A THIRTEEN YEAR ECOLOGICAL ANALYSIS (1987 - 2000) OF BIOTIC COMMUNITIES OF THE PECAN ORCHARD IN COLLEGE STATION, TEXAS

TZU-YIN LI and M. K. HARRIS

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TZU-YIN LI and M. K. HARRIS
Department of Entomology
Texas A&M University
College Station, Texas 77843 - 2475

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A thirteen years ecological analysis (1987 - 2000) of biotic communities of the Adriance Pecan Orchard in College Station, Texas.

Tzu-yin Li and M. K. Harris
Texas A&M University, Department of Entomology
College Station, Texas 77843-2475

ABSTRACT Although this paper was an ecological analysis for biotic community of the Adriance Orchard, but it was a representative of an artificial biotic community, the situation of the near by Brison Orchard and Story Orchard would be similar, It was also a valuable reference materials for pecan orchards in other areas. The unity of the terrestrial plant-animal community in the Adriance Orchard have been discussed and the importance of recognizing plants and animals as inter-related co-acting constituents of an integrated biotic community was stressed. The reasons for the community of Adriance Orchard were biotic have been properly explained. The total population of Adriance Orchard was made up of four major components: I. The plants including low grade plants. II. The invertebrates emphasizing insect predators and spiders. III. Vertebrates including amphibians, reptiles, birds, and mammals. This orchard in terms of stratified societies sub-divided into six definite societies: I. tree top society. II. Tree-trunk society. III. Shrub society. IV. Herb society. V. surface society. VI. Soil society. The concept of the biotic community possesses far-reaching implications in all the enterprises of economic biology, forestry, range administration, wild-life management and agricultural operations, generally, not to mention in detail the social sciences. A checklist of plants, invertebrates including insect predators and spiders, and vertebrates, respectively, was appended.

KEY WORDS Biotic community, food chain, predators, blackmargined aphid

Introductions

Community ecology deals with the relations between individuals and between species both of plants and animals and also with the relations between communities and their physical environments. At least 3 ranks of concrete communities can be distinguished in every region. The first and largest of these is a regional community that covers a considerable geographic area, perhaps including a biotic province, district, or a life belt; the stand then is a concreat community of lesser rank than the regional community. A stand is a grove of trees together with its associated plants and animals, a meadow, marsh or bog could be a stand (Dice, 1952), the pecan orchard is very close to a stand; The third and lowest rank of concrete community usually recognized is the microstand which are of various types and sizes and of numerous grades of ecologic importance, the smaller type of microstand may be cited each individual plant or animal which, together with its parasites and other associated species, constitutes a separate microstand (Dice, 1952). Plant

communities have been studied without attention to the animals, but the investigations of terrestrial animal communities without some consideration of plants is practically impossible. Animals and plants in any terrestrial environment are very intimately related, and the animal and plant communities are coexistent and may be considered together as a biotic association or community (Rasmussen, 1941).

Plants and animals are interdependent. Indeed, animals are likely to be more dependent on plants than on other animals, and plants more dependent on animals than on other plants. The concept of the biotic community possesses far-reaching implications in all the enterprises of economic biology, as forestry, agricultural operations, range administration, wild-life management, not to mention in the detail the social sciences (Taylor, 1935).

This paper deals with the results of a study of Adriance Pecan Orchard and its habitants. It is not only concerned with those species, but an attempt is also made to apply certain quantitative methods for this studies.

Physical Environment

Physiography. The pecan tree, *Carya illinoensis* (Wang.) K. Koch., are located in the Texas A&M University Plantation (Adriance Pecan Orchard) located about 26 km southwest of College Station. Texas. This orchard is about 8 hectares and are divided into two areas: treatment and control area. The investigation of blackmargined aphids and their predators were proceeded in the control area, and the biotic components (plants, invertebrates, vertebrates) in thewhole orchard. There are 18 rows, 21 columns and 110 pecan trees with 28 varieties (about 45 years old) in this orchard. The main varieties are "Stuart", "Success", "Desirable", "Mahan", and "Cheyenne".

The pecan orchard is surrounded on all sides except the southeast side by short-grass pastures grazing many cows daily, The southeast outside of the orchard are agricultural-pastoral area. There is a small stream flowing along the northwestern border near the orchard.

Climate: Table 12 and 13 shows monthly precipitation and temperature records at College Station, Texas 77841. Figure 1 shows average maximum and minimum summer temperature (pecan growing season) records during 1988 through 2000 for College Station, Texas.

