INVESTIGATIONS OF SPIDER POPULATIONS IN GRAIN SORGHUMS IN RELATION TO INSECT CONTROL

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INVESTIGATIONS OF SPIDER POPULATIONS

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PREFACE

From a review of the literature it was evident that there was little information available on the role of spiders in connection with control of insects in field crops, with the exception of recent publications resulting from research in cotton fields by W. H. Whitcomb and others in Arkansas. Since spiders are so commonly found in grain sorghums, especially in the heads, investigations were begun in 1965 to determine if they were of economic importance in connection with this crop.

This research project was suggested by Dr. Harvey L. Chada, Professor and Investigations Leader, Entomology Research Division, U. S. Department of Agriculture, and other members of the Oklahoma State University Entomology staff. Deep appreciation is extended to Professor Chada for making this study possible and for advice throughout the study and in the preparation of the manuscript. My gratitude is also extended to Professors W. A. Drew, Department of Entomology, and Dale E. Weibel, Department of Agronomy, for their valuable criticism and suggestions in carrying on the research and in reviewing the manuscript. Monetary assistance was provided by the Entomology Research Division, U. S. Department of Agriculture and by the Department of Entomology, Oklahoma State University.

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INTRODUCTION

Grain sorghums are a relatively low-value-per-acre crop frequently subject to yield losses due to insect attack. Controls with recommended chemicals are not always practical because of prohibitive costs and possible toxic residues resulting from their use. Consequently, insect control in grain sorghums by methods other than with insecticides should be investigated.

It had been observed in examining sorghums for insect infestations that usually there were large numbers of spiders present on the plants and in the sorghum heads. This suggested the possibility of their economic importance in insect control in their fields. Nothing was known about the role of spiders in grain sorghums. W. H. Whitcomb and co-workers in Arkansas have recently shown that spiders were of economic importance in controlling insects in cotton fields. Therefore, in 1965, a research program was designed to investigate the role of spiders as possible factors in insect control in sorghum fields. The objectives were: (1) to develop techniques for collecting and conducting feeding tests, (2) to determine spider populations and species present in grain sorghum fields and on the sorghum plants throughout the growing season, (3) to determine locations on the plant inhabited by the several species collected, (4) to make observations on spider feeding habits in the field, and (5) to conduct laboratory feeding tests with spiders offered sorghum insects of economic importance.

REVIEW OF LITERATURE

Spiders associated with cotton

The spider fauna on cotton in Arkansas has been studied extensively, but the spider populations on other row crops have had very little study. This review of literature for the most part will be limited to cultivated crops.

Whitcomb, Exline and Hunter (1963) made a six-year study of species composition and density of spider populations of Arkansas cotton fields. The collection from the cotton fields contained 143 species in 19 families. Included in this collection were 82 hunting-form and 61 web-builder species. A seasonal abundance of some of the species was established, with some abundant early in the spring, others later in the fall, and some with two population peaks. Daily examinations of 50 plants showed an average population of approximately 3,374 spiders present per acre in the herb-shrub zone (vegetative area). The populations varied as the season progressed and were different from field to field.

Kagan (1943) reported 9 families with 36 species of spiders on cotton in central Texas. He reported that none of the spiders collected were observed feeding on the cotton boll weevil, Anthonomus grandis Boheman, although the black widow spider, Latrodectus mactans (Fabricius), was collected. Whitcomb et al. (1963a) stated that L. mactans was observed feeding on the cotton boll weevil in the field and in the

laboratory.

While working on the natural control of cotton insects in the area of College Station, Texas, Fletcher and Thomas (1943) reported that in numerous instances spiders caught the first instar larvae of the cotton bollworm, Heliothis zea (Boddie). In general, they stated that spiders are most apt to prey upon the larger larvae. The percentages of H. zea larvae preyed on by spiders in four successive years were as follows: (1937 - 11.7%), (1938 - 3.5%), (1939 - 7.3%), (1940 - 7.3%).

Clark and Glick (1961) tagged pink bollworm moths, Pectinophora gossypiella (Saunders), by feeding a radioactive carbohydrate solution to them. These moths were then released in a one-fourth acre cage or in fields with or without cotton plants. The tagged moths were then captured by means of near-ultraviolet light traps. Some spiders fed on these trapped moths and became secondarily tagged by the radioactive spiders near the tagged-moth release point. Nine families of radioactive spiders were collected.

Whitcomb and Bell (1964) studied the food and collection locations on the plant of 19 spider families in Arkansas cotton. Whitcomb, Exline, and Hite (1963) compared spider populations on the ground stratum in an Arkansas pasture and an adjacent cotton field. The ground stratum populations in the cotton field appeared to be considerably larger than in the adjacent pasture. These spiders were collected by means of pitfall traps. Twelve families composed of 64 species were taken in both habitats.

Spiders collected from other cultivated crops

Everly (1938) made a study on spiders associated with sweet corn

and reported that jumping spiders and crab spiders were abundant throughout the season. During the latter part of August the web-spinning spiders were most numerous. He reported that Tetragnatha laboriosa Hentz could be found on practically every corn plant. Nine families were taken in this study.

Hensley, Long, Roddy, McCormick and Concienne (1961) collected 18 families of spiders from Louisiana sugar cane fields. Specht and Dondale (1960) made comparison studies on spider populations in sprayed and unsprayed New Jersey apple orchards. From the webs of the fall web-worm, Hyphantria cunea (Drury), Whitcomb and Tadic (1963) collected 40 spider species representing 9 families, most of which were observed feeding on the larvae. Lovell (1915) reported spiders belonging to the family Thomisidae would attack large butterflies, dragonflies or stinging insects such as wasps, bumblebees and honeybees.

Spiders found in areas other than cultivated crops

Barnes (1953) while studying the ecological distribution of spiders in non-forest areas of North Carolina collected a total of 139 species of spiders belonging to 24 families. It was found that each plant community displayed a distinct spider population structure characterized by the presence of certain species and by the relative density which each exhibited.

METHODS AND MATERIALS

A one-acre plot of RS 610 (43 rows) and OK 612 (43 rows) hybrid grain sorghum was planted for this test. Observations on the occurrence of spiders were started when the sorghum plants were about six inches tall.

Pit traps as a collecting device

The pit traps, which were a modification of those used by Fenton and Howell (1957), were placed in the field on June 16, 1965. Each consisted of a beer can having the end, which had not been used for the original opening, cut out. A geotome (soil tube) was used to make a round hole in the ground between two plants in the grain sorghum row, the exact circumference and depth of the can. This can was then placed into the hole with the top even with the soil surface, and the dirt was tightly packed around the top. A plastic "Dixie" cup which fit tightly into the can so that it was held flush with the top and at ground level was used to hold the collecting solution. The collecting solution consisted of one cup of 40 per cent formalin, 5 drops of liquid detergent, and enough water to make 1 gallon. This solution was poured into the pit trap to about one-fourth inch from the top. A round metal cover five inches in diameter with one six-inch metal leg welded to the side was placed over the trap to keep out rain and debris and also slow down evaporation. The installed trap is shown in Figure 1.

