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Spiders as Biological Control Agents of Agricultural Pests

F.A. Mansour, W.H. Whitcomb

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Names of Investigators:

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Cooperating Investigator(s): Willard H. Whitcomb

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ABSTRACT

During the years 1981,82 observations on populations fluctuations and species composition of the spiders were made and recorded in unsprayed groves of avocado and citrus (grapefruit) as well as in sprayed and unsprayed cotton fields in Israel. Both ground dwelling spiders and those found on foliage were sampled.

Field experiments were carried out to evaluate the effectiveness of spiders in the biological control of: spodoptera larvae in cotton fields, Boarmia larvae in avocadoes and Ceroplastes floridensis in citrus.

The results of these experiments show that spiders play a significant role in suppressing these nests.

Laboratory experiments were carried out to evaluate the effect of two commercial pesticides Dursban and Malathion on the spider Ch. m, the most dominant spider in citrus. It was found that Dursban was much more effective than Malathion. In comparing the effect of Malathion on the Ch. m population collected from the citrus groves in Afaik and Ch. m population collected from experimental cotton fields at Newe-Ya'ar, it was found that the Afaik surveys of spider populations were carried out in citrus and grapes in Florida. The biology of the spiders: Heteropoda venatora; Lycosa lenta and Trachelas similis were studied under laboratory conditions at the University of Florida - Gainesville.

strain appears to have some resistance (resistance factor 3.3

Surveys of

Evaluation of the research achievements with respect to the original research proposal.

In general, the research has been done according to the original research proposal. We have very important data about:

a) the spider composition in main agricultural habitats.

b) the fluctuations of the spider populations in these habitats.

c) the role that spiders play in suppression of injurious insects and their significance.

d) the effect of some pesticides on spiders.

e) the life cycle of certain species.

This information is crucial for utilizing spiders in pest management and a big step in advancing biological and integrated control

Description and results of cooperation.

The cooperation included constant exchange of information. The Israeli investigator, F. Mansour, spent the first year of the program in Florida, working in the laboratory of the American investigator Prof. W.H. Whitcomb. The Israeli investigator spent most of the time in studying identification of spiders which were found in the citrus and grape groves. This was very necessary for the Israeli part because of the weakness of this subject in Israel. During the second year of the research the American investigatior, Dr. Willard H. Whitcomb, spent one month in Israel working at the laboratory of the Israeli investigator. The exchange of information and joint planning between the cooperators enabled Drs. Whitcomb and Mansour to better understand the subject at hand and permitted them to evaluate the use of spiders in integrated control projects in the future.

RESEARCH ON SPIDERS IN FLORIDA CITRUS

The spider population in Florida groves is extensive. While studies have been made in the past, the information was not complete enough to give us a complete understanding of araneid activities or to allow us to make a comparison with spider activities in citrus in Israel. For these reasons a thorough investigation of the spiders present in the groves in Florida was carried out. Both the species of spiders present and their importance in Florida agriculture was determined. A direct comparison between the spiders present in Israel and Florida is not yet complete but almost no species were present in both areas. Representatives of the same genera were present in several cases. The roles spiders played in the two situations were identical. In the past the impact of spiders as predators of citrus pest in Florida has been considered minimal since many of the most destructive arthropod pests in citrus are sessile Homoptera. With the increased importance of weevil pests, such as Diaprepes abbreviatus (L.), Araecerus fisciculatus (De Geer), Pantomorus cervinus (Boheman) and Pachnaeus spp. this situation has changed.

METHODS AND MATERIALS

Three collection methods were used: branch shaking, pitfalls and incidental collecting. Spiders were collected by the shake method bi-monthly from a mature orange grove in Forest City, Seminole Co., Fa. from December 1979 - December 1980. Selected branches of a tree were of sufficient size and spread to overshadow a 2 x 1.5 m reinforced plastic ground cloth. Completely random selection of trees and/or branches was impractical because of the physical structure of the trees. Branches of some trees were too low to permit placing the cloth under them without disturbing the spiders present. Also, some trees had no branches, lacked branches large enough to permit comparisons or lacked branches within shaking grasp of the investigators.

Once an appropriate branch was located, it was grasped about midway between the trunk and foliage and shaken 3-5 times. After each of 10 branches (on separate trees) was shaken, spiders found on the cloth were captured in 7-dram plastic snap cap vials. At the conclusion of the last daily replication, most recognizable adult spiders were identified, counted and released. Less easily identified and immature spiders were preserved for taxonomic determination. No attempt was made to keep records on the ratio of adults to immatures.

Pitfall traps were made from quart size plastic jars into which 3 cm of ethylene glycol was placed. A plastic funnel was inserted in each jar. Five traps were placed in the Forest City grove and these checked weekly from October 1979 to June 1980. Incidental capture of spiders was also utilized to obtain species not easily collected by branch shakes.

Supplementary data were collected in an "organic" (never sprayed with pesticides) orange grove in Yalaha, Lake Co., Fla. as well as in groves near Apopka and Plymouth, Fla. Voucher specimens of the spiders collected in the current study are deposited in the Florida State Collection of Arthropods (FSCA), Division of Plant Industry, Florida State Department of Agriculture and Consumer Services, Gainesville, Fla. Most identifications were made by Dr. G.B. Edwards of FSCA.

RESULTS AND DISCUSSION

An updated summary list of spiders found in Florida citrus is presented in Table 1. We have changed some names from Muma's (1973, 1975) lists to reflect recent revisionary work. Additions made in the current study are noted. Ten of the most numerous spiders were selected for examination of relative abundance in shake samples over 1 year of sampling in the Forest City grove. These include Dictyna florens Ivie and Barrows, Theridion flavonotatum Becker, Araneus miniatus (Walckenaer), Gasteracantha cancriformis (Linnaeus), Leucauge spp. (probably mostly argyra (Walckenaer), Tetragnatha versicolor (Walckenaer, Trachelas similis

F. O. P.-Cambridge, Aysha velox (Becker), Hentzia palmarum (Hentz) and Thiodina sylvana (Hentz) (Table 2). There was a large degree of variation. Dictyna florens, Theridion flavonotatum, Araneus miniatus, Tetragnatha versicolor, and Hentzia palmarum appeared to be most numerous during the winter; Gasteracantha cancriformis was most abundant during the winter and early spring. Aysha velox, Trachelas similis, and Thiodina sylvana seemed to have peaks of abundance at various times of the year with little apparent pattern, although A. velox seemed to show a double peak-in winter and early fall. Leucauge spp. were most abundant in winter and fall.

Tetragnatha versicolor seemed to be more abundant in these samples than any other spider. However, Aysha velox was the most numerous in fall. Hentzia palmarum also reached relatively high numbers (84 in January 16 samples) during part of the year. Sample sizes of similar magnitude for the latter species have also been collected (D.B. Richman) on black mangrove during much of a year (1975) in coastal swamps near Cedar Key, Levy Co., Fla.

The organic Yalaha grove had a relatively extensive fauna, based on our few samples, but this fauna seemed to be no more complex than that at Forest City, where the usual foliar insecticides and fungicides had been applied. Winn Grove near Plymouth appeared to have a less diverse fauna as has also been shown for ants (Tryon and Whitcomb, in press). During one afternoon of observation only a few spiders were seen on the ground and one orb web was found in a tree. This is apparently a result of the destruction of many arthropod species through the use of chlorinated hydrocarbons. Only earwigs seem to be more numerous in Winn Grove than at other groves.

The existence of the salticid spiders Thiodina sylvana, Corythalia canosa (Walckenaer) and Lyssomanes viridis (Walckenaer) in citrus indicates at least some mesic fauna incursion, whereas the salticids Hentzia palmarum, Phidippus regius C.L. Koch, Phidippus workmani Peckham & Peckham and others indicates both transitional and xeric faunas. This probably is a result of the nature of citrus groves, with relatively uniform spacing of canopy, broken by bare or weed-filled areas between.

Weevils, especially Diaprepes abbreviatus, have become increasingly important as citrus pests in Florida (Woodruff, 1964, 1968; Selhime and Beavers, 1972) and thus their natural enemies have also become important. While spiders do not appear to be as effective predators of weevils as ants, they do at times attack various stages of weevils. Two salticids have been observed to feed on the weevil Diaprepes abbreviatus. Phildippus regius was collected feeding on adult weevils (T.D. Gowan and W.H. Whitcomb, personal observation) and Corythalia canosa has been observed several times feeding on neonate larvae (Whitcomb et al., 1982; D.B. Richman, personal observation). Both Aysha velox and Trachelas deceptus (Banks) have been observed to eat the eggs of Diaprepes (D.P. Richman, personal observation). Argiope trifasciata (Forskal) will also take adult weevils (W.H. Whitcomb, personal observation).

In summary, spiders are numerous and possibly important components of the predator complex in Florida citrus groves. While to date little definite data have been obtained indicating a major impact of spiders except in very specialized situations, they do form a major part of the predatory fauna. The spider fauna of citrus groves is a mixture of forest, ecotonal, and oldfield or xeric faunas; this fauna fluctuates greatly in numbers, as in many other ecosystems.

SPIDERS FROM FLORIDA GRAPE VINEYARDS

Spiders constitute a major part of the predatory arthropod fauna in agricultural systems. In recent years more interest has been developed in the faunas of spiders associated with agroecosystems (Turnbull 1973, Riechert 1974, Mansour et al., 1982). Spider faunas have been examined by several authors for various crops (e.g. Whitcomb et al., 1963, LeSar and Unzicker 1978, Muma 1975, Mansour et al., 1980). As far as we know, this does not include grapes. Grapes are an important fruit crop in many areas of the United States. In Florida, bunch or table grapes are grown in large vineyards near Orange Lake. As part of an ongoing study of spiders in agricultural systems a survey of spiders was made in Florida bunch grape vineyards near Orange Lake.

METHODS AND MATERIALS

Spiders were collected twice monthly from December 1979 through December 1980 from arbors of various bunch grape varieties at Florida's Vineyards in Orange Lake, Fla. Searching time was limited to one hour per bi-monthly visit except in cases where weather prohibited collecting (one month). Collections were made by postitioning a 6 x 4.5 ft. plastic ground cloth below the grapes at intervals spaced along the rows to avoid disturbing effects of previous sampling. With the ground cloth in position the wires on which the grapevines were strung were shaken three to five times. Spiders falling to the ground cloth were then collected in 7-dram plastic snap cap vials, stored in a portable cooler and returned to the laboratory for identification. Spiders were preserved in 70% isopropyl alcohol.

Voucher specimens are deposited in the Florida State Collection of Arthropods (FSCA), Division of Plant Industry, Florida Dept. of Agriculture and Consumer Services, Gainesville. Dr. G.B. Edwards of the FSCA identified most of the specimens.

RESULTS AND DISCUSSION

A total of 40 species of spiders of 12 families were collected on bunch grapes (Table 1). The fauna (as would be expected) is heavily weighted toward web builders and the salticids. No lycosids were collected, although a few species are known to climb vegetation. The most numerous spiders species in these samples included Aysha velox, Theridula opulenta, Scoloderus cordatus, Metaphidippus galathea, Eriophora ravilla, Phidippus regius, Peucetia viridans, Theridion muranium, Hentzia palamarum and Eustala anastera. This represents an old field and ecotonal fauna. Grapes, like citrus, are relatively stable ecologically speaking. Unfortunately, not enough specimens were collected of even the most abundant species to make much in the way of conclusion on their phenologies. Scoloderus cordatus immatures and a male were collected in July - September, with the male from September. Aysha velox adults were collected in December and January. Metaphidippus galathea immatures were collected in January and February and a male in March. Phidippus regius immatures were collected in July, September and December. Hentzia palmarum immatures were collected from January through August, with a female collected in December. Adults of H. palmarum have been collected in just about every month of the year on other vines, shrubs and trees (Richman, personal observations). This represents only a preliminary list, which will undoubtedly will be expanded in the near future.

Table 1. Spiders collected on Florida bunch grapes at Orange Lake, Florida, Dec. 1979 through Dec. 1980.

Theridiidae

Anelosimus studiosus (Hentz)

Argyredes sp.

Theridion crispulum Simon

T. muranium Emerton

Theridula opulenta (Walckenaer)

Tidarren sp.

Linyphiidae

Ceraticelus sp.

Ceratinopsis georgiana Chamberlin & Ivie

Grammonota texana (Banks)

Florinda coccinea (Hentz)

Araneidae

Acacesia sp.

Cyclosa sp.

Eriophora ravilla (C.L. Koch)

Eustala anastera (Walckenaer)

Larinia directa (Hentz)

Leucauge sp.

Metepeira sp.

Neoscona arabesca (Walckenaer)

Scoloderus cordatus (Taczanowski)

Mimetidae

Mimetus sp.

Pisauridae

Dolomedes sp.

Table 1. Cont.

Oxyopidae

Hamataliwa sp.

Puecetia viridans (Hentz)

Gnaphosidae

Poecilochroa sp.

Sergiolus sp.

Zelotes sp.

Clubionidae

Castineira crocata (Hentz)

Chiracanthium inclusum (Hentz)

Trachelas similis F. O. P.-Cambridge

Anyphaenidae

Anyphaena sp.

Aysha velox (Becker)

Thomisidae

Misumenoides alatorius (Hentz)

Misumenops celer (Hentz)

Philodromidae

Philodromus sp.

Salticidae

Hentzia palmarum (Hentz)

Metaphidippus galathea (Walckenaer)

Phidippus clarus Keyserling

P. pulcherrimus Keyserling

P. regius C.L. Koch

Thiodina sylvana (Hentz)

LIFE HISTORIES OF INDIVIDUAL SPECIES

Life history studies were critical for objectives two and three. The fluctuations and composition of the spider population on various crops throughout the season depends to a large extent on the life histories and the seasonal histories of individual species. Of course this could only be done for the most significant species. The Gainesville team had considerable experience in this kind of research. In fact, a life history of two species found on both grape and citrus had been completed previously: Chiracanthium inclusum, a clubionid closely related Chiracanthium mildei of Israel; and Lyssomanes viridis, a salticid. Four species were investigated during the course of the grant. These included: Corythalia canosa, Lycosa lenta, Heteropoda venatoria and Trachelas similis.

THE LIFE CYCLE OF HETEROPODA VENTORIA

The giant crab spider, Heteropoda venatoria (L.) is known to occur throughout much of the tropics and subtropics of the world where it is valued as a predator of cockroaches (Guthrie and Tindall 1968, Hughes 1977, Edwards 1979). Its feeding habits, like those of most spiders, vary somewhat and it has also been known to eat scorpions and bats (Bhattacharya 1941), although it is questionable as to whether it normally attacks such prey. This spider is often found associated with human habitation, possibly due to the abundance of prey (Subrahamanyam 1944, Edwards 1979). Although biological notes on H. venatoria have been published by several workers (Lucas 1871, Minchin 1904, Bristowe 1924, Bonnet 1930, Ori 1974, 1977), the only life history work to date was published by Bonnet (1932) and Sekiguchi (1943, 1944a,b, 1945). Bonnet (1932) based his study on only 12 spiders (of which seven matured) and lacked data on the post-embryonic stages. Sekiguchi (1943, 1944a,b, 1945) presented a more complete study, but the papers are difficult to translate and they still lack some data, especially in regard to variation in the number of instars and carapace width. We have raised H. venatoria in the laboratory and present here our data on life cycle of this important beneficial arthropod.

MATERIALS AND METHODS

Spiders were obtained from avocado groves in south Florida, near Homestead, Dade County. Egg sacs taken from our laboratory population of H. venatoria were used to obtain data for eggs, first and second postembryos and spiderling instars. Immature spiders, through 4th-5th-instars, were housed in Tygon® flexible plastic tubing, an adaptation of methods developed by Peck and Whitcomb (1967). Two tubing sizes were employed, 13 mm and 24 mm diameter. The smaller bore tubing was cut to 10 cm lengths while the 24 mm tubing was cut into lengths of 20 cm to house spiders from 5th to 9th instars. Plastic foam culture-vial stoppers for 14-19 mm openings sealed the ends of the tubing. Tube ends had only to be dipped into water weekly to maintain adequate moisture and humidity levels for the spiders. An open cell foam plug allowed for adequate ventilation while preventing the spider's escape from the tube. While these cages were not as large as would perhaps be ideal, they were easily maintained and stored in a relatively small area, and the spiders stayed healthy in them.

Moist cotton swabs were used to clean the tubes when clear vision into them was obscured by prey debris, spider wastes or mold. A rolled piece of 9 cm diameter filter paper was inserted into the 25 mm diameter tubes to further reduce cleaning frequency as the spiders tended to retreat onto the papers and defecate. Changing the filter paper at regular intervals maintained a high degree of sanitation.

Adult spiders were housed in 0.5 1 clear plastic cups. A heated cork boring tool was used to fashion holes in lids in which were inserted oped cell, plastic culture tube stoppers which allowed for ventilation. Paper can lids were inverted as bottoms to the plastic cup spider cages and these were lined with 9 cm filter paper to facilitate cleaning.