Table 12. Climate records of temperature (F) at East Wood, College Station, Texas (Elevation: 320 feet).

	1988	1989	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Jan.	47.5	55.2	46.4	50.3	50.2	50.3	51.8	50.9	48.4	55.6	54.6	54
Feb.	52.6	48.6	55.2	55.9	53.9	52.5	56.5	58.3	52.9	53.9	60.8	60.3
Mar.	60.1	60.4	61.3	54.5	58.9	57.4	62	57.2	62.6	57.7	61.4	64.4
April	67.2	68.7	67.8	67.6	64.4	68.6	67.8	68.7	62.3	65.3	70.4	68
May	73.6	77.5	75.7	72.4	72.5	73.4	77.3	81.5	72.8	79.3	75	77.5
June	80.7	79.6	80.8	81.3	81.3	82.6	81	83.7	79.3	86.7	81.4	81.2
July	84.8	82.6	83.9	84.1	84.4	85.1	86	88	85	88.6	82.7	85.9
Aug.	87.4	82.4	84.5	81.4	86.3	82.9	86.4	85	84.3	85.2	86.8	86.5
Sep.	80.9	77.5	77.3	80.2	77.9	77.0	81.6	79.1	80.7	82.1	79.2	80.9
Oct.	71.2	70.8	71.5	68.3	68.2	70.2	71.2	71.9	69.5	71	69.1	72
Nov.	63.8	61.6	54.9	55.7	54.9	63.4	60.1	61.3	55.1	62.2	61.3	56
Dec.	54.5	42.6	49.4	52.1	50.0	55.1	55.4	55.8	49.1	51.8	52.4	45.2
Monthly mean Tem.	68.7	67.3	67.4	67.0	67.0	68.2	69.8	70.1	66.8	70.0	70.0	69.3

Table 13. Climate records of precipitation (inch) at East wood, College Station, Texas (Elevation 320 feet).

Jan.	0.5"	6.4"	15.6"	4.9"	6.0''	2.4"	3.3"	0.3"	2.9"	3.8"	1.0".	3.1"
Feb.	1.2"	1.1"	2.9"	9.7"	2.0"	2.7"	1.1"	0.4"	4.0"	5.2"	1.2"	3.1"
Mar.	2.9"	3.6"	2.3"	3.7"	3.6"	2.3"	3.3"	1.0"	3.4"	2.4"	3.6"	0.7"
Apr.	1.4"	1.0"	5.7"	3.9"	4.9"	1.8"	4.2"	4.7"	4.0"	1.2"	2.6'	2.6"
May	1.7"	4.0"	3.5"	6.3"	7.3"	5.5"	7.5"	0.6"	3.7"	0.1"	4.2"	2.0"
June	1.5"	4.2"	5.5"	5.2"	11.1"	3.7"	3.1"	2.3"	6.7"	0.005"	4.9"	5.6"
July	2.5"	3.0"	1.0"	0.9"	0.01"	0.1"	3.7"	1.9"	0.9"	0.7"	2.4"	2.5"
Aug.	0.3"	2.8"	2.7"	0.5"	0.1"	5.0"	1.0"	10.3"	0.8"	3.8"	0.8"	0.0"
Sept.	0.8"	0.8"	6.8"	0.9"	0.3"	3.7"	5.5"	1.6"	3.7"	7.6"	0.7"	0.2"
Oct.	1.1"	2.0"	2.9"	3.6"	5.0"	18.8"	1.5"	1.7"	4.9"	8.8"	1.6"	1.5"
Nov.	1.3"	1.7"	1.3"	4.8"	2.9"	0.86"	2.9"	3.6"	4.2"	6.6"	1.1"	3.5"
Dec.	2.7"	1.0".	7.5"	4.5"	2.4"	10.7"	6.6"	1.7"	2.9"	4.8"	1.5"	9.7"
Monthly Total Prep.	17.9"	30.6"	57.7"	48.9"	45.6"	57.4"	41.8"	30.0"	42.2"	45.3"	24.4"	31.7"

Fig. 1. showed the monthly average maximum and minimum summer temperature (C) during 1988 - 2000 in College Station, TX.

