EMERGENCE, MOVEMENT, AND POLLEN FEEDING OF BOLL WEEVILS (COLEOPTERA: CURCULIONIDAE) IN THE MISSISSIPPI DELTA

D. D. Hardee
Research Leader, USDA-ARS-SIMRU
Stoneville, MS
G. D. Jones
Research Biologist, USDA-ARS-APMRU
College Station, TX
L. C. Adams
Entomologist, USDA-ARS-SIMRU
Stoneville, MS

Abstract

More boll weevils, *Anthonomus grandis grandis* Boheman, were captured after 20 May in 1995-1997 in grandlure-baited traps 1-5 km from cotton in Washington County, MS, than in traps near cotton. Even though few weevils were trapped from first bloom to mature boll (~ 1 July to 18 August), over 5X as many weevils were captured in traps 1-5 km away from cotton than in traps near cotton. This suggested that competition from male weevils feeding in cotton as well as cotton odors may have masked late season overwintering emergence. These results further suggested that overwintered weevils continue to emerge in low numbers into August, and that considerable movement of weevils (both overwintering and reproductive) occurred throughout the growing season. Numbers of overwintered weevils trapped from 23 March to 29 June 1996 were only 5% of those trapped during the same period in 1995. However, numbers captured from 18 August to 28 December 1996 equaled those for the same period in 1995, which showed the powerful ability of the boll weevil to rebuild from low numbers in a single season. Slightly over 50% of boll weevils responding to traps were females before July 1, these numbers increased to almost 100% females in mid-season, and declined to slightly over 50% females again in late season. Over 5,000 boll weevils were examined in 1996 for pollen grains in the mid-gut throughout the year, and over 300 taxa were identified. The majority of pollen in the mid-gut came from occurring Fagaceae (oak), Asteraceae (sunflower), Poaceae (grass), Malvaceae (mallow), Anacardiaceae (sumac), and Cheno-am (Chenopodium and Amaranthaceae, goosefoot and Amaranth families) depending on the time of year. These results indicate that non-cotton hosts are potentially important in survival of boll weevils throughout the year but not a factor in reproduction, since boll weevils have been found to reproduce only on cotton in the Mississippi Delta.

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Introduction

The boll weevil, *Anthonomus grandis grandis* Boheman, continues to damage cotton, *Gossypium hirsutum* L., severely where it has not been eliminated in the United States (Hardee and Herzog 1997, 1998). Since the discovery of the boll weevil pheromone, grandlure (Tumlinson et al. 1969, Hardee et al. 1972), for use in highly effective traps (Hardee 1976, Mitchell and Hardee 1974, Hardee et al. 1996), a considerable amount of research on emergence and movement of boll weevils has been conducted across the Cotton Belt (summarized by Hardee and Mitchell 1997). General trends showed that males and females respond to grandlure-baited traps in the spring, early and late summer, and fall, but mostly females respond in mid-summer, indicating an aggregation response early and late and primarily a sex pheromone response in mid-season. Beerwinkle et al. (1996) and Coppedge et al. (1996) recently reported studies in Texas which showed response patterns similar to those found in other earlier reports (Bottrell et al. 1970, Hardee et al. 1970, Ridgway et al. 1971). Peak early responses of overwintered weevils occurred during late May and early June. This was followed by a mid-season period of minimal response from late June through early August. An increase in responses occurred about mid-August, with peak late-season levels occurring during September, and a decline through the fall as winter approached.

The decline in response of boll weevils to traps around cotton fields as the crop approached squaring has been attributed to competition from males feeding in cotton or from cotton volatiles (Hardee et al. 1969). Moreover, the time of boll weevil emergence from overwintering habitat in the spring and early summer and the percent of winter survival are key factors in management and elimination programs. For example, at least seven states (AR, AZ, GA, MS, OK, SC, TX) at one time have used pheromone traps to recommend treatment thresholds and identify problem fields (Rummel et al. 1980, Ridgway et al. 1985, Johnson and Gilbreath 1982, Henneberry et al. 1988, Benedict et al. 1985, Anonymous 1998). In addition, the boll weevil trap baited with grandlure is a key component of the Boll Weevil Eradication Program (BWEP) currently underway in the U.S. Cotton Belt (Smith 1998). It is assumed that boll weevil emergence and movement patterns in the Mississippi Delta are similar to other areas, although these data have not been reported. As the BWEP progresses westward, this information will be necessary for optimum performance of traps used in the BWEP.

Although the larval stage of the boll weevil feeds on flower buds and fruit of the cotton tribe (Malvaceae: Gossypieae), the adult stage has a wider range of foraging resources (Rummel et al. 1978, Cross et al. 1975, Cate and Skinner 1978, Benedict et al. 1991, Jones et al. 1993, Jones and Coppedge 1996, Jones 1997, Jones et al. 1997, 1998). Adults forage on a variety of malvaceous plant taxa including: *Abutilon, Cienfuegosia, Gossypium, Hampea, Hibiscus, Sida, Sphaeralcea*, and *Thespesia* (Walker 1959, Stoner 1968, Cross et al. 1975, Chandler and Wright 1991, Jones et al. 1993).

Benedict et al. (1991) found not only Malvaceae pollen in the midgut of south Texas boll weevils, but also pollen from 14 other families of plants. In boll weevils from northeastern Mexico, they found Malvaceae pollen and pollen from five other families. Likewise, Jones et al. (1993) found boll weevils captured in northeastern Mexico contained Malvaceae pollen and pollen from 14 other families.

Pollen from 44 families (including Malvaceae) was found in overwintering boll weevils captured in Uvalde, TX (Jones and Coppedge 1996). In overwintering boll weevils captured in Crockett, and Munday, TX, Jones et al. (1997) found pollen from 29 and 35 plant families, respectively.

Alternate food sources play a significant role in adult boll weevil survival, especially during host-free periods. It has been suggested that foraging on non-malvaceous taxa during host-free periods is an evolutionary adaptation to living in the tropics where boll weevils remain active year round (Jones et al. 1993). Because Mississippi boll weevils are not active year-round, we wanted to determine if overwintering boll weevils foraged on non-malvaceous taxa prior to cotton production.

We report herein results of studies on emergence and movement of boll weevils in the Delta of Mississippi throughout a 3-yr period as affected by climate, proximity of traps to cotton, and phenology of cotton near traps. In addition, we report for the first time for the Mississippi Delta the possible foraging resources of the boll weevil as determined by analyses of pollen from their alimentary tract.

Materials and Methods

Trapping

A 10-ha field of cotton near Elizabeth (Washington County), MS, was selected as the central (or "core") field because of historically high boll weevil populations. Two Hardee traps (Hardee et al. 1996) were installed on the east and west side of the field on 21 March 1995 and operated continuously through 30 October 1997. At approximately 1.7-km intervals for 13 km in all 4 cardinal directions from the central field, a single Hardee trap was installed on the same date and operated as above. Cotton in the north trap line ranged from 1.7 to 5 km from traps, whereas traps in the east, south, and north trap lines ranged from <15 m to 1 km from cotton. The north trap line passed through an area composed mostly of rice, soybeans, and catfish ponds, whereas the other trap lines extended through an area composed predominantly of cotton fields of various sizes. Hibernation sites for overwintering boll weevils were very abundant near the core field and throughout the north trap line, whereas the other areas had less abundant hibernation sites. Cropping patterns for fields in all trap lines were similar in all years.

