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An annotated list of the spider mites (Acari: Prostigmata: Tetranychidae) of Israel

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ABSTRACT

An annotated list and key to twenty four species of spider mites (Prostigmata: Tetranychidae) known from Israel is provided. About half of the species are considered to be exotics, having invaded Israel within the last fifty years. Nine species, all of which belong to the subfamily Tetranychinae: *Eutetranychus orientalis, Eutetranychus palmatus, Oligonychus afrasiaticus, Oligonychus perseae, Panonychus ulmi, Panonychus citri, Schizotetranychus asparagi, Tetranychus turkestani and Tetranychus urticae,* are agricultural pests, whereas the others have little economic impact, or else are controlled by their natural enemies.

KEYWORDS: Acari, Tetranychidae, Israel, invasive species, plant feeding mites

INTRODUCTION

The spider mite family Tetranychidae (Prostigmata) contains many species that are major worldwide plant pests (Migeon and Dorkfeld, 2006-2014). Knowledge of the spider mites of Israel is based primarily on studies of agricultural economic pests, by authors that include Bodenheimer (1930), Klein (1936), Shulov (1957), Plaut (1963), Gerson *et* al. (1983), Dubitzki (1981), Gerson (1986), Swirski *et al*. (1986) and Dubitzki and Gerson (1987). Additional species were reported from Israel for the first time by Ben-David *et al*. (2007) and listed later by Klein and Zarabi (2011).

About half the local pest species do not appear to be indigenous. The number of spider mite pests has grown over the past 50 years, in association with the increase in the importation of exotic plant material, the establishment of new crops and the introduction of new varieties of traditional crops. Only four tetranychids, *Bryobia praetiosa* Koch, *Bryobia graminum* (Schrank) [initially listed as *Bryobia cristata* (Duges), Shulov 1957], *Tetranychus urticae* Koch, red-form (herein as *T. urticae* RF, previously known as *Tetranychus cinnabarinus*) (initially listed as *Epitetranychus althea* Hanstein, Bodenheimer, 1930), and *Eutetranychus orientalis* (Klein) have been reported from Israel before 1963. However, since then, numerous invasive pest species have been found locally.

This paper presents an annotated list of 24 spider mite species identified from agricultural systems in Israel. Hosts, distributional data and biological notes are presented, and a key to the Israeli species is provided. General information from abroad is based on Migeon and Dorkfeld (2006-2014), Seeman and Beard (2011) and on Vacante (2010), whereas additional data on the local fauna is based on 3 unpublished thesis suitably acknowledged, and on the senior author's own observations (abbreviated as BD 2007 and BD 2009). These observations and the fact that many of the indigenous shrubs and trees have not yet been surveyed for these mites, suggest that the species listed here represent only a part of the local spider mite fauna. The species are listed alphabetically by subfamily, genus and species.

BRYOBIINAE

Aplonobia histricina (Berlese, 1910)
(Figures 1-4)

This species is known from South Africa, Australia and Italy, and infests pear *Pyrus communis* (Rosaceae), *Sphaeralcea ambigua* (Malvaceae) and *Oxalis* spp. (Oxalidaceae) The mite also occurs sporadically on citrus trees. It oversummers as eggs, and resumes development in the autumn (Vacante, 2010). In Israel, *A. histricina* was collected on *Oxalis pes-caprae* at Yaqum on the coastal plain, March 1, 2004 (BD 2007).

Aponychus grandidieri (Gutierrez, 1966)
(Figures 5-9)

Until now this species was known only from Madagascar, where it was found on *Phragmites communis* (Poaceae). A colony of this species was collected on *Phragmites australis* at Samar, in the southern Arava Valley, July 28, 1981 (Gerson, unpublished).

Bryobia graminum (Schrank, 1781)
(Figures 10-17)

An almost cosmopolitan species known from about 30 host plants. In Israel, it was collected on *Colutea istria* (Fabaceae) at Avdat, in the south of Israel, on March 12, 1974. A colony was later found west of Jerusalem (at Sataf) on *Calicotome villosa* (Fabaceae), April 28, 2005 and again in April 17, 2006 (BD 2007).

Bryobia neopraetiosa Meyer, 1974
(Figures 18-24)

An Afrotropical species collected from about 40 host plants. In Israel, it was found at

Ein Iron, on the coastal plain, on an undetermined plant of the family Labiatae, April 29, 1974 (Gerson, unpublished).

Bryobia praetiosa Koch, 1836
(Figures 25-31)

This polyphagous, almost cosmopolitan species, also known as the clover mite, was first recorded in Israel by Bodenheimer (1930). More recently, it was collected from *Malva parviflora* (Malvaceae) in Upper Galilee, on April 29, 1974. During February 2005-May 2006, it was found on the same host in Rehovot and at Talme Yehi'el in the Coastal Plain, and in the Western Negev and at Ein Hazeva in the Arava Valley (Gerson, unpublished). Abroad, the mite is regarded as a pest and it sometimes invades human dwellings (Jeppson *et al*., 1975; Mumcuoglu and Shalom, 2013), but it has been reported to cause no economic damage in agriculture in Israel (Avidov and Harpaz, 1969).

Petrobia (Tetranychina) harti (Ewing, 1909)
(Figures 32-39)

This cosmopolitan species, known as the oxalis spider mite, usually infests *Oxalis* spp. (Oxalidaceae). When occurring in large numbers, it damages these plants, becoming a serious pest of lawns and gardens (Zheng and Hong, 2007). In Israel, it often occurs on *Oxalis corniculata* in the humid environments of greenhouses where ornamentals are grown. The mites spend most of their lives on the lower leaf surface where their eggs are deposited. Species of *Oxalis* differ in their suitability for *P. harti*, about 17 eggs/female were deposited on *O. corniculata*, but only about 10 eggs /female on *O. articulate*, and none on *O. pes-capra*e (Dubitzki and Gerson, 1987). In Israel, the mite was most abundant during late spring (April-May), its populations then declined and remained low during the summer and the following winter, apparently without undergoing diapause. However, under long-day photoperiods and temperatures of about 19ºC, *P. harti* may undergo a facultative summer diapause in the egg stage (Koveos and Tzanakakis 1991).

Petrobia (Petrobia) latens (Müller, 1776)
(Figures 40-43)

This cosmopolitan, polyphagous species, commonly known as the brown wheat mite, is a dry-weather pest of many crops, including small grains, onions and strawberry as well as fruit trees (Jeppson *et al*., 1975). The parthenogenetic females lay eggs, which may hatch under suitable moisture conditions or diapause. The mite has been shown to transmit the barley yellow streak mosaic virus (BaYSMV), which causes a barley disease in nature, and may be transmitted to non-diapausing eggs within the mite vector by transovarial passage (Smidansky and Carroll, 1996). In Israel, it was found in Rehovot on Buffalo grass *Stenotaphrum secundatum* (Poaceae), March 1st, 1970, apparently without causing any damage (Gerson, unpublished).

Petrobia (Mesotetranychus) tunisiae Manson, 1964
(Figures 44-47)

Initially discovered and described from Tunisia on "coarse grass" (Manson, 1964), this mite is now widely spread in many Mediterranean countries (Migeon and Dorkfeld, 2006-2014). In Israel, it was found on the following grasses (Poaceae): *Avena sterilis, Bromus madritensis, Hordeum leporium* and *Lolium rigidum* (Dubitzki and Gerson 1987). The mite occurs on these plants only during winter and spring (January to April) but was not found on any of these hosts afterwards, suggesting that it is a "winter species". In the laboratory, it was reared on *B. madritensis* under conditions of 14ºC during day, 8ºC at night, during a light regime of 14:10 L:D hours. A total of two generations were completed, each generation requiring 6-7 weeks. Females of the first generation deposited about 17 non-diapausing eggs, whereas females of the second generation produced fewer, mostly diapausing eggs (recognizable by being covered with whitish wax). Efforts to break their diapause (by dissolving the wax in chloroform) after one, two and three years showed that a few remained viable even after three years, indicating a prolonged diapause (Dubitzki and Gerson, 1987).