Materials and Methods

Surveys of predators and spiders on pecan clusters were conducted from June to September during 1987 through 2000 in Control Area of Adriance Orchard. The Control

Area received fertilization, N, Zn (mid April and early may), fungicide treatment (in August) and irregular mowing. Four pecan trees ('Stuart') were selected, six samples in different direction were chosen for each tree, and each sample contained ten compound leaves. Four pecan trees were surveyed twice weekly during June, July. August, and early September each year. Numbers of aphids and associated aphid's predators, parasitic arthropods, and spiders were recorded for identification.

The plant (fungi, mosses, ferns, epiphyte, herbaceous plants, grasses, shrubs, and vines) specimens bearing roots, flowers, or fruits were collected for identification during May through December following the surveys every years inside the whole 8 hectare pecan orchard.

The Checklist of Invertebrates besides insects and spiders and Vertebrates (amphibians, reptiles, birds, and mammals) were based on sight records in the whole orchard during 13 years. Some birds and mammals such as vultures, raccoons, weasels, and skunks were not necessary lived inside of the orchard, they usually came at night.

General Community Relationships

Animals are biotic factors external to the plant community - the view point of most plant ecologists; there are animal communities to which the plants are a portion of the habitat - the attitude of many animal ecologists; plants and animals are inter-related, co-acting constituents of an integrated biotic community, and were co-extensive to a large degree inter-dependent. All along, however, it is conceded that as plants, in addition to giving physiognomy to the biotic community, control the animals by means of food, cover, shelter, provision of breeding sites, the functions of the plant matrix will necessarily very largely rule (Phillips, 1931). Also, the biotic community is inter-related to the change of their outside climatic variations. Let's take some examples to explain this inter-relations through our 13 years studies in the Adriance Pecan Orchard.

Let's consider the inter-relation of plants with climatic factors and insects: About 110 pecan trees in this orchard are monoecious, male and female flowers are on the same trees. Female flowers, existing as spikes on the side of the shoot near its apex, have the potential of developing into nuts the grower will harvest 7 months later if provided they are pollinated, fertilized and properly cultivated. Pollination is mainly through wind blown, pollen grains carried by wind to the stigma during its receptivity. Obviously, pollen distribution is never ideal, chance pollination may occur with pollen from as far as 2 to 3 miles, therefore, wind direction is an important factor. Honey-bee (*Apis mellifica*) may also help pollination, but many factors will reduce the survival of bees: many natural enemies (Appendices: List of predators) such as *Polistes* sp. and *Vespula* sp.; Nectar and pollen sources will also limit the survival of honey bees, many wild flowers in the pastures originally are the honey bee's honey sources, but because of the pastures surround the Adriance Orchard being transferred into agriculture fields recently, the number of honey bees will be greatly reduced by man's intervention, when the bees are lower in numbers than normal, these pecan trees set poorer fruit crops than normal.

Let's take some examples of food relation within communities. One may define a food

chain as a sequence of species within a community, each member of which serves as food for the species next higher in the chain. In terrestrial communities certain food chains may be very simple, but when the primary herbivore is an invertebrate, the food chains may be very long and may also be extremely complex. Let's take a very practical example from the Adriance Pecan Orchard: the nymphs of different instar of yellow pecan aphid or blackmargined aphid feed on the compound leaves of pecan trees. This nymph is parasitized by parasitoid such as *Aphelinus perpallidus* Gahan (Aphelinidae), which, in turn, may be parasitized by another insect parasitoid. The final parasitoid, when it emerges as an adult, may happen to be caught and its juices sucked out by a spider (Appendices: Checklist of Spiders). The spider will possibly be captured by a wasp, *Polistes* sp.(Appendices: Checklist of Insect predator), to serve as food for its young. When the young wasp emerges it may be eaten by an insectivorous bird, such as *Bubulcus ibis* (Cattle Egret) (Appendices: Checklist of Birds). The bird in its turn may become a victim of a predaceous bird such as *Buteo jamaicensis* (Red-tailed hawk) (Appendices: Checklist of Birds) or mammal such as *Procyon lotor* (Raccoon) (Appendices: Checklist of Mammal). The food chain within the whole Adriance Pecan Orchard relating plants, invertebrates and vertebrates are more complicated than we have just discussed above(Fig. 2).