Traps were mounted on 1.1-m broom handles (2-3 cm diameter) and placed according to distance from the central field, some adjacent to (within 15 m) and some up to 5 km from cotton, in open areas but clear of danger from highway mowers and farm equipment. All traps were baited with the 2-wk Hercon lure containing 10 mg grandlure (Hercon Environmental, Emigsville, PA) (Hardee et al. 1996) and a Hercon kill strip (Toxstrip BW [2-(1-methylethoxy) phenolmethylcarbamate], Hercon Environmental) described by Hardee et al. (1975). Captured boll weevils were collected from all traps (twice weekly from March-September, once weekly or bi-weekly October-February), and lures and kill strips were changed every 10-14 days. Up to 10 boll weevils per trap from 25 March 1996 through 31 January 1997 were immediately frozen and later examined for pollen according to the procedure described below. In addition, samples of weevil collections from all traps were examined for sex ratio in 1996 and 1997.

Pollen Analyses

Ten to 15 boll weevils captured in traps at least weekly from March 1996 through January 1997 were analyzed for pollen to determine alternative foraging resources. Boll weevils were individually rinsed several times in 95% ethyl alcohol (ETOH) prior to processing. To consolidate pollen grains, one to 10 boll weevils (depending on number captured) per site per date (site-date) were placed into 12-ml centrifuge tubes and chemically dissolved with 5 ml of a 9:1 ratio of acetic anhydride to sulfuric acid. Samples were placed in a hot block for 15 minutes at 100°C, after which glacial acetic acid was added. The samples were centrifuged for 3 min, the supernatant decanted, and the residue mixed for 15 sec. Samples were rinsed twice with distilled water, and after each rinse, they were centrifuged, decanted, and mixed. The residue was strained by pouring it through a 450 μm stainless steel screen. (Straining separates the pollen, which flows through the screen, from "large" undissolved insect parts which may obscure pollen and prevent identification.) Samples were stained with safranine 0, and 95% ETOH was added, and again centrifuged, decanted, and mixed. After transferring to 2 dram vials, five drops of glycerin were added to each vial. Vials were left on a warm hot block (about 20° C) overnight to allow the ETOH to evaporate. Vials were mixed well and one drop of pollen residue was placed onto a glass slide. This drop was allowed to spread slightly before covering it with a glass coverslip. Light microscopy was used to examine the samples. For analyses, samples were divided by season; Spring = March, April, and May; Summer = June, July, and August; Fall = September, October, and November; and, Winter = December and January. All pollen identifications were made to the lowest rank possible utilizing the pollen collection at the USDA--ARS Areawide Pest Management Research Unit in College Station, TX.

Statistical Analyses

ANOVA was determined by season for each year and combined over years for three trap distances from cotton. Experimental design was completely random, and test of significance was performed at $P \leq 0.10$. The six seasons were approximately (1) 20 March to 20 May, (2) 21 May to 30 June, (3) 1 July to 28 July, (4) 29 July to 18 August, (5) 19 August to 31 October, and (6) 1 November to 30 December (1995 and 1996 only). Trap distances from cotton were (1) ≤ 15 m, (2) > 15 m - 400 m, and (3) 1-5 km. Number of traps for each distance and season varied from 4-20.

Results and Discussion

With the exception of seasons 1 and 6, more boll weevils were captured in traps 1-5 km from cotton than in traps < 400 m away (Table 1). From analyses combined over years, there were only significant differences ($P \leq 0.10$) between distances 1 and 3 in seasons 2-5 (Table 1). For all seasons, however, fewer weevils were captured in traps 15-400 m from cotton than in traps <15 m from cotton during the same periods (Tables 1-2). Since all of the traps 1-5 km from cotton were located on the north trap line (non-cotton habitats), these results support those of Coppedge et al. (1996) and Beerwinkle et al. (1996) in Texas in showing considerable response to traps in non-cotton areas (Table 2). From approximately 20 March to 20 May (4-leaf stage), and 31 October to 30 December (after harvest), more weevils were captured adjacent to cotton than away from cotton. The only significant difference detected for the latter period was in distances 1 (≤ 15 m from cotton) and 3 (1-5 km from cotton) for 1995 (F = 2.5; df = 2, 14; $P > F = 0.1178$) for 1996. However, between these periods, the highest numbers were captured away from cotton, including the period between 4-leaf stage and first bloom (~ 1 July) (Tables 3-5). Even though numbers trapped were very small from bloom to first mature boll (approximately 1 July to 18 August), over 5 times as many weevils were captured in traps 1-5 km from cotton than in traps near cotton for all three years (Tables 1-2). This supported the suggestion (Hardee et al. 1969) that competition with grandlure in traps from male weevils feeding in cotton as well as odors emanating from cotton fields may mask a true picture of late boll weevil emergence from hibernation in the Mississippi Delta. These results further suggested that weevils continue to emerge from hibernation into August (Mitchell et al. 1973) and/or considerable movement of weevils (both overwintering and reproductive) occurs throughout the growing season (Coppedge et al. 1996). Regardless of the answer, grandlure-baited traps placed around cotton fields may not be as effective between bloom and first mature boll in monitoring and eliminating boll weevil populations as previously thought. They also may not be an effective trigger for determining which fields are to be sprayed during the initial diapause phase of the BWEP. From mature boll to killing frost, response to traps near or away from cotton was not uniform for all three years, probably due to much lower temperatures in the winter of 1995-1996 than in the previous or following years. However, considerably more weevils were consistently captured in traps 1-5 km from cotton. A large number of weevils were captured after 1 October, and more were captured during this time adjacent to cotton (Table 1), suggesting that boll weevils may not move as far from infested fields in late season as they move from hibernation sites in the spring. This is further supported by the fact that as distances from the core field on the north trap line increased, numbers of overwintered weevils captured in traps declined (Tables 3-5). The trend of more overwintered weevils being captured away from cotton than near cotton between first square and first bloom is very obvious for all 3 years (Tables 3-5).

Results in Table 1 showed that peak overwintered weevil emergence as measured by trap captures occurred from mid-May to mid-June, and exact dates of high emergence seemed to follow 1-3 days after measurable rainfall from 1 April to 1 July for all years (Tables 6-8). Note that trap results shown in Tables 3-5 are only for the core field and the north trap line, but trap lines in other directions showed the same trend with fewer numbers trapped. Numbers of weevils trapped from 23 March to 29 June 1996 were only 5% of those trapped during approximately the same period in 1995 (Table 2). These lower numbers probably were influenced by colder temperatures in the winter of 1994-1996 (Figure 1). However, numbers captured from 10 August to 31 December 1996 actually exceeded those for the same period in 1995, which indicated the ability of the boll weevil to rebuild rapidly from low numbers in a single growing season. Parajulee et al. (1996), Jones and Sterling (1979), and Slosser et al. (1996) similarly reported greater emergence, earlier initiation of emergence and an extended emergence period following a mild winter compared to one with colder temperatures. Our results (Hardee, unpublished) agree with Leggett et al. (1988) in showing that use of heat units (El-Zik and Sevacherian 1979, Porter et al. 1996, and Beasley and Adams 1996) to predict emergence was no more accurate than use of Julian dates. This is probably due to equal influence of rainfall and temperature on emergence patterns. The results in Table 9 show that boll weevils responding to traps were slightly over 50% females before July 1 (overwintered), increased to near 100% female in mid-season (in-season), and declined to over 50% females again (migrating) in late season, which coincided with the earlier results of Hardee et al. (1969). Of interest is the capture of thirteen boll weevils (5♀, 8♂) between 3-16 January 1997. No weevils were captured in January and February 1996 or February 1997.

Boll weevil eradication is on-going in several parts of the U.S. Cotton Belt and is partially based on the premises that (1) boll weevils reproduce only on fruiting cotton; (2) a preponderance of boll weevils enter cotton before the first square is large enough for reproduction; and (3) boll weevils forage only on cotton and a very few other taxa.

Results cited earlier indicated a potentially wide range of adult host plants, which along with movement patterns, could strongly affect eradication strategies.

Boll weevils captured in Mississippi at 821 site-dates were processed for pollen, only 23 of which occurred in the winter (Table 10). Over 5,000 boll weevil adults were processed, with the majority occurring in the fall (Table 10). Boll weevils in the spring had a higher percentage of pollen (96%) than in other seasons, while boll weevils captured in the winter had the lowest percent with pollen (61%).

