SPIDERS OF ALFALFA WITH NOTES ON THE BIOLOGY OF *TETRAGNATHA LABORIOSA* HENTZ

by

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I. GENERAL INTRODUCTION

"Spiders are among the dominant predators of any terrestrial community. When the fauna of the soil and its plant cover is analyzed, they come to light in vast numbers, in such convincing abundance that it is evident they play a significant part in the life of every habitat." The above quotation by Dr. Willis J. Gertsch (1949) provided the motivation for initiating this study.

Although Kaston (1948) stated "On the whole spiders are of little economic importance," data obtained from other workers indicate their importance has been underestimated. As early as 1879 Comstock discussed several as predators in cotton fields. Turnbull (1960) and Bristowe (1941) suggested a possibility of prey preference in some spider species, and Bailey and Chada (1968) indicated the possibility of using them as biological control factors on insects in grain sorghums.

A review of the literature shows little available information on spiders in field crops, but by their numbers alone they demand further investigations. Large numbers of spiders were observed in alfalfa when previous workers had sampled for insect infestations. Since all spiders are predaceous (Savory 1928), their numbers suggested the possibility of economic importance in insect control in alfalfa. Nothing has been published about the role of spiders in forage crops. Therefore, in 1967, a research program was initiated to investigate the role of spiders in alfalfa. In order to gain insight into the importance of spiders in any kind of habitat, one must first be aware of the species which are present.

The specific objectives of the work were as follows:

1. to determine the species complex of spiders found in alfalfa throughout the year.

2. to record the population fluctuations of the major species present.

3. to measure the effect of cutting on the spider numbers in the field.

4. to evaluate the effect of time of day on sampling spider populations with reference to their position on the plants.

5. to determine the range of predation on economic insects by the more common spider species.

II. DESCRIPTION OF THE STUDY AREA

Studies of the effect of alfalfa harvest and the effect of time of day on the numbers of collectible spiders were conducted in the same alfalfa field near the town of Blacksburg, Virginia. The results were statistically analyzed. The trapezium-shaped 4.5 acre field was part of a farm owned by C. L. Price. This study area was located just north of the town limits. The field, gently sloping east to west, was separated on the west from U. S. 460 by a narrow graveled drive and about 10 feet of uncultivated right-of-way. The northern border was adjacent to a cornfield; the eastern edge was paralleled by red clover, and on the south side was a graveled road. The field was in its fifth year of alfalfa growth at the beginning of the study in 1967. Common plants in the field other than alfalfa were dandelion, *Taraxacum officinale* Weber; ripplegrass, *Plantago lanceolata* L.; and Johnson-grass, *Sorgum halepense* L.

III. CLIMATE

The climate in the Blacksburg area is relatively mild in the summer months. The U. S. Weather Bureau recorded 124 days between the last freezing temperature of spring and the first freezing temperature of fall during 1967. During the summer months the temperature rose to 87°F. (August 4), while the winter temperature dropped to -3°F. (February 8). The annual average temperature for 1967 was 49.6°F. The annual rainfall for the Blacksburg area is about 34 inches, distributed rather evenly throughout the year. The total precipitation for 1967 was 34.48 inches.

IV. SPIDER SURVEY

A. Introduction

Because of the tremendous number of spiders in alfalfa, it was evident that a spider survey was needed to determine the species present. Included are species from several fields in the Blacksburg area and one field in Triplet, Virginia. All the seasonal fluctuation data, however, came from C. L. Price's field north of Blacksburg. The major portion of this survey is concerned with collecting, classifying, and plotting seasonal distributions of the spider species found.

No attempt has been made in this section to voice assumptions about the possibility of using spiders as biological control agents. Instead, the aim here is to lay a foundation for studies which may be able to shed light on this possibility.

B. Literature Review of Spider Surveys

Nothing is known about the role of spiders in alfalfa. This section will provide a background for comparisons between this survey and surveys conducted on spiders in other crops, primarily in cotton. There is also a review of the literature pertaining to other spider surveys in uncultivated habitats.

1. Cultivated Crops

Everly (1938) collected 9 families of spiders associated with sweet corn in Ohio. During the latter part of the year, he found *Tetragnatha laboriosa* Hentz on almost every plant. Specht and Dondale (1960) compared spider populations in sprayed and unsprayed New Jersey apple orchards. They found that mean numbers of spiders in three unsprayed orchards were higher than in seven sprayed orchards. Hunting spiders appeared to be more strongly affected by sprays than web-builders. Whitcomb and Tadic (1963) collected 9 families and 40 species in Arkansas occupying the webs of the fall webworm *Hyphantria cunea* (Drury), most of which were found feeding on the larvae. Hensley et al (1961) found 18 families of spiders inhabiting Louisiana sugar cane fields.

Kagan (1943) found 36 species of spiders, including *Latrodectus mactans* (Fabricius), the black widow, representing 9 families, on cotton in central Texas. He reported none feeding on the boll weevil *Anthomonus grandis* Boheman. Whitcomb, Exline, and Hunter (1963) reported 143 species and 19 families from cotton in Arkansas. They found *L.mactans* feeding on the boll weevil in the field and in the laboratory. Their six year study of species composition and population density established the seasonal abundance in cotton for some species. There was much variation in seasonal abundance. Some had two population peaks. Daily examinations of 100 plants in a field of insecticide free cotton revealed an estimated population of 3,374 spiders per acre in the herb-shrub zone. In addition to seasonal variations there were large variations from field to field. Whitcomb and Bell (1964) added 17 species to the list and reported spiders feeding on both pest and beneficial insects. They also indicated that the enormous numbers of spiderlings in the cotton field serve as much needed food for various other predators. Whitcomb, Exline, and Hite (1963) compared spider populations of the ground stratum in an Arkansas pasture and cotton field. Of 64 species taken from both areas, only 26 were common to both. Twenty-two were collected only in the cotton field, sixteen only in the pasture. The population in the cotton field appeared considerably larger than in the pasture.

2. Areas other than Cultivated Crops

Weese (1924) published one of the earliest works on spider ecology. His work on the Illinois elm-maple forest which included all invertebrates, showed that spiders adapt to seasonal rhythms and that humidity affects the rate of spider development. Elliot (1930) determined the dominant spider species in each stratum of the Indiana beech-maple forest for each season. Gibson's ecological study of the spiders of a river terrace forest in western Tennessee (1947) is also worthy of note. Muma and Muma (1949) found in their study of a population of prairie spiders that some spiders are restricted to certain habitats. Lowrie (1942) discussed spider distribution on the southern shores of Lake Michigan. In 1948 he described the physical and biotic factors of the dune environment and their possible effects on spider populations. The spider distribution study by Barnes (1953) on the non-forested marine shoreline habitats of North Carolina revealed 24 families consisting of 139 species, and showed that zonation and succession was exhibited by spiders as one moved from low tide to the shrub areas. Barnes and Barnes (1955) also studied spider distribution in the broomsedge community of the Piedmont and demonstrated that the population structure of spider species and their relative densities remains essentially the same in a plant community extending over a wide geographical area. Duffy (1962) found that plant form (living and dead) had a definite effect on both the numbers and types of spiders found. During a comparitive study of the spider fauna of four different plant communities in a small valley in south central Ohio, Cannon (1965) found the spider fauna more abundant in the Mixed Mesophytic forest community with a greater variety of species than in the Mixed Oak and Chestnut Oak community. Cannon also found a distinction between the fauna of the Old Field community and the forest communities. Berry (1967) discovered that the spider species found in the old field succession are characteristically associated with certain types of plant communities.

C. Materials and Methods

From March 28, 1967 to June 20, 1968, a spider survey was conducted in alfalfa fields, primarily around Blacksburg. During the warmer season from April to October, samples were taken at intervals as close to one week as possible. During the colder months from November to March, collections were made once or twice a month. This was considered permissible since spider activity is much reduced during the winter and also because weather limited the days in which sampling could be conducted. Three collecting methods were used throughout the study, and one other was used toward the latter part of the survey. Temperature and humidity data were taken on each collection date by means of a Bacharach sling psychrometer.

1. Suction Sampler (D-Vac)

Beginning on June 21, 1967, samples were taken with a suction sampler designed by Dietrick et al. (1959) at Riverside, California for sampling all arthropods, including those found in the litter and upper soil layers (Figure 1). This unit allows a choice of several end pieces which vary in the size of the area sampled and conversely in the suction pressure The one-half square foot area sample size was selected because greater suction was obtained with it than with larger sizes. Both day and night samples were taken. Day samples were usually made between 12 noon and 3 p. m. Night samples were taken after dusk, usually around 9:15 p.m. One hundred such sample units were taken on each sample day. As soon as the sample was taken, the bag was withdrawn from the machine while the engine was still running so that all the spiders were held firmly in place by air pressure. The bag was taped closed and the sample was immediately returned to the laboratory. Tullgren funnels (14 inches at the top) were used for separating the spiders from the litter and soil in the samples (Figure 2). The spiders were collected as they dropped through a wire mesh into a bottle of 70% alcohol at the bottom of the funnel. Each sample was left in the funnels for 24 hours. The spiders were then separated from the other arthropods and classified. After separation and classification each spider species was stored in a separate vial of 70% alcohol.

2. Collection by use of a sweep net

Beginning on March 28, 1967, weekly samples were taken by means of a standard 15 inch sweep net. This collection method took only those specimens which climb up on the foliage to hunt or to construct a snare. Five hundred sweeps were used as one sample unit. These were placed in a plastic bag and returned to the laboratory. All spiders that could be hand picked from the sample were placed in alcohol. The rest of the sample was then placed in Tullgren funnels and a procedure was followed similar to that used with the suction sampler

Figure 1. D-Vac sampler as used to collect spiders from alfalfa.

3. Manual collection of spiders from plants

Beginning March 28, 1967, all spiders observed in the field were collected manually. Before sweep samples were taken, a fifteen minute preliminary search of some of the alfalfa plants was made. Data was recorded for each spider giving its location on the plant, whether or not it was feeding, and the type of prey, if any.

4. Collection of spiders by use of the head lamp

During the summer of 1968, the head lamp collecting method developed by Wallace (1937) was used for sampling wolf spiders at night. The length of the sampling times ranged from thirty to forty-five minutes. The beam from a lamp worn on the forehead reflected from the eyes of the spider, which appeared a bright green. Those spiders observed could then be easily collected, however the numbers collected by this procedure were few.

D. Results and Discussion

1. D-Vac Sampler

During the period from June 21, 1967 to June 20, 1968, fourteen families of spiders were collected by the D-Vac in alfalfa fields. These data are summarized in Table 1.

By far the majority of spiders collected by this method belonged to the families Linyphiidae and Tetragnathidae. The linyphiids are represented by 1553 specimens, while the Tetragnathidae consisted of 1202 specimens. The linyphiids in

Figure 2. Tullgren funnels used for separating spiders from soil and litter in D-Vac samples.

alfalfa are composed mostly of the Erigonianae and are primarily ground dwellers, building small webs over tiny rocks and clumps of soil. This family included by far the most genera in this study (13) and Kaston (1953) estimated that about one-fifth of all the spider genera in the United States were among the Erigoninae. The tetragnathids collected in alfalfa consist of three genera with Tetragnatha laboriosa and Pachynatha tristriata Koch accounting for most of the specimens. Tetragnatha builds a typical orb web between the alfalfa stems, while Pachygnatha runs over the plants and the ground in search of food. The Thomisidae and Oxyopidae were also very common in D-Vac samples. The thomisids prefer to wait motionless on the plant with legs one and two held open until some insect wanders within its reach. The oxyopids are very active predators, running rapidly over the vegetation while searching for their prey. The family Thomisidae was represented by 6 genera and 15 species, totaling 167 specimens, the primary one being Misumenops asperatus (Hentz), which comprised about 50 per cent of their number. The Oxyopidae had only one species, Oxyopes salticus Hentz whose numbers totaled 94.

The families Lycosidae and Salticidae were both well represented in the D-Vac samples. The lycosids, or wolf spiders, are almost exclusively ground dwellers, only occasionally climbing very high on the vegetation. The D-Vac sampler was by far the best means of collecting them. The Salticidae, or jumping spiders, like the wolf spiders are hunters, rather than web builders. They have the best eye sight in the order Araneida and obtain their food by stalking a moving object, then pouncing upon it and subduing it with their poison. Spiders of the family Argiopidae, called orb-weavers, were collected 25 times, many of the specimens being immature forms of _Acanthepeira stellata_ Walckenaer. Immatures of _Argiope aurantia_ Lucas, called the garden spider, or writing spider, were occasionally found in the samples, but adults were seen most commonly on higher vegetation surrounding the field. The families Hahniidae, Theridiidae, Agelenedae, and Gnaposidae were only incidentals in alfalfa. These families were collected only 11 times in all. During the summer of 1967 the Clubionidae, Mimetidae, and Anyphaenidae also appeared only rarely, but during other tests conducted in the summer of 1968 they were collected more commonly. The Clubionidae and Anyphaenidae are among the group of two-clawed hunting spiders (along with the Thomisidae, Salticidae and Gnapolidae). They are found on the foliage and on the ground, making tubular retreats in rolled up leaves, under stones, in litter, etc. Their numbers appear to reach a peak in alfalfa in October, although this is by no means certain. The Minetidae (represented by one species, _Mimetus epeiroides_ Emerton, are usually found in webs of other species, but this phenomenon was never observed in alfalfa.

found in webs of other species, but this phenomenon was never observed in alfalfa.

As shown in Figure 3, spider populations increased in size as the temperatures increased and the season progressed, the largest numbers being found from mid-July to late August. Occurrence data on the four most commonly observed spiders from June 21, 1967 to June 20, 1968 are presented in Figures 4 to 7. Both Tetragnatha laboriosa and Oxyopes salticus had two population peaks, rising in late March to mid-April and again in August. The T. laboriosa and O. salticus numbers in March and April were primarily composed of immatures, as were those in September. Figure 4 shows T. laboriosa with a "third peak" occurring in February. The presence of so many spiders in the samples at this time was due to a warm period of several days preceeding the collection date. Spiders along with various other arthropods become active whenever a warm spell occurs during winter months. Pachygnatha tristriata (Figure 5) and Misumenops asperatus (Figure 6) both show peaks in August. M. asperatus immatures make up most of their peak, while the P. tristriata peak was almost exclusively the result of adult numbers. Stoner (1960) in his survey of range arthropods of central Oklahoma found their populations to usually have two peaks of abundance.

All the spiders collected by the D-Vac sampler from alfalfa were examined and identified as precisely as possible.

Representative specimens were then sent to taxonomists for verification and further identification when necessary Many immature specimens could only be identified to the genus level. There were 14 families composed of 75 genera and 112 species identified as follows:

Family Theridiidae

Euryopis funebris (Hentz)
Euryopis gertschi Levi
Euryopis limbata (Walckensaer)
Theridion albidum Banks
Theridion neshamini Levi
Theridion pennsylvanicum Emerton
Theridula opulenta (Walckenaer)

Family Linyphiidae

Bathyphantes albiventris (Banks)
Bathyphantes pallidus (Banks)
Ceraticelus similis Banks
Eperigone tridentata Emerton
Eperigone trilobata Emerton
Eridantes erigonoides (Emerton)
Erigone autumnalis Emerton
Frontinella communis Emerton
Grammonota inornata Emerton
Islandia flaveola Banks
Linyphia maculata Emerton
Meioneta fabra (Keyserling)
Meioneta maculata (Banks)
Meioneta micaria (Emerton)
Meioneta unimaculata (Banks)
Meioneta spp.
Meioneta 2 n. sp.
Microlinyphia mandibulata (Emerton)
Walckenaera vigilax (Blackwall)

Family Argiopidae

Acacesia foliata (Hentz)
Acanthepeira stellata Walckenaer
Araniella displicata (Hentz)
Argiope aurantia Lucas
Argiope trifasciata (Forskal)
Conepeira juniperi (Emerton)
Conepeira n.sp.
Cyclosa turbinata (Walckenaer)

Family Argiopidae (Cont'd)

Eustala triflex (Walckenaer)
Gea ergaster (Walckenaer)
Larinia directa (Hentz)
Mangora gibberosa (Hentz)
Mangora placida (Hentz)
Metepeira labyrinthea (Hentz)
Neoscona arabesca (Walckenaer)
Wixia anaglyphe (walckenaer)

Family Tetragnathidae

Mimognatha foxi (McCook)
Pachygnatha autumnalis Keyserling
Pachygnatha trilineata Keyserling
Pachygnatha tristriata Koch
Tetragnatha laboriosa Hentz

Family Mimetidae

Mimetus epeiroides Emerton

Family Agelenidae

Agelenopis sp.

