BIONOMICS OF THE CRAB SPIDER GENUS MISUMENOPS IN TWO ARIZONA COTTON FIELDS

by

Michael Joseph Plagens

A Thesis Submitted to the Faculty of the

DEPARTMENT OF ENTOMOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 8 1

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Request for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Michael J. Plagens

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Floyd G. Werner
F. G. WERNER
Professor of Entomology

May 1, 1981
Date

ACKNOWLEDGMENTS

Many persons helped make my thesis a success. The consultations, advising, and editorial assistance given by Dr. Floyd Werner were invaluable. Dr. Theo Watson and Dr. Roger Huber, who also served on my graduate committee, gave valuable comments with regards to the aims of my research and the preparation of the manuscript.

The innumerable helpful comments, suggestions, and assistance contributed by Glen Jackson and Dr. Harry Graham at the USDA Biological Control Laboratory were also extremely valuable and much appreciated.

I am also indebted to my wife, Paula, for daily encouragement and support and to Sharon Sherman for typing the manuscript.

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF ILLUSTRATIONS

LIST OF TABLES

ABSTRACT

Population dynamics of the typical crab spiders, _Misumenops_, were studied in two Arizona cotton fields. A field located 17 km north of Mammoth in Pinal Co. was sampled at 7 to 14 day intervals during 1979 and 1980 and another field located in Avra Valley, Pima Co. was sampled at 7 day intervals during 1980. Visual observations of predation, behavior and location on the plants were conducted. Nearby vegetation, including creosote bush, mesquite, alfalfa and weeds, were also sampled for crab spiders. The life cycle and prey acceptance of _Misumenops_ were studied in the laboratory.

Population levels of _Misumenops_ varied greatly between the two fields and seasonally, but generally peaked during late June or early July, and then again in late August or early September. On a seasonal basis, _Misumenops_ comprized from 45 to 79 percent of all spiders collected and had densities ranging from $1.3/m^2$ at the Avra Valley field to $2.5/m^2$ at the Mammoth field. Desert shrubs and herbs harbor numerous _Misumenops_ and it is proposed that this represents the nursery for crab spiders which subsequently colonize the cotton.

Misumenops deserti (Schick) reared in the laboratory required 103 days (for males) and 131 days (for females) to become adult and consumed 2.7 first-instar _Lygus_ nymphs per day. Feeding trials showed that _Misumenops_ prey normally consists of soft, active, diurnally active insects and spiders.

INTRODUCTION

Much of the past literature on spiders has dealt primarily with their taxonomy and only recently has much attention been focused on their ecology in North America (Chew, 1961; Reichert, 1974; Turnbull, 1973), although considerably more such work has been done in Europe (Luczac, 1963, 1966, 1971, 1975; Kajack, 1978). Even less attention has been given to the ecology of spiders in crop systems (Chiang, 1974). Several recent studies have been concerned with cotton spiders in the Gulf States (Laster and Brazzel, 1968; Dinkins, et al., 1970; Smith and Stadelbacher, 1978), Texas and Arkansas (Kagan, 1943; Whitcomb, 1964, 1967; Ridgeway, et al., 1967; Pieters and Sterling, 1974; Fuchs and Harding, 1976) and California (Leigh and Hunter, 1969). Information on Arizona cotton spiders is limited to casual reference to spiders in publications dealing with cotton insects (Werner, et al., 1979; Bryan, et al. 1976).

The purpose of this study was to expand the information on Arizona crop spiders so that their importance in the cotton agroecosystem of Arizona could be better appreciated. However, to study the behavior and ecology of every species of spider would be far too complex for a single study such as this. Preliminary sampling, and Werner, et al. (1979), indicated that spiders of the genus Misumenops (family Thomisidae), the typical crab spiders, were particularily numerous among the spiders in Arizona cotton. Misumenops were therefore singled out for study to determine their biology, behavior, and ecology.

Two fields located in Pima and Pinal Counties were selected for field population study, while studies on the life cycle and feeding habits were conducted in the laboratory.

LITERATURE REVIEW

Crop Spiders

The importance of maintaining diverse and adequate populations of predators including parasitoids in crop systems in order to stabilize the population of pest species has been emphasized by numerous workers (e.g. DeBach, 1964; Huffaker, 1974). Stenophagous (pest group specific) predators respond numerically to an increase in the number of their specific host by consuming more prey and producing more offspring, and finally causing a reduction in numbers of the pest population (e.g., Huffaker and Kennet, 1956). This numerical response and subsequent host reduction is commonly preceded by a lag, which reflects the time necessary for acquisition and conversion of host matter and energy into offspring (Nicholson, 1955). Clark and Grant (1968), MacArthur (1955), and Reichert (1974) suggest that euryphagous (nonspecific) predators are important stabilizers during this lag, that is when the pest numbers are growing but before the stenophagous predator has responded. Spiders are particularly well adapted to this role since they are relatively abundant in most habitats, including marginal habitats (Turnbull, 1973) and many can go for extended periods of time with little or no food (Gertsch, 1939; Bristow, 1941; Greenstone and Bennett, 1980).

The ecological significance of spiders in forest (Vite, 1953; Turnbull, 1960) and orchard crops (Chant, 1965; Dondale, 1956, 1958) has been much more thoroughly studied than in cultivated crops, probably due to the generally better success of biological control in these more stable habitats. Several works have catalogued the spider species found in a particular crop in a particular area. For example, Wheeler (1973) listed the spiders in northern New York alfalfa, Howell and Pienkowski (1971) for alfalfa in Virginia, and Yeargan and Dondale (1974) for alfalfa in northern California. It is worth noting that these lists differ greatly in their species composition because of the different climates, surrounding habitats and geographical location. Lists have also been compiled for cole in England (Pimentel, 1961), for grain sorghum in Oklahoma (Bailey and Chada, 1968) and for guar in Texas (Rogers, 1977).

Cotton Spiders. Of the cultivated row crops, cotton has had its spider populations studied the most thoroughly. Dinkins and Brazzel (1970), Laster and Brazell (1683) and Smith and Stadelbacker (1978) noted the particular abundance of spiders in Mississippi cotton fields, which prompted an in-depth study by Lockley, et al. In their most recent report (1979), or a continuing study, they recorded population fluctuations in thirty fields. Through most of the season spiders were more numerous than the combined total of predacious insects. They categorized all the spiders they collected into two groups: Web Builders and Hunters (which included Misumenops). Web builders and hunters showed an early season peak but the hunters also had a late season peak.

Williard H. Whitcomb, et al. pioneered much work on spiders in Arkansas cotton and in 1963 published an extensive work listing all the spiders found and considerable biological and ecological information. Much of their information was collected by many hours of visual examination of plants in the field and in this way discriminated what part of the plant different species inhabited and in many cases observed predation by the spiders. In Texas cotton Kagan (1943) listed 37 species but did not include any information on their ecology. Pieters and Sterling (1974) studied the aggregation of cotton arthropods in Texas and included information on spiders. Aggregation of spiders within the field was the least among the arthropods tested.

Leigh and Hunter (1969) listed the common spiders of cotton in the San Joaquin Valley of California, providing information on their behavioral and ecological characteristics.

Six species, including Misumenops deserti, were reared in the laboratory. Feeding tests conducted in the laboratory and observations in the field showed the spiders predated on a number of important cotton pests. Notably, Misumenops deserti fed readily on nymphs and adults of Lygus hesperus. A number of the spider species were abundant and thus deemed likely to be an important factor in limiting growth of pest populations.

General Spider Biology

Spiders, like insects, belong to the phylum Arthropoda, but more specifically to the subphylum Chelicerta and thus are taxonomically quite distinct from insects. Only the insects and mites are more successful groups of arthropods in terms of numbers and numbers of species. What wings have done for insect evolution, silk has done for spiders. Silk, originally a waste product, is used by spiders for dispersal (ballooning), capture of prey, protection, mating, construction of the egg sack, defense and as a drag line (Gersch, 1979).

Not all spiders use silk in the same fashion. The spiders most familiar to us use sticky silk to construct snares for capturing prey. Othersuse silk of many small entangling webs to capture prey. Still others have completely abandoned silk for capturing prey yet retain it for its other many purposes. Five common families of this latter type are Salticidae, Oxyopidae, Lycosidae, Clubionidae and Thomisidae (to which *Misumenops* belong). Each of these spider groups represents a different prey-capture strategy: An orb weaver's web will mostly capture small, lightweight, flying insects; the black widow's web catches primarily insects that crawl along the ground; and the fisher spider's web catches insects flying over water. The spider families not using silk for prey capture, also represent different predatory strategies. The Salticidae, for example, are diurnal hunters with keen eyesight, and that rove over the substrate searching mostly for slower moving insects, but can often stalk faster moving insects which have landed momentarily. The Lycosidae, on the other hand, are also roving hunters with good eyesight, but are often nocturnal and thus would take quite a different set of prey from the Salticidae. The Thomisidae, including *Misumenops*, represent yet another silkless strategy. They sit motionless at strategic points on the plant or substrate, waiting to ambush an insect that comes their way. Because different spiders employ different prey strategies, they take a different set of prey, and thus have different effects on an ecosystem.

Misumenops

Taxonomy. The Thomisidae as a whole are a medium sized family with representatives over most of the world; however, the genus *Misumenops*, as it is now defined, is limited to North America, with more western than eastern species (Gertsch, 1939). The revisions of the Thomisidae by Gerstch (1939) and Schick (1965) indicate four species of *Misumenops* occur in southern Arizona. *M. celer*, *M. dubius*, and *M. deserti* are closely related and difficult to differentiate. The fourth species is *M. coloradensis*. Immatures of all four species can only be assigned to the genus as the taxonomic characters are those of the adult genitalia.

Morphology. The sexes of *Misumenops* are highly dimorphic, with the adult females ranging between 4 and 7 mm, white to yellowish green in color with variable red markings on the carapace and legs I and II. Adult males are usually smaller (especially the abdomen), have longer, more slender legs, and have the same basic color but with more extensive variable red markings on the abdomen, and tibiae and tarsi of legs I and II (Schick, 1965). An adult female *Misumenops* is shown in Figure 1 and an adult male in Figure 2.