The relationship between the numbers of organisms and their position in the food chain of the community has been called the pyramid of numbers. The pyramid of numbers is especially evident in aquatic communities, where the basic producers of food are mostly 1-cell plants. In terrestrial communities, on the contrary, it often happens that certain herbivores are actually smaller and more numerous than the plants upon which they feed. This is true, for example, of most of the herbivorous insects (Dice, 19520). Certain species vary also in their food requirements during successive stages of their life history. The larvae of *Chrysoperla rufilabris* (Green lacewings) are important predators of aphids, mites, small larvae of Lepidoptera(caterpillars) and eggs of various insects, while adult feed only on honeydew, nectar and pollen. The concept of pyramid of numbers is not always fully applicable in natural communities.

Adriance Orchard Community

For research and economic reasons, Texas A&M University has created this Adriance pecan Orchard which is essentially designed to promote a favorable environment for growth and improved pecan nut yield and quality. Therefore, agricultural practices such as fertilizer, pesticide (besides control area), drainage, irrigation, mow, and harvesting are included. This is not a natural community. The orchard is locked when works done, but it is obviously half open, animals can get through wired fence ant times..

Vegetation (Appendices - A checklist of plants). Dominant plant is pecan trees (Carya *Illinoinensis*(Wang.) K. Koch Engelm. & Graebn.), of course, it was the only tree species with 27 varieties besides native one in this orchard, the dominant plants-pecan trees not only give physiognomy to the community, but provide protection, shelter, breeding sites and food to the insects and other animals. The sub-dominant plants were 29 species Herbaceous Plant; then came after the 9 species of grasses; one species of shrub and two species of

vines brought up the rear.

This pecan orchard community starts below ground in the basement level. The first visible level is the ground or forest floor, followed by the shrub and small tree levels, finally, the pecan tree canopy tops the forest. These inter-connected canopies compete for moisture, nutrients and sunlight. All the animals abound within these plant communities, but are seldom seen because of the dense vegetation. Community members depend upon each other, interactions take place within as well as between other communities.

The lower classes of plants are scattered everywhere in the orchard. The true fungi, most species of mushrooms, which carpet the floor of the orchard during late spring or late fall after rainfall. Squirrels, skunks and armadillos and turtles coming from outside may eat them during the short time when mushrooms are visible. Lichens (Algae and Fungi live together in one) and mosses both grow mostly on the pecan trunks and branches, they may grow on the logs, stones, or soil. The beautiful pecan trees are decorated with multi-colored fungi and lichens. Sometimes you can see another lower classes plant, the fronds of the royal fern growing in a circular cluster and bearing red-brown spores located near the border of this orchard.

There were at least 17 families, 34 genera, and 41 species of higher classes plants (Angiospermae) (Appendices - A checklist of plants) found in the orchard. The dominant Herbaceous Plant was *Ipomoea cordatotriloba* (Convolvulaceae, July, Au., Set., and Oct); sub-dominant were *Rapistrum rugosum* (Brassicaceae, Jan, May, Jn., Jl., Oct., Nov.) and *Parthenium hysterophorus* (Asteraceae, Jn., Sep., Oct., Nov.); then *Ratibida columnifera* (Asteraceae, May, Jl., Oct., Nov.); and *Verbena officinalis* (Verbenaceae, Jl., Oct.) Came after.

There were another herbaceous plant, *Tillandsia usneoides* L. (Bromeliaceae, Spanish Moss), it looked like a moss, but was not a true moss, a member of pineapple. It was the gray hairy plant which often draped over branches of pecan trees in summer. This plant depended on nutrients and moisture carried by the air, it was easily affected by air pollution. Because this plant grews upon another plant without taking nourishment from it, therefore called them epiphyte.

There were nine species of grasses belong to one family, Poaceae, and five genera: Bothriochloa , Leptochloa, Paspalum, Sorghum, and Urochloa, respectively. Only one species of shrub, *sesbania drummondii,* and two species of vines, *Ampelopsis arborea,* and *Vitis rotundifolia* in this orchard.

Grasses, herbaceous plants, shrubs, and vines underneath pecan trees provide host plants for many insect pests, predators to survive and continue their lifer circle in the winter; this vast, abundant green vegetative area also attracted many other vertebrates such as amphibian, reptilian, birds, and small mammals to come to this area, at the same times, these animals would also bring some beneficial or harmful effects to this orchard.

Table 14. Analysis of genus/ species relations in plant community.