Family Hahniidae

Neoantistea sp. prob. riparia

Family Lycosidae

Arctosa funera (Hentz)
Lycosa avida Walckenaer
Lycosa helluo (Walckenaer)
Lycosa rabida Walckenaer
Pardosa distincta Blackwall
Pardosa floridana Banks
Pardosa milvina (Hentz)
Pardosa paufilla Montgomery
Pardosa saxatilis (Hentz)
Pardosa saxatilis var. atlantica Emerton
Pardosa sp.
Pirata insularis Emerton
Pirata minutus Emerton
Schizocosa bilineata (Emerton)
Schizocosa sp.

Family Oxyopidae

Oxyopes salticus Hentz

Family Gnaphosidae

Drassyllus sp.

Family Dictynidae

Dictyna volucripes Keyserling

Family Clubionidae

Agroeca pratensis Emerton
Castianiera variata Gertsch
Clubiona abbotii Koch
Clubiona catawba Gertsch
Clubiona pikei Gertsch
Clubiona spiralis Emerton
Meriola decepta Banks
Meriola distincta Banks
Meriola ornata Banks

Family Anyphaenidae

Anyphaena pectorosa Koch
Anyphaenella saltabunda (Hentz)
Gayennia britcheri Gertsch

Family Thomisidae

Misumenoides aleatorius (Hentz)
Misumenops asperatus (Hentz)
Misumenops oblongus (Keyserling)
Philodromus sp.
Synema parvulum (Hentz)
Thanatus formicinus (Olivier)
Thanatus sp.
Tibellus oblongus (Walckenaer)
Tibellus sp.
Tmarus angulatus Walckenaer
Xysticus auctificus Keyserling
Xysticus discursans Keyserling
Xysticus fertivus Gertsch
Xysticus triguttatus Keyserling
Xysticus sp.

Family Salticidae

Habronattus coronatus (Hentz)
Hentzia palmarum (Hentz)
Marpissa lineata (Koch)
Marpissa pikei (Peckham)
Metaphidippus galathea (Walckenaer)
Metaphidippus protervus (Walckenaer)
Onondaga lineata (Koch)
Paraphidippus aurantius (Lucas)
Paraphidippus marginatus (Walckenaer)
Phidippus audax (Hentz)
Phidippus sp.
Sitticus floridanus Gertsch
Zygoballus betinni Peckham
Zygoballus sexpunctatus (Hentz)

Table 1.

Summary of spider specimens collected by the D-Vac sampler from alfalfa.

June 21, 1967-June 20, 1968

Families	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total	%
Linyphiidae	159	591	341	165	92	10			2	24	74	32	13	1553	48.60
Tetragnathidae	55	252	365	157	46	20			85	41	104	47	30	1202	37.62
Thomisidae	5	22	96	15	12	6					6	3	2	167	5.22
Oxyopidae		6	63	8	3	1				9	2	2		94	2.94
Lycosidae	3	12	26	3	4				2	3	5	5		73	2.28
Salticidae		15	31	3	6					1				56	1.75
Argiopidae	2	9	7	2	1									21	0.65
Clubionidae	1	4	4											9	0.28
Hahniidae		5												5	0.15
Mimetidae			3	1									1	5	0.15
Theridiidae	3	1	*											4	0.12
Anyphaenidae		3	1		*									4	0.12
Agelenidae	1	1												2	0.06
Gnophosidae		1												1	0.03
Totals	229	921	919	359	164	37			89	78	191	189	46	3195	
per cent	7.16	28.82	28.76	11.23	5.13	1.15			2.78	2.44	5.97	5.91	1.43		

* Collected during 1968 samples

Figure 3. Seasonal occurrence of spiders collected in D-Vac samples from alfalfa.

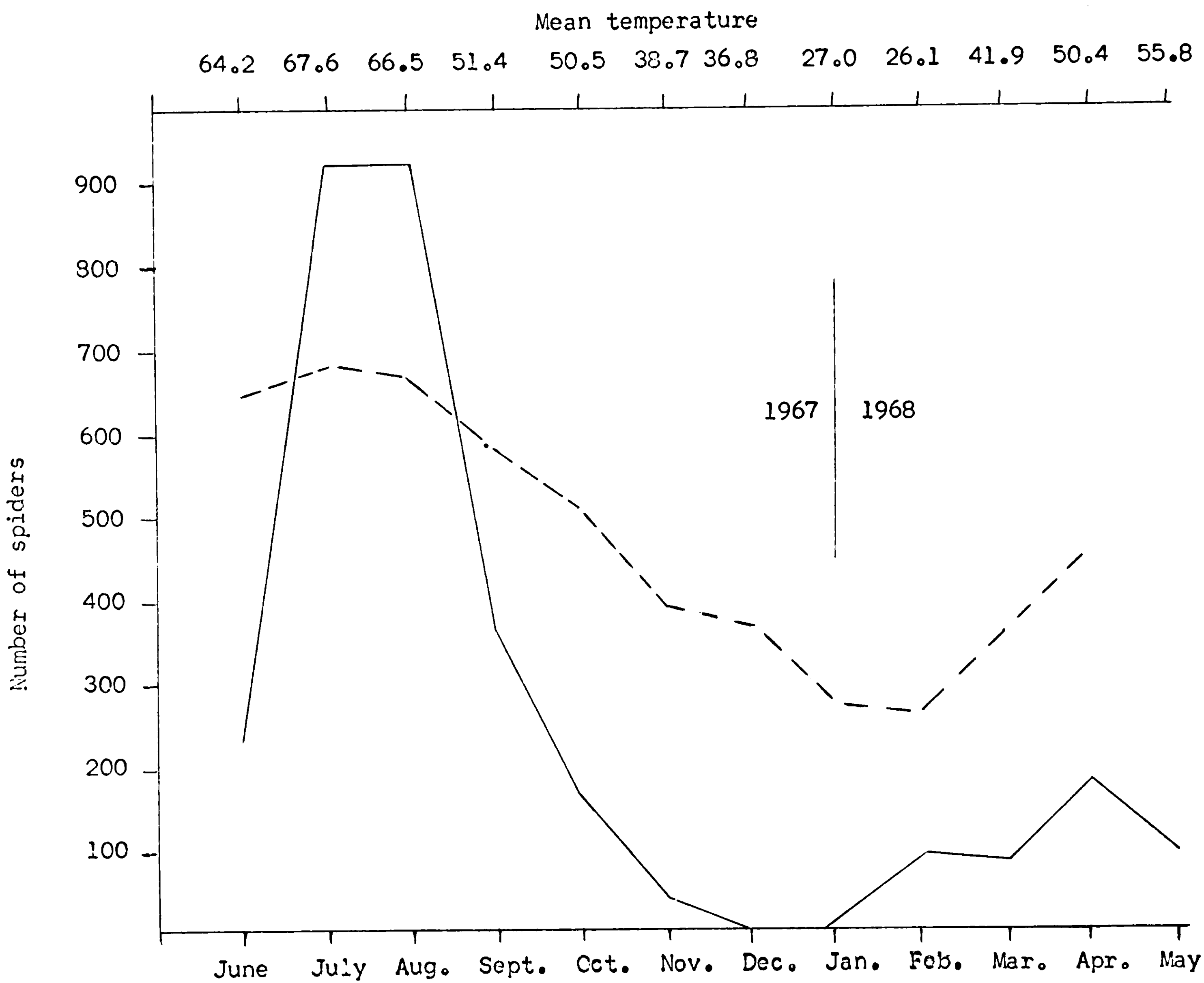
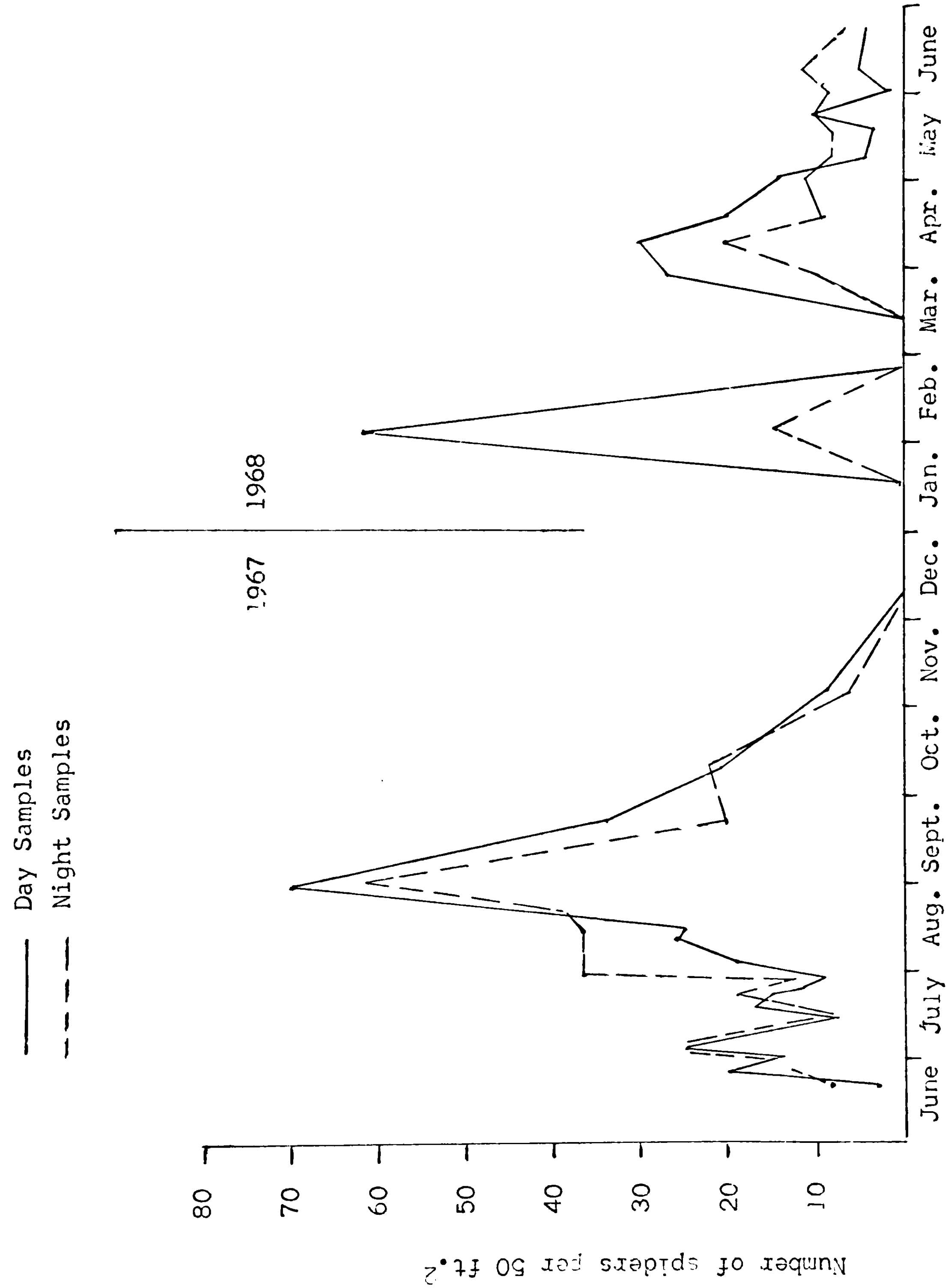
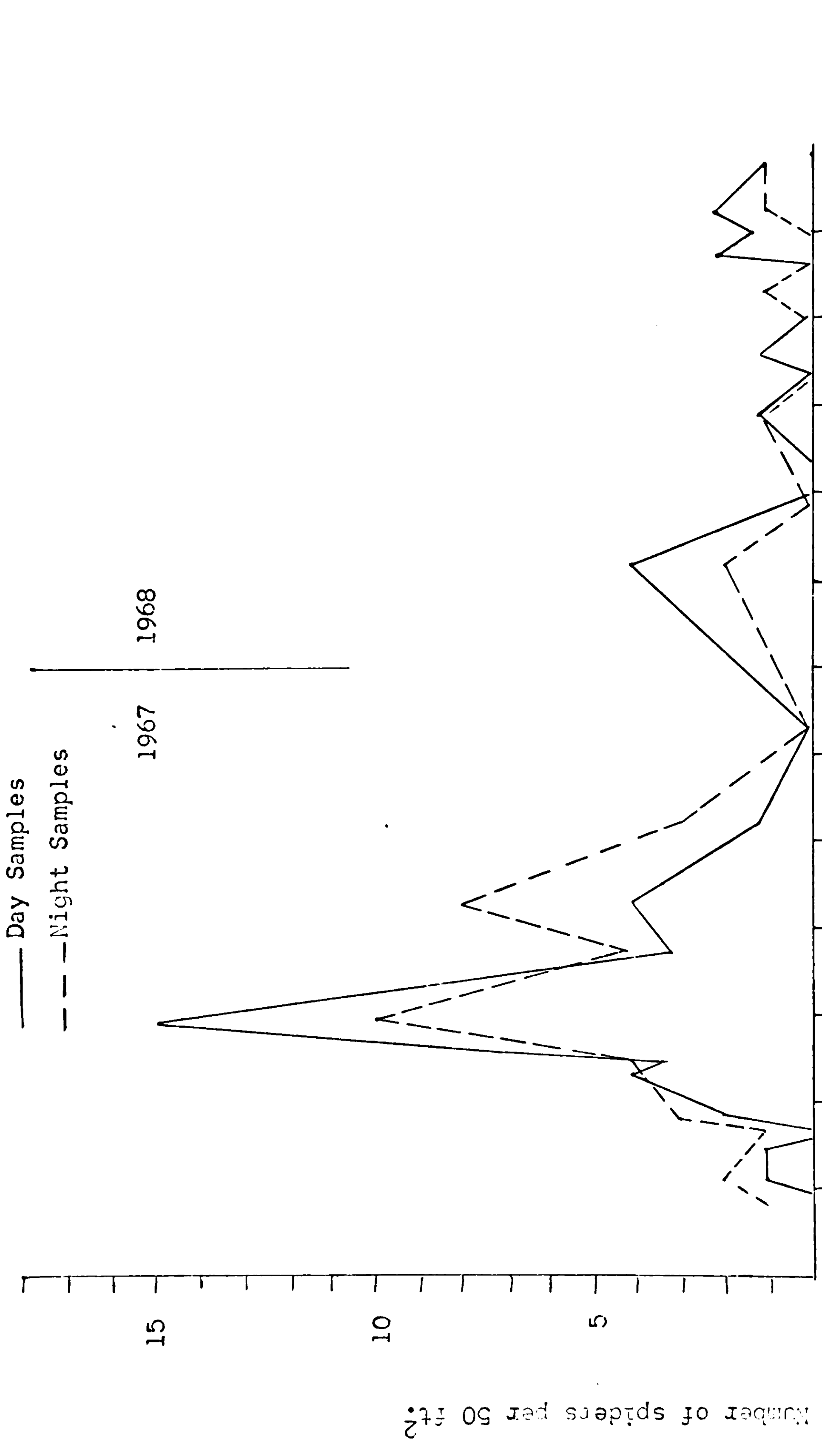

Mean temperature
64.2
67.6
66.5
51.4
50.5
38.7
36.8
27.0
26.1
41.9
50.4
55.8
1967
1968
Number of spiders
900
800
700
600
500
400
300
200
100
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May

Figure 4. Seasonal occurrence of *Tetragnatha laboriosa* caught in D-Vac samples.