First instar H. venatoria were reared on adult vestigial-winged fruit flies, Drosophila melanogaster Meigen, for which the spiders showed a clear preference over an occasional cabbage looper larva, Trichoplusia ni (Hübner). Later instars were fed on adult native fruit flies (family Drosophilidae, genus unknown), which were larger than D. melanogaster, but the spiderlings showed greatest weight gain on mealworm larvae (Tenebrio molitor L.). Mealworms became the mainstay of the spiders' diet through the 10th and 11th instars, when the spiders were fed adult crickets, Acheta domesticus (L.), to extend feeding intervals. Houseflies, Musca domestica L., were introduced in the pupal stage during the middle instars and were fed on as the adult flies emerged.

Earlier instar spiders were maintained in a laboratory room and transferred during penultimate or adult stages to an environmental growth chamber. Temperatures in the room were stabilized at 27°C in the summer and 24°C in the winter, ± 2°C. The spiders were kept under fluorescent lights. The eggs, postembryos, and first instars used for later observations were all maintained in the environmental chamber, which was kept at a constant 26.7°C on a 13:11 L:D light period. Humidity was controlled within the chamber by a supersaturated NaCl solution bath in a 20 x 15 x 8 cm tray. The tray was partially filled with small pebble-sized rocks to increase the surface area available for moisture exchange. The humidity control method was adapted from a technique described by Winston and Bates (1960) and it stabilized humidity levels within the 60-70% range as monitored by a gygrothermograph.

Mating was observed in plastic gerbil cages, which were modified to prohibit escapes by gluing taffeta-like cloth between the upper and lower portions of the cage.

Carapace widths were measured at the widest points with an ocular micrometer and a binocular microscope.

RESULTS AND DISCUSSION

The courtship and mating of *H. venatoria* was described by Bonnet (1932) and Sekiguchi (1944b). Our observations generally agree with these published accounts except where noted in the following discussion. In the current study, males introduced to a cage with a female were observed to construct a sperm web approximately 2 hours prior to mating. After sperm induction male spiders groomed their pedipalps for 5-25 seconds. The males vibrated their bodies prior to mounting, as described in detail by Rovner (1980). After mounting, the male rubbed his first pair of legs on the females abdomen before and sometimes during insertion of the pedipalps. Copulation occurred in bouts lasting from one to six hours over a period of 24 hours. The pedipalps were inserted alternately, for an average of 20.4 seconds for each insertion (n=70, SD=6.8 seconds). Bonnet (1932) reported that insertion lasted 6-7 seconds, not counting transfer time. Males were often cannibalized by the female after mating, which could account for the higher proportion of females to males found in the field.

Approximately 12-14 days after mating, a circular, flattened, creamy white egg sac was produced by the female. The size of the sac ranged from 1.27 to 2.54 cm in diameter, and was from 3.18 to 6.35 mm thick. A network of silk was deposited on the underside of a flat surface, such as a leaf or plastic housing container lid. The eggs (each ca. 1.5 mm dia.) were deposited on this base, and covered with another layer of silk. After the egg sac was sealed around the edges and removed from the foundation, the female carried it with her pedipalps underneath her body during the incubation period. The female usually did not eat during this time. Infertile egg sacs were sometimes droped or eaten by the female. A large number of infertile egg sacs (54% of those produced in the laboratory) were constructed by the reared spiders. This might be expected due to the artificially imposed mating schedule. An average of 2.16 fertile egg sacs were produced per female, with five the highest number. An average of 163 eggs were laid in each fertile egg mass (n=13 egg masses, SD=28.97) constructed by the experimental spiders. Bonnet (1932) reported 207 spiderlings emerging from the one egg mass from a female he had raised after obtaining it as an immature spider on bananas shipped from Africa. Sekiguchi (1944a) obtained 188-436 eggs/mass. In field observations we have found as many as 400 spiderlings in one egg sac. This may indicate that a high degree of variability in egg mass size is common. No data were taken on the numbers in consecutive egg sacs.

Peck and Whitcomb (1970) included a discussion of the postembryonic stages and reviewed the terminology used in the literature to describe them. The definitions used in the present study follow theirs and are given below to avoid confusion. The first postembryo is defined as being that stage after the chorion of the egg had been shed from most of the embryo, but remained as a crumpled mass at the posterior end. The second postembryo is defined as being that stage after the vitelline membrane had been shed and the embryo was completely free, with legs able to move. After the first molt the spiderling was considered to be a first instar. This molt occurred inside the egg sac. Bonnet (1932) and Sekiguchi (1944a) considered the emerged spiderlings to be second instars.

Several egg sacs were removed from CO_2-anesthetized female spiders, opened, and placed in covered petri dishes for observation. The egg stage lasted from 8-14 days (n=6 egg masses). Eclosion required recorded complete data for only one female H. venatoria and found a total of 11 instars. He, however, apparently included the second postembryo as the first instar. Of the adults in our study for which complete data were available, the males (n=3) had 8-10 instars ($\bar{X}$=8.7, SD=1.2) which lasted 241 days (SD=56.2) and the females (n=13) had 9-12 instars ($\bar{X}$=10.6, SD=1.0) which lasted 315.6 days (SD=21.0). The survival rate from first instar to adult in the laboratory was approximately 85%. Total length of life from egg to death for our laboratory reared specimens was for males (n=4) 355-586 days ($\bar{X}$=464.5 days, SD=112.0) and for females (n=16) 298-710 days ($\bar{X}$= 580.3 days, SD=128.6). Rovner (per. com.) found that some females of H. venatoria can survive for three years as adults in the laboratory.

The mean carapace width for each instar (not separated by sex) is shown in Figure 1 to have a nearly linear relationship with the stadia, as might be expected. This and the large number of stadia seem to agree with a suggestion made by Hagstrum (1971) that large spiders have added stadia, rather than accelerated growth between successive molts. Sekiguchi (1945) shows similar data for the female of H. venatoria in Japan. The carapace widths for our spiders are summarized in Table 1.

The ratio of females to males for reared spiders was 2.4/1 (22 females/9 males). The sex ratio for adult specimens collected in Homestead, Dade Co., confusion. The first postembryo is defined as being that stage after the chorion of the egg had been shed from most of the embryo, but remained as a crumpled mass at the posterior end. The second postembryo is defined as being that stage after the vitelline membrane had been shed and the embryo was completely free, with legs able to move. After the first molt the spiderling was considered to be a first instar. This molt occurred inside the egg sac. Bonnet (1932) and Sekiguchi (1944a) considered the emerged spiderlings to be second instars.

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The ratio of females to males for reared spiders was 2.4/1 (22 females/9 males). The sex ratio for adult specimens collected in Homestead, Dade Co., Fla. on August 14-19, 1981 was 3.4/1 (71 females/21 males). The sex ratio in Homestead might be due to cannibalism of the males by females, as mentioned previously. Of the females collected, 18.3% were carrying egg sacs, and all instars were observed to be present in the field. Summer seemed to be the major period of egg production both in the laboratory and in the field.

This spider probably offers one of the best possibilities for the use of spiders in biological control as it is well adapted for living in close association with humans and is readily reared. As these spiders habitually feed on cockroaches, H. venatoria behavior and ecology may be an important key in the biological control of one of mankind's oldest pests.

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SUMMARY

The giant crab spider, Heteropoda venatoria (L.) was reared in the laboratory. These spiders reached adulthood after 8-10 instars for the males and 9-12 instars for the females and took approximately one year to mature from the egg. The postembryonic stages were found to last approximately 2 weeks.

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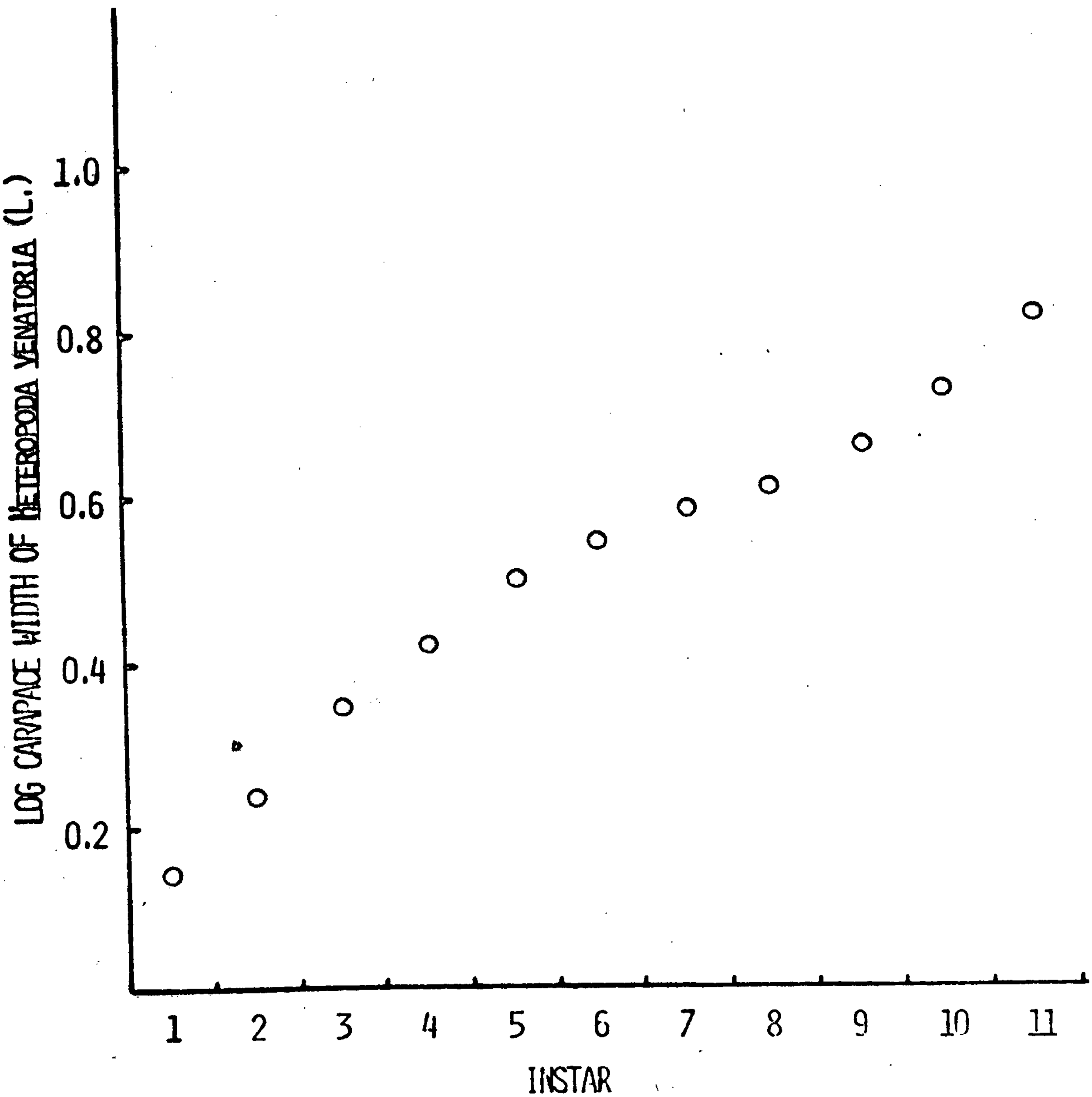
Table 1. Carapace width and duration of stadia in laboratory-reared *Heteropoda venatoria* (L.).

Instar	Carapace width (mm)	n	S.D.	Duration of stadium (days)	n	S.D.
1st	1.37	10	0.06	11.80	44	1.56
2nd	1.69	32	0.08	14.68	40	1.33
3rd	2.20	27	0.13	26.32	37	5.28
4th	2.60	22	0.16	27.97	30	4.21
5th	3.10	41	0.26	28.52	31	5.67
6th	3.44	38	0.21	36.11	37	5.41
7th	3.79	39	0.16	36.42	33	6.60
8th	4.06	39	0.29	44.46	28	10.56
9th	4.53	43	0.57	40.69	26	16.63
10th	5.36	43	0.55	35.48	23	12.57
11th	6.67	33	0.71	28.11	9	6.57
12th	--	-	--	23.0	4	7.83

Figure 1. Relationship between logarithm of carapace width and stadia for laboratory-reared Heteropoda venatoria (L.).



THE LIFE HISTORY OF TRACHELAS SIMILIS F. O. P.-CAMBRIDGE

Clubionid spiders or sac spiders are abundant components of the spider fauna in most temperate agricultural systems. Members of the genera Chiracanthium, Clubiona, and Trachelas, can often be found in relatively large numbers in pastures, alfalfa fields, citrus groves and other habitats with reasonably stable conditions. The genus Trachelas was revised by Platnick and Shadab (1974a, b) and contains 49 species from North and Central America and the West Indies. Three of the species, in 3 species groups, are found in Florida citrus groves. These are T. volutus Gertsch, T. similis F. O. P.-Cambridge, and T. deceptus (Banks) (Mansour, et al., 1982). Of these T. similis is the most abundant. In addition to their possible importance as predators, Trachelas spp. have been known to cause envenomization in humans (Platnick and Shadab, 1974a), although this has not yet been recorded in the case of T. similis. Platnick and Shadab (1975a) note that adults have been taken year round and have also been collected on camellias, avocados, cherry laural, citrus and Spanish moss in flood-plain forest, in litter and by beating shrubs. We present here data on the life history of T. similis obtained from laboratory reared samples.

METHODS AND MATERIALS

Eggs were obtained from females shaken from citrus tree limbs onto a cloth near Forest City, Seminole Co., Fa. Records were kept on molts, deaths and escapes. Spiderlings from egg sacs constructed by 4 females were used to replace those that escaped or died in early instars. Immature spiders, through about the 4th or 5th instar, were housed in glass Tygon^{R} tubing after a method described by Peck and Whitcomb (1967). Cotton swabs, clipped from the wooden stick were inserted into each end of the smaller tubes. Tygon^{R} tubes were closed at both ends with foam culture tube stoppers. Moisture was supplied by dipping one of the ends into water 2-3 times a week. Prey items were introduced through the removable swab end of the tube. Tubes were cleaned with moistened cotton swabs.

First instar *T. similis* were fed 1st and 2nd instar cabbage looper larvae (*Trichopleusia ni* (Hubner) exclusively until the spiders were approximate in size to vestigial winged *Drosophila melanogaster* Meigen, which were then utilized for food. The fruit flies were aspirated 2-4 at a time into the rearing tubes. The diet was further varied with *Tenebrio* sp. beetle larvae and later housefly pupa (*Musca domestica* (1.). Spiderling tubes were stacked into layers in 1.9 1 plastic containers. Ventilation was provided through an opening cut into the covers.

Earlier instars were maintained in a laboratory room and later placed in an environmental growth chamber. The temperature in the laboratory was maintained at $24^{\circ}C \pm 2^{\circ}$ during the winter and $27^{\circ}C \pm 2^{\circ}$ in summer. The spiders were kept on a 13:11 L:D light schedule following advice from Susan E. Riechert. Penultimate and mature spiders were maintained in the growth chamber at a constant $26.7^{\circ}C$ and 13:11 L:D lighting schedule. Relative humidity in the chamber was 60-70%, controlled by a supersaturated NaCl bath partially filled with pebble-sized rocks to increase surface area for moisture exchange (Winston and Bates, 1960).

Plastic petri dishes were used for matings. The dishes were modified to minimize escapes during the introduction by inserting sections of 13 mm Tygon[R] flexible plastic tubing through holes in the vertical walls of the dishes. The tubing was then closed with a dry foam stopper. Spiders were introduced through the tube and into the dish.

Egg size and carapace width measurements were made through a binocular microscope with a calibrated ocular micrometer. Carapace width was recorded at the widest possible distance across the cephalothorax.

RESULTS AND DISCUSSION

Trachelas similis produced 25 spiderlings per egg sac in the laboratory (n=20, S.D. = 7.3). Field captured specimens produced 27.9 spiderlings per egg sac (n=32, S.D. = 13.9). In constructing an egg sac, the female first layed down a circular mat of silk with figure-eight movements of her abdomen. Then, with a zigzag motion, radial chords of silk were constructed. These alternated with brief bouts of figure-eight silking on previously constructed base silk. The actual egg laying was not observed, but the female was seen finishing construction by silking over the completed egg sac. The process was started at about 7:00 A.M. and completed 6 h later. Eggs reached post-embryonic stages 10 days after oviposition (n = 3).and the first true molt occurred 16-20 days after oviposition (n = 3). Emergence from the sac occurred 24.4 days after egg sac construction (n = 33, S.D. = 4.11). The durations of the various stadia are shown in Table 1. Males took, on the average, 9 days less than females to reach maturity, but had the same number of instars (5). This is not unusual as the males and females were of similar size, based on carapace width measurements (Table 1).

Survival to adulthood in all cases was 95%. Moisture was the most critical during the first few weeks of spiderling development. Total time from egg to adult averaged 141.5 days for males and 150.5 days for females. Peck and Whitcomb (1970) found that the clubionid Chiracanthium inclusum (Hentz) had 4-10 instars, but males often had the same number as females. The period from to egg to maturity for C. inclusum averaged 118.8 days (S.D. = 47.2). A comparison between instar and the log of carapace width for T. similis (Fig. 1) shows a simple linear relationship, as found in other spiders (See Hagstrum 1971).

More than 45 matings occurred in the laboratory during the current study, some females copulating on successive occasions with separate males. At least 20 viable egg sacs were produced from these. In at least one case a female produced a second egg sac. Males were occasionally cannibalized by the females.

