NAPPO
North American Plant Protection Organization
Organización Norteamericana de Protección a las Plantas
MEXICO - USA - CANADA

DP 03: Morphological Identification of Spider Mites (Tetranychidae) Affecting Imported Fruits

Prepared by the members of the NAPPO Expert Group (previous Technical Advisory Group) on Fruit *Tetranychus* Mites

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Contents

Review

NAPPO Protocols are subject to periodic review and amendment. The next review date for this NAPPO Protocol is 2019. A review of any NAPPO Surveillance Protocol may be initiated at any time upon the request of a NAPPO member country.

Endorsement

This Protocol was approved by the North American Plant Protection Organization (NAPPO) Executive Committee on October 20, 2014, and is effective immediately.

Approved by:

Greg Wolff
Executive Committee Member
Canada

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Implementation

Not applicable.

Amendment Record

Amendments to this Protocol will be dated and filed with the NAPPO Secretariat.

Distribution

This Protocol is distributed by the NAPPO Secretariat, to the Industry Advisory Group (IAG) and Sustaining Associate Members (SAM), the International Plant Protection Convention (IPCC) Secretariat, and to other Regional Plant Protection Organizations (RPPOs).

General pest information

Spider mites (Acari: Tetranychidae) represent one of the two main groups of plant-feeding mites. The common name 'spider mites' originates from the ability of many species to produce silk, which they use to spin webs under which they reproduce and feed. The webbing is one characteristic that can help detect spider mites on plants, especially when populations are high. Spider mites are found on a broad diversity of vascular plants, including trees, shrubs and herbaceous plants, from all over the world. Many agricultural and horticultural crops are affected, including greenhouse, field and fruit crops, ranging from fruit trees to low-growing bushes. Spider mites essentially feed on the leaves of their host plants, and for this reason, the risk of introduction is highest for plant material imported for breeding purposes. However, they can occasionally occur on fruits (or the leaves of vegetables), especially during high infestations. Therefore, they may be found on imported commodities such as apple, pears, citrus, and mango, which are commonly imported into the countries (Canada, United States, Mexico) of the NAPPO region.

Spider mites represent a risk of introduction and establishment as pests for any country that imports plant material because of the following reasons: **(1)** many spider mite species are highly polyphagous, feeding on a broad range of host plants, many of which are yet to be recorded; for instance, spider mites can feed on neighbouring plants (e.g. weeds, other crops) in the absence of preferred hosts, which may act as a temporary reservoir, and then subsequently colonize the crop plant; **(2)** they tend to have a high developmental rate and fecundity, thereby quickly infesting a plant; **(3)** despite their lack of wings, they can disperse relatively well to new host plants, by crawling on plants and the soil surface at the speed of 5 cm to 6 m / h, or by being carried on winds using their silk; they can also spread passively by being carried on plants, tools and clothing; **(4)** spider mites are parthenogenic, that is, females can produce males (rarely females) without prior fertilisation (arrhenotokous parthenogenesis). Therefore, a single, unfertilized female (even if only at the egg stage) can establish a new population by producing males and then mating with her sons to produce females, if a suitable host is available for feeding. Some species (e.g. *Bryobia* spp.) do not produce males at all, with unfertilized females producing only females (thelytokous parthenogenesis); **(5)** they tend to develop resistance to pesticides rapidly, whereas some of their main predators (e.g. phytoseiid mites) are, usually, much more sensitive; and **(6)** they are tiny and can easily hide in cracks or depressions on fruits (e.g. near the calyx or around the stalk of apples) without getting detected. All these characteristics make many spider mite species potentially major pests, for which the development of effective control strategies, including chemical and biological control options, is difficult. Foliage, in addition to fruits, represents another risk for the introduction of spider mites when leaves 'contaminate' (as leaves are prohibited) the fruit shipment. Moreover, even in cases where the primary host(s) of a spider mite is not imported as a commodity, the potential for introduction still exists via fruits or plant material arriving with international travellers, when this material is not declared.

The family Tetranychidae includes at least 71 genera and over 1250 described species (online catalogue of Tetranychidae: http://www.montpellier.inra.fr/CBGP/spmweb; Migeon and Dorkeld 2013). The most important pests worldwide belong to a few genera, especially *Tetranychus*, *Eotetranychus*, *Oligonychus*, and *Panonychus*. There are keys to species for some regions of the world, including the United States (Baker and Tuttle 1994), Africa (Smith Meyer 1974, 1987), China (Wang 1981; Wang and Cui 1999), India (Gupta and Gupta 1994), Japan (Ehara 1964), Taiwan (Tseng 1990). A particularly useful document has been published by Seeman and Beard (2011) on *Tetranychus* species that occur in Australia or exotic species that represent a threat to Australian agriculture. Other important references that can be consulted for further information and which have been used to elaborate this document include: Jeppson et al. 1975, Helle et al. 1985, Bolland et al. 1998 (printed version of species catalogue), Zhang 2003, and Migeon and Dorkeld 2013 (online, most recent version of species catalogue).

