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Exploration for hymenopterous parasitoids of thrips

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Abstract

As part of a project to evaluate parasitoid species as biological control agents against western flower thrips, *Frankliniella occidentalis* (Pergande), a survey was made in its native (United States) and newly invaded areas of distribution (Europe). In addition, parasitoids were collected form closely related *Frankliniella* and *Thrips* species, either by active search or by correspondence. Two parasitoid species, the eulophids *Ceranisus menes* (Walker) and *Ceranisus americensis* (Girault) were collected as female adults and parasitised hosts from wild vegetation and cultured crops, infested with *F. occidentalis* and related species at several locations in Europe and elsewhere. They were subsequently processed, shipped and reared in the laboratory, together with their thrips hosts. Methods for collecting, processing and shipment of both thrips and parasitoids are described and preliminary rearing results are presented.

Key words: *Frankliniella occidentalis*, *Ceranisus menes*, *Ceranisus americensis*, thrips parasitoids, foreign exploration.

Introduction

Since its first introduction in 1983, western flower thrips, *Frankliniella occidentalis* (Pergande), has rapidly spread throughout Europe and currently is a key pest in many greenhouse crops. Its great economical impact, because of direct damage to flowers and fruits, made fast actions necessary. These first concentrated themselves on chemical applications, but because these severely hampered IPM programmes already in use, major efforts were put into improvement and development of biological control methods. Research has largely focussed on predators and, more recently, on pathogens. Although this has resulted in a satisfactory solution for some crops, thrips pests cannot be controlled in a number of other crops. No previous attempts have been made using hymenopterous parasitoids as biological control agents of *F. occidentalis*. A literature review showed that, at the start of the project, no parasitoids were known to attack and develop on *F. occidentalis* specifically. Only one, *Ceranisus americensis* (Girault), had previously been found in association with *F. occidentalis* infesting alfalfa in Alberta-Canada in 1922 (Seamans, 1923). No proof was available of its ability to attack and develop on western flower thrips and it had never been reported since. On the other hand, a number of parasitoid species had been recorded from closely related thrips pest species within the genera *Frankliniella* (e.g. *Frankliniella intonsa* Trybom, *Frankliniella schultzei* Trybom) and *Thrips* (*Thrips tabaci* Lindeman, *Thrips palmi* Karny) all belonging to the same subfamily (Thripidae Thripinae) (Loomans and van Lenteren, 1990; 1995). Literature reviews also showed that thrips parasitoids are specific to species within the same (sub)family of Thysanoptera and that no negative side-effects, such as parasitising beneficials (like predatory thrips) or hyperparasitism, had been found. Based on host records and geographic distribution records, my interest was at first directed at species belonging to the genus *Ceranisus* (Walker) (Hymenoptera Eulophidae), solitary larval parasitoids of thrips species that are closely related to *F. occidentalis.* In this paper , we present the result of my exploration for parasitoids of *F. occidentalis* and describe and discuss methods for their collection, processing and shipment.

Materials and methods

Selection of exploration areas

Research on parasitoids of *F. occidentalis* had to start almost from scratch. Since only few parasitoid species of thrips had been reared in the laboratory until 1990, sampling *Frankliniella* populations in the field would be an important means to collect potential candidates. Previous experience in selecting the best natural enemy for a particular pest, showed that all options should be open and combinations of exotic and indigenous pests and natural enemies are worthwhile trying (van Lenteren, 2000). Therefore we followed a threefold approach:

1. Exploration in its native home (USA)

A major part of the search was concentrated on sampling *F. occidentalis* populations in its original area of distribution (Southwest USA, Northwest Mexico). A central theory of classical biological control says that the best prospect for finding natural enemies of a particular pest will be found at the pest's evolutionary centre-of-origin (DeBach, 1964; Rosen and DeBach, 1992; Bellows and Legner, 1993). Many explorations for natural enemies (Van Driesche and Bellows, 1996; González *et al*., 1993, 1994) have followed this approach with great success. West of the Rocky Mountains, i.c. California, Arizona and Mexico, *F. occidentalis* is infesting outdoor agro-ecosystems (field crops and orchards: Bryan and Smith, 1956; Pearsall and Myers, 2000) as well as natural habitats (Bailey, 1938, 1957; Goeden and Ricker, 1968, 1974ab, 1976abc, 1986abc, 1987ab, 1989; Yudin *et al*., 1986,1988; Pearsall and Myers,

2000) and this area has a high diversity of species in the genus *Frankliniella* (Sakimura and O' Neil, 1979; Mound and Marullo, 1996). In this way also climatic conditions of the regions of origin were matched with those of the "target" areas in Europe: greenhouses in the temperate and Mediterranean area and field crops in the Mediterranean area.

2. Exploration in newly invaded areas (Europe)

On the other hand, neo-classical biological control theory (Hokkanen and Pimentel, 1984, 1989), indicates that new combinations of a pest and a natural enemy (Carl, 1982) are likely to result in successful biological control results. Therefore, besides regular sampling of *Frankliniella* populations in The Netherlands, other newly invaded areas were explored as well. The Mediterranean area seemed the most appropriate region to search for thrips parasitoids, because:

- this region probably is most similar to the ecological conditions of glasshouses in northwest Europe and the original area of distribution of the western flower thrips, California; in this region *F. occidentalis* rapidly has become a major pest, in protected as well as outdoor crops (Spain 1986 - Lacasa, 1990; Portugal 1989 - Mateus and Mexía, 1995; France 1986 - Bournier and Bournier, 1987; Italy 1988 - Arzone *et al*., 1989);
- most recent records on field observations of parasitoids attacking thrips originated from the Mediterranean Area (France: CAB, 1971; Dessart and Bournier 1971; Italy: Domenichini, personal communication, 1990; Greece: Gijswijt, personal communication, 1990. Twelve parasitoid species, attacking thrips species, have been described from Europe, five of them from this region. It was thought that the chance of finding parasitoids would be greatest at the end of the season, when *F. occidentalis* and crops were still present and there would have been a parasitoid population build-up during the summer.

3. Exploration for related host species worldwide

Besides that we also included populations of closely related *Frankliniella* and *Thrips* species, distributed world wide, preferably from areas with climatic conditions similar to European glasshouse conditions. Collection of this parasitoid material was done either through correspondence with colleague researchers or by active search in the field. Infested field crops and flowering wild vegetation were searched for adult parasitoids and sampled for thrips larvae.

Site selection within the collection areas

F. occidentalis is known for its very wide host range and hidden life-style: eggs are laid inside host plant tissue, larvae and adults are feeding on leaf and flower tissues and pollen. Adults and larvae are often found inside flowers ('western flower thrips'). Similar niche preferences are known for *F. schultzei* ('cotton bud thrips') and *F. intonsa* ('flower thrips'). There is a large amount of literature available on collecting and culturing either thrips or parasitoids. Little or no information, however, was available on the combination of both groups. The review of literature provided important information on known parasitoids of thrips, the European thrips species and their host plants, and methods to collect, monitor and rear parasitoids (Loomans and van Lenteren, 1995). Specialists working on thrips, parasitoids or both, taxonomists as well as researchers of biocontrol were requested for information on the occurrence and collection of parasitoids and thrips in the South of Europe and Western USA. Collection was performed by sampling *F. occidentalis* populations in its original area of distribution (USA) and newly invaded areas (South of Europe), and on closely related species like *T. tabaci*, distributed worldwide, preferably in areas with climatic conditions similar to Northwest European glasshouses. Collection of parasitoid material was done either through correspondence with colleague researchers or by active search. Infested field crops and flowering wild vegetation were searched for adult parasitoids and sampled for thrips larvae.

In selecting habitats, we directed our search to agroecosystems, infested with *F. occidentalis* which thrips parasitoids might invade, as well as natural ecosystems. During my collection trip in the South of Europe, in 1990, we concentrated our search to the major vegetable growing areas: Provence (France), Maresme, Valencia and Murcia region (Spain) and Emilia Romagna, Po Valley and Tuscany (Italy). In this latter region, we made additional collections in 1991. In these regions several crops, vegetables (tomato, cucumber, pepper, bean, lettuce and strawberry) as well as ornamentals (carnation, chrysanthemum and others), field crops as well as protected crops, were searched and sampled for thrips parasitoids. Special attention was paid to crops that were controlled biologically or grown organically, and thus not intensively treated with pesticides, as well as to abandoned crop-sites, field-edges and glasshouse surroundings. Crops searched were cucumber, sweet pepper, egg-plant, piment, strawberry and French bean (vegetables), gladiolus, carnation, chrysanthemum and rose (ornamentals), alfalfa, onion and leek. During travelling in between these areas wild vegetation, especially flowers, was searched in natural, undisturbed sites, including roadsides, sides of ditches, ruderal places, parking lots and pastures (grassland). In the USA (California, Arizona) and Mexico (Mexicali area), a more or less similar programme was followed, but there we largely focussed our search on natural ecosystems (roadsides, ruderal sites, desert shrubs) and agroecosystems (field crops, orchards, gardens). Colleagues working on biocontrol and familiar with the local occurrence of thrips infestations and language helped me out.

In the Netherlands, thrips infested field crops (pea, onion, leek, cabbage) and wild vegetation were sampled regularly from late spring till early fall from 1990 till 1996. Occasionally, protected crops were sampled as well. Areas, sites and habitats searched for thrips parasitoids in The Netherlands:

- Natural vegetation along roadsides, field-edges, dikes and ditches: Ede-Utrecht (N224), Wageningen-Utrecht (N225), Ewijk-Hedel (N322), Ravenstein-Sevenum (N277), Lierop-Veghel (N266)-Ravenstein (N265),

Arnhem-Zutphen (N48)-Borne (N346), Nijmegen-Arcen (N271), Deventer-Hoogeveen (N48), Goeree-Overflakkee, Westland, Berkel en Rodenrijs, Noord-Limburg, Betuwe (Waaldijk), Peelland (N270), Slagharen-Hardenberg, Veluwezoom, Zuid-Limburg;
- Cultivated crops in greenhouses, open fields and gardens, or as undergrowth in orchards, meadows and pastures.