Over 41,000 pollen grains were found in the boll weevil samples, with 301 pollen types, 82 families, 132 genera, and 28 species encountered in the site-date samples (Table 10). Fall samples contained more pollen types (187) than other seasons, and both summer and fall samples contained pollen from the greatest number of plant families; however, more genera were represented in fall samples (89, Table 10). Mean number of pollen grains in the fall (80) was more than double that of any other season (Table 10).

Frequency of occurrence indicates how often a pollen type is encountered within the samples and is calculated by totaling the number of samples in which a type occurs, dividing (that sum) by the total number of samples, and multiplying by 100. The most frequently encountered pollens in the spring were Fagaceae (oak family), Asteraceae (sunflowers), and Poaceae (grasses) (Table 11). In the summer, this shifted to Poaceae, Asteraceae, Fagaceae, and Malvaceae (mallows). The top families again changed in the fall to Asteraceae, Anacardiaceae (sumac family), and Cheno-am (Chenopodium and Amaranthaceae, goosefoot, and Amaranth families). In the winter, Asteraceae was the major family encountered.

Relative frequency indicates a pollen type's importance within the samples. It is calculated by totaling the number of samples in which a pollen type occurs and dividing (that sum) by the total number of taxa. Since plant families were the main focus, total number of families per season was used. The quotient was multiplied by 10 to keep the relative frequencies below 100. The most important pollen types in the spring were from Asteraceae, Fagaceae, Poaceae, and Salicaceae (Table 12), and in the summer were Asteraceae, Fagaceae, Malvaceae, and Poaceae. A major shift occurred in the fall with Asteraceae, Anacardiaceae, Cheno-am, and Poaceae pollen being most important and in the winter to Asteraceae as the most important type.

It is not surprising that Asteraceae and Poaceae pollen types were of major importance, because these families contain more genera and species than any other plant family. In addition, pollen types from these families can easily be identified to the family rank. How much actual pollen feeding occurs on grass pollen is not known. However, honeybees actively forage on grass pollen, especially when other foraging resources are limited. This also may be true for boll weevils.

What is interesting about this study was the re-appearance in the fall of pollen types from only "spring-time" plants, like *Pinus* (pine), *Quercus* (oak), *Callicarpa americana* L. (American beautyberry), etc. (Table 13). There are several reasons pollen from these taxa may re-appear. First, these pollen types may be left in and/or on traps, and boll weevils might eat this pollen while trapped. Second, soil contains pollen accumulated throughout the year. It is possible that soil pollen may be a source of food for hungry boll weevils. Finally, 1996 was an unusual year for flowering plants in that many "spring" flowering plants bloomed again in the fall.

From the pollen analyses, there is no doubt that boll weevils forage on a wide variety of pollen (see Table 14 for common names). Regardless of the season, Asteraceae pollen is a major alternative foraging resource. This may be due in part to the ubiquitous nature of the family, the number of Asteraceae species, and the ease of pollen recognition. The abundance of pollen within the flowering heads, the abundance of flowers on the plants, and the abundance of blooming plants year around makes this family a prime alternative foraging resource for not only boll weevils but all insects.

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References

Anonymous. 1998. Cotton Insect Control Guide. Mississippi Cooperative Extension Service, p. 11.

Beasley, C. A., and C. J. Adams. 1996. Field-based, degree-day model for pink bollworm (Lepidoptera: Gelechiidae) development. J. Econ. Entomol. 89: 881-890.

Beerwinkle, K. R., J. D. Lopez, Jr., and G. H. McKibben. 1996. Seasonal responses of boll weevils to pheromone traps in cropped and adjacent uncropped areas of east-central Texas. Southwest. Entomol. 21: 407-419.

Benedict, J. H., T. C. Urban, D. M. George, J. C. Segers, D. J. Anderson, G. M. McWhorter, and G. R. Zummo. 1985. Pheromone trap thresholds for management of overwintered boll weevils (Coleoptera: Curculionidae). J. Econ. Entomol. 78: 169-171.

Benedict, J. H., D. A. Wolfenbarger, V. M. Bryant, Jr., and D. M. George. 1991. Pollens ingested by boll weevils (Coleoptera: Curculionidae) in southern Texas and northeastern Mexico. J. Econ. Entomol. 84: 126-131.

Bottrell, D. G., R. E. Reeves, L. K. Almand, D. D. Hardee, and W. H. Cross. 1970. Studies of boll weevil populations and their movement in the High and Rolling Plains of Texas using male baited traps, 1968. Tex. Agric. Exp. Stn. MP-948.

Cate, J. R., and J. L. Skinner. 1978. The fate and identification of pollen in the alimentary canal of the boll weevil. Southwest. Entomol. 3: 263-265.

Chandler, L. D., and J. E. Wright. 1991. Longevity of the boll weevil (Coleoptera: Curculionidae) on cotton and alternate feeding sources under various temperature regimes in the laboratory. J. Econ. Entomol. 84: 1699-1704.

Coppedge, J. R., G. D. Jones, T. M. O'Neil, J. R. Raulston, and D. W. Spurgeon. 1996. Movement of boll weevils relative to cotton phenology, pp. 972-976. *In* P. Dugger and D. Richter [eds.], Proceedings Beltwide Cotton Production Research Conferences, Nashville, TN. National Cotton Council, Memphis, TN.

Cross, W. H., M. J. Lukefahr, P. A. Fryxell, and H. R. Burke. 1975. Host plants of the boll weevil. Environ. Entomol. 4: 19-26.

El-Zik, K. M., and V. Sevacherian. 1979. Modeling cotton growth and development parameters with heat units, pp. 234-235. *In* James M. Brown [ed.] Proceedings Beltwide Cotton Production Research Conferences, Phoenix, AZ. National Cotton Council, Memphis, TN.

Hardee, D. D. 1976. Boll weevil trap. U.S. Patent No. 3,987,577.

Hardee, D. D., and G. A. Herzog. 1997. 50th Annual Conference Report on Cotton Insect Research and Control, pp. 809-833. *In* P. Dugger and D. Richter [eds.], Proceedings Beltwide Cotton Production Research Conferences, New Orleans, LA. National Cotton Council, Memphis, TN.

Hardee, D. D., and G. A. Herzog. 1998. 51st Annual Conference Report on Cotton Insect Research and Control. *In* P. Dugger and D. Richter [eds.], Proceedings Beltwide Cotton Production Research Conferences, San Diego, CA. National Cotton Council, Memphis, TN. In Press.

Hardee, D. D., and E. B. Mitchell. 1997. Boll weevil, *Anthonomus grandis* Boheman (Coleoptera: Curculionidae): A summary of research on behavior as affected by chemical communication. Southwest. Entomol. 22: 466-491.

Hardee, D. D., W. H. Cross, and E. B. Mitchell. 1969. Male boll weevils are more attractive than cotton plants to boll weevils. J. Econ. Entomol. 62: 165-169.

Hardee, D. D., W. H. Cross, P. M. Huddleston, and T. B. Davich. 1970. Survey and control of the boll weevil in West Texas with traps baited with males. J. Econ. Entomol. 63: 1041-1048.

Hardee, D. D., G. H. McKibben, R. C. Gueldner, E. B. Mitchell, J. H. Tumlinson, and W. H. Cross. 1972. Boll weevils in nature respond to grandlure, a synthetic pheromone. J. Econ. Entomol. 65: 97-100.

Hardee, D. D., G. H. McKibben, and P. M. Huddleston. 1975. Grandlure for boll weevils: Controlled release with a laminated plastic dispenser. J. Econ. Entomol. 68: 477-479.