The taxonomy of spider mites is not completely understood. There are still many undescribed species, and some known species are difficult to identify accurately because of within species variation, the strong similarity among closely related species, the difficulty of properly mounting male specimens, and the rarity of males. It is therefore advised that the specimens are compared with other material identified by a specialist of Tetranychidae, and that they are kept for future reference or taxonomic studies.

This document mainly provides: (1) an overview on how to detect, collect, prepare and identify specimens of Tetranychidae in general; (2) detailed diagnostic features and biological information such as host plants and developmental rate for the species that are considered of most (quarantine) concern to one of more of the countries in the region (Mexico, United States, Canada); (3) an identification key to the most common genera of spider mites that may be intercepted on fruit commodities imported in the NAPPO region; and (4) a key to pest and quarantine species (and a few common pests occurring in the NAPPO region) for the genera *Tetranychus* and *Amphitetranychus* (keys for the species of other genera, *Eotetranychus*, *Oligonychus*, and *Schizotetranychus*, which include quarantine species, are not included here, due to various technical constraints).

Detection

All spider mites are strictly phytophagous and spend most of their life cycle on plant organs, especially leaves. They tend to favour the underside of leaves over the upper surface, although this depends on the species and both surfaces may be occupied during high infestations. In large numbers, their feeding on individual plant cells produces typical speckling of leaves, leading to large areas of yellowing and bronzing. In countries with temperate climates, overwintering (as eggs or females) may occur in other refuges, such as cracks of tree bark or plant stems, or in leaf litter at the base of the host plants. When populations are large, or if the mites are in dispersal mode, spider mites can also occur on fruits. The presence of webbings may indicate the presence of

spider mites nearby. Typically, they will be under the webbing, as its primary role is protection of eggs and the colony.

Their small size and cryptic behavior make spider mites (as well as most other mites) difficult to detect with the naked eye and thus single individuals or even infestations can be easily overlooked. Leaf damage by spider mites can be recognized with the naked eye, but the detection of the mites usually requires the use of hand-lens or a stereoscope. Detection may be hampered in the following circumstances:

- Low-level infestation may produce little or no detectable symptoms
- The presence on the plant of the egg stage only, which is very hard to detect because eggs are small and immobile (for example, after chemical or physical treatment of the plant material, which sometimes removes or kills all mobile life stages, but sometimes not the eggs because they are more hidden, or more resistant to chemicals).

Note that feeding damage can be mistaken for symptoms caused by a pathogen, so the potential presence of mites should be carefully considered (see Childers et al. 2003 for the case of false spider mites and viral pathogens).

Collecting

Mites can be collected from plants in several ways. If collecting is done in the field, foliage or plant parts can be (a) beaten so that mites fall off onto a funnel leading to a collecting jar, or onto a (black or white) plastic tray where mites could be picked with a moist hair brush; or (b) cut and placed into plastic bags (may include blotting paper to avoid excess moisture) for later removal of the mites. Mite specimens can be extracted from plant material (foliage, fruits) in the lab by:

(1) Examination of plant parts using a hand lens (preferably 20X) or a stereoscope. Live mites are the most easily detected because of their movement. Potential hiding places (e.g. leaf domatia, bark cracks, fruit calyx) should be inspected and sometimes dissected as mites hide in tight shelters. Mites can be collected using a moist, fine hair brush (preferably 00, 0 or 1) and stored in vials of 70–95% alcohol for later slide-mounting or DNA extraction. If foliage is not to be examined soon, it should be stored at about 5°C to try keeping mites live for several days. When mites are live (and therefore moving and readily seen if disturbed), this method can be more effective in extracting most mites, but it is more time-consuming than the washing method.

(2) Washing of foliage with 70–95% alcohol. The use of 95% alcohol is best to preserve DNA. Mites are extracted from foliage by manually dipping and shaking leaves into a jar of alcohol. Leaves are then disposed of, and mites sitting at the bottom of the jar can be transferred into a petri dish (for specimen examination and preparation), using a spray bottle to push the mites out after having decanted the top fluid out. An alternative method is to place the foliage into a large jar or a sealed plastic bag filled with alcohol or soapy water (beware of possible holes in plastic bags). The jar/bag is shaken and then left for >1h to help dislodge the mites off the foliage, until sieving of the content through a 40–50 μm mesh. Residues are then washed off the sieve into a small jar for later examination under stereoscope.