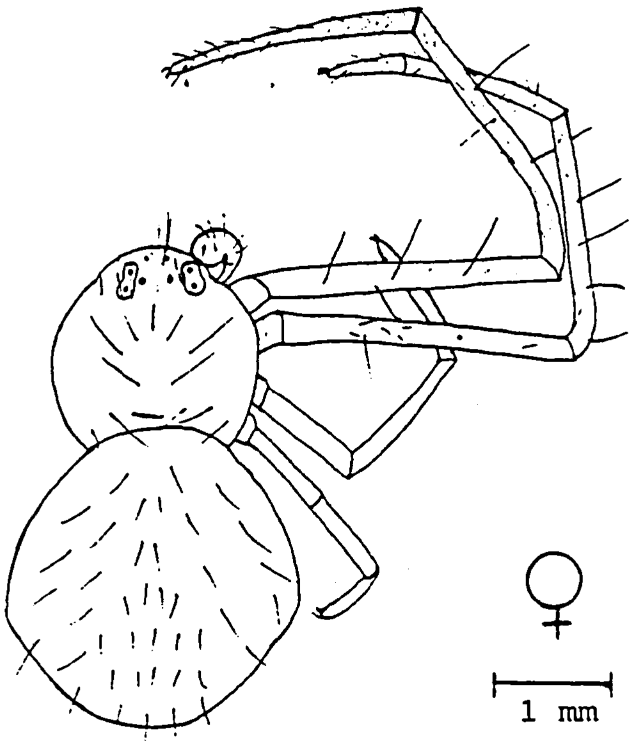


Fig. 1. Misumenops deserti (Schick) female collected at Mammoth, Pinal Co., Arizona.

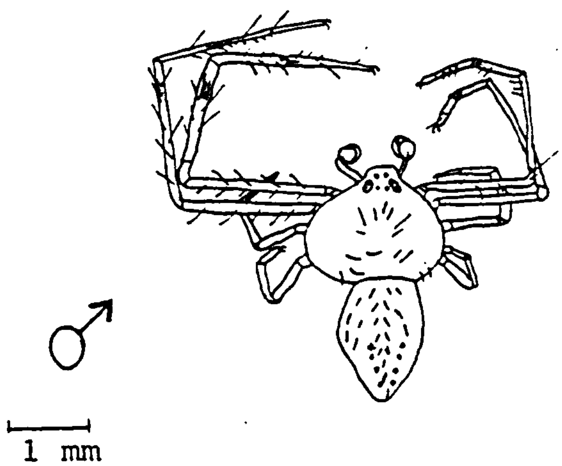


Fig. 2. Misumenops deserti (Schick) male collected at Mammoth, Pinal Co., Arizona.

As seen in the figures, legs I and II are elongate and laterigrade, that is, having the normally ventral side twisted to face anteriorly. This is an adaption for capturing prey that unwittingly wander into the waiting spider, for these legs are provided with sensitive tactile setae, strong recurved setae, and strong musculature. Eight eyes, situated in two rows at the anterior of the cephlothorax, have limited ability to see beyond a few millimeters, but there are very sensitive tactile/acoustic setae which may be capable of detecting vibrations in close proximity (Gertsch, 1979).

Life Cycle. The thomisids carry on very little premating behavior. The male approaches cautiously and if the female is receptive he will immediately begin the transfer of sperm from his pedipalps to her genital pore. The entire procedure generally requires less than 10 minutes. Upon completion, the male departs quickly before the female takes him as a prey item (Muniappan and Chada, 1970). The female can store the sperm for extended periods, producing a number of egg masses without mating again (Gertsch, 1939 and personal observation).

Once mated, the female will continue feeding if additional reserves are needed for egg production. The process of constructing the egg mass and development are well described in the literature (Gertsch, 1939, 1979; Schick, 1965; Muniappan and Chada, 1970). Typically, a portion of a leaf is folded over and the egg sac is constructed in the hidden space. The egg sac consists of three layers, an inner loosely woven layer, a very tough middle layer and a few loose filaments which form the exterior and attachment to the leaf. The female remains firmly secured to the egg sac, sitting watch and protecting it for 2-3 weeks until the young spiderlings emerge.

The first one or two instars are spent within the egg sac, continuing embryonic development. Upon emergence, spiderlings climb upward on the plant in order to disperse by ballooning at the next breeze. Apparently, neither female predation on her emerging young, nor cannibalism by the young within the first few days occurs.(personal observation).

Misumenops molt a variable number of times before reaching maturity, with males averaging 6 to 9 molts and females 8 to 13. _Misumenops desirti_ reared in the laboratory by Leigh and Hunter (1969) required 188 to 531 days for females to reach maturity and 145 to 395 days for the males. Muniappan and Chada (1970), working with the closely related _Misumenops celer_, found that 118 to 311 days were required for the female to reach maturity. Adults and subadults overwinter in debris as reported by Gertsch for Thomisidae (1939) and many other spiders (1969). Records of winter activity of _Misumenops_ are few. Chew (1961) found very low populations in creosote bush at Portal, Arizona on 02, December, 1958, and none on 04, February, 1959.

Behavior and Ecology. The behavior and ecology of the spider communites inhabiting desert plants have been studied by Fautin (1946), Chew (1961), and Jennings (1971). All three workers found crab spiders, and <u>Misumenops</u> in particular, to be the principal component of those communities. In the Great Basin Desert, they were found principally in sagebrush (Fautin); in creosote bush, forbs, and small shrubs at Portal, Arizona (Chew); and in 11 species of forbs in a New Mexico desert (Jennings). Thus, all three investigators have found that <u>Misumenops</u> prefer shrubs and herbacious plants. Even in more mesic environments the typical crab spiders are generally restricted to shrubs and herbs (Schick, 1965; Gertsch, 1939; Lovell, 1915; and Judd, 1964).

It is not surprising, therefore, that <u>Misumenops</u> are found in many herbacious crops. Some of these crops where the crab spiders have been found abundantly are grain sorghum in Oklahoma (Bailey and Chada, 1968), soybeans in Florida (Whitcomb, 1980), guar in Texas (Rogers and Horner, 1977) alfalfa in New York (Wheeler, 1973), Virginia (Howell and Pienkowski, 1971) and California (Yeargan and Dondale, 1974) as well as many other crops in California (Schick, 1965).

Many of these workers noted the preference by <u>Misumenops</u> for the inflorescence and terminals. Whitcomb and Bell (1964) produced much data by careful visual observation in Arkansas cotton with regard to <u>Misumenops</u> behavior. They too noted their preference for terminals as well as their diurnal habits. Misumenops are found in cotton in Mississippi (Lockley, et al., 1979) and Texas (Kagan, 1943) but are particularly abundant in the irrigated cotton of California (Leigh and Hunter, 1969) and Arizona (Werner, et al., 1979).

Effects of Insecticides

The effects of insecticides on predators are often more severe than on the intended pest, because the few predators left in a field after insecticide treatment cannot take enough prey to survive. Early immigrating predators, too, have a difficult time getting established.

Insect predators migrating into recently treated cotton normally enter as flying adults, requiring larger prey (or a greater number of small prey) to survive and produce off-spring. Spiders, on the other hand, most often arrive as ballooning early instars, in larger numbers, but requiring much smaller and fewer prey, such as small Diptera (Muniappan and Chada, 1968) and thrips (personal observation); having short life cycles, often are the first herbivores to recover following insecticide treatment. This together with the fact that spiders can go for longer periods of time without prey (Greenstone and Bennett, 1980), would suggest that they could be very important predators of pest species following insecticide treatment.

The effect of insecticides on the important predators of an agroecosystem is an important part of making wise IPM decisions. Such data can be derived from laboratory toxicity tests, but none have been reported for spiders. However, field analysis of populations following treatment with specific insecticides have occasionally included data for spiders as a group, but not for individual species or groups of species. For instance, Brown and Shanks (1976) and Keever, et al. (1977) both found that systemic insecticides were less harmful to spider populations than to sucking insect pests and predators (eg., Geocoris, Nabis, Orius). Aguillar (1975) found that parathion applied to cotton killed most of the predators, including spiders, but that spiders recovered more rapidly than insects. Johnson, et al., (1973) in Oklahoma also found that the systemic, dimethoate, did not reduce spider populations, while methyl parathion nearly eliminated spiders as well as the other predators. Spiders again recovered more quickly than the other predators following insecticidal treatment. Vickerman and Sunderland (1977) recorded a 90% drop in winter wheat spider populations following application of dimethoate.

Van Steenwyk, et al., (1975) and Johnson, et al. (1976) published on the effects of various pest control regimen on cotton predators, including spiders. As expected, regimen with the fewest treatments resulted in larger spider populations. The devasting effect of methyl parathion on spiders was again reported.

METHOD AND MATERIALS

Sampling

Two cotton fields in southern Arizona were sampled during the study. The first was near Mammoth in Pinal County and the second in Avra Valley, Pima County, Arizona.

Mammoth. The Mammoth field, which was sampled at 7 - 14 day intervals during 1979 and 1980, is located approximately 17 km north of Mammoth, along state highway 77 just south of Aravaipa Creek. The cultivated land is within the flood plain of the Aravaipa, with steeper ground both to the north and the south. On all of the steep slopes are vegetation with mesquite, creosote bush, palo verde and saguaro shrub as dominants. Several adjacent and nearby fields had been fallow for several seasons and had large weeds growing in them. A map of the vicinity of the Mammoth site can be found in Appendix A.

This small cotton area is relatively isolated from other cotton growing areas and this may have reduced the number of migrations of pests from other fields. During 1979 no applications of insecticides were made and during 1980 only two, Orthene® (acephate) on 02 August and methyl parathion on 09 August. Both applications were directed at stinkbugs.

Avra Valley. The Avra Valley field, which was sampled at approximately 7 day intervals during 1980, is located northwest of Tucson and is near the southern end of a rather extensive cotton growing region. Most areas within 3 to 4 km were in cotton. However, some fields were left fallow after winter wheat; there was an alfalfa field ½ km to the west, and the southwest had a large fallow area with very little vegetation. A map of the immediate vicinity around the Avra Valley site can be found in Appendix B.

In 1980, pest populations were relatively low over most of the southern Arizona, so that only two applications of insecticides were made. Sevin® was applied on 17 July and methyl parathion on 23 July, and both sprays were for control of pink bollworm and lygus.

Sampling and Collection Techniques. As already discussed, spiders of different species possess different behavior patterns. Some are noctornal, other diurnal; some inhabit webs; other wander over the surface; some inhabit the terminal portions of the plant; others live closer to the ground (Gertsch, 1979; Whitcomb, et al., 1963) and thus it seems reasonable that varying the methods and time of sampling would result in different descriptions of the same spider population.

For this study, the ground cloth method was used. Leigh and Hunter (1969) used this method to study California cotton spiders and stated that the ground cloth sampled spiders from the entire plant zone rather than just the terminal sections that sweeping and D-Vac are likely to sample. Shepard, et al., (1974) found that the ground cloth gave higher means for spiders and other arthropods than did sweeping or D-Vac. Whitcomb (1963, 1980) and Leigh and Hunter (1969) found visual inspection of the plant to be superior for detecting some species of spiders and the whole plant bag sampling method developed by Gonzales, et al. (1977) showed a high degree of accuracy. These last two methods require much time and resources which were not available for this study and therefore the ground cloth offered a convienient compromise.

The cloth utilized was white, with one surface vulcanized, and measured 1 m x 1 m. This cloth was rolled out in the furrow between two rows, without disturing the plants, after which the plants were shaken vigorously over the cloth. All insects and spiders that fell to the cloth were easily seen and collected with an aspirator and put in alcohol or an ice chest for return to and identification in the laboratory. Ten such 1 m^2 samples were taken for each date and field. For Mammoth 1979, all 1 m samples for one date were combined, but for Mammoth 1980 and Avra Valley 1980, each 1 m sample was kept separate. All sampling was conducted between 0800 and 1000 hours.