Family	No. of species	No. of Genera	No. of Sp./Gen.	%Gen./only 1 sp.
Apiaceae	1	1	1	100
Asclepiadaceae	1	1	1	100
Asteraceae	13	10	1.3	70
Brassicaceae	1	1	1	100
Bromeliaceae	1	1	1	100
Convolvulaceae	1	1	1	100
Euphorbiaceae	2	1	2	0
Malvaceae	1	1	1	100
Onagraceae	2	2	1	100
Sapindaceae	1	1	1	100
Scrophulariaceae	1	1	1	100
Solanaceae	2	2	1	100
Verbenaceae	2	2	1	100
Poaceae	8	5	1.6	40
Juglandaceae	1	1	1	100
Fabaceae	1	1	1	100
Vitaceae	2	2	1	100
Total plants	41	34	1.15	89

The % of genera with only one species for plants was 89%, and the average numbers of species per genus was 1.15.

Invertebrates (Appendices - A checklist of invertebrates, table 1-11). The pecan is native to Texas, more than 20 species of insects such as pecan nut case bearer, pecan aphids, hickory shuck worm, and pecan weevil... caused damage to the leaves, nuts, twigs, buds, branches or bark of the pecan in Texas. To increase the productive potential of the pecan, trees must be protected from destructive insect pests. Natural enemy was one of the important control means. Therefore, the investigation of predators on pecan trees was proceeded during 1988-2000.

Spider: Table 1. showed the spiders collected for identification to species by years over 12 years (1988-2000).

There were 14 family, 34 genera, and 51 species of spiders (both hunting and web-making species) in our collections, included many unidentified genera and species among them (Appendices-A checklist of spiders).

Table 2-10 showed the spiders collected for identification to species by months from 1988-2000, respectively. The spiders were more abundant in June (97), July (87) and August (77), The density of spiders had a positive correlation to that of the blackmargined aphids in that periods of time.

Table 15 . Relation between the number of genera and species in fourteen spider families.

Family	No. of sp.	No. of gen.	No. of sp.per gen.	% of gen.with only 1 sp.
Anyphaenidae	2	2	1	50
Araneidae	8	6	1.4	66.6
Corinnidae	2	2	1	0
Gnaphosidae	3	3	1	100
linyphiid	3	2	1.5	50
Mimetidae	2	2	1	100
Miturgidae	1	1	1	100
Oxyopidae	1	1	1	100
Philodromidae	2	1	2	0
Pisauridae	1	1	1	100
Salticidae	12	7	1.7	16.6
Theridiidae	8	3	2.6	66.6
Thomisidae	5	2.5	2	50
Uloboridae	1	1	1	100
Total Spider	51	34.5	1.4	64.2 %

Table 15 showed that the dominant family of spiders was Salticidae, and sub-dominant families were Araneidae and Theridiidae. The average numbers of species per genus were 1.4. The percentage of genera with only one species present for fourteen families of spiders was 64.2. The difference in species/ genus frequencies between ecological surveys of relatively small region was attributed to existing competition between species of the same genus, resulting in a strong tendency for the species of any genus to be distributed as ecotypes in different habitats, or if not, to be unable to coexit permanently on the same area of the same habitat (Elton, 1946).

The dominant species of spider was *Hentzia palmarum* (Hentz) (Family Salticidae), sub-dominant species was *Tutaibo anglicanus* (Hentz)(Family Linyphiidae); the *Misumenops* sp.(Family Rhomisidae), *Philodromus* sp.(Family Philodromidae), and *Hibana* sp. (Family Anyphaenidae) were numerous (Table 1).

The density of spiders by years read as follows (Table 1):

Years	1988	1989	1995	1996	1997	1998	1999	2000
Density of spider	93	81	22	39	36	40	48	50

The number of spiders collected from 1991-1994 was not included because of the incomplete collection. The density of spider by years was varied, the density in 1988 was the highest and in 1995 was the lowest, and the trend sounds drop off year by year.

Jumping spiders and crab spiders feed on many different kinds of insects, including blackmargined aphids, yellow pecan aphids, caterpillars and occasionally beneficial insects. Jumping spider eggs are laid in silk sacs attached to rough bark, one generation a year. Crab spiders disperse by ballooning. Small spider are carried on strands of silk blown by the wind, one or two generations per year.

The biology of spiders is well-suited for pest control. Having arrived in a crop they will remain even when food is scarce, their low metabolic rate can be lowered by 30-40 percent without impairing performance, allowing them to survive for many months without food. When the pest arrive it can be rapidly exploited because the spider's distensible abdomen and capacity to store fats allow a doubling of weight over a short period. When prey are abundant many spider kill more than they need, prey items being incompletely consumed or abandoned. Webs trap can kill large numbers of aphids even though the spider does not feed on them (Sunderland 1988).