Table 1. Carapace width and duration of stadia in laboratory reared <u>Trachelas</u> <u>similis</u> F. O. P.-Cambridge

Instar	Carapace Width (mm)						Duration of stadium (days)					
	Male	n	S.D.	Female	n	S.D.	Male	n	S.D.	Female	n	S.D.
1st*	0.69	7	0.03	0.69	7	0.03	17.3	9	6.2	26.6	20	26.0
2nd	0.87	9	0.06	0.98	22	0.12	18.9	10	5.4	20.9	15	4.1
3rd	1.29	12	0.11	1.29	17	0.11	22.3	6	10.9	18.6	13	5.1
4th	1.62	12	0.13	1.62	20	0.19	28.0	6	4.8	31.1	10	6.0
5th	2.21	5	0.15	2.31	12	0.11	30.6	8	4.8	28.9	11	6.0
Adult	2.61	11	0.25	2.66	22	0.17	—	-	-	—	-	-
Total time from emergence to adult							117.1			126.1		

*From emergence from egg sac.

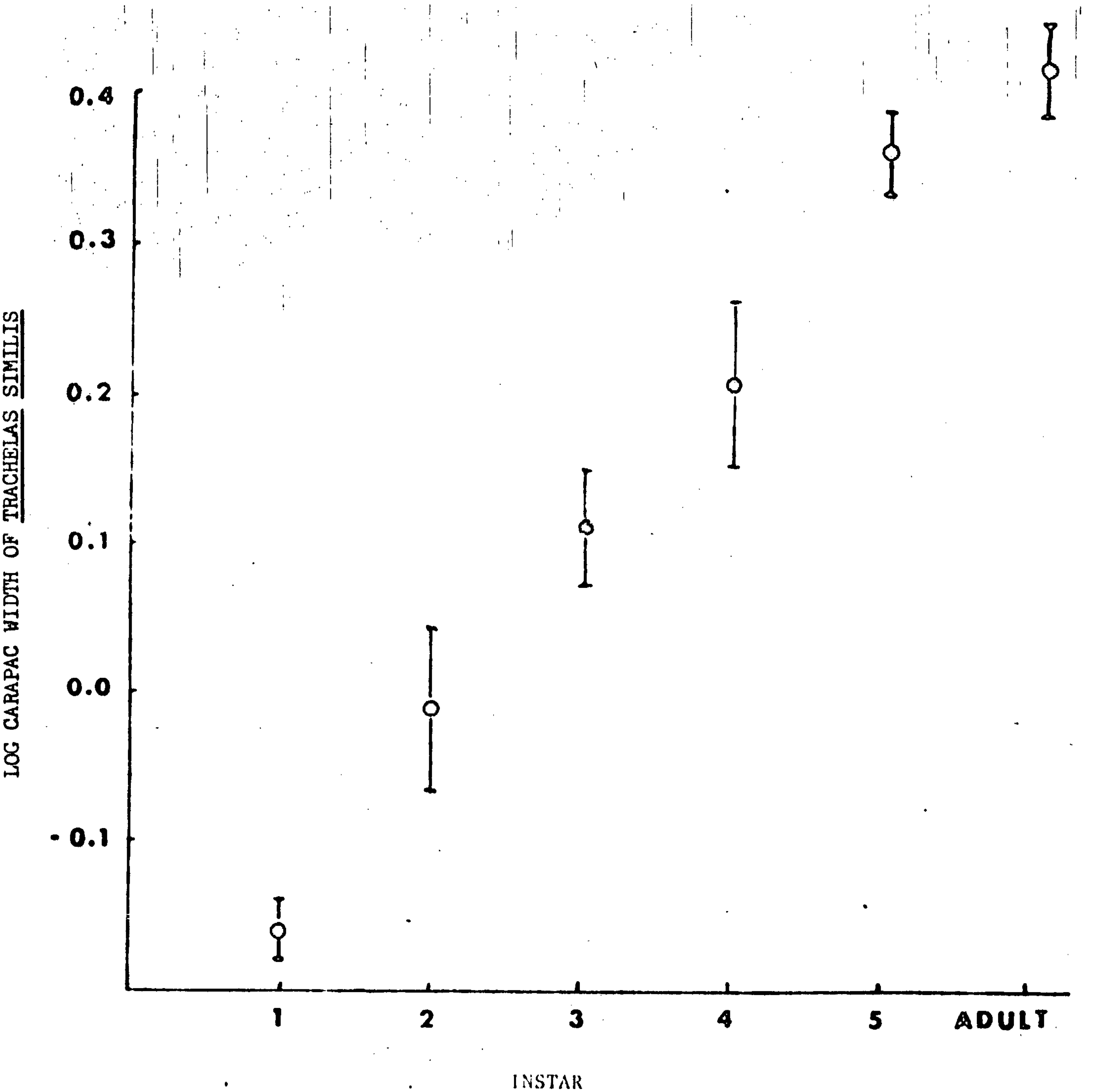


Figure 1. Relationship between logarithm of carapace width and stadia for laboratory-reared Trachelas similis F. O. P.-Cambridge.

ASPECTS OF THE LIFE HISTORY AND REPRODUCTION OF THE WOLF SPIDER, Lycosa lenta Hentz.

During the period of grant research, seasonal phenology and aspects of the reproductive biology of Lycosa lenta were studied.

L. lenta is present in the Gainesville area as adults throughout the year. In the spring, parous females, 8-9th-instar, and 3-4th-instar spiderlings appear. The adult females appearing in the Spring have mated the previous year (only 2 of 100 sampled were willing to mate in the Spring, and the rest all oviposited), oviposited once or twice, and subsequently overposit again in the Spring. 8th-9th-instar spiderlings mature by June, and initial ovipositions by this cohort occur in July and September, later ones in Spring of the following year. 2nd-3rd-instar spiderlings appearing in Spring overwinter as 8th-9th-instars.

Maturation of the gonads occurs in the prepenultimate instar in both sexes, when they take their final form. Spermatogonial and Oogonial mitotic proliferation in the gonads occurs at the beginning of the penultimate instar, and gonial enlargement occurs with feeding. Meioses were not observed in females, but apparently occurred near the middle of the penultimate instar, since resting-stage oocytes with partially developed yolk masses were apparent at that time. Meioses were observed in males near the middle penultimate. Divisions began distally to proximally and peripherally to luminally in the testes. Mature spermatids first appeared distally, and later moved through the lumina to the proximal vasa deferentia. Both sexes are semelgenic and iteroparous. Apparent corpora lutea were present in the ovaries of parous females, with very thick, wrinkled, brownish (in polychrome stains) empty sacs, and were present in the approximate ratios to oocytes of 0:3, 1:2, and 2:1 in serial section counts, with totals of oocytes plus corpora lutea counted averaging about 900 (n=13 observations).

Copulation and courtship are similar to other wolf spiders described. However, where others have been reported to make multiple palpal insertions per epigynal side before switching, L. lenta males make only one palpal insertion and hematodochal expansion per side before switching. They alternate an average of 3-4 switches per minute, with always only one insertion per side. Mating averages approximately 7 minutes (range for successful matings 2.5-21.5 min.).

First oviposition in well-fed females averaged 21 days (10-44 days) after mating (n=63) observations). Mean number of eggs for first oviposition (n=63) was 274, for second oviposition (n=11, data incomplete) 256, with fertility well over 99% for both ovipositions. Average weight of eggs for first oviposition (n=19) was 0.00135, for second oviposition (n=3) 0.00139 (mu 1 = mu 2). Both average egg weight and fecundity were equally correlated with female size expressed as the product of carapace width vs. length at the 0.53 level, and in the regressions, Beta was not equal to 0. Coefficient of determinations were approximately 27%. It is expected that this will be higher as egg weights and numbers are correlated with female preovipositional weight (work still in progress).

Three males were observed to make sperm webs after mating, all built on the substrate surface, from 2½ to 48 hours after mating. Several males successfully fertilized 4 females, and one male which successfully mated with eight females before dying fertilized five of them. The last two have not produced eggs. While males will willingly attempt to mate 24 hours or less after moulting to adult, females require a period of feeding and maturation of their eggs to the resting stage before becoming receptive to mating. Before this time they are attractive to males, but do not make the body movements in courtship characteristic of receptive females, i.e., tail wigwig with deposition of scented silk, male-approaching movements with receptive leg gestures.

MORTALITY (574 total from oviposition)

Instar	No. Dead	% mortality
PE	213	62.9
1	162	55.1
2	94	47.2
3	12	11.4
4	2	2.1
5	2	2.2
6	4	5.3
7	0	0.0

Note: Overall & survival from oviposition to maturity - 14.8%

MATURITY

Instar	No. mature	Males	Females
4	1	1	0
5	12	10	2
6	25	8	17
7	44	8	36
8	3	0	3

Total Mature: 27 males (31.8%)
58 females (68.2%)

Table 1 Comparison of stadium duration for laboratory-reared male and female *Corythalia canosa*. Gainesville, Florida, 1981-1983.

Stadium	No. of individuals ♂	No. of individuals ♀	No. of days ♂ Range	No. of days ♂ Average	No. of days ♀ Range	No. of days ♀ Average	Average for both
Oviposition to 1st Post Embryo	27	55	7-11	8.3 ± 1.0	6-13	8.2 ± 1.2	8.3 ± 1.2
2nd PE	27	55	9-12	10.6 ± 0.6	8-13	10.7 ± 1.1	10.7 ± 0.9
1	27	63	17-31	23.8 ± 3.4	16-47	25.3 ± 5.4	24.8 ± 4.9
2	27	63	9-27	17.9 ± 4.7	11-34	18.6 ± 5.3	18.4 ± 5.1
3	27	63	12-23	16.7 ± 3.1	9-36	17.9 ± 5.3	17.5 ± 4.7
4[a]	26	63	13-66	21.6 ± 9.7	5-51	19.6 ± 6.5	20.2 ± 7.6
5	16	61	16-36	25.2 ± 6.2	18-48	27.4 ± 6.2	27.0 ± 6.3
6	7	40	24-38	30.3 ± 5.3	21-102	33.7 ± 16.1	33.2 ± 15.0
7	3	0	---	---	31-51	40.3 ± 8.2	---
8	All mature		---	---	---	---	---

[a] Maturity reached by some specimens

CARAPACE MEASUREMENTS IN mm

STAGE	INSTAR	GROUP	# INDIVIDUALS	RANGE	MEDIAN	MODE	AVERAGE	σ^2	σ
EARLY	2	ALL	189	0.28(0.63-0.91)	0.81	0.81	0.80	0.002	0.046
EARLY	2	♀	54	0.18(0.71-0.89)	0.81	0.81	0.81	0.001	0.038
EARLY	2	♂	27	0.28(0.63-0.91)	0.81	0.84	0.81	0.004	0.062
LATE	2	ALL	97	0.31(0.76-1.07)	0.86	0.86	0.87	0.003	0.055
LATE	2	♀	56	0.31(0.76-1.07)	0.86	0.84	0.87	0.004	0.061
LATE	2	♂	26	0.21(0.76-0.97)	0.89	0.89	0.87	0.002	0.049
EARLY	3	ALL	99	0.30(0.84-1.14)	0.94	0.94	0.95	0.004	0.060
EARLY	3	♀	55	0.30(0.84-1.14)	0.94	0.94	0.96	0.003	0.058
EARLY	3	♂	27	0.30(0.84-1.14)	0.97	0.97	0.97	0.003	0.058
LATE	3	ALL	87	0.43(0.84-1.27)	0.99	1.02	1.02	0.006	0.076
LATE	3	♀	54	0.43(0.84-1.27)	0.99	0.99	1.02	0.007	0.083
LATE	3	♂	27	0.23(0.91-1.14)	1.03	1.02	1.02	0.004	0.063
EARLY	4	ALL	90	0.48(0.99-1.47)	1.14	1.17	1.14	0.008	0.090
EARLY	4	♀	57	0.48(0.99-1.47)	1.14	1.17	1.14	0.009	0.097
EARLY	4	♂	28	0.36(0.99-1.35)	1.14	1.14	1.15	0.006	0.077
LATE	4	ALL	89	0.46(1.04-1.50)	1.19	1.19	1.19	0.011	0.105
LATE	4	♀	56	0.46(1.04-1.50)	1.18	1.19 & 1.22	1.19	0.013	0.114
LATE	4	♂	30	0.36(1.04-1.40)	1.19	1.17	1.19	0.008	0.091

CARAPACE MEASUREMENTS IN mm

STAGE	INSTAR	GROUP	# INDIVIDUALS	RANGE	MEDIAN	MODE	AVERAGE	σ^2	σ
EARLY	5	ALL	89	0.54(1.14-1.68)	1.32	1.32	1.34	0.012	0.108
EARLY	5	♀	59	0.54(1.14-1.68)	1.32	1.37	1.34	0.013	0.116
EARLY	5	♂	28	0.38(1.19-1.57)	1.32	1.32	1.35	0.009	0.094
LATE	5	ALL	82	0.59(1.14-1.73)	1.37	1.40	1.38	0.010	0.100
LATE	5	♀	57	0.59(1.14-1.73)	1.37	1.40	1.38	0.011	0.107
LATE	5	♂	22	0.36(1.24-1.60)	1.38	--	1.38	0.007	0.086
EARLY	6	ALL	73	0.60(1.30-1.90)	1.55	1.57	1.54	0.013	0.113
EARLY	6	♀	56	0.60(1.30-1.90)	1.57	1.57	1.55	0.012	0.111
EARLY	6	♂	16	0.40(1.35-1.75)	1.47	1.47 & 1.57	1.50	0.013	0.113
LATE	6	ALL	50	0.55(1.35-1.90)	1.55	1.57	1.54	0.008	0.093
LATE	6	♀	38	0.55(1.35-1.90)	1.55	1.57	1.55	0.010	0.098
LATE	6	♂	12	0.17(1.40-1.57)	1.47	1.45	1.50	0.003	0.053
EARLY	7	ALL	46	0.43(1.45-1.88)	1.70	1.73	1.70	0.010	0.101
EARLY	7	♀	39	0.43(1.45-1.88)	1.70	1.75	1.70	0.011	0.104
EARLY	7	♂	7	0.28(1.57-1.85)	1.65	1.73	1.69	0.007	0.083

[a] Includes those specimens which reached maturity plus those specimens which died during development at various stages.

Table Days required to reach maturity, calculated from oviposition date for reared *Corythalia canosa*, Gainesville, Florida, December 1981 to April 1983.

Male			Female		
Days required	No. of instars	Month of maturity	Days required	No. of instars	Month of maturity
79	4	OCT.	111	6	NOV.
95	5	AUG.	112	6	JUN.
95	5	NOV.	112	7	DEC.
95	5	AUG.	113	5	NOV.
96	5	AUG.	114	6	NOV.
98	5	AUG.	114	6	DEC.
102	5	OCT.	115	6	AUG.
104	5	NOV.	115	6	SEPT.
108	5	OCT.	124	6	DEC.
108	5	NOV.	125	6	NOV.
111	6	NOV.	126	6	NOV.
115	6	JAN.	131	6	NOV.
119	6	NOV.	132	6	NOV.
120	6	SEPT.	132	6	DEC.
122	6	JUL.	135	7	NOV.
128	6	AUG.	135	6	JUL.
131	6	NOV.	136	7	OCT.
131	6	NOV.	136	5	NOV.
135	7	NOV.	138	7	NOV.
137	7	DEC.	138	7	OCT.
137	5	FEB.	139	6	NOV.
145	6	NOV.	140	6	FEB.
151	7	NOV.	142	7	DEC.
153	7	JAN.	145	7	NOV.
155	7	OCT.	145	7	JAN.
166	5	MAY	146	7	OCT.
176	7	FEB.	146	7	DEC.
182	7	JAN.	147	7	DEC.
185	7	NOV.	148	7	DEC.
			149	7	OCT.
			150	7	DEC.
			150	7	DEC.
			152	7	DEC.
			154	7	NOV.
			154	7	NOV.
			156	7	DEC.
			158	7	DEC.
			158	7	JAN.
			162	7	FEB.
			164	7	JUL.
			166	7	NOV.
			166	7	OCT.
			169	7	DEC.
			170	7	OCT.
			171	7	JAN.
			171	7	OCT.
			172	6	JAN.
			174	7	NOV.
			175	7	FEB.

FEMALE

Days required	No. of instars	Month of maturity
182	7	MAR.
183	8	OCT.
184	6	AUG.
186	7	FEB.
193	8	JAN.
250	7	DEC.
266	8	APR.

