due to feeding damage to the leaves and from shading of the leaf by sooty mold that grows on aphid honeydew. Black pecan aphids, *Melanocallis caryaefoliae* (Davis), are especially destructive and have a low economic threshold because their feeding leads quickly to leaflet abscission. Leaf quality must be maintained to the end of the season to reduce alternate bearing (see Wood 2003); therefore, aphid control required many insecticide applications which often led to the typical problems of secondary pest outbreaks and aphid resurgence. Dutcher et al. (2003) [also see Wood (2003) and below] described the current management protocols for pecan aphids and discussed some potential interactions between aphids and other insect pests. Dutcher also described the monitoring methods available for the species.

Minor pests. Spittlebug, caterpillars, scales, root borers, scorch mite and leafminers are also pecan pests that have received research attention in the last 25 years. However, they were not discussed in this symposium.

Fire ants. Harris et al. (2003) discussed his current research on the impact of beneficial insects of red imported fire ant (RIFA), *Solenopsis invicta* (Buren). He described a variety of sampling methods used for censusing ant and beneficial insect populations as well as insecticide treatments evaluated for their efficacy against ants as well as their impact on beneficials in the orchard. He reported that RIFA directly affect both yellow aphids and their natural enemies. Moreover, reducing RIFA with the methoprene insecticide formulation Extinguish (Wellmark International, Bensenville, IL) did not affect other species and increased the diversity of ant species in the plots. Chlorpyrifos (Lorsban 4E, Dow AgroSciences, Indianapolis, IN) applied as a trunk spray also significantly reduced RIFA in the plots.

Beneficial arthropods. Ellington et al. (2003) discussed resistance to pesticides as a major problem for pecan growers in New Mexico. He summarized the known beneficial insects attacking the major pests. He reported that nut casebearer and yellow pecan aphids are often regulated adequately by beneficials. However, black pecan aphids are an important fall problem. He described his efforts to use augmentative biological control to address aphid and leafminer problems. Richman (2003) discussed some sampling methods and the diversity of spiders in New Mexico pecan orchards. He reported that the sac spiders were the most abundant and most important species during aphid outbreaks.

Mizell and Schiffhauer (1987a) compared trunk traps to pecan bark for populations of beneficials and other insects overwintering on pecan. The ladybird, *Olla v-nigrum*

(Mulsant), a green lacewing, *Chrysopa nigricornis* Burmeister and spiders were consistently found in traps and under the bark. An anthocorid, a mirid, a brown lacewing, an earwig species and a stink bug, *Nezara viridula* (L.) also were found.

The establishment of the multicolored Asian ladybird, *H. axyridis*, to the U.S. has dramatically changed the pecan aphid situation in the Southeast. Mizell and Schiffhauer (1987b) described the seasonal abundance of pecan aphids in relation to the crape myrtle aphid, *Tinocallis kahawaluokalani* (Kirkaldy), and their natural enemies prior to the establishment of *H. axyridis*. They reported that the common generalist predators of both aphids responded in high numbers to the peaks in aphid populations and touted the possibility of using crape myrtle, *Lagerstroemia indica* (L.), and its host-specific aphid to augment beneficials in pecan orchards. Recent work by the author (Mizell, unpublished data) after the establishment of *H. axyridis* in Florida, has concerned the impact of *H. axyridis* on the same native beneficials. It appears that *H. axyridis* is causing dramatic reductions in both aphid species as well as the native beneficials. Whereas, Mizell and Schiffhauer (1987b) commonly detected the presence of ten different beneficial species (in four Orders), in significant numbers, *H. axyridis* was the dominant predator in 2001. Moreover, seven species of beneficials or their immature stages including coccinellids, chrysopids and syrphids were never detected on pecan or crape myrtle. At the same time, yellow pecan aphids remained in low populations throughout the season. *H. axyridis* appears to be actually reducing the numbers of other beneficials on an area-wide basis as opposed to directly eliminating them through competition or cannibalism individually on pecan and crape myrtle. This conclusion was drawn based on the absence of other beneficials on any host plant with aphid populations when *H. axyridis* was absent.