Day Samples
Night Samples
1967
1968
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
10
20
30
40
50
60
70
80
Number of spiders per 50 ft.²

Figure 5. Seasonal occurrence of *Pachygnatha tristriata* caught in D-Vac samples.



Day Samples
Night Samples
1967
1968
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
April
May
June
15
10
5
Number of spiders per 50 ft²

Figure 6. Seasonal occurrence of *Misamenops asperatus* caught in D-Vac samples.

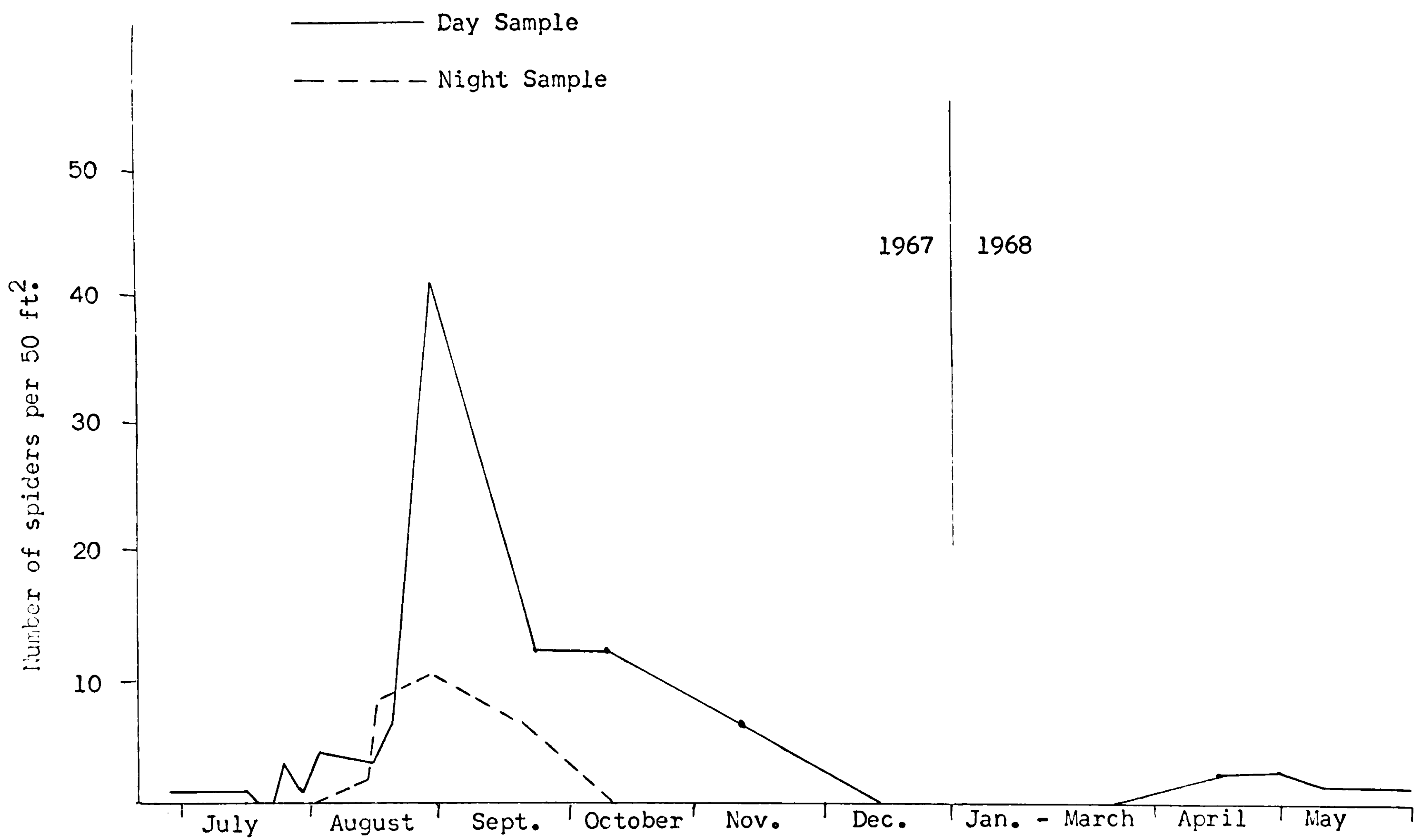
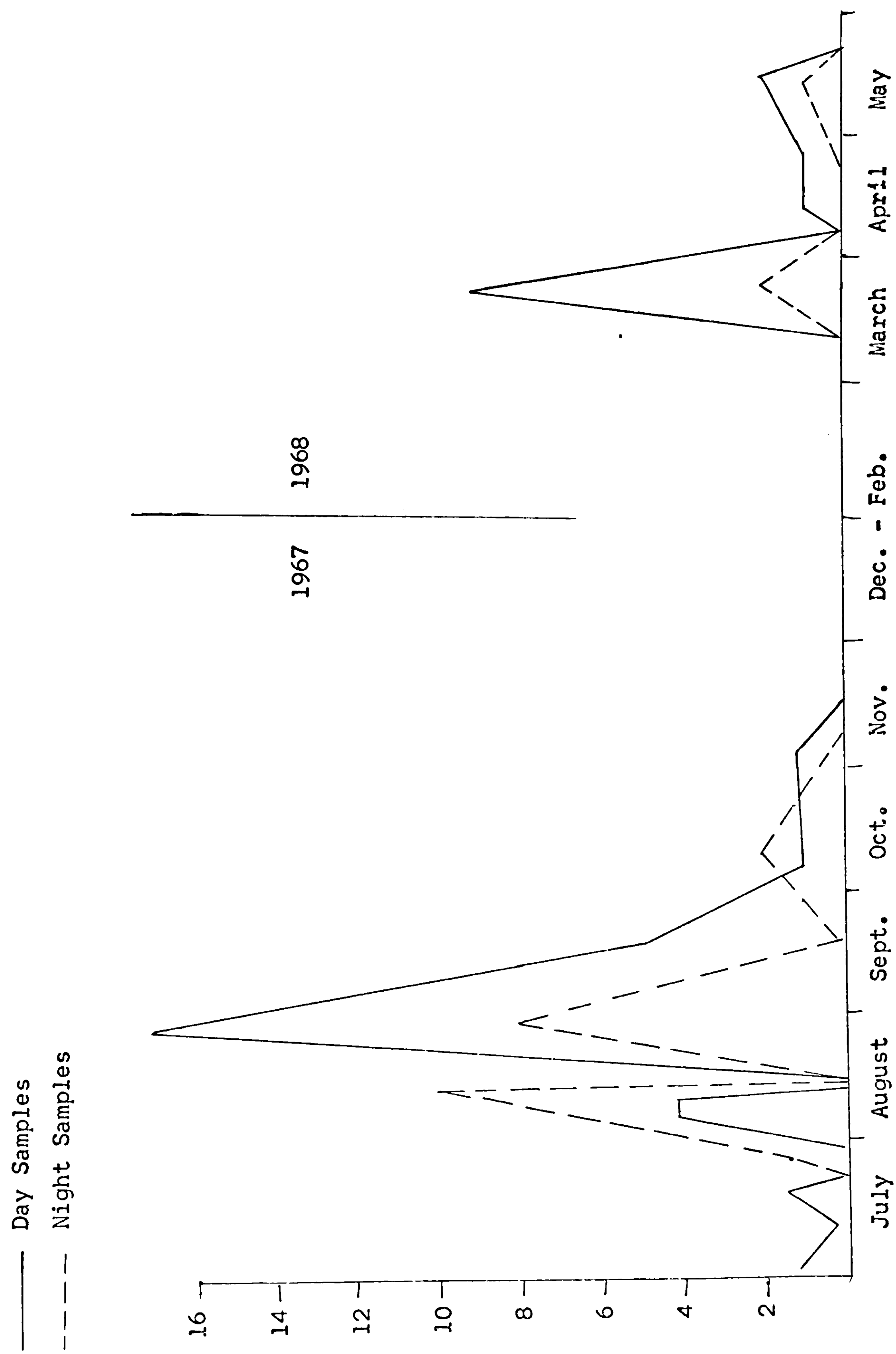

Day Sample
Night Sample
1967
1968
50
40
30
20
10
Number of spiders per 50 ft.^{2}
July
August
Sept.
October
Nov.
Dec.
Jan. - March
April
May

Figure 7. Seasonal occurrence of *Oxyopes salticus* caught in D-Vac samples.


Day Samples
Night Samples
Number of spiders per 50 ft.^{2}
16
14
12
10
8
6
4
2
July
August
Sept.
Oct.
Nov.
Dec. - Feb.
March
April
May
1967
1968

2. Sweep Net Collections

During the period from March 28, 1967 to November 5, 1968, twelve families were collected from alfalfa by the sweep net. These data are summarized in Table 2. As with the D-Vac samples, Figure 8 shows that the spider numbers increased as the temperature increased and the season progressed. This figure is misleading, however, in the months of April and May. The numbers collected in April represent more sample dates than the other months. May, on the other hand, received 4.35 inches of rain with some rain falling almost every day, thus limiting the amount of collections that could be taken. For this reason, the broken line in Figure 8 shows the average number of spiders per hundred sweeps which eliminates this error. It can be seen that the rate of buildup in both lines was similar to that of Figure 3, showing two peaks, one in spring and the other in late summer.

Most of the spiders collected with the sweep net belong to the families Tetragnathidae and Thomisidae. These two families represented 77.5% of all the spiders collected by this method. The tetragnathids are orb-weaving spiders, while the thomisids are hunters. The Salticidae and Oxyopidae were also well represented in the samples. They are also hunters, as previously discussed. (D-Vac samples, p.15,16.) With two exceptions, Agelenidae and Gnaphosidae, which were less common families, all the families collected with the D-Vac sampler were collected also with the sweep net. The

Linyphiidae, which topped the list of specimens taken by the D-Vac were well down in the sweep sample totals. This was expected because the members of this family (at least the Erigoninae) are found primarily on the ground, rarely climbing upon vegetation. Habits of the other spiders have been previously discussed. Occurrence data of the four most commonly observed species are shown in Figures 9-12. Comparisons of these graphs with those showing D-Vac collections will reveal a similarity in the general times at which the major peaks occur in each species. Only night samples are shown for Pachygnatha tristriata (Figure 10) because specimens collected with the sweep net during the day were rare. (See Effect of Time of Day, VI, p.67.) Most of the spiders making up the Pachygnatha peak in October were adults. This is readily understandable since this species overwinters in the adult stage (Kaston, 1948). Misumenops asperatus (Figure 11) showed both a mild spring peak in May, due largely to adult numbers, and a larger peak in August and September. This latter peak differs from that of Pachygnatha tristriata because it is comprised primarily of immature forms, although some adults were collected.

As shown in Figure 9, Tetragnatha laboriosa individuals reached adulthood in May, and adults were collected in considerable numbers until late August. The overwintering population, however is made up of immatures. Oxyopes salticus (Figure 12), whose May and August peaks were both composed primarily of immature forms, had very few adults represented in alfalfa. Large numbers of adult O. salticus were collected in red clover in July, however.

Spiders collected by sweeping totaled 1001, belonging to 47 genera and 59 species in 12 families identified as follows:

Family Theridiidae

Achaeranea tepidariorum Koch
Euryopis funebris (Hentz)
Theridion albidum Banks
Theridion differens Emerton
Theridion rabuni Chamberlain and Ivie
Theridula opulenta (Walckenaer)

Family Linyphiidae

Eridantes erigonoides (Emerton)
Frontinella communis Emerton
Meioneta micaria (Emerton)
Microlinyphia mandibulata (Emerton)

Family Argiopidae

Acanthepeira stellata Walckenaer
Araneus trifolium (Hentz)
Araneus sp.
Araniella displicata (Hentz)
Argiope aurantia Lucas
Argiope trifasciata (Forskal)
Cyclosa conica (Pallas)
Cyclosa turbinata (Walckenaer)
Eustala triflex (Walckenaer)
Gea heptagon (Hentz)
Larinia directa (Hentz)
Metepeira labyrinthea (Hentz)
Micrathena gracilia (Walckenaer)
Wixia anaglyphe (Walckenaer)

Family Tetragnathidae

Mimognatha foxi (McCook)
Pachygnatha tristriata Koch
Tetragnatha laboriosa Hentz

Family Mimetidae

Mimetus epeiroides Emerton

Family Hahniidae

Neoantistea sp. prob. riparia

Family Lycosidae

Arctosa funerea (Hentz)
Lycosa helluo (Walckenaer)
Pardosa milvina (Hentz)
Pardosa saxatilis (Hentz)
Pardosa sp.

Family Oxyopidae

Oxyopes salticus Hentz

Family Clubionidae

Chiracantheum inclusum (Hentz)
Clubiona abbotii Koch
Meriola decepta Banks

Family Anyphaenidae

Aysha gracilia (Hentz)

Family Thomisidae

Misumenoides aleatorius (Hentz)
Misumenops asperatus (Hentz)
Misumenops oblongus (Keyserling)
Philodromus minutus Banks
Philodromus sp.
Thanatus sp.
Tibellus oblongus (Walckenaer)
Tmarus angulatus Walckenaer
Xysticus auctificus Keyserling
Xysticus discursans Keyserling
Xysticus transversatus (Walckenaer)
Xysticus triguttatus Keyserling
Xysticus sp.

Family Salticidae

Agassa cyanea (Hentz)
Euophrus sp.
Evarcha hoyi (Peckham)
Hentzia palmarum (Hentz)
Marpissa bina (Hentz)
Metaphidippus protervus (Walckenaer)
Paraphidippus aurantius (Lucas)
Paraphidippus marginatus (Walckenaer)
Phidippus audax (Hentz)
Phidippus clarus Keyserling
Phidippus rimator (Walckenaer)
Zygoballus betinni Peckham
Zygoballus sexpunctatus (Hentz)

Table 2.

Summary of spider specimens collected by the sweep net from alfalfa

March 28-November 5, 1967

Families	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	%
Tetragnathidae	5	128	52	18	35	141	50	89	22	540	53.94
Thomisidae		27	12	8	50	63	41	23	12	236	23.57
Oxyopidae		9	16		9	33		10	5	82	8.19
Salticidae		8	2	5	7	21	15	12	4	74	7.39
Argiopidae		5	3	4	8	3	2	3	1	29	2.89
Linyphiidae		9	1	3	3	4	3	1		24	2.39
Lycosidae	1		1			3		2		7	0.69
Clubionidae			1		1	2		*		4	0.39
Theridiidae				3		*		*		3	0.29
Hahniidae					1					1	0.09
Mimetidae					*		1	*		1	0.09
Anyphaenidae								*			
Totals	6	186	88	41	114	270	112	140	44	1001	
per cent	0.59	18.58	8.79	4.09	11.38	26.97	11.18	13.98	4.39		

* Collected during 1968 samples

Figure 8. Seasonal occurrence of spiders collected in sweep net samples.