Insect Predator and Parasitoid There were 7 orders, 16 families, and 34 species of predators and parasitoid collected on pecan during 1988-2000.

Table 16. Relation between the number of genera and species in 16 insects families.

Family	No. of sp.	No. of gen.	No. of sp. per gen.	% of gen. with only 1 sp.
Coccinellidae	8	8	1	100
Syrphidae	2	2	1	100
Alydidae	2	2	1	100
Anthocoridae	1	1	1	100
Coreidae	2	2	1	100
Miridae	5	5	1	100
Reduviidae	3	3	1	100
Aphelinidae	1	1	1	100
Ichneumonidae	1	1	1	100
Formicidae	1	1	1	100
Polistidae	1	1	1	100
Vespidae	1	1	1	100
Chrysopidae	2	2	1	100
Hemerobiidae	2	2	1	100
Mantidae	1	1	1	100
Thysanoptera	1	1	1	100
Total insects	34	34	1	100

Table 16 showed the dominant family with more genera for insects was Coccinelidae, the sub-dominant was Miridae; but the dominant species with more numbers is *Chrysoperla rufilabris* (Chrysopidae), the sub-dominant was other predators in Coccinellidae and Miridae (Table 11). The average number of species per genus were 1, the percentage of genera with only one species present for 16 families of insects was 100, the competition

between insect species of the same genus was more severe than that of the spider species just as we have discussed previously.

Some important insect species would be discussed as follow:

Chrysoperla rufilabris of Neuroptera were the most abundant aphidophagous insect found associated with pecan aphids. Other natural enemies are discussed briefly and appear to have played a lesser role in affecting the population dynamic of aphids on pecan. The adult and larval chrysopid abundance was closely related to the population peak of the blackmargined aphid (Li 1990). The adult and eggs were found throughout the year including the winter. Eggs, larvae, and adult were present from June to November, and the largest number of adults occurred in July and August. Chrysopid eggs were deposited in groups of 2 to 12; usually 4 to 7, and rarely singly.

Two species of Hemerobiidae were collected, *Micromus subanticus* were more abundant.

The role of Neuroptera as aphid predators depends heavily on local conditions (New 1988). The efficacy of lacewings depends not only on the particular predator-prey combination, but also on ecological factors such as the age structure of the prey population, foliage density and height of the crop, incidence of parasitism, and climate. Far more attention has been paid to the predatory role of Chrysopidae than to that of Hemerobiidae. Generally, chrysopidae are larger and more conspicuous than Hemerobiidae, the biology of most species of hemerobiids is unknown. Polyphagy of chrysopids render them unsuitable for use in certain field situations, they will undoubtedly attack other natural enemies as well as the target prey. Complex patterns of dormancy may also limit their usage.

Five species of Coccinellidae were collected. Adult and larvae of each species were observed feeding on aphids. *Harmonia axyridis, Hippodamia convergens,* and *Cycloneda munda* were the most common species. The voracity of Coccinellidae is impressive with late instar larvae capable of consuming numbers of pecan aphids per day. Coccinellids are the most common and intensively studied predators on aphids. Aphidophagous coccinellids are ubiquitously found with aphids throughout the world. They are well known group biologically, but their significance in aphid population dynamics is poorly known. Evaluating the effectiveness of predators is difficult because aphid population dynamics cannot be observed in the absence of predation. More behavioral and ecological work is required of the type needed for population models in which the quantitative effects of the different natural enemies are separately determined (Frazer, 1988).

Larvae of two species of Syrphidae were found to be aphidophagous. A variety of field and laboratory methods have been used to evaluate syrphid effectiveness (Chambers 1988). Their impact on aphid population can be substantial and may be attributed to: (1) the mobility and searching ability of the adult females. (2) the habit in certain species of depositing eggs among the larval food. And (3) the rapid rise in voracity as larvae grow, the third instar of *Melanostoma corollae* killing 80-90 % of the total food consumed. Failure to recognize the importance of syrphid predation can arise because of the difficulties inherent in field sampling and methods of analysis do not bring human and syrphids into contact with one another. Typically, hover fly larvae are not active during daylight hours unless hungry, and some species rest lower down the plant, away from aphid colonies.