Pecan has many arthropod pests that often require application of pesticides for suppression. The negative impact of chemical pesticides on beneficials is of major concern as once insecticide applications begin and beneficials are drastically reduced, further applications are needed for the original target pest as well as secondary pests that are released from suppression when their natural enemies are also destroyed. Mizell and Schiffhauer (1990) and Mizell and Sconyers (1992) evaluated most of the then available pecan pesticides for their impact on beneficials. They reported that fungicides and acaricides caused <50% mortality to all beneficial species tested. Endosulfan (Thiodan, FMC Corp., Philadelphia, PA, Phaser, Aventis CropSciences, Research Triangle Park, NC) and phosalone (Zolone, Aventis CropSciences, Research Triangle Park, NC) were least toxic, but none of the insecticides were safe for all species tested. Since 1992 several new insecticides have become labeled for use on pecan and most of these chemicals have lower impact on beneficials.

Pecan weevil. Pecan weevil, *Curculio caryae* (Horn), is a key direct pest of pecan across the pecan belt (not in CA) and has been the focus of much research effort in the last 25 years. Many monitoring methods are available for this pest and the ability to detect emerging adults is quite good. Recently, Tedders and Wood (1994) invented the Tedders trap, made of masonite in a pyramid 4' in height with a collection device modified from the boll weevil trap. The Tedders trap is placed on the ground next to the tree trunk and colored black, mimics the visual cues presented to the weevils by the tree's silhouette. Trap efficiency can be increased by coloring the tree trunk white with either whitewash or white plastic wrap such that the visual cues from the tree in competition with the trap are suppressed. The Tedders trap works well in commercial orchards but is not compatible with cattle that are often grazed in the native pecan orchards in Texas, Oklahoma and Kansas. As a result an industrious Kansas pecan grower, Mr. Circle, invented the "Circle" trap (Reid and Mulder 2003) that also exploits the tendency of pecan weevils to respond to the tree trunk upon emergence. Cottrell and Wood (2003) summarized past and current research on pecan weevil biology and sampling methods. He also described an experiment

to evaluate trunk applications of carbaryl (Sevin®) to control pecan weevil adults. He reported that rates of 6-8X the recommended rate of carbaryl were moderately effective at controlling weevils that were caged on the trunks during the test for 13 days post-treatment.

Shapiro-Ilan (2003) described his research to obtain and culture new entomopathogens from pecan orchards and to evaluate the occurrence and efficacy of entomopathogens against pecan weevil. He reported that weevil larvae were only moderately susceptible to the nematodes tested. However, adult pecan weevils were susceptible to four species and five strains of nematodes and strains of the fungus *Beauveria* spp. He described the results of a strategy (exploiting weevil behavior in a similar manner to the Tedders trap) using trunk applications of entomopathogens to control weevil adults as they emerge from the ground. He also indicated a conflict between use of fungicides and entomopathogens in the orchard.

Mulder et al. (2003) reviewed the weevil sampling methods and compared the Circle and Tedders traps for their efficiency for monitoring pecan weevils in Oklahoma. He reported that the Circle trap provided the greatest capture rate for pecan weevils at all times during the season. They found no improvement in trap catch when weevil pheromone was added. They recommended using two large Circle traps/tree and an economic threshold of 0.3 weevils/trap/day for treatment decisions.

Pecan is native to the U.S. and as a result has very few exotic pests other than RIFA. However, it does have many pests in common with other *Carya* spp., the hickories. As a result ecological events that occur in orchards are often directly linked to vegetation outside the orchard and present unique and difficult management problems. Hickory shuckworm, pecan budmoth, lepidopterous caterpillars and pecan weevil are some examples. These interactions make pecan pest management different from most other crops and perhaps offer some opportunities for new research emphasis.