Collection: equipment and methods

For field collections of live thrips and parasitoids we used general devices and followed advises described earlier by Sakimura (1937), Lewis (1973), Bournier (1983) for Thysanoptera and Noyes (1982, 1989) and Steyskal *et al*. (1986) for Hymenoptera (see also Schauff, 1999) and general handbooks such as Huffaker and Messinger (1976) and DeBach (1964). Equipment included sweep-nets, beating trays (black and white), white blotting paper sheets (60 x 40 cm), various aspirators (constructed from a 60 cm piece of plastic tubing, a piece of gauze material (80 mesh) and disposable transparent pipette tip, 9.3 Ø mm, the outer edge of which fits tightly into the inner edge of an Eppendorf tube®, Ø 9.34 mm), various marten hair brushes (size 10 and 15, 00 and 000), large and small plastic vials, reaction tubes (Eppendorf®) and boxes to store these (Boehringer Mannheim 800058, 50 units each), food (honey, pollen, water, bean pods), field-rearing units (jars, plastic rings, Sealon-film: see below), preservation material (either alcohol 70% or AGA (ethanol: acetic acid: glycerol: water), syphons and various additional laboratory tools (various pairs of tweezers, droppers, preservation needles, scalpels, scissors, hand-lenses, min.-max. thermometer, pencils, etc.). While travelling we stored most of this equipment in a special easy-to-carry kit, originally designed for storing fisherman's tools (Albatros®). Methods for collection, processing, and small-scale rearing of both thrips and beneficials are described as well by Steiner *et al*. (1996) and Steiner and Goodwin (1996).

The method of collection varied with the situation and no special sampling plan was followed. We basically followed 3 methods of collection and trapping:

1. Sampling field crops, pastures and roadside vegetation, in general those stands consisting out of a single plant species by using a sweep-net (for collection of live and reference material), for instance alfalfa fields, clover undergrowth (USA, Mexico), *Polygonum* bushes (France, Italy). Plots were sampled by making at least 50 sweeps per plot; if no adult parasitoids or thrips larvae were found, the sampling was stopped. When thrips larvae were present, we both sampled first and second larval instars. These larvae were transferred into aerated glass tubes (± 50 larvae/tube with additional food, usually a host plant flower or leaf) until further processing.
2. Sampling individual plants, by beating in particular the flowering heads or growing points, over a white, occasionally black tray or paper sheet (for collection of live and reference material); Sampling individual plants for thrips larvae by collecting thrips infested leaves; these were stored in a plastic or paper bag until processing, usually later on the same day (for the collection of live thrips larvae);
3. Monitoring seasonal occurrence of a parasitoid population (phenology) by using sticky traps.

The presence of thrips and parasitoids on the sampling site was verified by tapping flowers, beating vegetation above a white surface (tray or blotting paper). The majority of samples were preserved as a reference source for future collections. However, wherever possible, live beneficials were collected and reared in the laboratory for assessment as effective controlling agents for thrips.

Storage and processing

Parasitoids and thrips specimens were collected and processed on the spot, using an aspirator, putting live adult parasitoids and thrips in an Eppendorf tube with a droplet of honey and some reference thrips adults on alcohol in an Eppendorf tube. Occasionally, whole plants were individually put into a bag and taken into the laboratory for further processing of the material, separating parasitoids and thrips adults and larvae as mentioned above or putting them in an emergence box (ventilated, dark enclosure, with an Erlenmeyer or plastic vial on top or side. Adult parasitoids found were aspirated and put into vials supplied with honey and stored in cooling boxes. Live plant material was stored in bags respectively until processing. In warm and hot climate conditions, like prevailing in southern Europe and the United States, keeping the material cool is a prerequisite for preserving live material. A refrigerator, working on the battery of the car or a cooling box with cooling elements, could solve this problem during part of the day (about 12-15 °C). Later that day parasitoids were offered young thrips larvae, using the rearing methods described below. Rearing was done partly in the trunk of the car (20-35 °C), partly in laboratories and hotel rooms on the way. Samples of larvae collected were transferred into rearing tubes. No dissections of larvae were made. At every sampled spot, adult thrips were collected and put on alcohol 70 % or AGA for identification. Adult parasitoids were stored live at 15 °C until usage and larvae were reared until pupation and subsequently shipped to Wageningen.

Travel-rearing units

While being en route, we reared part of the collected adult parasitoids and thrips larvae on freshly hatched thrips larvae. The materials and methodology used basically followed that of the laboratory rearing set-ups described Murai and Loomans (2001). We used both the artificial method on pollen and honey-water and the bean-pod method for rearing thrips (*F. occidentalis* while travelling in the USA and Europe; *F. intonsa* while travelling in the south of Europe). The pollen-water units were stored in closed plastic boxes, bean jars in open boxes, both as much shockproof as possible, in the back of the car, while travelling or in the hotel room. Some rearing units were placed in a climate room, office or laboratory at a base camp (Cavaillon-France, Riverside-California). Adult thrips cultures (oviposition units) could be maintained rather well, producing even-aged cohorts of larvae. Culturing the emerged and para-

sitised larvae to maturity, however, proved to be rather difficult, because of a lack of fresh food and light (back of the car), but largely because of condensation inside the jars and rings, due to (slight) changes in temperature.

Field-cultures

Field collected adult parasitoids readily attacked first stage larvae of *F. occidentalis* when brought into contact with them. While travelling, however, rearing was mostly unsuccessful, due to hot climate conditions. Therefore in almost all cases, adults collected during the trip were shipped to the Laboratory of Entomology for further processing (USA-material) and those collected at the end of the trip were stored at 12 °C and personally taken to my laboratory. Maintaining a thrips culture at a base station (Cavaillon, France; Riverside, USA) resulted in some additional offspring, but conditions and maintenance intervals were inappropriate. Artificial rearing of sampled larvae on pollen and honey-solution was more successful (table 1). However the rearing system used was quite vulnerable under travelling conditions and a number of rearing efforts failed because of that. Parasitoids and thrips both reared from a single batch of sampled larvae (table 1) can give an indication of the possible relationship between *Ceranisus menes* (Walker) (Hymenoptera Eulophidae) and the thrips species found.

Shipment

Thrips parasitoids were processed and shipped either as adult females (in a ventilated plastic vial, provided with a droplet of honey, as parasitised larvae in transparent vials with pollen and honey-water between stretched film (see below), or as parasitoid pupae. In the latter case, pupae were collected from the cultures, placed on moist filter-paper, covered with a second piece of moist filter-paper, folded and placed into a closed plastic tube (1 cm Ø, 10 cm tall) or Petri dish. Live thrips were shipped either as eggs (in host plant tissue, mostly bean pods) or as larvae or adults. Prior to being shipped the moving and feeding phases of thrips were provided with a (piece of) bean pod, wrapped in tissue (to avoid or absorb condensation in case of strong temperature changes on the road and placed in a ventilated tube (single bean pod) or vial (multiple bean pods). Bean pods were cut at such a length that they were firmly fixed inside the vial or tube and could not move. All material was shipped by courier service on top of some ice bars, separated by layers of paper.

Results

The results of the explorations are presented in tables 1-5. Only those sites are mentioned were parasitoids, as adults or larvae, were found. Individuals collected during field surveys in Europe were all females and all parasitoids belonged to a single species, *C. menes*. Females of different origins differed, however, in colouring of the abdomen, varying from yellow (to buff = brownish yellow) to brown with a pale base (see figure 1a, b, c). Asian specimens were of the yellow-shape type (figure 1b), its colour varying in intensity of black bars on the side of the abdomen from none (distinctively yellow: a few in Indian collections) to brown with a yellow base. In the USA two additional species were collected: *C. americensis* and a new species, described as *Ceranisus loomansi* Triapitsyn.

The Netherlands

From 1990-1996, over 200 sites were sampled within various natural habitats (roadsides, sides of ditches and fields, hedgerows; broom bushes near forest edges), cultivated fields (commercial fields: leek, onion, rape, potato, cabbage, pea and fieldbean; private gardens:

Table 1. Number of parasitoids (*C. menes*) present in batches of thrips larvae collected from host plants at different localities, autumn 1990 - 1993. Thrips larvae were reared to maturity using an artificial method on pine pollen and honey-solution 10 %. Only batches containing parasitoids are listed.

Locality (year)	plant species	thrips		parasitised		# adults
		number	species	# larvae	%	emerged
Mediteranean (1990)						
Hyères (Fr) [g]	*Rosa* sp.	800	*F. occidentalis*	113	14%	66
Perpignan (Fr)	*Polygonum aubertii*	40	*T. major* *T. tabaci*	10	25%	1
St. Maximin (Fr)	*Centranthus ruber*	12	*T. tabaci* *T. brevicornis*	1	8%	0
Bologna (Italy)	*Hieracium* sp.	90	*F. pallida* *F. intonsa*	14	15%	6
Netherlands (1992)						
Wageningen	*Ligustrum ovalifolium*	45	*T. tabaci/T.major*	2	5 %	2
Beek en Donk	*Ligustrum ovalifolium*	87	*T. tabaci/T.major*	6	7 %	4
Renkum	*Matricaria recutita*	21	*T. tabaci*	1	5 %	1
Reeuwijk [g]	Cactaceae 1	425	*F. occidentalis* *F. schultzei*	107	15 %	83
Waddinxveen [g]	Cactaceae 2	46	ibid.	3	7 %	0