INSTAR DURATION OF LABORATORY REARED CORYTHALIA CANOSA

Instar	No. of individuals	No. of days						
		Min.	Max.	Median	Average	Mode	σ^2	σ
1	199	14	47	24	24.5	21 & 26	23.58	4.85
2	105	9	34	17	18.5	16	25.26	5.03
3	93	9	37	16	17.9	16	25.80	5.08
4	90	5	35	19	19.4	18	24.10	4.90
5	76	16	48	26	26.8	22 & 23	38.43	6.20
6	47	22	102	30	35.5	27	35.50	5.96
7	3	32	50	39	40.3	-	40.33	6.35

OVERALL NO. OF DAYS FROM OVIPOSITION TO MATURITY

ALL

# Individuals to maturity	86
$\bar{x}$	143.45
σ^2	986.36
σ	31.4
mode	NONE
median	141
range	187 (79-266)

♀

#0	57
$\bar{x}$	151.9
σ^2	881.1
σ	29.7
mode	NONE
median	148
range	155 (111-266)

♂

#0's	29
$\bar{x}$	126.9
σ^2	777.9
σ	27.9
mode	NONE
median	122
range	106 (79-185)

MEASUREMENTS (mm)

	Mean	0^2	0	No. of individuals	Range
egg[a]	1.05	0.0003	0.018	100	
Carapace Measurements of field-collected Adults (mm)					
♂	1.64	0.0080	0.089	10	1.47-1.78
♀	1.80	0.0160	0.126	10	1.57-2.03
Carapace Measurements of lab-reared adults					
♂	1.53	0.0148	0.122	10	1.37-1.75
♀	1.69	0.0086	0.093	10	1.52-1.83

[a] Diameter measured same day as oviposition.

Table Comparison of carapace width of male and female in each late instar of Corythalia canosa, Gainesville, Florida, 1981-1983 (first instar excluded) (measurements taken in late instar).

Instar	Number of Individuals ♂	Number of Individuals ♀	Average width in mm ♂ (σ)	Average width in mm ♀ (σ)	Average width in mm Both (σ)	Range for both
2	27	54	0.87 (0.05)	0.86 (0.04)	0.86 (0.04)	0.26 (0.76-1.02)
3	27	56	1.02 (0.06)	1.02 (0.08)	1.02 (0.08)	0.38 (0.86-1.27)
4	28	58	1.20 (0.08)	1.19 (0.10)	1.19 (0.10)	0.48 (1.02-1.50)
5	29	59	1.39 (0.08)	1.38 (0.12)	1.38 (0.11)	0.59 (1.14-1.73)
6[a]	17	57	1.53 (0.09)	1.57 (0.09)	1.56 (0.09)	0.55 (1.35-1.90)
7	8	38	1.67 (0.07)	1.70 (0.09)	1.70 (0.09)	0.36 (1.52-1.88)
8	1	4	1.85 (0.00)	1.76 (0.10)	1.78 (0.10)	0.30 (1.60-1.90)

[a] Maturity reached by some individuals.

DURATION OF EARLY STAGE DEVELOPMENT

IN DAYS

# Individuals	Range	Average	Median	Mode	σ^2	σ
Oviposition to 1st PE:						
191	6(6-12)	7.78	7	7	1.22	1.10
Oviposition to 2nd PE:						
325	7(7-14)	8.58	8	8	2.05	1.43
Oviposition to 1st instar:						
309	12(14-26)	19.04	19	19	2.71	1.65
1st PE to 2nd PE:						
172	1(1-2)	1.12	1	1	0.10	0.32

SPIDERS IN SPRAYED AND UNSPRAYED COTTON FIELDS IN ISRAEL AND THEIR ROLE AS BIOCONTROL AGENTS.

INTRODUCTION

Several pest insects damage cotton in Israel. Crop protection results from the maintenance of these pests below damaging levels usually by the use of insecticides. The widespread use of chemicals on cotton was associated with a score of new problems including the resurgence of some pests. Such a phenomenon may be explained, at least in part, by assuming that the widespread use of insecticides has affected the parasites and predators which were responsible for generally keeping the populations of the above pests below the economic level.

In cotton fields there is a broad range of predatory arthropods, which may contribute to pest suppression. Spiders are included in this range, but in Israel there is no information about their feeding behavior and effectiveness as predators.

This study was aimed at establishing and comparing the composition and abundance of spiders found in cotton fields in two regions in Israel and evaluating their role as biocontrol agents especially for *Spodoptera littoralis* larvae.

MATERIALS AND METHODS

Sampling of Spiders

Three cotton fields were sampled:

1. An unsprayed field at Newe-Ya'ar, 1981.
2. A commercial field at Newe-Ya'ar during 1981 and 1982 - 500 meters distant from above.
3. A commercial field at Moshav Noov in the Golan Heights.

Visual samples of one meter of row were taken. After the whole plant was examined, the ground cloth was used for sampling the same plants. A white vulcanized cloth (1 by 1m) was rolled out in the furrow between two rows, without disturbing the plants, after which the plants were shaken vigorously. All spiders that fell onto the cloth were collected and preserved in 70% ethyl alcohol for identification in the laboratory. Ten such 1 m samples were taken at random once a week throughout the season. All sampling was conducted between 07:00 and 10:00 h. Pitfall traps used to sample ground dwelling spiders were examined once a week. Ethylene glycol was used in the five pitfall traps that were maintained throughout the growing season. The traps consisted of uncovered half liter plastic buckets. In 1981 pitfall traps were randomly placed in the unsprayed cotton field and in 1982 in the commercial field at Newe-Ya'ar. Traps were placed about 5 meters from the edge of the field and then every five rows forming a diagonal line across the field. Taxonomic determination for all spiders specimens were conducted in the laboratory of Dr. G. Levy at the Hebrew University of Jerusalem. Spiders were identified to species when possible. Because of the serious difficulties in identifying spiders in this part of the world, we are obliged to be satisfied with identification to families. Total numbers of spiders counted in all sampling methods were used to determine the percentage of the more abundant families.

List of Pesticide Applications

Newe-Ya'ar - Commercial 1981		Newe-Ya'ar - Commercial 1982		Noov - Commercial 1981	
Pesticide	Date of Spray	Pesticide	Date of Spray	Pesticide	Date of Spray
Thionex	5. 6.81	Thionex (endosulfan)	5.6.82	Thionex	3.8.81
Thionex	15. 7.81	Thionex	27.6.82	Thionex	17.8.81
Nuavacron + Parathion	22. 7.81	Parathion + Actellic	12.8.82	Actellic	25.8.81
Actellic + Parathion	17. 8.81	Nuvacron + Actellic	23.8.82	Actellic	2.9.81
Actellic + Parathion	24. 8.81	Cymbush + Parathion	30.8.82	Actellic	11.9.81
Actellic + Parathion	31. 8.81	Cymbush + Parathion + Aqmatrin	7.9.82	Actellic	22.9.81
Actellic + Parathion	7. 9.81	Parathion + Actellic	12.9.82		
Actellic + Parathion	14. 9.81	Parathion + Cymbush	25.9.82		
Thionex + Parathion	5.10.81				

Evaluation of the role of spiders.

a. Spider population in comparison to noxious insects:

During 1982, the Newe-Ya'ar commercial field was again planted to cotton (same variety) and sampled for spider population and noxious insects by the same means and procedure described above.

Tests were conducted in the laboratory to determine which of the noxious insects collected in this cotton field serve as prey for the spiders. Those spiders which were found to be most abundant were caged in plastic containers with cotton pests. Insects which were eaten within 24 h were considered to be potential prey (aphids, Egyptian cotton leafworm, Heliothis spp., leafhoppers, spider mites).

Elimination Experiment.

In the unsprayed cotton field, eight healthy cotton plants were picked in random. Two plants were taken off from the two sides of each plant of the experiment in order to prevent contact between them and between other adjacent plants. Only spiders were carefully eliminated from 4 plants by the means mentioned above. Other arthropods were returned to the same plants. On the other 4 experimental plants, the spider fauna was left undisturbed. Four egg masses of the Egyptian cotton leafworm, Spodoptera littoralis containing 350-500 eggs 3 days old which were laid in the laboratory upon pieces of paper were attached with pins to the underside of 4 leaves at different heights in each of the 8 plants. All the experimental plants were caged with clothing bags 60 cm in diameter for 5 days. To indicate the fate of these egg masses the following parameters were examined and evaluated on a scale of 0-4:

a. Number of larvae: a measure of the number of larvae upon the leaf (0 = no larvae present; 1 = 1-5; 2 = 5-10; 3 = 10-20; 4 = >20 larvae present).

b. Damage of leaf: a measure of the feeding of the larvae on the leaf (0 = no damage to leaf; 4 = entire leaf surface nibbled by hatched larvae).

RESULTS AND DISCUSSION

Population level

The population trends for total spiders in three cotton fields for 1981 are shown in Fig. 1. In the unsprayed cotton field, the spider populations increased sharply from the beginning of the season to a peak in mid-July (an average of 14 spiders/meter). A second peak was observed in September (19.2 spiders/meter) after which the population decreased to 6.5 spiders/meter. The population dropped rapidly, thereafter, when the cotton plants reached maturation.

In the commercial fields at Newe-Ya'ar in the two subsequent years of the study, 1981, 1982, the fluctuation of spider population is nearly equal (Fig. 2). The spider population increased sharply to a peak in July (15 spiders/meter in 1981 and 13 spiders/meter in 1982). The population dropped sharply thereafter with the intensive pesticidal treatments. It can be seen that when the interval between application was relatively long enough the spider population began to rise.

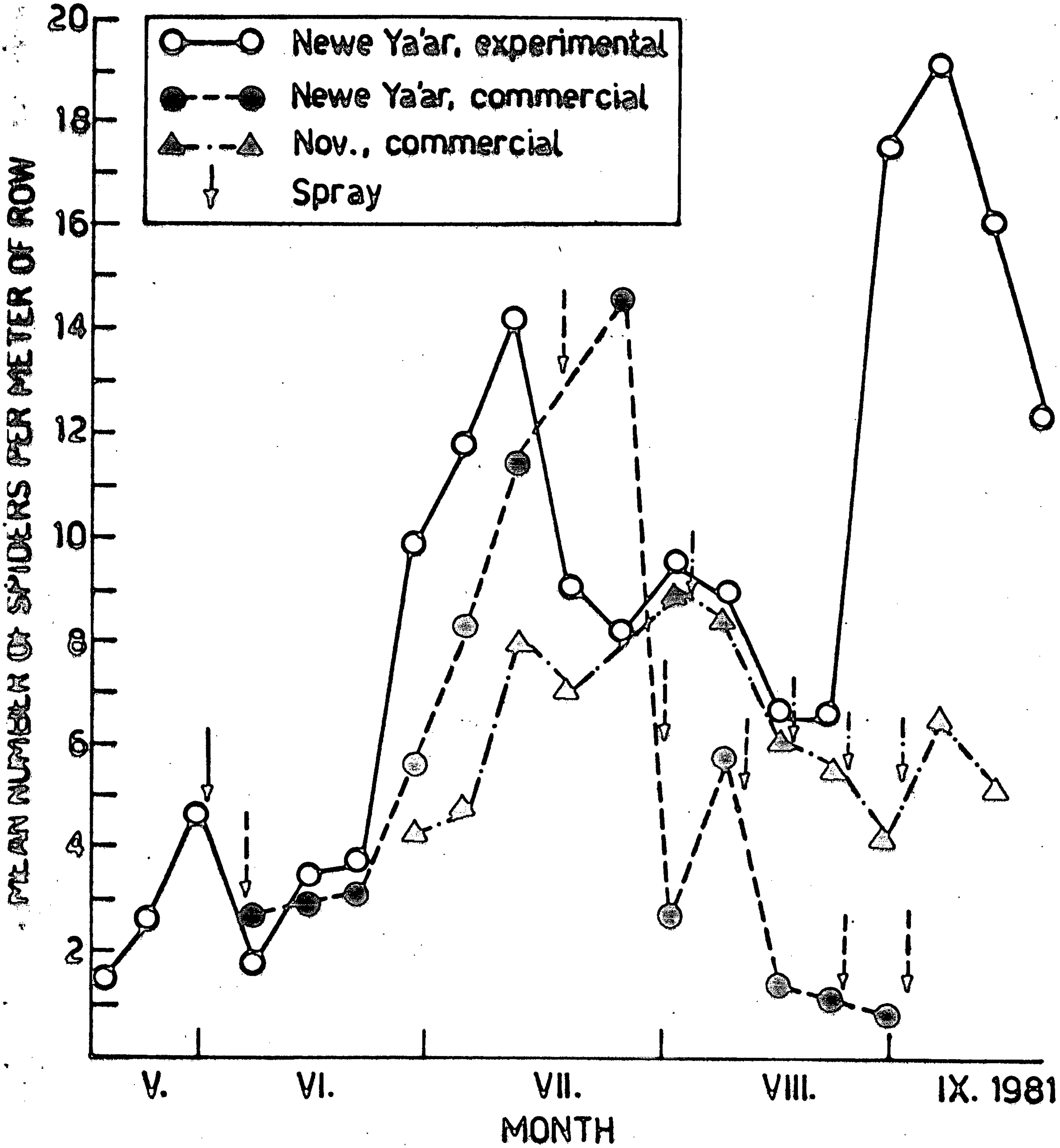
In general the same situation was observed in the cotton fields at Moshav Noov (Fig. 1) the population began to increase and peaked at the end of July (9 spider/m) and thereafter dropped with the intensive applications of pesticides.

Spiders that were captured in pitfall traps both in sprayed and unsprayed cotton fields at Newe-Ya'ar are given in Table 3. There were no differences between these two fields in regard to average spiders that had been captured weekly in each pitfall trap.

Population composition

A record of spider families found on cotton fields is given in Table 1. Total numbers collected and percent of total spiders and mean weekly by numbers of row are given in Table 2. Representatives of the families Dysderidae, Oecobiidae, Pholcidae, Zodariidae were found in very small numbers in the unsprayed cotton field only. Very few spiders (together only about 1%) of the family Mimetidae were found only in the commercial field in 1981 and 1982 at Newe-Ya'ar. One spider of the family Pisauridae was found in the unsprayed field and three were found in the commercial field in 1982.

Fig. 1. Seasonal and relative abundance of spiders from commercial and unsprayed cotton fields, 1981.



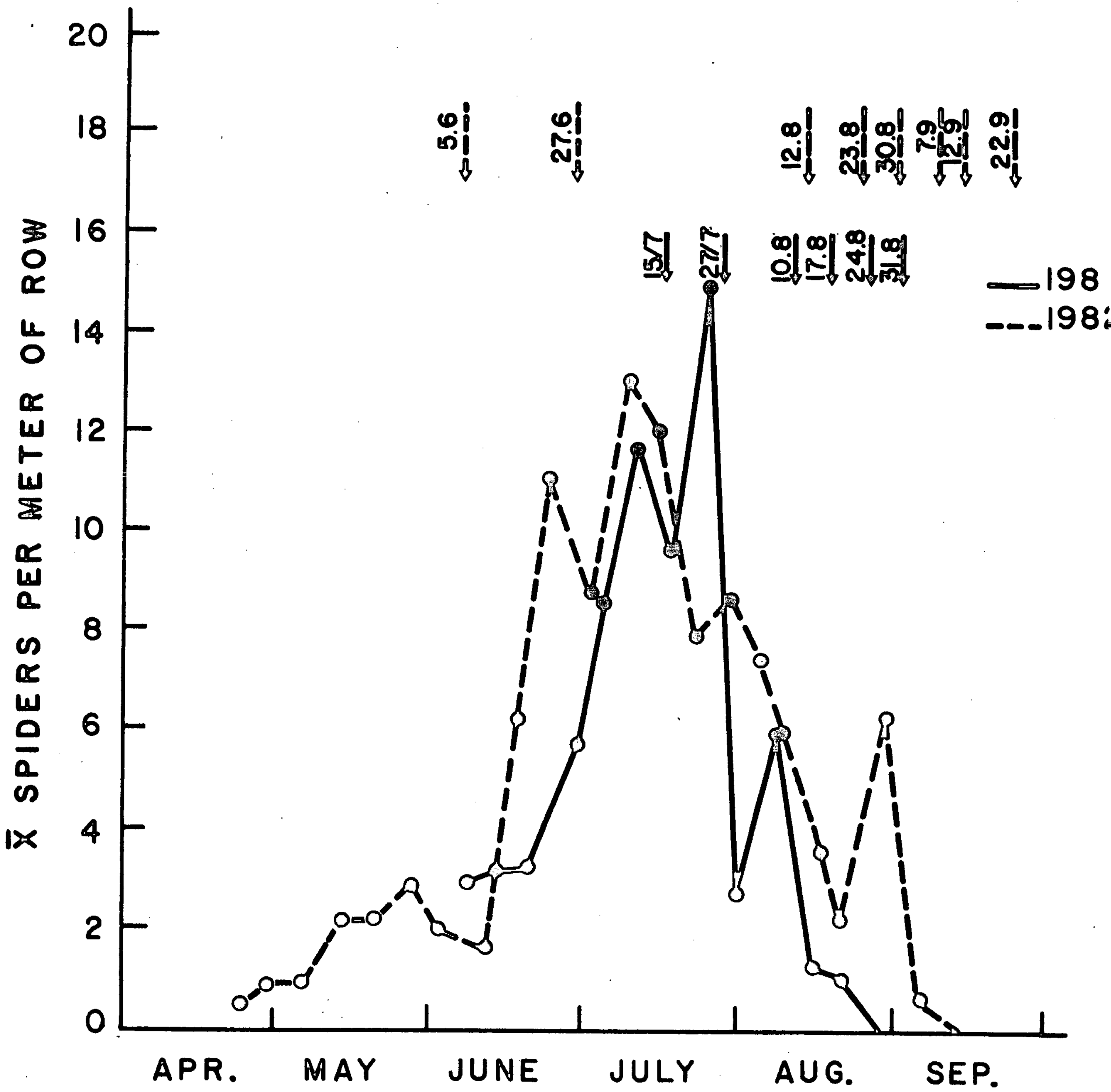


Fig. 2. Seasonal and relative abundance of spiders from commercial cotton field at Newe-Yaar. Arrows denote pesticidal application.