Figure 1. Pit Trap and Cover in Place in the Sorghum Row

The pit traps were in the 11th, 22nd, and 33rd rows of each sorghum variety with 6 traps on each row, 27 feet apart. At one-week intervals, the material was collected and put into jars. Insects and spiders were then separated from debris by washing with warm water through a tea strainer. After further separation, the spiders were stored in 70 per cent alcohol.

Manual collection of spiders from plants

Beginning June 21, 1965, all spiders observed on the plants were collected manually. Ten plants in each sorghum hybrid were examined daily in the morning from the top of the plant to the ground. Each spider collected was placed in an individually numbered vial. Data recorded on each spider collected consisted of collection location on the plant and what it was or had been feeding on, if anything. Care was taken not to disturb the plant, to avoid losing spider specimens. After all visible spiders were collected, the sorghum head was opened, and spiders found therein were collected.

Collecting by use of Berlese funnels

A modification of the Berlese funnel was used to collect spiders from the sorghum heads. It consisted of a metal funnel 11 inches deep attached to the bottom of a cylinder having a diameter of 11 inches and a depth of 14 inches. The lower opening of the funnel was attached to the screw top of a one-quart glass fruit jar. The arthropods were forced out of the sample by heat from a 200-watt electric light bulb, and were collected in 70 per cent alcohol in the jar. The socket of this bulb was soldered to the center of a metal cover which fitted tightly over the top of the cylinder. The sample, which was composed of 10 sorghum heads, was supported by a 14-mesh wire screen at the bottom of the cylinder. The Berlese funnels used are shown in Figure 2.

Each sample of RS 610 and OK 612 sorghum heads was collected in a paper bag at predetermined locations throughout the fields. The paper bag was held under each head while it was being cut to catch all spiders

Figure 2. Berlese Funnels Used for Collecting Spiders from Sorghum Heads

that might have fallen during the cutting process. A large rubber band was used to seal the opening of the bag to prevent the escape of the spiders.

Before collecting each group of spiders from the jars, one pint of water was poured through the funnel to wash hanging spiders into the jar. Each sample was left in the funnel for a period of 24 hours. The spiders were then taken from the jars, placed into 70 per cent alcohol.

Feeding test with spiders

It was assumed that spiders found in large numbers in sorghum fields played an important role in reducing population levels of insects

of economic importance since Whitcomb and Bell (1964) stated that all spiders are predaceous. Therefore, feeding tests with 19 commonly found spider species were conducted in the laboratory.

Each feeding chamber consisted of a one-pint ice cream carton with the center portion of the lid removed, leaving only the rim. A piece of light weight muslin was held in place over the carton opening by means of the lid rim. This muslin prevented the escape of spiders, but at the same time allowed observation of the feeding.

Some of the spiders constructed webs from the muslin to the bottom of the carton. In order to avoid disturbing the web, a round hole large enough to accommodate a four-dram vial was cut in the side of the carton. Food for the test spider was supplied by means of this vial, and the vial also provided a place of retreat for the spiders.

A single spider was placed in each test chamber, and there were three replications. Each of the 19 test spiders was fed on the same insect on a feeding day. The insects used were all six larval instars and the adult of the corn earworm, Heliothis zea (Boddie); the adult and larvae of the ladybird beetle, Hippodamia convergens Guerin; the adult and larvae of the green lacewing, Chrysopa sp.; and the adult sorghum midge, Contarinia sorghicola (Coq). The spiders were recorded as feeding if they fed on the insect within a two-day period; if they had not fed, they were recorded as not feeding. The feeding test was as shown in Figure 3.

Figure 3. Arrangement of Spider Feeding Chambers in the Laboratory

RESULTS AND DISCUSSION

Soil pit trap collections

During the June 16 - September 16, 1965, period, spiders representing 16 families were collected from soil pit traps in sorghum fields. A summary of these data is presented in Table 1.

Most of the spiders collected in pit traps belonged to the families Erigonidae and Lycosidae. The former was represented by 648 and the latter by 502 specimens during the collecting period. Most of the species of these two families are ground-inhabiting forms. Kaston (1953) stated that of about 500 spider genera in the United States, about one-fifth belong in the family Erigonidae. Whitcomb et al. (1963c) reported that the erigonids appear to prefer cultivated fields over pasture habitats. Although members of the family Dictynidae build webs high on cotton plants (Whitcomb et al. 1963c), 75 per cent of the webs built by these spiders were on the lower parts of the sorghum plants. They ranked third (156) in the numbers of spiders collected. The remaining 13 families were found in lesser numbers as shown in Table 1.

The families Salticidae and Oxyopidae are hunting spiders which were well represented in the pit trap collections. These two families were also very numerous on all parts of the plants. The family Theridiidae was also common in the pit traps. The black widow spider, Latrodetus mactans (Fabricius), a member of this family, was collected

TABLE 1

SUMMARY OF SPIDER SPECIMENS COLLECTED FROM PIT TRAPS IN SORGHUM,
June 16-September 16, 1965

	Dates are first day of each weeks collection													
	June		July					August				September		
Families	16	24	2	9	16	23	30	6	13	20	27	3	10	Total
Erigonidae	22	39	40	59	27	25	23	38	37	117	54	120	47	648
Lycosidae	10	23	28	43	37	36	53	49	43	52	50	39	39	502
Dictynidae		2	3	2	5	3	10	6	21	28	37	17	22	156
Salticidae	1	1	3		5	4	10	13	10	10	7	9	8	81
Oxyopidae		1	2	7	5	12	20	10	3	5	3	4	6	78
Theridiidae	4	4	10	4	10	8	7	6	4	7	4	6	3	77
Nesticidae			1			2	2	2	1	5	4	9	11	37
Thomisidae	1	2		1	2	2		2	5	1	3	3	3	27
Argiopidae	1	1	3	2	1	1	1	1	2	2	2	1		18
Gnaphosidae	1	2				1			1	2	3		4	14
Agelenidae		1	1	1		1	3	1	3		1			12
Clubionidae			2							3				5
Anyphaenidae						1		2						3
Linyphiidae													1	1
Pisauridae				1										1
Uloboridae					1									1
Totals	40	76	83	120	93	96	129	130	130	232	168	208	146	1,663

35 times. The family Nesticidae was sometimes found under clods of dirt and was taken quite frequently in the traps. The family Thomisidae was commonly found on sorghum plants, but was taken only occasionally from the traps. Spiders of the family Argiopidae, known as the orb weavers, were seldom found in the pit traps, because they construct orb webs on vegetation and stay close to the web they construct. The family Gnaphosidae was collected only in the pit traps, as would be expected, since the members of this family are usually found on the ground. The family Agelenidae was not commonly collected in the pit traps; however, they were common on the sorghum plants. These spiders built a funnel web and were usually found on the lower one-third of the sorghum plant. The families Clubionidae and Anyphaenidae were seldom collected in the pit traps. These families have similar habits and are most often found on the plant. There was only one specimen collected for each of the three following families: Linyphiidae, Pisauridae, Uloboridae.