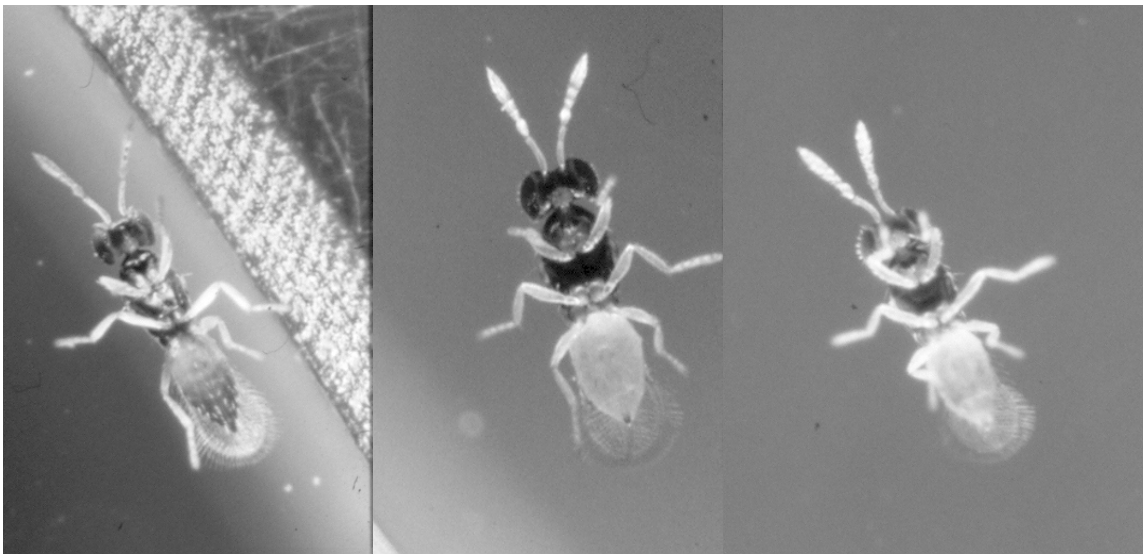
g = collected inside glasshouses

Table 2. Collections of thrips parasitoids *C. menes* at different localities and host plants in The Netherlands in association with thrips species (Thysanoptera) (positive sites only; 1990 - 93), colour-types b = brown, y = yellow (see figure 1).

Plant species	month	habitat	location (#, colourtype)
Fabaceae (Papilonaceae)			
Pisum sativum	VII.90	field	Venzelderheide (1b)
Trifolium repens	VII.92	orchard	Someren (1b)
Lathyrus sp.	VII.92	garden	Wageningen (2b)
Lotus corniculatus	VIII.92	roadside	Scherpenzeel (1y)
Apiaceae (Umbelliferae)			
Pastinaca sativa	VIII.92	roadside	Kesteren (24y; 7y), Velddriel (12y, 2b), Dreumel (4y; 3y), Wamel (1y), Andelst (2y)
"	VIII.92	dike slope	Heerewaarden (1y)
Angelica sylvestris	VII.92	road-ditch	Wageningen (1b)
Heracleum sphondylium	VI.92	road-ditch	Kesteren (1y)
Asteraceae (Compositae)			
Achillea millefolium	VII.92	fieldedge	Stramproy (1b), Boekel (2b)
"	VII.92	roadside	Asten (3b), Lierop (3b), St. Anthonis (2b), Uden (2b), Mook (1b)
Matricaria recutita	VI.93	fieldedge	Renkum (10b)
"	VI.91	side ditch	Wageningen (10b)
"	VI.91	fieldedge	Wageningen (9b; 4b), Reek (2b)
"	VI.91	abandoned	Wageningen (1b)
Senecio jacobea	VI.92	roadside	Kesteren (2y), Rhenen (2y)
Senecio vulgaris	VI.92	abandoned	Kesteren (1y), Lienden (1y)
Rubiaceae			
Galium verum	VI.92	garden	Wageningen (1y)
Cruciferae			
Sinapis arvensis	VII.92	roadside	Ravenstein (4y)
Brassica sp.	VII.93	roadside	Dreumel (52y), Ravenstein (4y)
"	VIII.92	disturbed	Veenendaal (3y), Ede (7y)
Rosaceae			
Filipendula ulmaria	VI.92	side pond	Wageningen (1y)
"		side ditch	Wageningen (7y), Veenendaal (2y)
Caprifoliaceae			
Sambucus nigra	VI.90	field-edge	Aaldonk (1b)
Ericaeae			
Erica tetralix	VI.92	garden	Wageningen (3b)
Hypericaceae			
Hypericum perforatum	VIII.92	roadside	Liempde (4b), Boxmeer (2y)
Polygonaceae			
Polygonum aubertii	VIII.92	fence	Wageningen (1y), Wychen (2b)
"	IX.92	fence	Raalte (3y)
Oleaceae			
Ligustrum ovalifolium	VI.93	bush	Wageningen (23buff)
"	VII.93	bush	Wageningen (6buff; 3buff)
"	VII.93	hedge	Wageningen (3buff), Beek-Donk (11buff)
Cactaceae			
Various species	XI.91	glasshouse	Reeuwijk (11buff); Waddinxveen (3buff)

bean, pea, onion, leek and cabbage, mostly infested with *T. tabaci*; in total 43 plots) and greenhouses (sweet pepper, cucumber, ornamentals: in total 11 plots). On 54 occasions (~25%) thrips parasitoids (*C. menes*) were found (table 2). Our search, however, was more qualitative than quantitative and not completely random or systematic. Searches were "success-motivated": after a number of failures (~5) in finding thrips parasitoids in some sites (e.g. forestedges, greenhouses) and on some plants species (e.g. Umbelliferae) these were less intensively checked again on later occasions.

On one occasion *C. menes* was found in a crop outdoors: on July 4th a single female of was found in a private pea plot at Venzelderheide, 500 m from the Dutch-German border. In the laboratory it readily attacked first stage larvae of both *F. occidentalis* and *F. intonsa*, but rearing was not successful. On only occasion females of *C. menes* were found inside a glasshouse, amongst a mixed population of *F. occidentalis* and *F. schultzei* inhabiting cactus flowers in Reeuwijk: They originated from Holambra, Brazil and were accidentally imported with a quarantine shipment of cactuses. From a sample



a) brown colour-type b) yellow colour-type c) buff colour-type

Figure 1. *C. menes*: a) brown colour-type specimen (Hyères, France); b) yellow colour-type specimen (Brignoles, France) and c) buff colour-type specimen (Holambra, Brazil). Width : length ratio of abdomen for brown = 0.67; yellow = 0.50; buff = 0.55.

of larvae, 107 (15 %) parasitoid pupae emerged (table 1). In an additional sample, collected in Holambra itself, contained 2 specimens of the same colour-type, found in association with *F. schultzei*.

Individuals of *C. menes* were found on flowering plants in general and were not limited to specific host plants. Nor was occurrence strictly correlated with the presence of thrips larvae. Two colour-types of *C. menes* were found in various habitats and host plants belonging to a wide range of families. Although some types were collected from certain host plant flower colours (brown: *Achillea*, *Matricaria*; yellow: *Pastinaca*), there does not seem a relation between colour of the host plant and the colour of the parasitoid. Regardless various samples taken from *Tanacetum vulgare* L., in roadsides and ditches, we never collected thrips parasitoids from these stands. Except for *Pastinaca sativum* L., we rarely did so either on other Apiaceae (Umbelliferae) that are very common, such as *Anthriscus sylvestris* (L.) Hoffm.; *Daucus carota* L., *Angelica sylvestris* L., *Heracleum sphondylium* L. and regardless the mostly large amounts of (adult) thrips foraging on their flower-heads and the presence of larvae. This is in sharp contrast to the relative abundant population that we found on a large bush of ligustrum (*Ligustrum ovalifolium* L.) in Wageningen. During a number of years, at the flowering period of this bush (figure 2), large numbers were caught, either on sticky traps or by hand during a 3-4 week period, its fluctuation largely coinciding with the presence of open flowers and of (adult) thrips. The number of thrips larvae, however, was relatively low and few were parasitised (table 1).

Samples containing *C. menes* were taken in association with adults and larvae of a single thrips species, either *T. tabaci* Lindeman, *Thrips major* Uzel, *Thrips vulgatissimus* Haliday, *Thrips fuscipennis* Haliday or *F. intonsa*, or from a multiple species population. Larvae of *T. vulgatissimus* taken from *Rumex crispus* L. (yellow dock, Polygonaceae) collected at various sites (Deurne, Ravenstein, Renkum, St Anthonis, Wageningen) and of *T. tabaci* (Wageningen) from *Sambucus nigra* L. (common elder, Caprifoliaceae) were not parasitised in the field, but when exposed in the laboratory to *C. menes*, they were readily attacked and parasitised. No parasitoids emerged from larvae of *Limothrips denticornis* (Haliday) collected in wheat fields. Larvae (131 L1, 14 early L2), collected late May 1992, were taken into the laboratory. When exposed to female *C. menes*, they were rarely attacked, parasitisation was unsuccessful and no offspring was produced.

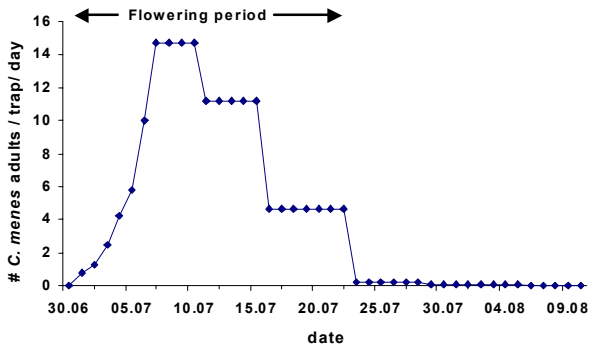


Figure 2. Monitoring the incidence of *C. menes* adults on ligustrum, *L. ovalifolium*, near the Laboratory of Entomology, Wageningen, The Netherlands, during 1995; 4 yellow sticky traps (Horiver®) exposed for the entire bush (4 m high, 4m Ø).

Table 3. Collections of thrips parasitoids *C. menes* at different localities and host plants in the Mediterranean Area in association with thrips species (Thysanoptera) present (positive sites only; 1990-91); n.i. = not identified, colour-types b = brown, y = yellow (see figure 1).