Early in the season, when the plants were small, an entire plant could be held over the ground cloth and shaken. However, as the plants became larger and branched, more and more of the plant could not be sampled because it was over the adjacent furrow. Also, as the canopy closed, shaking the plant on one side of the furrow greatly distrubed and knocked insects from the plants across the furrow. This was compensated for by shaking plants from both sides of a furrow once the plants became too large to hold entirely over the drop cloth.

Taxonomic determinations for all specimens were conducted in the laboratory by means of a dissecting microscope. Adult thomisids which possessed the following characteristics, as listed in Kaston (1978), were counted as *Misumenops*: greenish-yellow to white in color with variable red markings; tubercles of the lateral eyes confluent; carapace, abdomen and legs spinose; and anterior lateral eyes larger than the anterior medians. Immature thomisids were classified on the same basis: yellow to white in color, but lacking red markings; confluent tubercles of lateral eyes (very evident and contrasting); and spinose carapace abdomen and legs as characters used to distinguish *Misumenops*.

Visual Observations

At both Mammoth and Avra Valley sites pertinent visual observations were made and recorded. For each sample date the height and maturity of the cotton plants were recorded since a number of workers have correlated the plant maturity with arthropod populations (Fuchs and Harding, 1976; Leigh and Hunter, 1969; Lockley, et al., 1979; Smith and Stadelbacker, 1978; Whitecomb, 1963).

The plants were examined for crab spiders and their location on the plant noted. When Misumenops were located with prey, this was also noted together with the identification to species (if possible) of said prey. Also, on several occasions Misumenops knocked from the plants onto the drop cloth were still grasping a prey item. This too was noted together with the species of prey. Predation upon Misumenops by other predators was also observed and recorded.

A number of workers (Gertsch, 1939, 1979; Lovell, 1915) have noted the preference of Thomisidae for blossoms, there waiting for potential pollinators to take as prey. Six sets of 50 blossoms were examined during 1980 for the presence of Misumenops.

Sampling of Surrounding Vegetation

Sampling of vegetation in the vicinity of both the Mammoth and Avra Valley sites was conducted on a qualitative basis. At Mammoth, mesquite, creosote bush, sunflowers, winter wheat and herbacious weeds were swept and the presence or absence of Misumenops recorded. At the Avra Valley site, mesquite, creosote bush, sunflowers, winter wheat and herbacious weeds were swept and the presence or absence of Misumenops recorded. At the Avra Valley site, mesquite, creosote bush, baccharis, burroweed (Happloppus tenuisectus) and alfalfa were swept and the presence or absence of Misumenops recorded.

Laboratory Rearing

The container consists of an upper portion made from an inverted clear plastic cup, 7.5 cm in diameter, with a 1.2 cm diameter hole cut in the side and the bottom removed and replaced with organdy. The soft plastic cover of the cup, which now represents the bottom of the cage, has two 3 mm holes near its center through which cut plant stems can be passed into a reservoir of water held below the cage in a snap cap vial, the cap of which is glued to the underside of the cage bottom. Through the hole in the side of the cage, which also served as the entry port for prey, a small glass vial of water stopped with sponge was inserted to provide moisture for the spiders and prey. This system is similar to that of Tamaki, et al. (1978), and those currently in use by Jackson (1980).

This setup produces a more natural system for the spider and its prey than do the empty containers used by some workers, which no doubt produce altered behavior and feeding patterns. The spiders, as in its natural environment, sits on vegetation where the succulent and leafy plant provides food and habitat space for the potential prey. The cages were kept at (25°C) and 40% RH with a photoperiod of 12 hours light/ 12 hours dark.

A field-collected Misumenops deserti female collected on 29 July 1979 continued to produce offspring in the laboratory for nearly a year. A batch of eggs laid 12 October produced

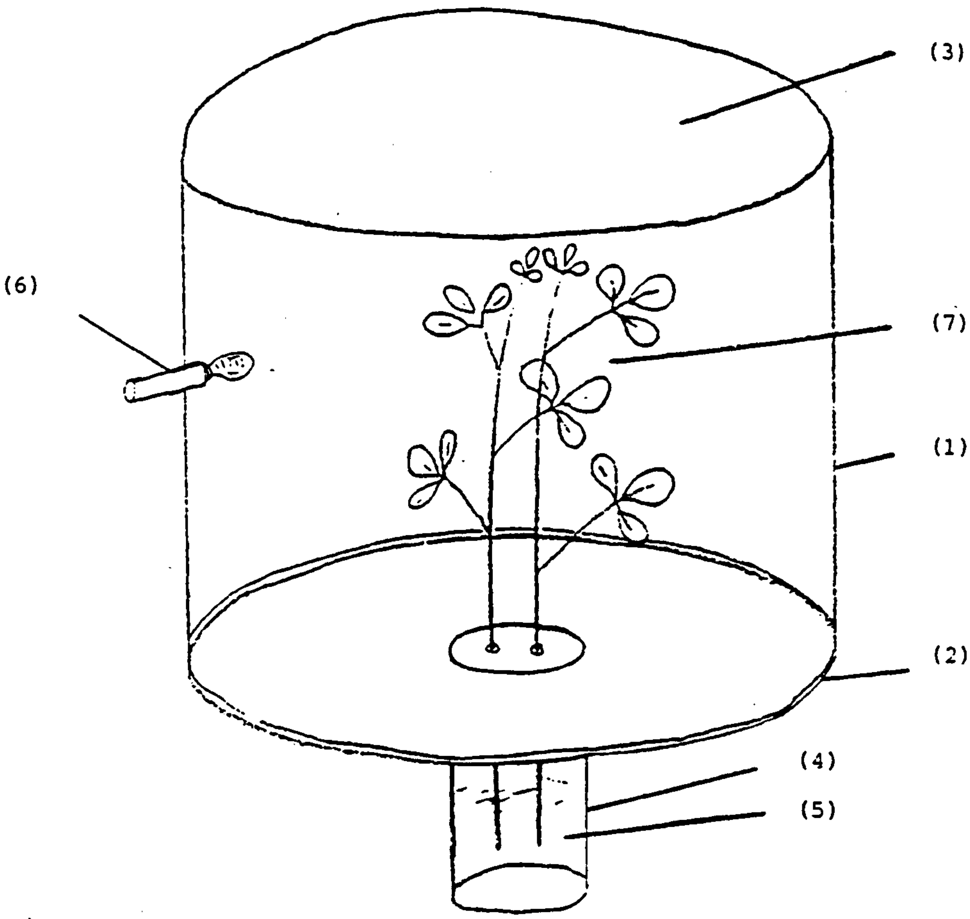


Fig. 3. Diagram of cage used in rearing and feeding test experiments.

Legend: (1) inverted clear plastic cup (2) soft plastic lid (3) organdy (4) snap-cap vial (5) reservoir of water (6) glass vial with water (7) cut alfalfa stems

37 spiderlings on 30 October. Into each of six cages, one newly emerged Misumenops spiderling was introduced together with the prey, two first instar Lygus nymphs. The cages were checked at approximately daily intervals and the number of Lygus consumed by each spider was recorded. Those which had been consumed were replaced with new first-instar nymphs and if the spider had consumed all of the prey, the number of first-instar nymphs provided was increased, the intent being to provide more prey than the spider could consume. Tamaki, et al., (1978) also had this intent when studying Nabis and Geocoris predation on Lygus under similar conditions.

The occurrence of a molt by the spider was also recorded as were the appearance of secondary sex characteristics and any observed behavior. A control cage without a spider was also run, into which the same number of first instar Lygus were put, and mortality recorded. This control cage was continued until completion of the rearing.

Feeding Tests

The cages used for the feeding study were identical with those used for rearing and kept under the same conditions of temperature, relative humidity and photoperiod. Various stages and sexes of Misumenops were placed individually in the cages and various potential prey were introduced into the cages and predation noted. Prey selected were from those commonly found in the cotton agroecosystem. The spider would often appear much distended after feeding, and in many cases actual predation was observed. It was necessary to introduce potential prey into cages without spiders as a control, to insure that dead prey items had in fact been consumed by the spider and had not died of other causes.

RESULTS

Field Sampling

Mammoth, 1979. The population trends for adult *Misumenops* spp., spiderling *Misumenops*, total spiders, plant growth, *Lygus* spp. (a potential prey item for *Misumenops*) and *Nabis* plus Reduviidae (representative of insect general predators) are shown in Table 1. Also adult total *Misumenops* spp., and total spiders are shown graphically in Figure 4.

From these data it can be seen that *Misumenops* numbers grew steadily through the season, with a slight early season lag, and a peak on 15 September. The population dropped rapidly thereafter, with the onset of maturation of cotton and the cessation of watering. *Misumenops* represented from 58 to 92 per cent of the total spider population in each weekly sample, and 75.5 per cent for the whole season.

Table 1. Cotton height and population trends for spiders, *Misumenops*, *Lygus*, *Nabis*, and Reduviidae at Mammoth, Pinal County, Arizona, 1979. All population densities are based on ten (10) 1 m^2 randomly selected samples, taken by means of a ground cloth.

Date	Cotton height/(cm)	No. spiders/m^2	Number of *Misumenops*/m^2			No. *Lygus*/m^2	Predacious Insects	
			Total	Spiderling	Adult		*Nabis*	Reduviidae
16 June	10	1.50	1.00	1.00	0	0	0	0
23 June	15-25	3.14	2.88	2.14	0.71	0	0.29	0
21 July	30-60	2.66	2.40	1.07	1.33	0.20	0.33	0
26 July	55-65	4.35	4.00	1.95	2.05	0.35	0.20	0
06 Aug.	80-110	5.20	4.80	3.30	1.50	2.00	1.20	0.50
17 Aug.	100-120	7.90	5.70	2.30	3.40	0.50	1.50	0.50
01 Sept.	140	8.20	5.70	4.10	1.60	4.80	2.90	0
15 Sept.	140	10.50	8.60	7.10	1.50	2.90	1.50	0.50
29 Sept.	140	6.30	3.70	3.20	0.50	1.30	2.30	0.80