One species of Anthocoridae, *Orius insidiosus,* was found in catkins in April and May, adults are very small, 1/16 inch long, have a black 'V'-shaped mark on their back. Adult and nymphs have piercing sucking month parts that are used to suck fluid from their prey. Anthocorids are currently being used as part of control programs throughout the world in field crops, glasshouse, and stored products. *Orius* sp., although polyphagous, also show strong preferences when a choice of food is available. Thus *O. vicinus* feeds preferentially on mites and aphids; *O. tristicolor* is a particularly important predator of thrips, but will feed on mites and various aphids (Hodson 1988)..

Five species of Miridae were collected. Adults and nymphs of *Deraeocoris nebulosus* are predacious on a wide range of insects and mites including pecan aphids. This species overwinters as an adult in protected area such as under bark. Another 4 species were collected from catkins in April and may.

The quantity of pecan plant bug, *plagiognathus carye,* flower thrips, *Franklininiella occidentalis,* and other mirid insect on 1500 pairs of three-stalked catkin (male flowers were located) of pecan tree were checked and counted once for every two days from April 10 to May 8 in Adriance Orchard during 1991 and 1992. The most numerous among them were *P. caryae,* and *Frankliniella tritci.* The number of *P. caryae* was 4827 and 2395 in 1991 and 1992, respectively (Table 11). The number of *F. occidentalis* was 13424 and 7646 in the same periods. *P. caryae* and *F. occidentalis* both feed on catkins where the male flowers were located during pecan flowering season. *P. caryae* laid eggs underneath barks of pecan shoots thus plant tissues were damaged and resulted in malnutrition. Both species might consume pollens of anthers male flowers thus shifted the pollen shedding to an earlier or later time which cause the problems of female stigma receptivity. We also found some bigger mirids, *Lygocoris caryae* and green color mirids, *Orthotylus rumus,* they coexisted with *P. caryae. Neurocolpus* sp.and were collected accidentally during this collection. Some predators such as *Orius* sp. (Anthocoridae) and spiders also coexited with mirids.

Three species of Reduviidae were found feeding on pecan aphids. *Arilus cristatus* is big one, and have assassin broad mouth parts; *Sinea spinipes* and *Zelus exsanguis* both are small one. Two species of leaffooted bugs (Coreidae), *Acanthocephala femorata* and *Leptoglossus phyllopus,* the hind section of the hind legs is flattened into a leaf like segment, the adult of the previous one is more robust, hind legs contain spines, this species can feed on other insects.

One species of Aphelinidae, *Aphelinus perpallidus,* was reared from black mummies of *M. caryella,* they were encountered every year. The fire ants, *Solenopsis invicta,* were rarely encountered on the foliage of 45 years old pecan, probably because those canopies were too huge to reach them. We found in another pecan orchard that fire ants were encountered more frequently on the foliage of about 10-15 years old pecan trees. Fire ants feed on both pest and beneficial insects and honeydew, they also 'farm' aphids by driving away or killing beneficial insects that feed on them, their aggressive nature and painful sting interfere with orchard operations such as grafting, mowing, investigating and harvesting. Their overall impact in pecan is probably negative. Two species of paper wasp, *Polistes* spp.(Polistidae) and *Vespula* spp.(Vespidae), found nesting in and around pecan orchard, these wasps are generally considered beneficial because they feed on pest caterpillars and

other insects.

A very few occasion we found *Mantis* sp. (Mantidae) and their egg sac on pecan branches or leaves, mantis was a predator.

The relative usefulness of the various natural enemy species is, in most case, still to be determined. Some may prove to be of exceptional value such as Araneae and Chrysopidae, while the effectiveness of other may be limited by low density, poor timing in relation to the phenology of the aphid or a weak response to aphid density, such as Coccinellidae, Anthocoridae, Syrphidae, Reduviidae and certain Miridae. However, even these minor species, when taken together, may contribute significantly to aphid control (Sunderland 1988).

The role of predators as aphidophage is still un-assessed in many agro-ecosystems, and techniques for increasing their numbers and effectiveness have barely begun to be developed. Nevertheless, evidence for their importance is growing and it is likely that they will receive more attention in the future. For the possible implementation of biological control to the integrated pest management system for pecan aphids, continues studies of the distribution and biology of different natural enemy species of blackmargined aphid and yellow pecan aphid are needed.

