PARASITISM OF *FRANKLINIELLA AUSTRALIS* (THYSANOPTERA: THRIPIDAE) BY *THRIPINEMA KHRUSTALEVI* (TYLENCHIDA: ALLANTONEMATIDAE) ISOLATE CHILE

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ABSTRACT

Thripinema khrustalevi (Chizov et al.) isolate Chile, a parasite of *Frankliniella australis* (Morgan), was collected from *Cestrum parqui* (L'Herit.) in the Aconcogua Valley of central Chile. Percent infection of males and females of *F. australis* by *T. khrustalevi* in the flowers of *C. parqui* was estimated biweekly for two years at three locations, including the La Campana National Park. Males were less infected than females. Numbers of *F. australis* adults and larvae in the flowers of *C. parqui* were greatest in the winter and early spring when parasitism of the adult females was low. Populations declined in late spring when parasitism was high. Parasitism remained high through the summer and fall, and populations of thrips remained very low. Highest parasitism of the females and males of *F. australis* was 84 and 60%, respectively.

Key Words: biocontrol, description, *Frankliniella australis*, insect parasitic nematode, nematode, parasite, *Thripinema khrustalevi*, Thysanoptera

RESUMEN

Individuos de *Thripinema khrustalevi* (Chizov et al.) parasitando al trips *Frankliniella australis* (Morgan) fueron colectados en *Cestrum parqui* (L'Herit.) en el valle de Aconcagua en Chile central. El porcentaje de machos y hembras de *F. australis* infestados por *T. khrustalevi* en flores de *C. parqui* fue estimado cada dos semanas durante dos años en tres localidades, incluido un sector del Parque Nacional La Campana. La cantidad de adultos y larvas de *F. australis* en flores de *C. parqui* fue mayor en invierno e inicio de primavera cuando el parasitismo de las hembras adultas fue bajo. Las poblaciones disminuyeron a fines de primavera cuando el parasitismo fue alto, permaneciendo así durante todo el verano y otoño, observándose poblaciones del trips muy bajas en el mismo periodo. Las tasas más altas de parasitismo de *F. australis* fueron de 84 y 60%, en hembras y machos, respectivamente.

Palabras Clave: control biológico, descripción, *Frankliniella australis*, nemátodo parásito de insecto, nemátodo, parásito, *Thripinema khrustalevi*, Thysanoptera

Translation provided by author.

Nematodes infesting Thysanoptera were first recorded from Europe by Uzel (1895) and from North America by Russell (1912). Neither species was described. Sharga (1932) described a nematode as *Tylenchus aptini* from *Aptinothrips rufus* (Gmelin) collected in England. Lysaght (1936) proposed the taxon *Anguillulina aptini* for this species. Wachek (1955) transferred the species to the genus *Howardula*. Nickle and Wood (1964) reported *Howardula aptini* infecting *Frankliniella vaccinii* Morgan and *Taeniothrips vaccinophilus* Hood collected in blueberry.

Siddiqi (1986) created a new genus, *Thripinema*, based on host range and the oval shape of the parasitic female. His revision of the genus included renaming the nematodes described by Sharga (1932), Nickle and Wood (1964), and Reddy et al.(1982) as *T. aptini*, *T. nicklewoodi*, and *T. reniraoi*, respectively. Chizov et al. (1995) described *Thripinema khrustalevi* from the thrips hosts, *Thrips trehernei* Prisner and *T. physopus* L. Tipping et al. (1998) described *T. fuscum* from *Frankliniella fusca* (Hinds) in peanut. Teulon et al. (1997) reported an unidentified species of *Thripinema* infecting *Thrips obscuratus* (Crawford) in New Zealand.

Loomans et al. (1997) reviewed the biology and life cycles of *Thripinema* species. One heterosexual generation develops in the haemocoel of the adult thrips abdominal and thoracic cavities. The oviparous parasitic female releases eggs into the haemocoel and the motile vermiform larvae feed on the thrips' internal fluid. Mature larvae exit the host by boring through the wall of the midgut. From the midgut, the larvae move to the pyriform rectum where they reside for a period before issuing from the anus (Sharga, 1932; Lysaght, 1936) or the ovipositor (Reddy et al., 1982). Little is known about the free-living stage. The female attaches to and enters the thrips host by boring through the soft intersegmental membranes (Lim et al., 2001). Loomans et al. (1997) noted that there was no record of a parasitized male thrips, but Tipping et al. (1998) noted that males of *F. fusca* collected in peanuts were frequently infected by *T. fuscum*. In laboratory experiments, male *F. occidentalis* were parasitized by *T. nicklewoodi* as readily as the females (Lim et al., 2001).