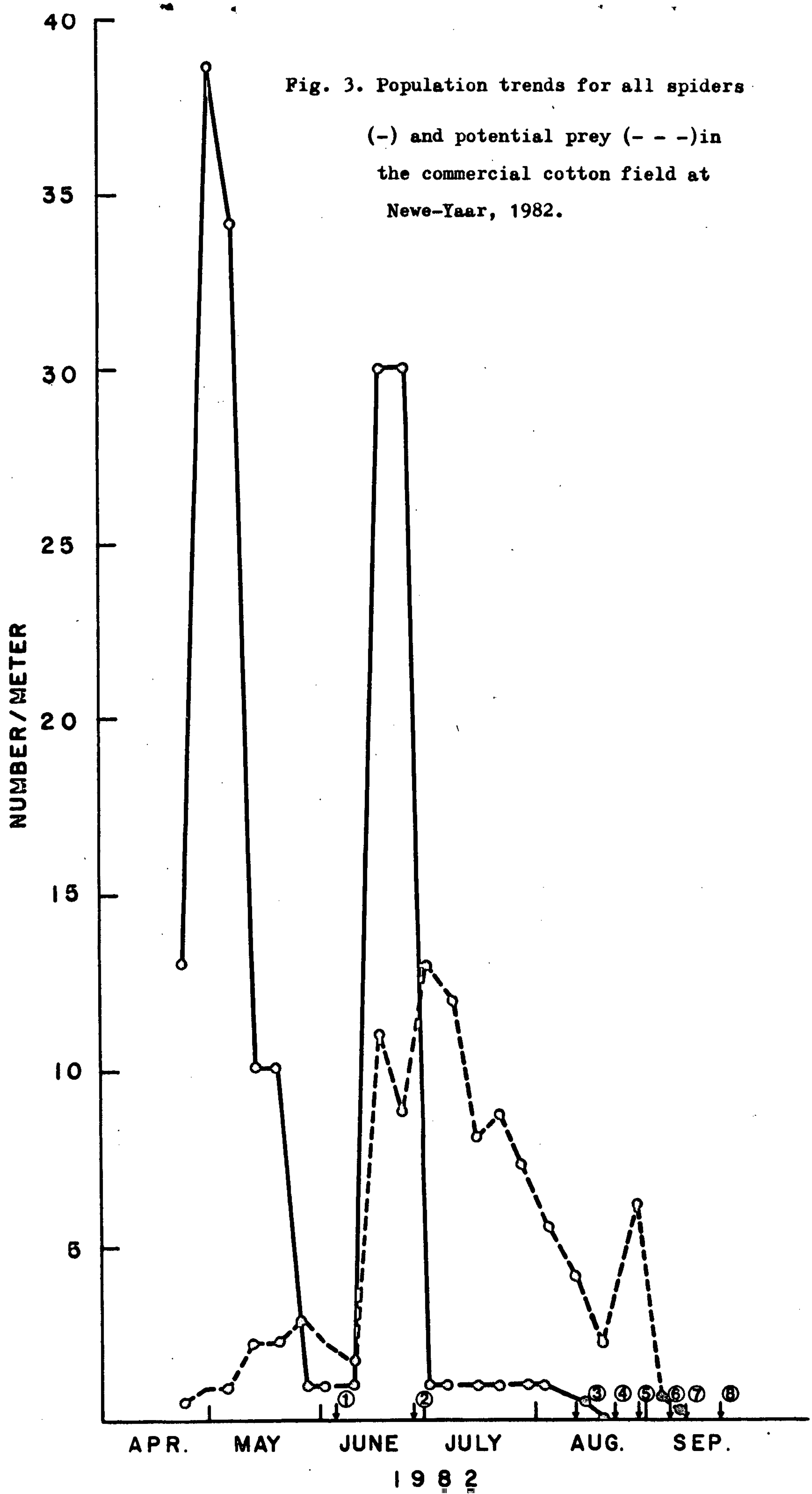


Fig. 3. Population trends for all spiders (-) and potential prey (- - -) in the commercial cotton field at Newe-Yaar, 1982.

In the unsprayed field Chiracanthium mildei represented early in the season 61 to 78% and later 22-46% of the total spiders in each weekly sample and 35.8% for the whole season. The Clubionids with the Philodromids represented 51% for the whole season. Dictynids, Gnaphosids and Theridiids represented about 8% each and they began to appear in high numbers during the middle of July; 10% to 20% of the total spiders in each weekly sample.

In the sprayed field in 1981, Clubionidae, Gnaphosidae and Philodromidae represented nearly equal percentage 22.9%, 21.2%, 20.4% respectively for the whole season. In 1982 these families represented 5.5%, 26.6%, 26.3% respectively. The Clubionids declined while the Gnaphosids and Philodromids increased. In the commercial field at Noov the dominant spiders were philodromids which represented 57.28%. In regard to spiders dwelling in the field ground, in the sprayed field, three families, Lycosidae (39.25%), Philodromidae (27.75%) and Gnaphosidae (23%) represented 90% of the whole spider population while in the unsprayed field these families represented 52%. The family Zodaridae, which represented 5.25%, was not present in the sprayed field. Two to three spiders of the families Clubionidae, Oxyopidae, Dysderidae were captured only in the unsprayed field.

Role of spiders as biocontrol agents.

a. Spider population in comparison to noxious insects as potential prey

The population trends for total spiders and their potential prey in the commercial field at Newe-Ya'ar during 1982 are shown in Fig. 3. The potential prey are the total of those noxious insects found to serve as prey in laboratory feeding tests and include the following: Aphids, Egyptian cotton leafworm, Heliothis, leafhoppers and spider mites. It seems that there is a certain correlation between the spider population and their potential prey - the noxious insects. When the potential prey peaked to an average of 38.5/m on April 30, the spider population was about 1 spider/m and thereafter the potential prey population began to decline sharply until it reached 1/m on May 28, while the spider population increased and reached 3 spider /m on that date. Seven days later, on June 4 the noxious insects remained 1/m.

The first pesticide application was on June 5 (Thionex) aimed at aphids and leaf-hoppers. On June 11 the spider population decreased to an average of 1.6 spider/m while the potential prey remained 1/m. Six days later - June 17 - the potential prey rose very sharply to 30/m and remained as such to June 23. The spider population rose to 11 spider/m. On June 27, the second pesticide application was applied (Thionex). On July 1 the spider population peaked to 13 spider/m, the noxious insects declined sharply to 1/m and remained in this level until August 15. In the meanwhile the spider population declined gradually to an average of 2.2 spider/m and again peaked to 6.2 spider/m and thereafter dropped sharply to 0.6 spider/m within 15 days.

b. Elimination experiment

The result of this experiment is presented in Table 4. Wherever spiders were undisturbed, larvae of S. littoralis were found in very low portions 5 days after exposure. Most of the larvae disappeared the day after hatching indicating that they were preyed upon. On the 23% of the leaves in which were signs of feeding, the damage to leaves was minimal (degree) in 82% of the cases. On the other hand, on plants from which spiders were eliminated, 5 days after exposure, damage to egg masses was low and a very high portion of larvae were observed. On the 51% of leaves which were nibbled, the damage to leaves was high.

Thus, wherever spiders were eliminated, S. littoralis infestations developed unhindered and caused severe damage. This did not occur where spiders were left undisturbed upon the cotton plants. Comparison of the fate of S. littoralis infestations in the presence and absence of spiders, clearly indicates that spiders are the responsible agents for the low density of S. littoralis and for the negligible damage observed.

A record of spiders found on cotton fields in Israel.

Family	Newe-Ya'ar			Noov
	Untreated 1981	Commercial 1982	Commercial 1981	1981
ARANEIDAE	+	+	+	+
CLUBIONIDAE: Chiracanthium mildei	+	+	+	+
DICTYNIDAE	+	+	+	+
DYSDERIDAE	+	-	-	-
GNAPHOSIDAE	+	+	+	+
LINYPHIIDAE	+	+	+	+
LYCOSIDAE	+	+	+	+
MIMETIDAE	-	+	+	-
OECOBIIDAE	+	-	-	-
OXYOPIDAE	+	+	+	+
PHILODROMIDAE	+	+	+	+
PISAURIDAE	+	+	-	-
PHOLCIDAE	+	-	-	-
SALTICIDAE	+	+	+	+
THERIDIIDAE: Theridion Sp.	+	+	+	+
THERIDIIDAE: Steatoda Sp.	+	+	+	+
THOMISIDAE	+	+	+	+
ULOBORIDAE	+	+	+	+
ZODARIIDAE	+	-	-	-
UNKNOWN	+	+	-	+

Total numbers collected and percent of total spiders and Mean weekly numbers, per meter of row of the most common spider families inhabiting cotton fields at Newe-Ya'ar and Noov.

Family	Newe-Ya'ar Unsprayed 1981 Total	Newe-Ya'ar Unsprayed 1981 Percent	Newe-Ya'ar Sprayed 1981 Total	Newe-Ya'ar Sprayed 1981 Percent	Newe-Ya'ar Sprayed 1982 Total	Newe-Ya'ar Sprayed 1982 Percent	Noov Sprayed 1981 Total	Noov Sprayed 1981 Percent
ARANEIDAE	30	1.64	24	3.33	33	3.2	10	1.26
CLUBIONIDAE	652	35.8	165	22.9	56	5.5	37	4.68
DICTYNIDAE	139	7.63	42	5.84	95	9.5	18	2.28
GNAPHOSIDAE	154	8.46	153	21.2	53	5.2	42	5.32
LINYPHIIDAE	66	3.62	74	10.29	269	26.6	39	4.94
LYCOSIDAE	15	0.82	8	1.11	67	6.6	2	0.25
OXYOPIDAE	148	8.13	8	1.11	2	0.2	7	0.88
PHILODROMIDAE	276	15.16	147	20.4	267	26.3	452	57.28
SALTICIDAE	86	4.72	20	2.78	14	1.3	56	7.09
THERIDIIDAE	161	8.84	57	7.92	100	9.8	73	9.25
THOMISIDAE	74	4.06	18	2.5	37	3.6	47	5.95
OTHER SPIDERS	19	1.04	3	0.41	18	1.80	6	0.76
Total	1820	100	719	100	1011	100	789	100
Samples	19		13		20		14	
Meter of row per sample	10		10		10		10	
Spiders/meter of row/week	9.58		5.53		5.05		5.63	

3

Total numbers collected and percent of total spiders and mean weekly numbers per pitfall trap for the spiders' families inhabiting cotton fields at Newe-Ya'ar.

Family	Newe-Ya'ar - Unsprayed 1981		Newe-Ya'ar - Sprayed 1981	
	Total	Percent	Total	Percent
CLUBIONIDAE	3	0.65	-	-
DICTYNIDAE	29	6.18	27	6.75
DYSDERIDAE	2	0.40	-	-
GNAPHOSIDAE	76	15.00	92	23.00
LINYPHIIDAE	56	11.80	6	1.50
LYCOSIDAE	121	25.45	157	37.25
OXYOPIDAE	2	0.45	-	-
PHILODROMIDAE	53	11.15	111	27.75
SALTICIDAE	38	8.00	5	1.25
THERIDIIDAE	58	12.20	2	0.50
ZODARIDAE	25	5.25	-	-
UNIDENTIFIED	11	2.30	-	-
Total	476	100	400	100
Samples	15		13	
Traps per sample	5		5	
Spiders/Trap/Week	6.34		6.15	

Fate of Spodoptera lettoralis egg masses attached to the foliage of cotton plants in the presence and absence of spiders. (9.81)

5 days after exposure															
Treatment	Total fertile egg masses		Total leaves	Total damaged leaves	Number of larvae on damaged leaves					Damage to leaf				
					0[1]	1	2	3	4	0[2]	1	2	3	4
Spiders	14	Total	233	60	6	39	15	0	0	0	49	5	4	2
Present		%	100	23	10	65	25	0	0	0	82	8	7	3
Spiders	8	Total	184	93	0	10	0	47	36	0	18	31	35	9
Absent		%	100	51	0	11	0	51	38	0	19	33	38	10

1 0 = No larvae present; 1 = 1-5; 2 = 5-10; 3 = 10-20; 4 > 20.

2 0 = No signs of feeding on leaf; 4 = entire leaf surface nibbled by larvae

SPIDERS INHABITING AVOCADO ORCHARDS IN WESTERN GALILEE - ISRAEL AND THEIR ROLE AS NATURAL ENEMIES OF BOARMIA SELENARIS.

INTRODUCTION

Avocado is an important export crop of Israel. During the past few years, the giant looper, Boarmia (Ascotis) Selenaria Schiff, has increasingly injured avocado trees in Israel, especially in Western Galilee. It damages both leaves and fruits (Wysoki et al., 1975).

Since biological control had been decided upon for avocado orchards (Swirski et al., 1978) surveys of natural enemies were begun and Wysoki & Izhar, 1980 mentioned that spiders were seen preying upon B. Selenaria larvae.

The aim of the present study was to determine the spider populations inhabiting avocado orchards in Western Galilee and their role as natural enemies of avocado pests and particular B. Selenaria.

MATERIALS AND METHODS

The study was carried out in commercial avocado orchards at Regba (15 hectares) on the Hoss, Nabal and Fuerte varieties.

Sampling of Spiders: Three methods of collection were used: branch shaking, pitfall traps and Berlese funnel. Every two weeks each sample was collected by randomly selecting 10 big branches - one branch per tree. Spiders were collected by tapping the branch sharply 3-5 times with a cylinder stick covered with hard rubber. Most of the organisms, thus dislodged, were collected in a silk funnel which was held underneath the branches. The funnel was of pyramidal shape, 55 x 60 cm wide and 60 cm deep. Spiders were collected individually from the funnel into plastic cages. They were then classified, counted and recorded. Several specimens of each type were placed in plastic cages and reared to maturity for positive identification.

For sampling spiders present in undercover, pitfall traps and Berlese funnel were used. The pitfall traps were plastic bowls (16 cm in diameter and 10 cm in depth) containing 3 cm of ethylen glycol. Five traps were placed in different places in the orchard and these checked once every two weeks from Oct. 1981 to Aug. 1982. The large quantity of foliage and the trash undercover disturbed the function of pitfall traps and, therefore, this material was taken in bags to the laboratory several times throughout the season and there, spiders were separated by Berlese funnel. In addition, a night collection was made as well.

Evaluation of the role of spiders as biocontrol agents of Boarmia Selenaris.

Two adjacent avocado trees were chosen at random in the Regba orchard. Three branches of each tree were used for the bicontrol experiment. Spiders were carefully eliminated from 3 branches by repeatedly shaking the branches. The arthropods thus dislodged, were collected by silken funnel and were returned to the same branches, except for the spiders, which were put on other branches. On the other 3 experimental branches, the spider fauna were left undisturbed.

Larvae of Boarmia selenaris -2- days old which were reared in the laboratory on an artificial diet were used to infest the foliage of all 6 branches: 2 branches with 100 larvae each; 2 branches with 150 larvae each; and the other 2 with 200 larvae each. All 6 branches were caged with clothing cages. Four days later the cloth coverings were removed and the fate of the larvae in both groups of branches evaluated. Ten leaves from each branch were removed and the number of larvae present, as well as the damage caused to the leaves assessed.

RESULTS AND DISCUSSION

The population trends for the total spiders in the avocado orchard of Regba for the year 1981 are given in Fig. 1. During the months of January to June the spider population numbered between 48 to 280 spiders per sample. Then the spider population increased sharply to two peaks: the first on August 27th when 760 spiders were captured, and the second on September 21st when 812 spiders were captured. Thereafter, the population began to decrease. On November 1st 300 spiders were captured and then once more the population began to increase. Spiders collected from avocado foliage, as well as those captured in pitfall traps are given in Table 1.

The Theridion sp. represented 63% of all the spiders captured during the year and Clubiona species a further 20%. The population trends of these two species, all individuals and adults alone, are given in Figs. 2 and 3. These fluctuations are presented in Table 2. From mid December 1980 until the end of March 1981 Theridion sp. represented between 78 and 95% of the total population. In this period of time Clubiona sp. represented 0.8 to 11%. From April to end of June, Theridion sp. represented 11 to 34% and Clubiona sp. represented 46 to 82%. From mid July to December 1981 the picture returned so that Theridion represented 55 to 86%, Clubiona 6 to 31%. Adults of Theridion sp. were present during December to end of July while the adults of Clubiona sp. were present from December 1980 to mid February 1981 and once again from September to December 1981. During samples taken at the beginning of April, it was found that Clubiona sp. increased sharply. The population trend held until the middle of July. Conversely, Theridion sp. increased sharply during the middle of July and held on until the latter part of December. This could be a result of reproduction in which, thereafter, the populations were affected by certain factors such as pesticide treatments, lack of prey, cannibalism.

Lycosidae spiders represented 58% of the total spiders captured in pitfall traps and Linyphidae a further 19%. Lycosidae spiders were very abundant at night.

Fig. 1. Population trends for all spiders in the avocado orchard at Regba.