As shown in Figure 4, spider populations in pit traps increased as the sorghum plants increased in size and the season progressed, largest numbers being collected during the August 15 - September 15 period. Data on distribution of five of the most commonly observed spiders throughout the June 16 - September 16 period are presented in Figure 5. It will be observed that spiders of these five species were present throughout the period of observation, which was the period of development of the sorghum crop. The two peaks of spider abundance shown in Figure 4 followed periods of rainfall. It is not believed that there was any correlation between spider populations and rainfall. It may be that wet ground conditions caused ground-inhabiting forms,

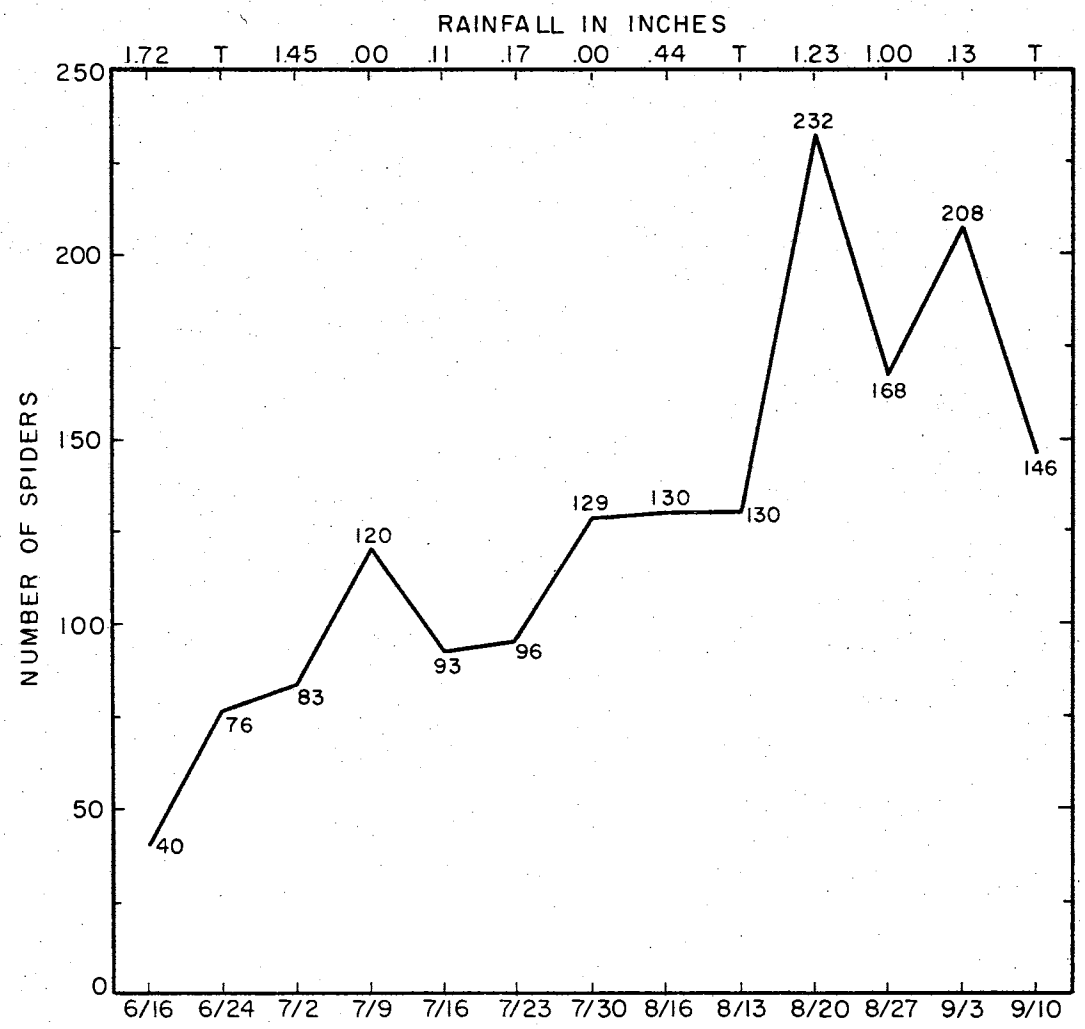

Figure 4. Spider collections at weekly intervals, June 16 - September 16, 1965.

