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INTERACTIONS BETWEEN CITRUS PSYLLA, *TRIOZA ERYTREAE* (*HEM. TRIOZIDAE*), AND SPIDERS IN AN UNSPRAYED CITRUS ORCHARD IN THE TRANSVAAL LOWVELD

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During a two year survey, a total of 3,054 spiders represented by 21 families were sampled in an unsprayed citrus orchard in the Transvaal Lowveld. Numerically the Salticidae was the dominant family (34.4 %) followed by the Theridiidae (21.9 %), Thomisidae (11.9 %), Araneidae (7.9 %), Clubionidae (7.0 %) and the Tetragnathidae (3.7 %). Eighteen species of spiders were observed to prey on citrus psylla, *Trioza erytreae* (Del Guercio) (Hemiptera : Triozidae), while six species trap nymphs and adults under their retreats and webs. There were significant positive correlations between the weekly psylla populations and the weekly populations of web-building spiders and wandering spiders present one to four weeks later but no significant correlation between the weekly spider populations and the weekly psylla populations present one to five weeks later. This seems to indicate that while spiders are unable to keep citrus psylla populations at acceptable low levels, they may contribute in reducing their numbers.

KEY-WORDS : Araneae, citrus psylla, spiders, *Trioza erytreae*.

Many of the pests and potential pests that occur on citrus in South Africa are under effective biological control (**Bedford,** 1978). However, the natural enemies of a few others, like the citrus psylla, are unable to keep these pests below the economical threshold. The adult citrus psylla, *Trioza erytreae* (Del Guercio) (Hemiptera : Triozidae) is the only known vector of the greening disease of citrus in South Africa (**McClean & Oberholzer,** 1965 ; **Catling,** 1970). Production loss due to greening has been estimated at Rands 35 million annually (**Van den Berg** *et al.,* 1987b).

Large numbers of spiders are often present in citrus trees as reported in other countries (**Shulow,** 1938 ; **Carroll,** 1980 ; **Mansour** *et al.,* 1982 ; **Mansour & Whitecomb,** 1986) and in South Africa (**Catling,** 1970 ; **Van den Berg** *et al.,* 1987a).

Several unidentified spider species have been observed to prey on the citrus psylla (**Van der Merwe,** 1923 ; **Catling & Annecke,** 1968 ; **Catling,** 1970) while **Van den Berg** *et al.* (1987a) observed thirteen species of spiders preying on adult citrus psylla and they expressed the opinion that spiders are possibly the most important predators of this pest.

The aim of the present study was to determine which species of spiders trap and/or prey on the citrus psylla and to establish whether correlations exist between the populations of citrus psylla and of wandering and web-building spiders in an unsprayed citrus orchard.

MATERIALS AND METHODS

STUDY AREA

The study was carried out in a citrus orchard of 80 × 60 m on the Burgershall Experimental farm in the Eastern Transvaal (25°07' S and 31°05' E). The orchard consisted of about 200 planted trees and 19,500 seedlings, in bottomless nursery bags, placed in rows between the planted trees. The seedlings were allowed to establish themselves in the soil. The trees and seedlings ranged from 0.2 to 2.1 m in height and no pesticides had been used on them from 1986 till the end of 1989. The citrus psylla was the most abundant insect in this orchard. From time to time aphids (*Toxoptera citricidus* (Kirkaldy) and *Aphis gossypii* Glover) as well as associated parasitoids and predators of the citrus psylla and the aphids were plentiful but were always outnumbered by psylla. Meteorological data were obtained from a weather station about 500 m away.

FIELD OBSERVATION

In the first part of the work, spiders that occurred in the orchard were studied. Initially, spiders with citrus psylla in their webs (web-building spiders), those with psylla nymphs or adults trapped under their retreats (wandering spiders) or webs (web-building spiders), and those that were busy feeding on psylla were collected.