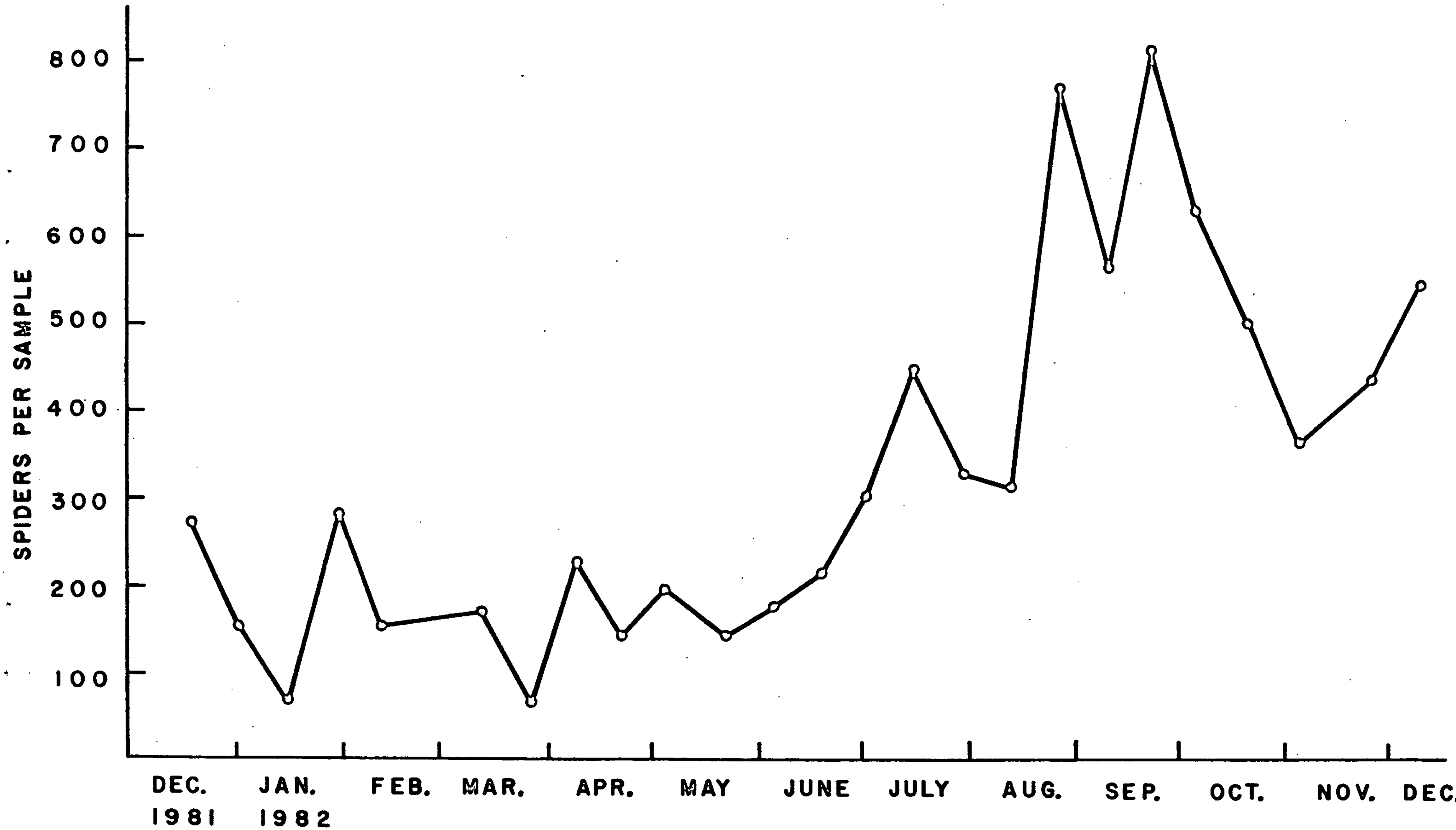


Fig. 2. Seasonal fluctuations of the Theridion sp. in the avocado orchard at Regba.

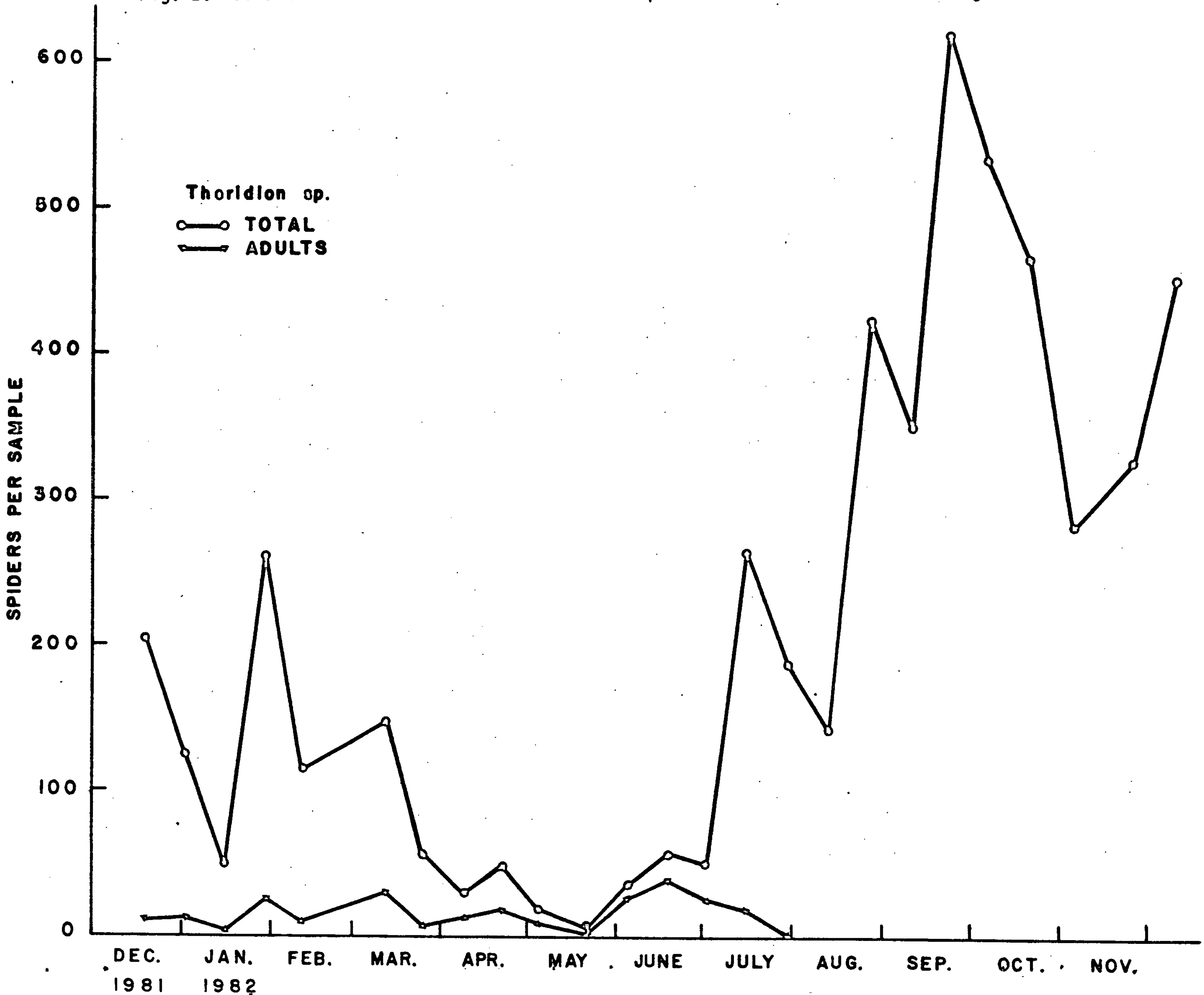
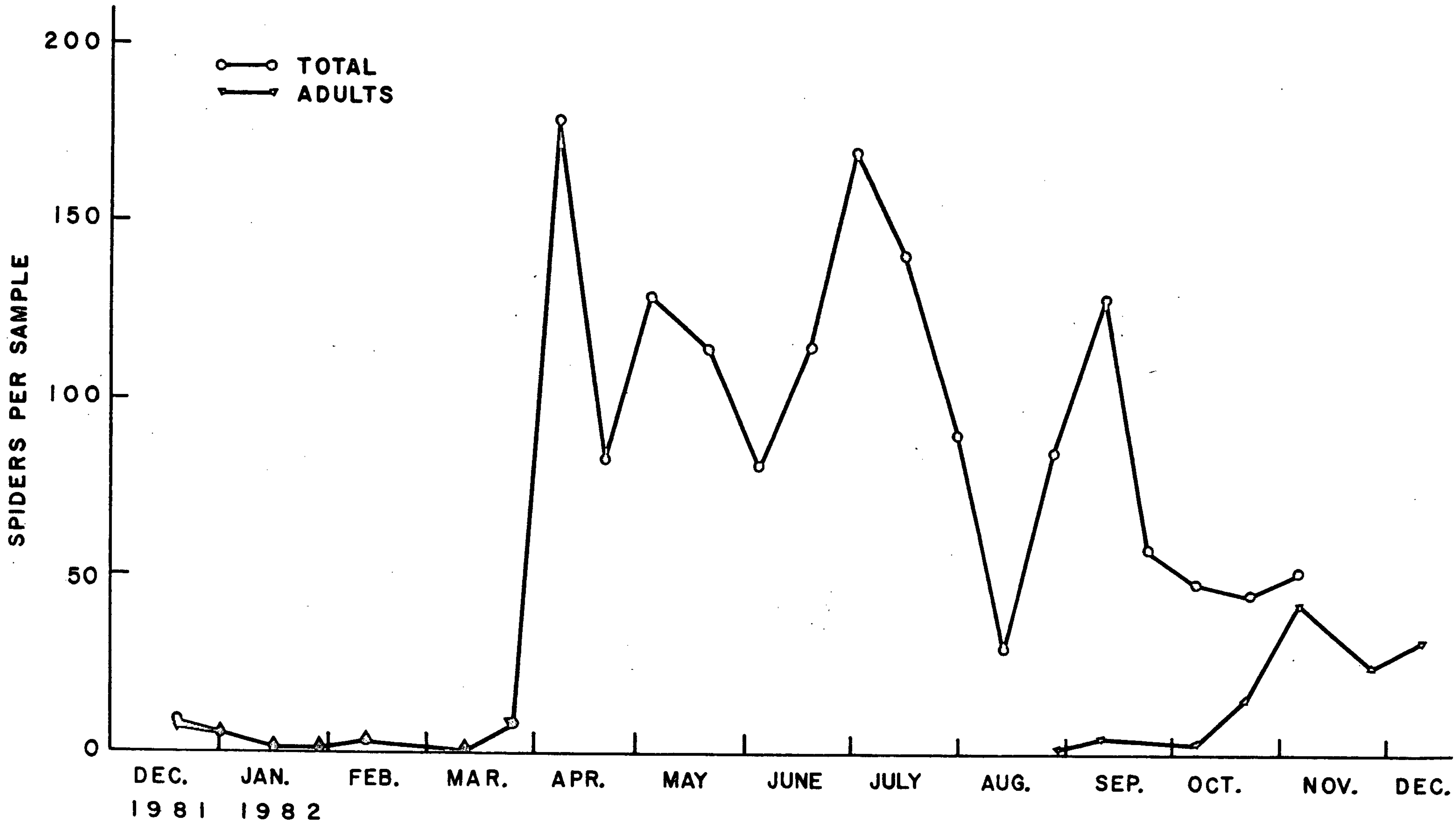


Fig. 3. Seasonal fluctuations of the Clubiona sp. in the avocado orchard at Regba.



Evaluation of spiders as biocontrol agents of B. Selenaris in avocado.

The results of this experiment are presented in Table 3. Wherever spiders were undisturbed, most populations of B. Selenaris larvae were absent (1.37 larvae per leaf) and damage to leaves was minimal (2.26 perforations per leaf) 4 days after exposure. On the other hand, on branches from which spiders were eliminated, spiders did exist (10.4 larvae per leaf). Damage to infested larvae was severe (21.0 perforations per leaf). Perforations were 1-3mm in diameter.

Thus, wherever spiders eliminated B. Selenaris infestations caused severe damage after they continued to be present on leaves. This did not occur where spiders were left undisturbed upon the avocado branches.

Comparisons of the fate of B. Selenaris infestations in bresence and absence of spiders clearly indicates that spiders are the responsible agents for the low density of Bourmia larvae and for the negligible damage observed.

Table 1. Total numbers collected and percent of total spiders of spider families inhabiting avocado orchard at Regba.

Family	Foliage		Pitfall traps	
	Total	%	Total	%
ARANEIDAE	56	0.67	-	-
CLUBIONIDAE Clubiona sp.	1665	20.00	3	0.3
DICTYNIDAE	455	5.46	6	0.7
DYSDERIDAG	-	-	51	5.7
GNAPHOSIDAE	24	0.28	33	3.7
LINYPHIDAE	27	0.32	169	18.8
LYCOSIDAE	7	0.08	524	58.3
MIMETIDAE	6	0.07	-	-
OECOBIDAE	15	0.18	39	4.3
OXYOPIDAE	1	0.01	1	0.1
PHILODROMIDAE	58	0.69	6	0.7
PISAURIDAE	4	0.04	4	0.4
SALTICIDAE	296	3.55	10	1.1
THERIDIIDAE:				
Theridion sp.	5234	62.84	5	0.5
Others	130	1.56	29	3.2
THOMISIDAE	26	0.31	2	0.2
ULOBORIDAE	305	3.66	1	0.1
Unidentified	20	0.24	16	1.8
TOTAL	8329	100	899	100

Table 2. Fluctuation between the two major spider populations in avocado orchard at Regba.

Date	Spiders Per Sample				
	Total of all spiders	Clobione sp.		Theridion sp.	
		No.	%	No.	%
8.12.80	271	7	2.6	234	86.3
1. 1.81	155	5	3.2	126	81.3
15. 1.81	67	1	1.5	52	77.6
29. 1.81	282	1	0.3	267	94.7
11. 2.81	154	3	1.9	121	78.6
12. 3.81	169	0	0.0	148	87.5
26. 3.81	65	7	10.8	55	84.6
8. 4.81	227	179	78.8	30	13.2
21. 4.81	142	82	57.7	48	33.8
4. 5.81	199	155	77.9	31	15.6
21. 5.81	142	116	81.7	16	11.3
4. 6.81	174	80	45.9	37	21.3
18. 6.81	215	114	53.0	67	31.2
1. 7.81	301	170	56.4	58	19.3
15. 7.81	447	140	31.3	266	59.5
30. 7.81	326	90	27.6	192	58.9
13. 8.81	311	28	9.0	145	46.6
27. 8.81	772	85	11.0	427	55.3
10. 9.81	562	129	22.9	351	62.4
23. 9.81	813	57	7.0	621	76.4
6.10.81	631	48	7.6	535	84.8
21.10.81	562	60	10.7	460	81.8
5.11.81	363	51	14.0	286	78.8
26.11.81	434	25	5.8	333	76.7
10.12.81	545	32	5.9	458	84.0

Table 3. The fate of Boarmia selenaris larvae on avocado foliage with presence and absence of spiders.

	Branch	No. of larvae on each branch	4 days after exposure		
			Number of		
			Leaves Tested	Larvae Present	Holes in Leaves
Spiders Absent	1	100	10	81	191
	2	150	10	109	208
	3	200	10	123	232
	Total	450	30	313	631
	$\bar{x}$			10.43	21.03
Spiders Present	1	100	10	11	16
	2	150	10	13	23
	3	200	10	17	29
	Total	450	30	41	68
	$\bar{x}$			1.37	2.26

THE SPIDERS OF A CITRUS GROVE IN ISRAEL AND THEIR IMPORTANCE AS PREDATORS OF CEROPLASTES FLORIDENSIS.

INTRODUCTION

Citrus crop is one of the most important crops in Israel. Israeli citrus groves provide a habitat for a variety of spider species, some of which may reduce pest populations, but no general study of these has been made in Israel except for a preliminary study work listing some species published by Shulov in 1938.

In the citrus groves of Kibbutz Afik in northern Israel there is a plot (#4) of grapefruit trees - the area consists of 5 acres, (20 dunams), 31 rows, with the trees spaced 6 x 3 meters apart. Pesticides were used only for controlling the fruit fly (Ceratits capitata Wied) and for other pests only when the situation was critical. During Sept. 1982, when general observations were made on the tree foliage, spiders were seen turning the scale - Ceroplastes floridensis and preying upon it. This observation was also observed in laboratory tests. To the author's knowledge, there is no information about spiders as predators to these scales. Damage caused by this serious pest results from deposition of "honeydew" on which sooty-mold fungi develop both on foliage and fruits.

Plot No. 21 was used during 1980-82 for the present study, the purpose of which was to broaden our knowledge of spider populations and their importance as predators of citrus pests especially to C. floridensis.

MATERIALS AND METHODS

Sampling of Spiders: Three collection methods were used: branch shaking, pit-fall and Berlese funnel. Every two weeks each sample was collected by randomly selecting 10 large branches - one branch per tree. Spiders were collected by tapping the branch sharply 3-5 times with a cylinder stick covered with hard rubber. Most of the organisms thus dislodged were collected in a silk funnel which was held underneath the branches. The funnel was of pyramidal shape, 55 x 60 cm wide and 60 cm deep. Spiders were collected individually from the funnel into plastic cages. They were then classified, counted and recorded. Several specimens of each type were placed in plastic cages and reared to maturity for positive identification.