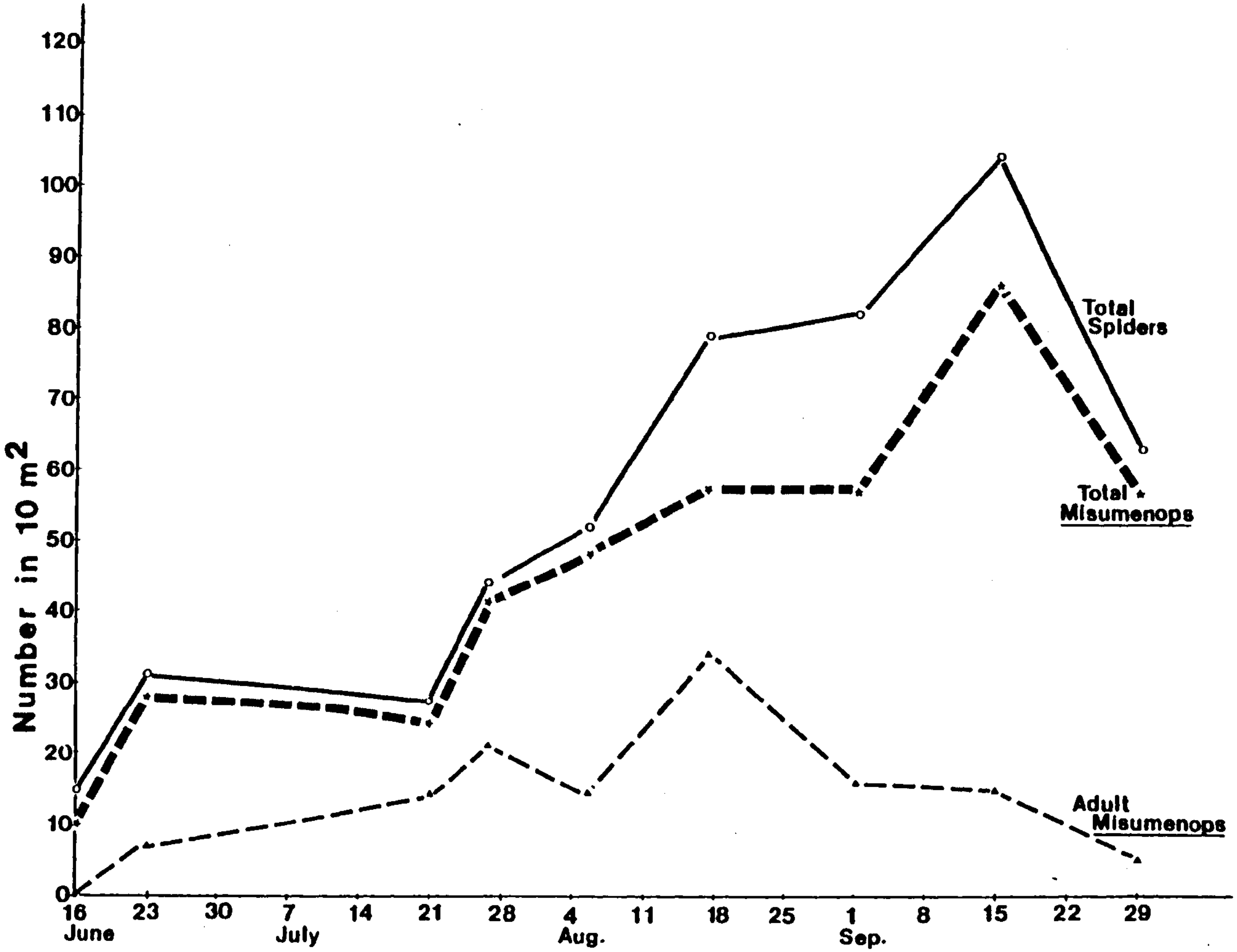


Fig. 4. Population trends for adult and total *Misumenops* spp. and total spiders in the Mammoth, Pinal County, cotton field, 1979.

Mammoth, 1980. The population trends for adult *Misumenops* spp., spiderling Misumenops spp., total spiders, plant growth, potential prey items of *Misumenops* (as determined by the laboratory feeding trials), and other general predators are shown in Table 2. Also, adult *Misumenops*, total *Misumenops*, total spiders and potential prey are shown graphically in Figure 5. The potential prey shown in Table 2 and Figure 5 are the total of *Lygus*, *Nabis* nymphs, *Orius*, fleahoppers, *Geocoris*, *Chrysopha* adults and Cicadellidae. Thus, the total doe not reflect those potential prey items that are not sampled with the ground cloth, e.g., Diptera.

Of the general predators collected (Coccinellidae, Reduviidae, Nabidae, Chrysopidae larvae, *Orius*, *Geocoris*, *Collops* and spiders), spiders comprised from 40.9 to 78.7 percent in each weekly sample, and 57.6 percent for the whole season. *Misumenops* represented from 0 to 63.7 percent of the total spider population for each weekly sample, and 45.1 percent for the whole season. This was considerably less than in 1979 (79.5 percent).

Table 2. Cotton height and population trends for spiders, _Misumenops_, potential prey for _Misumenops_ and predacious insects at Mammoth, Pinal County, Arizona, 1980.

All population densities are the mean (±S.D.) for ten (10) randomly selected 1 m^2 samples taken by means of a ground cloth.

Orthene® was applied on 02 August and methyl parathion on 17 August.

Many Lepidoptera larvae were present 23 August through 06 September.

Date	Cotton height (cm)	No. spiders/m^2	Number of _Misumenops_/m^2			Potential prey/m^2	Predacious insects/m^2
			Total	Spiderling	Adult		
14 July	50-70	4.8 ±1.8	2.1 ±1.4	1.1 ±1.0	1.0 ±0.9	5.7 ±4.1	3.8 ±2.8
20 July	90-110	10.2 ±3.7	6.5 ±3.1	3.1 ±1.2	3.4 ±2.3	14.4 ±4.6	7.3 ±3.2
26 July	90-110	7.2 ±3.0	4.4 ±1.8	1.4 ±1.5	3.0 ±1.2	13.9 ±4.4	7.6 ±3.5
04 Aug.	90-120	5.8 ±3.1	1.3 ±1.4	0.7 ±1.3	0.6 ±0.8	5.4 ±3.4	4.6 ±2.3
09 Aug.	90-130	7.6 ±3.5	2.1 ±1.4	1.0 ±1.2	1.1 ±1.1	4.3 ±4.8	5.7 ±2.4
17 Aug.	90-150	—	—	—	—	—	—
23 Aug.	100-160	2.6 ±4.2	0.6 ±1.6	0.6 ±1.6	0	0.3 ±0.7	1.7 ±1.9
30 Aug.	100-170	0.9 ±1.4	0	0	0	0.4 ±0.5	1.3 ±1.4
06 Sept.	100-170	5.9 ±3.3	3.3 ±2.1	3.0 ±2.1	0.3 ±0.5	0.3 ±0.5	1.6 ±1.1

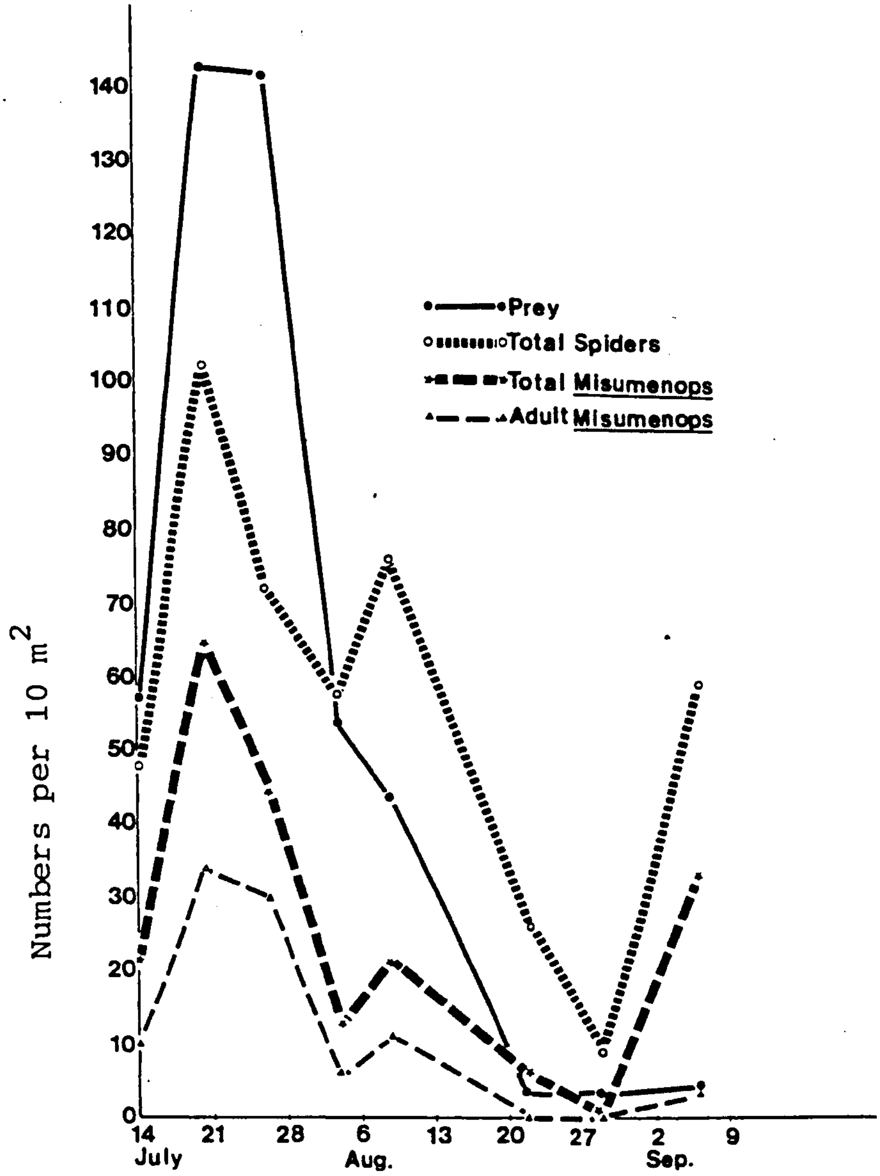


Fig. 5. Population trends for adult and total <u>Misumenops</u>, total spiders, predacious insects and potential prey for <u>Misumenops</u> in the Mammoth, Pinal County, cotton field, 1980.

Avra Valley, 1980. The population trends for adult *Misumenops* spp. spiderling, *Misumenops* spp., total spiders, plant growth, potential prey, and other general insect predators are shown in Table 3. Also, adult *Misumenops* spp., total *Misumenops* spp., total spiders, and potential prey are shown graphically in Figure 6.

The data show that *Misumenops* spp. and other spiders increased slowly in numbers to an early season peak on 27 June and declined gradually to a low on 08 August. After 08 August, *Misumenops* and other spiders increased again but then dropped off again once irrigation was halted. Sevimole® (Sevin® and Molasses) was applied on 17 July and methyl parathion on 25 July for control of pink bollworm and *Lygus*.

Of the general predators collected (Coccinillidad, Reduviidae, Nabidae, Chrysopidae larvea, *Nabis*, *Orius*, *Geocoris*, *Collops* and spiders), spiders comprised from 31.3 to 84.6 percent in each weekly sample, and 44.2 percent for the whole season. *Misumenops* spp. represented from 22.6 to 92.3 percent of the total spider population for each weekly sample, and 46.2 percent for the whole season. The mean seasonal density of *Misumenops* in the Avra Valley field was lower ($1.3/m^2$) than at Mammoth for both 1979 ($2.2/m^2$) or 1980 ($2.5/m^2$).