SAMPLING METHODS

The population size of spiders were monitored during the daytime on plants only. Spider species that may have been present on the soil during the day which could possibly feed on psylla in the trees at night where thus not monitored. The spider population was sampled once a week between 8 h 00 and 10 h 00 as follows : from 7 January to 30 December 1987 the spiders on 10 randomly chosen seedlings were collected in the following manner. Each seedling was bent over a cotton cloth (800 × 1.340 mm) laid on the soil and tapped sharply with a stick from three to five times. The dislodged spiders were collected and placed into alcohol. From 4 January to 27 December 1989 this procedure was repeated weekly on 50 randomly chosen seedlings. The families and where possible species of the spiders, were determined according to the keys of Lawrence (1964).

During January and February 1987 the population size of adult psylla was estimated weekly on 20 randomly chosen seedlings. The population size of the adult citrus psylla was also monitored on the same weekly basis as for the spiders. From 5 February to 30 December 1987 adult psylla on 20 randomly chosen seedlings were caught with a battery operated suction apparatus (Black & Decker Super Spir 2000) and were then shaken into alcohol. The numbers of psylla estimated weekly during January and February 1987 and the numbers caught weekly with the suction apparatus in February (both on 20 citrus seedlings), were used to calculate estimated numbers of psylla for the weeks in January. From 4 January to 27 December 1989, the adult psylla on 100 marked seedlings were counted weekly.

STATISTICAL ANALYSIS

Population data of adult citrus psylla and of spiders were examined for each six month period separately and then for the full year in the following manner : Pearson's correlation

cofficients (P.c.c.) were calculated in 11 different ways. Firstly, the weekly populations of citrus psylla were correlated with those of spiders occurring at the same time. Similarly, P.c.c. were also calculated for the weekly populations of the citrus psylla and the weekly populations of spiders that occurred either 1, 2, 3, 4 or 5 weeks earlier and also 1, 2, 3, 4 or 5 weeks later, respectively.

RESULTS

OBSERVATIONS ON SPIDERS

Based on their behaviour, spiders are frequently divided into different guilds. For this study they were divided into web-building and wandering spiders.

WEB-BUILDING SPIDERS

Members of this group construct webs to catch their prey. They spin their webs on, between and around citrus leaves, between branches and between trees and usually catch flying insects like adult citrus psyllids. During this study it was frequently observed that web-building spiders like the Theridiidae spun their webs close to the leaf surface over psylla nymphs. It has been observed that many of these nymphs and adults then crawl into the webs where they are preyed on or die because they could not escape. Furthermore, leaves with webs seem to be less suitable for oviposition and feeding by psylla than other leaves.

WANDERING SPIDERS

These spiders wander around seizing small arthropods and, amongst others, also citrus psylla adults. This has been observed for species of the Thomisidae like *Misumenops rubrodecorata* Millot and *Synaema* sp.

Many of these wandering spiders are nocturnal and construct tubular retreats of silk in which they spend part of the day. The retreats are often spun underneath young citrus leaves and occasionally over psylla nymphs. Because of the activities of the spiders, some of the nymphs crawl from where they are settled and become entangled in the silk strands. This has been observed with species like *Myrmarachne* sp. (Salticidae), *Chiracanthium lawrencei* Roewer and *Clubiona* sp. (Clubionidae). When the remaining nymphs reach adulthood, they are unable to escape, and crawl into the silk strands as observed for the two last mentioned species. Whether these spiders in fact feed on insects caught in their retreats, is still uncertain.

SPIDER SPECIES INVOLVED

Spider species observed to prey on or trap citrus psylla in their webs are listed in table 1 and those that trap them under their retreats or webs are given in table 2. Included in table 1 are those spiders which are already known to prey on citrus psylla (**Van den Berg** *et al.*, 1987a), and will be referred to as "a". Observations made during this study will be indicated by "or. obs.". This brings the number of species that cause mortality to citrus psylla to 22 (tables 1 and 2).