Sharga (1932) reported that infection of *A. rufus* by *T. aptini* in the UK was lowest in March (12.3%) and highest in July (37.5%). Lysaght (1937) reported a maximum of 64% in late August and early September, and infection levels less than 10% from November to March. Reddy et. al. (1982) determined from weekly samples that percent infection of a population of *Megaluriothrips* sp. by *T. reniraoi* in India ranged between 45 and 63%. Infection of *T. trehernei* by *T. khrustalevi* in Russia ranged between 10 and 50% (Chizhov et al. 1995). The highest percent infection of *F. fusca* females by *T. fuscum* in Florida observed by Tipping et al. (1998) and Funderburk et al. (2002) was 68%.

Surveys of the natural enemies of thrips in Chile were begun following the accidental introduction of *Frankliniella occidentalis* (Pergande) in 1992. Nematodes were found infecting a native species of thrips, *Frankliniella australis* (Morgan). Morphological and morphometric studies show that the nematode is closely related to *Thripinema khrustalevi.* In this paper we consider the nematode as *T. khrustalevi* isolate Chile. The nematode was first discovered infecting thrips collected in the La Campana National Park. *Cestrum parqui* (L'Herit.) (Solanaceae) is a native plant species that serves as a reproductive host for populations of *F. australis* and *F. occidentalis* in Chile. We report the infection rates of *F. australis* in the flowers of *C. parqui* from three locations in the Aconcogua Valley of Central Chile. Population densities of thrips and other natural enemies of thrips also are reported.

Materials and Methods

Estimating Weekly Infection Rates

The three locations sampled were: (1) La Campana National Park near the access gate to Sector Ocoa, (2) near the city of Quillota, and (3) near the city of Llay Llay. Flowers of *C. parqui* were present on most sample dates from May 1999 to June 2001. From 15 to 20 females of *F. australis* were dissected from each of four samples of about 10 inflorescences randomly collected on each sample date at each location, and the number parasitized was determined. Densities of male thrips were always less than densities of females, and estimates of parasitism of males were not possible on some dates. Further, only 5 males were dissected from each of four samples on dates when males were present in adequate numbers. Parasitism of males was estimated on 12, 12, and 20 sample dates at the Llay Llay, Quillota, and La Campana locations, respectively. Adults of *F. occidentalis* also were dissected. Percent infection of males and females at each location transformed to arcsine square root were subjected to ANOVA and significant differences were determined using a t-test.

Thrips were dissected under a stereomicroscope at ×35 in distilled water and considered infected if any stage of the nematode was detected. The swollen females, eggs, and juvenile stages were easily detected during dissection. These stages are present in thrips within several days of infection by the infective-stage females (Lim et al., 2001). Prior to swelling, an infective-stage female in the absence of other stages of nematodes sometimes went undetected during dissection. To determine how much parasitism was being underestimated with the dissection procedures, 20 females on 9 to 12 dates depending on the location were maintained individually for 7 days and then dissected. This method provided percent infection that was consistently about 10% greater than the estimate of percent infection from females dissected immediately after collection.

Estimating Densities of Insect Populations

Four samples of five open flowers were collected biweekly from October 1999 to June 2001 at each of the locations listed above. Flowers were placed in vials containing soapy water and returned to the laboratory for processing. Samples were examined under a stereoscope at x35, and the numbers of thrips and natural enemies determined.

Results and Discussion

Adults of *F. occidentalis* collected from the flowers were never infected by *T. khrustalevi* isolate Chile. Similarly, Funderburk et al. (2002) reported that infection of *F. occidentalis* by *T. fuscum* in peanut flowers was rare. Adults and larvae of *F. occidentalis* were readily infected under laboratory conditions (unpublished data). The reason that these field populations of *F. occidentalis* were not parasitized by *T. fuscum* or *T. khrustalevi* is not clear. *Thripinema nicklewoodi* is an important parasite of *F. occidentalis* in the western USA (Loomans et al., 1997), and the species has potential for biological control if introduced into Chile or other geographic regions.