Table 3. Cotton height and population trends for spiders, Misumenops, potential prey for Misumenops, and predacious insects at Avra Valley, Pima County, Arizona, 1980.

Date	Cotton height (cm)	No. spiders/m²	Number of Misumenops/m²			Potential prey/m²	Predacious insects/m²
			Total	Spiderling	Adult		
23 May	5-10	1.1 ±1.1	0.3 ±0.5	0.3 ±0.5	0	1.2 ±1.2	0.2 ±0.4
30 May	6-15	1.3 ±0.8	0.9 ±0.7	0.9 ±0.5	0	2.1 ±1.8	1.0 ±1.2
06 June	10-20	2.9 ±2.1	0.7 ±1.1	0.7 ±1.1	0	9.6 ±4.0	5.2 ±2.7
13 June	20-30	1.9 ±1.3	0.8 ±0.9	0.6 ±0.7	0.2 ±0.4	4.7 ±2.0	1.9 ±1.7
20 June	30-40	2.8 ±1.4	1.2 ±1.0	0.8 ±0.8	0.4 ±0.5	6.8 ±2.9	2.6 ±2.2
27 June	35-40	4.3 ±2.8	2.4 ±2.3	2.2 ±2.3	0.2 ±0.4	8.5 ±3.3	5.9 ±3.1
03 July	40-45	4.0 ±1.6	1.6 ±1.4	1.3 ±1.3	0.3 ±0.5	6.9 ±2.3	4.6 ±2.4
11 July	55-70	3.0 ±1.4	2.2 ±1.5	1.5 ±1.1	0.7 ±0.9	10.3 ±5.6	4.2 ±1.6
22 July	60-75	1.9 ±1.3	1.5 ±1.0	0.5 ±0.7	1.0 ±0.9	5.3 ±3.5	1.9 ±1.5
25 July	60-80	1.8 ±1.2	1.1 ±1.0	0.6 ±0.7	0.5 ±0.7	5.4 ±2.0	0.5 ±0.7
01 Aug.	60-85	1.7 ±1.1	0.8 ±1.0	0.2 ±0.4	0.6 ±0.8	10.3 ±5.6	2.3 ±2.0
08 Aug.	60-90	0.9 ±1.2	0.3 ±0.7	0.1 ±0.3	0.2 ±0.4	7.0 ±4.7	1.0 ±1.2
15 Aug.	65-95	4.5 ±2.9	2.4 ±1.5	1.7 ±1.4	0.7 ±0.8	5.7 ±2.9	4.3 ±2.2
22 Aug.	65-95	5.5 ±2.0	2.2 ±1.5	1.2 ±1.2	1.0 ±1.3	9.7 ±4.1	7.1 ±2.8
29 Aug.	70-100	3.1 ±1.9	0.7 ±1.1	0.5 ±1.0	0.2 ±0.4	4.8 ±2.3	6.8 ±2.5
05 Sept.	70-100	5.0 ±3.0	1.9 ±1.5	1.6 ±1.3	0.3 ±0.5	4.5 ±3.2	8.3 ±3.7

All population densities are the mean (±S.D.) for ten (10) randomly selected 1 m² samples.

Sevin was applied on 17 July and methyl parathion on 23 July.

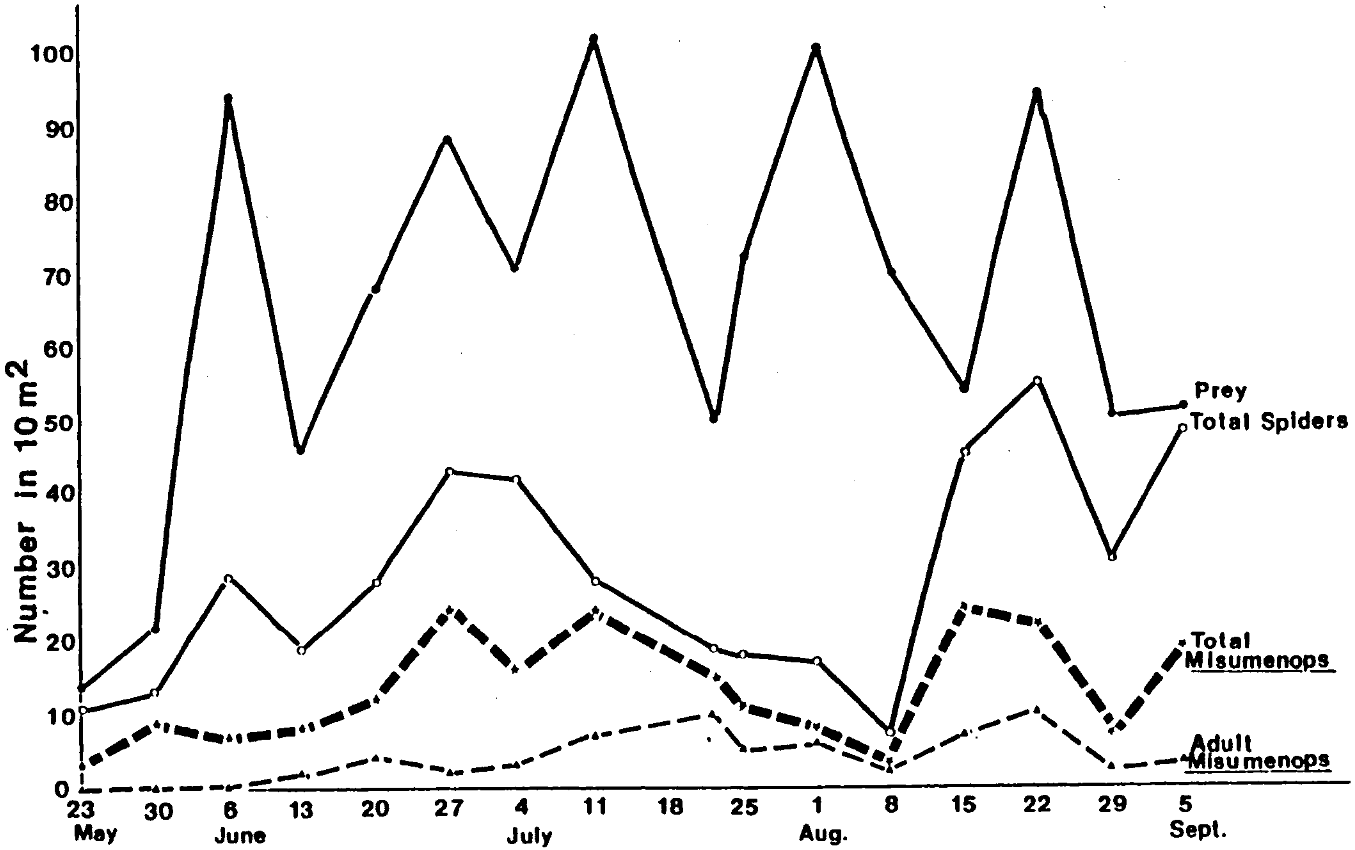


Fig. 6. Population trends for adult and total *Misumenops* spp., total spiders, predacious insects and potential prey for Misumenops in the Avra Valley, Pima County, cotton field, 1980.

Visual Observations

Table 4 shows the date, location, and number of blossoms harboring the *Misumenops* in each of six sets of 50 cotton blossoms examined. Out of the 300 blossoms examined, only 3 had *Misumenops* in them. Other observations yielded information about where *Misumenops* were found on the cotton plant. Individuals were most often found at developing terminals and squares, but some were also found on middle layer leaves. Commonly, the spider was found at the base of the midrib, aligned along its axis, on either the upper or lower surface. A walking insect would be forced to cross this point if leaving or entering the leaf.

Predation by *Misumenops* in the field included a braconid, dipterans, fleahoppers, *Lygus*, *Geocoris*, *Orius*, thrips, and other *Misumenops*. Those arthropods found preying on *Misumenops* were a *Chrysopa* larva, the Oxyopid spider *Peucetia viridans* (Hentz), and other *Misumenops*. These observations are combined with the data collected in laboratory feeding trials in Table 6.

Sampling of Surrounding Vegetation

At Mammoth, all of the plants sampled for *Misumenops* harbored them. At Avra Valley the situation was similar, with all plants sampled having at least a few present. Both mesquite and creosote bush had good numbers of *Misumenops*, but alfalfa harbored abundant *Misumenops* as well as other spiders. During the summer months 25 sweeps in alfalfa

Table 4. *Misumenops* inhabiting the blossoms of cotton at Mammoth and Avra Valley, Arizona, 1980.

Date	Location	Number of Blossoms examined	Number of Blossoms with *Misumenops*
20 July	Mammoth	50	1
26 July	Mammoth	50	1
06 Sept.	Mammoth	50	0
11 July	Avra Valley	50	0
22 July	Avra Valley	50	0
22 Aug.	Avra Valley	50	1
	Total:	300	3

generally produced over 100 _Misumenops_. Even during the winter they were fairly common in alfalfa: ten sets of 15 sweeps on 01 January, 1981 had an average of 6.9 (S.D.=4.5) per set. Table 5 lists plant species sampled for _Misumenops_, the location, and the time of year when the plant is growing and would be expected to harbor them.

Laboratory Rearing

Of the 6 spiderlings kept in the laboratory and fed first instar _Lygus_ nymphs, 3 females and 1 male were reared to maturity, while 2 spiders managed to escape before becoming adults. Table 6 summarizes the number of days and _Lygus_ consumed between each molt (counted from emergence from the egg sack). The mortality of _Lygus_ nymphs in the control cage, which contained no spiders, was 127 out of 517 or 24%. This percantage of the total _Lygus_ offered, was subtracted from the apparent number of _Lygus_ consumed for each intermoult period to obtain a corrected value for _Lygus_ consumed.

The three females and one male were fed first instar _Lygus_ nymphs after reaching maturity, and until the females had produced their second set of offspring; their corrected, per day consumption of first instar _Lygus_, was 2.0 per day for the three females (S.D.= .19) and was 1.1 per day for the single male.

Table 5. Plants growing in the vicinity of the Mammoth and Avra Valley fields harboring <u>Misumenops</u> during 1979, 1980, and 1981.

Collections were made by means of a ground cloth.

Plant	Location	Dates	Time of year when growing
Creosote Bush	Avra Valley	5/80, 8/80, 2/81	All year
Creosote Bush	Mammoth	7/80	All year
Mesquite	Avra Valley	5/80, 8/80	Spring through Fall
Mesquite	Mammoth	7/80	Spring through Fall
Baccharis	Avra Valley	2/81	All year
Burroweed	Avra Valley	9/80, 2/81	All year
Alfalfa	Avra Valley	6/80, 7/80, 9/80 1/81, 2/81	All year
Sunflowers	Mammoth	8/79	Late Summer
Winter Wheat	Avra Valley	3/80	Spring
Weeds	Avra Valley	9/80, 2/81	Diff. spp. all year
Weeds	Mammoth	8/79, 3/80, 7/80	Diff. spp. all year

Table 6. Length of intermoults and corrected numbers of first-instar Lygus nymphs consumed by 3 female Misumnops deserti (Schick) reared in the laboratory.