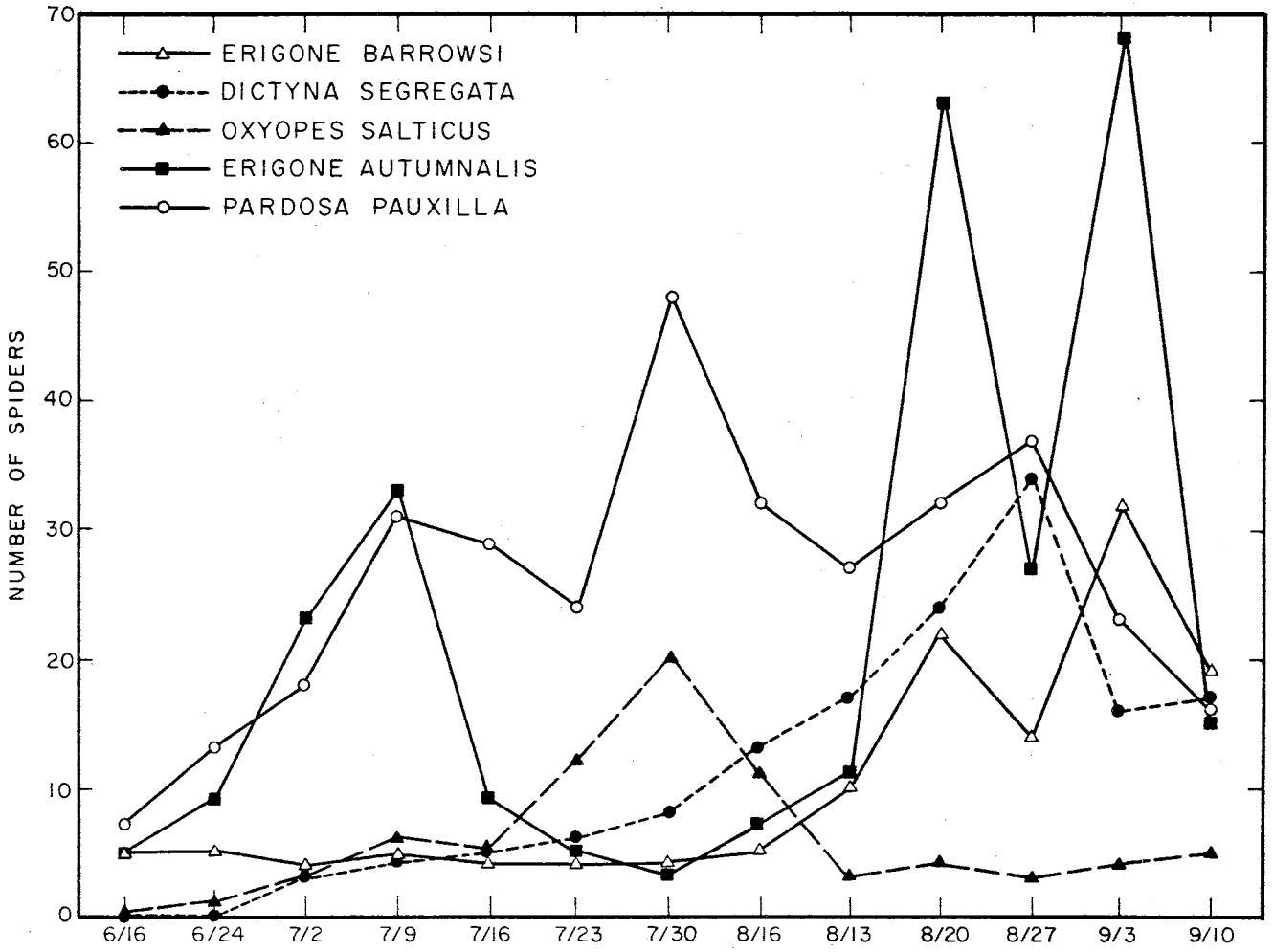

Figure 5. Seasonal distribution of five spiders commonly caught in pit traps, June 16 - September 16, 1965.

such as the erigonids and the lycosids, to move about more, thereby getting into the pit traps. It was found by Stoner (1960), that there were usually two peaks of abundance in the arthropod populations in range land of central Oklahoma.

All of the spiders collected from the pit traps were examined, and insofar as possible, identifications were made to genus and species. In some cases only immature forms were available, and identification only to genus was possible. There were 40 genera and 40 species in the 16 families identified as follows:

Family Erigonidae	Number of specimens
Erigone autumnalis Emerton	283
Erigone barrowsi Crosby and Bishop	126
Tennesseellum formicum (Emerton)	84
Grammonota inornata Emerton	74
Meioneta sp.	36
Erigone sp.	18
Walckenaera vigilax (Blackwall)	9
Meioneta micaria Emerton	8
Eperigone tridentata (Emerton)	4
Eperigone trilobata (Emerton)	3
Grammonota texana Banks	1
Scylaceus pallidus (Emerton)	1
Islandiana flavela (Banka)	1
Family Lycosidae	
Pardosa pauxilla Montgomery	337
Lycosa antelucana Montgomery	72
Schizocosa sp.	30
Pardosa delicatula Gertsch and Wallace	20
Schizocosa avida (Walckenaer)	11
Lycosa sp.	9
Lycosa punctulata Hentz	6
Lycosa baltimoriana (Keyserling)	5
Pardosa sp.	5
Lycosa helluo Walckenaer	4
Schizocosa ocreata (Hentz)	1
Geolycosa sp.	1
Schizocosa bilineata (Emerton)	1
Pirata sp.	1
Trochosa sp.	1

	Number of specimens
Family Dictynidae	
Dictyna segregata Gertsch and Mulaik	147
Dictyna sp.	8
Dictyna bicornis Emerton	1
Family Salticidae	
Habronattus cornatus (Hentz)	52
Phidippus audax (Hentz)	24
Metaphidippus sp.	4
Habronattus rutherfordi Gertsch and Mulaik	1
Family Oxyopidae	
Oxyopes salticus Hentz	77
Oxyopes apollo Brady	1
Family Theridiidae	
Theridion rabuni Chamberlin and Ivie	40
Latrodectus mactans (Fabricius)	33
Theridion murarium Emerton	3
Theridion sp.	1
Family Nesticidae	
Nesticus pallidus Emerton	37
Family Thomisidae	
Ebo latithorax Keyserling	12
Oxyptila sp.	7
Misumenops sp.	6
Xysticus sp.	2
Family Argiopidae	
Acanthepeira stellata (Walckenaer)	10
Araneus sp.	5
Cyclosa turbinata (Walckenaer)	2
Larinia sp.	1
Family Gnaphosidae	
Zelotes sp.	7
Drassyllus mephisto Chamberlin	3
Drassyllus creolus Chamberlin and Gertsch	1
Zelotes hentzi Barrows	1
Drassyllus sp.	1
Peocilochroa sp.	1

	Number of specimens
Family Agelenidae	
Agelenopsis sp.	12
Family Clubionidae	
Clubiona abbotii C. L. Koch	3
Castianeira sp.	2
Family Anyphaenidae	
Aysha gracilus (Hentz)	3
Family Linyphiidae	
Frontinella communis (Hentz)	1
Family Pisauridae	
Pisaurina sp.	1
Family Uloboridae	
Uloborus sp.	1

Manual collections from sorghum plants

During the June 24 - September 15, 1965, period, spiders representing 13 families were collected manually from all parts of the sorghum plants. A summary of these collections is shown in Table 2.

As was the case with the pit trap collections, most of the spiders were collected manually during the latter part of the growing period of the sorghum plant, August 1 - September 15. It will be observed that the rate of buildup in spider populations was similar to that shown in Figure 4 for the pit trap collections, with two peaks, one early in July and the other in late August and early September. The former occurred during the blooming period of the plants. Then there was a steady increase in populations until plant maturity, followed by a sharp decrease after maturity. These data are presented in Figure 6.