TETRANYCHINAE

Eotetranychus hirsti Pritchard and Baker, 1955
(Figures 48-53)

This species has been reported from India, Pakistan and Cyprus, on *Nerium* (Apocynaceae)*, Bauhinia* (Fabaceae) and *Ficus* (Moraceae). In Israel, it was collected from *Ficus carica* in dry regions in the southern Dead Sea (Ne'ot HaKikkar), the Arava (at Hazeva) and in Ne'ot Smadar during May-July 2005-2006. At the first location, E. hirsti was found together with T. turkestani in a mixed population with *Tetranychus turkestani* (BD 2007).

Eutetranychus orientalis (Klein, 1936)
(Figures 54-60)

The biology and morphology of this indigenous species, known as the oriental red spider, were discussed in detail by Klein (1936). In Israel, it occurs throughout the country (Ben-David, 2009) and is a minor pest of citrus, and sometimes affects other crops, such as almond, persimmon, and avocado. In Europe, it is considered a quarantine pest (EPPO, 2010), that invaded Spain in 2011 (Ferragut *et al.,* 2013). Heavy infestations of the mite cause leaf stippling and drop and twig dieback, thus affecting yield. *Eutetranychus orientalis* is very polyphagous, its host list includes over 200 plants in Africa, Asia and Australia (Migeon and Dorkfeld, 2006-2014). In the Middle East, this pest may complete more than 20 generations/year (Avidov and Harpaz, 1969). Morphologically, it is very polymorphic (Meyer, 1987), which is consistent with results obtained upon comparing DNA sequences of the molecular marker ITS2 from individual females obtained throughout the country (Ben-David, 2009). Nevertheless, one common sequence was present in mites from the different populations, collected on various host plants, indicating gene flow between these subpopulations, which is inconsistent with the possibility of the existence of cryptic sister-species in Israel. The possibility that the local species may be one of the taxa similar to *E. orientalis* recently described from Yemen (Meyer, 1996; Smiley and Baker, 1995), was rejected after a careful study of all local specimens.

***Eutetranychus palmatus* Attiah, 1967**
(Figures 61-65)

This East-Mediterranean species is known to infest a few species of palms (Arecaceae also known as the Palmae), and caused economic damage primarily to the date palm, *Phoenix dactylifera*. The mite lives on the palm fronds throughout the year, its numbers peaking by mid-summer, and then subsequently declining (Palevsky *et al*., 2010). Due to the co-occurrence of *E. palmatus* and *Oligonychus afrasiaticus* on date palms, the damage incurred by the former is usually masked by that of the latter. However, when only *E. palmatus* occurs on dates, its distinctive damage to the fruit is manifested. Such damage to the fruits remains even after they are washed, indicating that *E. palmatus* should, under certain conditions be considered as a minor pest of dates (especially when *O. afrasiaticus* does not occur on the palm tree (Palevsky *et al*., 2010).

***Oligonychus afrasiaticus* (McGregor, 1939)**
(Figures 66-73)

This species (known as the old world date mite) occurs in North Africa, the Middle East to Iran and in Saudi Arabia. Its known hosts include date palms and various grasses. In Israel, it infests green dates only from around May to September, when the fruit begins to yellow. The mites cover the bunches with dense webbing that hinders photosynthesis and accumulates much dust. The infested fruit becomes reddish, produces gum-like exudations, shrivels and may split, greatly reducing market value. Heavy infestations can lead to partial or total yield loss. During the period from May to September, the mites reproduce rapidly, and very large populations occur. The date variety “Medjool” is infested almost two months earlier than variety “Deglet Noor”, with variety “Barhi” being intermediate (Palevsky *et al*., 2003, 2005). During the rest of the year, the mites occur on various Poaceaeus plants (especially Bermuda grass *Cynodon dactylon*, sorghum sp. and sugar cane *Saccharum officinarum*) or, in very low numbers, on the palm fronds. The mite prefers hot, dry weather and may produce 10-12 generations/year; in the summer, the generation time is less than 14 days. A female deposits 30-50 eggs, lives about 3-4 weeks in the summer. It is yet unknown where they spend the winter months. The pest is dispersed by winds and possibly by insects and fruit-eating birds. Single acaricide treatments applied as soon as the first mites occur on the fruit provide season-long control (Palevsky *et al*., 2003).

***Oligonychus coniferarum* (McGregor, 1950)**
(Figures 74-78)

This species is known from Turkey, Yemen, USA, Hawaii and Honduras living on conifers (Families Cornaceae, Cupressaceae and Pinaceae). A colony was found on *Cupressus sempervirens* in the Bahá'í gardens in Haifa, April 6, 2006 and on *Pinus halepensis* in Bar'am in Upper Galilee, October 12, 2006. A large population can inflict damage to the canopy (BD, 2007).

***Oligonychus mangiferus* (Rahman and Sapra, 1940)**
(Figures 84-88)

This species (known as the red mango mite) has a wide distribution in the tropics and subtropics. Abroad it infests cotton, pomegranates, grapes, Lychee, roses and many other commercial host plants, but in Israel it has so far been found only on mango (Gerson, 1986) and pomegranates in the Arava, and is not known to cause any economic damage (BD, 2009). The mite lives and feeds mostly on the upper leaf surface, where it spins delicate silk threads in which dust may gather. A female produces 20-35 eggs; a life cycle can be completed in a 14 days. In Egypt, it produces 21 generations/years and has a single peak in its population in April (Zaher and Shebata, 1972). The optimum temperature for the development and reproduction of the mite was 24-28ºC (Fu and Zhang, 2002). Mite feeding on mango leaves causes the leaves to wilt, then redden and finally drop, thereby reducing tree yield. Pruning and removing old, infested inflorescences reduced mite numbers and increased yields in Egypt.

***Oligonychus perseae* Tuttle, Baker and Abbatiello, 1976**
(Figures 89-93)

This pest of avocado, known as the persea mite, is of Neotropical origin (Tuttle *et al*., 1976). It was discovered in the north of Israel in late 2001 and has since spread to most avocado growing areas, causing extensive leaf and even fruit drop. The mite establishes small colonies on the underside of the leaves, spinning densely woven nests along the veins, causing feeding damage that appears as circular necrotic spots (Aponte and McMurtry, 1997). Maoz *et al*. (2011a) determined that on the Hass variety, the pest's economic injury level was reached when leaf damage reached 15%, and that control measures were to be taken (the action threshold) when there were 50-100 mites per leaf. The numbers of this pest were significantly reduced in an avocado orchard (the Hass variety) by *Euseius scutalis* (Phytoseiidae), an indigenous predator (Maoz *et al*., 2011b). Provisioning the predator with Rhodes grass (*Chloris gayana,* Poaceae) pollen, sown between the trees, greatly increased its efficacy.

***Oligonychus senegalensis* Gutierrez and Etienne, 1981**
(Figures 79-83)

Gerson *et al*. (1983) misidentified this species as *Oligonychus tylus* Baker and Pritchard. In Israel, it occurs in small numbers on date palms and on Bermuda grass

(*Cynodon dactylon*) in the Arava region. In the early 1980's, it caused damage to date palms in that area (Gerson *et al*., 1983), but has since declined to be a very minor component of the spider mite guild that infests date palms (Palevsky *et al*., 2003).