Rearing was conducted at 25°C, 40% RH, and a photoperiod of 12 hours light/ 12 hours dark.

	Females			Male		
		No. Lygus consumed			No. Lygus consumed	
Intermoult	Length (days)	per day	Total	Length (days)	per day	Total
First	15.7	0.7	11.3	16.0	0.8	13.0
Second	14.3	1.7	23.7	14.0	1.7	24.0
Third	14.0	2.7	38.3	19.0	2.6	49.0
Fourth	36.3	3.3	120.0	39.0	2.6	100.0
Fifth	17.7	4.6	82.3	10.0	4.9	49.0
Total	98.0	2.7	275.6	98.0	2.4	225.0
Adult	110.0	2.0	216.3	112.0	1.1	123.0

The three females were mated with field caught M. deserti males 21 days after adult female markings appeared. After 7 to 22 days they each produced an egg mass. Subsequent egg masses were produced without mating again. Spiderling Misumenops emerged from six of the seven egg masses produced, averaging 25.2 spiderlings per egg mass (S.D.= 5.4). The sixth egg mass did not produce offspring and was eventually abandoned by the female after 20 days (all of the other egg masses had hatched within 15 to 17 days). This female was remated with the laboratory reared male and then produced a fertile batch of eggs. Cannibalism upon the spiderlings by the adult female or the other spiderlings was not observed for 5 days after emergence even though they were confined together in the small cage.

The male and one of the females thus reared will be deposited in the spider collection at the Florida State Museum of Arthrapods in Gainsville, Florida. The others remain in the author's collection.

Feeding Tests

Table 7 lists the prey items tested, the stage of the spider, and whether the prey item was rejected, accepted, or managed to defend itself effectively. Field observations of predation are also included in the table. Generally they consist of fairly fast moving, soft, diurnally active species.

Table 7. Prey items accepted or rejected by <u>Misumenops</u> of various stages in the field and in laboratory test cages.

Stage of Misumenops	Prey item	No. observations	Consumed?	Source	Remarks
Adult female	Alfalfa Hopper	2	No	Lab	Repelled attack with kick
Adult femlae	*Lygus* adults	many	Yes	Field, Lab	
Adult female	Diptera spp.	many	Yes	Lab	
	Diptera spp.	3	Yes	Field	
Adult Female	Lady Beetle adult	7	No	Lab	Attacked but rejected
Adult Female	*Collops* beetle	6	No	Lab	Usually rejected
	Collops beetle	1	Yes	Lab	
Adult Female	*Nabis* adult	3	No	Lab	Usually repelled attack
	Nabis adult	1	Yes	Lab	
	Nabis nymph	3	Yes	Lab	
Adult Female	Pink Bollworm adult	4	No	Lab	
Adult Female	Cicadellidae	many	Yes	Field, Lab	
Adult Female	Fleahoppers	many	Yes	Field, Lab	
Adult Female	*Nyssius* adult	1	Yes	Field	
Adult Female	Braconidae	10	Yes	Lab	
	Braconidae	1	Yes	Field	

Table 7 -- Continued

Stage of *Misumenops*	Prey item	No. observations	Consumed?	Source	Remarks
Adult female	*Chrysopa* adult	4	Yes	Lab	
	Chrysopa larva	4	No	Lab	Repelled attack
Adult Female	Lycosid spider	2	Yes	Lab	
Adult Female	*Misumenops*	many	Yes	Lab	
Adult Female	Alfalfa weevil larva	3	No	Lab	
Late Instar	*Geocoris*	many	Yes	Field	
Late Instar	*Orius*	many	Yes	Field	
Late Instar	Cicadellidae	many	Yes	Field, Lab	
Late Instar	Diptera	many	Yes	Lab	
Late Instar	Fleahoppers	many	Yes	Field, Lab	
Early Instar	Fleahopper nymphs	many	Yes	Lab	
Early Instar	*Lygus* nymphs	many	Yes	Lab	
Early Instar	Thrips	many	Yes	Lab	
Early Instar	Chalcidoid wasp	many	Yes	Lab	

Some prey items tested illustrate very well how the behavior of the potential prey item may prevent it from being a usual prey for Misumenops. Pink bollworm adults introduced into the feeding test cages with starved Misumenops were not fed on even after 5 days. This was because the moths remained completely motionless during the daylight hours when the spider was actively waiting to ambush potential prey. The fact that Misumenops would take Pink bollworm adults if the opportunity arose was verified when the moths were disturbed during the day and thus activated; once within range they were immediately seized and eaten.

If the Misumenops were in the feeding test cages on alfalfa stems, alfalfa weevil larvae introduced as potential prey would literally eat the alfalfa stem out from under it without being taken. However, if a Misumenops was placed in a plain glass vial together with an alfalfa weevil larva it did consume the larva. Apparently this is because the weevil is relatively sessile when feeding on the plant but much more active when separated from its host plant and trying to return to it by crawling around.

Adult Nabis were observed on several occasions to effectively prevent attacks by Misumenops by directing their long, sharp beak into the attacking spider, while alfalfa hoppers were able to terminate an attack with a swift kick of their powerful hind legs. The defensive odors of coccinelids and *Collops* may have kept *Misumenops* from preying upon them, but those of the Hemiptera are apparently ineffectual in this regard. Thus whether an insect will be prey item in the diet of *Misumenops* is a function of its behavior and morphology.

Newly emerged *Misumenops* require fairly small prey items such as thrips or newly emerged nymphs of hemiptera. Newly emerged spiderlings were able to survive only 8 to 10 days in the laboratory without prey. An adult female, which had been fed well, survived 30 days in a laboratory cage without prey.

DISCUSSION

Generally, populations of *Misumenops* were high and constituted a major portion of the predator complex in the two cotton fields studied and thus would contribute significantly to the overall ecological balance in these fields. However, as shown by the field sampling data, populations of *Misumenops* vary greatly from field to field, area to area, from year to year, and seasonally. Thus the role that *Misumenops* plays in the ecology of these fields varies, just as it certainly does between the many diverse cotton growing regions of Arizona.

From the literature and the data collected the following factors are the most important in determining population levels and will be described separately: (1) the life cycle of *Misumenops*, (2) the surrounding vegetation, (3) the growth of the plant, (4) the available prey, (5) insecticides, and (6)other predators (including those which prey on *Misumenops*).

Life Cycle of Misumenops

As mentioned earlier, and as supported by the rearing study, *Misumenops* require from 145 to 531 days to reach maturity, which is generally much longer than the cotton growing season. Thus, *Misumenops* cannot complete its entire life cycle within the cotton field, and therefore requires a more stable, nearby habitat, in order to continue from season to season. This will be discussed more thoroughly under the importance of surrounding vegetation.

The highly variable length of life cycle for Misumenops, which is probably related to the amount of prey available, has the effect of producing populations with a wide age distribution, i.e., with all instars represented. This may be a mechanism by which large populations can partition the available prey, since small spiders take small prey, larger spiders the larger prey. Thus, Misumenops might have little effect on a population of a pest species which has a narrow age distribution, since only a portion of the population would optimally prey on that stage.

Another important factor in the life cycle of Misumenops is that for a female to produce offspring it first must accumulate reserves for a batch of eggs (usually 25 or more). The reserves must also be sufficient to carry it through the incubation period of 14 to 21 days, since it will only feed if an insect happens by when it is guarding its eggs (Gertsch, 1939 and personal observation). This, together with the long life cycle, would result in a rather slow production of offspring within the field in response to a population increase of pest species. This does not mean, however, that Misumenops could not have a significant effect on a pest species, or show a numerical response to that pest, as will be described later.

The life cycle of _Misumenops_ may also affect accurate measurement of field populations. If a significant portion of the females in a field have produced egg sacs they would be guarding them closely, and attached firmly to them (Gertsch, 1939, personal observation). Thus, any of the commonly employed sampling methods, excluding possibly visual examination, would produce inaccurately low counts since they can only be removed with much difficulty from their eggs.

The behavior of male spiders is interesting and may contribute to some extent to the ecological impact of _Misumenops_. As with most spiders, (Bristow, 1941), males consume much less food after maturity, are rather thin and long legged, and roam about the vegetation in search of females. In this process they risk predation and once mated often become the first postnuptial meal for the female. Thus as adults, males contribute less in terms of the number of prey they consume, but as spiderlings they contribute about the same as the females as shown by the rearing data and other published rearing records (Leigh and Hunter, 1969; Munniappan and Chada, 1970).

Surrounding Vegetation

In 1961, Robert M. Chew published "Ecology of Spiders in a Desert Community." The study area was located 5 miles north of Portal in the San Simone Valley, and is dominated by creosote bush. He and other workers (Jennings, 1971; Fautin, 1946) have recorded the dominance of <u>Misumenops</u> in western desert vegetation. The areas surrounding both the Mammoth and Avra Valley sites, which were not in cultivation, were desert shrub, with creosote bush a major component. My sampling too, has showed their abundance in the desert shrub around the Mammoth and Avra Valley fields, and suggesting that this desert shrub represents the "nursery" for <u>Misumenops</u>, which eventually colonize the cottonfield. It is also the stable permanent habitat required to complete its long life cycle.

Spiders, of course, are not capable of flight, but can be moved with the wind by "ballooning" silk from their spinnerets. Typically spiderlings balloon shortly after emergence from the egg sac. Other stages of spiders probably balloon also, but the freqüency with which they do so is not well documented. As shown by the <u>Misumenops</u> populations in the two fields (Figs. 4, 5, 6), adults were found in the field very early in the season when the plants were only a few inches tall; apparently they were carried their by ballooning.

The number of spiders which can migrate from the surrounding desert shrub would be a function of the amount of prey that has been available to them, which, in turn, is related to precipitation. The amount of precipitation which falls during the wet seasons can be highly variable in Arizona. Large migrations might occur following a wet season when populations are high and the prey populations are falling as the available moisture is used up. The age and number of spiders reaching the cotton would also be influenced by the distance of the shrub area from the field, the extensiveness of the shrub area, and the wind direction and velocity. The Mammoth field had much more desert shrub in the vicinity than did the Avra Valley field, and this may have been the principal reason why Mammoth had considerably higher spider densities.

Additional research would be necessary to determine if alfalfa, too, is a stable enough habitat for Misumenops to complete its entire life cycle. The high productivity of potential prey in alfalfa would act as a magnet for Misumenops and can support huge populations. Significant migration from alfalfa following cutting may occur and contribute to the Misumenops populations in nearby cotton just as Lygus and some predators do (Stern, et al., 1975). Strip-cutting of alfalfa has been used to reduce the movement of Lygus into cotton (Stern, et al., 1975), but its effect on Misumenops movement is not known. Strip cropping of sorghum and corn with cotton did not affect populations of spiders in Oklahoma (Burleigh, et al., 1973). The idea that weedy vegetation surrounding cropland can act as a nursery for general predators such as spiders, is not new and reports have been published by Altieri and Whitcomb (1979, 1980) and Fuchs and Harding (1976).