Locality	host plant	thrip species abdomen	Date 1990/91	# parasitoid (colour)
Italy				
Pietra Ligure	*Centranthus ruber*	*Thrips brevicornis*	16.IX.90	16 b
Bologna (San Luca)	*Trifolium repens*	*Frankliniella pallida* *Frankliniella intonsa*	13.IX.90	1 b
"	*Hieracium* sp.	*Frankliniella pallida* *Frankliniella intonsa* *Thrips hispanicus* *Thrips hukkineni* *Frankliniella occidentalis*	13.IX.90	1 b
"	*Dittrichia viscosa*	n.i.	28.IX.91	51 y
"	*Solidago virgaurea*	n.i.	28.IX.91	7 b
Pietramora	-	-	02. X.91	1y, 2b
Pescia	*Dittrichia viscosa*	n.i.	25.IX.91	21y
Ponte di Serravalle	*Picris hieracioides*	n.i.	25.IX.91	1y, 1b
Borello-Ranchio	*Dittrichia viscosa*	n.i.	26.IX.91	5y, 5b
Piavola	*Polygonum aubertii*	n.i.	26.IX.91	1y
Cesena	*Polygonum aubertii*	n.i.	04. X.91	6y
Torreglia	*Leontodon* sp.	n.i.	27.IX.91	1y, 1b
France				
Beausoleil	*Centranthus ruber*	*Thrips tabaci* *Thrips brevicornis* *Frankliniella occidentalis* *Thrips* (*fuscipennis*?)	11.IX.90	7 b
Pernes les Font.	*Hieracium* sp.	*Thrips hukkineni* *Taeniothrips hispanicus* *Frankliniella occidentalis*	18.IX.90	4 b
Salon de Prov.	*Centranthus ruber*	*Frankliniella occidentalis* *Thrips tabaci*	29.IX.90	1 b
St. Maximin (Autoroute)	*Centranthus ruber*	*Thrips tabaci* *Thrips brevicornis*	29.IX.90	6 b
St. Maximin (Aire Barcelone)	*Centranthus ruber*	*Thrips brevicornis* *Thrips tabaci*	29.IX.90	4 y
Brignoles	*Medicago sativa*	*Thrips tabaci*	29.IX.90	2 b
Hyères [g]	*Rosa* spp.	*Frankliniella occidentalis*	17.IX.90 28.IX.90	6 b 66 b
"	*Lantana camara*	--	28.IX.90	1 b
Jonquières Saint-Vincent	*Hieracium* sp.	*Thrips tabaci* *Taeniothrips pallidivestis* *Thrips hukkineni* *Taeniothrips hispanicus*	18.IX.90	2 b
Salses (Perpignan)	*Polygonum aubertii*	*Thrips major* *Thrips tabaci*	18.IX.90	12 b, 8 y
"		ibid.+ (*Taeniothrips* sp.)	27.IX.90	74 b, 78 y

g = collected inside glasshouses

Southern Europe

During late summer 1990, 125 plots (host plants, greenhouses) were sampled in 96 different sites in the Mediterranean Area. We sampled greenhouse crops (cucumber, melon, sweet pepper, pepper, aubergine, bean, tomato; chrysanthemum, gerbera, *Datura*, rose), open field crops (leek, strawberry, tomato, aubergine, sweet pepper, pepper, bean, tomato; carnation, chrysanthemum, rose, aubergine, gladiolus) and various natural types of vegetation (road sides, abandoned sites: various flowering plants). In southern Europe greenhouse crops are grown in plastic houses. Most often these are not closed systems, but wide open at the sides, thus allowing a constant moving about of pests and natural enemies.

At several locations in the South of France adults of *C. menes* could be collected from flowers of wild vegetation, inhabited by various thrips species belonging to the genera *Frankliniella*, *Thrips* and *Taeniothrips* (Thripidae Thripinae) (table 3). In samples from 2 loca-

Table 4. Collection results of adult thrips parasitoids, April - May 1993, USA/Mexico; brown, yellow indicates the colour-type of *C. menes.* All adult females, except *C. loomansi*; [s] = sweep-net collections, * = collected, preserved brought into culture.

Species	date	place	site	host plant	nr
California					
C. americensis	29 IV.	Cape San Martin	roadside	*Lupinus* sp.	1
C. americensis	02 V.	Riverside	parking	*Brassica nigra*	4
C. americensis?	05 V.	Temescal	roadside	*Brassica nigra*	3
C. americensis	13 V.	Needles	field	alfalfa	8
C. americensis	15 V.	Lake Casitas	roadside	*Juniperus* sp.	1
C. americensis	15 V.	Lake Cachuma	picnic-area	*Juniperus* sp.	1
C. americensis	16 V.	Mendota	roadside	*Brassica nigra*	4*
C. americensis	17 V.	Davis	field	alfalfa	2
C. americensis	18 V.	Davis	roadside	*Brassica nigra*	3
C. menes brown	02 V.	Riverside	parking	*Brassica nigra*	2
C. menes brown	04 V.	Irvine	orchard	*Brassica nigra*	1*
C. menes brown	05 V.	la Sierra	roadside	*Brassica nigra*	1
C. menes brown	14 V.	Fillmore	roadside	*Brassica nigra*	1
C. menes brown	14 V.	Ventura Co	roadside	*Brassica nigra*	9
C. menes brown	15 V.	Castas Springs	roadside	*Brassica nigra*	2
C. menes brown	15 V.	Castas Springs	roadside	Compositae	1
C. menes brown	15 V.	Santa Barbara	roadside	*Brassica nigra*	8
C. menes brown	15 V.	Lake Cachuma	picnic-area	*Juniperus* sp.	1
C. menes brown	15 V.	Los Olivos	roadside	*Brassica nigra*	12
C. menes brown	15 V.	Santa Maria	roadside	*Brassica nigra*	29*
C. menes brown	17 V.	Davis	roadside	*Brassica nigra*	3*
C. menes brown	18 V.	Woodland	glasshouse	alfalfa seedlings	1
C. menes brown	17 V.	Yolo	roadside	*Brassica nigra*	13
C. menes yellow	17 V.	Yolo	roadside	*Brassica nigra*	14*
C. menes yellow	16 V.	Lodi	fieldedge	alfalfa[s]	1*
C. menes yellow	17 V.	Davis	roadside	*Brassica* sp.	2
C. menes yellow	18 V.	Woodland	testplot	*Brassica* spp.	1
Arizona					
C. americensis	10 V.	Bonita Valley I	orchard	white clover[s]	1
C. americensis	10 V.	Bonita Valley II	orchard	white clover	1
C. americensis	10 V.	Willcox	garden	*Impatiens balsamina*	1*
C. americensis	13 V.	CampVerde	roadside	*Melilotus officinalis*	20*
C. americensis	13 V.	Sedona	roadside	*Melilotus officinalis*	4
C. americensis	13 V.	Sedona	waste dump	*Melilotus officinalis*	1
C. loomansi	13 V.	Oak Creek Canyon	forestroad	*Lupinus* sp.	400*
Mexico					
C. menes brown	06 V.	San Luis	field	alfalfa[s]	1
C. menes brown	06 V.	Benito Juárez	field	alfalfa[s]	?1
C. menes brown	07 V.	Colonia Bolsa	field	alfalfa[s]	?2
C. menes brown	07 V.	Gurrita	field	alfalfa[s]	?1
C. menes brown	07 V.	Campillo	field	alfalfa[s]	?1
Total live specimens					
C. menes yellow	Lodi, Yolo				15
C. menes brown	Irvine, Santa Maria, Davis				60
C. americensis	Willcox, Mendota, Camp Verde				43
C. loomansi	Oak Creek Canyon				400

tions parasitised larvae were found (table 1). Collection of parasitoids of thrips was less successful in cultivated crops in France as well as Italy and Spain. On one occasion only adults of *C. menes* were collected inside a glasshouse, from a rose crop at Hyères (France), infested with *F. occidentalis*. In 93 flowers of different varieties, 66 adults were present and from an additional 800 larvae collected 113 were parasitised.

In northern Italy, it was difficult to locate thrips infested crops. No recoveries of thrips parasitoids were there made during September 1990. Collections made on several places in Northern and Central Italy in September 1991 (table 3) show, however, that *C. menes* is distributed regularly in these parts of Italy on ruderal locations. At one location, a natural reserve field near Collina San Luca (Bologna), recoveries of *C. menes*

Table 5. Overview of the different habitats and number of plots surveyed in Europe and the USA (Netherlands: 1990-1996; France, Italy, Spain: September 1990; Hungary: 1995; USA-Mexico: April-May 1993). The number of plots were thrips parasitoids were found is placed between brackets (for details, see tables 1, 2 and 3).

Country	Habitat					Total
	Cultivated crops and plants				Natural	
	greenhouse	open field	garden	undergrowth	(incl. fences)	
Europe						
Netherlands	11 (2)	17 (0)	26 (1)	5 (1)	~ 140 (50)	~ 200 (54)
Hungary	15 (0)	1 (0)	6 (0)	0 (0)	8 (2)	30 (2)
France	11 (2)*	3 (0	0 (0)	0 (0)	23 (9)	37 (11)
Italy	18 (0)	3 (3)	0 (0)	0 (0)	16 (2)	37 (2)
Spain	10 (0)	28 (0)	0 (0)	0 (0)	13 (0)	51 (0)
Total	*65 (4)*	*52 (3)*	*32 (1)*	*5 (1)*	*200 (63)*	*355 (69)*
USA						
California	4 (1)*	6 (2)**	7 (0)	1 (0)	49 (24)	67 (27)
Arizona	1 (0)	5 (0)**	4 (1)	5 (2)***	28 (4)	42 (7)
Mexicali	0 (0)	13 (5?)**	3 (0)	1 (0)	8 (0)	25 (5)
Total	*5 (1)*	*24 (7)*	*14 (1)*	*7 (2)*	*85 (28)*	*134 (39)*

* rose crop Hyères - France, 1990; *Brassica* spp., Woodland - California, 1993; ** = alfalfa (California, Arizona; including melon and onion, Mexico); *** = apple orchard.

could be made (tables 1and 3) as adult ánd parasitised larvae during that year. In the same locality this parasitoid was collected before in August (Galazzi *et al*., 1992) on natural vegetation (*Trifolium repens* L*., Polygonum aubertii* L. Henry). In 1991, *C. menes* was collected again near Bologna and Cesena on wild plants (Galazzi *et al*., 1992) and were shipped to Wageningen for further evaluation.