*In the case of detection of spider mites on foliage, *before* any manipulation of specimens is done or any contact with chemicals (clearing agent, mounting medium) is made, we recommend that:

- the color of live specimens is noted; color may represent an additional diagnostic feature.
- some specimens are preserved in 95% alcohol, at ≤15°C, for the purpose of DNA analysis; genetic markers (e.g. regions of Cytochrome oxidase unit I) may confirm species identity, especially in the case where no males are present in the samples.

Morphological identification

Specimen preparation

When present, both females and males of spider mites should be mounted on microscopic slides. Immature stages (larva, protonymph, deutonymph), and in many cases also females, can be identified to genus only. For many species (e.g. *Tetranychus*, *Oligonychus* spp.), males are required to determine the species because in those cases, the aedeagus is the most diagnostic character. Picking specimens of a range of body size and shapes will increase the likelihood of slide-mounting some males and females, as well as representatives of all species present in a sample. However, some samples may have no males at all because they are rare compared to females; a ratio of about 1 male: 3 or more females is common. In some samples, there are no males at all, often making the species identification tentative at best. The sex ratio may in part be influenced by the phenology of the host.

Microscope specimen slides can be prepared directly from live mites picked using a moist brush or metal probe, while specimens kept in alcohol can be picked up using a probe ending with a looped-tipped minuten pin. If no clearing is deemed necessary (but see next paragraph), the mite may be placed directly into a droplet of mounting medium (e.g. Hoyer's medium, or a mixture of PVA or polyvinyl alcohol) on the centre of a slide, and a (preferably 12–15 mm round) coverslip is slowly placed onto the mounting medium. Slides should be dried for 2 days to 2 weeks in an oven at 40–50°C. After the drying stage, slides made with water-soluble medium (e.g. Hoyer's medium; not PVA) should be sealed ('ringed') around the cover slip using insulating paint (e.g. Glyptal®), applied with a brush or a polyethylene bottle applicator, to prevent water from getting into the medium and ruining the mount in high-humidity environments.

For larger or dark specimens, or when urgent species identification is required (e.g. if a fruit shipment is on hold), it may be necessary to clear them in a clearing agent (e.g. lactic acid, Nesbitt's fluid) before slide-mounting, into a small dish (e.g. cavity block). These clearing agents are more effective than the mounting media (Hoyer's, PVA), which also contribute to the clearing of specimens (during the drying process). For urgent identifications, slide-mounted specimens may be examined without ringing the slide. In cases of specimens difficult to clear, the coverslip could be pressed a bit more onto the specimen to ensure that interior organs are pushed out, allowing more light to go through the specimen and characters to be seen more clearly.

Specimens should be mounted dorso-ventrally (venter down) on the slide, and with mouthparts placed closer to the user (as a compound scope will reverse the image), except for males of the subfamily Tetranychinae which should be placed laterally so that the aedeagus is in lateral profile. However, if a specimen cannot be placed side-ways, it is often possible to turn the aedeagus laterally by pressing the coverslip and checking and readjusting its position by alternate examination from a stereoscope to a compound scope. Slides should be labelled with origin, host, habitat, collecting method, date and collector. See Helle and Sabelis (1985), Krantz and Walter (2009), or Zhang (2003) for more information.

Subclass Acari

The majority of mites (Arachnida: Acari) have 8 legs (except the larval stage, which has 6 legs) and can be distinguished from other arachnids by having a single body part, no conspicuous segmentation, and being usually minute (<1 mm).

Family Tetranychidae

Spider mites (Tetranychidae) belong to the superfamily Tetranychoidea, which comprise five families, of which Tetranychidae is the largest. Under a compound microscope, the superfamily Tetranychoidea can be distinguished from all other mites by their chelicerae, modified into long, recurved, J-shaped stylets (Fig. 2). These stylets are enclosed into a hemispherical capsule called the stylophore and are used to pierce plant tissues. Spider mites (Tetranychidae) can be distinguished from other tetranychoids mostly by their palps (from which silk is produced in female Tetranychinae), which typically curve inwards and bear a strong claw-like seta (on the palp tibia) and a thumb-like structure (i.e. the palp tarsus) (Fig. 3**Error! Reference source not found.**). They also have two pairs of eyes laterally on the prodorsum (Fig. 2) and lack the elongate, filamentous setae inserted posteriorly, which are present in members of another family (Tuckerellidae).