TABLE 2

SUMMARY OF SPIDER SPECIMENS COLLECTED MANUALLY FROM
ENTIRE SORGHUM PLANT FROM
JUNE 24-SEPTEMBER 15, 1965

	June	July					August					September		
Families	24-30	1-8	9-14	15-20	21-26	27-30	1-4	5-10	11-16	17-24	25-30	2-7	8-15	Total
Thomisidae	3			1	4	2	5	3	7	12	26	22	14	99
Salticidae	1		4	1	2	3	4	5	5	17	13	18	15	96
Argiopidae	3	8	8	1	3	7	6	15	15	13	4	3	4	90
Theridiidae		1				1	4	2	2	7	5	5	5	30
Agelenidae		4	1	6		1	3	2	2					19
Oxyopidae	1	1					3	2	5	4		1	1	18
Linyphiidae		1					1	2	2	1	6	1		14
Anyphaenidae	1					2	1		2	3	4	1		14
Tetragnathidae						1	2	4	5	1		1		14
Lycosidae	1						1	2	2	2	2		1	11
Clubionidae			1						1	1	1	1	4	9
Dictynidae	1						1		1	1	2	2		8
Nesticidae											1			1
Totals	11	15	14	9	9	17	31	37	49	62	64	55	44	423

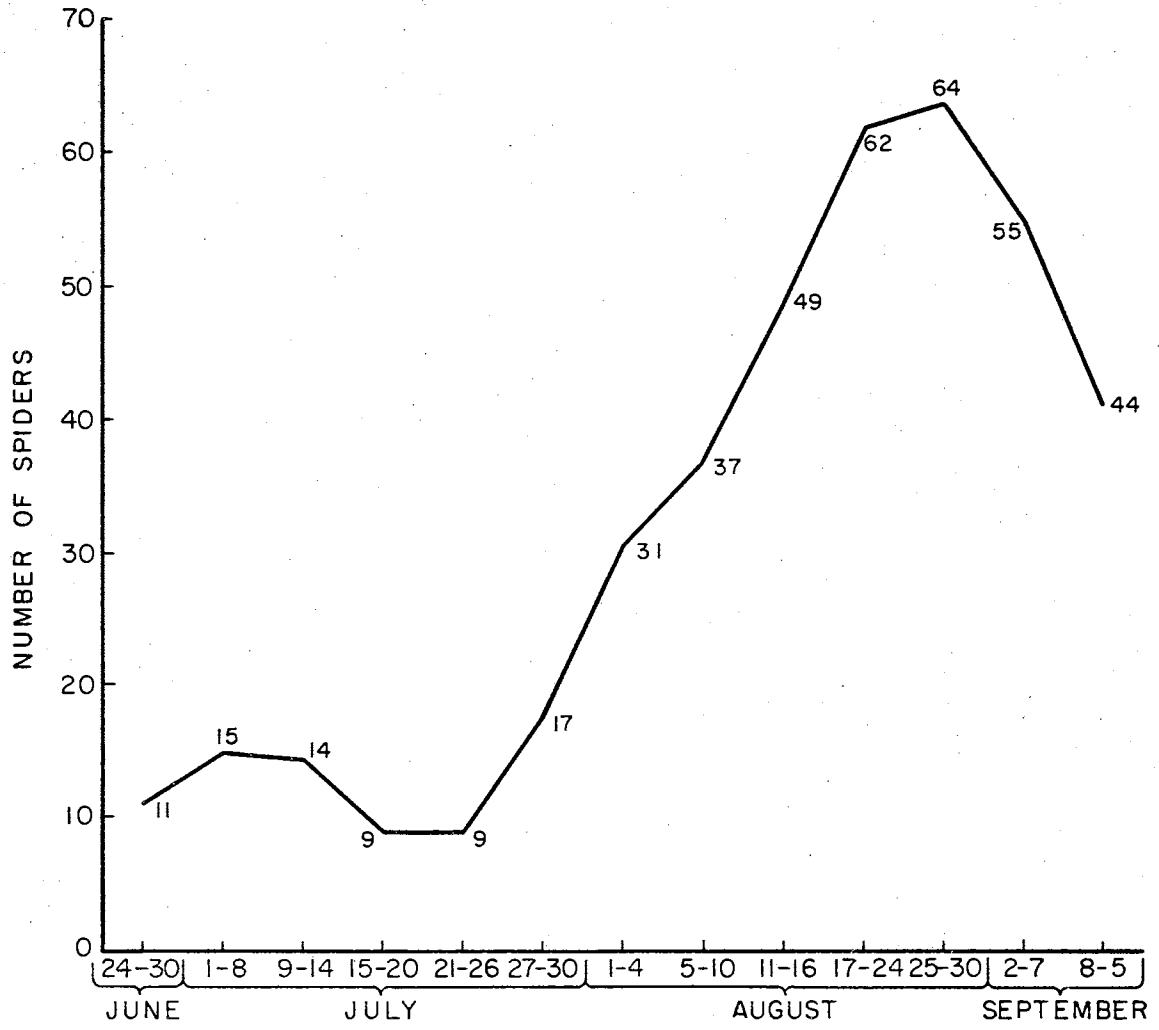

Figure 6. Seasonal distribution of spiders collected manually from sorghum plants.

Most of the spiders collected manually from the plants belong to the families Thomisidae, Salticidae, and Argiopidae. These families represented 67.37 per cent of all the spiders collected in this manner. The families Thomisidae and Salticidae are hunting forms, while the argiopids are orb-web builders. It will be observed that, with one exception, Tetragnathidae, the same families that were collected manually from the plants were also collected from pit traps. Habits of these spiders were discussed previously.

Spiders collected manually from the plants totaled 423 belonging to 34 genera in 13 families. Of these, 34 species were identifiable. The following is a list of the families, genera, and where identifiable, species of spiders collected from the plants, including numbers of each:

	Number of specimens
Family Thomisidae	
Misumenops oblongus (Keyserling)	54
Misumenops asperatus (Hentz)	31
Philodromus sp.	7
Ebo latithorax Keyserling	2
Xysticus sp.	2
Thanatus sp.	2
Misumenops celer (Hentz)	1
Family Salticidae	
Phidippus audax (Hentz)	61
Metaphidippus galathea (Walckenaer)	23
Habronattus coronatus (Hentz)	3
Thiodina puerpera Hentz	2
Icius elegans (Hentz)	2
Metaphidippus insignis (Banks)	2
Peckhamia picata (Hentz)	2
Hentzia sp.	1
Family Argiopidae	
Acanthepeira stellata (Walckenaer)	26
Argiope trifaciata (Forskal)	17

Family Argiopidae (Continued)	Number of specimens
Araneus sp.	14
Neoscona sp.	12
Mangora gibberosa (Hentz)	6
Argiope aurantia Lucas	4
Cyclosa turbinata (Walckenaer)	4
Eustala sp.	4
Metepeira labyrinthea (Hentz)	3
Family Theridiidae	
Latrodectus mactans (Fabricius)	17
Theridion glaucescens Becker	8
Theridion murarium Emerton	3
Theridion rabuni Chamberlin and Ivie	2
Family Agelenidae	
Agelenopsis sp.	19
Family Oxyopidae	
Oxyopes salticus Hentz	18
Family Linyphiidae	
Frontinella communis Hentz	12
Linyphiella coccinea (Hentz)	2
Family Anyphaenidae	
Aysha gracilis (Hentz)	7
Anyphaena celer (Hentz)	7
Family Tetragnathidae	
Tetragnatha laboriosa Hentz	14
Family Lycosidae	
Pardosa pauxilla Montgomery	7
Lycosa antelucana Montgomery	2
Lycosa gulosa Walckenaer	2
Family Clubionidae	
Chiracanthium inclusum (Hentz)	7
Clubiona abbotii C. L. Koch	2