Adults and second instars of *F. australis* collected from the flowers of *C. parqui* were parasitized. The ovaries of the infected females were reduced and eggs absent. After entering the

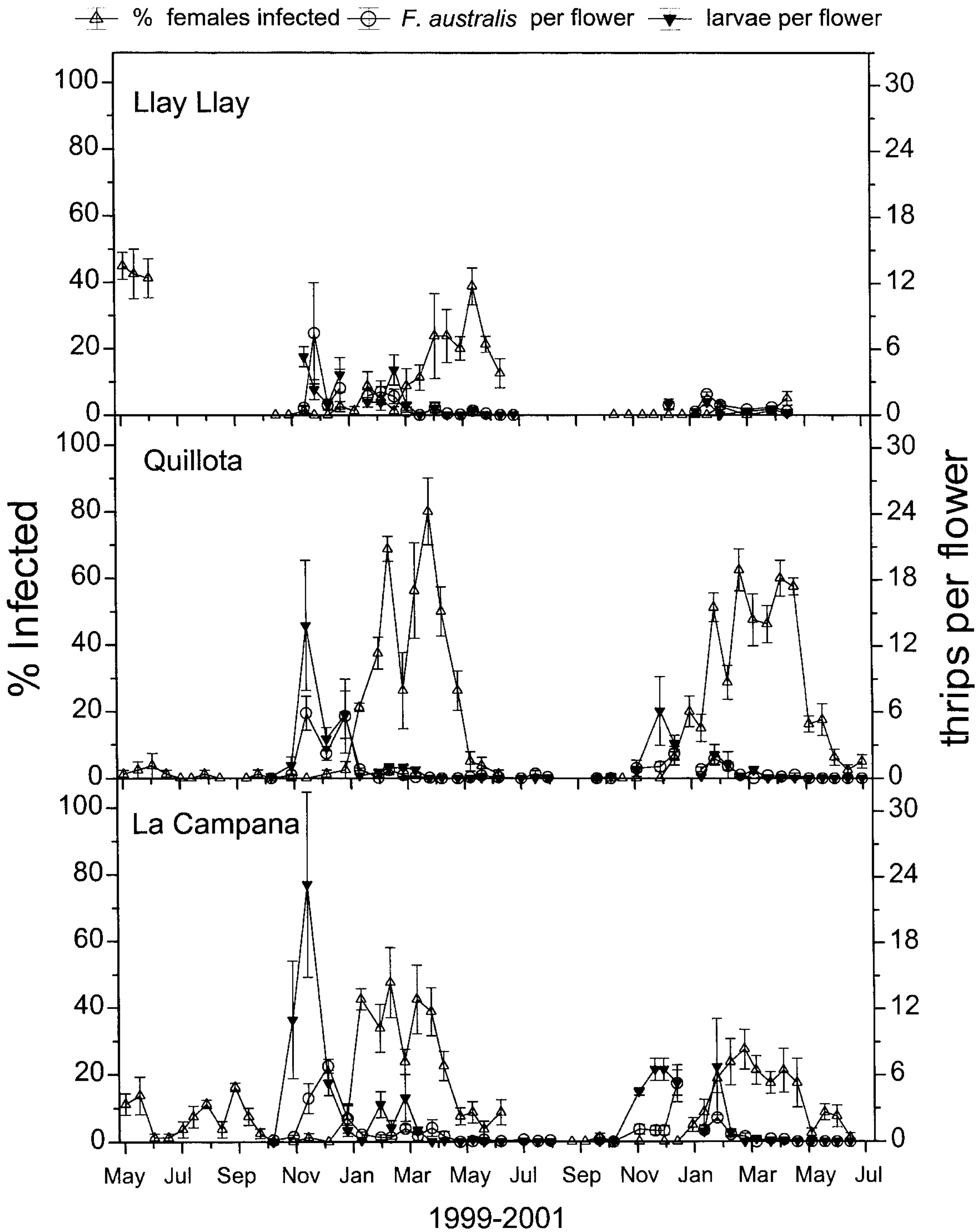

Fig. 1. Mean number (±SEM) of adult and larval *F. australis* and mean percent parasitism (±SEM) of the females of *F. australis* from biweekly samples taken between May 1999 to June 2001 at three locations in central Chile (Region V).