POPULATION FLUCTUATIONS OF SPIDERS

A total of 413 spiders were collected during 1987 and 2,641 during 1989. Of these there were 12 wandering and nine web-building families. The relative abundances of wandering

TABLE 1

Spider species that prey on adult citrus psylla

Family	Species	Reference*
1. Adult psylla present in webs		
Araneidae	*Araneus* sp.	a
	Cyclosa sp.	a
	Neoscona sp.	a
	Isoxya sp.	or. obs.
Dictynidae	*Lathys* sp.	a
Linyphiidae	*Microlinyphia* sp.	or. obs.
Metidae	*Leucauge medjensis* De *Lessert*	a
	Leucauge sp.	or. obs.
Nephilidae	*Nephila* sp.	or. obs.
Salticidae	Unidentified sp. (AcH 1031)	a
	Unidentified sp. (AcH 1460)	a
Tetragnathidae	*Tetragnatha* sp.	a
Theridiidae	*Achaearanea* sp.	a
	Enoplognatha sp.	a
	Theridion sp.	a
	Theridula sp.	a
2. Adult psylla preyed on		
Thomisidae	*Misumenops rubrodecorata* (Millot)	a
	Synaema sp.	or. obs.

* a = Van den Berg *et al.* (1987); or. obs. = original observation.

TABLE 2

Spider species that trapped citrus psylla under their retreats or webs

Family	Species	Stage of psylla trapped
Clubionidae	*Chiracanthium lawrencei* Roewer	Nymphs
	Chiracanthium sp.	Nymphs & Adults
	Clubiona sp.	Nymphs & Adults
Salticidae	*Myrmarachne* sp.	Nymphs & Adults
Theridiidae	*Achaearanea* sp.	Nymphs
	Theridion sp.	Nymphs

and web-building spiders sampled during 1987 are given in fig. 1a and 1b respectively and those collected in 1989 in fig. 2a and 2b. In terms of the total numbers caught over both survey periods, the Salticidae were the dominant family representing 34.4 % followed by the Theridiidae (21.9 %), Thomisidae (11.9 %), Araneidae (7.9 %), Clubionidae (7.0 %) and Tetragnathidae (3.7 %). The other 15 families represented only 13.2 %, each family containing less than 3.5 %.

Population fluctuations of citrus psylla

The citrus psylla populations were relatively high in January (about 13 % of total), declined to their lowest during June (1 %) and increased rapidly to peak in December (30 %).

Interaction between citrus psylla and spider populations

Comparisons of the population fluctuations of citrus psylla and spiders for 1987 and 1989 are given in fig. 1 and fig. 2 respectively. The weekly data were examined for each six month period separately and then for the full year. Significant positive correlations were found between the weekly adult psylla populations and the weekly populations of wandering spiders that occurred one and four weeks later (table 3) and between the weekly adult psylla populations and the weekly populations of web-building spiders present two, three and four weeks later. It is therefore possible that the psylla populations directly influenced populations of web-building spiders and to a smaller extent those of wandering spiders that were present in the orchard.

On the other hand, no significant correlations could be found between populations of wandering or web-building spiders and those of subsequent psylla populations. The best correlations for any of the six month periods varied from P.c.c. = − 0.0992 ($p = 0.6604$; $n = 22$) to 0.3311 ($p = 0.1060$; $n = 25$) for web-building spiders and P.c.c. = − 0.2447 ($p = 0.2725$; $n = 22$) to 0.0474 ($p = 0.8222$; $n = 25$) for wandering spiders. Spider populations did not therefore appear to directly influence the populations of the citrus psylla to any great extent.

DISCUSSION

Observations were made that, apart from preying on the citrus psylla, spiders also trap nymphs and adults under their retreats and webs. Furthermore, their webs also seem to protect the leaves from psylla infestations. This is in agreement with the report of **Fox & Griffith** (1976) that the presence of silken webs have a great overall effect on the reduction of pine aphids in Europe and that of **Riechert & Lockley** (1984) that insects are also removed from plants by the disruptive activities of spiders.

Spiders from 21 families were found in an unsprayed citrus orchard at Burgershall. The relative family composition is reasonably similar to those found in citrus orchards in Israel (**Shulov,** 1938; **Mansour & Whitecomb,** 1986), as well as California (**Carroll,** 1980) and Florida (**Mansour** *et al.,* 1982) in the U.S.A.