Hardee, D. D., A. A. Weathersbee, III, J. M. Gillespie, G. L. Snodgrass, and A. R. Quisumbing. 1996. Performance of trap designs, lures, and kill strips for the boll weevil (Coleoptera: Curculionidae). J. Econ. Entomol. 89: 170-174.

Henneberry, T. J., T. Meng, and L. A. Bariola. 1988. Boll weevil: grandlure trapping and early-season insecticide applications in relation to cotton infestations in Arizona. Southwest. Entomol. 13: 251-259.

Johnson, D. R., and M. E. Gilreath. 1982. Boll weevil, *Anthonomus grandis grandis* Boheman, pheromone trapping as an index of population trends. J. Ga. Entomol. Soc. 17: 429-433.

Jones, R. W. 1997. Pollen feeding by the boll weevil (Coleoptera: Curculionidae) following cotton harvest in East Central Texas. Southwest. Entomol. 22: 419-429.

Jones, G. D., and J. R. Coppedge. 1996. Pollen feeding by overwintering boll weevils, pp. 976-977. *In* P. Dugger and D. Richter [eds.], Proceedings Beltwide Cotton Production Research Conferences, Nashville, TN. National Cotton Council, Memphis, TN.

Jones, G. D., J. R. Coppedge, and D. Gryder. 1997. Foraging resources of overwintering boll weevils in Crockett and Munday, Texas, pp. 980-981. *In* P. Dugger and D. Richter [eds.], Proceedings Beltwide Cotton Production Research Conferences, New Orleans, LA. National Cotton Council, Memphis, TN.

Jones, G. D., D. D. Hardee, and J. R. Coppedge. 1998. Spring-time boll weevil foraging resources. *In* P. Dugger and D. Richter [eds.], Proceedings Beltwide

Cotton Production Research Conferences, San Diego, CA. National Cotton Council, Memphis, TN. In Press.

Jones, D., and W. L. Sterling. 1979. Temperature thresholds for spring emergence and flight of the boll weevil. Environ. Entomol. 8: 1118-1122.

Jones, R. W., J. R. Cate, E. M. Hernandez, and E. S. Sosa. 1993. Pollen feeding and survival of the boll weevil (Coleoptera: Curculionidae) on selected plant species in northeastern Mexico. Environ. Entomol. 22: 99-108.

Leggett, J. E., W. A. Dickerson, K. P. Burnham, S. H. Roach, A. R. Hopkins, and F. R. Planer. 1988. Boll weevil (Coleoptera: Curculionidae): Emergence profile of overwintered weevils measured by grandlure-baited traps and predicting total emergence. Environ. Entomol. 17: 903-910.

Mitchell, E. B., and D. D. Hardee. 1974. In-field traps: A new concept in survey and suppression of low populations of boll weevils. J. Econ. Entomol. 67: 506-508.

Mitchell, E. B., P. M. Huddleston, N. M. Wilson, and D. D. Hardee. 1973. Boll weevils: Relationship between time of entry into diapause and time of emergence from overwintering. J. Econ. Entomol. 66: 1230-1231.

Parajulee, M. N., L. T. Wilson, D. R. Rummel, S. C. Carroll, and P. J. Trichilo. 1996. Climatic data-based analysis of boll (Coleoptera: Curculionidae) overwintering survival and spring emergence. Environ. Entomol. 25: 882-894.

Porter, P. M., M. J. Sullivan, and L. H. Harvey. 1996. Cotton cultivar response to planting date on the southeastern coastal plain. J. Prod. Agric. 9: 223-227.

Ridgway, R. L., L. A. Bariola, and D. D. Hardee. 1971. Seasonal movement of boll weevils near the High Plains of Texas. J. Econ. Entomol. 64: 14-19.

Ridgway, R. L., W. A. Dickerson, J. R. Brazzel, J. E. Leggett, E. P. Lloyd, and F. R. Planer. 1985. Boll weevil pheromone trap captures for treatment thresholds and population assessments, pp. 138-141. *In* James M. Brown [ed.], Proceedings Beltwide Cotton Production Research Conferences, New Orleans, LA. National Cotton Council, Memphis, TN.

Rummel, D. R., J. R. White, and G. R. Pruitt. 1978. A wild-feeding host of the boll weevil in West Texas. Southwest. Entomol. 3: 171-175.

Rummel, D. R., J. R. White, S. C. Carroll, and G. R. Pruitt. 1980. Pheromone trap index system for predicting need for overwintered boll weevil control. J. Econ. Entomol. 73: 806-810.

SAS Institute. 1989. SAS/STAT User's Guide, version 6, 4th version, vol. 2. SAS Institute, Cary, NC.

Slosser, J. E., R. Montandon, D. R. Rummel, L. T. Wilson, and T. W. Fuchs. 1996. Survival of diapausing and nondiapausing boll weevils (Coleoptera: Curculionidae) subjected to freezing temperatures. Environ. Entomol. 25: 407-415.

Smith, J. W. 1998. Boll weevil eradication: Area-wide pest management. Ann. Entomol. Soc. Am. 91: 239-247.

Stoner, A. 1968. *Sphaeralcea* spp. as hosts of the boll weevil in Arizona. J. Econ. Entomol. 61: 1100-1102.

Tumlinson, J. H., D. D. Hardee, R. C. Gueldner, A. C. Thompson, P. A. Hedin, and J. P. Minyard. 1969. Sex pheromones produced by male boll weevils: isolation, identification, and synthesis. Science 166: 1010-1012.

Walker, J. K. 1959. Some observations of the development of the boll weevil on the wine cup, *Callirhoe involucrata* (Nutt.) A. Gray. J. Econ. Entomol. 56: 755-756.

Table 1. Interaction of proximity of traps to cotton and plant phenology on boll weevil trap captures. Washington County, MS (1995-1997).

Year	Time period[2]	No. weevils/trap/wk for time period at distance[1]: 1[3]	2[4]	3[5]	$\bar{x}$
1995	1	17	6	11	11
	2	18	20	52	30
	3	1	2	5	3
	4	4	9	9	7
	5	125	84	84	98
	Total	165	121	161	149
	6	110	44	6	53
1996	1	1	0	0	<1
	2	1	1	5	2
	3	0	0	1	<1
	4	1	3	26	10
	5	95	94	147	112
	Total	98	98	179	125
	6	66	22	10	33
1997	1	3	2	2	2
	2	17	12	29	19
	3	1	1	2	1
	4	1	2	5	3
	5	110	89	129	109
	Total	132	106	167	134
	6	---	---	---	---
x for all 3 years	1	7	3	4	5
	2	12	11	29	17
	3	1	1	3	2
	4	2	5	13	7
	5	110	89	120	106
	Total	132	109	169	137
	6	88	33	7	43

[1] Trap distances from cotton: 1: $\leq$ 15 m; 2: > 15 m - < 400 m; 3: 1 - 5 km

[2] Time Periods:

	1995	1996	1997
1	18 Mar - 20 May	23 Mar - 18 May	9 Mar - 24 May
2	21 May - 1 Jul	14 May - 29 Jun	25 May - 28 Jun
3	2 Jul - 29 Jul	30 jun - 27 Jul	
4	30 Jul - 19 Aug	28 Jul - 17 Aug	29 Jun - 26 Jul
5	20 Aug - 28 Oct	18 Aug - 2 Nov	27 Jul - 16 Aug
6	29 Oct - 30 Dec	3 Nov - 28 Dec	17 Aug - 31 Oct

[3] 1995: 20 traps through 30 Sep, 9 traps 1 Oct-31 Dec; 1996: 20 traps through 12 Oct, 9 traps 13 Oct-21 Mar 97; 1997: 17 traps through 30 Oct.
[4] 1995: 5 traps through 30 Sep, 4 traps 1 Oct-31 Dec; 1996: 4 traps 13 Oct-21 Mar 97; 1997: 9 traps through 30 Oct.
[5] 1995 and 1996: 8 traps through 30, 28 Sep; 4 traps 1 Oct and 29 Sep through 24, 22 Mar 96, 97; 1997: 8 traps 23 Mar-30 Oct.
[6] $\bar{x}$ for 1995-1996.