CONCLUSIONS

Pecan scientists are to be commended for their highly effective interdisciplinary research efforts over the last 25 years. Good progress has been made in understanding pecan physiology and pest management and their interactions. New developments portend similar efforts in the future. Monitoring tools are the first requirement in the development of any IPM system and many new methods are now available to the producer. Pecan is the only nut crop native to the U.S. and is a highly nutritious food product. It is expensive to produce relative to almonds, walnuts and other nut species, and pecan culture and management is intense and difficult under commercial conditions. Advances in arthropod pest management have been instrumental in maintaining a viable pecan industry.

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LITERATURE CITED

- Andersen, P. C., and R. F. Mizell, III. 1987. Physiological effects of galls induced by *Phylloxera notabilis* Pergande (Homoptera: Phylloxeridae) on pecan leaf tissue. *Environ. Entomol.* 16: 264-268.
- Bissell, T. L. 1929. Notes on *Leptoglossus phyllopus* L. and *L. oppositus* Say. *J. Econ. Entomol.* 22: 597-598.
- Cottrell, T. E., and B. W. Wood. 2003. Pecan weevil management: past, present and toward a future strategy. *Southwest. Entomol.* See paper in this Supplement.
- Dutcher, J. D. 1989. Stink bugs and leaffooted bugs. In W. D. Goff, J. McVay, and W. S. Gazaway [eds.]. *Pecan Production in the Southeast: A Guide for Growers*. Auburn Univ. Circ. ANR-459.
- Dutcher, J. D., G. W. Hudson, and H. C. Ellis. 2003. Recent advances in pecan pest management in improved and seedling pecan orchards. *Southwest. Entomol.* See paper in this Supplement.
- Dutcher, J. D., and J. W. Todd. 1983. Hemipteran kernel damage of pecan. pp. 1-11 In J. A. Payne [ed.]. *Pecan Pest Management - Are We There?* MPEAAL 13:1-140.
- Ellington, J., T. Carrillo, and J. Drake. 2003. Pecan integrated biological control. *Southwest. Entomol.* See paper in this Supplement.
- Harris, M., A. Knutson, J. Millar, B. Ree, J. Jackman, J. McVay, M. Nesbitt, R. Mizell, and J. Dutcher. 1997. Pecan nut casebearer pheromone in the southeastern U.S. *Proc. Southeastern Pecan Growers Assoc.* 90: 116-117.
- Harris, M., A. Knutson, A. Calixto, A. Dean, L. Brooks, and B. Ree. 2003. Impact of red imported fire ant on foliar herbivores and natural enemies. *Southwest. Entomol.* See paper in this Supplement.
- Knutson, A. 1998. Effects of pheromone dose, lure, age, and trap design on capture of male pecan nut casebearer (Lepidoptera: Pyralidae) in pheromone-baited traps. *J. Econ. Entomol.* 91: 715-722.
- Millar, J., A. Knutson, J. McElfresh, R. Gries, G. Gries, and J. Davis. 1996. Sex attractant pheromone of the pecan nut casebearer (Lepidoptera: Pyralidae). *Bioorg. Med. Chem.* 4: 331-339.
- Mizell, R. F. III, and D. E. Schifffhauer. 1986. Larval infestation levels of pecan bud moth, *Gretchena bolliana* Slingerland, in relation to cultivar and position on the tree. *Environ. Entomol.* 15: 436-438.
- Mizell, R. F., F. Martin, and P. C. Andersen. 1988. Pecan nursery stock: Models of height and diameter growth and impact of pecan bud moth *Gretchena bolliana* (Lepidoptera: Tortricidae). *Environ. Entomol.* 17: 13-17.
- Mizell, R. F., and D. E. Schifffhauer. 1987a. Trunk traps and overwintering predators in pecan orchards: survey of species and emergence times. *Fla. Entomol.* 70: 238-244.
- Mizell, R. F., and D. E. Schifffhauer. 1987b. Seasonal abundance of the crapemyrtle aphid *Sarucallis kahawahuokalani* (Kirkaldy) in relation to the pecan aphids *Monellia caryella* (Fitch) and *Monelliopsis pecanis* (Bissell) and their common predators. *Entomophaga* 32: 511-520.
- Mizell, R. F., and D. E. Schifffhauer. 1990. Effects of pesticide on pecan aphid predators *Chrysoperla rufilabris* (Neuroptera: Chrysopidae), *Hippodamia convergens*, *Cycloneda sanguinea* (L.), *Olla v-nigrum* (Coleoptera: Coccinellidae), and *Aphelinus perpallidus* (Hymenoptera: Encyrtidae). *J. Econ. Entomol.* 83: 1806-1812.
- Mizell, R. F., III., & M. C. Sconyers. 1992. Toxicity of imidacloprid to selected arthropod predators in the laboratory. *Fla. Entomol.* 72: 277-280.