The most promising spider family in terms of natural control of citrus pests in California is the Clubionidae (**Carroll,** 1980) and in Israel the Clubionidae and Theridiidae (**Mansour & Whitecomb,** 1986). Members of these families found during the present studies represented 6.9 % and 22.5 % of the total respectively. Furthermore, the genera *Chiracanthium, Clubiona* (Clubionidae) and *Theridion* (Theridiidae) found in Israel and California, were also found during the present investigations.

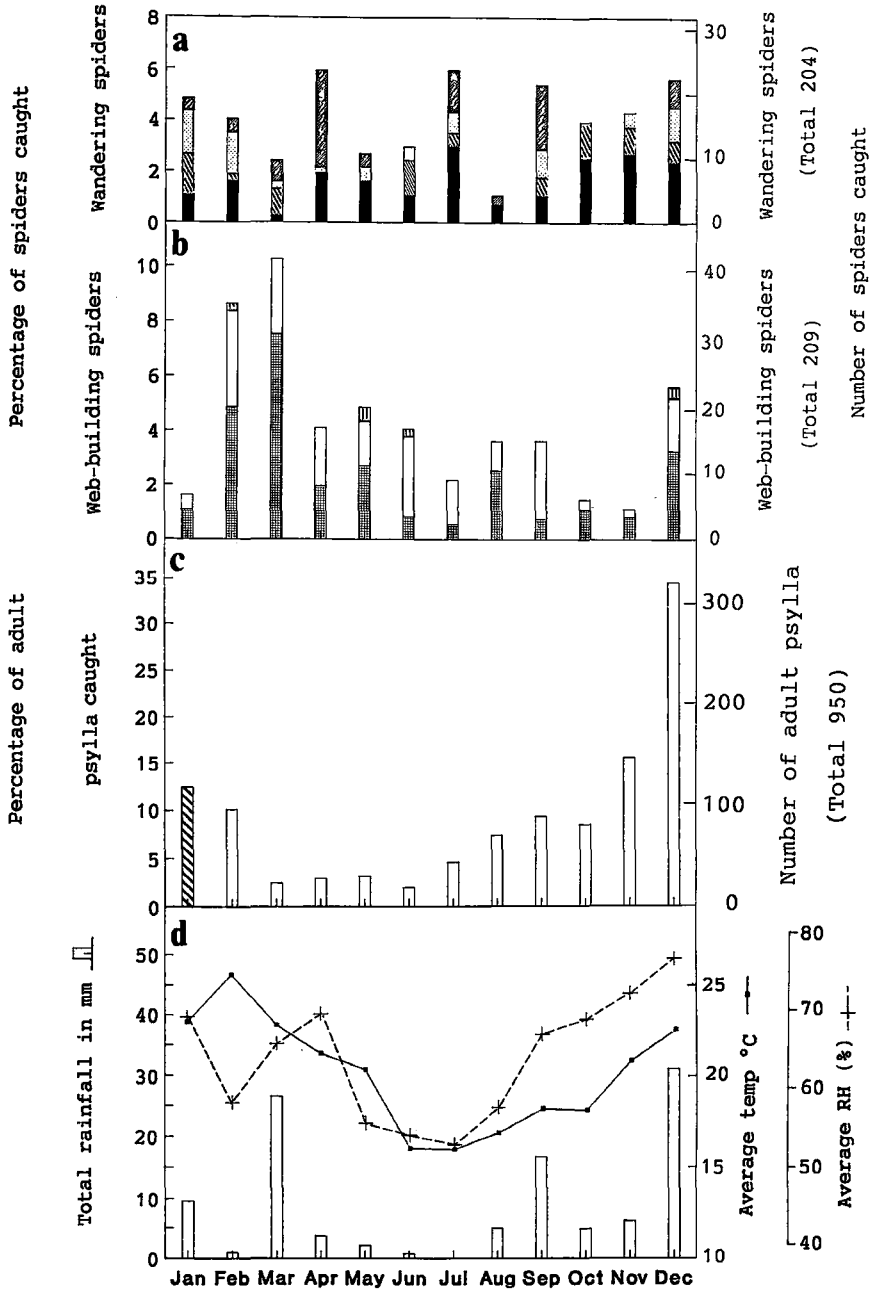

Fig. 1. Relative abundance of spiders caught on 10 and adult psylla on 20 citrus seedlings at Burgershall during 1987 (fig. 1a Wandering spiders : ■ = Salticidae, ▨ = Thomisidae, □ = Clubionidae, ▨ = Other families ; fig. 1b Web-building spiders : ▦ = Theridiidae, □ = Araneidae, ▥ = Other families ; fig. 1c Citrus psylla adults ▨ = counts, ▥ = estimated ; fig. 1d Meteorological data - monthly).