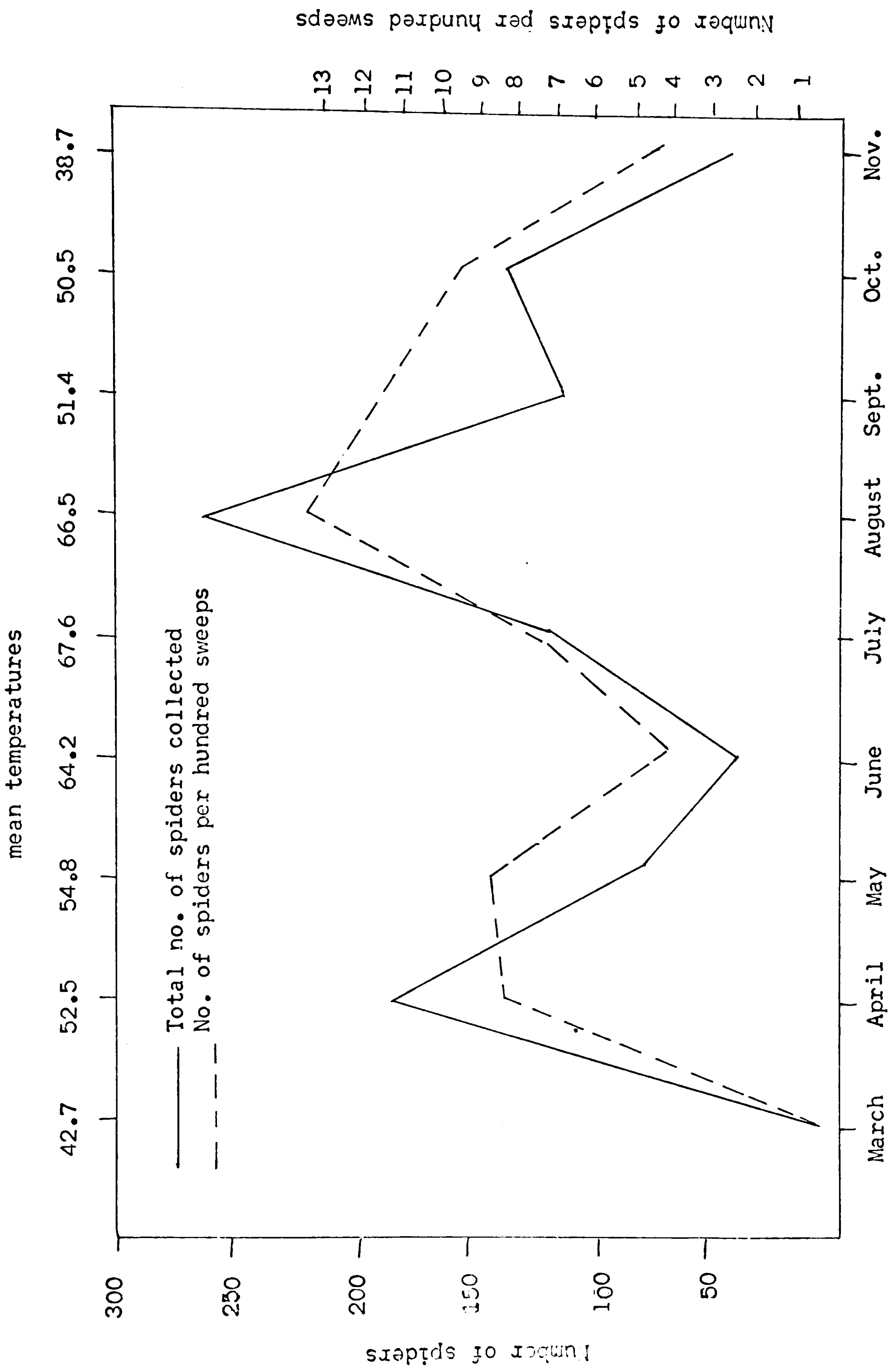

mean temperatures
42.7
52.5
54.8
64.2
67.6
66.5
51.4
50.5
38.7
Total no. of spiders collected
No. of spiders per hundred sweeps
March
April
May
June
July
August
Sept.
Oct.
Nov.
300
250
200
150
100
50
Number of spiders
Number of spiders per hundred sweeps
1
2
3
4
5
6
7
8
9
10
11
12
13

Figure 9. Seasonal occurrence of *Tetragnatha laboriosa* caught in sweep samples.

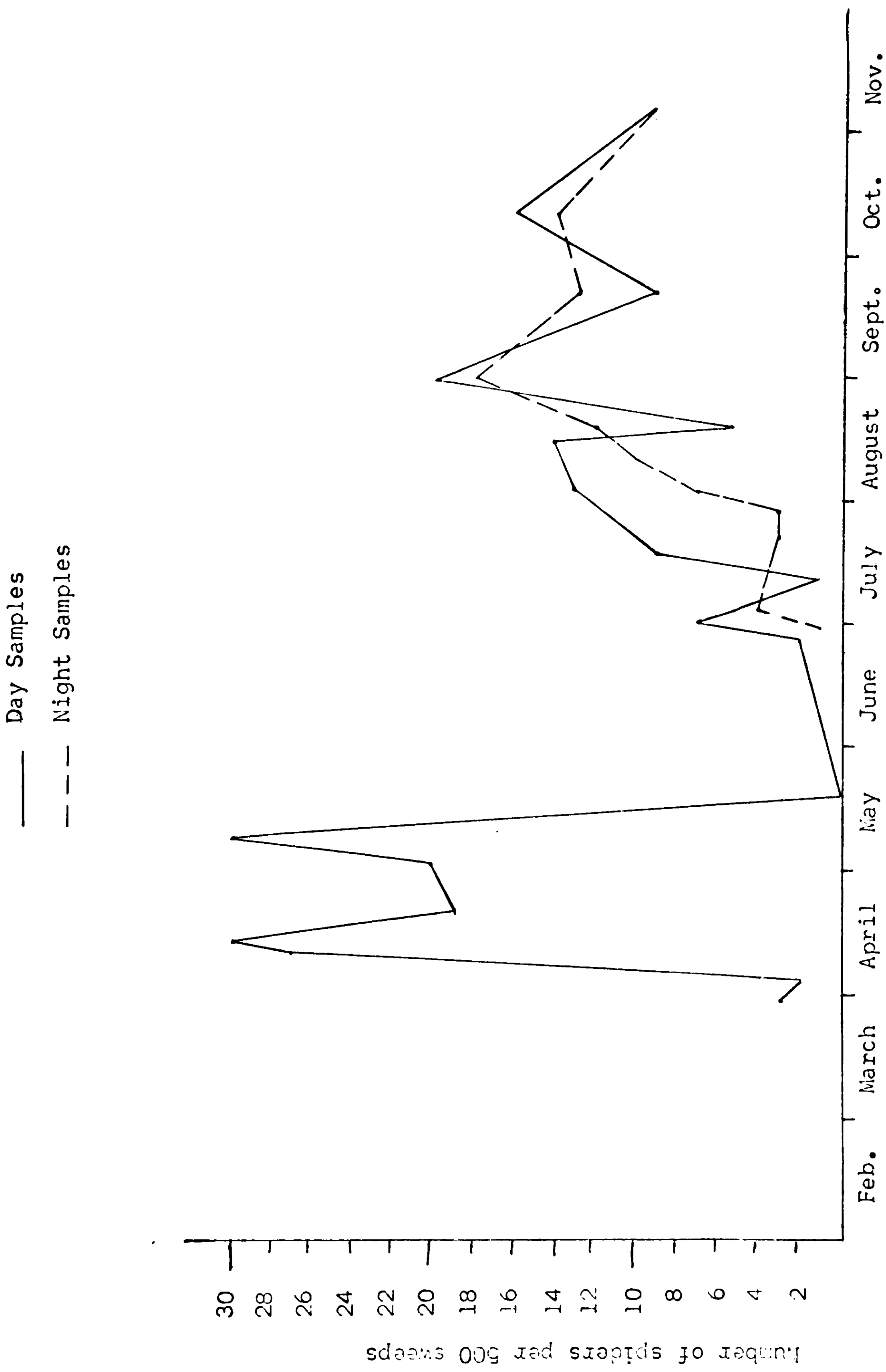

Day Samples
Night Samples
Feb.
March
April
May
June
July
August
Sept.
Oct.
Nov.
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
Number of spiders per 500 sweeps

Figure 10. Seasonal occurrence of _Pachygnatha tristriata_ caught in night sweep samples

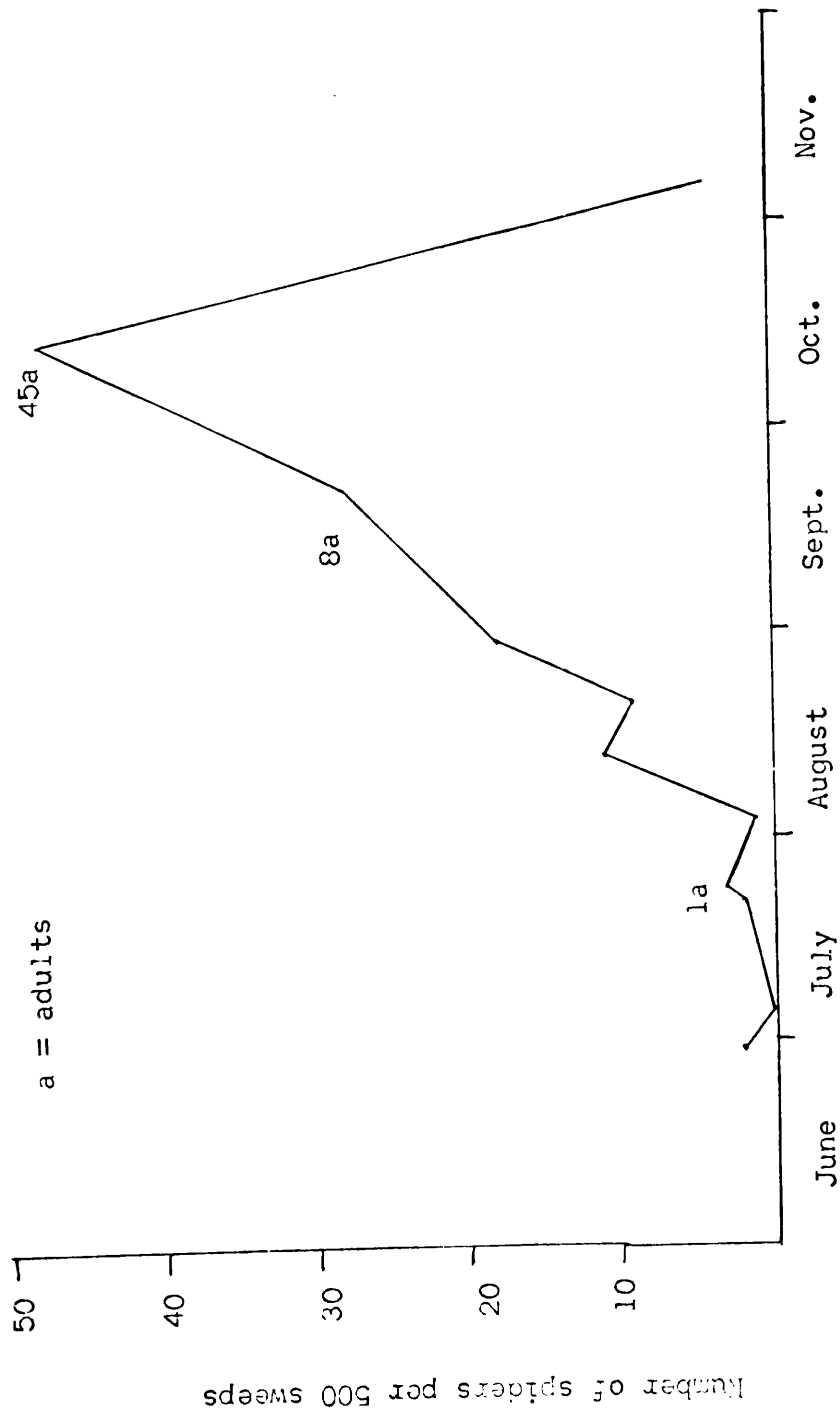
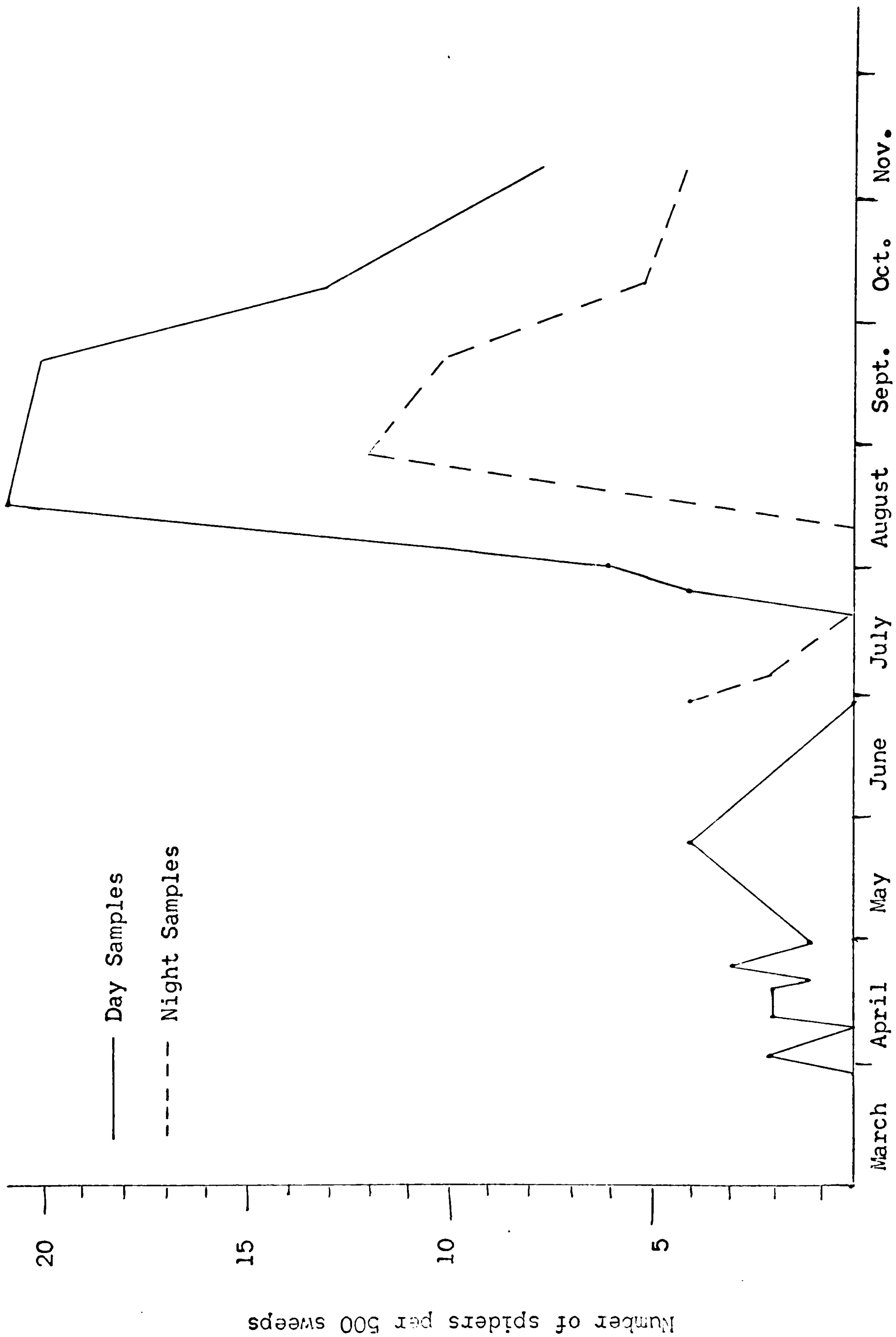
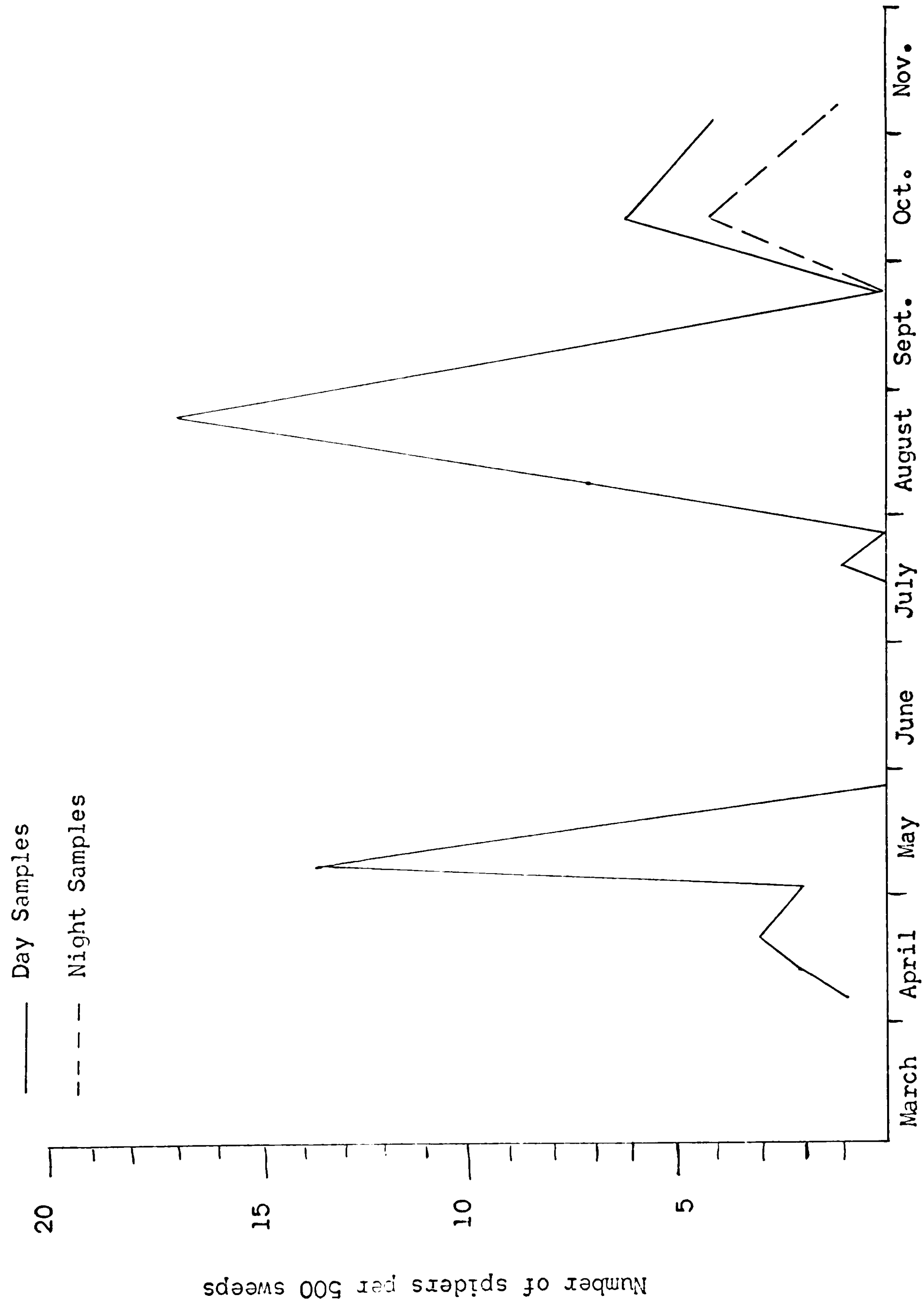

