SEASONAL DYNAMICS OF INSECT COMMUNITY STRUCTURE IN TEXAS HIGH PLAINS COTTON

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Abstract

An understanding of the seasonal dynamics of the community structure of canopy-dwelling cotton insects is important in developing an ecologically intensive pest management strategy. The fundamental understanding of seasonal cotton insect community structure dynamics is useful for better-informed management decision-making. It was hypothesized that cotton canopy-dwelling insect community structure in the Texas High Plains changes over the cotton growing season. A study in furrow-irrigated cotton characterizing season-long fluctuations in the canopy-dwelling insect community was conducted at the Texas AgriLife Research and Extension Center at Lubbock, Texas during 2008. Insect samples were collected from 200 row-ft sections of cotton (40-inch row spacing) using a Keep it Simple Sampler (KISS). Six samples were collected on each of 11 weekly sampling dates during the cotton growing period of 5 July to 24 September 2008. This study revealed that the canopy-dwelling insect community in cotton is mainly comprised of insects from the orders Coleoptera, Hemiptera, Diptera, Neuroptera, Hymenoptera, Lepidoptera, Orthoptera, and Homoptera. Within these orders, 54 discrete families were identified. Members of Coleoptera, Hemiptera, and Diptera appeared in the greatest abundances. Analysis revealed insect community structure variation with cotton phenological stage. As such, insect management decision-making in cotton production may vary throughout cotton's phenological growth stages. Information produced in this study may be valuable in developing a holistic, ecologically intensive approach to management of target pest species, while considering the entirety of the canopy-dwelling cotton insect community.

Introduction

Cotton, *Gossypium hirsutum* L., is a major agronomic crop in the Texas High Plains (THP). The THP region constitutes the world's most concentrated region of cotton production. Approximately 39.7% of the United States cotton was produced in Texas in 2009 according to NASS (2010), while 67% of Texas cotton is produced in the THP (EPA 2009). Annual total cotton acreage in the THP is ~1.8 million acres (Williams 2009). The agroecosystem in the region represents the largest virtually contiguous patch of cotton in the world, and as such, is largely a monoculture. The cotton agroecosystem comprises numerous ecologically and economically important insect communities. Following boll weevil eradication and adaptation of transgenic cotton cultivars, the need for pesticide applications in the region have been greatly reduced (McCorkle 2008). Reduced area-wide pesticide use resulted in increases in the populations of secondary pests such as plant bugs, which, in the past, had their populations inadvertently suppressed with application to control key pests including boll weevils and the Heliothine complex (Parajulee 2004). Despite reduced pesticide use, insect pests remain a consideration in cotton production. During the last decade, cotton yield losses due to arthropod pests in the Texas High Plains ranged from 1-22% (Parajulee 2008). Regional percent cotton yield loss due to insects in 2008 was 0.38%, accounting for 21,148 bales lost (Williams 2009). Insect pests not only cause yield losses, but due to additional costs of managing and controlling them, production costs increase as well.

An insect community is the set of insect populations inhabiting a defined area. The field crop ecosystem comprises various biotic communities such as insect community, plant community, microbial community, etc. The insect community from a cotton field can be categorized into different groups based on their locations; examples include aerial, canopy-dwelling, and ground-dwelling communities. It was hypothesized that the cotton canopy-dwelling insect community structure in the Texas High Plains changes over the cotton growing season. Cotton insect community structure in the Texas High Plains has not been adequately characterized. An understanding of local and regional patterns of variation in community structure is essential for the development of ecologically intensive pest management strategies in cotton. Earlier research has focused extensively on studying specific pest species and their populations as opposed to whole communities. The purpose of this study was to determine the community structure of cotton canopy-dwelling insects, and to examine the effect of cotton phenology on the insect community structure.