Family Dictynidae	Number of specimens
Dictyna segregata Gertsch and Mulaik	8
Family Nesticidae	
Nesticus pallidus Emerton	1

Spider location on plant

The location on the sorghum plant from which spiders were collected throughout the growing season was recorded, and the data are presented in Table 3. It is indicated that there were differences between families of spiders with respect to the location they inhabited on the plant. Two species of Thomisidae were found exclusively on the upper one-third of the plant throughout its life and finally in the sorghum head. This probably was true because these spiders sought seclusion in the whorl and later in the head from which they preyed upon insects. Theridiidae, Agelenidae, and Lycosidae were found exclusively on the lower one-third of the plant. The black widow spider, which belongs to the family Theridiidae, builds its irregular shaped web on plants near the surface of the ground. The funnel-web spiders, Agelenidae, also build webs on plants close to the ground. Members of the family Lycosidae are generally ground inhabitors, which accounts for their being on the lower part of the plant. Several families were collected from all parts of the plants because they are very active.

It is of interest to note that seven of the species in Table 3 were found mainly in the sorghum head. This fact would seem to be of considerable importance, since it is this part of the plant that usually sustains greatest loss due to insect infestation. Most of

TABLE 3

LOCATION OF SPIDERS ON SORGHUM PLANTS THROUGHOUT GROWING SEASON

	Percent on plant section			
	Lower 1/3	Middle 1/3	Upper 1/3	Sorghum Head
Family Thomisidae				
Misumenops oblongus Keys			3.71	96.29
Misumenops asperatus (Hentz)			3.23	96.77
Family Salticidae				
Phidippus audax (Hentz)	13.56	13.56	6.78	66.10
Metaphidippus galathea (Walck)	4.55	9.09	9.09	77.27
Family Argiopidae				
Acanthepeira stellata (Walck)		8.34	54.16	37.50
Argiope trifaciata (Forskal)		100.00		
Family Theridiidae				
Latrodectus mactans (Fab)	100.00			
Family Agelenidae				
Agelenopsis sp.	100.00			
Family Oxyopidae				
Oxyopes salticus Hentz	11.76	5.90	11.76	70.58
Family Linyphiidae				
Frontinella communis Hentz	36.36	36.36	27.28	
Family Tetragnatha				
Tetragnatha laboriosa Hentz		100.00		
Family Lycosidae				
Pardosa pauxilla Montgomery	100.00			
Family Clubionidae				
Chiracanthium inclusum (Hentz)	25.00			75.00
Family Dictynidae				
Dictyna segregata Gertsch & Mulaik	75.00	12.50	12.50	

TABLE 4

SUMMARY OF SPIDER SPECIMENS COLLECTED FROM SORGHUM HEADS USING BERLESE FUNNELS

Families	July										August														September								Total
	13	15	17	19	21	23	25	27	29	31	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	1	3	5	7	9	11	13	15	
Thomisidae			1		4	1	5	3	9	5	3	8	2	10	10	7	6	5	6	14	13	19	11	20	17	18	8	4	5	7	8	2	2	234
Salticidae	1	2	4	2	2	5	5	4	3	8	4	9	2	6	2	9	5	5	5	5	9	5	14	10	6	7	5	4	4	1	1	3	5	160
Argiopidae	2	3	1	1		1		1			1					1						2				5	4	1	1			2	26
Theridiidae				1	1			1		2			2		1		1			2			1	1		2		1			1			17
Anyphaenidae	1		1			1				2			1			1		3		1			1			2			1		1			16
Oxyopidae	1					1						1				2					1		1			1		1	1					10
Clubionidae																		1				2					1							4
Dictynidae																					1													1
Totals	5	5	7	4	7	9	10	9	12	17	8	18	7	16	13	20	12	14	11	22	24	26	30	31	23	30	19	14	12	9	11	5	9	468

Phidippus audax (Hentz) and Metaphidippus gelathea (Walckenaer) (Salticidae) were collected from the sorghum head, but both of these species could be found in any location on the plant. All of the Acanthepeira stellata (Walckenaer) (Argiopidae) were collected from the upper half of the plant. These species were usually on the plant in close proximity to their large orb web. Each specimen of Argiope trifaciata (Forskal) had its orb web constructed on the middle one-third of the sorghum plant. Oxyopes salticus Hentz (Oxyopidae) was well represented in the sorghum head but was also taken on all parts of the plant. Frontinella communis Hentz (Linyphiidae) were not collected from the sorghum head but were equally represented on the other parts of the plants. Tetragnatha laboriosa Hentz (Tetragnathidae) was always taken in its web, which was in the middle part of the plant. Most of the Chiracanthium inclusum (Hentz) (Clubionidae) were taken from the head, but some of them were taken in the lower one-third of the plants.

Spiders collected from sorghum heads in Berlese funnels

Because spiders and their webs were commonly observed in sorghum heads, and because it was believed that some of the spiders were missed in making manual collections from the plants, collections from sorghum heads were made by use of Berlese funnels. These data are presented in Table 4.

Most of the spiders collected from the sorghum heads in Berlese funnels were taken during August and early September when the heads were in the "dough" stage of development. This stage of development corresponded with the occurrence of the greatest number of insect pests attacking the head. As the head matured, collections dropped off