a = adults
45a
8a
1a
June
July
August
Sept.
Oct.
Nov.
50
40
30
20
10
Number of spiders per 500 sweeps

Figure 11. Seasonal occurrence of *Misumenops asperatus* caught in sweep samples.



Day Samples
Night Samples
March
April
May
June
July
August
Sept.
Oct.
Nov.
20
15
10
5
Number of spiders per 500 sweeps

Figure 12. Seasonal occurrence of *Oxyopes salticus* caught in sweep samples.


Day Samples
Night Samples
March
April
May
June
July
August
Sept.
Oct.
Nov.
20
15
10
5
Number of spiders per 500 sweeps

3. Manual collection of spiders

Manual collections of spiders from the alfalfa plants yielded no species which were not collected by the two previous methods. It did, however, suggest something about the position of the spiders on the plants. Within the Tetragnathidae, *Tetragnatha laboriosa* was found almost exclusively in the upper third of the plants. Of 27 specimens collected 26 were in the upper 1/3 and 1 was near the center of the plant. Their webs were spun between adjacent stems. *Pachygnatha tristriata* was never taken from the plant in these collections during the day, but sweep net samples indicate large numbers climb up on the vegetation at night. The Salticidae were found distributed rather evenly over the plants, of 5 specimens taken, 2 were in the upper 1/3, 2 were near the center and 1 was nearer the ground. The Thomisidae were usually found in the upper portions, of 12 specimens found, 8 were in the upper half and 4 in the lower half. On some occasions, however, they could not be found on the stems in any quantity even with a sweep net. No correlation with humidity could be drawn from data collected, but humidity variances within the stand itself could possibly account for this phenomenon. *Oxyopes salticus* was collected from all areas of the plant, but the largest numbers were found on the upper half. Of 9 specimens collected 6 were on the upper half, 3 on the lower half.

4. Use of the Head Lamp

Probably the best known method for collecting the wolf spiders is by use of the head lamp. This method, however, did not prove very successful in alfalfa fields. In the study field the genus Lycosa was the only representative and here the number collected for five nights totaled four specimens. Wallace (1937) said that often the wolf spiders in areas of vegetation will be startled by the rustling of the plants as one walks through them and retreat into their burrows thus escaping capture.

E. Summary and Conclusions

Spiders were collected in D-Vac samples from June 20, 1967 to June 21, 1968. A total of 3,195 spiders were collected, including 14 families consisting of 75 genera and 112 identifiable species. Most of the spiders collected by the D-Vac belonged to the Linyphiidae, Tetragnathidae and Thomisidae. The Linyphiidae, comprising about 50 per cent of the specimens, build webs over clumsp of soil; the Tetragnathidae, which make up about 37.5 per cent of the spiders collected, usually construct snares between adjacent stems, and the Thomisidae hunt their prey building no snares. That the Thomisidae and Salticidae appear to be more difficult to pick up with the D-Vac than other groups is based on the average numbers collected with the sweep net as opposed to the D-Vac samples. Spiders were taken in all seasons with population peaks occurring in April and August. The seasonal distribution of four species, Tetragnatha laboriosa, Pachygnatha tristriata, Oxyopes salticus and Misumenops asperatus, were recorded. Several days of comparatively warm weather results in considerable spider activity.

Sweep net samples were taken from March 28, 1967 to November 5, 1967. Twelve families comprising 47 genera and 59 identifiable species totaled 1,001 specimens. The Tetragnathidae, Thomisidae, Oxyopidae and Salticidae were the dominant families, the latter three being hunting forms. Essentially the same families were collected in both sweep net and D-Vac samples. The Linyphiidae were well down in the order of families taken with the sweep net because of their ground dwelling habits.

Manual collections of spiders from alfalfa plants showed a relationship between families and location on the plant, which was due to their feeding and web-building habits. Bailey and Chada (1968) found similar relationships. The Thomisidae and Oxyopidae were collected more often on the upper half of the plant, while the Salticidae were found distributed rather evenly. The Tetragnathidae were divided because of different habits of the two primary genera. Tetragnatha laboriosa was found on the upper third of the plant, while Pachygnatha tristriata was found on the ground during the day and on all parts of the plants at night.

The head lamp was used to collect wolf spiders but did not prove very successful. The rustling of the alfalfa as the collector walked through the stand is believed to have caused the lycosids to retreat into their burrows.

V. EFFECT OF ALFALFA HARVEST ON SPIDER POPULATIONS

A. Introduction

Alfalfa is periodically removed by cutting and harvesting operations. These procedures quite obviously has an immediate effect on the spider populations in alfalfa fields by either removing them along with the alfalfa, by causing mortality and migration from the fields because of increased temperatures, lower humidities and reduced prey densities or by forcing them to seek shelter within the field. The habitat may suffer a drastic change, going immediately from lush plants in or near bloom stage to a sometimes desertlike stubble.

Since spiders are among the primary predators of the insect fauna in alfalfa, a preliminary study was undertaken in the summer of 1968 to determine the effect of alfalfa harvest on the spider populations in the field.

B. Literature Review

Although no studies have been published on the effects of alfalfa harvest on spiders, several reports have indicated some of the effects on insects. Graber and Sprague (1935) found that damage to alfalfa by the leafhopper *Empoasca fabae* (Harris) was confined mostly to the second growth, particularly when the first growth was cut early. Deferment of the first cutting provided for a more abundant and complete deposition of eggs in the stand. Such eggs, and nymphs hatching from them, were destroyed in the curing of the hay. Searles (1934) in a simultaneous work, validated their findings. Graber (1941) reported larger number of eggs were laid when cool weather occurred in late spring. Many of the insects preferred to lay their eggs in the regrowth of alfalfa with a delayed first cutting that recovered more rapidly. Pienkowski and Medler (1962) found the time of major build-up of leafhoppers to vary considerably. By not defering the first cutting and by cutting the second growth in early bloom there was considerable reduction in the amount of nymphal feeding damage and yellows.

Faulkner (1954) reported the number of thrips in cotton were always highest when alfalfa growing in adjacent fields were cut for hay, indicating that the thrips migrated into the cotton when unsuitable conditions occurred in alfalfa.

Hamlin et al, (1943) stated that early cutting of the first and second alfalfa crops usually provided the most practical method of control for the alfalfa weevil, *Hypera postica Gyllenhal*. The clean cutting at the time of the flower-bud stage of growth along with prompt removal of the hay, leaves the weevil larvae and pupae on the bare fields where most of them die of starvation or exposure to heat.

The author has been able to find no previous works which studied the effect of harvest on spiders in alfalfa. Spider dispersal, however, has been studied. Southwood (1962) discussed migratory movement in various taxa. He concluded that the level of migratory movement is positively correlated with the degree of impermanence of the habitat. He stated that spiders have no control over direction or duration when they move by ballooning. Bristowe (1939) analyzed the data for airborne spiders given by Glick (1939) into families. The Linyphiidae accounted for 80 per cent of Glick's catches. Nielsen (1932) and Brandegaard (1937) associated the aerial dispersal of spiders with a rise in temperature and low humidity. Wellington (1945) notes that thermal convection was the most important type of convective process in the distribution of wingless insects.

C. Materials and Methods

Beginning on the day of cutting, July 8, 1968, a spider survey was conducted to determine the effect of cutting on spider populations. Collections were taken at regular intervals until July 24, 1968 with the D-Vac sampler. The .75 square foot end piece was selected because of the larger area sampled. Increased suction was not necessary to remove most spiders from the stubble. Five sample units of 18.75 square feet were taken and placed in separate bags. These were placed in an ice chest to reduce activity and were then immediately returned to the laboratory. Each bag was then placed in a five gallon can. CO_2 was added to the can to knock down the spiders and insects before placing them in the Tullgren funnels (Figure 13). A procedure was then followed similar to that for the previously described survey.

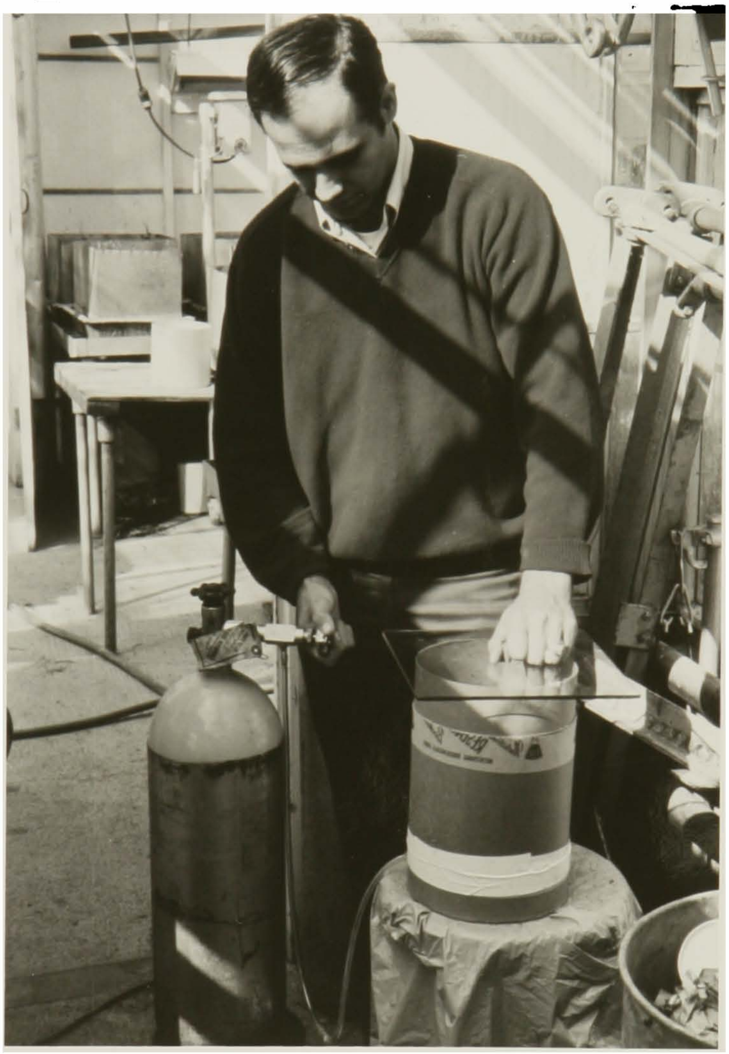
D. Results and Discussion

1. Methods of dispersal used by spiders

Before discussing the effect of cutting on the various spider families present in alfalfa, it may be appropriate here to mention the avenues of dispersal which are open to spiders. Probably the most well known and highly publicized method of dispersal by spiders is ballooning. Almost all young spiders balloon, and many adults practice the habit, limited only by size and weight. Since all spiders are carnivorous, young spiderlings newly emerged from the egg sac must disperse rather rapidly to other areas where the competition for existing food is not great. Often as soon as it has emerged from the egg case, the spiderling climbs to the tip of a grass blade or stem. Facing the wind it extends its legs to their fullest, tilts the abdomen upward and emits threads which are paid out by the air currents. When the pull is great enough, the spiderling releases its hold on the stem and drifts away on gossamer. In this manner spiders may travel only a few feet or they may travel hundreds of miles (Gertsch, 1949). Ballooning has made possible the widespread distribution of spider speci

Some groups are more inclined to balloon than others. Bristowe's (1939) analysis of Glick's work showed the Linyphiidae to comprise 80 per cent of the specimens collected. This is not surprising because the members of this group are

Figure 13. Use of CO_2 in Anesthecizing Spiders from samples.



so small that both adults and immatures can balloon with ease. Other groups do not balloon at all. Wolf spiders, for example, have very little ballooning activity. The act of ballooning, as will be shown later, appears to be an important factor in explaining the effect of cutting on the spider populations.

Spiders also disperse by walking. This method does not cover nearly as much distance nor is it nearly as fast as ballooning. None the less, it is a very important avenue of dispersal, especially for those spider species which do not balloon. When an environment undergoes as drastic a change as that of an alfalfa field during the cutting and harvesting operations, all methods of dispersal will be utilized in order to escape from persistent adverse conditions.

2. Fluctuations in spider numbers after cutting alfalfa

From the day of cutting, July 8, 1968, until July 24, 1968, samples were taken to measure the effects of cutting on various spider groups. When the numbers of all spiders were examined, a statistical analysis of the numbers collected revealed no significant difference between collection dates. This was also true of Tetragnatha laboriosa, by far the most common spider species in the field. Since it is a web-builder, it does not have the ability to walk moderately long distances and although it can and does balloon it its immature stages, this method of escape was not used to any great extent. The spiderlings of this species may have gone into cracks in the soil in order to escape the heat and low humidities.

The temperature during the collecting period often reached 115° in the direct sunlight at ground level. Pachygnatha tristriata numbers also showed no significant difference between collection dates when subjected to analysis. This species, as will be shown in section VI, is most active at night. It builds no webs but climbs on the vegetation in search of food. The heat would have less effect on this species than some others because during the day it spends most of its time under leaves and surface debris. The Lycosidae, which have similar nocturnal feeding habits, were little effected by cutting. They remained in burrows in the soil by day and fed mostly at night after the high temperatures past.