Materials and Methods

This 2008 study was carried out at the Texas AgriLife Research and Extension Center at Lubbock. A furrow-irrigated cotton field was selected for this study. Cotton variety FiberMax 9063B2F was planted on 12 May 2008 and managed with standard cotton production practices in the region. Six samples were collected on each of 11 weekly sampling dates during the cotton growing period of 5 July to 24 September. Samples were collected using a Keep It Simple Sampler (KISS), which is a handheld pneumatic sampling device, in this case made locally by modifying an Echo® PB-265 backpack leaf blower (nominal air flow rating: 458 cubic feet per minute, or cfm) with an insect collecting mesh net (Beerwinkle et al. 1997). This sampling method is limited in that it can exclude tiny insects from being collected or counted during the sampling process. In addition to adhering to the sampling cloth, tiny insects are difficult for sample processors to see among other extraneous plant material found in the samples. The KISS unit can only capture insects from the upper canopy of cotton plants that are blown into a collecting net. Thus, the ground dwelling insects, insects covered in by plant tissues or flowering structures, and very small insects such as thrips, aphids and whiteflies were not collected in the samples. Thus this study was limited to the larger cotton canopy-dwelling insect fauna. Samples were stored in Zip-Loc® bags at -10°C until processed. Insects were separated from superfluous sample material, counted, and identified, minimally, to family level using morphological and taxonomic keys, as well as high-resolution digital photographs taken using a Dino-Lite USB Digital Microscope and Minresco AM-413ZT polarizing portable imaging system and accompanying DinoCapture software (Mineralogical Research Co.). Only adult insects were counted. To serve as voucher specimens, insects were preserved in 70% denatured ethyl alcohol-filled glass vials or pinned. Voucher specimens are maintained at the Texas AgriLife Research and Extension Center, Cotton Entomology Program in Lubbock, TX. Data were analyzed with Analysis of Variance (ANOVA) and principle component analysis, and means were separated using the PROC GLM procedure (SAS Institute 2009).

Results and Discussion

A total of 66 samples were collected from cotton on 11 different sampling dates during the 2008 cotton growing season. In total, 13,200 row-ft of cotton were sampled in this study. The total number of insect specimens captured was 3,736. It was determined that the canopy-dwelling insect community in cotton is comprised of insects from the orders Coleoptera, Hemiptera, Diptera, Neuroptera, Hymenoptera, Lepidoptera, Orthoptera, and Homoptera (Figure 1). Members of Coleoptera, Hemiptera, and Diptera appeared in the greatest abundances. Within all orders, 54 discrete families were identified and only two insect samples were yet to be identified to their family. Orders with the most families were Coleoptera, with 13 families, Hemiptera, with 10 families, and Diptera, with 9 families (Table 1). Family compositions of these three orders are illustrated in Figures 2-4.

Overall, the observed seasonal dynamics of the canopy-dwelling insect community structure fluctuated during the sampling period (Figure 5). Initially, this seems to support the original hypothesis of seasonal variation in insect populations increasing rapidly at the beginning of the sampling period, peak towards the middle, and then decline rapidly towards the end, mimicking a standard growth curve (Figure 5). Insect populations of orders Orthoptera and Homoptera remained steadily low in cotton throughout the sampling period. All orders, with the exception of Coleoptera, were detected in very low numbers at sampling initiation. However, Coleopterans were detected in high numbers initially, with 333 found on 5 July 2008 (Figure 5). Many hooded beetles and lady beetles were found at that time, which contributed greatly to the Coleopteran numbers. Their numbers decreased during the remainder of July and early August but then reached another peak in mid-August before declining again. Interestingly, Dipterans peaked around the first week of August, and then declined suddenly, after which another, but much smaller peak, was reached several weeks later in late August (Figure 5). It is possible that crop moisture conditions may have induced a temporary period of habitat unsuitability for Dipterans. Hemipterans peaked at the highest level, and were followed by Coleopterans, Dipterans, Neuropterans, Hymenopterans, Lepidopterans, Homopterans, and finally, Orthopterans (Figure 5).

Figure 6 illustrates principle component cluster analysis of sample composition with respect to insect families. Each group of colored dots represents six samples from each specific sample week; thus, there are eleven groups, one group per week. Samples from Weeks 1 and 11 were of similar family composition, although composition varied widely throughout other sampling weeks (Figure 6). Thus, insect community structure varied with cotton phenology, and a larger assortment of insects was observed during the mid-season cotton flowering and fruiting stages. Wider

variation in family composition was seen between individual samples during Weeks 5 and 8 (Figure 6). It is possible that this was observed due to rapid population changes occurring at that time, as can be seen in Figure 5.

Analysis of these data revealed that insect community structure varies with cotton phenological stage. This is important information to bear in mind when considering insect pest management. Since the insect community structure is not rigid and constant, ecologically sound management decisions should be tailored with this knowledge. Information produced in this study may be valuable in developing a holistic, ecologically intensive approach to management of target pest species, while considering the entirety of the canopy-dwelling cotton insect community.