***Panonychus citri* (McGregor, 1916)**
(Figures 94-97)

Panonychus citri (known as the citrus red mite) has been collected from about 110 different host plants, but is mainly a pest of all varieties and species of citrus wherever it is grown. It has been reported from Israel since the late 1970s, mostly along the coastal plain (Swirski *et al.,* 1986). This pest, like many other spider mites, is dispersed by "ballooning", floating on air streams by holding onto a silken thread. This species completes a generation in 14 days at 26°C and each female lays about 40 eggs. The eggs, each with a prominent stalk, are usually placed along the main vein usually on the upperside of young leaves. Pest populations are more numerous on new citrus growth during early winter and spring, least abundant in the summer, but reproduction is continuous. The citrus red mite is very susceptible to high temperatures and low humidity, explaining its population decline during summer. Mite feeding causes stippling spots that combine to cause yellow or silvery areas on the leaves. Heavy infestations result in leaf drop, twig dieback, low-quality fruit and even tree death. The expression of damage is enhanced by dry conditions and strong winds (Jeppson *et al*., 1975).

In Israel, the citrus red mite is only of minor economic importance in citrus groves in years of mild winters, probably due to its many natural enemies, which are primarily predatory mites of the family Phytoseiidae (Swirski *et al.,* 1986). If necessary, the pest may be controlled with conventional acaricides, but abroad it has developed extensive resistance to most pesticides (Whalon *et al*.*,* 2010).

***Panonychus ulmi* (Koch, 1836)**
(Figures 98-99)

This species, known as the European red mite (ERM), attacks pome and stone fruit trees wherever they are grown, as well as many other plants. It has been reported from the Middle East since the 1950's, and in Israel since the late 1960's (Plaut, 1963). It is a serious pest of apples wherever they are grown.

During the summer, the mite completes a generation in 14 days. Each female lays about 40 summer eggs, primarily on the lower side of young leaves. The adults, however, are evenly distributed on both sides of the leaf. Like many other spider mites, ERM is dispersed between trees by ballooning, floating on air streams by holding onto a web thread. It is probably dispersed between countries on seedlings, root stock or fruit. The populations are heaviest on apple trees during early summer (late June), and decline by August, perhaps due to the attack by their natural enemies. In the north of Israel, the ERM produces 8-9 generations/year (Shahar, 1985). By mid-summer, the females begin to lay diapause eggs, which are protected by a whitish waxy cover (thus different from the red summer eggs), and placed on the bark and twigs, near spurs and within buds, as well as on the fruit. Larval emergence from these eggs in the coming spring depends on the temperatures that have accumulated above the threshold of development, which is 5-6°C in colder regions, and around 7°C in the Middle East. Egg hatch requires about 6 weeks. A very high humidity during the period of egg hatch reduces the survival rates of the emerging larvae.

Heavy ERM infestations on apples results in leaf drop and small, low-quality fruit. When such infestations occur during May to June, fruit size is reduced; if most damage takes place later in the season, the next year's yield would be affected. The effect of the pest on apple yield (quantity as well as quality) depends on the affected cultivar. The damage is greater when the trees are suffering from water stress (Palevsky *et al.*, 1996). Larger pest populations occur on the southern and eastern sides of apple trees as compared to the north and west (Shahar, 1985). The mites prefer certain apple cultivars (e.g. Red Delicious, Orleans over others, such as Grand and Golden Delicious). ERM may be controlled with various acaricides, but has developed resistance to many of them.

In Israel, ERM populations are usually maintained below their economic injury level by natural enemies, especially predatory mites of the family Phytoseiidae (e.g. *Typhlodromus athiasae* Porath and Swirski). There is considerable evidence that pest outbreaks often follow the application of broad spectrum pesticides. This suggests that the careful use of selective pesticides, which do not harm the natural enemies, would be instrumental to the management of the ERM (Palevsky, 2000).

***Schizotetranychus asparagi* (Oudemans, 1928)**

(Figures 100-104)

This is a cosmopiltan species that infests primarily Asparagaceae. It was collected from a colony infesting *Asparagus virgatus* grown commercially under netting (shaded) for flower arrangements. Large populations are common in the summer. This species has been known in Israel since the early 1990's (Ben-David et al., 2007).

***Tetranychus evansi* Baker and Pritchard, 1960**

(Figures 105-108)

This polyphagous species, known as the tomato red spider mite, is of South American origin, and is a pest of Solanaceous crops, especially tomatoes. It is an aggressive invasive species that was established in various parts of the world in the past 20 years (Navajas *et al*., 2013). In Israel, it has not caused much damage so far (Ben-David et al., 2007). It occurs primarily on *Solanum nigrum*, but has also been collected on potatoes (*Solanum tuberosum*), eggplant (*Solanum melongena*) and *Withania somnifera,* in the summer and autumn. It is widespread in Israel, from the Hula Valley in the north to Samar in the southern Arava Valley (BD 2007).

***Tetranychus ludeni* Zacher, 1913**

(Figure 109)

This species is known as the dark red mite or bean mite. In the tropics, it is common outdoors and in temperate zones in greenhouses. This mite is present in Africa, North and South America, Asia, Europe, Australia and in New Zealand, and has been reported as a pest of cotton, beans, eggplant and cucurbits. In Israel, it was first found on *Lavatera sp*. (Malvaceae) in October 10, 2004 in the coastal plain but might have been introduced into the country much earlier. Later, it was collected on *Solanum melongena* and *Withania sp*. (Solanaceae), *Prunus persica* (Rosaceae), *Cucurbita* sp. (pumpkin) and *Cucumis sativus* (Cucurbitaceae), cultured *Salvia* (Lamiaceae), garden *Dahlia, Heterotheca subaxillaris* and *Conyza bonariensis* (Asteraceae) (BD 2007). In Israel, it is not considered an economic pest, being abundant on the local wild vegetation and rarely causes economic damage.

***Tetranychus neocaledonicus* Andre, 1933**

(Figure 110)

This is a cosmopolitan, polyphagous species, which thus far has not caused any economic damage in Israel. It was collected off *Acalypha wilkesiana* (Euphorbiaceae) in Rehovot, August 31, 2006 (BD 2007).

***Tetranychus turkestani* Ugarov and Nikolskii, 1937**

(Figures 111-112)

This polyphagous, globally-distributed species, whose host list includes over 200 host plants from 59 botanical families (Migeon and Dorkfeld, 2006-2014), was not known in Israel before the 1960's. It injures diverse crops, including cotton, strawberry and other low growing crops, as well as deciduous perennials, such as Rosaceae. Damage caused by this species is very similar to that of *Tetranychus urticae* Koch (see below). The females of *T. turkestani* may undergo a winter diapause (Jeppson *et al*., 1975). Although listed from Israel (Migeon and Dorkfeld, 2006-2014), *T. turkestani* was overlooked and has not received any attention. This might have been due to past misidentifications and confusion with the green morph of *T. urticae*, first reported as a pest of apples in Israel in 1965 (Plaut and Feldman, 1966). It is not known when *T. turkestani* invaded Israel, but in the last decade, it has been very abundant in deciduous fruit tree orchards, affecting mainly almond, apple, fig, peach, pear and plum (BD 2007).