The Linyphiidae, however, were effected by the cutting procedure. Their numbers showed a significant rise during the four days following the cutting (Table 3). During this period the alfalfa was still on the ground providing some cover. The curing alfalfa seemed to attract a large number of insects which, because the crop had been cut, were brought into contact with the ground dwelling Linyphiids. This may have made them a little more active and more susceptible to the D-Vac collecting procedure. After the alfalfa was picked up the field was left in stubble. No vegetational cover was present and the numbers of Linyphiidae went down. These spiders are so small that both adults and immatures are excellent ballooners. However, the sampling procedure showed no significant migration out of the field after cutting.

The numbers of the Salticidae and Thomisidae collected were small, but adequate for statistical analysis. There was a significant difference between the numbers collected during the one week period following the cutting and the numbers collected on the dates after July 17 (Table 3). These spiders are predators which hunt their food on the vegetation. Their numbers decreased after cutting and did not rise again until July 17, when the alfalfa had grown high enough to give them some cover. The immature stages of both families are very good ballooners. This is probably the method used in dispersing from the field after its cutting. The adults, often too large for this action, probably migrated from the field by walking.

E. Summary and Conclusions

Spiders were collected for a sixteen day period following cutting of the alfalfa on July 8, 1968. When the numbers of all spiders collected were analyzed, the cutting was found to have no significant effect on them. *Tetragnatha laboriosa* and *Pachygnatha tristriata* were not significantly effected, nor were the Lycosidae.

Other families, however, showed a definite response to cutting. The Erigoninae were collected in larger numbers

Table 3. Average number of spiders per day during the 16 day period following cutting.1/

	Salticidae		Thomisidae		Linyphiidae	
	mean		mean		mean	
July 8	.20	b c	.00	b	18.20	b
July 9	.00	c	.20	b	21.40	a b
July 10	.40	b c	.20	b	32.00	a
July 12	.40	b c	.80	a b	34.00	a
July 15	.20	b c	.60	a b	17.60	b
July 17	.80	a c	.80	a b	12.60	b
July 19	.20	b c	.40	b	21.00	a b
July 22	.40	a	.80	a b	18.00	b
July 24	1.00	a	1.60	a	16.80	b

1/ Means in a given column with similar letters are not significantly different according to Duncan's Multiple Range Test ($P = .05$).

during the first four days following the cutting. After this time their numbers went down. The rise was probably due to a larger number of insects coming in contact with this ground-dwelling subfamily because the crop lay on the ground after cutting. No significant amount of ballooning occurred here, although this family is well known for its ballooning habits. The Salticidae and Thomisidae were also effected by the cutting of alfalfa. Their numbers decreased after cutting and did not rise again until July 17 when alfalfa was high enough to give some cover. The immatures probably ballooned to areas outside the field, while the adults, often too large for this action, probably migrated from the field by walking.

VI. EFFECT OF TIME OF DAY ON SURVEYS OF SPIDER POPULATIONS

A. Introduction

The sampling of insect populations in alfalfa is of considerable importance to the survey entomologist in predicting outbreaks of insect pests and in recommending control procedures. It is well known that climatic factors play an important role in the activities of many insects. Such factors, along with aspects of behavior may cause insects to be more susceptible to certain collection procedures at different times of day. Samples were thus taken on August 14 and October 9, 1968 to check the effect of time of day on surveys of spider populations.

B. Literature Review

Strickland (1961) mentioned that field measurements are often confused because population density, behavior, weather and mechanical efficiency influence the results. DeLong (1932) pointed out that under conditions of extreme temperature or marked fluctuations during short periods, insects apparently change position on the plant in response to these changing physical conditions and may be found on the higher portions of the plant, near the surface of the ground, or even below the surface at times. He stated that humidity may also be a factor in this reaction. Sweep net catches would therefore change with the time of day samples were taken. Romney (1945) discovered that samples of the beet leafhopper, *Circulifer tenellus* (Baker) varied as much as 200 per cent with the sweep net depending on the time samples were taken. He found little effect of temperature or time of day on sample taken with a metal cylinder. In studying the jarring method of sampling for the plum curculio, *Conotrachelus nenuphar*, Wylie (1951) found the summer temperatures in Arkansas too high for satisfactory jarring during most of the daylight hours. Johnson (1954) found a double peak of aerial density in the populations of *Aphis fabae* during different times of day. Part of this double peak was associated with low temperature and low light intensity. Hughes (1955) in his studies on the numbers of *Meromyza variegata*, a chloropid fly, found the microclimate of the grass in which it was found to be directly related to the prevailing conditions of air temperature, wind, rain, and solar radiation, as modified by the structure of the vegetation. Because of this he noted a striking difference among the sweep net catches of the species at different times of day. Dumas, Boyer, and Whitcomb (1962) studied the effect of time of day on surveys of predaceous insects in field crops. They found the numbers of two hemipterous predators to give significantly different results at the three times of day studied. Those of a third species did not. Counts of the ground beetle *Lebiaanalis* were significantly lower at midday than at morning or evening. Differences in all spider counts were slight. There were indications that results might have been different if samples had been larger or if nocturnal counts had been taken.

C. Materials and Methods

On August 14 and again on October 9, 1968 samples were taken of the spiders in an alfalfa field at 3 hour intervals over a period of 24 hours to check the effect of time of day on the surveys of spider populations. The first sample on August 14 was taken at 3 p.m. the first sample taken on October 9 was taken at 6 a.m. Both the sweep net and D-Vac sampler were used. The D-Vac, however, was only used from 9 p.m. because of excessive moisture on the plants at night. Four sample units of 100 sweeps each were placed in separate bags and then put into an ice chest to reduce arthropod activity. The samples were immediately returned to the laboratory. Specimens were anesthetized with CO_2 and placed in Tullgren funnels. A procedure was then followed similar to that conducted during the spider survey (Section IV.). Four samples of 18.75 square feet each were likewise taken with the D-Vac and a similar procedure was followed.

D. Results and Discussion

The sweep samples for many species reflected the activity of the spiders on the vegetation because this sampling procedure only took the spiders on the plants themselves whereas, the D-Vac collected spiders whether they were on the ground or on the plants. When the numbers of Pachygnatha tristriata were examined, it was found that the numbers collected on August 14 were too small for analysis. On October 9, however, there was a highly significant difference between the numbers collected from 6 a.m. to 6 p.m. and the numbers collected from 9 p.m. to 6 a.m. (Table 4). Only one spider was collected during the daylight hours while night samples revealed the spider in abundant numbers reaching a peak at 3 a.m. There was a transition period at 6 o'clock a.m. The numbers collected here did not differ significantly from those from either of the two collection periods mentioned above. Neither temperature nor humidity changes explain the activity pattern of this species (Figure 14). There appears to be a negative response to light which caused these spiders to stay on the ground. The extremely small numbers collected with the sweep net on August 14 may have been the result of extremely high humidities. From 9 p.m. until 9 a.m. the vegetation in the field was very wet. Sweep samples contained many slugs and few spiders. After each series of sweeps, the net had to be twisted to wring out the water in order for subsequent samples to be taken. This large amount of water on the alfalfa plants may have prevented the spiders from moving actively on the vegetation.

The largest numbers of Tetragnatha laboriosa were collected during the daylight hours, centering around midday (Table 4). There were slight differences observed in the patterns for

Figure 14. Effect of time of day on surveys of *Pachygnatha tristriata*.

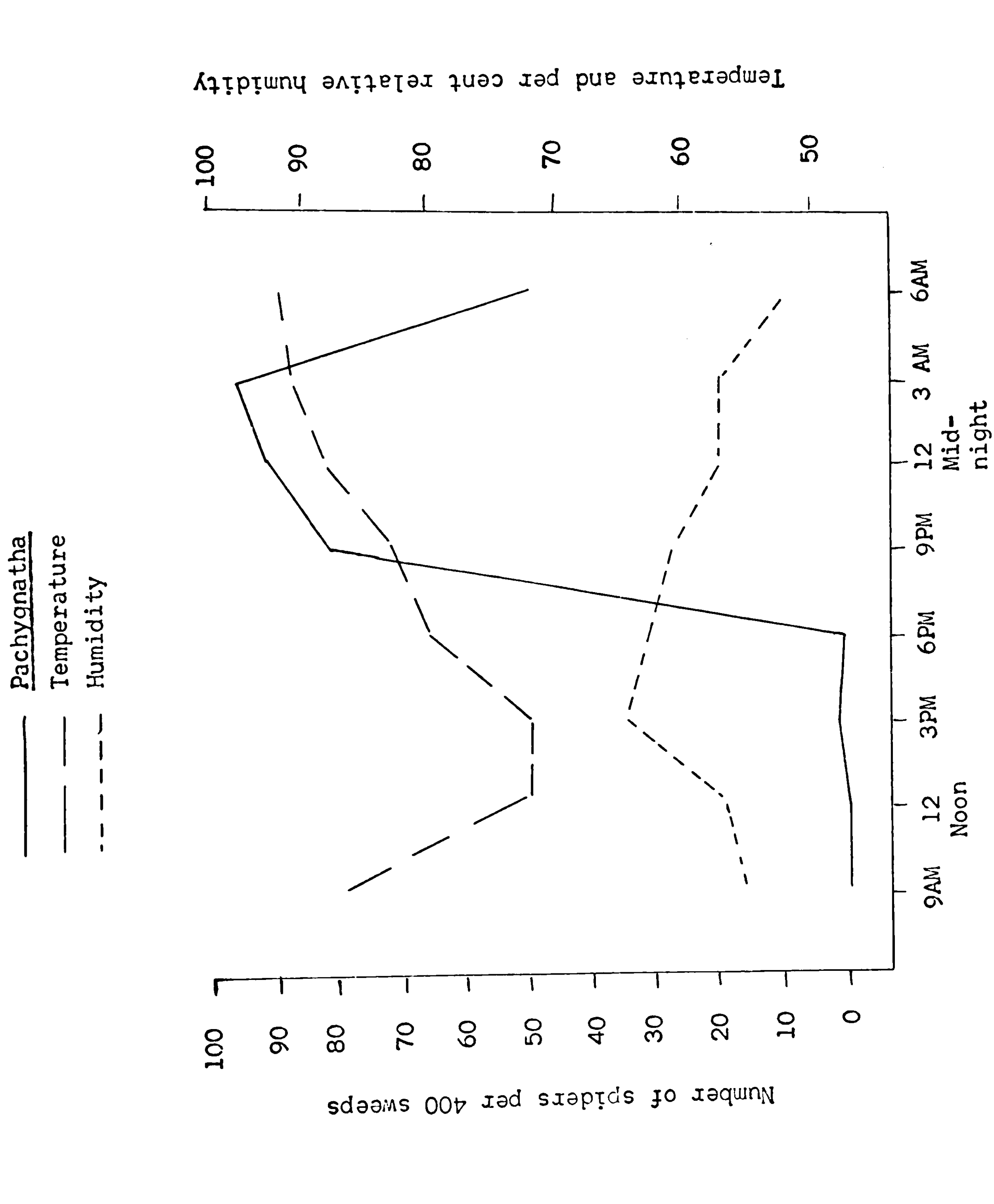

Pachygnatha
Temperature
Humidity
Temperature and per cent relative humidity
100
90
80
70
60
50
Number of spiders per 400 sweeps
100
90
80
70
60
50
40
30
20
10
0
9AM
12
Noon
3PM
6PM
9PM
12
Mid-
night
3 AM
6AM

Table 4. Average number of spiders per hundred sweeps per collection time during the 24 hour sampling periods. 1/

	P. tristriata			*T. laboriosa*			
Time	Aug. 13-14 mean	Oct. 9-10 mean		Aug. 13-14 mean		Oct. 9-10 mean	
6 AM	-	12.50	ab	1.00	b	5.75	c
9 AM	-	0.00	b	6.00	a	12.75	b
12 Noon	-	0.00	b	7.00	a	21.00	a
3 PM	-	0.25	b	2.50	b	17.25	ab
6 PM	.50	0.00	b	2.50	b	19.75	a
9 PM	.25	20.50	a	1.25	b	2.50	c
12 Mid.	.25	22.75	a	1.25	b	2.50	c
3 AM	-	24.25	a	2.50	b	3.00	c

1/ Means in a given column with similar letters are not significantly different according to Duncan's Multiple Range Test (P = .01).

Table 5. Average number of spiders per hundred sweeps per collection time during the 24 hour sampling periods.

time	all spiders				web spinning spiders			
	Aug. 13-14		Oct. 9-10		Aug. 13-14		Oct. 9-10	
	mean		mean		mean		mean	
6 A.M.	1.75	c d	27.00	-	1.25	b c	6.50	c
9 A.M.	13.00	b	29.95	-	7.75	a	14.75	b
12 Noon	28.50	a	41.50	-	8.25	a	23.75	a
3 P.M.	19.25	a b	47.75	-	3.25	b	20.50	a b
6 P.M.	17.25	b	41.50	-	3.25	b	22.75	a b
9 P.M.	3.75	c d	29.25	-	1.50	b c	4.00	c
12 Mid-night 3 A.M.	2.25	d	34.00	-	.50	c	5.00	c

1/ Means in a given column with similar letters are not significantly different according to Duncan's Multiple Range Test (P = .01).

Table 6. Average number of spiders per hundred sweeps per collection time during the 24 hour sampling periods.

time	Salticidae Aug. 13-14 mean		Salticidae Oct. 9-10 mean		Thomisidae Aug. 13-14 mean		Thomisidae Oct. 9-10 mean	
6 A.M.	0.25	b	0.25	c	0.25	b	7.00	c d
9 A.M.	2.00	a b	1.25	a b	2.50	b	8.50	b c
12 Noon	5.25	a	2.25	a b	11.50	a	13.25	a b
3 P.M.	2.75	a b	3.00	a	11.00	a	18.00	a
6 P.M.	5.00	a	.50	b	8.50	a	13.25	a b
9 P.M.	0.25	b	0.00	c	1.75	b	4.50	c d
12 Mid-night	0.00	b	0.00	c	0.50	b	4.75	c d
3 A.M.	0.00	b	0.00	c	0.00	b	3.25	d

1/ Means in a given column with similar letters are not significantly different according to Duncan's Multiple Range Test (P. = .01).