For sampling spiders present in undercover trash, pitfall traps and a Berlese funnel were used. The pitfall traps were plastic bowls (16 cm diameter and 10 cm depth) containing 3 cm of ethylen glycol. Five traps were placed in different places in the grove and these checked once every two weeks from October 1980 to January 1981. The large quantity of foliage and trash disturbed the function of pitfall traps. This material was taken in bags to the laboratory several times throughout the season and spiders were separated by Berlese funnel.

Evaluation of the role of spiders as biocontrol agent of *Ceroplastes floridensis* Mask

During October, 1982 when the citrus trees were naturally infested with *C. floridensis*, 2 adjacent trees were chosen and 3 branches of each tree were used for the following biocontrol experiment:

Spiders were carefully eliminated from three branches by repeatedly shaking the branches. The arthropods thus dislodged were collected by silken funnel and returned to the same branches except for the spiders, which were released elsewhere. On the other three experimental branches, the spider fauna and other arthropods were left undisturbed. Thereafter, *C. floridensis*, of all stages, were counted and between 12-15 scales were found on each of the six branches. The two groups of branches were caged with clothing bags. Two weeks after the experiment was set up, the fate of the scales in the two groups of branches was evaluated according to 1)number of scales and 2)leaves with sooty-mold fungi.

RESULTS AND DISCUSSION

Spider population and composition: The population trends for the total number of spiders in the experiment at Afik for the years 1980-81 are shown in Fig. 1. During the first two months of sampling the spider population decreased from 270 spiders/sample at mid October to 60 spiders/sample at mid December.

Fig. 1. Population trends for all spiders in the citrus grove at Afeq.

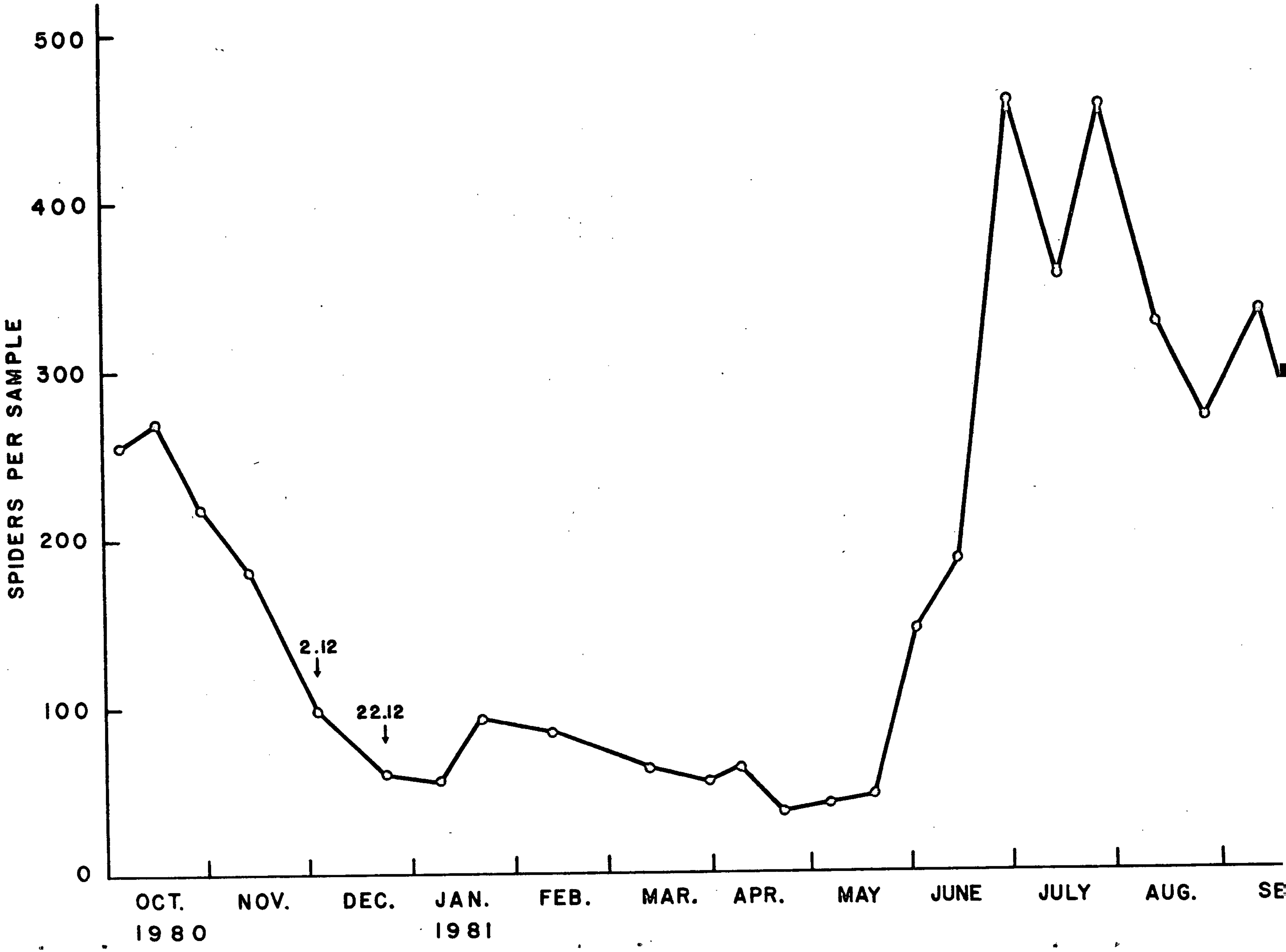


Fig. 2. Seasonal fluctuations of the spider <u>Chiracanthium</u> <u>mildei</u> in the citrus grove at Afeq.

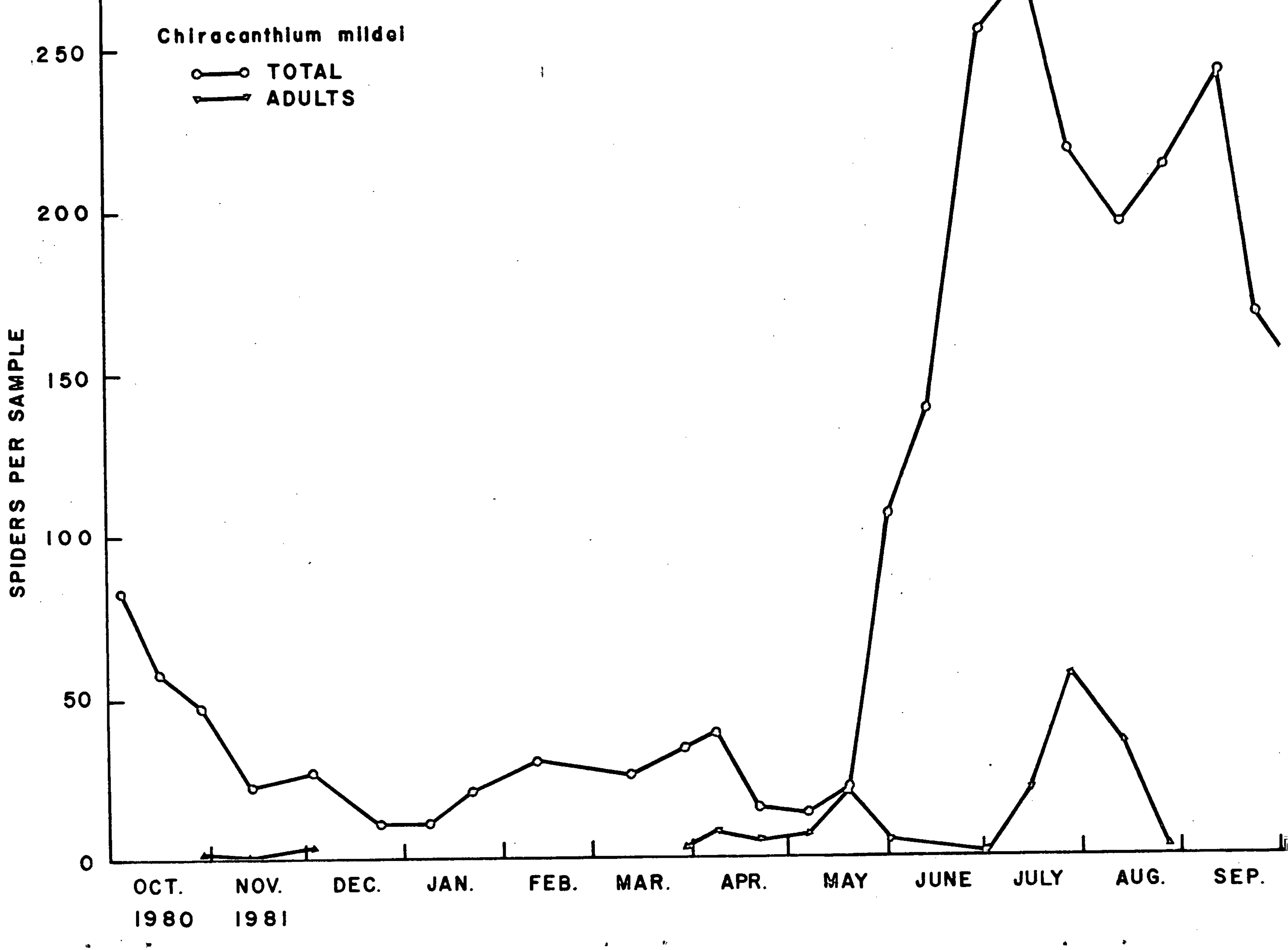
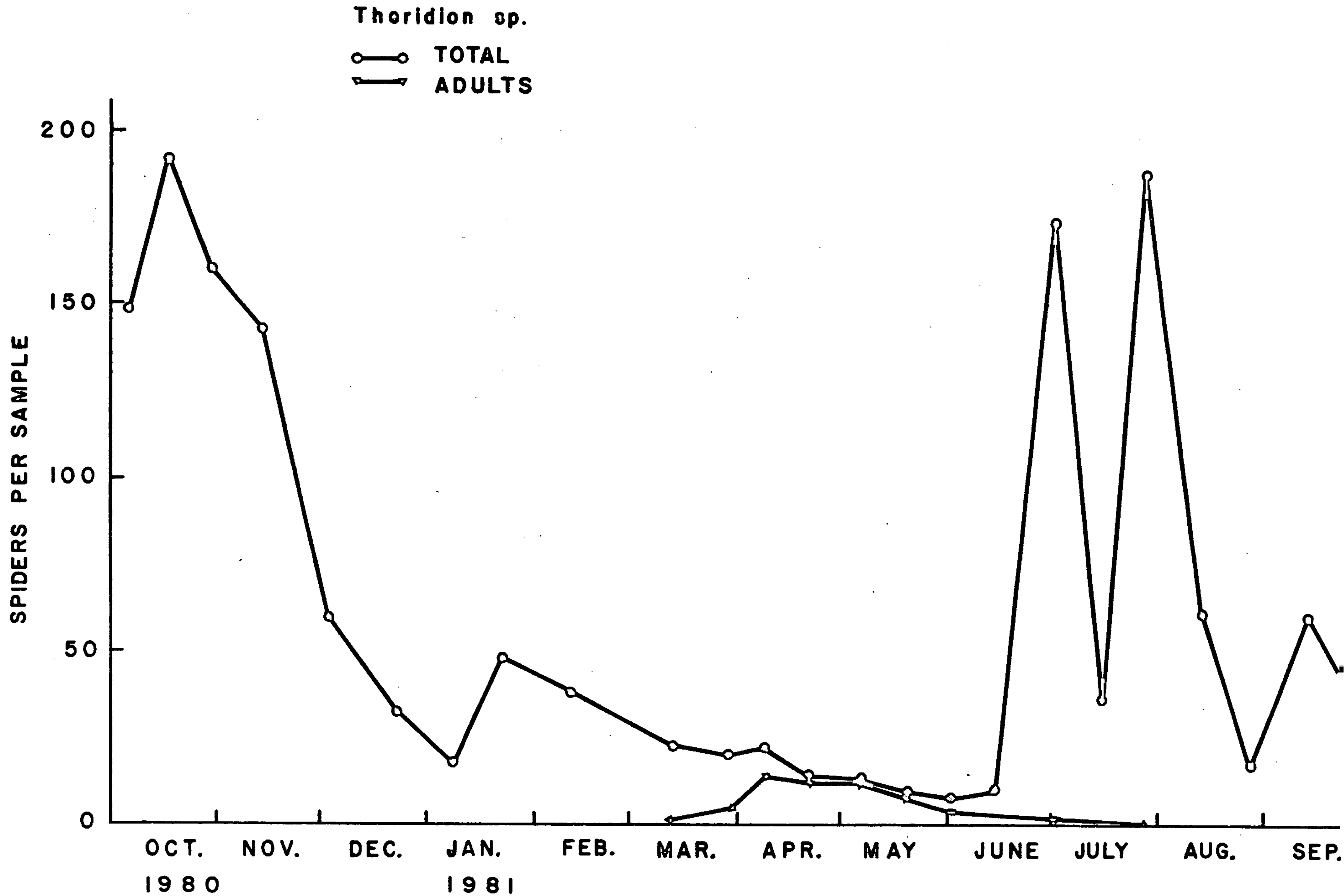


Fig. 3. Seasonal fluctuations of the Theridion sp. in the citrus grove at Afeq.



Two pesticidal applications with Malathion were made during December and no apparent affect was shown on the spider population. From January to May, the total population ran between 38 to 91 spiders per sample. Then the spider population increased sharply to peak twice; the 1st on June 5 when 460 spiders were captured and the 2nd July 29 when 456 spiders were collected. On Aug. 10, 18 of the 31 rows of the experimental plot received a pesticide treatment with Anthio = formothion + Ravyon = Carbaryl. On Aug. 13 a sample was taken in both the sprayed and the unsprayed areas. In the sprayed area 25 spiders were caught, and during Aug. to Oct. no more than 5 spiders were captured. On the other hand, during the same time span, the unsprayed area yielded from between 232-325 spiders per sample. Interestingly enough, Malathion did not affect the spider population, while Anthio + Ravyon did. This may show that strains of Ch. mildei and Theridion sp. inhabiting this grove are resistant to Malathion or the spiders themselves are not affected by this organophosphoric chemical.

The spider population once more began to increase, peaking during mid September when 340 spiders were snared. With the onset of fall the spider population then, once more, began to decrease. Spiders collected from citrus foliage as well as captured in pitfall traps are given in Table 1. The spider Chiracanthium mildei represented 52% of all the spiders captured during the year, and Theridion sp. a further 34%. The population trends of these two species - all individuals and adults alone - are given in Figs. 1 and 2. Their fluctuations are presented in Table 2. From Oct. 1980 to the end of Dec. 1980 Theridion sp. represented between 55-76%, Clubionidae (Ch. mildei) 13-32% of the total population. During mid May to Sept. 1981, Ch. mildei represented 48-79% of the total spider population and the adults peaked on the end of Sept. after it began to increase sharply at the beginning of July.

Both adults of Ch. mildei and Theridion sp. first appeared in March. Adults population of Theridion sp. peaked on April and very few adults - 2 to 4 per sample were found during June and July. It will be noticed that there is a high population during the summer time for both species which could be a result of reproduction potential in this period in which, thereafter, was affected by several factors such as: pesticide treatment, climate conditions, cannibalism and others.

In regard to spiders captured in pitfall traps, Gnaphosidae represented 43.2% and Lycosidae a further 35.2%. These families together with Linyphidae represented 87% of all spiders captured during the period of sampling.

Evaluation of spiders as biocontrol agents of C. floridensis.

The results of this experiment are presented in Table 3. Wherever spiders were undisturbed, populations of C. floridensis were unable to develop. The increase in the numbers of scales was extremely minimal. There was no damage to leaves nor was honey-dew or sooty mold observed. In the period 18/10/82 to 2/11/82 (14 days) the number of scales only increased from 47 to 56. During the same time period, on the other hand, on branches from which spiders had been eliminated, scales did develop and increased tenfold, from 44 to 439. Damage to infested leaves was severe and conspicuous. Two hundred and six leaves (41% of the total) were found heavily infested with sooty mold fungi on heavy honeydew produced by the scales. Thus, wherever spiders were eliminated, C. floridensis infestations developed unhindered and caused severe damage. This did not occur where spiders were left undisturbed upon the citrus branches. Comparison of the fate of C. floridensis infestations in the presence and absence of spiders clearly indicates that spiders are the responsible agents for the low density of C. floridensis and for the negligible damage observed in this citrus grove.

Table 1. Total numbers collected and percent of total spiders of spider families inhabiting citrus groves at Afaik.