***Tetranychus urticae* Koch, 1836**

(Figures 113-115)

The most common spider mite pest in Israel is the red form (RF) of *T. urticae* Koch, formerly known as *Tetranychus cinnabarinus* Boisduval (Auger *et al.,* 2013) or the carmine spider mite. In Israel, it has been collected from over 80 commercial, wild and ornamental plant species assigned to 32 botanical families. *Tetranychus urticae* RF is a serious pest of agricultural crops, affecting such diverse hosts as cotton, roses, and many herbaceous plants in the Cucurbitceae and Solanaceae (Avidov and Harpaz, 1969), as well as apples and pears (Plaut and Feldman, 1966). RF overwinters in greenhouses, in polyethylene-covered low tunnels and on some perennials (e.g. *Solanum nigrum*). In the spring and early summer, as temperatures rise and greenhouses are opened, the mites move onto crops in open fields, mainly by aerial dispersion (Dubitzki, 1981; Yarmus, 1982). This pest and *T. turkestani* were mostly found in separate agricultural ecosystems: the former in deciduous orchards and the latter infesting vegetable crops. Mixed populations occurred on watermelon, the preferred host in laboratory assays. Such overlapping in habitats suggests a measure of reproductive interaction, which can affect their fitness (Ben-David et *al*., 2009).

The green form of *Tetranychus urticae* (The GF or TSSM, the two-spotted spider mite) is an introduced, very polyphagous pest in this region. In North America and Europe, it is a major pest of many crops, including cotton, roses, ornamentals, strawberries, watermelons, tomatoes, and others. The mites usually colonize the lower side of the leaf where they feed by sucking out cell constituents. This decreases chlorophyll content and photosynthetic rates, leading to leaf wilt and even death, reducing the quantity and quality of the yield. In the Middle East, the mite may occur on apples, whose leaves become mottled and drop. Some damage is caused by the webbing which may cover parts of plants and protects the mites from some natural enemies and from pesticides.

Apparently this pest invaded Israel about 50 years ago, when the mite was found in pear and apple orchards (Plaut and Feldman, 1966). It is possible that this invader was actually *T. turkestani*, erroneously identified as *T. urticae* GF, because neither of these greenish mites had been recorded from Israel. However, at least since the beginning of the 21th century, both TSSM and *T. turkestani* are present locally. Their current distribution suggests that *T. urticae* RF and *T. turkestani* may have outcompeted and displaced *T. urticae* GF, as it was rarely found on its known hosts in any of the growing regions in Israel during a 2004-2009 study (Ben-David, 2009).

At 25-30°C, the development of a generation of *T. urticae* RF requires about two weeks, and each female deposits over 100 eggs; the optimal conditions for reproduction are 24°C and about 40% relative humidity (RH) (Hazan *et al*., 1974). In the Middle East, the pest may produce 20-25 generations/year. Females disperse by ballooning or by forming webbed "balls" that contain all mite stages, become detached from the host plants and are then blown about by winds. The females of *T. urticae* GF undergo a winter reproductive diapause, become pink-orange in color (due to accumulating lipids in their bodies), search out resting sites (dropped leaves and other debris in the top layers of the soil), and lay no eggs. In the spring, as temperatures rise and the days begin to lengthen, these females begin to lay eggs (Helle and Sabelis, 1985). The TSSM develops rapid and extensive resistance to most pesticides in use, and the formerly much-used pyrethroids tend to encourage its populations (Gerson and Cohen, 1989). In the field in Israel, *T. urticae* RF is often controlled by many indigenous predatory mites of the family Phytoseiidae and by ladybird beetles of the genus *Stethorus* (Coleoptera: Coccinellidae). On covered crops, such as strawberries and roses, it is controlled by *Phytoseiulus persimilis* Athias-Henriot (Phytoseiidae), an introduced (and commercially available) predator.

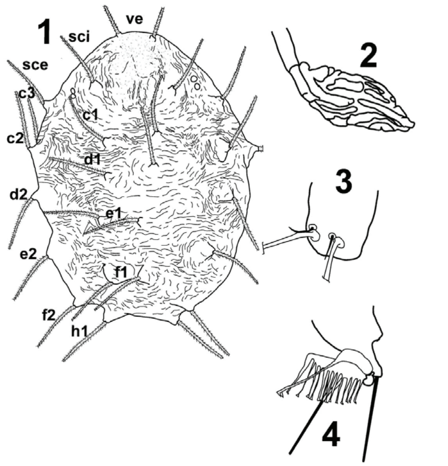
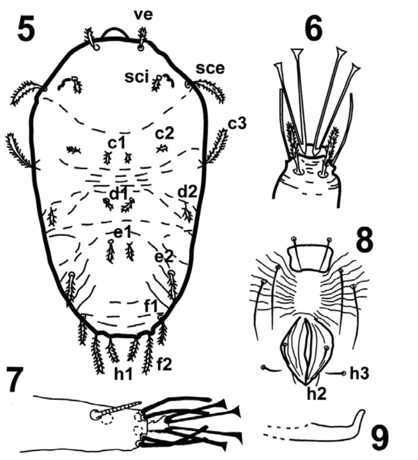


Fig. 1-4. *Aplonobia histricina* (Berlese). Female: 1. Dorsal view. 2. Peritreme. 3. Duplex setae on tarsus I. 4. Empodium I.



Figs. 5-9. *Aponychus grandidieri* (Gutierrez). FEMALE: 5. Dorsal view. 6. Empodium. 7. Tarsus I. 8. Anogenital area. MALE: 9. Aedeagus.

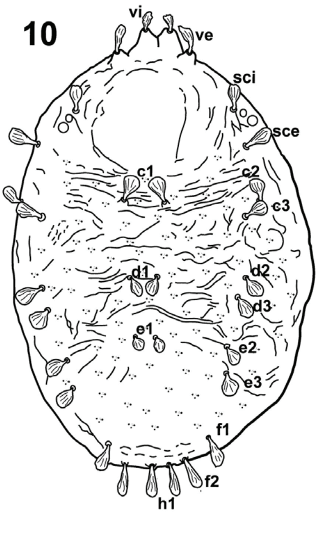
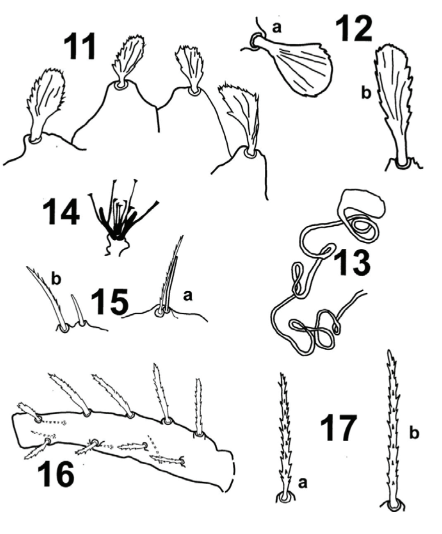


Fig. 10. *Bryobia graminum* (Schrank). FEMALE: Dorsal view.



Figs. 11-17. *Bryobia graminum*. FEMALE. 11. Anterior setiferous projections. 12. Dorsal setae, a. c1. b. h1. 13. Spermatheca. 14. Empodium I. 15. Duplex setae, a. Tarsus III, b. Tarsus IV. 16 Femur I. LARVA. 17. Dorsal setae, a. c1, b. h1.

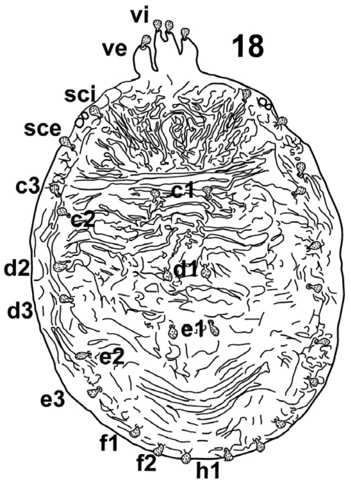
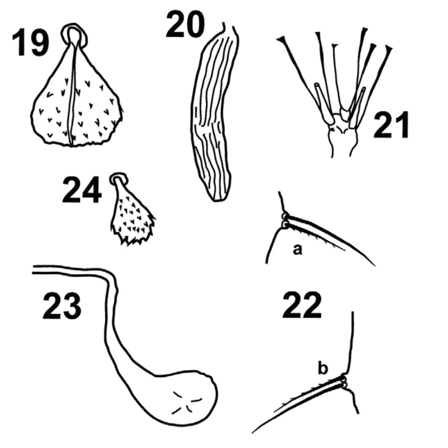


Fig. 18 *Bryobia neopraetiosa* Meyer. FEMALE: Dorsal view.