- Mizell, R. F., and W. L. Tedders. 1995. Use of the modified Tedders trap to monitor stink bugs in pecan. Proc. Southeastern Pecan Growers Assoc. 88: 36-40
- Mizell, R. F., H. C. Ellis, and W. L. Tedders. 1996. Traps to monitor stink bugs and pecan weevils. The Pecan Grower. 8: 17-20.
- Mizell, R. F., W. Tedders, C. Yonce, and J. Aldrich. 1997. Stink bugs and stink bug trapping: Where we are. Proc. Southeastern Pecan Growers Assoc. 90: 50-52.
- Moznette, G. F., T. Bissell, and H. S. Adair. 1931. Insects of the pecan and how to control them. USDA Farmers' Bull. No. 1654.
- Mulder, Jr., P. G., W. Reid, R. A. Grantham, S. Landgraf, L. Taliaferro, M. E. Payton, and A. Knutson. 2003. Evaluations of trap designs and a pheromone formulation used for monitoring pecan weevil, *Curculio caryae*. Southwest. Entomol. See paper in this Supplement.
- Polles, S. G. 1979. Black pit and kernel spot of pecans. Special emphasis on southern green stink bug. Proc. 14th Conf. Ga. Pecan Growers Assoc. 10: 29-37.
- Polles, S. G., J. W. Todd, and E. K. Keaton. 1973. Some insects causing black kernel spot of pecans. Proc. 8th Conf. Ga. Pecan Growers Assoc. 4: 32-34.
- Reid, W., and P. Mulder, Jr. 2003. Insect pest management systems for native pecans. Southwest Entomol. See paper in this Supplement.
- Richman, D. B. 2003. Spiders (Araneae) of pecan orchards in the southwestern United States and their role in pest suppression. Southwest. Entomol. See paper in this Supplement.
- Ring, D. R., M. K. Harris, and J. A. Payne. 1989. Sequential sampling plan for integrated pest management of pecan nut casebearer (Lepidoptera: Pyralidae). J. Econ. Entomol. 82: 906-909.
- Shapiro-Ilan, D. I. 2003. Microbial control of the pecan weevil, *Curculio caryae*. Southwest. Entomol. See paper in this Supplement.
- Stevenson, D. E., A. E. Knutson, W. Ree, J. A. Jackman, A. Dean, J. H. Matis, J. McVay, M. Nesbitt R. Mizell, J. Dutcher, W. Reid, M. Hall, D. Barlow, M. T. Smith, P. Mulder, M. W. Smith, J. G. Millar, and M. K. Harris. 2003. Pecan nut casebearer pheromone monitoring and degree-day model validation across the pecan belt. Southwest. Entomol. See paper in this Supplement.
- Tedders, W. L., and B. Wood. 1994. A new technique for monitoring pecan weevil emergence (Coleoptera: Curculionidae). J. Entomol. Sci. 29: 18-31.
- Wood, B. W. 2003. Pecan production in North America. Southwest. Entomol. See paper in this Supplement.
- Yates, I. E., W. L. Tedders, and D. Sparks. 1991. Diagnostic evidence of damage on pecan shells by stink bugs and coreid bugs. J. Amer. Soc. Hort. Sci. 116: 42-46.