In Spain population densities of *F. occidentalis* were already at its decline during mid September 1990, after severe infestations earlier that year. In the South (Murcia and Valencia region), most of the greenhouse crops already had been harvested. *F. occidentalis* still was present but in low numbers, on crops (piment, sweet pepper) as well as wild vegetation. In spite of sampling several crops and wild vegetation no thrips parasitoids were found. *F. occidentalis* was more abundant in the north, but here also no parasitoids were found. In 1991, in Cabrils (Catalunya, Spain), colleagues sampled one hundred and thirty fields with vegetable (tomato, cucumber, pepper, bean, lettuce and strawberry) and ornamental (carnation and others) crops which were not intensively sprayed with pesticides along the Spanish Mediterranean coast. Parasitoids, identified as *C. menes*, were only found in carnation. After rearing it for one generation in the laboratory, the offspring was shipped to Wageningen. Collections made in the Mediterranean area of Europe, France and Italy (see Galazzi *et al*., 1992) and later in Spain (Pays Vasco, Cantabria, Navarra: Goldarazena *et al*., 1999), resulted in obtaining different colour-types of *C. menes*. In the Emilia Romagna region of Italy collections of wild plants resulted in the collection of *C. menes* too.

In addition, specimens of *C. menes* were collected in Portugal (Azores-San Miguel in 1995- collection: I. Silva; Santa Cruz-Torres Vedras in 1994) in Italy (Sicily in 1995), Belgium (Limburg in 1992), France (Les Landes in 1992; Picardia and Touraine in 1999), Hungary (in 1995) and Turkey (Antalya in 1997). Most of these were collected on roadside and ruderal vegetation, occasionally specimens were recovered from greenhouses in large amounts (on Sicily, November 1998 in a 4 week old tomato crop). All these specimens belonged to the brown colour-type, but in samples from Emilia Romagna and Hungary yellow types occurred as well. Only some of these are included in our evaluation experiments (see table 6).

Other natural enemies, although not actively searched for, such as different *Orius* species and mirid bugs, were observed on various occasions in crops and vegetation infested with thrips in Italy, France as well as Spain.

Southwest USA

Because previous surveys in Europe resulted in the collection of (various strains) of only a single native species, *C. menes*, foreign exploration was initiated to search for potentially other, more host specific parasitoid species. We therefore focussed on the original area of distribution of *F. occidentalis*, thus also matching climatic conditions of the "target" areas, greenhouses in temperate and Mediterranean areas with its origin. During my initial survey in California, Arizona and Mexico (Mexicali area) parasitoids were found at various locations on flowering plants. These belonged to the families of Cruciferae (genus *Brassica* - 17 out of 33 sites) and Fabaceae (genus *Trifolium* (white clover) - 2 out of 5); genus *Melilothus* (sweet clover) - 3 out of 5 sites, genus *Medicago* (alfalfa) - 6 out of 16, genus *Lupinus* (lupine) - 4 out of 9), but not on broom, totalling a score of 32 sites out of 68 (47%). Only female parasitoids were collected: *C. menes* in the coastal area and central valley in California and in Mexico, *C. americensis* also in the interior of Arizona and in California. Two colour-types of *C. menes* were found: the brown type throughout the searched region from Mexicali to Davis, the yellow type only in the northern part of the Central Valley, near Davis.

Table 6. Collections of thrips parasitoids (Hymenoptera Eulophidae) at different localities, either by active search (a) or correspondence (c).

Parasitoid	Locality	country	year	colour-type		collection host[1]
C. menes	Europe	France	1990	yellow + brown	a	Tt/Fo*
C. menes	Europe	Italy	1990/1991	yellow + brown	ac	Tt/Fo*
C. menes	Europe	Spain	1991	brown	ac	Tt/Fo*
C. menes	Europe	Netherlands	1990/1993	yellow + brown	a	Tt*
C. menes	Asia	Japan	1990/1992	yellow	c	Fi
C. menes	Asia	Philippines	1992	yellow	c	Mu
C. menes	N. America	California	1993	yellow + brown	a	Fo*
C. menes	S. America	Brazil[2]	1991/1992	Intermediate	a	Fs
C. americensis	N. America	California	1993		a	Fo*
C. americensis	N. America	Arizona	1993		a	Fo*

[1] Fo = *F. occidentalis*, Fi = *F. intonsa*, Fs = *F. schultzei*, Tt = *T. tabaci,* Mu = *Megalurothrips usitatus*; * = including a range of native species on the collection sites; [2] = collected in the Netherlands on an import shipment from Brazil.

Collections through correspondence

C e r a n i s u s m e n e s

Additional live specimens of *C. menes* were received through correspondence from various places in the world. In collaboration with IITA-Benin, several hundred adults of *C. menes* and *Megalurothrips* larvae, collected from flowering leguminose plant species (*Pueraria*, *Centrosema* spp., *Tephrosia candida* (Roxburgh) de Candolle (Leguminosae), originating from The Philippines (1992), Malaysia (Sarawak and mainland: 1994) and India (Haiderabad: 1995), were shipped to the laboratory and subsequently bred for 1 or more generation before translocation-shipment to Benin (Tamò *et al*., 1997). All of these were representing sexual strains. Some of these were occasionally tested by us on *F. occidentalis* and *F. schultzei*. In 1990 and 1991 specimens of an asexual strain of *C. menes* were shipped from a laboratory culture in Shimane in Japan to Wageningen. In 1991 64 fields with a variety of field crops were sampled near Cabrils (Spain). From 5514 thrips larvae that we collected, parasitoids were only found in very low numbers and in carnation only. Ten adults emerged and were shipped to our laboratory and subsequently identified as *C. menes* (brown colour-type).

O t h e r p a r a s i t o i d s p e c i e s c o l l e c t e d

Parasitoids from three other species were introduced into the laboratory and preliminary studies on their effectiveness against F. occidentalis were carried out:

- About 400 live adult individuals (females and males) of a previously unknown parasitoid species of thrips, collected from broadleaved lupine [*Lupinus latifolius* Lindl. ex J.G. Agardh (Fabaceae)]. It was collected in May 1993 south of Flagstaff, where the Arizona State Highway 89A between Flagstaff and Sedona passes through Oak Creek Canyon and the Coconino National Forest (table 4). They were shipped to the laboratory and introduced into cultures of *F. occidentalis* and *F. schultzei*. It was later described as *C. loomansi* (Triapitsyn and Headrick, 1995; Triapitsyn, 2005). Attempts to rear this species on *F. occidentalis* in the laboratory failed: although females readily attacked, oviposited and developed on larvae of both species, parasitoids remained in the pupal stage for many months and did not survive. Three female offspring emerged from a single female culture, originating from Temescal, California, but died in the process;
- *Thripobius semiluteus* (Bouçek), known as a parasitoid of leaf-inhabiting thrips species belonging to the Panchaetothripinae (Thripidae) (Bouçek, 1976), was received in June 1990 from a laboratory culture in Holland, originating from the USA. It readily attacked and developed on first stage larvae of *Heliothrips haemorrhoidalis* (Bouché), but showed no reaction to first and second stage larvae of *F. occidentalis* during behavioural observations and rearing on *F. occidentalis* failed. From Taiwan 58 pupae were received from a parasitoid attacking *Rhipiphorothrips cruentatus* Hood (Thripidae Panchaetothripinae) in wax apple fields. However, only two adults emerged and died before testing. They were reported as *Ceranisus* sp. (Chiu, 1984), identification of both adults showed that they were similar to *T. semiluteus*, mentioned above;
- In 1994, several hundred specimens (males as well as females) of an egg parasitoid [*Megaphragma* spp. (Polaszek personal communication)] were shipped to Wageningen as parasitised eggs of *Megalurothrips sjostedti* (Trybom) (Thripinae Thripidae) in stems of *Dolichus lablab* L., *Cajanus cajan* (L.) Millspaugh (pigeon pea), *Centrosema pubescens* Bentham (Leguminosae) from Benin, 1994 (see Tamó *et al*., 1993). Preliminary tests on emerged adults were carried out on eggs of *F. occidentalis*. No response was observed, however, to thrips eggs, not when offered as infested leaves, not when eggs were offered directly. Because adults lived for 2 or 3 days, we could not fully explore its potential. A good rearing method needs to be developed before final conclusions can be made over its ability to parasitise *F. occidentalis*. In table 6 the origin and localities are summarised of those species and strains of thrips parasitoids, that were tested during my laboratory experiments.

Discussion

Foreign explorations for parasitoids have been performed for various thrips pests in field crops: for *T. tabaci* (CAB, 1971: in the Caribbean and India); Sakimura, 1937: Japan), for *T. palmi* (Hirose *et al*. 1989, 1990, in Thailand), for *M. sjostedti* (Tamò *et al*. 1997, in Asia and Cameroon), for *Heliothrips haemorrhoidalis* Bouché (McMurtry *et al*., 1991; Froud *et al*., 1997), for *Taeniothrips inconsequens* (Uzel) (Teulon *et al*., 1996 in Central Europe) and more recently for *Scirtothrips perseae* Nakahara (Hoddle *et al*., 2002 in Central America). Except for a few (Sakimura, 1937; Tamò *et al*., 1997) most efforts to control thrips pests with exotic natural enemies have been unsuccessful. A thorough and systematic exploration for natural enemies of *F. occidentalis* populations in its native home has never been performed properly. Except for a rather local survey around Davis - California (Greene and Parrella, 1993), our small-scale survey was in fact the first explorative survey throughout the area of origin of *F. occidentalis*. Later explorations in native area of distribution of *F. occidentalis* carried out in greenhouse and field grown ornamentals in November 1993 and during 1994 (Heinz *et al*., 1996) and in 1998 (Ripa, INIA - Chile) did not result in the collection of any parasitoids.