Table 2. Influence of plant phenology and direction on boll weevil trap captures in Washington County, MS (1995-1997)

Inclusive dates	Core field	No. boll weevils/trap/week at Different directions from core field: North	East	South	West	$\bar{x}$[1]
				1995		
18 Mar - 20 May	62	11	4	21	9	11
21 May - 1 Jul	96	52	5	19	11	22
2 Jul - 29 Jul	3	5	<1	1	1	2
30 Jul - 19 Aug	26	9	3	3	3	5
20 Aug - 28 Oct	297	92	66	131	103	98
Sub-total	484	169	78	175	127	138
29 Oct - 30 Dec	55	6	12	19	13	12
Total	539	175	90	194	140	150
				1996		
23 Mar - 18 May	5	<1	<1	<1	<1	<1
19 May - 29 Jun	14	8	<1	<1	1	2
30 Jun - 27 Jul	1	1	<1	<1	<1	<1
28 Jul - 17 Aug	5	26	1	<1	2	3
18 Aug - 2 Nov	243	272	52	114	77	129
Sub-total	268	307	54	115	81	139
3 Nov - 28 Dec	12	1	1	2	21	6
Total	280	308	55	117	102	145
				1997		
9 Mar - 24 May	28	16	1	3	2	6
25 May - 28 Jun	45	29	6	20	12	17
29 Jun - 26 Jul	1	2	<1	1	1	1
27 Jul - 16 Aug	2	5	<1	2	2	2
17 Aug - 31 Oct[2]	122	129	57	171	85	110
Sub-Total	198	181	65	197	102	136
				$\bar{x}$ for 1995 - 1997		
9 Mar - 24 May	32	9	2	8	4	6
25 May - 1 Jul	52	30	4	13	8	14
2 Jul - 29 Jul	2	3	<1	1	1	1
30 Jul - 19 Aug	11	13	2	2	2	5
20 Aug - 31 Oct	229	164	58	139	88	112
1 Nov - 31 Dec[3]	34	3	6	10	17	8
Total	360	222	72	173	120	146

[1] Mean of all 4 directions.
[2] Traps removed 31 October 1997.
[3] $\bar{x}$ for 1995 - 1996.

Table 3. Number of overwintered boll weevils captured (19 Mar-31 Jul 1995) in traps at core field and at 1.6 km intervals for 13 km north in boll weevil emergence and movement study, Washington County, MS

Week of	No. weevils captured/trap at: Core field[a]	N-1	2	3	4	5	6	7	8	$\bar{x}$[b]
19 Mar	8	4	0	0	1	1	0	0	0	0.8
26 Mar	17	17	1	2	2	0	0	0	0	2.8
02 Apr	38	29	10	31	9	5	1	6	3	11.8
09 Apr	16	0	1	2	1	1	0	0	2	0.9
16 Apr	20	13	1	0	1	1	0	0	0	2.0
23 Apr	81	42	9	14	14	6	2	6	4	12.1
30 Apr	16	34	24	7	6	5	1	6	7	11.2
07 May	145	46	24	15	31	9	15	22	24	23.2
14 May	210	87	70	29	32	8	13	26	35	37.5
21 May	286	207	120	79	99	62	29	29	52	84.6
28 May	105	50	101	97	96	61	48	20	19	61.5
04 Jun	132	180	221	139	184	43	45	35	49	112.0
11 Jun	29	34	63	21	16	16	15	3	7	21.8
18 Jun	14	7	12	14	14	9	8	7	5	9.5
25 Jun	10	32	34	47	25	22	10	4	10	23.0
02 Jul	3	15	26	12	6	5	5	5	0	9.2
09 Jul	2	13	21	15	7	8	5	1	3	9.1
16 Jul	2	0	1	0	0	1	0	0	0	0.2
23 Jul	4	0	1	3	0	0	0	0	4	1.0
30 Jul	8	1	2	2	1	0	0	0	0	0.8
Total	1166	811	742	529	545	263	197	170	224	

[a] $\bar{x}$ of two traps.
[b] $\bar{x}$ of N1-N8.

Table 4. Number of overwintered boll weevils captured (24 Mar-31 Jul 1996) in traps at core field and at 1.6 km intervals for 13 km north in boll weevil emergence and movement study, Washington County, MS

	No. weevils captured/trap at:									
Week of	Core field[a]	N-1	2	3	4	5	6	7	8	$\bar{x}$[b]
24 Mar	1	0	0	0	0	0	0	0	0	0.0
31 Mar	1	0	0	0	0	0	0	0	0	0.0
07 Apr	0	0	0	0	0	0	0	0	0	0.0
14 Apr	3	1	0	0	0	0	0	0	0	0.1
21 Apr	6	0	0	0	0	0	0	0	0	0.0
28 Apr	9	1	0	0	0	0	0	0	0	0.1
05 May	10	0	0	0	0	0	0	0	0	0.0
12 May	12	6	0	0	1	0	0	0	0	0.9
19 May	22	1	0	1	0	0	0	0	0	0.2
26 May	40	14	2	15	7	0	2	3	0	5.4
02 Jun	6	26	20	16	3	0	1	3	1	8.8
09 Jun	6	6	3	13	3	0	2	0	0	3.4
16 Jun	6	27	25	20	5	0	0	1	0	9.8
23 Jun	1	11	6	11	1	0	2	2	0	4.1
30 Jun	2	4	2	6	0	2	0	0	0	1.8
07 Jul	1	0	0	0	0	0	0	0	0	0.0
14 Jul	1	3	0	0	0	0	0	0	0	0.4
21 Jul	0	1	1	1	0	1	1	0	0	0.6
28 Jul	2	7	0	0	0	0	1	0	1	1.1
Total	129	108	59	83	20	3	9	9	2	

[a] $\bar{x}$ of two traps.
[b] $\bar{x}$ of N1-N8.

Table 5. Number of overwintered boll weevils captured (23 Mar-1 Aug 1997) in traps at core field and at 1.6 km intervals for 13 km north in boll weevil emergence and movement study, Washington County, MS

	No. weevils captured/trap at:									
Week of	Core field[a]	N-1	2	3	4	5	6	7	8	$\bar{x}$[b]
23 Mar	1	0	0	0	0	0	0	0	0	0.0
30 Mar	20	2	1	1	0	0	0	0	0	0.5
06 Apr	2	2	0	0	0	0	0	0	0	0.2
13 Apr	2	5	0	1	0	0	0	0	0	0.7
20 Apr	1	0	0	0	0	0	0	0	0	0.0
27 Apr	10	20	0	0	2	0	0	0	0	2.8
04 May	43	40	11	3	0	0	0	0	0	6.8
11 May	44	34	6	4	1	0	0	0	0	5.6
18 May	49	26	0	1	0	1	0	0	0	3.5
25 May	87	37	44	46	26	23	5	4	5	23.6
01 Jun	54	90	34	37	16	21	2	9	8	27.1
08 Jun	62	55	24	54	23	37	17	12	8	28.8
15 Jun	48	94	33	51	5	38	16	45	37	39.9
22 Jun	18	98	5	33	8	32	15	4	7	25.5
29 Jun	0	17	9	17	7	5	1	1	3	7.5
06 Jul	0	4	0	1	0	0	0	0	0	0.6
13 Jul	0	0	0	0	0	0	0	0	0	0.0
20 Jul	3	3	0	0	0	0	0	1	0	0.5
27 Jul	1	0	1	0	0	0	0	0	0	0.2
Total	445	527	168	249	88	157	56	76	68	

[a] $\bar{x}$ of two traps.
[b] $\bar{x}$ of N1-N8.