Summary

It was hypothesized that cotton canopy-dwelling insect community structure in the Texas High Plains changes over the cotton growing season. Eleven weeks of sampling during the 2008 cotton growing season revealed that the canopy-dwelling insect community in cotton is comprised of insects from the orders Coleoptera, Hemiptera, Diptera, Neuroptera, Hymenoptera, Lepidoptera, Orthoptera, and Homoptera. Within these orders, 54 discrete families were identified. Overall, the seasonal dynamics of cotton canopy-dwelling insect community structure fluctuated. Insect community structure varied with cotton phenology, and a greater variety was observed during the cotton flowering and fruiting periods. This is important information to bear in mind when considering insect pest management.

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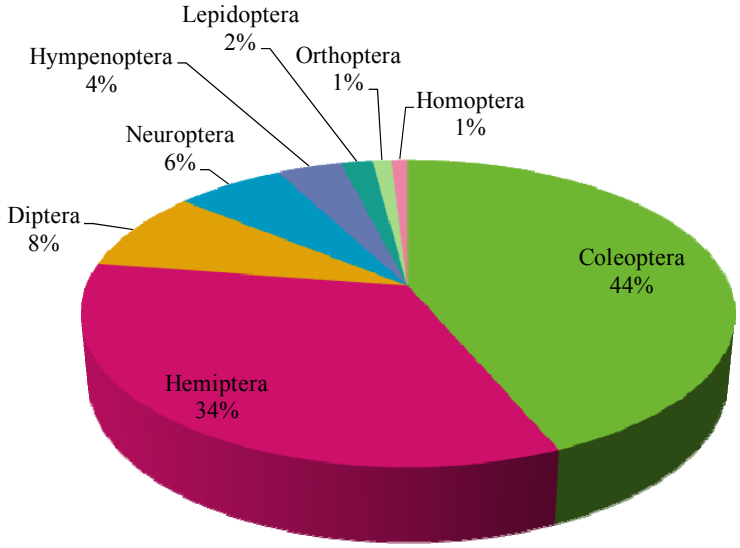

Figure 1. Cotton canopy-dwelling insect community composition break down shown by insect order and percentage of individual specimens found in each order, Lubbock, Texas, 2008.

Table 1. Total number of cotton canopy insects representing different insect orders and families during the period of 5 July to 24 September 2008, Lubbock, TX.

Order	Family	Number
Coleoptera	Anthicidae	837
	Bruchidae	481
	Carabidae	157
	Cerambycidae	61
	Chrysomelidae	52
	Cicindelidae	12
	Coccinellidae	7
	Curculionidae	6
	Dermestidae	5
	Elateridae	4
	Melyridae	3
	Nitidulidae	2
	Tenebrionidae	1
Hemiptera	Lygaeidae	188
	Miridae	36
	Anthocoridae	31
	Nabidae	28
	Pentatomidae	14
	Raehopalid	12
	Berytida	5
	Reduviidae	2
	Colletidae	2
	Largidae	743
	Thyreocoridae	243
Diptera	Dolichopodidae	154
	Syrphidae	67
	Agromyzidae	15
	Culicidae	12
	Otitidae	8
	Tachinidae	8
	Esilidae	5
	Bombyliidae	5
	Tephritidae	4
Homoptera	Achilidae	5
	Cicadellidae	6
	Dictyopharidae	5
	Membracidae	20
Hympenoptera	Apedidae	37
	Barchidae	8
	Braconidae	21
	Colletidae	3
	Formicidae	35
	Halictidae	10
	Ichneumonidae	23
	Sphecidae	3
	Vespidae	2
Lepidoptera	Gelechiidae	9
	Noctuidae	57
	Pieridae	1
Neuroptera	Chrysopidae	231
	Hemerobiidae	7
Orthoptera	Acrididae	4
	Gryllidae	35
	Tettigoniidae	2