Our exploration in the area of origin resulted in the collection of different thrips parasitoid species: *C. americensis* and two colour-types of *C. menes*. The first species was only collected there and is relatively unknown to science: it was first described from specimens collected in alfalfa in Utah-USA in 1912 (Girault, 1917) and has previously been found in association with *F. occidentalis* infesting alfalfa in Alberta-Canada in 1922 (Seamans, 1923). My collections show that it is common on flowering plants in Southwestern USA (cf. Triapitsyn and Headrick, 1995), in the coastal region as well as in the inland areas. *C. menes* on the contrary was collected only in the coastal areas of California and Mexicali, with a marked difference between the two colour-types: whereas the brown type was found throughout the sampled area, the yellow colour-type only occurred in central California.

C. menes is a common parasitoid of thrips, not only in the area of origin of *F. occidentalis*, but also in newly invaded areas. It is distributed almost worldwide (Loomans and van Lenteren 1995). Most records originate from eastern Asian countries, where it is locally abundant (Japan, Korea, The Philippines, Taiwan, Thailand, India and Indonesia). From there it has been successfully introduced into Hawaii. Occasionally individuals have been reported from Dominican Republic, Brazil, Argentina, Australia and New Zealand. In Europe this species has been collected on several occasions. Our field surveys show that the occurrence of different parasitoid species is generally very low, irrespective of the host plant species, season and locality. Where it is common, it is largely associated with flowering host plants, the presence of thrips and the geographical location, more than to the mere presence of thrips larvae. Previous samplings mostly resulted in fairly low numbers collected (CAB, 1971: surveying *T. tabaci*), in others [Vuillet, 1914; Bühl, 1937: working on *Kakothrips robustus* (Uzel)], however, high numbers were found.

Explorations in various regions in the world show a predominance of *C. menes* as parasitoids attacking thrips. Surveys of natural enemies of *T. palmi*, carried out in Thailand (Hirose *et al*., 1993) and Japan (Hirose *et al*., 1992) on solanaceous and cucurbit crops, all showed a similar predominance of *C. menes*. Tamò *et al*. (1993, 1997) in his survey for parasitoids attacking *Megalurothrips* in India and Malaysia (mainland, Sarawak) also found a dominance of *C. menes* on leguminose crops, weeds and trees. Explorations in newly invaded areas, such as Australia (Steiner *et al*., 1996; Steiner and Goodwin, 1996, 1998; Goodwin and Steiner, 1996) on *F. occidentalis* and on related thrips hosts, showed that *C. menes* was the most common parasitoid attacking thrips. Like in our survey, *C. menes* occurred in about 20% of the sampled locations.

It seems that both species, *C. menes* and *C. americensis*, mainly occur on flowering wild vegetation in natural habitats (table 5), with annual herbs, weeds, bushes (large range of families), in coastal and river landscapes (characterised by a relative high humidity and a moderate temperature) but not in a desert-like climate such as prevails in internal California and Arizona. They were also not found near forest edges and in natural reserves. In disturbed habitats (sides of roads, ditches, dikes, parking lots, etc.) and in pioneer vegetation rather than in vegetation in a further stage of succession, but not in hayfields and grassland. In natural habitats, *C. menes* appears rather common in some host habitats and on some host plants, but rarely abundant. When it was found (earliest record in May, latest in September), it was mostly present in flowering annual herbs and weeds and in bushes on disturbed sites, in vegetation on sides of ditches, roads, near field edges, in hedgerows, fences, etc., but very rarely inside field plots and greenhouses (tables 2, 3 and 4). Previous collections of thrips parasitoids in The Netherlands were rather limited: Gijswijt (2003) collected *C. menes* from heather in Bussum in 1962 and *Ceranisus pacuvius* (Kütter) was found in the 1950s in pea plots on Goeree-Overflakkee (Fransen, 1960). My surveys, however, in commercial and private pea plots in that area in June 1990 did not result in the collection of any thrips parasitoids. Also at various other locations and habitats (not mentioned in the tables) similar surveys did not result in the collection of *C. menes*, although thrips (adults and larvae) were present. Collections made in malaise traps in natural reserves (The Netherlands: van Zuijlen *et al*., 1996) or hayfields (Germany: Mohr *et al*., 1992), did not reveal the presence of thrips parasitoids, where very low numbers of thrips were trapped (van Zuijlen *et al*., 1996). No parasitoids were found near forest edges or collected from broom bushes.

Both *Ceranisus* species were rarely found in agricultural and/or horticultural production-systems such as greenhouses or field crops, regardless high infestations of *F. occidentalis*. Also Heinz *et al*. (1996), in their survey for natural enemies of *F. occidentalis* in ornamental crops, both in the greenhouse and from the field, did not reveal the presence of any thrips parasitoids. Mateus

(personal collection, 1994) only trapped few specimens when monitoring for *F. occidentalis* in 14 plots of tomato, cucumber and melon using sticky traps in (plastic) greenhouses in the Algarve, Portugal. On the other hand, large numbers were trapped in autumn inside greenhouses with tomato crops in Sicily (Loomans, personal collection, 1998) and in Greece (Roditakis, personal collection, 2000). Besides possible, yet unknown, preferences of this parasitoid for certain host habitats, intensive chemical spraying practices certainly will have played a role in the low frequency of its presence in protected crops. Results published by Hirose *et al*. (1992, 1993) also showed a very low percentage of parasitisation by *C. menes* in sprayed crops in Thailand.

C. menes is know for its broad range of hosts of closely related thrips species, all belonging to the same subfamily Thripinae (Thripidae). Only Daniel (1986) has reported *Zaniothrips ricini* Bhatti and *Retithrips syriacus* Mayet (Thripidae Panchaetothripinae) as hosts. Sampling wild vegetation inhabited by populations of *Frankliniella* (*intonsa*, *occidentalis*, *pallida*, *schultzei*), *Thrips* (*tabaci*, *major*, *brevicornis*, etc.) and/or *Taeniothrips*, in The Netherlands as well as in the south of Europe, showed that a number of these were parasitised by *C. menes*. Preliminary rearing results showed that *C. menes* is able to attack and develop on *F. occidentalis* and *F. schultzei* in the laboratory as well as in the glasshouse. *C. menes* was found earlier in association with *F. occidentalis* collected from rose in September 1988 in Cabrils (Spain) (Bordas, personal communication) and in the autumn of 1990 in Israel on several occasions (Kuslitzky, personal communication).

Only females were collected during sampling and in the laboratory they reproduced parthenogenetically. Although males are known of *C. americensis* (Triapitsyn and Headrick, 1996), we only found females, which reproduced parthenogenetically once brought to the laboratory. Sampling *C. menes* in Europe and North America only has resulted in the collection of females (cf. Vuillet, 1914; Bühl, 1937). Only on one occasion, a male *C. menes* was collected from *Ligustrum* in Wageningen, July 1994. It is of interest to notice that in field collections of *C. menes* made in several Asian countries males are mostly absent as well: sampling vegetation in India and Malaysia resulted in the collection of adult *C. menes* (always females, never males), but when exposed to host larvae in the laboratory, they readily produced males as well as females (50:50). In Asian populations females mostly are predominating [(sex ratio 0.60: Sakimura, 1937 (Japan); Daniel, 1986 (India); 0.47: CAB, 1971 (India); 0.48: Hirose, 1989 (Thailand); van Heurn, 1923 (Indonesia)]. Murai (1988, 1990) recorded a gradual change in sex ratio in the laboratory: after several generations females reproduced parthenogenetically. The differences between these populations in apparent sex-ratios remain unclear.

Characteristic differences exist in colour type of the abdomen of *C. menes* females collected at several origins. *C. menes* was originally described from a yellow holotype (Walker, 1839). Later descriptions include specimens of other colour-types as well: a brown colour-type (DeSantis, 1961) and the sexual bicoloured forms with narrow transverse bands (e.g. van Heurn, 1923; Sakimura, 1937). Collection results indicate that the yellow type is distributed across the holarctic region and India, that the brown type occurs in the nearctic, neotropical and westpalaearctic region, whereas the sexual bicoulored form has been recorded from the aethiopian, autralian and oriental region up to Japan and Korea. The existence of morphological types (adults and also pupae can already be distinguished by their colour and size), indicate that different (sub)species might be involved. Triapitsyn (2005) indicated, however, that the lectotype of *C. menes* has a partially brown (in its distal half) metasoma whereas that of the paralectotype is completely yellow, and showed that both colour-types can morphologically be considered as one species.

Conclusions

From the potential group of candidate parasitoids of thrips, mentioned in literature, we were able to collect and evaluate only a limited number of parasitoid species. However, we found that some are more common than previously known. *C. menes* was found to be the most common parasitoid of thrips species within the genera *Frankliniella*, *Thrips*, etc. It occurs worldwide and is widely distributed in Europe. In Italy, Spain, France and The Netherlands it was found regularly on natural vegetation infested by a wide variety of thrips species, belonging to the genera *Frankliniella*, *Thrips* and *Taeniothrips* (Thysanoptera: Thripidae, Thripinae), including important pest species like *F. occidentalis* and *T. tabaci*. It rarely invaded cultivated crops, either in glasshouses or open field. In 1993 it was first recorded from California-USA, was the first thrips parasitoid recorded to attack and develop on *F. occidentalis*. *C. americensis* is a second thrips parasitoid species which is known to attack this host. The collection of parasitoids (*C. menes*, *C. americensis*), able to attack and develop on already existing thrips pests like *F. occidentalis* and *T. tabaci*, is considered as an important step towards the biological control of these new pest species. Our explorations indicate that differences might exist between different colour-types of *C. menes*, and their host preference for and performance on *F. occidentalis* and *T. tabaci* were part of our evaluation programme. From a taxonomic point of view, this study can contribute to a proper identification and separation of various colour-types within the *C. menes* species group.

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References

ARZONE A., ALMA A., RAPETTI S., 1989.- *Frankliniella occidentalis* (Perg.) (Thysanoptera: Thripidae) nuovo fitomizo delle serre in Italia.- *Informatore Fitopatologico*, 39 (10): 43-52.

BAILEY S. F., 1938.- Thrips of economic importance in California.- *Agricultural Experiment Station Berkeley, California*, 346: 1-77.