Figs 19-24. *Bryobia neopraetiosa* Meyer. FEMALE: 19. Seta c1. 20. Peritreme. 21. Empodium I. 22. Duplex setae, a. Tarsus III, b. Tarsus IV. 23. Spermatheca. LARVA. 24. Seta c1.

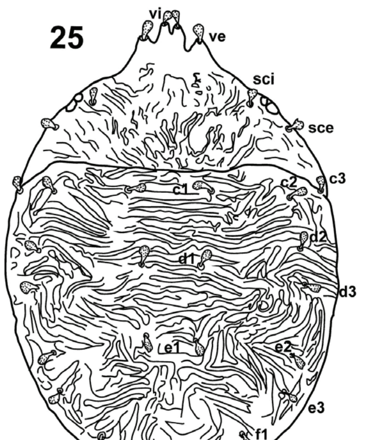
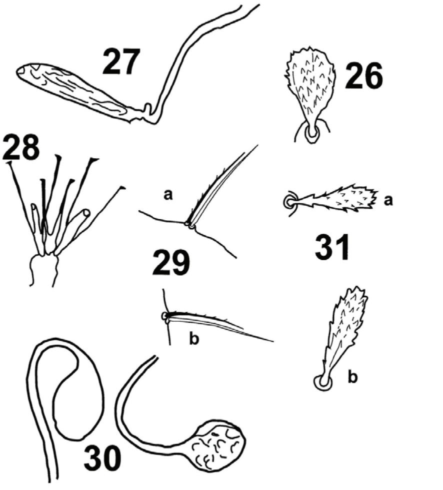


Fig. 25. *Bryobia praetiosa* Koch. FEMALE: Dorsal view.



Figs. 26-31. *Bryobia praetiosa* Koch. FEMALE: 26. Seta c2. 27. Peritreme. 28. Empodium I. 29. Duplex setae, a. Tarsus III, b. Tarsus IV. 30. Spermathecae. LARVA: 31, a. Seta c2, b. Setae e1.

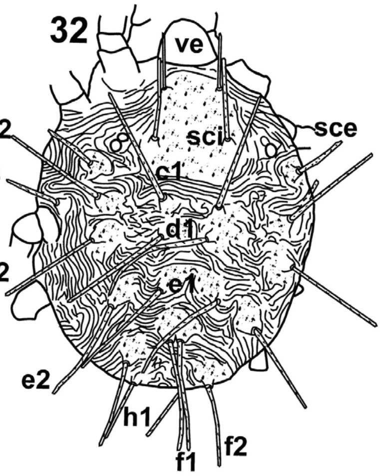
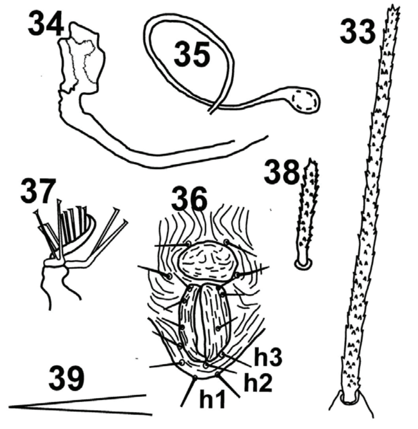


Fig. 32. *Petrobia harti* (Ewing). FEMALE: Dorsal view.



Figs. 33-39. *Petrobia harti* (Ewing). FEMALE: 33. Seta c1. 34. Peritreme. 35. Spermatheca. 36. Anogenital area. 37. Empodium I. MALE: 38. Seta c1. 39. Aedeagus.

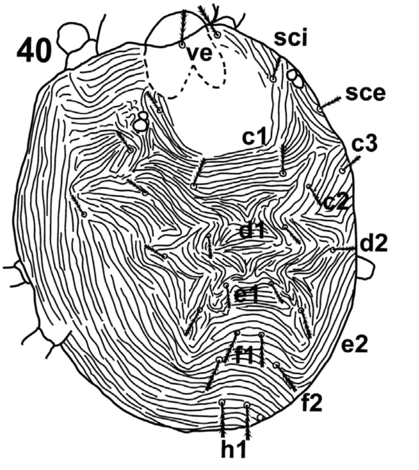
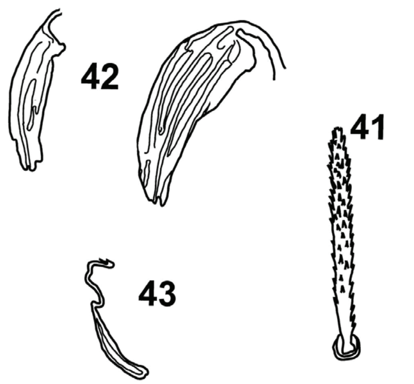


Fig. 40. *Petrobia latens* (Muller). FEMALE: Dorsal view.



Figs. 41-43. *Petrobia latens* (Muller). FEMALE: 41. Seta c1. 42. Peritreme. 43. Spermatheca.

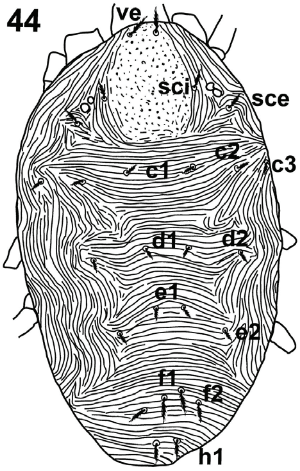
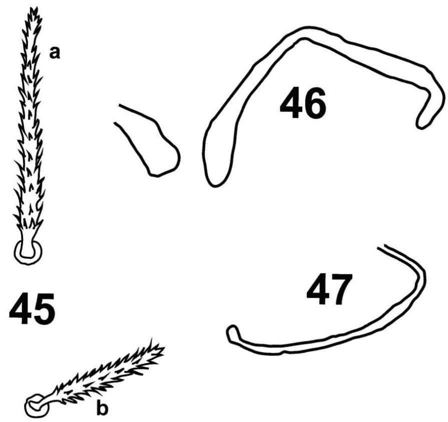


Fig 44. *Petrobia tunisiae* Manson. FEMALE: Dorsal view.



Figs. 45-47. *Petrobia tunisiae* Manson. FEMALE: 45, a. Seta ve. b. Setae c1. 46. Peritr4eme. 47. Spermatheca.

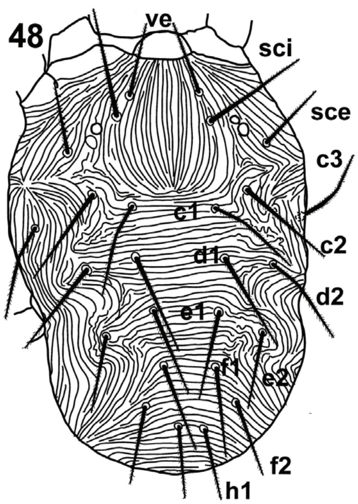
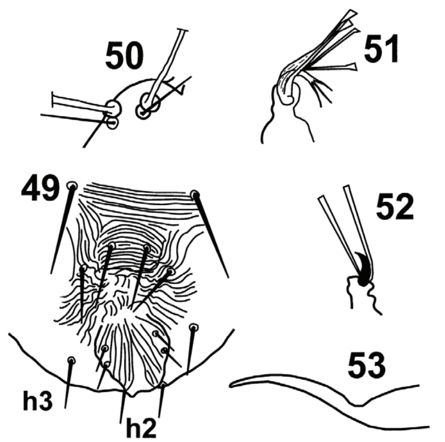


Fig. 48. *Eotetranychus hirsti* Pritchard & Baker. FEMALE: Dorsal view.