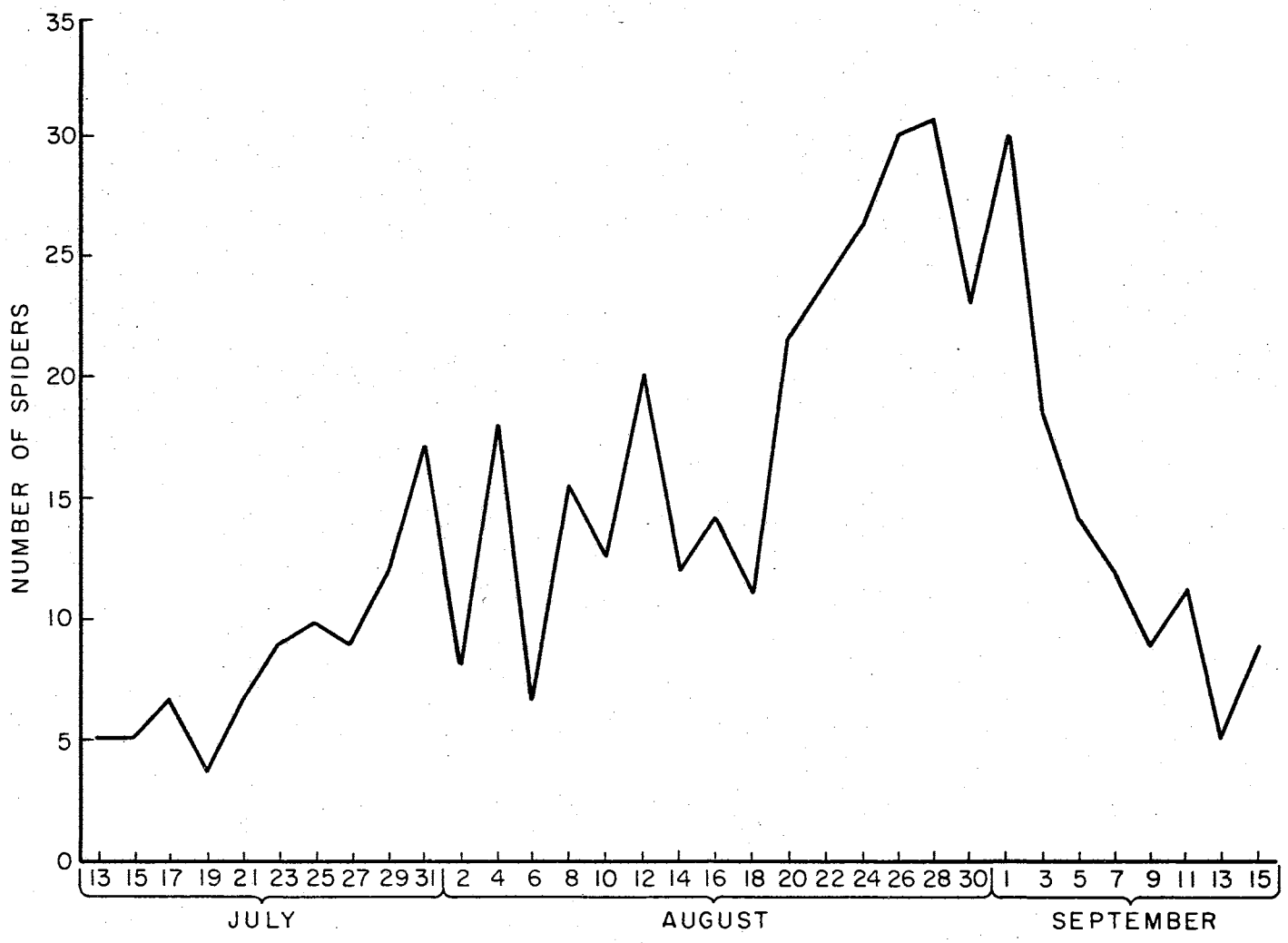

Figure 7. Seasonal distribution of spiders collected from sorghum heads by means of Berlese funnels.

rapidly. These data are also presented graphically in Figure 7. This graph corresponds quite closely to that for seasonal spider distribution for the other methods of collections.

As was the case where manual collections were made, Thomisidae and Salticidae comprised the largest number of specimens collected. A total of 468 spiders was collected by this method which averaged 14.2 spiders for 20 heads.

The 468 spiders collected from sorghum heads in Berlese funnels included 8 families and 23 genera. Twenty of the genera were identified to species. Some were immature and could not be identified with certainty beyond genus. A list of the families, genera, and species, with numbers of specimens of each follows:

Family Thomisidae	Number of specimens
Misumenops asperatus (Hentz)	146
Misumenops oblongus Keyserling	65
Xysticus sp.	10
Ebo latithorax Keyserling	7
Oxyptila sp.	3
Misumenops celer (Hentz)	2
Philodromus sp.	1
Family Salticidae	
Phidippus audax (Hentz)	105
Metaphidippus galathea (Walckenaer)	50
Hentzia sp.	3
Habronattus viridipes (Hentz)	1
Sassacus papenhoei Peckham	1
Family Argiopidae	
Acanthepeira stellata (Walckenaer)	15
Neoscona sp.	4
Araniella displicata (Hentz)	2
Cyclosa turbinata (Walckenaer)	2
Mangora gibberosa (Hentz)	1
Eustala sp.	1
Araneus sp.	1

Family Theridiidae	Number of specimens
Theridion glaucescens Becker	11
Theridion rabuni Chamberlin and Ivie	4
Theridion murarium Emerton	2
Family Anyphaenidae	
Aysha gracilus (Hentz)	11
Anyphaena celer	5
Family Oxyopidae	
Oxyopes salticus Hentz	10
Family Clubionidae	
Clubiona abbotii	4
Family Dictynidae	
Dictyna segregata Gertsch and Mulaik	1

Spider feeding tests

A feeding test was conducted on 19 species belonging to 9 spider families. The results are shown in Table 5.

Phidippus audax (Hentz), *Metaphidippus galathea* (Walckenaer), and *Habronattus coronatus* (Hentz), all members of the family Salticidae, were the only spiders which fed on all insects used in the feeding test. These are very aggressive spiders and would usually attack the insects within a few minutes after they were put into the container with them. These spiders were frequently observed feeding on the same insects in the field.

Misumenops asperatus (Hentz), *M. oblongus* Keyserling, and *Ebo latithorax* Keyserling, which are members of the family Thomisidae, would feed readily on the first three instars, but not on the last three or adults of the corn earworm. However, they fed readily on the

TABLE 5

SPIDER FEEDING TEST ON SOME HARMFUL AND BENEFICIAL INSECTS OF GRAIN SORGHUM

	Corn Earworm 1/							Coccinellidae 2/		Chrysopidae 3/		Sorghum 4/
	5/ 1	2	3	4	5	6	Adult	Larvae	Adult	Larvae	Adult	Midge
	6/											
Phidippus audax (Hentz)	X	X	X	X	X	X	X	X	X	X	X	X
Metaphidippus galathea (Walck)	X	X	X	X	X	X	X	X	X	X	X	X
Habronattus coronatus (Hentz)	X	X	X	X	X	X	X	X	X	X	X	X
Misumenops asperatus (Hentz)	X	X	X	0	0	0	0	X	0	X	X	0
Misumenops oblongus Keys	X	X	X	0	0	0	0	X	0	X	X	0
Ebo latithorax Keys	X	X	X	0	0	0	0	X	0	X	X	0
Acanthepeira stellata (Walck)	0	0	X	X	X	X	X	X	X	X	X	0
Argiope trifasciata (Forskal)	0	0	X	X	X	X	X	X	X	X	X	0
Argiope aurantia Lucas	0	0	X	X	X	X	X	X	X	X	X	0
Mangora gibberosa (Hentz)	0	0	X	X	X	X	X	X	X	X	X	0
Neoscona benjamina (Walck)	0	0	X	X	X	X	X	X	X	X	X	0
Frontinella communis (Hentz)	X	X	0	0	0	0	0	0	0	0	0	X
Aysha gracilis (Hentz)	X	X	X	X	X	0	0	X	X	X	X	0
Clubiona abbotii C. L. Koch	X	X	X	X	0	0	0	X	X	X	X	0
Oxyopes salticus Hentz	X	X	X	X	X	0	0	X	X	X	X	0
Latrodectus mactans (Fab)	0	0	X	X	X	X	X	X	X	X	X	0
Pardosa pauxilla (Mont)	0	X	X	X	X	X	X	X	X	X	X	0
Lycosa punctulata Hentz	0	X	X	X	X	X	X	X	X	X	X	0
Lycosa antelucana Mont	0	X	X	X	X	X	X	X	X	X	X	0