BAILEY S. F., 1957.- The Thrips of California.- *Bulletin of the California Insect Survey*, 4 (5): 141-220.

BELLOWS T. S. JR., LEGNER E. F., 1993.- Foreign exploration, pp. 25-41. In: *Steps in classical arthropod biological control* (Van DRIESCHE R. G., BELLOWS T. S. Jr., Eds).- Entomological Society of America, Lanham, USA.

BOUÇEK Z., 1976.- Taxonomic studies on some Eulophidae (Hym.) of economic interest, mainly from Africa.- *Entomophaga*, 21 (4): 401-414.

BOURNIER A., 1983.- *Les thrips. Biologie. Importance agronomique*.- Institut National de la Recherche Agronomique, Paris, France.

BOURNIER A. I., BOURNIER J. P., 1987.- L'introduction en France d'un nouveau ravageur: *Frankliniella occidentalis*.- *Phytoma*, 388: 14-17.

BRYAN D. E., SMITH R. F., 1956.- The *Frankliniella occidentalis* (Pergande) complex in California (Thysanoptera: Thripidae).- *University of California, Publications in Entomology*, 10 (6): 359-410.

BÜHL, C., 1937.- Beiträge zur Kenntnis der Biologie, wirtschaftliche Bedeutung und Bekämpfung von *Kakothrips robustus* Uz..- *Zeitschrift für Angewandte Entomologie*, 23: 65-113.

CAB, 1971.- *Investigations of the natural enemies of thrips for the use as biological control agents against glasshouse thrips in the United Kingdom*.- CAB, CIBC report, European Station, Delémont-Switzerland.

CARL K. P., 1982.- Biological control of native pests by introduced natural enemies.- *Biocontrol News and Information*, 3: 191-200.

CHIU H. T., 1984.- The ecology and chemical control of grapevine trip (*Rhipiphorothrips cruentatus*) on wax apple.- *Plant Protection Bulletin*, 26 (4): 365-378.

DANIEL A. M., 1986.- Thrips-parasite interactions in some Panchaetothripine Thysanoptera (Insecta: Arthropoda).- *Proceedings of the Indian National Science Academy. Part B, Biological Sciences*, 52: 437-444.

DEBACH P. (Ed.), 1964.- *Biological Control of Insect Pests and Weeds*.- Chapman and Hall, London, UK.

DESANTIS L., 1961.- Dos nuevos parasitos de tisanopteros de la Republica Argentina (Hymenoptera: Entedontinae).- *Notas Museo La Plata, Zoologica*, 20 (187): 11-19.

DESSART P., BOURNIER A., 1971.- *Thrips tabaci* Lindman (Thysanoptera), hôte inattendu d'*Aphanogmus fumipennis* (Thomson) (Hym. Ceraphronidae).- *Bulletin et Annales de la Societe Royale Entomologique de Belgique*, 107: 116-118.

DRIESCHE R. G. VAN, BELLOWS JR. T. S., 1996.- *Biological Control*.- Chapman and Hall, New York, USA.

FRANSEN C. H. J., 1960.- Levenswijze en bestrijdingsmogelijkheden van de erwtetrips (*Kakothrips robustus* Uzel).- *Verslagen Landbouwkundig Onderzoek*, *Pudoc Wageningen*, 664: 1-51.

FROUD K. J., STEVENS P. S., 1997.- Life table comparison between the parasitoid *Thripobius semiluteus* and its host greenhouse thrips, pp. 232-235. In: *Proceedings of the Fiftieth New Zealand Plant Protection Conference*, Lincoln University, Canterbury, New Zealand, 18-21 August, 1997.

GALAZZI D., MAINI S., LOOMANS A. J. M., 1992.- *Ceranisus menes* (Walker) (Hymenoptera Eulophidae): collection and initial rearing on *Frankliniella occidentalis* (Pergrande) (Thysanoptera Thripidae).- *Bollettino dell'Istituto di Entomologia "Guido Grandi" della Università degli Studi di Bologna*, 46: 123-129.

GIJSWIJT T., 2003.- Naamlijst van de Nederlandse bronswespen (Hymenoptera: Chalcidoidea).- *Nederlandse Faunistische Mededelingen*, 18: 17-79.

GIRAULT A. A., 1917.- Notes and descriptions of miscellaneous Chalcidflies (Hymenoptera).- *Proceedings of the US National Museum*, 53 (2213): 445-450.

GOEDEN R. D., RICKER D. W., 1968.- The phytophagous insect fauna of the Russian thistle (*Salsola kali* var. *tenuifolia*) in southern California.- *Annals of the Entomological Society of America*, 61: 67-72.

GOEDEN R. D., RICKER D. W., 1974a.- The phytophagous insect fauna of the ragweed, *Ambrosia acanthicarpa*, in southern California.- *Environmental Entomology*, 3 (4): 827-834.

GOEDEN R. D., RICKER D. W., 1974b.- The phytophagous insect fauna of the ragweed, *Ambrosia chamissonis*, in southern California.- *Environmental Entomology*, 3 (4): 835-839.

GOEDEN R. D., RICKER D. W., 1976a.- The phytophagous insect fauna of the ragweed, *Ambrosia dumosa*, in southern California.- *Environmental Entomology*, 5 (1): 45-50.

GOEDEN R. D., RICKER D. W., 1976b.- The phytophagous insect faunas of the ragweeds, *Ambrosia chenopodiifolia*, *A. eriocentra*, and *A. ilicifolia*, in southern California.- *Environmental Entomology*, 5 (5): 923-930.

GOEDEN R. D., RICKER D. W., 1976c.- The phytophagous insect fauna of the ragweed, *Ambrosia psilostachya*, in southern California.- *Environmental Entomology*, 5 (6): 1169-1177.

GOEDEN R. D., RICKER D. W., 1986a.- Phytophagous insect faunas of the desert shrub *Hymenoclea salsola*, in southern California.- *Annals of the Entomological Society of America*,

79: 39-47.

GOEDEN R. D., RICKER D. W., 1986b.- Phytophagous insect faunas of two introduced *Cirsium* thistles, *C. ochrocentrum* and *C. vulgare*, in southern California.- *Annals of the Entomological Society of America*, 79: 945-952.

GOEDEN R. D., RICKER D. W., 1986c.- Phytophagous insect faunas of the two most common native *Cirsium* thistles, *C. californicum* and *C. proteanum*, in southern California.- *Annals of the Entomological Society of America*, 79: 953-962.

GOEDEN R. D., RICKER D. W., 1987a.- Phytophagous insect faunas of the native thistles, *Cirsium brevistylum, C. californicum*, and *C. tioganum*, in southern California.- *Annals of the Entomological Society of America*, 80: 152-160.

GOEDEN R. D., RICKER D. W., 1987b.- Phytophagous insect faunas of native *Cirsium* thistles, *C. mohavense, C. neomexicanum*, and *C. nidulum*, in the Mojave desert of southern California.- *Annals of the Entomological Society of America*, 80: 161-175.

GOEDEN R. D., RICKER D. W., 1989.- Phytophagous insect faunas of the desert shrubs *Bebbia juncea* and *Trixis californica* in southern California.- *Annals of the Entomological Society of America*, 82 (3): 325-331.

GOLDARAZENA A., LOOMANS A. J. M., JORDANA R., 1999.- Parasitic and parasitoid enemies of thrips (Insecta, Thysanoptera) in Northern Spain, an introduction, pp. 37-42. In: *Proceedings of the sixth international symposium on thysanoptera*, Antalya, Turkey, April 27-May 1, 1998.

GONZÀLEZ D., 1989.- Foreign exploration for natural enemies of RWA, pp. 113-128. In: *Proceedings 3rd Russian Wheat Aphid Workshop*, 25-27 October 1989, Albuquerque, New Mexico.

GONZÁLEZ D., GILSTRAP F., MCKINNON L., ZHANG J., ZAREH N., ZHANG G., STÁRY P., WOOLLEY J., WANG R., 1993.- Foreign exploration for natural enemies of Russian wheat aphid in Iran and in the Kunlun, Tian Shan, and Altai Mountain Valleys of the People's Republic of China, pp. 197-209. In: *Proceedings 5th Russian Wheat Aphid Workshop*, 26-28 January 1993, Fort Worth, Texas.

GONZÁLEZ D., GILSTRAP F., MCKINNON L., WOOLLEY J., STÁRY P., WAGGONER M., ZHANG G., 1994.- Foreign exploration for natural enemies of Russian wheat aphid in southern Xinjiang, pp. 208-222. In: *Proceedings 6th Russian Wheat Aphid Workshop*, 23-25 January 1994, Fort Collins, Colorado.

GOODWIN S., STEINER M. Y., 1996.- Survey of Australian native natural enemies for control of thrips.- *Bulletin IOBC/wprs*, 19 (1): 47-50.

GREENE I. D., PARRELLA M. P., 1993.- An entomophilic nematode, *Thripinema nicklewoodii* and an endoparasitic wasp, *Ceranisus* sp. parasitizing *Frankliniella occidentalis* in California.- *Bulletin IOBC/wprs*, 16 (2): 47-50.

HEINZ K. M., HEINZ L. M., PARRELLA M. P., 1996.- Natural enemies of western flower thrips indigenous to California ornamentals.- *Bulletin IOBC/wprs*, 19 (1): 51-54.

HIROSE Y. (Ed.), 1989.- *Exploration for Natural Enemies of* Thrips palmi *in Southeast Asia*.- Institute of Biological Control, Faculty of Agriculture, Kyushu University, Fukuoka, Japan.

HIROSE Y., 1990.- Prospective use of natural enemies to control *Thrips palmi* (Thysanop., Thripidae), pp. 135-141. In: *The use of natural enemies to control agricultural pests* (BAY-PETERSEN J., Ed.).- Proceedings of the International Seminar "The use of parasitoids and predators to control agricultural pests", Tsukuba, Japan, October 2-7, 1989. FFTC book series 40.