Table 6. Dates of measurable rainfall in boll weevil emergence and trapping study (Washington County, MS; 1995)

Day/Month	Amt. of Rainfall (in)	Day/Month	Amt. of Rainfall (in)
27 Mar	0.55	01 Jun	1.46
29 Mar	0.03	02 Jun	0.04
04 Apr	0.12	11 Jun	0.18
05 Apr	Trace	12 Jun	1.47
11 Apr	2.05	21 Jun	0.16
19 Apr	0.08	28 Jun	0.29
20 Apr	2.63	29 Jun	0.35
21 Apr	2.15	30 Jun	0.07
22 Apr	0.13	01 Jul	0.04
23 Apr	2.45	05 Jul	1.85
29 Apr	0.01	06 Jul	2.54
01 May	0.01	10 Jul	0.08
02 May	0.01	14 Jul	0.06
04 May	0.63	21 Jul	0.79
05 May	0.06	22 Jul	0.10
07 May	0.08	27 Jul	0.25
09 May	0.09	29 Jul	0.12
16 May	0.13		
19 May	0.18		
26 May	Trace		
27 May	0.12		
30 May	0.30		
31 May	1.51		

Table 7. Dates of measurable rainfall in boll weevil emergence and trapping study (Washington County, MS; 1996)

Day/Month	Amt. of Rainfall (in)	Day/Month	Amt. of Rainfall (in)
25 Mar	2.14	02 Jun	2.23
26 Mar	0.06	08 Jun	0.11
29 Mar	0.1	09 Jun	0.16
31 Mar	0.46	10 Jun	0.02
01 Apr	0.46	13 Jun	0.12
04 Apr	0.01	14 Jun	0.03
05 Apr	0.02	19 Jun	2.30
06 Apr	0.38	25 Jun	0.06
13 Apr	0.81	27 Jun	0.21
15 Apr	0.88	14 Jul	0.01
20 Apr	0.78	15 Jul	0.46
21 Apr	0.64	21 Jul	0.09
23 Apr	1.54	23 Jul	0.04
29 Apr	0.05	24 Jul	0.02
30 Apr	0.35	25 Jul	0.50
11 May	1.35	26 Jul	0.06
28 May	0.35	27 Jul	0.03
29 May	0.75	28 Jul	0.11
		29 Jul	0.25
		31 Jul	1.75

Table 8. Dates of measurable rainfall in boll weevil emergence and trapping study (Washington County, MS; 1997)

Day/Month	Amt. of Rainfall (in)	Day/Month	Amt. of Rainfall (in)
19 Mar	0.72	01 Jun	0.02
26 Mar	0.45	10 Jun	1.34
28 Mar	0.20	11 Jun	0.71
05 Apr	0.45	13 Jun	0.33
06 Apr	0.65	17 Jun	0.19
23 Apr	0.35	18 Jun	0.18
24 Apr	0.10	20 Jun	0.01
25 Apr	0.05	29 Jun	0.93
26 Apr	0.82	30 Jun	0.45
27 Apr	0.75	06 Jul	0.19
28 Apr	1.16	09 Jul	0.43
29 Apr	0.13	10 Jul	0.29
03 May	2.25	14 Jul	0.01
20 May	0.32	17 Jul	0.01
21 May	0.02	18 Jul	0.19
22 May	0.01	23 Jul	1.37
24 May	0.13	30 Jul	0.44
25 May	0.07		
27 May	0.80		
28 May	1.52		
29 May	0.33		
31 May	0.39		

Table 9. Percent females during major part of boll weevil emergence and movement period in 1996 and 1997 in the Delta of Mississippi

Week of (1996)	% females	Week of (1997)	% females	$\bar{x}$
14 Apr	92	13 Apr	58	75
21 Apr	56	20 Apr	35	46
28 Apr	57	27 Apr	44	50
05 May	25	04 May	52	38
12 May	45	11 May	52	48
19 May	52	18 May	49	50
26 May	34	25 May	51	42
02 Jun	52	01 Jun	49	50
09 Jun	29	08 Jun	50	40
16 Jun	72	15 Jun	48	60
23 Jun	36	22 Jun	50	43
30 Jun	68	29 Jun	57	62
07 Jul	100	06 Jul	33	66
14 Jul	78	13 Jul	--	78
21 Jul	100	20 Jul	82	91
28 Jul	59	27 Jul	100	80
04 Aug	86	03 Aug	89	88
11 Aug	73	10 Aug	73	73
18 Aug	77	17 Aug	59	68
25 Aug	66	24 Aug	53	60
01 Sep	59	31 Aug	56	58
08 Sep	58	07 Sep	65	62
15 Sep	58	14 Sep	65	62
22 Sep	56	21 Sep	65	60
29 Sep	51	28 Sep	60	56
06 Oct	53	05 Oct	59	56
13 Oct	48	12 Oct	57	52
20 Oct	45	19 Oct	55	50
27 Oct	47	26 Oct	53	50
$\bar{x}$	60	$\bar{x}$	57	58

Table 10. Seasonal and overall totals of pollen collection and identification, Washington County, MS, 1996-1997

	Results during:				
Factor	Spring	Summer	Fall	Winter	Overall Total
# sites	71	248	479	23	821
# boll weevils processed	240	1,043	3,718	80	5,081
# sites that had boll weevils with pollen	68	220	408	14	710
% with pollen	96	89	85	61	87
# pollen grains	2,057	6,185	32,742	256	41,240
mean # pollen grains	30	28	80	18	156
# pollen types	104	126	187	14	301
mean # pollen types	7	5	5	2	19
# pollen types identified	84	109	147	12	226
# types unknown	20	17	40	2	75
# pollen families represented	47	60	60	10	82
# pollen genera represented	64	65	89	7	132
# pollen species represented	12	15	13	1	29

Table 11. Frequency of occurrence calculated for the most common plant families encountered in Mississippi boll weevils, 1996-1997

	Frequency in			
Family	Spring	Summer	Fall	Winter
Anacardiaceae	32.35	25.40	56.62	
Asteraceae	58.82	51.21	92.16	90.00
Brassicaceae	13.24	2.02	0.74	13.04
Cheno-Am	16.18	27.42	49.51	4.35
Cyperaceae	4.41	18.55	13.97	
Euphorbiaceae	1.47	1.61	9.31	13.04
Fabaceae	29.41	4.84	6.62	
Fagaceae	76.47	39.11	4.17	
Juglandaceae	32.35	9.68		
Malvaceae		31.85	34.80	
Moraceae	20.59	2.42	1.47	
Oleaceae	45.59	15.32	1.96	
Poaceae	58.82	71.37	40.44	17.39
Potamogetonaceae		3.63	21.81	
Salicaceae	47.06	15.73	3.19	4.35
Ulmaceae	14.71	12.50	30.64	
Vitaceae	20.59	2.02	5.64	

Table 12. Relative frequency calculated for the most common plant families encountered in Mississippi boll weevils, 1996-1997

	Relative frequency in			
Family	Spring	Summer	Fall	Winter
Anacardiaceae	4.59	10.32	38.50	
Asteraceae	8.33	20.82	62.67	9.00
Brassicaceae	1.88	0.82	0.50	3.00
Cheno-Am	2.29	11.15	33.67	1.00
Cyperaceae	0.63	7.54	9.50	
Euphorbiaceae	0.21	0.16	6.33	1.30
Fabaceae	4.17	1.97	4.50	
Fagaceae	10.83	15.90	2.83	
Juglandaceae	4.58	3.93		
Malvaceae		12.95	23.67	
Moraceae	2.92	0.98	1.00	
Oleaceae	6.46	6.23	1.33	
Poaceae	8.33	29.02	27.50	4.00
Potamogetonaceae		1.48	14.83	
Salicaceae	6.67	6.39	2.17	1.00
Ulmaceae	2.08	5.08	20.83	
Vitaceae	2.92	0.82	3.83	