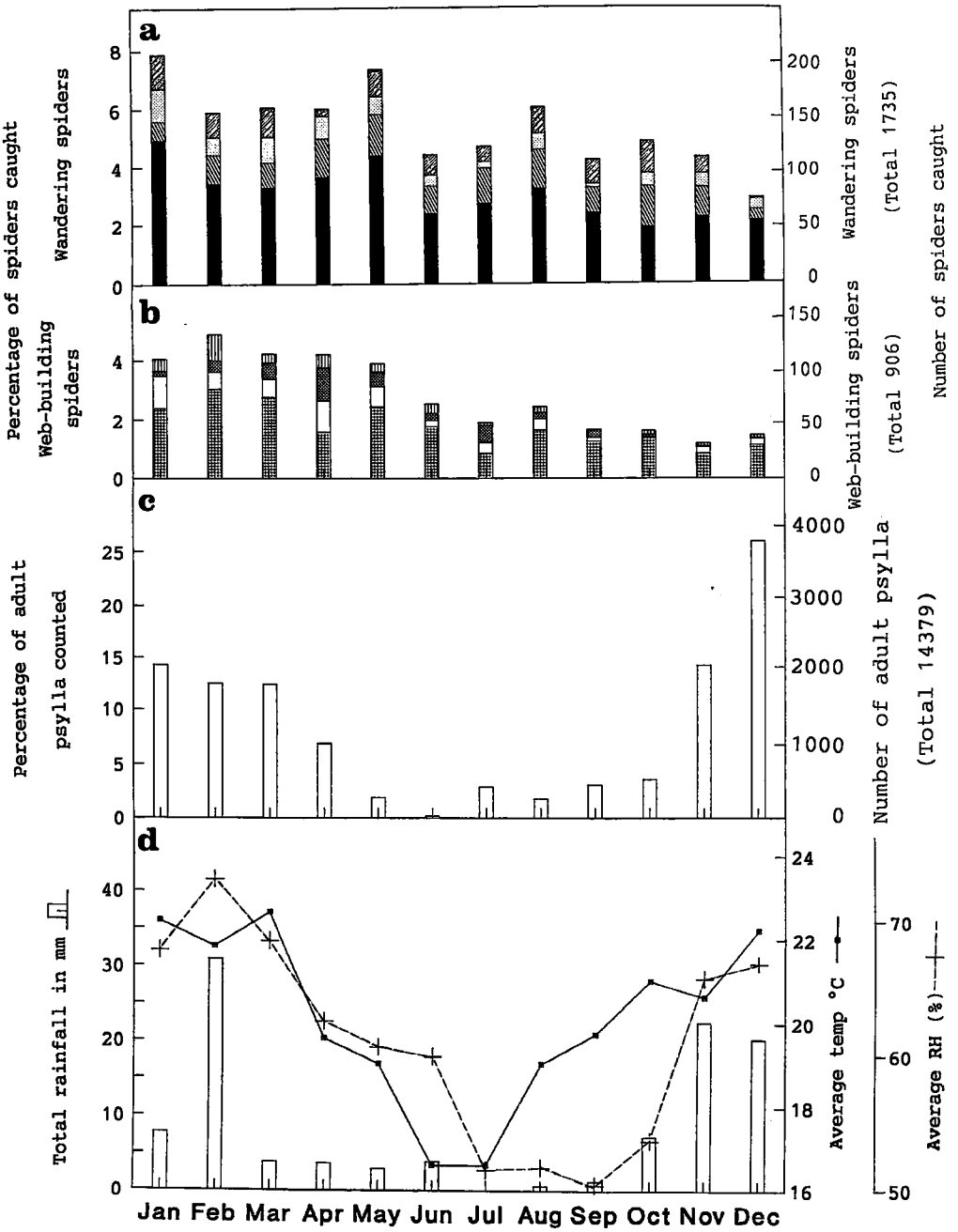

Fig. 2. Relative abundance of spiders caught on 50 and adult psylla counted on 100 citrus seedlings at Burgershall during 1989; (fig. 2a Wandering spiders: ■ = Salticidae, ▨ = Thomisidae; □ Clubionidae, ▨ = Other families; fig. 2b Web-building spiders: ▦ Theridiidae, □ = Araneidae, ■ = Tetragnathidae, ▥ = Other families; fig. 2c Citrus psylla adults ⊡: fig. 2d Meteorological data - monthly).

TABLE 3

Significant correlations between the weekly populations of citrus psylla adults and the weekly populations of wandering and web-building spiders that occurred either 1, 2, 3, 4 or 5 weeks later [Pearson's correlation coefficient (P.c.c.)]

Correlations between psylla adults and :	Part of year	P.c.c.	p*	n
Wandering spiders one week later	First half of 1987	0.4721	0.0229	23
	Second half of 1987	0.5379	0.0067	24
	Full year 1987	0.5050	0.0148	47
Wandering spiders four weeks later	Second half of 1989	0.1912	0.0475	21
Web-building spiders two weeks later	Second half of 1987	0.5982	0.0026	23
	Full year 1987	0.4987	0.0341	45
Web-building spiders three weeks later	First half of 1987	0.7085	0.0003	21
	First half of 1989	0.6253	0.0006	26
Web-building spiders four weeks later	First half of 1989	0.6671	0.0002	26
	Second half of 1989	0.5039	0.0001	21
	Full year 1989	0.5942	0.0001	47

* Correlations are significant where $p \leqslant 0.05$.

The population size of the psylla adults may have directly influenced populations of wandering and web-building spiders. However, spider populations did not appear to significantly influence the adult psylla population in the orchard. This is in accordance with the statement of **Riechert & Lockley** (1984) that in the long term no spider species can hold a prey population in check but that spiders can be stable assemblages, which remove significant numbers of insects from the systems through their predatory and disruptive activities.