1/ Heliothis zea (Boddie) 2/ Ladybird beetle 3/ Green lacewing
4/ Adult 5/ Instars 6/ X - feeding, 0 - not feeding

larvae of the ladybird beetle and larvae and adult of the lacewing fly. These species tried to capture the sorghum midge, but were unsuccessful.

Acanthepeira stellata (Walckenaer), Argiope trifasciata (Forskal), A. aurantia Lucas, Mangora gibberosa (Hentz), and Neoscona benjamina (Walckenaer), all belonging to the orb-weaver family (Argiopidae), would feed on all insects used in the feeding test, except the sorghum midge and the first two instars of the corn earworm. However, these insects had to be droped into the web before they would feed on them. Although these spiders would not feed on the sorghum midge, it is believed that spiders belonging to this family are very beneficial in helping to control this pest. On August 2, in a web of A. stellata, there were 286 sorghum midge which were trapped and unable to escape. During this period of the summer every argiopid web had some sorghum midge trapped in it. A. stellata were observed in the field feeding freely on the honeybee while the sorghum was blooming.

Frontinella communis (Hentz) would feed only on the smaller insects such as the first two instars of the corn earworm and the sorghum midge. Oxyopes salticus Hentz, and Clubiona abbotii C. L. Koch, seemed to feed on the same insects, except the latter would not feed on the corn earworm after it had reached the fifth instar. The black widow spider, Lactrodectus mactans (Fabricus), seemed to prefer the larger insects; it would not feed on the sorghum midge or the first two instars of the corn earworm. This species was observed feeding on grasshoppers, field crickets, and various moths in the field. Pardosa pauxilla (Montgomery), Lycosa punctulata Hentz, and L. antelucana Montgomery, all members of the family Lycosidae, would not feed on the first instar

of the corn earworm or the sorghum midge. They seemed to prefer the larger specimens of the insects used in the feeding test.

SUMMARY AND CONCLUSIONS

Before this study could be undertaken it was necessary to develop techniques for collecting and conducting feeding tests with spiders. These techniques are described.

Spiders were collected in pit traps from the time the sorghum plants emerged through the soil surface until after plant maturity -- during the June 16 - September 16 period. Numbers of specimens collected increased for each collection date as the season progressed until the plants approached maturity. A total of 1,663 spiders were collected. These included 16 families consisting of 40 genera and 40 identifiable species. Most of the spiders collected in pit traps belonged to the families Erigonidae, Lycosidae, and Dictynidae. The first two are primarily ground-inhabiting forms. It was of interest to find that the black widow spider, Latrodectus mactans, was quite commonly caught in the traps. The pit trap method of collecting spiders in sorghum fields was found to be valuable in that data were obtained on populations which were not found on the plants.

Daily spider collections were made manually from 20 sorghum plants. A total of 423 specimens were collected, and these represented 13 families. There were 34 genera and 34 identifiable species. As might be expected, the plant inhabiting families, Thomisidae, Salticidae, and Argiopidae were the most numerous. Again, the black widow spider was commonly collected, it being the next most numerous. Daily collection

numbers increased as the season progressed and plant size increased.

Although essentially the same families were represented in the pit trap and manual collections, the dominant families for each collecting method were considerably different. Because of difficulty in capturing spiders manually, data obtained from pit traps are valuable for supplementing the plant collection data in determining overall spider populations in a sorghum field.

In making manual collections of spiders from sorghum plants, data were recorded on location on the plant from which they were taken, and this involved 11 families comprised of 13 genera. It was found in most cases that there was a relationship between spider families and collection location on the plant, and that this was due to web-building and feeding habits. Latrodectus mactans, Agelenopsis sp., and Pardosa pauxilla were always found on the lower one-third of the plant; Argiope trifaciata and Tetragnatha laboriosa were found inhabiting the middle one-third of the plant; Misumenops oblongus, M. asperatus, Metaphidippus galathea, Phiddipus audax, Oxyopes salticus, and Chiracanthium inclusum were found mainly on the upper one-third of the plant and in the head. The orb-weavers of the family Argiopidae were found mainly on the middle one-third of the plant. Large orb-weaver webs were found between rows, plants, and sorghum heads. They usually contained large numbers of sorghum midge. Spiders found on the upper one-third of the plant and the head probably are of greatest economic significance, because most of the damage by insects to grain sorghums occurs to the head.

Spiders were collected from grain sorghum heads by means of Berlese funnels and heat. Eight families were represented, and specimens in

Thomisidae and Salticidae were the most numerous. These data are much in line with the manual collection data and indicate that these families are probably of importance as insect control factors on the sorghum plant. Spider populations in the sorghum heads increased progressively from the time of head exsertion to maturity, and then they decreased rapidly.

Feeding tests with 19 spider species belonging to 9 families were conducted in the laboratory. Phidippus audax, Metaphidippus galathea, and Habronattus coronatus, all belonging to the family Salticidae, were the only spiders that fed on all insects offered. These included the corn earworm, coccinellid larvae and adults chrysopid larvae and adults, and sorghum midge. The three species mentioned above fed readily on sorghum midge, but others did not. Although many midge were caught in webs of orb-weavers, the spiders were not observed feeding on them. The fact that the spiders fed readily on insects offered under laboratory conditions suggests the possibility of developing spider mass-rearing techniques in connection with use of spiders as biological control factors.

In summarizing data on spider collections by all methods it was found that there were 61 identifiable species in 57 genera of 17 families. This is an indication of the possible economic importance of spiders in connection with the grain sorghum crop because all spiders are predaceous. Since the spider populations increased as the season progressed, it is apparent that they must have fed upon sorghum insects associated with the sorghum plants. Although Kaston (1948) stated, "On the whole spiders are of little economic importance," data obtained here on their

abundance in sorghum fields and observations on their feeding habits would suggest the possibility of using them as biological control factors. Further research with spiders, especially those inhabiting the upper one-third of the plant and the head, would be justified in this connection.

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