Table 13. Plant families, genera, and species of pollen grains found in Mississippi boll weevils by season

Taxa[1]	Collected in: Spring	Summer	Fall	Winter
Acanthaceae				
Ruellia			X[2]	
Aceraceae				
Acer				
negundo	X	X		
Alismataceae		X	X	X
Sagittaria	X	X	X	
Amaranthaceae				
Alternanthera			X	
Anacardiaceae				
Rhus	X	X	X	
glabra			X	
Schinus	X			
Toxicodendron	X	X	X	
diversilobium			X	
radicans			X	
Apiaceae	X	X	X	
Polytaenia	X			
Apocynaceae		X	X	
Aquifoliaceae				
Ilex	X	X	X	
Araceae			X	
Araliaceae				
Aralia				
spinosa			X	
Arecaceae		X		
Asteraceae	X	X	X	X
Ageratina			X	
Ambrosia			X	X
trifida	X			
Artemisia	X	X	X	X
Aster			X	
Bidens			X	
Circium	X			
Doelleringia			X	
Helianthus			X	
Iva			X	X
Polymnia			X	
Solidago			X	
Taraxacum	X		X	
Balsaminaceae			X	
Impatiens			X	
Berberidaceae				
Berberis		X		
Betulaceae	X	X		
Alnus		X	X	
Betula	X	X	X	
Carpinus				
caroliniana	X	X		
Ostrya				
virginiana	X	X	X	
Brassicaceae	X	X	X	X
Brassica	X	X	X	X
Caprifoliaceae				
Sambucus				
canadensis[3]	X	X		
Lonicera		X		
Viburnum	X	X		
Caryophyllaceae		X	X	X
Stellaria	X			
Chenopodiaceae				
Chenopodium		X	X	
Cheno-Am[4]	X	X	X	X
Cistaceae				
Helianthemum			X	

Table 13. Continued

Taxa[1]	Collected in: Spring	Summer	Fall	Winter
Clusiaceae		X		
Hypericum	X	X	X	
Convolvulaceae				
Convolvulus				
equitans				X
Cornaceae				
Cornus	X			
drummondii	X			
Cucurbitaceae		X		
Cucurbita		X		
Cupressaceae/				
Taxodiaceae[5]	X	X	X	X
Cyperaceae	X		X	
Carex	X			
Cyperus			X	
Ebenaceae				
Diospyros	X	X		
virginiana	X			
Eqisetaceae				
Equisetum		X	X	
Ericaceae		X	X	
Euphorbiaceae			X	
Acalypha		X	X	X
hederacea		X		
Croton			X	
Euphorbia			X	
Sapium				
sebiferum	X	X		
Fabaceae	X	X	X	
Acacia	X		X	
Dalea			X	
Gleditsia	X	X		
Glycine max		X	X	
Medicago	X		X	
Melilotus	X	X	X	
Mimosa		X		
Robinia			X	
Sesbania	X	X	X	
Trifolium	X	X	X	
dubium	X	X		
Vicia	X			
Fagaceae			X	
Castanea		X		
Fagus	X	X		
Quercus	X	X	X	
Geraniaceae				
Erodium		X		
Grossulariaceae				
Itea			X	
Ribes			X	
Hamamelidaceae				
Liquidambar				
styraciflua	X	X	X	
Hydrophyllaceae		X	X	
Nemophila			X	
Juglandaceae				
Carya	X	X		
Juglans		X		
Lamiaceae	X	X	X	
Lentibulariaceae				
Utricularia	X			
Liliaceae		X	X	
Loganiaceae				
Buddleja			X	
Lythraceae		X		
Lagerstroemia				
indica			X	

Table 13. Continued

Taxa[1]	Collected in: Spring	Summer	Fall	Winter
Lythrum	X		X	
Magnoliaceae				
Magnolia		X	X	
Malpighiaceae		X		
Malvaceae		X	X	
Abutilon			X	
Gossypium				
hirsutum		X	X	
Hibiscus			X	
Malvaviscus			X	
Sida			X	
Meliaceae				
Melia				
azedarach	X		X	
Menispermaceae				
Menispermum			X	
Moraceae	X	X		
Broussonetia	X			
Morus	X	X	X	
Myricaceae				
Morella	X	X		
Nyctaginaceae	X			
Abronia	X			
Nymphaeaceae				
Nuphar			X	
Nyssaceae				
Nyssa	X	X	X	
Oleaceae				
Fraxinus	X	X	X	
Ligustrum		X		
Onagraceae				
Oenothera	X			
Papaveraceae		X		
Hypercoum	X			
Papaver				
Pinaceae				
Pinus	X	X	X	
Tsuga			X	
Plantaginaceae				
Plantago		X		
Platanaceae				
Platanus	X	X	X	
Poaceae[6]	X	X	X	X
Zea				
mays		X	X	
Polemoniaceae		X	X	
Polygalaceae				
Polygala				
cymosa		X		
Polygonaceae		X	X	
Brunnichia			X	
Polygonum		X	X	
Rumex	X	X		
Portulacaceae				
Portulaca	X		X	
Potamogetonaceae		X	X	
Potamogeton		X		
Primulaceae			X	
Ranunculaceae	X	X	X	
Clematis	X	X	X	
Ranunculus			X	
Rhamnaceae				
Berchemia	X	X		
scandens				
Ceanothus			X	
americanus	X	X		
Frangula				

Table 13. Continued

Taxa[1]	Collected in: Spring	Summer	Fall	Winter
Rosaceae	X	X	X	
Photinia	X			
Prunus	X			
Rosa			X	
Rubus	X			
Rubiaceae				
Cephalanthus				
occidentalis		X	X	
Rutaceae				
Zanthoxylum			X	
Salicaceae				
Populus		X		
Salix	X	X	X	X
Sapotaceae				
Sideroxylon	X			
Saxifragaceae			X	
Saxifraga			X	
Scrophulariaceae		X		
Pedicularis				
canadensis		X		
Castilleja		X		
Solanaceae	X		X	
Solanum		X	X	
Tiliaceae				
Tilia		X		
Typhaceae				
Typha		X		
angustifolia			X	
Ulmaceae	X			
Celtis	X	X	X	
Planera			X	
aquatica			X	
Ulmus	X	X		
crassifolia			X	
Urticaceae		X		
Urtica	X		X	
Verbenaceae		X	X	
Callicarpa			X	
Phyla	X		X	
Verbena			X	
Violaceae				
Viola	X		X	
Vitaceae				
Ampelopsis			X	
Vitis	X	X		

[1] Common names are listed alphabetically in Table 14.
[2] "X" indicates presence of the taxon in samples from that season.
[3] Two different *Sambucus canadensis* pollen types were encountered. There are several varieties of this species in the United States. Unfortunately, the APMRU Pollen Reference Collection does not have reference material for the varieties.
[4] Most Chenopodiaceae and Amaranthaceae pollen grains are very similar and the majority of time no differentiation was made. However, when the grains are very different, a distinction was made.
[5] No differentiation between Cupressaceae and Taxodiaceae pollen was made.
[6] Only a few members of the grass family can be differentiated to the generic level; therefore, all grass pollen, except corn, was lumped together under Poaceae.