Surrounding vegetation can also be a source of prey for _Misumenops_ already in the cotton such as _Lygus_ from the alfalfa and fleahoppers from the weeds (Almand, et al., 1976).

Growth of the Plant

Obviously as the cotton grows, the amount of habitat space available for _Misumenops_ and their prey increases. As the season progresses, more and more spiders enter from the surrounding vegetation while those that entered earlier reach maturity and begin producing offspring as well. As the structure of the cotton becomes larger and more branched, sampling efficiency goes down, giving a lower estimate of population densities.

Some of the many actions taken by the farmer which could affect plant growth, and thus prey and spider populations are the date of planting; the timing, evenness and amount of irrigation; fertilizer; soil types and drainage; the cotton variety; whether grown from stub or seed; weed, disease, and insect control; cultivation and length of season. An example of how the time of planting can affect spider and prey populations is seen for the Mammoth field. The farmer planted his cotton later in 1979 than he did in 1980 (see Tables 1 and 2). Thus _Misumenops_ migrating into the field early in the 1979 season would have found less habitat space and fewer prey than at the same period in the 1980 season.

Available Prey

The prey available for Misumenops are those prey which they are capable of taking, which do not possess an effective defense strategy, and which exhibit behaviors that normally exposes them to predation by *Misumenops*. Thus only those species which possess these characteristics can affect the ability of cotton to retain migrating *Misumenops* and to contribute to their reproduction.

Misumenops, as mentioned previously, can go for extended periods without prey, but will move from a site if a suitable amount of prey is not taken (Gertsch, 1979; personal observation). Thus, if prey are not present in sufficient numbers, when the *Misumenops* migrate into an area they can migrate out (by ballooning). However, if prey are abundant, those that enter from surrounding areas would remain, and therefore increase their numbers in response to high pest populations.

Insecticides

If an application of insecticides does not kill the *Misumenops* directly, it will reduce the populations of available prey and thus, will result in their decline as they move or die because of the lack of prey. But since *Misumenops* can go for extended periods without prey and because individuals migrating in are very small, requiring only minimal prey, populations could be expected to recover more rapidly than other predators following use of insecticides. This contention is supported in the literature (Aguillar, 1975; Smith, 1978).

The severity of the effect that an insecticide has on the spider population will be a function of the type of insecticide used, the formulation, and the timing. The effects of these factors are not recorded in the literature and the four applications made during this study were not adequate to make any generalizations except that populations were much reduced following use of methyl parathion.

The fact that adult Misumenops are often found in the field soon after insecticide treatment further supports the contention that even adults may be capable of ballooning considerable distances. Adult females which are brooding an egg sac may escape insectide treatment because they are often consealed under a curled leaf. They would then reappear in the samples once the spiderlings had emerged. Even if the guarding female is destroyed by the insecticide, the eggs within the sac may escape injury and subsequently hatch.

Other Predators

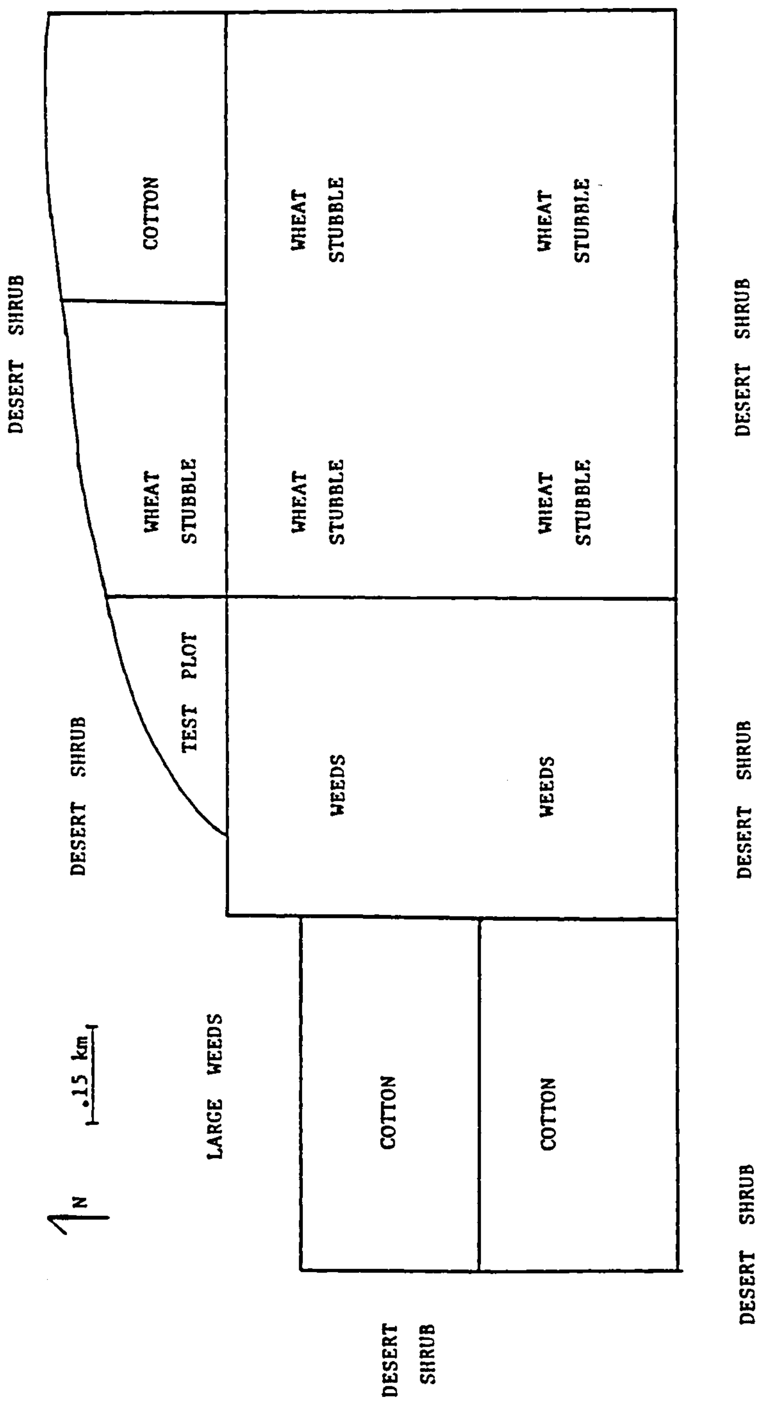
Following the application of insecticides in cotton, populations of lepidopterous larvae commonly increase rapidly. Lepidopterous larvae are generally not used as prey by Misumenops because they are slow moving, and in the case of bollworms because they feed within the boll. Eventually chrysopids, nabids, Orius and Geocoris build up on the lepidoptera. Orius, Geocorus, chrysopid adults, and nabid nymphs were found to serve as prey for Misumenops. But, Chrysopa larvae and nabid adults occasionally feed on Misumenops, particularly the young spiderlings, the stage which would be migrating into the field in greatest abundance following insecticide use. Thus, if populations of chrysopids and nabids are very high, they could have a considerable effect on the re-entry of Misumenops.

Stenophagous predators and parasitoids should effectively compete with Misumenops for particular prey items, but only after they become established. However, stenophagous predators generally show a lag in response to a numerical increase in their prey species because time is required for assimilation and production of offspring (Clause, 1972). During this lag, Misumenops and the other spiders might provide a degree of stability to the prey population, but because of their relatively slow response time they should eventually be pre-empted by the more efficient stenophagous predators and parasitoids. Misumenops would then be forced to switch to other prey, and if the predators and parasitoids possess the characteristics necessary to be prey items, they would then be taken as prey. Misumenops may then again provide stability to the system by exerting predatory pressure on the stenophagous predator before it overshoots its prey's population.

The Misumenops remaining in the field after insecticide application may also delay or inhibit subsequent colonization by predators and parasitoids which could fall prey to the _Misumenops_. This may be still another aspect of the stabilizing role spiders play in ecosystems (Reichert, 1974).

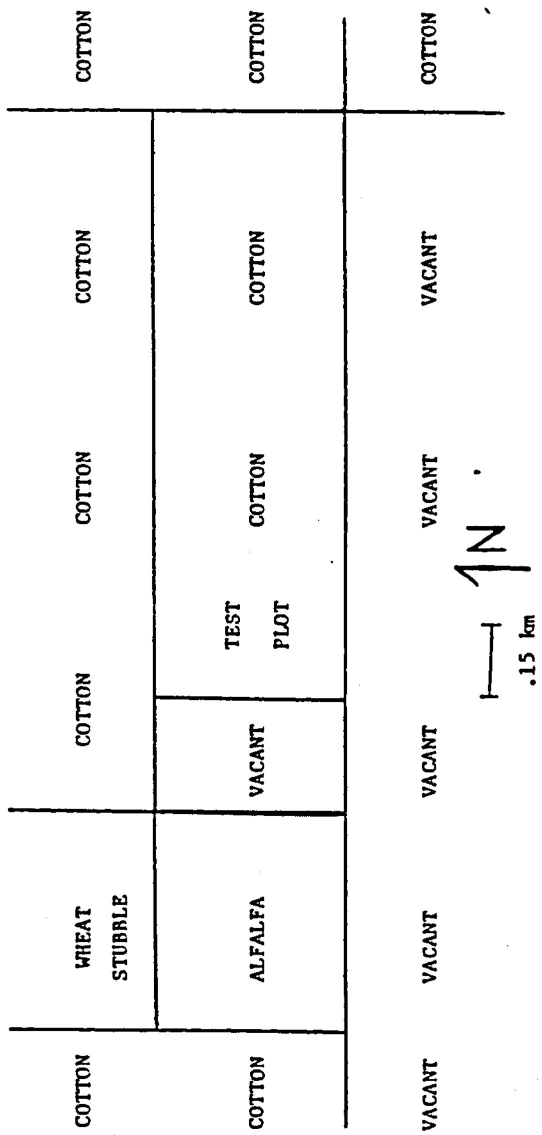
APPENDIX A

MAP OF MAMMOTH FIELD AND VICINITY



APPENDIX B

MAP OF AVRA VALLEY FIELD AND VICINITY



REFERENCES CITED

Aguillar, F. 1975. Spiders of the cultivated fields - II: fluctuations of araneid families in cotton fields of the central coast. Revista Pervana de Entomol. 18(1):25-28.

Almand, L. K.; W. L. Sterling and C. L. Greer. 1976. Seasonal abundance and dispersal of the cotton fleahopper. Texas Agric. Exp. Sta., B-1170, 14pp.