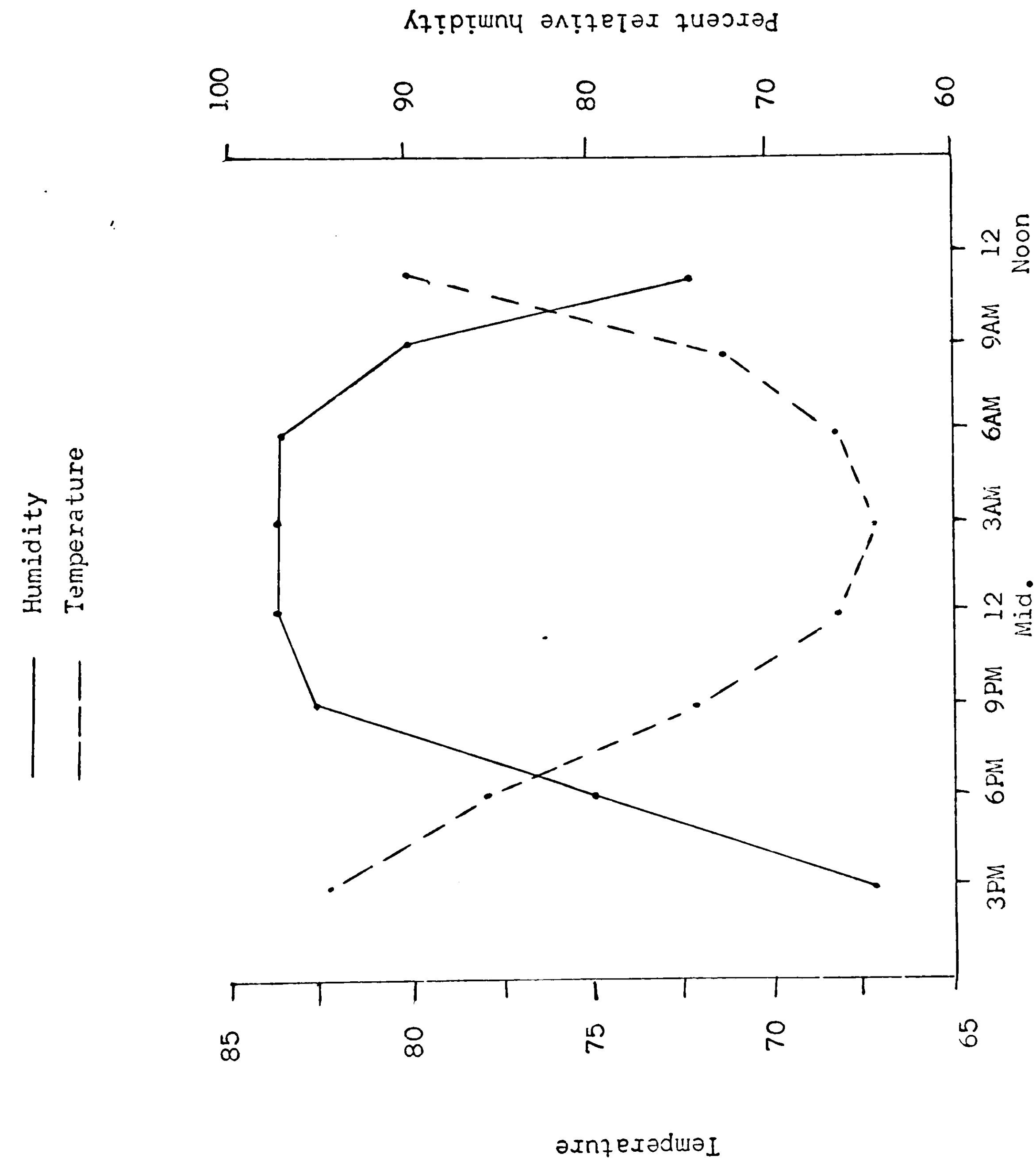
August 14 and October 8. No relationships could be found here with temperature or humidity. D-Vac samples showed no significant difference in the numbers collected, although 9 p.m. was the latest the D-Vac was used. Fewer of these spiders were on the vegetation at night when high humidities caused dampness.

The combined data for the web-spinning spiders (Table 5) followed the same pattern as those for Tetragnatha laboriosa. These data consist mostly of Tetragnatha laboriosa numbers, and therefore cannot be accepted as a generalization for the entire group.

The Salticidae and Thomisidae were very similar in their susceptibility to sweep net sampling at different times of day (Table 6). The majority of spiders in both families were collected between noon and 6 o'clock p.m. This was the period of highest temperatures and lowest humidities (Figure 15 & 16) There is a probable relationship between these factors and the number of spiders collected.

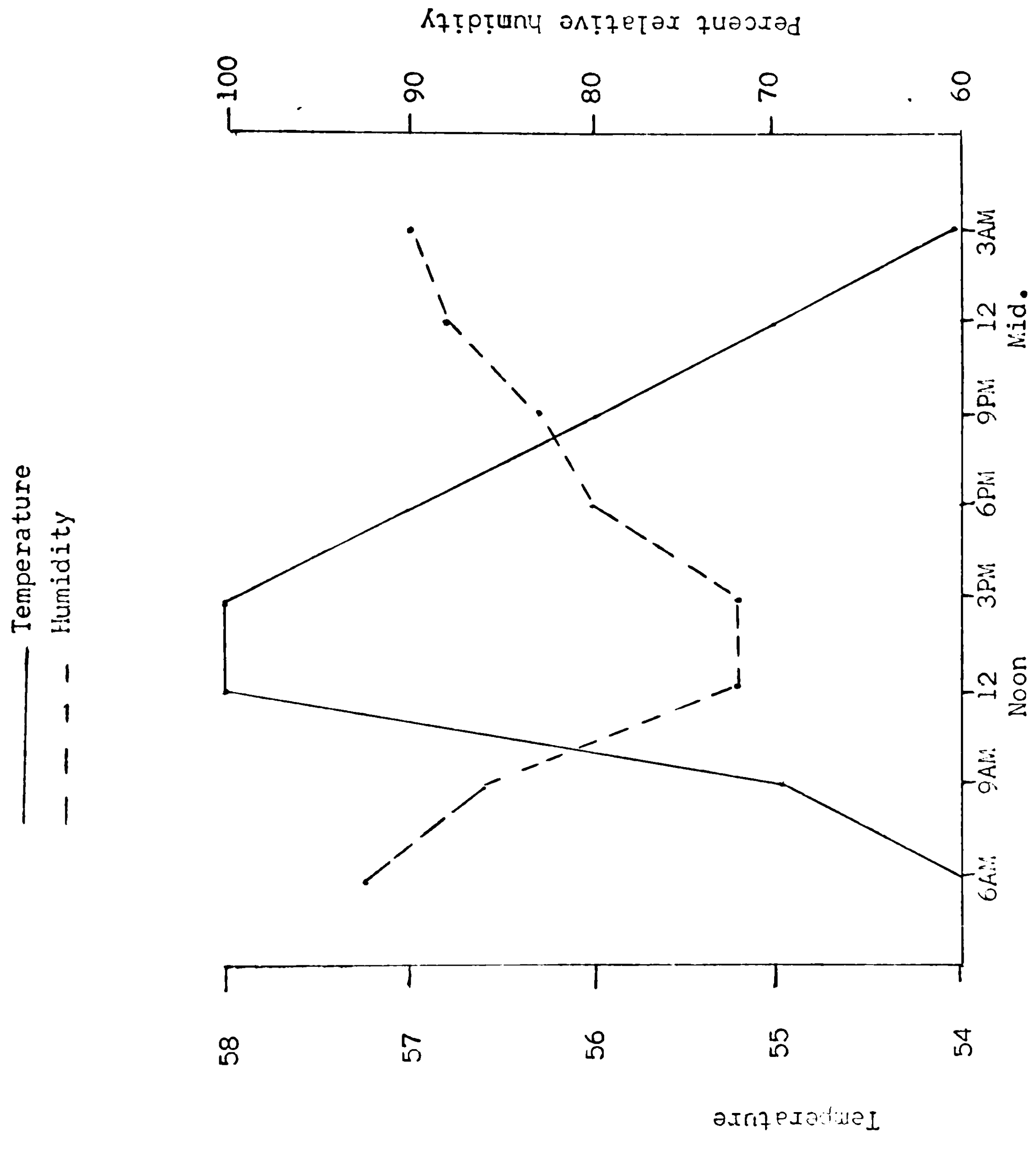
When the numbers of all spiders collected with the sweep net were examined for the date of August 14, it was observed that the majority of spiders was taken at 12 noon and 3 p.m. (Table 5). This agrees with the analysis of the individual groups. The samples of October 9, however, showed no significant difference between the numbers taken at the different times of day. This was due to the large numbers taken at night. These figures tend to balance the catches of other spiders during the daylight hours.

Figure 15. Temperatures and humidities recorded at three hour intervals on August 13-14.



Humidity
Temperature
Percent relative humidity
100
90
80
70
60
12
Noon
9AM
6AM
3AM
12
Mid.
9PM
6PM
3PM
85
80
75
70
65
Temperature

Figure 16. Temperatures and humidities recorded at three hour intervals on October 9-10.


Temperature
Humidity
Percent relative humidity
100
90
80
70
60
Temperature
58
57
56
55
54
6AM
9AM
12
Noon
3PM
6PM
9PM
12
Mid.
3AM

E. Summary and Conclusions

The sample numbers of several groups of spiders collected at three hour intervals over two twenty-four hour periods were found to vary significantly at different times of day. On October 9, the adults of *Pachygnatha tristriata* were found to be far more active on the plant at night with a peak of activity coming at 3 a.m. There was almost no activity during the daylight hours. On August 14, however, high humidity at night causing water to stand on the leaves of the plants is believed to have inhibited much of their climbing activity. *Tetragnatha laboriosa* was collected most often around noon with the sweep net.

The Salticidae and Thomisidae were collected most often between noon and 6 p.m. This was the period of highest temperatures and lowest humidities.

VII. SPIDER FEEDING TESTS

A. Introduction

The large numbers of spiders found in alfalfa indicate their role may be a very important one in reducing or controlling population levels of insects of economic importance. All spiders are predaceous and indiscriminate feeding has usually been accepted as the rule. This has been repeatedly stated in past publications (Comstock 1912; Savory 1928; Gertsch 1949 and Kaston 1953). Savory (1928) thought that sight might determine the type of action taken in capturing a particular insect. He found that *Agelena labyrinthica* cautiously stalks and wraps in silk bees which land on its sheet web, but readily bites and carrys to the corner of the web large bluebottle flies the same size. Gertsch (1949) cited the arboreal tarantula as an example of indiscriminate feeding. This spider cannot differentiate between a bird or a large insect, and makes its capture in exactly the same manner: by springing upon it and striking it with its fangs.

Studies of the food of particular spider species are rare. Bailey and Chada (1968) conducted laboratory feeding tests on 19 spider species belonging to 9 families. They found that almost any insect tested was satisfactory food for at least one spider species. Only three species (all belonging to the Saltícidae) fed on all insects used.

In order to study the feeding habits of selected spider species found in alfalfa, laboratory feeding tests were conducted with methods similar to those used by Bailey and Chada (1968).

B. Materials and Methods

Two types of feeding chambers were used in conducting feeding tests on 10 spider species in the laboratory. In the first type modified from Bailey and Chada (1968) each chamber consisted of a one-pint ice cream carton with the center portion of the lid replaced by cheese cloth which was held in place by the lid rim (Fig. 17) The cheese cloth prevented the escape of the spiders and allowed observation of their feeding. A small round hole was cut in the side of each carton and closed with a cork. The prey could then be placed into the carton with ease. In the case of *Tetragnatha laboriosa* this hole also prevented disturbance of the web when the prey was introduced, since part of the web was constructed against the cheese cloth lid.

The other chamber type consisted of small clear plastic cups 4.2 centimeters in diameter (Fig. 18). Holes were put in the lid by penetrating them with a hot needle. The spiders were easier to observe in these containers.

A single spider was placed in each chamber. Each of the 10 test species was fed the same insect on a feeding day. The insects used were the second and forth instars and the adult of the alfalfa weevil, *Hypera postica* (Gyllenhal);the adult and larvae of the ladybird beetle, Hippodamia parenthesis Say; the adult of the green lacewing, Chrysopa sp.; the pea aphid, Acyrthosiphon pisum (Harris); the tarnished plant bug, Lygus lineolaris Say; a damsel bug, Nabis sp.; the potato leafhopper, Empoasca fabae (Harris); a leaf bug, Adelphocoris sp.; the meadow spittlebug, Philaenus leucophthalmus (6) and the meadow grasshopper, Conocephalus strictus (Scudder). The spiders were recorded as feeding if they fed on an insect within a two-day period. If they did not feed during this period, they were recorded as not feeding.

C. Results and Discussions

The feeding tests were conducted on 10 spider species belonging to 5 families. The results are shown in Table 7.

No difference was found in the tests of the two types of feeding chambers, even though it was at first suspected that the smaller plastic cups, which brought the spider and its prey much closer together, would make it simpler for the spider to feed on certain insects which it might not ordinarily catch.

None of the spiders fed on all the insects offered, although Phidippus audax (Hentz) fed on all but the second instar weevil larva. Phidippus rimator (Walkenaer) and Paraphidippus marginatus (Walckenaer) fed on all the insects but the adult and second instar of the alfalfa weevil and the larva of the ladybird beetle. These spiders approached the coccinellid larva several times and made mild attempts to attack, but always backed away before biting. *Zygoballus sexpunctatus* (Hentz) fed only on the second instar of the alfalfa weevil, the pea aphid and the potato leafhopper. All the above spiders are members of the family Salticidae. They are very agressive spiders and usually attacked the insects as soon as they were put into the container with them.

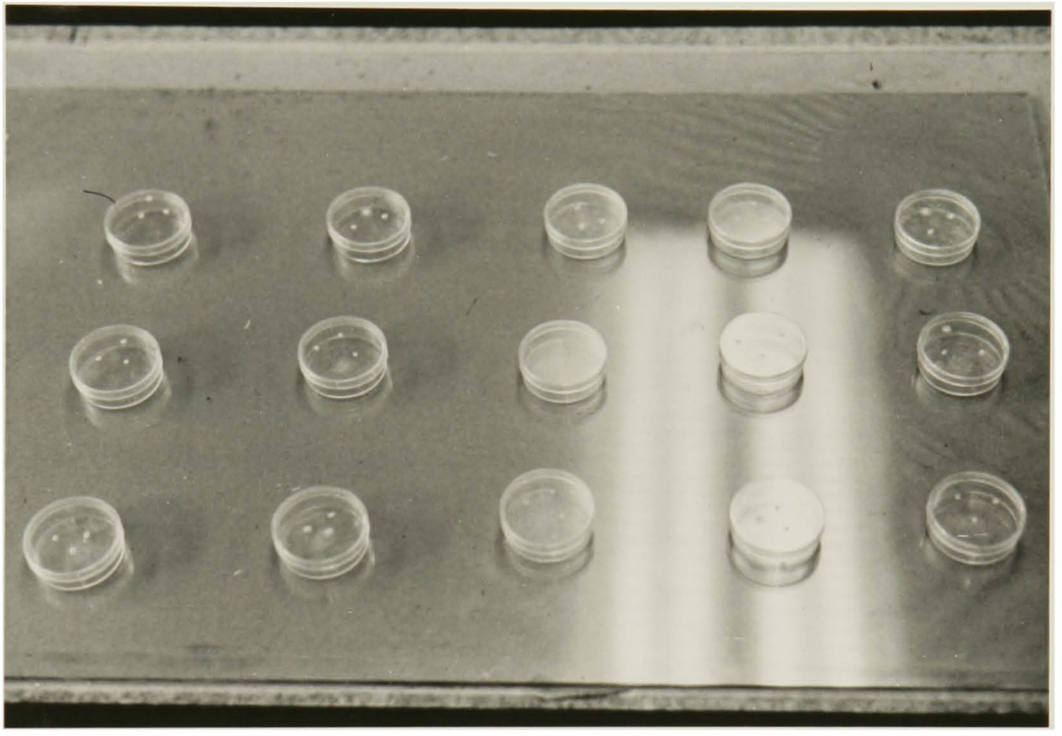
Misumenops asperatus (Hentz) and *Xysticus triguttatus* Keyserling would not feed on the adult and second instar of the alfalfa weevil, the pea aphid or the larva and adult of the ladybird beetle. Bailey and Chada (1968) found *M. asperatus* to feed on both the larva and adult of the ladybird beetle, *Hippodamia convergens* Guerin. In addition, *X. triguttatus* did not feed on *Nabis* sp. or the potato leafhopper, although several unsuccessful attempts were made to catch the leafhopper. *Misumenoides aleatorius* (Hentz) fed only on the second and forth instars of the alfalfa weevil, the tarnished plant bug, the leafbug *Adelphocoris* sp., the potato leafhopper and the adult of the green lacewing. The above two families, the Salticidae and Thomisidae, were frequently observed feeding on some of the same insects in the field. *Misumenops asperatus* and *Phidippus* sp. were also found feeding on syrphid flies.

Table 7.