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RÉSUMÉ

Interactions entre le Psylle du Citrus, *Trioza erytreae* [*Hem. : Triozidae*] et les araignées dans un verger de Citrus non traité dans le Lowveld Transvaal

Une étude effectuée sur 2 années dans un verger de Citrus non traité du Lowveld Transvaal a permis de répertorier 3 054 araignées appartenant à 21 familles. Sur le plan numérique, la famille la plus importante était celle des Salticidae (34,2 %), suivie par les Theridiidae (22,5 %), les Thomisidae (11,7 %), les Araneidae (8,1 %), les Clubionidae (6,9 %) et les Tetragnathidae (3,6 %).

On a observé une prédation sur le Psylle du Citrus, *Trioza erythreae*, chez 18 espèces d'araignées alors que 6 espèces capturaient les nymphes et les adultes dans leurs retraites et dans leurs toiles. Il y avait des corrélations positives significatives entre les populations hebdomadaires du psylle et les populations hebdomadaires d'araignées, qui tissent des toiles ou qui chassent en se déplaçant, présentes 1 à 4 semaines plus tard. Par contre, il n'a pas été trouvé une corrélation significative entre les populations hebdomadaires d'araignées et les populations hebdomadaires de psylles présentes 1 à 5 semaines plus tard.

Ces résultats semblent indiquer que si les araignées sont incapables de maintenir les populations de psylles des Citrus à des niveaux acceptables, elles contribuent toutefois à réduire leur nombre.

MOTS CLÉS : *Araneae, Citrus, Trioza erytreae,* prédation.

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