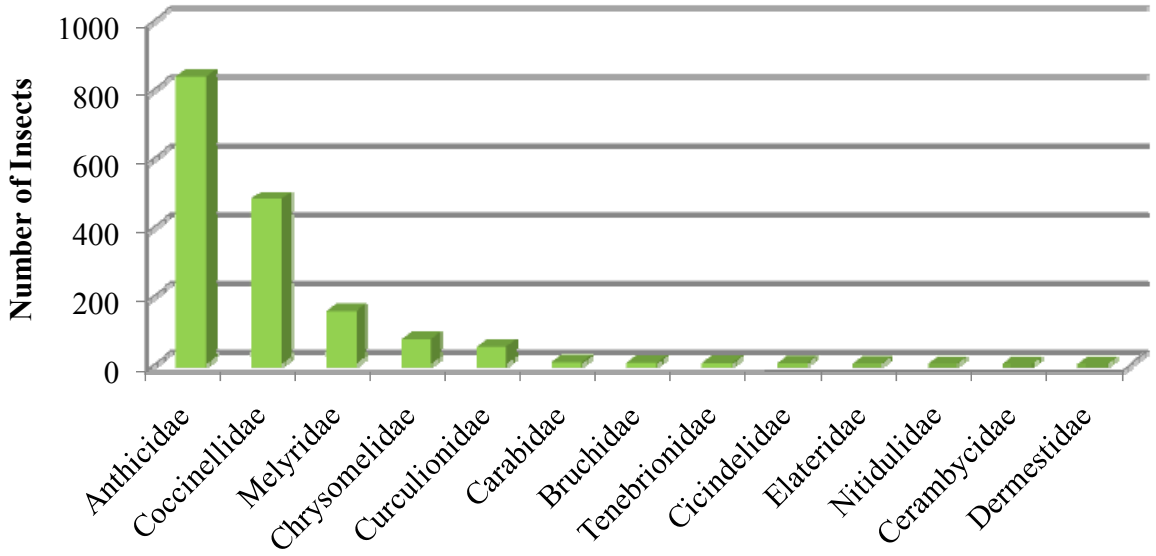

Figure 2. Number of individual insect specimens per family in order Coleoptera. The specimens were collected with a KISS unit, from the cotton canopy during the period of 5 July to 24 September 2008, Lubbock, TX.

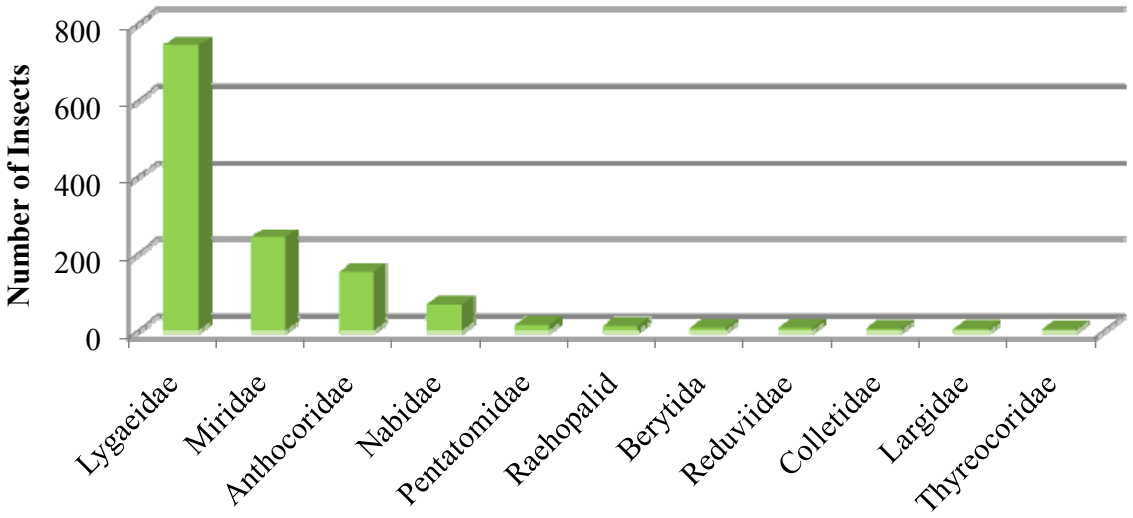

Figure 3. Number of individual insect specimens per family in order Hemiptera. The specimens were collected from the cotton canopy during the period of 5 July to 24 September 2008, Lubbock, TX.