HIROSE Y., TAKAGI M., KAJITA H., 1992.- Discovery of an indigenous parasitoid of *Thrips palmi* Karny (Thysanoptera: Thripidae) in Japan: *Ceranisus menes* (Walker) (Hymenoptera: Eulophidae) on eggplant in home and truck gardens.- *Applied Entomology and Zoology*, 27: 465-467.

HIROSE Y., KAJITA H., TAKAGI M., OKAJIMA S., NAPOMPETH B., BURANAPANICHPAN S., 1993.- Natural enemies of *Thrips palmi* and their effectiveness in the natural habitat, Thailand.- *Biological Control*, 3: 1-5.

HODDLE M. S., NAKAHARA S., PHILLIPS P. A., 2002.- Foreign exploration for *Scirtothrips perseae* Nakahara (Thysanoptera: Thripidae) and associated natural enemies on avocado (*Persea americana* Miller).- *Biological Control*, 24 (3): 251-265.

HOKKANEN H., PIMENTEL D., 1984.- New approach for selecting biological control agents.- *Canadian Entomologist*, 116 (8): 1109-1121.

HOKKANEN H. M. T., PIMENTEL D., 1989.- New associations in biological control: theory and practice.- *Canadian Entomologist*, 121 (10): 829-840.

HUFFAKER C. B., MESSENGER P. S., 1976.- *Theory and practice of biological control*.- Academic Press, New York, USA.

LACASA P. A., 1990.- Datos de taxonomía, biología y comportamiento de *Frankliniella occidentalis*.- *Cuadernos Phytoma España*, 4: 9-15.

LACASA A., CONTRERAS J., SANCHEZ J. A., LORCA M. Y., GARCIA F., 1996.- Ecology and natural enemies of *Frankliniella occidentalis* (Pergande) in South-east Spain.- *Folia Entomologica Hungarica,* 57 (suppl.): 67-74.

LENTEREN J. C. VAN, 2000.- A greenhouse without pesticides: fact or fantasy?- *Crop Protection*, 19 (6): 375-384.

LEWIS T., 1973.- *Thrips, their biology, ecology and economic importance*.- Academic Press, London, UK.

LOOMANS A. J. M., 1991.- Collection and first evaluation of hymenopterous parasites of thrips as biological control agents of *Frankliniella occidentalis*.- *Bulletin IOBC/wprs*, 14 (5): 73-82.

LOOMANS A. J. M., LENTEREN J. C. VAN, 1990.- Hymenopterous parasitoids as biological control agents of *Frankliniella occidentalis* (Perg.).- *Bulletin IOBC/wprs*, 13: 109-114.

LOOMANS A. J. M., LENTEREN J. C. VAN, 1995.- Biological control of thrips pests: a review on thrips parasitoids.- *Wageningen Agricultural University Papers*, 95-1, 89-201.

MATEUS C., MEXÍA A., 1995.- Western flower thrips response to color, pp. 567-570. In: *Thrips Biology and Management* (PARKER B. L., SKINNER M., LEWIS T.)*: proceedings of the 1993 International Conference on Thysanoptera 1995*, NATO ASI Series A276.

MCMURTRY J. A., JOHNSON H. G., NEWBERGER S. J., 1991.- Imported parasite of greenhouse thrips established on California avocado.- *California Agriculture*, 45 (6): 31-32.

MOHR N., RISCH S., SORG M., 1992.- Vergleichende Untersuchungen zur Fauna ausgewählter Hautflüglertaxa (Hymenoptera) von Streuobstwiesen im Nordpfälzer Bergland.- *Beiträge Landespflege Rheinland-Pfalz*, 15: 409-493.

MOUND L. A., MARULLO R., 1996.- The thrips of Central and South America: an introduction (Insecta: Thysanoptera).- *Memoirs on Entomology International*, 6: 1-487.

MURAI T., 1988.- Studies on the ecology and control of flower thrips, *Frankliniella intonsa* (Trybom).- *Bulletin of the Shimane Agricultural Experiment Station*, 23: 1-73.

MURAI T., 1990.- Rearing method and biology of thrips parasitoid, *Ceranisus menes*.- *International Organisation of Biological Control/West Palearctic Regional Section Bulletin* 13, 142-146.

MURAI T., LOOMANS A. J. M., 2001.- Evaluation of an improved method for mass-rearing of thrips and a thrips parasitoid.- *Entomologia Experimentalis et Applicata,* 101 (3): 281-289.

NOYES J. S., 1982.- Collecting and preserving chalcid wasps (Hymenoptera: Chalcidoidea).- *Journal of Natural History*, 16 (3): 315-334.

NOYES J. S., 1989.- A study of five methods of sampling Hymenoptera (Insecta) in a tropical rainforest, with special reference to the Parasitica.- *Journal of Natural History*, 23 (2): 285-298.

PEARSALL I. A., MYERS J. H., 2000.- Population dynamics of western flower thrips (Thysanoptera: Thripidae) in nectarine orchards in British Columbia.- *Journal of Economic Entomology*, 93 (2): 264-275.

ROSEN D., DEBACH P., 1992.- Foreign exploration: the key to classical biological control.- *Florida Entomologist*, 75: 409-431.

SAKIMURA K., 1937.- Introduction of *Thripoctenus brui* Vuillet, parasite of *Thrips tabaci* Lind., from Japan to Hawaii.- *Journal of Economic Entomology*, 30 (5): 799-802.

SAKIMURA K., 1961.- Field observations on the thrips vector species of the tomato spotted wilt virus in the San Pablo area.- *California Plant Disease Reporter*, 45: 772-776.

SAKIMURA K., O'NEIL K., 1979.- *Frankliniella*, redefinition of genus and revision of minuta group species (Thysanoptera: Thripidae).- *USDA Technical Bulletin*, 1572: 1-48.

SCHAUFF E. M., 1999.- *Collecting and Preserving Insects and Mites: Techniques and Tools*, [online] URL: http://www.sel.barc.usda.gov/selhome/collpres/collpres.htm (viewed October 30, 2006).

SEAMANS H. L., 1923.- The alfalfa thrips and its effect on alfalfa seed production.- *Canadian Entomologist*, 55 (5): 101-105.

STEINER M. Y., GOODWIN S., 1996.- *Biological control of western flower thrips,* Frankliniella occidentalis *(Pergande), in Australia. Phase 1. The search for natural enemies*.- Report to the Horticultural Research and Development Corporation and the Horticultural Stock and Nursery Act., NSW Agriculture Horticultural Research and Advisory Station, Gosford, Australia.

STEINER M. Y., GOODWIN S., 1998.- Methods for collecting and rearing thrips (Thysanoptera) and their natural enemies.- *Australian Journal of Entomology*, 37 (2): 101-106.

STEINER M. Y., GOODWIN S., WELHAM T., 1996.- Collecting and rearing thrips and their natural enemies, pp. 15-19. In: *Proceedings 1995 Australian and New Zealand Thrips Workshop: Methods, biology, ecology and management*, (GOODWIN S., GILLESPIE P., Eds).- NSW Agriculture, Gosford, Australia.

STEYSKAL G. C., MURPHY W. L., HOOVER E. M., (Eds), 1986.- Insects and mites: Techniques for collection and preservation.- *U.S. Department of Agriculture. Miscelaneous Publications*, 1443: 1-103.

TAMÒ M., BAUMGÄRTNER J., DELUCCHI V., HERREN H. R., 1993.- Assessment of key factors responsible for the pest status of the bean flower thrips *Megalurothrips sjostedti* (Trybom) (Thysanoptera, Thripidae).- *Bulletin Entomological Research*, 83: 251-258.

TAMÒ M., BOTTENBERG H., ARODOKOUN D., ADEOTI R., 1997.- The feasibility of classical biological control of two major cowpea insect pests, pp. 259-270. In: *Advances in cowpea research* (SINGH B. B., MOHAN RAJ D. R., DASHIELL K. E., JACKAI L. E. N., Eds).- Copublication of International Institute of Agriculture (IITA) and Japan International Center for Agricultural Sciences (JIRCAS). IITA, Ibadan, Nigeria.

TEULON D. A. J., CAMERON E. A., LOOMANS A. J. M., 1996.- In search of the univoltine thysanopteran parasitoids *Ceranisus menes* Walker and *C. pacuvius* Walker (Hym., Eulophidae).- *Entomologist's Monthly Magazine*, 132 (1586-1587): 177-182.

TRIAPITSYN S. V., 2005.- Revision of *Ceranisus* and the related thrips-attacking entedonine genera (Hymenoptera: Eulophidae) of the world.- *African Invertebrates*, 46: 261-315.

TRIAPITSYN S. V., HEADRICK D. H., 1995.- A revision of the Nearctic species of the thrips-attacking genus *Ceranisus* Walker (Hymenoptera: Eulophidae).- *Transactions of the American Entomological Society*, 121: 227-248.

TRIAPITSYN S. V., HEADRICK D. H., 1996.- Description of the male of *Ceranisus americensis* (Girault) (Hymenoptera: Eulophidae).- *Pan-Pacific Entomologist*, 72: 168-170.

VUILLET A., 1914.- Nôte sur un Chalcidien parasite de thrips de pois.- *Comptes rendus des Scéances de la Société de Biologie*, 75: 552-554.

WALKER F., 1839.- *Monographia Chalciditum*. 1.- London, UK.

YUDIN L. S., CHO J. J., MITCHELL W. C., 1986.- Host range of western flower thrips *Frankliniella occidentalis* (Thysanoptera: Thripidae), with special reference to *Leucaena glauca*.- *Environmental Entomology*, 15: 1292-1295.

YUDIN L. S., TABASHNIK B. E., CHO J. J., MITCHELL W. C., 1988.- Colonization of weeds and lettuce by thrips (Thysanoptera: Thripidae).- *Environmental Entomology*, 17: 522-526.

ZUIJLEN J. W. VAN, PEETERS T. M. J., WIELINK P. S. VAN, ECK A. P. W. VAN, BOUVY E. H. M., (Eds), 1996.- *Brand-stof: een inventarisatie van de entomofauna van het natuurreservaat 'De Brand' in 1990*.- Insektenwerkgroep K.N.N.V.-afdeling Tilburg, Nederland.

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