thrips host, the females of the new isolate change into the characteristic swollen shape of the genus, and the ovary becomes convoluted with numerous flexures. Up to several hundred nematodes were observed in individual females of *F. australis*. All stages of the nematode were observed in infected males and females. Males and females of *T. fuscum* were observed exiting the thrips via the anus as reported by Lysaght (1937) for *T. aptini*, Nickle and Wood (1964) for *T. nicklewoodi*, and Tipping et al. (1998) for *T. fuscum*.

Open flowers of *C. parqui* were present on nearly all sample dates from May 1999 to June 2001 at the Quillota and La Campana locations (Fig. 1). Flowering was suppressed during the winter and there were several sample dates in July and August 2000 when population densities and % infection of thrips could not be estimated because of a scarcity of open flowers at these locations. Temperatures were lower at the Llay Llay location, and open flowers were not available for sampling for several months each winter. About 96% (range 95 to 97% between the locations) of the adult thrips in the flower samples were *F. australis*, with the remainder being *F. occidentalis*. No natural enemies other than *T. khrustalevi* were observed that could have contributed significantly to suppression of populations of thrips. The only predator in the flower samples was *Orius insidiosus* (Say), but only four adults and nymphs were found total in all of the samples. A total of 13 adults of *Ceranisus menes* (Walker) (Hymenoptera: Eulophidae), a larval parasite of thrips, were collected.

Numbers of *F. australis* increased greatly in the *C. parqui* flowers each year in October/early November when levels of % parasitism of the adult females was very low (Fig. 1). Adults and larvae were abundant through the remainder of each spring. Populations of adults and larvae decreased to near extinction in February, persisting in low numbers until the following spring. Parasitism of the adult females increased each January and was high at each location through the summer and fall until the beginning of winter in May/early June. Parasitism of males was almost always less than parasitism of females (data not shown). On dates when parasitism of males and females was estimated, % parasitism of males vs females averaged 9.2 (range 0 to 35) vs 15.2 (range 0 to 45), 11.3 (range 0 to 60) vs 16.8 (range 0 to 69), and 4.5 (range 0 to 35) vs 16.8 (range 0 to 42.5) at the Llay Llay, Quillota, and La Campana locations, respectively. Parasitism of the females was significantly greater at the La Campana location, according to the t-test (error df = 158, $P < 0.0001$) and the difference approached significance at the Llay Llay location (error df = 94, $P = 0.08$).

Reported cases of suppression of thrips populations by natural enemies were lacking until recently (Parrella and Lewis, 1997), and the population attributes of thrips including rapid colonization and growth were believed to possibly outstrip the capacities of natural enemies to regulate populations (Mound and Teulon, 1995). Funderburk et al. (2000) and Ramachandran et al. (2001) showed that *O. insidiosus* suppressed rapidly colonizing and developing populations of thrips in pepper. Funderburk et al. (2002) showed that *T. fuscum* was an important natural enemy affecting the population dynamics of *F. fusca* in peanut. Several other investigators reported high levels of infection during summer and fall for other species of *Thripinema* (Sharga, 1932; Lysaght, 1937; Reddy et al., 1982) which may indicate that natural suppression of thrips populations under local conditions by species of *Thripinema* is widespread. We conclude in this study that *T. khrustalevi* isolate Chile is an important natural enemy of *F. australis* in *C. parqui*.

ACKNOWLEDGMENTS

The authors thank K. B. Nguyen (Department of Entomology and Nematology, University of Florida) for the identification of the nematode *Thripinema khrustalevi*, and L. E. Mound (Division of Entomology, Commonwealth Scientific and Industrial Research Organization) for verifying the identification of *Frankliniella australis*. Stuart Reitz (USDA-ARS) and Russell Mizell (North Florida Research and Education Center, University of Florida) made comments on the manuscript. Ruby Mariana Silva Cutbill provided encouragement and permitted the sampling on her eco-tourism ranch in Quillota, Chile. We are thankful to the park rangers at the La Campana National Park for their many assistances. This article is Florida Agricultural Experiment Station Journal Series number R-08739.

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