Spider feeding tests on some harmful and beneficial insects of alfalfa

	Hypera											Hippodamia	
	2nd Inst.	4th Inst.	adult	Acyrtho-cyphon	Lygus	Conoce-phalus	Filaenus	Adelpho-coris	Empoasca	Nabis	Chrysopa	larva	adult
Thomisidae													
Misumenops asperatus (Hentz)	O	X	O	O	X	X	X	X	X	X	X	O	O
Misumenoides aleatorius (Hentz)	X	X	O	O	X	O	O	X	X	O	X	O	O
Xysticus triguttatus Keyserling	O	X	O	O	X	X	X	X	O	O	X	O	O
Salticidae													
Zygoballus sexpunctatus (Hentz)	X	O	O	X	O	O	O	O	X	O	O	O	O
Paraphidippus marginatus (Walckenaer)	O	X	O	X	X	X	X	X	X	X	X	O	X
Phidippus rimator (Walckenaer)	O	X	O	X	X	X	X	X	X	X	X	O	X
Phidippus audax (Hentz)	O	X	X	X	X	X	X	X	X	X	X	X	X
Oxyopidae													
Oxyopes salticus (Hentz)	X	X	O	X	X	X	X	X	X	X	X	O	O
Tetragnathidae													
Tetragnatha laboriosa Hentz	X	O	O	X	X	O	X	X	X	X	O	O	O
Lycosidae													
Pardosa saxatilis (Hentz)	O	X	O	X	X	X	X	X	O	X	X	X	X

Figure 17. Arrangement of plastic cup feeding chambers in the laboratory.



Oxyopes salticus (Hentz) fed on all the insects tested except the adult of the alfalfa weevil and the larva and adult of the ladybird beetle. Bailey and Chada (1968) recorded *O. salticus* as feeding on the larva and adult of the coccinellid beetle, *Hippodamia convergens* Guerin.

Tetragnatha laboriosa Hentz, the only orb-weaver tested, did not feed on the forth instar or the adult of the alfalfa weevil, the adult and larva of the ladybird beetle, the green lacewing adult or the meadow grasshopper, but fed on the other insects tested. It was observed to feed on several small diptera in the field.

Pardosa saxatilis (Hentz) fed readily on all the test insects except the second instar and adult of the alfalfa weevil and the potato leafhopper.

D. Summary and Conclusions

Feeding tests with 10 spider species belonging to five families were conducted in the laboratory. *Phidippus aufax* fed on all insects tested except the second instar of the alfalfa weevil. These included the forth instar and adult of the alfalfa weevil, the adult and larva of the ladybird beetle, the adult of the green lacewing, the pea aphid, the tarnished plant bug, a damsel bug, the potato leafhopper, a leaf bug, the meadow spittlebug, and the meadow grasshopper. *Phidippus rimator* and *Paraphidippus marginatus* fed readily on all but the second instar and adult of the alfalfa weevil and the larva of the ladybird beetle. *Misumenops asperatus* and Oxyopes salticus seemed to feed on the same insects, except that the former failed to feed on the second instar of the alfalfa weevil and pea aphid.

By comparing the size and speed of the above predators to those of the potential prey, as well as by examining superficially the exocuticle of the test insects, it appears that size, speed, and hardness of the cuticle of the prey are the major criteria for determining whether a spider will feed on a particular insect, although the poor response to the larva and adult of the ladybird indicate that other factors may also affect prey suitability. The results obtained by Bailey and Chada (1968) using a different species of ladybird beetle show that certain spiders will feed readily on certain coccinellids.

Some observations indicated a possibility of prey preference. During the tests, Phidippus rimator accepted Adelphocoris sp. within two minutes after the specimen was offered, although it had failed to feed on the fourth instar alfalfa weevil for more than three hours. Also,while in the presence of the pea aphid, Misumenop asperatus fed readily on the fourth instar weevil larva, and occasionally on Nabis sp. but would not feed on the aphid.

VIII. NOTES ON THE BIOLOGY OF TETRAGNATHA LABORIOSA HENTZ

A. Introduction

Tetragnatha laboriosa Hentz is a very common orb-weaving spider in meadows and other areas of tall grass. Unlike many of its close relatives, Tetragnatha laboriosa is often found in dry fields away from the vicinity of water. It is the most common single species found in alfalfa in southwest Virginia. For this reason, preliminary laboratory and field studies were conducted to learn something about its biology.

B. Laboratory Studies

1. Materials and Methods

Spiderlings in the third and forth instar were collected from the field by sweeping and by the D-Vac sampler on March 29, April 9, and April 17, 1968 for the purpose of initiating a preliminary study on the effect of temperature and humidity on the growth rate of T. laboriosa. The rearing method used was modified from Peck and Whitcomb (1967). Each spiderling was reared in a separate three inch piece of #6 glass tubing, both ends of which were then plugged with loose cotton, allowing diffusion of air and water vapor, but restraining the specimen (Figure 19). These glass tubes were stored in 7 in. fingerbowls where the humidity was regulated by varying sulfuric acid concentrations (modified from Springer, 1968). The temperature was regulated by (1) a temperature controlled laboratory room (17°C), and (2) a Percival temperature controlled growth chamber (27°C).

Figure 18. Fingerbowl with glass tubes for rearing spiders.

Four conditions were studied--17°C and 90% relative humidity; 27°C and 90% relative humidity; 27°C and 75-80% relative humidity; 27°C and 0% relative humidity. Food consisted of adult *Drosophila melanogaster* Meig. Each spiderling was fed daily. On the first day, two flies were placed in each vial. On each successive day, the number of flies given was obtained by adding one to the number eaten on the previous day. It was felt that this method always provided the spider with ample food. The number of flies eaten by each specimen was recorded for each day and the dates of each molt were noted. Specimens reaching adulthood were mated in the laboratory. The females were placed in 10 dram plastic vials and kept at 90% relative humidity at room temperature. The dates of egg-sac formation were noted and the eggs were counted.

2. Results and Discussion

At 17°C and 90 per cent relative humidity only two spider in twenty one reached adulthood. The time of development for the last two instars averaged 18 days. At 27°C and 0 per cent RH, all spiders died after four days. Much better success was obtained at 27°F and 90% relative humidity. At 27°C and 75-80 per cent RH, 7 specimens out of 17 matured to adults. The time of development of the last two instars averaged 13.5 days At 27°C and 90 per cent RH, 7 spiders of 11 reached adulthood with the last two instars averaging 11.5 days. The results

Table 8

Days between copulation and egg sac formation and the number of eggs present in each egg sac.

Spider number	Egg sac number 1		2		3	
	No. days bet. cop. & E.S. formation	No. eggs present	No. days bet. cop. & E.S. formation	No. eggs present	No. days bet. cop. & E.S. formation	No. eggs present
1	6	64	6	50		
2	6	22	6	10	6	22
3	5	41				
4	5	66*				

* Only egg sac with viable eggs. Fifteen spiderlings emerged.

Table 9.

Number of days required for development of late instars of *Tetragnatha laboriosa*.

	Conditions										
	17°C; 90% RH		27°C; 0% RH		27°C; 75-80% RH				27°C; 90% RH		
Spider number	A*	B*	A*	B*	A*	B*	C	D	A*	B*	C
1	9	13	-	-	7	6	12	-	6	4	3
2	9	7	-	-	7	3	6	-	6	4	
3	-	-	-	-	8	7	6	-	7	6	3
4	-	-	-	-	11	7	-	-	7	4	-
5	-	-	-	-	7	5	4	5	7	7	-
6	-	-	-	-	9	4	4	-	7	-	-
7	-	-	-	-	7	-	-	-	7	4	-

* A = last instar; B = next to last instar; etc.

of this study are summarized in Table 9.

Although this spider is often found in dry grasses away from water, these preliminary investigations indicate a high humidity is needed to produce optimal conditions for this species.

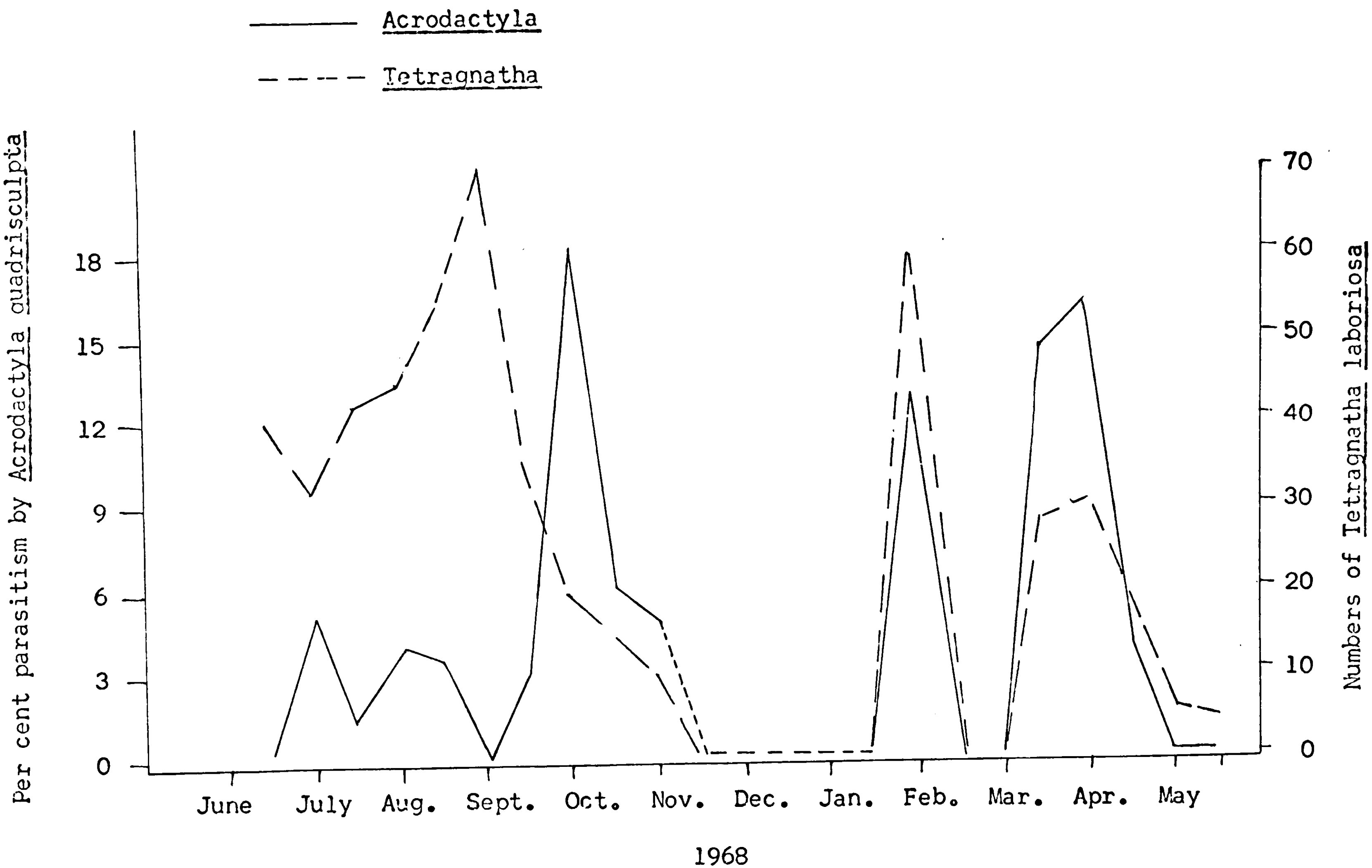
Four females spun egg sacs after mating in the laboratory. Two of the spiders made only one egg sac; one produced two sacs, and one female spun three cocoons before her death. Table 8 summarizes the results obtained from egg counts. Only one egg sac had viable eggs. Of the 66 eggs present, only 15 hatched.

C. Notes on Biology of an Ectoparasite of *T. laboriosa*

1. Materials and Methods

Collections made from March 27, 1967 to June 21, 1968 allowed the seasonal distribution of *Tetragnatha laboriosa* Hentz to be plotted (Figures 4 and 9.) During this time an external parasite, *Acrodactyla quadrisculpta* Gravenhorst (Hymenoptera:Ichneumonidae), was occasionally found attached to the anterior portion of the abdomen. The parasitized spiders were counted and a seasonal distribution for the parasite was plotted (Fig. 20). Townes and Townes (1960) gives host records and references to its biology. They report it to be palearctic in distribution. Its primary habitat is dense vegetation in damp places. Their earliest collection date mentioned was

Figure 19. Seasonal occurrence of _Acrodactyla quadrisculpta_ Gravenhorst and _Tetragnatha laboriosa_ Hentz.


Acrodactyla
Tetragnatha
Per cent parasitism by Acrodactyla quadrisculpta
18
15
12
9
6
3
0
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
1968
Numbers of Tetragnatha laboriosa
70
60
50
40
30
20
10
0

April 28 at Pender Harbor, B.C. Their latest collection date was October 22 at Cultus Lake B.C. They recorded a peak of abundance in July and August. Parasitized spiders were collected in the study field on Feb. 5, March 27, and April 24, 1968, in an attempt to rear some of the parasitic larvae to adulthood. Four of these spiders were reared at 17°C and 5 were reared at 27°C.

2. Results and Discussion

It appears that very early and very late instars of the spider are not parasitized. The larva usually attaches to the anterior portion of the abdomen (Figure 21), but in rare instances where there are two parasites per host, one of the larvae will attach to the posterior of the abdomen.

Three of nine spiders parasitized were observed to molt, one dying in the process. Near the end of its larval development the parasite grew, rapidly almost tripling in size over a period of three days. Death of the host quickly followed. All the larvae reaching this stage were observed to pupate (Figure 22). Figure 23 shows a pupa which was not encapsulated in a cocoon, presumably because of differing laboratory conditions from those of the other specimens.

Both male and female adults of the wasp (See Figure 24) were reared in the laboratory, but never at the same time. On several occasions virgin females were placed in containers with suseptable instars of Tetragnatha laboriosa but no egg laying occurred. Table 10 summarized the number of days required for development from pupa to adult under the two conditions studied.

Figure 20. *Tetragnatha laboriosa* with larval stage of *Acrodactyla quadrisculpta* Gravenhorst.

Figure 21. Cocoon of *Acrodactyla quadrisculpta* Gravenhorst.

Figure 22. Naked pupa of *Acrodactyla quadrisculpta* Gravenhorst.

Figure 23. Adult mole of *Acrodactyla quadrisculpta* Gravenhorst.

Table 10. Effect of temperature on pupal development of *Acrodactyla quadrisculpta* Gravenhorst.

	Days in pupal stage	
pupa number	17°C	27°C
1	12	9
2	13	8
3	14	9
4		7

IX. SPIDERS OF ALFALFA WITH NOTES ON THE BIOLOGY OF TETRAGNATHA LABORIOSA HENTZ

James O. Howell

ABSTRACT

Several areas of the bionomics of spiders of alfalfa in Virginia were given preliminary investigation. The species complex of the spider fauna was determined and the seasonal occurrence of the four major species were plotted. The D-Vac sampler and the sweep net were the major sampling methods utilized. Fourteen families consisting of 75 genera and 112 identifiable species were found. *Tetragnatha laboriosa* Hentz, *Pachygnatha tristriata* Koch, *Misumenops asperatus* (Hentz) and *Oxyopes salticus* Hentz were the most common species found.

The effect of cutting of alfalfa on the spider numbers in the field was measured with the aid of the D-Vac sampler. The numbers of *T. laboriosa*, *P. tristriata*, and the family Lycosidae were not effected by the cutting process, while the Linyphiidae, Thomisidae, and Salticidae had a definite response.

The effect of time of day was measured with the sweep net and the D-Vac sampler. *P. tristriata* was found to be far more active on the plant at night. This was believed to be the result of a negative phototropism. *T. laboriosa* was collected during the periods of highest temperatures and lowest humidities.

Feeding tests with 10 spider species belonging to five families were conducted in the laboratory. Although other factors were apparent, it appeared that size, speed, and hardness of cuticle were the major criteria for determining whether a spider would feed on a certain insect.

Laboratory studies on the growth rates of *T. laboriosa* indicated a temperature of 27°C and 90% humidity was more advantageous than lower temperatures and humidities. An ichneumonid parasite of *T. laboriosa*, *Acrodactyla quadrisculpta* Gravenhorst, was collected on its host in the field and reared to adulthood in the laboratory. Its seasonal occurrence was plotted and found to peak at about the same as did *T. laboriosa*.

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XI. VITA

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