Vertebrate (Appendices-A checklist of vertebrates (Villee, 1973))

Not many vertebrates found in this orchard it was due to merely a small pecan orchard; but because of the orchard linking up the outside environments through many different channels, therefore, some vertebrates were still involved. The relationship among amphibians, reptiles, mammals, pecan trees , insect pests and it's predators were closed related and should not be ignored. The most numerous and important vertebrates were birds, many of them fed on insect pest including some predators, some others preyed on small animals.

Amphibians Only three species of frog and toad were recorded. They fed on miscellaneous insects as none were particularly abundant. They capture insects and worms by flipping its forked tongue forward out of the mouth, whereupon the prey adhered to its sticky surface. They were usually terrestrial except in the breeding season. Toads were crepuscular in habits; they burrowed or took shelter by day and came out in the moist evening to feed upon insects. Southern Leopard Frog widely distributed throughout the State; Southern Gray Treefrog was relatively large tree frog, usually not on ground but in trees. They were found generally in the eastern half of the State; Gulf Coast Toad widely distributed throughout the southeastern portion of the State.

Reptiles Only 2 order, 7 species of reptiles were recorded. Lizards fed on insects using a long club-shaped tongue, but snakes differed from lizards most notably in being able to swallow animals several times their own diameter. Snakes used animal food such as frogs, toads, rodents, and small mammals. Turtles had no teeth; but their food, mostly flesh, could be grasped and torn by the sharp edges of the horny covering of the jaws. Ornate Box Turtle preferred pastures, invaded fields, widely distributed throughout the State. Texas Horned Lizard preferred crop lands, range and pastures, widely distributed throughout the

State, previously sold as pets, now protected by Texas law; Six-Lined Race Runner and Five-Lined skink occur mainly in the eastern half of the State. Texas snake preferred upland, wooded lands, invaded fields, found mainly in the eastern half of the State; Southern Copperhead preferred wooded lands, invaded fields, venomous, color and pattern variable, widely distributed throughout the State.

Birds (Appendices - Checklist of vertebrates; Banks, 1998; Dunn, 1996; Robison, 1990). Seventeen families, 34 genera, and 41 species of birds were the most common and the most likely to be seen year around in the Adriance Orchard. There were several characteristics for these birds: One was closely related to the pecan insect pests, many of them were insectivorous; another was their population numbers, they were abundant and widespread throughout the orchard and nearby area such as sparrows and grackles; other birds were less numerous but were easily seen or fun to watch such as mockingbird, the blue jay, the cardinal, the cattle egret, the hummingbirds, and the woodpeckers. Some birds would persist around a given area for a while, but they would also move on. In dealing with seasonal occurrence, we have given the times of year that the birds were most likely to be seen in this orchard.

Those birds in the checklist depended on our steady observation using field guide and binocular through 13 years. Most of these birds were not permanent resident in this orchard, they were frequently coming in and out of this orchard..Sometimes in the pecan's growing season during summer and august, many birds came in flocks, they were not only killing the insect pest including predators, but also harmed to the pecan nuts, therefore, the air cannon was used by technician to scare them.

Many of the birds we mentioned are insectivorous such as Cattle Egret feed on the insects that the cattle flush up from the grass and also picks insects off animals'(horse, cow...) backs; Turkey Vulture feed on carrion, and Red-tailed hawks with extraordinarily keen eyesight watched for rodents, lizards, snakes, and other small animals; Eastern Screech Owl hunted by their extremely sharp sense of hearing as well as excellent eyesight at night for mouse, lizard etc; Chimney Swift and Scissor-tail Flycatcher both caught flying insects; Red-bellied Woodpecker and Yellow-bellied Sapsucker both sharp bill were used to chisel out insect food; Yellow-billed cuckoo mainly fed on caterpillars and other insects. Some other birds such as Mourning Dove, Rock Dove, American Crow fed on vegetable food in the spring, and later on a local outbreak of pecan aphids. American Robin, House Sparrow fed on varied food: grains seeds, nuts, and also insects.

Economic ornithology has been carefully investigated by the US Bureau of Biological Survey, whose experts have gathered a great mass of statistics and other data concerning the food habits of birds, the object being to convey precise information as to which were the useful and which were the harmful species. It would be difficult to overstate the value of this work, for these researches demonstrated beyond peradventure the enormous usefulness of the birds in destroying insect pests which, but for this check of their natural rate of increase, would ruined every year many millions of dollars worth of crops, and threaten with defoliation and death many kinds of trees (Pearson, 1936).

Mammal Only 7 orders, 10 families and 14 species of mammals were recorded. The