Figs. 49-53. *Eotetranychus hirsti* Pritchard & Baker. FEMALE: 49. Anogenital area. 50. Duplex setae tarsus I. 51. Empodium I. MALE: 52. Empodium I. 53. Aedeagus.

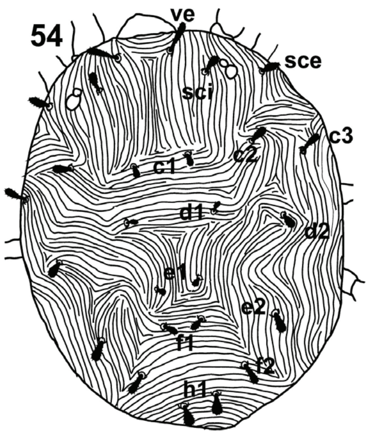
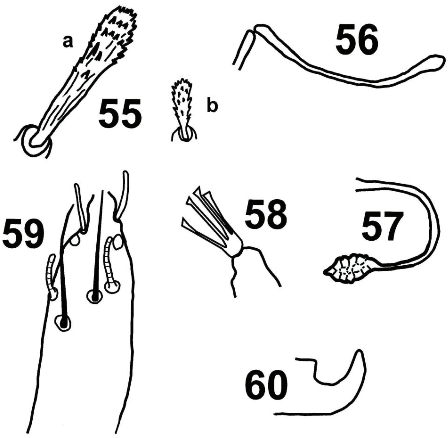


Fig. 54. *Eutetranychus orientalis* (Klein). FEMALE: Dorsal view.



Figs. 55-60. *Eutetranychus orientalis* (Klein). FEMALE: 55, a. Seta ve. b. Seta c1. 56. Peritreme. 57. Spermatheca. 58 Empodium I. 59. Tarsus I (duplex setae absent). MALE: 60. Aedeagus.

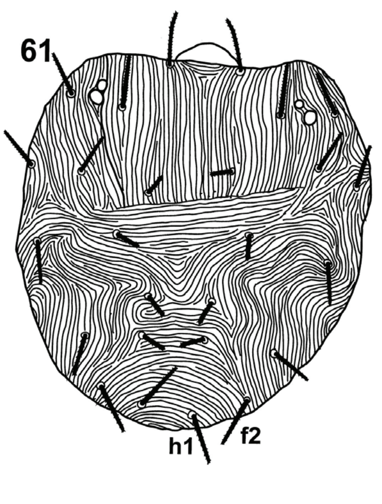
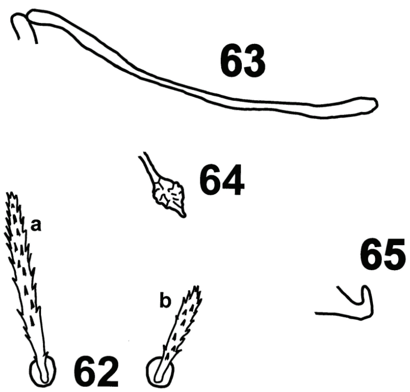


Fig. 61. *Eutetranychus palmatus* Attiah. FEMALE: Dorsal view.



Figs. 62-65. *Eutetranychus palmatus* Attiah. FEMALE: 62, a. Seta c3. b. Seta d1. 63. Peritreme. 64. Spermatheca. MALE: 65. Aedeagus.

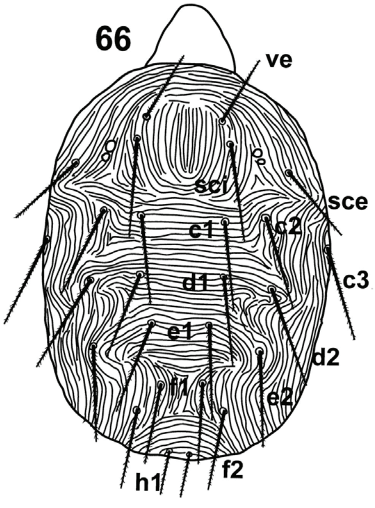
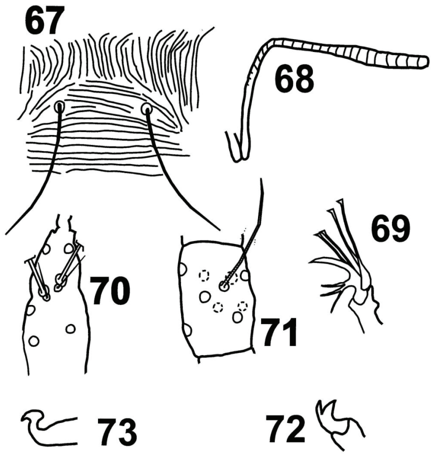


Fig. 66. *Oligonychus afrasiaticus* (McGregor). FEMALE: Dorsal view.



Figs. 67-73. *Oligonychus afrasiaticus* (McGregor). FEMALE: 67. Genital area. 68. Peritreme. 69. Empodium I. 70. Tarsus I. 71. Tibia I. MALE: 72. Empodium I. 73. Aedeagus.

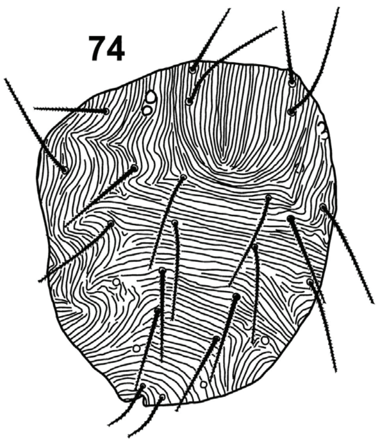


Fig. 74. *Oligonychus coniferarum* (McGregor). FEMALE: Dorsal view.

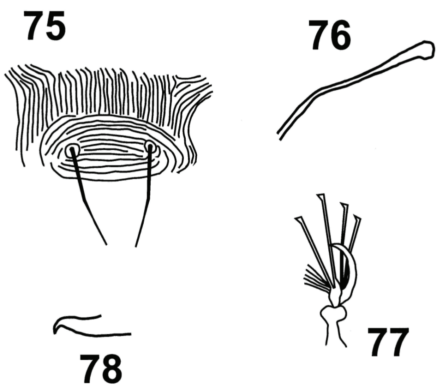


Fig. 75-78. *Oligonychus coniferarum* (McGregor). FEMALE: 75. Genital area. 76. Peritreme. 77. Empodium I. MALE: 78. Aeadeagus.

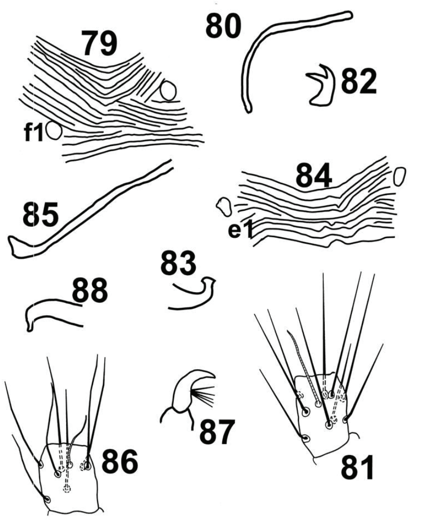


Fig. 79-88. *Oligonychus senegalensis* Gutierrez & Etienne. FEMALE: 79. Striae between f1. 80. Peritreme. 81. Tibia I. MALE: 82. Empodium I. 83. Aeadeagus. *Oligonychus mangiferus* Gutierrez & Etienne. FEMALE: 84. Striae between e1. 85. Peritreme. 86. Tibia I. MALE: 87. Empodium I. 88. Aeadeagus.