Family and Genera	Foliage		Pitfall traps	
	No.	%	No.	%
ARANEIDAE	47	1.0	-	-
CLUBIONIDAE: Chiracanthium mildei	2377	51.8	3	2.4
DICTYNIDAE	15	0.3	3	2.4
DYSDERIDAE	-	-	2	1.6
GNAPHOSIDAE	47	1.0	54	43.2
LINYPHIDAE	54	1.2	11	8.8
LYCOSIDAE	-	-	44	35.2
PISAURIDAE	16	0.4	-	-
SALTICIDAE	17	0.4	-	-
THERIDIIDAE:	329	7.2	5	4.0
Theridion sp.	1566	34.2	-	-
Euryopis sp.	10	0.2	-	-
Steatoda sp.	23	0.5	-	-
THOMISIDAE	19	0.4	2	1.6
ULOBORIDAE	9	0.2	-	-
Unidentified	17	0.4	1	0.8

Table 2. Fluctuation between the two major spider populations in a citrus grove at Afaik.

Date	Spiders Per Sample				
	Total of all spiders	Clubionidae		Theridiidae	
		No.	%	No.	%
5.10.80	256	83	32.4	148	57.8
16.10.80	270	57	21.1	192	71.1
29.10.80	219	47	21.5	159	72.6
13.11.80	180	23	12.8	142	78.9
3.12.80	98	27	27.5	59	60.2
23.12.80	60	11	18.3	33	55.0
8. 1.81	56	11	19.6	17	30.3
22. 1.81	91	21	23.1	48	52.7
11. 2.81	84	30	35.7	38	45.2
12. 3.81	64	26	40.6	23	35.9
29. 3.81	57	34	59.6	20	35.1
8. 4.81	64	39	60.9	22	34.4
21. 4.81	38	15	39.5	14	36.8
6. 5.81	42	13	30.9	13	30.9
19. 5.81	44	21	47.7	10	22.7
1. 6.81	145	106	73.1	8	5.5
14. 6.81	184	138	75.0	10	5.4
1. 7.81	461	255	55.3	175	37.9
15. 7.81	354	272	76.8	36	10.2
28. 7.81	457	219	47.9	189	41.3
13. 8.81	325	195	60.0	62	19.1
27. 8.81	269	213	79.2	17	6.3
13. 9.81	336	242	72.0	61	18.1
24. 9.81	250	168	67.2	40	16.0
5.10.81	232	151	65.1	52	22.4

Table 3. The fate of <u>Ceroplastes floridensis</u> on grapefruit foliage with presence and absence of spiders.

	Citrus branch	18.10.1982		2.11.1982		
		Number of		Number of		
		Leaves	Scales	Infested Leaves	Scales on Infested Leaves	Leaves with Sooty Mold Fungi
Spiders Present	1	138	17	12	15	0
	2	181	15	6	6	0
	3	153	15	22	35	0
	Total	472	47	40	56	0
	%	100	100	8.47	119.14	0
Spiders Absent	1	167	13	56	104	70
	2	208	17	88	186	103
	3	130	14	74	149	33
	Total	505	44	218	439	206
	%	100	100	43.16	997.72	40.79

The effect of Malathion and Dursban on the spider Chiracanthium mildei - A resistant strain to Malathion.

Bicontrol experiments which were carried out in citrus groves at Kibbutz Afaik and in cotton fields at the experimental station - Newe-Ya'ar indicated that spiders play an important role in suppression serious pests in the two agroecosystems. Surveys of the spider populations throughout the year showed that Ch. mildei was the most dominant spider in both habitats. It was very interesting to compare the susceptibility of these spider populations from both areas to Malathion - a commercial pesticide commonly used against the fruitfly in citrus groves in Israel. Laboratory experiments were also carried out to evaluate the effect of Dursban - another commercial pesticide commonly used against citrus pests in Israel on Ch. mildei which came from the citrus grove at Afaik.

Materials and Methods.

Chiracanthium mildei spiders used in this study had been collected both from the citrus grove at Afaik and from the cotton field at Newe-Ya'ar. They were from different ages and they had been reared in the laboratory under constant conditions of $25^{o}\pm1^{o}C$ and 55-60% RH. To avoid cannibalism, they were kept singly in 30 cm^3 clear plastic containers, with a perforated top covered with cloth for ventilation. They were fed with Drosophila milanogaster. When more than half of the spiders became adults, the spiders were divided into groups in which each group consisted of the same number of spiders from each certain age. These groups were formerly as replicates in the toxic tests.

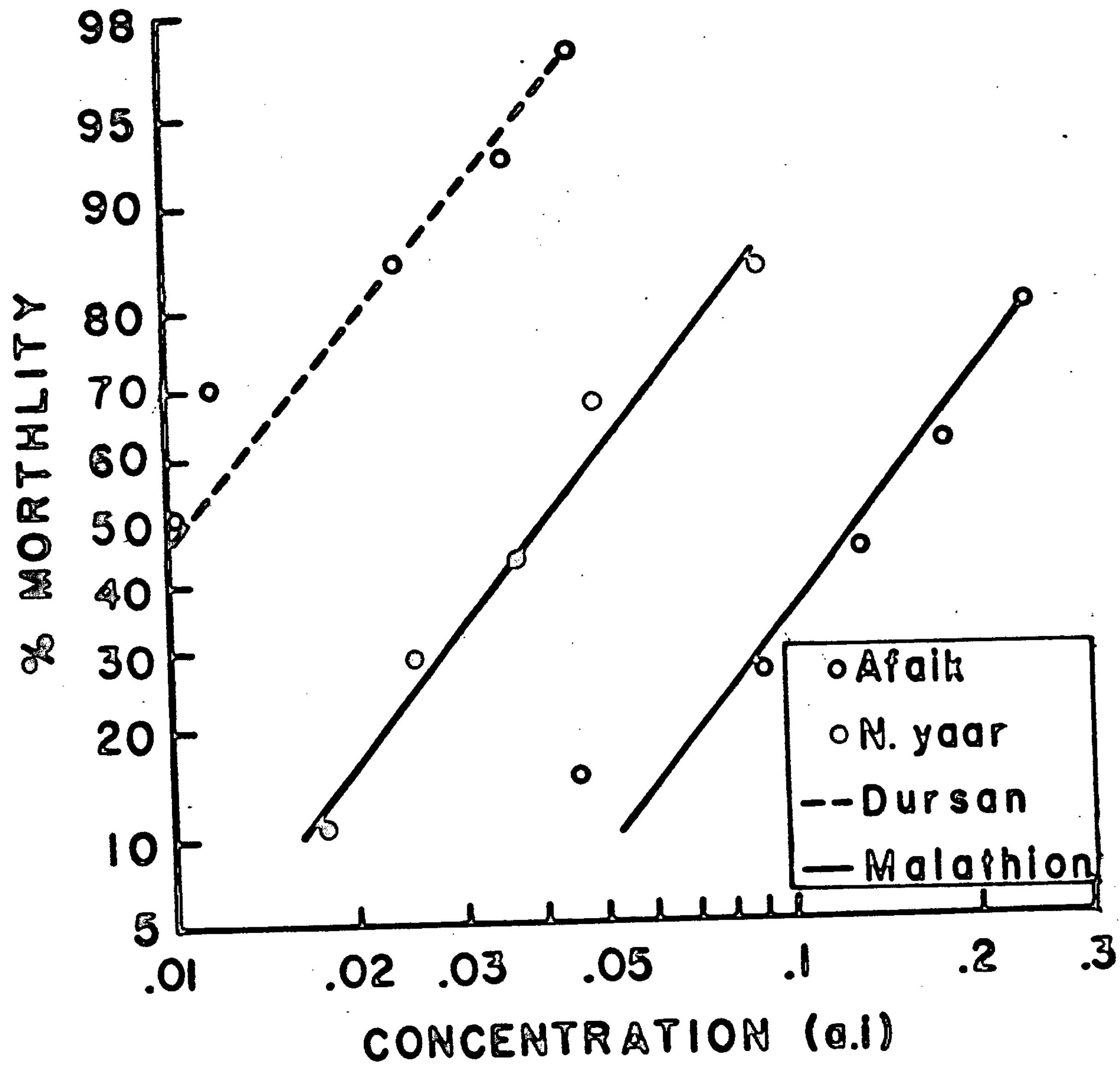
The following formulations were used in the study:

Malathion E.C 50%

Dursban 4EC 48%

The pesticidal formulations were diluted in water to the concentrations needed, with a wetting agent (which included Octylphenol - Octaglycil ehter) added at the rate of 10 ppm.

Fig. 1. Dosage-mortality curves of resistant and susceptible strains of the spider Chiracanthium mildei.



Grapefruit leaves from unsprayed groves were dipped for 5 seconds in the aqueous emulsions of the chemicals. In parallel a comparable control leaves were dipped in water with wetting agent only. After leaves were dried at room temperature they were cut in shapes so as to fit padding the interior surface of the 30 cm^3 plastic containers. Then spiders were enclosed in these padded containers, one per container. The padded container with the spiders were kept at 25°±1°C and 55-60% RH. After 24 hours of forced contact with the pesticide residues the spiders were returned to the rearing containers and mortality counts were made from one day until one week after treatment.

To obtain dosage-mortality curves, 10 spiders were used in each test. These tests were replicated on five different days, thus employing a total of 50 spiders assessed at each of 5 concentrations. Results were plotted on probit-log paper. Natural mortality did not occur in the control.

Results and Discussion.

The probit-log concentration curves of the pesticides tested against the Afaik strain and the Newe-Ya'ar strain are given in Figure 1. The LC-50s are recorded in Table 1. The Newe-Ya'ar strain was found to be more susceptible to Malathion. On the basis of the LC50 the Afaik strain showed a resistance factor of x 3.3. Apparently, the spider Chiracanthium mildei has become resistant to Malathion because of its wide use throughout the years in citrus groves against the fruitfly.

- Even though Dursban is an op pesticide like Malathion it had much more acute toxicity to the spider than Malathion. The LC50 of Dursban was 0.011 while of Malathion it was 0.14.

The present study probably is the first and the pioneer one to indicate that there are strains of spiders which have resistance to certain pesticides, a matter which could be of great benefit in an integrated control program.

Table 1. LC50 values for a resistant and susceptible strain of Chiracanthium mildei to Malathion based on the percentage concentrations (in a.i) shown in Figure 1.

Newe-Ya'ar Strain	Afaik Strain	Resistance Factor
0.042	0.14	3.33

SUMMING UP

What has been done?

Most authors only prepare checklists of species occuring in various crops and indicate dominant species. There are several papers and many data on this subject. Fewer papers contain estimates of spider abundance, such as relative numbers (density) and population dynamics over the growing seasons; most information being concerned with relative numbers. Only a few papers analyze spider biomass, migration distribution in crop and tree fields or differences in the quality, density and structure of spider communities in crops and natural ecosystems. There are several papers on the effects of pesticides and agrotechnical treatments on spiders, but papers exclusively devoted to predation by agrosystem spiders and to relation between them and crop entomofauna are lacking.

Where do we we go and what needs to be done?

In some ecological situations spiders can largely contribute to the prey reduction and regulation. In each ecosystem the impact of spiders follows two pathways. This is the predatory pressure of the whole group of spiders on the entomocoenosis, and the pressure of particular spider species on some species of phytophagous insects (Luczak, 1979).

The first function lies in the fact that spiders have an effect on the whole community of prey at various trophic levels, and due to this they contribute, together with other general predators, to the stability of the biocoenosis (Ehler and Van dom Bosch, 1974; Riechert, 1974).

The second function is an individual effect of a spider species on a definite prey species. There are spiders that can have a regulatory effect on a single prey population, or a single prey type, as Japanese ecologists showed. This type of spider activity is of particular importance to biological pest control. Such activity is related to the occurrence of different types of polyphagy among spiders.

The results obtained by American, Japanese and Polish arachnologists in crop fields and on the other hand by Canadian and Israeli arachnologists in orchards, provide evidence that spiders can be used as the natural enemies of pests in several key crops. It is known that under crop conditions spiders are important enemies of aphids, mites and lepidopters larvae and eggs. Pests of rice fields account for 50-80% of the diet of some spiders. Many Japanese papers show that spiders are very useful in biological pest control. Experimental studies in Israel and Poland and in the United States pointed out that spiders have a serious indirect effect (through their prey) on plant condition and the degree of plant injury. Due to their predatory activity, the yield increased since without predators a large part of the plant biomass was consumed by phytophages.

In addition to the possible direct use of dominant crop spiders as natural enemies of phytophagous insects, the stabilizing effect of polyphagous predators, including spiders, on the ecosystem should be enhanced on a large scale by the integrated pest control (application of selective insecticides), and also by the differentiation of crop structure (Emden and Williams, 1974). The stability of agrocoenoses can also be increased by the introduction of spiders into crop fields. Spiders are less resistant to pesticide than many phytophagous insects, nevertheless, they are more resistant than many species of predatory insects, thus they have an advantage over other predators.

So far there have not been large material collected dealing with the study of spiders in agroecosystem, but the number of entomologists and arachnologists increases from year to year as a result of the growing interest in agriculture and in the pollution of the environment in the world.

We know through several years of experience which species of spiders are of particular importance.

The major objective should be the increase of the effectiveness of spiders in key crops. To make progress in this issue we need crucial information of these areas:

1. Which species overwinter in the field, which each year?
2. What are the rates of food consumption of each member of the guild?
3. What is the feeding efficiency of each species?
4. Where are the migrants coming from?
   a) from nearby fields?
   b) from afar?
5. How do they get into the field?
   a) by walking?
   b) by ballooning?
6. When do they come?
7. What proportion of the total spider population in a given field disperse or balloon from a nearby area?
8. What is the composition of the flora in these nearby areas, and do certain spiders prefer certain floral hosts and combinations?
9. Would the establishment of grass or legume strips enhance the colonization of adjacent row crops or orchards by spiders?
10. Could spider populations in these uncultivated strips be managed to increase colonization levels in row crops and orchards?
11. In row crops does the environment of narrow rows allow greater species diversity in the growing season?
12. What alternate prey do they feed on?
13. How many generations per year are there?
14. Do we have a self-perpetuating population or is it continually added to by migration (tree crops)?

It has been found that the interspecific competition can weaken the predation by spiders, lower their numbers, and increase their mortality (Dubrowski-Prot and Luczak, 1970, 1972; Luczak and Dubrowski-Prot, 1971; Kessler-Geschlere, 1972; Enders, 1974, 1975; Uetz, 1977).

It is interesting whether interspecific composition (both among spider species and between spiders and other intervebrate groups of predators) is higher or not in agroecosystem as compared with natural ecosystems.

An unambiguous evidence for the occurrence of the functional and numerical responses in spiders to increasing prey densities would be a very strong argument for their usefulness in the biological control of insect pests in crops(Luczak, 1979).

It should be tested whether under natural conditions there are spider species showing the functional response and the numerical responses. The views of arachnologists are not consistent in this respect, but some authors found a limited functional response in spiders (Putnam and Herne, 1966; Turnbull, 1973; Mansour, Rosen and Shulov, 1980) and numerical response (Turnbull, 1966; Putnam, 1967; Lopaz and Teetes, 1976).

1. Is there a true numerical response (row and tree crops)?
2. Does territorialism interfere with numerical response of the important orchard species?
3. What types of numerical responses are there?
   a) aggregative?
   b) reproductive?
   c) reduced interspecific (competition)?
4. What steps can be taken to effect numerical response?
   a) increase prey abundance?
   b) increase source of new migrants?

5. What factors effect functional response?

   a) preying abundance?

   b) sex ♂ or ♀ ?

   c) stadium?

   d) temperature?

6. What negative factors are we concerned with?

   a) pesticides?

   b) natural enemies?

   c) other factors?

According to our knowledge for the time being there are no complete answers and enough data to these key questions. Basic knowledge in these topics will make the habitate minipulation for utilizing spiders in integrated pest management more available. For this aim it is necessary to find:

A. Factors giving numerical response.

B. Factors giving functional response.

C. To apply likely factors of numerical and functional response like:

   1. increase alternate prey that do not hurt the crop using native plants and weeds.

   2. increasing sources.

   3. to reduce natural enemies.

   4. to use selective insecticides.

CONCLUSION

It is possible to increase the number of spiders in crop fields both directly and indirectly. The direct way lies in the introduction of spiders into crop fields, which is applied by Japanese workers. They experimentally pointed out that 30% of the number of a beneficial spider introduced into a cabbage field established themselves (Suzuki and Okuma, 1975), and more than 50% in a mulberry orchard (Kayashima, 1972). Of course, the introductions into crop fields have to be repeated each year. The number of predators, including spiders, can be indirectly raised by sowing admixtures of other plants in row and tree crops, by changing the density of crop plants, or by a belt management of crop fields (Murdoch, 1975). The introduction of predators is difficult to carry out, thus their protection due to the application of selective chemicals as an important matter for plant protection.

Spiders are susceptible to insecticides used at high rates and several times per season. But selective insecticides do not kill spiders, and this is another way to maintain their high numbers in crop and tree fields, therefore indirectly to increase agrocoenosis stability and to make possible the regulatory effect of oligophagous spiders on herbivorous prey.

As it can be seen from the results summarized above, spiders can sometimes be effective predators of particular pest species in crops. Therefore, in addition to their role as members of the group of general predators in maintaining biocoenosis stability, single spider species can have an important and individual effect on single insect populations abundant in the ecosystem. If, in addition, these are crop pest populations, the importance of spiders as a factor of biological control increases (Luczak, 1979).

These general conclusions may justify further investigation of these little-studied natural enemies, looking for possibilities of manipulating the agricultural habitate to increase spider populations, with a view to increase spider populations, with a view to utilize them in integrated control programs.