Table 14. Family, genera, and species names with common names of plants identified in pollen analyses in Mississippi, 1996-1997

Taxon	Common Name
Abronia	sand verbena
Abutilon	indian mallow
Acacia	acacia
Acalypha	three-seeded mercury
Acalypha hederacea	?
Acanthaceae	acanthus family
Acer negundo	box elder
Aceraceae	maple family
Ageratina	?
Alismataceae	arrowhead or water Plantain family
Alnus	alder
Alternanthera	chaff flower
Amaranthaceae	amaranth family
Ambrosia	ragweed
Ambrosia trifida	giant ragweed
Ampelopsis	peppervine
Anacardiaceae	sumac family
Apiaceae	parsley family
Apocynaceae	dogbane family
Aquifoliaceae	holly family
Araceae	arum family
Aralia spinosa	hercules' club, devil's walking stick
Araliaceae	ginseng family
Arecaceae	palm family
Artemisia	sagebrush, wormwood
Aster	aster
Asteraceae	sunflower family
Balsaminaceae	touch-me-not family
Berberidaceae	barberry family
Berberis	barberry
Berchemia scandens	rattan vine
Betula	birch
Betulaceae	birch family
Bidens	bur marigold
Brassica	mustard
Brassicaceae	mustard family
Broussonetia	paper mulberry
Brunnichia	eardrop vine
Buddleja	butterfly bush
Callicarpa	beautyberry
Caprifoliaceae	honeysuckle family
Carex	sedge
Carpinus caroliniana	American hornbeam, blue beech
Carya	hickory, pecan
Caryophyllaceae	pink family
Castanea	chinquapin
Castilleja	indian paintbrush
Ceanothus americanus	New Jersey tea
Celtis	hackberry
Cephalanthus occidentalis	button bush
Chenopodiaceae	goosefoot family
Chemo-Am	
Chenopodiaceae	goosefoot, pigweed
Amaranthaceae	amaranth family
Chenopodium	goosefoot, pigweed
Circium	thistle
Cistaceae	rockrose family
Clematis	clematis
Clusiaceae	St. John's wort family
Convolvulaceae	morning glory family
Convolvulus equitans	bindweed
Cornaceae	dogwood family
Cornus	dogwood
Cornus drummondii	rough leaf dogwood
Croton	croton
Cucurbita	gourd
Cucurbitaceae	gourd family
Cupressaceae	cypress family (includes junipers)
Cyperaceae	sedge family
Cyperus	flat sedge

Table 14. Continued

Taxon	Common Name
Dalea	dalea
Diospyros	persimmon
Diospyros virginiana	common persimmon
Doelleringia	?
Ebenaceae	ebony family
Eqisetaceae	horsetail family
Equisetum	horsetails
Ericaceae	heath family
Erodium	stork's bill
Euphorbia	spurge
Euphorbiaceae	spurge family
Fabaceae	legume or bean family
Fagaceae	beech family
Fagus	beech
Frangula, SY= Rhamnus	buckthorn
Fraxinus	ash
Geraniaceae	geranium family
Gleditsia	locust
Glycine max	soybean
Gossypium	hirsutum cotton
Grossulariaceae	?
Hamamelidaceae	witch-hazel family
Helianthemum	rockrose
Helianthus	sunflower
Hibiscus	rose mallow, hibiscus
Hydrophyllaceae	waterleaf family
Hypercoum	?
Hypericum	St. John's-wort
Ilex	holly
Impatiens	touch-me-not
Itea	sweet-spire
Iva	sump weed, marsh elder
Juglandaceae	walnut family
Juglans	walnut
Lagerstroemia indica	crepe myrtle
Lamiaceae	mint family
Lentibulariaceae	bladderwort family
Ligustrum	privet
Liliaceae	lily family
Liquidambar styraciflua	sweetgum
Loganiaceae	logania family
Lonicera	honeysuckle
Lythraceae	loosestrife family
Lythrum	loosestrife
Magnolia	magnolia
Magnoliaceae	magnolia family
Malpighiaceae	malpighia family
Malvaceae	mallow family
Malvaviscus	wax mallow
Medicago	bur clover
Melia azedarach	chinaberry
Meliaceae	mahogany family
Melilotus	sweet clover
Menispermaceae	moonseed family
Menispermum	moonseed
Mimosa	mimosa, cat's claw
Moraceae	mulberry family
Morella, SY=Myrica	wax myrtle
Morus	mulberry
Myricaceae	myrtle family
Nemophila	baby blue eyes
Nuphar	splatter dock
Nyctaginaceae	four-o'clock family
Nymphaeaceae	water lily family
Nyssa	blackgum
Nyssaceae	blackgum family
Nyctaginaceae	four-o'clock family
Nymphaeaceae	water lily family
Nyssa	blackgum
Nyssaceae	blackgum family
Oenothera	evening primrose

Table 14. Continued

Taxon	Common Name
Oleaceae	olive family
Onagraceae	evening primrose family
Ostrya virginiana	hop-hornbeam
Papaver	poppy
Papaveraceae	poppy family
Pedicularis canadensis	lousewort
Photinia	photinia
Phyla	frog fruit
Pinaceae	pine family
Pinus	pine
Planera aquatica	water elm
Plantaginaceae	plantain family
Plantago	plantain
Platanaceae	plane-tree family
Platanus	sycamore
Poaceae	grass family
Polemoniaceae	phlox family
Polygala cymosa	?
Polygalaceae	milkwort family
Polygonaceae	knotweed family
Polygonum	smartweed
Polymnia	leaf-cup
Polytaenia	prairie parsley
Populus	cottonwood
Portulaca	purslane
Portulacaceae	purslane family
Potamogeton	pondweed
Potamogetonaceae	pondweed family
Primulaceae	primrose family
Prunus	plum
Quercus	oak
Ranunculaceae	crowfoot family
Ranunculus	buttercup
Rhamnaceae	buckthorn family
Rhus	sumac
Rhus glabra	smooth sumac
Ribes	currant, gooseberry
Robinia	locust
Rosa	rose
Rosaceae	rose family
Rubiaceae	madder family
Rubus	dewberry
Ruellia	ruellia
Rumex	dock
Rutaceae	citrus family
Sagittaria	arrowhead
Salicaceae	willow family
Salix	willow
Sambucus canadensis	common elderberry
Sapium sebiferum	Chinese tallow
Sapotaceae	sapodilla family
Saxifraga	saxifrage
Saxifragaceae	saxifrage family
Schinus	pepper tree
Scrophulariaceae	figwort family
Sesbania	rattlebox
Sida	sida
Sideroxylon, SY=Bumelia	ironwood
Solanaceae	nightshade family
Solanum	nightshade
Solidago	goldenrod
Stellaria	chickweed
Taraxacum	basswood
Taxodiaceae	linden family
Tilia	sumac
Tiliaceae	poison oak
Toxicodendron	poison ivy
Toxicodendron diversilobium	clover
Toxicodendron radicans	small hop clover
Trifolium	dandelion
Trifolium dubium	bald cypress family
Tsuga	hemlock
Typha	cat-tail
Typha anguistifolia	narrow leaf cat-tail
Typhaceae	cat-tail family
Ulmaceae	elm family
Ulmus	elm
Ulmus crassifolia	cedar elm
Urtica	nettle
Urticaceae	nettle family
Utricularia	bladderwort
Verbena	vervain, verbena
Verbenaceae	vervain family
Viburnum	viburnum
Vicia	vetch
Viola	violet
Violaceae	violet family
Vitaceae	grape family
Vitis	grape
Zanthoxylum	hercules club
Zea mays	corn

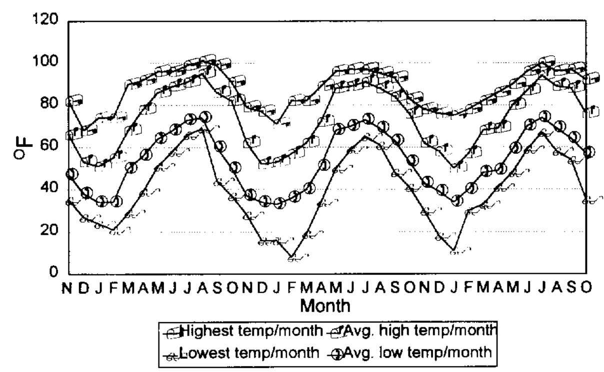

Figure 1. Maximum and minimum single readings and average maximum and minimum temperatures per month from Nov. 1994 through October 1997 (Stoneville, MS).