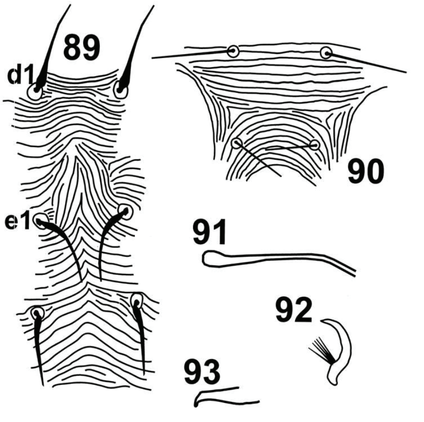


Fig. 89-93. *Oligonychus perseae* Tuttle, Baker & Abbatiello. FEMALE: 89. Striae between d1, e1 and f1. 90. Genital area. 91. Peritreme. MALE: 92. Empodium I. 93. Aeadeagus.

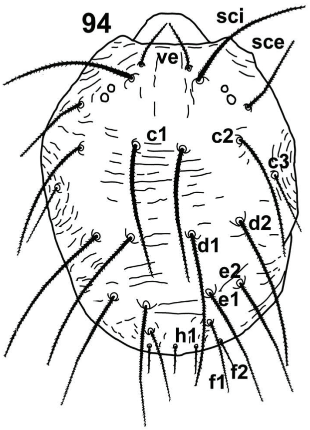
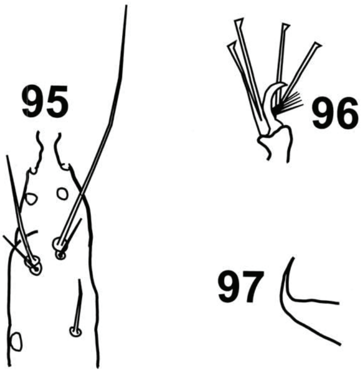


Fig. 94. *Panonychus citri* (McGregor). FEMALE: 94. Dorsal view.



Figs.95-97. *Panonychus citri* (McGregor). FEMALE: 95. Tarsus I. 96. Empodium I. MALE: 97. Aedeagus.

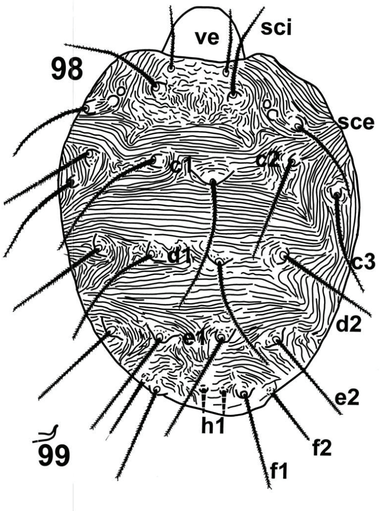


Fig. 98-99. *Panonychus ulmi* (Koch). FEMALE: 98. Dorsal view. MALE: 99. Aedeagus.

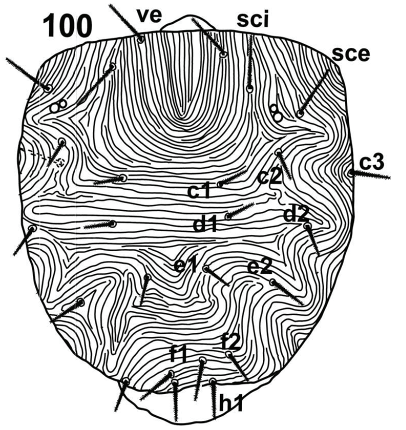


Fig. 100. *Schizotetranychus asparagi* (Oudemans). FEMALE: Dorsal view.

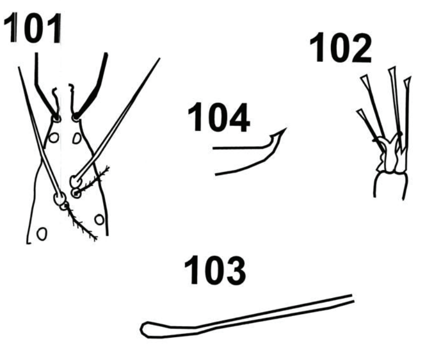


Fig. 101-104. *Schizotetranychus asparagi* (Oudemans). FEMALE: 101. Tarsus I. 102. Empodium I. 103. Peritreme. MALE: 104. Aedeagus.

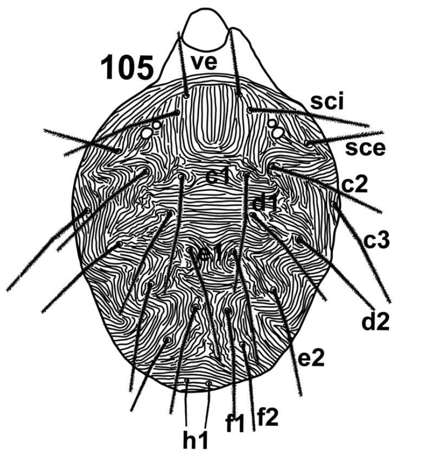


Fig. 105. *Tetranychus evansi* Baker & Pritchard. FEMALE: Dorsal view.

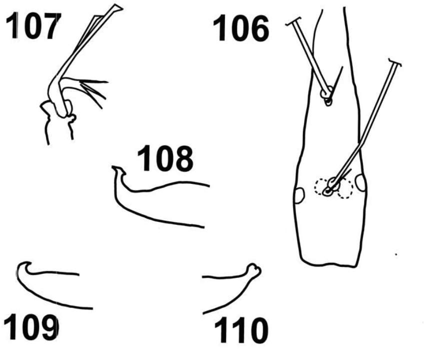


Fig. 106-110. *Tetranychus evansi* Baker & Pritchard. FEMALE: 106. Tarsus I. 107. Empodium I. MALE: 108. Aedeagus. 109. *Tetranychus ludeni* Zacher. MALE: Aedeagus. 110. *Tetranychus neocaledonicus* Andre. MALE: Aedeagus.

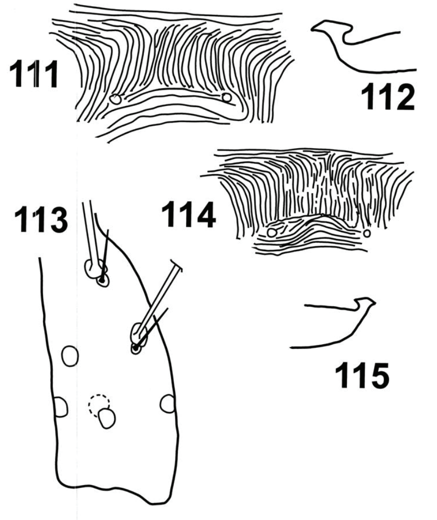


Fig. 111-115. *Tetranychus turkestani* Ugarov & Nikolskii. FEMALE: 111. Pregenital striae. MALE: 112. Aedeagus. 113-115. *Tetranychus urticae* Koch. FEMALE: 113. Tarsus I. 114. Pregenital striae. MALE: 115. Aedeagus.