Altieri, M. A. and W. H. Whitcomb. 1979. The potential use of weeds in the manipulation of beneficial insects. Hort. Science. 14:12-18.

__________. 1979. Predacious arthropods associated with Mexican tea in north Florida. Florida Entomol. 62(3):175-182.

Bailey, C. L. and H. L. Chada. 1968. Spider populations in grain sorghum. Ann. Entomol. Soc. Amer. 61(3):567-571.

Bristowe, W. S. 1939-1941. The Comity of Spiders. Ray Society, London. Vol I:1-228. Vol. II:229-560.

Brown, G. C. and C. H. Shanks, Jr. 1976. Mortality of two spotted spider mite predators caused by the systemic insecticide carbofuran. Environ. Entomol. 5(6):1155-1159.

Bryan, D. E.; R. E. Fye, C. G. Jackson and R. Patana. 1976. Nonchemical control of pink bollworms. U. S. Dept. Agric. ARS W-39. 26 pp.

Burleigh, J. G.; J. H. Young, R. D. Morrison. 1973. Strip croppings effect on beneficial insects and spiders associated with cotton in Oklahoma. Environ. Entomol. 2(2):281-285.

Byerly, K. F.; A. P. Guitierrez, R. E. Jones and R. F. Luck. 1978. A comparison of sampling methods for some arthropod populations in cotton. Hilgardia. 46:257-282.

Chant, D. A. 1956. Predacious spiders in orchards in south-eastern England. Jour. Horticult. Sci. 31:35-46.

Chew , D. A. 1961. Ecology of the spiders of a desert community. Jour. New York Entomol. Soc. 69:5-41.

Chiang, H.C. 1974. Recent advances in research on predators of insect pests in North America: Proceedings of a joint symposium of the Entomological Society of America and the Entomological Society of Canada, Montreal, Quebec. November 30, 1972. Entomophaga. Mem. Hors. Ser. No. 7. 88 pp.

Clausen, C. P. 1972. Entomophagous Insects. Hafner Publ. Co., New York. 688 pp.

Clarke, R. D. and P. R. Grant. 1968. An experimental study of the role of spiders as predators in a forest litter community. Part 1. Ecology 49:1152-1154.

DeBach, P. 1964. Biological Control of Insect Pests and Weeds. Rheinhold Publ. Co., New York. 844 pp.

Dinkins, R. L.; J. R. Brazzel, and C. A. Wilson. 1970. Seasonal incidence of major arthropods in Mississippi cotton fields. Jour. Econom. Entomol. 63(3):814-817.

Dondale, C. D. 1956. Annotated list of spiders (Araneae) from apple trees in Nova Scotia. Canadian Entomol. 88:697-700.

Dondale, C. D. 1958. Note on population denoitres of spiders (Arneae) in Nova Scotia apple orchards. Canadian Entomol. 90:111-113.

Faulin, R. W. 1946. Biotic communities of the northern shrub biome in western Utah. Ecol. Monogr. 16:251-310.

Fuchs, T. W. and J. A. Harding. 1976. Seasonal abundance of arthropods in various habitats in the Lower Rio Grand Valley of Texas. Environ. Entomol. 5(2):288-290.

Gertsch, W. J. 1939. A revision of the typical crab spiders (Misumeninae) of America north of Mexico. Bull. Amer. Mus. Nat. Hist. 76:277-442.

________. 1979. American Spiders. Rheinhold Publ. Co., New York. 274 pp.

Gonzalez, D.; D. A. Ramsey, T. F. Leigh, B. S. Ekborn, and R. Van den Bosch. 1977. A comparison of vacuum and whole plant methods for sampling predacious arthropods on cotton. Environ. Entomol. 6(5):750-760.

Greenstone, M. H. and A. F. Bennett. 1980. Foraging strategy and metabolic rate in spiders. Ecology. 61(5):1255-1259.

Howell, J. O. and R. C. Pienkowski. 1971. Spider populations in alfalfa, with notes on spider prey and effect of harvest. Jour. Econ. Entomol. 64(1):163-168.

Huffaker, C. B. 1971. Biological Control. Plenum Press, New York. 511 pp.

Huffaker, C. B. and C. E. Kennet. 1956. Experimental studies on predation: Predation and cyclomen-mite populations on strawberries in California. Hilgardia. 26(4):191-222.

Jackson, C. G. 1980. Personal communication. USDA Biological Control Laboratory., Tucson, Arizona.

Jennings, D. T. 1971. Plant associations of Misumenops coloradensis. Gertsch in central New Mexico. Southwest Naturalist, 16(2):201-207.

Johnson, E. K.; J. H. Young, R. D. Molnar and R. D. Morrison. 1976. Effect of three insect control schemes on populations of cotton insects and spiders, fruit damage, and yield of Westburn 70 cotton. Environ. Entomol. 5(3):508-510.

Judd, W. W. 1964. Spiders and their insect prey from the heads of Ox-eye daisey, Chrysanthemum leucanthemum L., in southwestern Ontario. Proc. Entomol. Soc. Ontario. 95:137-139.

Kagan, M. 1943. The araneida found on cotton in central Texas. Ann. Entomol. Soc. Amer. 36:257-258.

Kajak, A. 1978. Analysis of consumption by spiders under laboratory and field conditions. Ekologia Polska. 26(3):409-427.

Kaston, B. J. 1978. How to Know the Spiders. Wm. C. Brown, Dubuque, Iowa. 272 pp.

Keever, D. W.; J. R. Bradley and M. C. Ganyard. Effects of diflubenzuron (Dimilin) on selected beneficial arthropods in cotton fields. Environ Entomol. 6(5):732-736.

Laster, M. L. and J. R. Brazzel. 1968. A comparison of predator populations in cotton under different control programs in Mississippi. Jour. Econ. Entomol. 61(3):714-719.

Leigh, T. F., and R. E. Hunter. 1969. Predacious spiders in California cotton. California Agric. 23(1):4-5.

Lockley, T. C., J. W. Smith, W. D. Scott and C. R. Parencia. 1979. Population fluctuations of two groups of spiders from selected cotton in Panola and Pontotoc counties, Mississippi, 1977. Southwest Entomol. 4(1)20-24.

Lovell, J. H. 1915. Insects captured by the Thomisidae. Canadian Entomol. 47:115-116.

Luczac, J. 1963. Differences in the structure of communities of web spiders in one type of environment (young pine forest). Ekologia Polska. 11:159-221.

__________. 1966. The distribution of wandering spiders in different layers of the environment as a result of interspecies competition. Ekologia Polska. 14:234-244.

__________. 1975. Spider communities of the crop-fields. 1(3):93-110. IN: Studies on Crop-Field Ecosystems. L. Ryszkowski (ed.) Polish Ecological Studies. Part I. 252 pp.

Luczac, J. and E. Dabrowska-Prot. 1971. The effect of competition between two spider species on the predation intensity and spider reduction under conditions of varying predator density. Arach. Congressus Internationalis. V:193-200.

MacArthur, R. 1955. Fluctuations of animal populations, and a measure of community stability. Ecology. 36:533-536.

Muniappan, R. and H. L. Chada. 1970. Biology of the crab spider, Misumenops celer. Ann. Entomol. Soc. Amer. 63:1718-1722.

Nicholosn, A. J. 1955. Compensatory reactions of populations to stress, and their evolutionary significance. Austrailian Jour. Zool. 2(1):1-8.

Pieters, E. P. and W. L. Sterling. 1974. Aggregation indices of cotton arthropos in Texas. Environ. Entomol. 3(4):598-600.

Pimentel, D. 1961. Competition and species per genus structure of communities. Ann. Entomol. Soc. Amer. 54(3):323-333.

Ridgeway, R. L.; P. D. Lingren, C. B. Cowan Jr., and J. W. Davis. 1967. Populations of arthropod predators and Heliothis spp. after applications of systemic insecticides to cotton. Jour. Econ. Entomol. 60(4):1012-1016.

Reichert, S. E. 1974. Thoughts on the ecological significance of spiders. Bio Science. 34:352-356.

Rogers, C. E. and N. V. Horner. 1977. Spiders of guar in Texas and Oklahoma. Enviorn. Entomol. 6(4);523-524.

Schick, R. X. 1965. The crab spiders of California. Bull. Amer. Mus. Nat. Hist. 129:1-180.

Shepard, M.; G. R. Carner and S. G. Turnipseed. 1974. A comparison of three sampling methods for arthropods in soybeans. Environ. Entomol. 3(2):227-232.

Smith, J. W. and E. A. Stadelbacker. 1978. Predatory arthropods: Seasonal rise and decline of populations in cotton fields in the Mississippi Delta. Environ. Entomol. 7(3):367-371.

Stern, V. M.; R. Van Den Bosch, T. F. Leigh, O. D. McCutcheon, W. R. Salee, C. E. Houston and M. J. Garber. 1967. Lygus control by strip cutting alfalfa. Univ. Calif. Agric. Ext. Serv. AXT-241. 13 pp.

Turnbull, A. L. 1960. The spider population of a stand of oak (Quercus robur L.) in Wytham Woods, Berk., England. Canadian Entomol. 92(2):110-124.

__________. 1973. Ecology of the true spiders. Annual Review of Entomol. 18:305-348.

VanSteenwyk, R. A.; N. C. Toscana, G. R. Ballmer, K. Kido and H. T. Reynolds. 1975. Increase of Heliothis spp. in cotton under various insecticide treatment regimes. Environ. Entomol. 4(6):993-996.

Vickerman, G. P. and K. D. Sunderland. 1977. Some effects of dimethoate on arthropods in winter wheat. Jour. Applied Ecology. 14(3);767-777.

Vite, J. P. 1953. Untersuchungen über die ökologie und forstliche Bedeutung der Spinnen im Walde. Zeitschr. Angew. Entomol. 34:314-334.

Werner, F. G.; L. Moore and T. F. Watson. 1979. Arizona cotton insects. Coop. Extension Serv., Univ. of Arizona. A23-R. 38 pp.

Wheeler, A. G. 1973. Studies on the arthropod fauna of alfalfa. V. Spiders (Araneida). Canadian Entomol. 105:425-432.

Whitcomb, W. H. 1967. Field studies on predators of the second-instar bollworm, Heliothis zea (Boddie). Jour. Georgia Entomol. Soc. 2(4):113-118.

Whitcomb, W. H. 1980. Personal communication. Dept. of Entomology, University of Florida, Gainesville, Florida.

Whitcomb, W. H.; H. Exline and R. C. Hunter. 1963. Spiders of the Arkansas cotton field. Ann. Entomol. Soc. Amer. 56(5):653-660.

Whitcomb, W. H. and K. Bell. 1964. Predacious insects, spiders, and mites of Arkansas cotton fields. Agric. Exper. Station, Div. of Agric., University of Arkansas. Bull. No. 690. 84 pp.

Yeargan, K. B. and C. D. Dondale. 1974. The spider fauna of alfalfa fields in northern California. Ann. Entomol. Soc. Amer. 67(4):681-684.