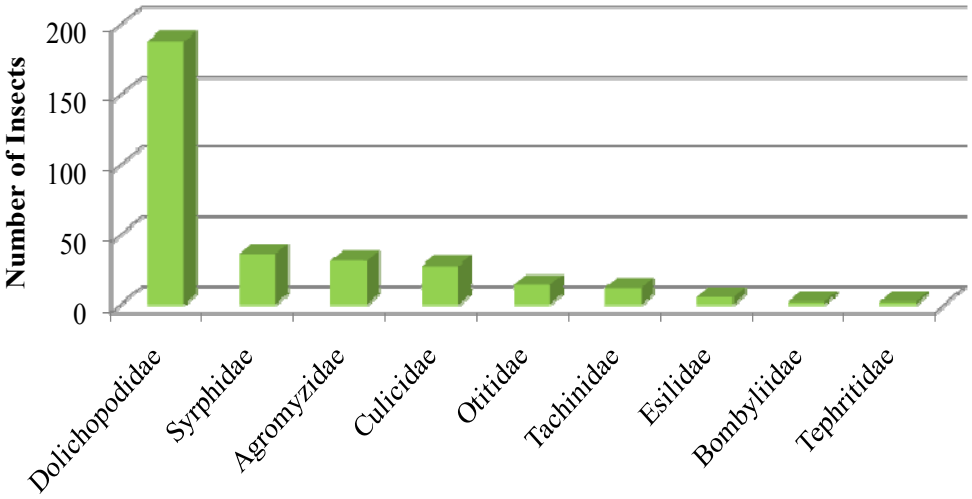

Figure 4. Number of individual insect specimens per family in order Diptera. The specimens were collected from the cotton-canopy during the period of 5 July to 24 September 2008, Lubbock, TX.

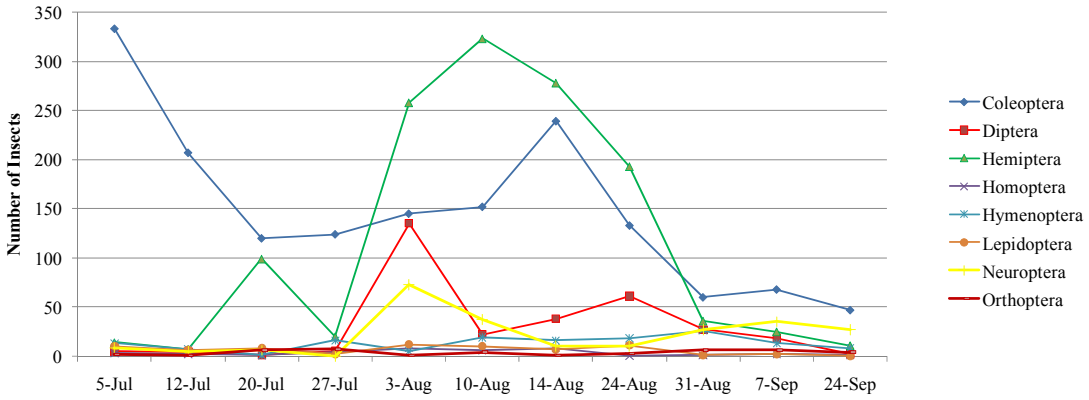

Figure 5. Temporal dynamics of insect populations sampled from cotton-canopy during the period of 5 July to 24 September 2008, Lubbock, TX.

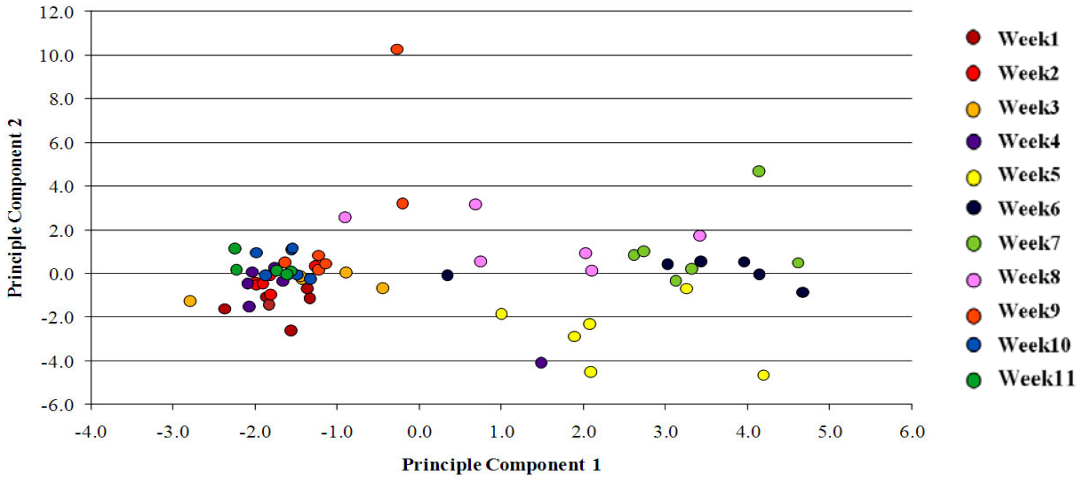

Figure 6. Temporal variation in community structure of cotton canopy-dwelling insects revealed by principal component analysis of insect family data collected during the period of 5 July (week 1) to 24 September (week 11).