KEY TO TETRANYCHIDAE SPECIES OF ISRAEL

Females and males mentioned in the key are adult stages.

1. Empodium with tenant hairs (fig. 4), females with 2-3 pairs of anal setae (fig. 36); males with five pairs of genito-anal setae .... **2** (subfamily **Bryobiinae)**
-. Empodium without tenant hairs (figs 58, 69), females with 1-2 pairs of anal setae; males with four pairs of genito-anal setae ....**8** (subfamily **Tetranychinae)**
2. (1). True claws uncinate (fig. 14, 28); propodosoma with 4 pairs of setae (fig. 10), hysterosoma with 12 pairs of setae (fig. 10)...**4** (***Bryobia***)
-. True claws pad-like (fig. 4); propodosoma with 3 pairs of setae, hysterosoma with 10 pairs of setae **3**
3. (2). Empodium uncinate (fig. 37) ....**6** (***Petrobia***)
-. Empodium pad-like (fig. 4) .... ***Aplonobia histricina***
4. (2). Dorsal setae of larvae 30-40 µm long, filiform (fig. 17), dorsal setae of females 23-25 µm long (fig. 12)..***Bryobia graminum***
-. Dorsal setae of larvae shorter (less than 30 µm), spatulate (fig. 31); dorsal setae of adult females 25-33 µm long **5**
5. (4). Larvae with dorsal setae 21-28 µm long; females with dorsal setae about 33 µm long,

outer lobes on anterior margin of propodosoma triangular (fig. 25) ....***Bryobia praetiosa***
-. Setae of larvae 14-18 μ long, dorsal setae of females 25-30 μ long, outer lobes on anterior margin of propodosoma teat-like (fig. 18) .... ***Bryobia neopraetiosa***
6. (3). Dorsal setae set on tubercles (fig. 32) .... ***Petrobia harti***
-. Dorsal setae not on tubercles (fig. 40) **7**
7. (6). Peritremes terminating distally in an anastomose complex structure (fig. 42) ....***Petrobia latens***
-. Peritremes terminating distally in a simple bulb (fig. 46) .... ***Petrobia tunisiae***
8. (1). Tarsus I with or without a single set of loosely-associated duplex setae (fig. 59) **9**
-. Tarsus I with two sets of closely-associated duplex setae (fig. 50).......................................**11**
9. (8). Female with one pair of anal setae; setae *f1* in marginal position (fig. 5) ....***Aponychus grandidieri***
-. Female with two pairs of anal setae; setae *f1* in normal (dorso-central) position (fig. 54).... ....**10 *(Eutetranychus)***
10. (9). Dorsal marginal setae short, spatulate, setae *f2* never reaching setae *h1* (fig. 54) ....***Eutetranychus orientalis***
-. Dorsal marginal setae long, rod-like (figs 61, 62), setae *f2* reaching setae *h1* .... ***Eutetranychus palmatus***
11. (12). With two pairs of para-anal setae (fig. 49) **12**
-. With a single pair of para-anal setae.. **15**
12 (11). Empodium ending in a tuft of hairs (fig. 51) ....***Eotetranychus hirsti***
-. Empodium claw-like **13**
13. (12). Empodium a single claw-like structure (fig. 96) .... **15** (***Panonychus***)
-. Empodium split into two claw-like structures (fig. 101)... .... ***Schizotetranychus asparagi***
14. (13). Dorsal setae *h*1 (dorso-centrals) and *f*2 (dorsolaterals) subequal in length (fig. 94)..... .... ***Panonychus citri***
-. Dorsal setae *h*1 about a third the length of setae *f*2 (fig. 98)................... ***Panonychus ulmi***
15. (11). Duplex setae on tarsus I distal, proximate (fig. 70), empodium claw-like, with proximoventral hairs (figs 77, 87)..**16** (***Oligonychus***)
-. Duplex setae on tarsus I well separated, empodium split into 3 pairs of proximoventral hairs (fig. 106)... **20** (***Tetranychus***)
16. (15). Tibia I with 7 tactile setae (fig. 86) **17**
-. Tibia I with more than 8 tactile setae (fig. 81) **18**
17. (16). Distal bent portion of aedeagus forms an acute angle with the shaft and abruptly narrows at the tip (fig. 88), on broad-leaf plants ....***Oligonychus mangiferus***
-. Distal bent portion of aedeagus forms a short, truncate, caudolaterally direct bent (fig. 78); on conifers .... ***Oligonychus coniferarum***
18. (16). Dorsal opisthosomal striae between setae *e1* and *f1* forming inverted V shaped pattern (fig. 89)... **19**
-. Dorsal opisthosomal striae between setae *e1* and f1 forming V-shaped pattern (fig. 79)...... ....***Oligonychus senegalensis***
19. (18). Aedeagus pointing downwards, without a knob (fig. 93) .... ***Oligonychus perseae***
-. Aedeagus pointing upwards, aedeagal knob large with axis parallel to axis of shaft (fig. 73). ....***Oligonychus afrasiaticus***
20. (15). Female with proximal pair of duplex setae on tarsus I close to proximal tactile setae, almost in line with them (fig. 106)... **23**

-. Female with proximal pair of duplex setae on tarsus I distal to proximal tactile setae (fig. 113) **21**
21. (20). Aedeagus knob with 1-2 acute projections (fig. 115) **22**
-. Aedeagus knob recurved, berry-like, anterior and posterior projections rounded (fig. 110 .. .. ***Tetranychus neocaledonicus***
22. (21). Aedeagus knob large, at least twice as wide as neck (fig. 112), female pregenital striae unbroken (fig. 111) .... ***Tetranychus turkestani***
-. Aedeagus knob less than twice as wide as neck, female pregenital striae a mixture of solid and broken lines (fig. 114) ....***Tetranychus urticae***
23. (20). Aedeagus pointing upwards, knob with an acute posterior projection, (fig. 108)......... ....***Tetranychus evansi***
-. Aedeagus pointing upwards, knob with a recurved hook (fig. 109)...... ***Tetranychus ludeni***

DISCUSSION

Ten of the 24 spider mite species known from Israel can be regarded as pests, although most have either no, or little, economic impact, or else are controlled by their natural enemies. *Eutetranychus orientalis* and *Panonychus citri* infest citrus, the former may require some control measures, whereas the latter rarely do. *Eutetranychus palmatus* and *Oligonychus afrasiaticus* affect palm trees. The former at times causes some minor damage, but does not require any specific treatments. The latter, which can seriously reduce the commercial value of date fruits, may be controlled by a single acaricide treatment applied as soon as the first mites occur on the fruits, providing season-long control (Palevsky *et* al., 2003). *Panonychus ulmi* and *Tetranychus turkestani* damage fruit trees. The former is a serious pest of apples, the other occurs on many crops, and both require pesticide treatments. *Oligonychus mangiferus* is rarely treated against in mango groves; its damage can be reduced by horticultural methods (as noted above). *Oligonychus perseae* is a minor pest of avocado throughout Israel; it may be controlled by the indigenous predator *Euseius scutalis* (Phytoseiidae) (Maoz *et al.,* 2011b). *Tetranychus evansi*, an important pest of solanaceous crops in other countries, is wide spread on *Solanum nigrum* in Israel but has not yet caused any economic damage to crops. *Schizotetranychus asparagi* is a minor pest in commercially grown ornamental asparagus. Finally, the red form of *Tetranychus urticae* is the major tetranychid pest in Israel, affecting many crops. It is an economic pest to vegetables grown in open fields in the summer, which require pesticide applications. In greenhouses, it is troublesome year round, but is often controlled by predatory mites of commercial origin (especially *Phytoseiulus persimilis* Athias-Henriot, Phytoseiidae),

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