Females are about 0.5 mm long (depending on species), oval-shaped, and can be yellow, green, red or brownish (e.g. Fig. 4); they are large and usually darker or of a different colour than the two nymphal stages and the larvae; they can be quickly recognized under a compound scope by the many tight, wavy striae surrounding the genital opening (Fig.5). Males are smaller and are usually more pointed posteriorly than females. The aedeagus is found near the posterior tip. At least within Tetranychinae, to which all species of quarantine importance belong, males are also usually distinguished from females by having: a seta modified into a blunt spur dorsally on the palp femur; three additional solenidia on tarsus I; and proximoventral hairs of empodium I fused into a claw. Immature stages can be distinguished by having only three pairs of legs (larva), no setae on trochanters (protonymph) or one seta on each of trochanters I–III (deutonymphs) (adults also have a seta on trochanter IV).

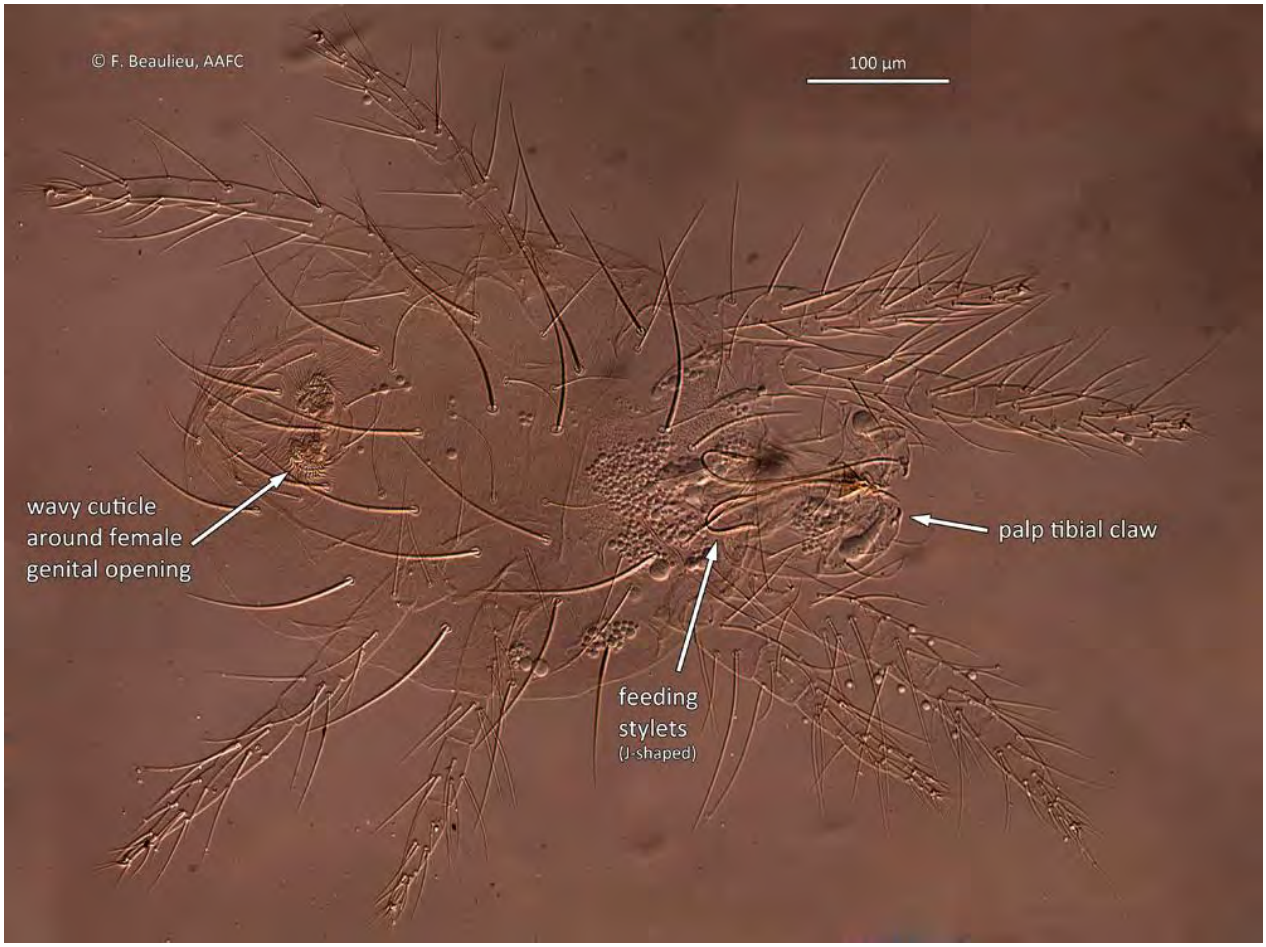

Figure 1. Dorsal view of female *Tetranychus*. Digital photograph of slide-mounted specimen.

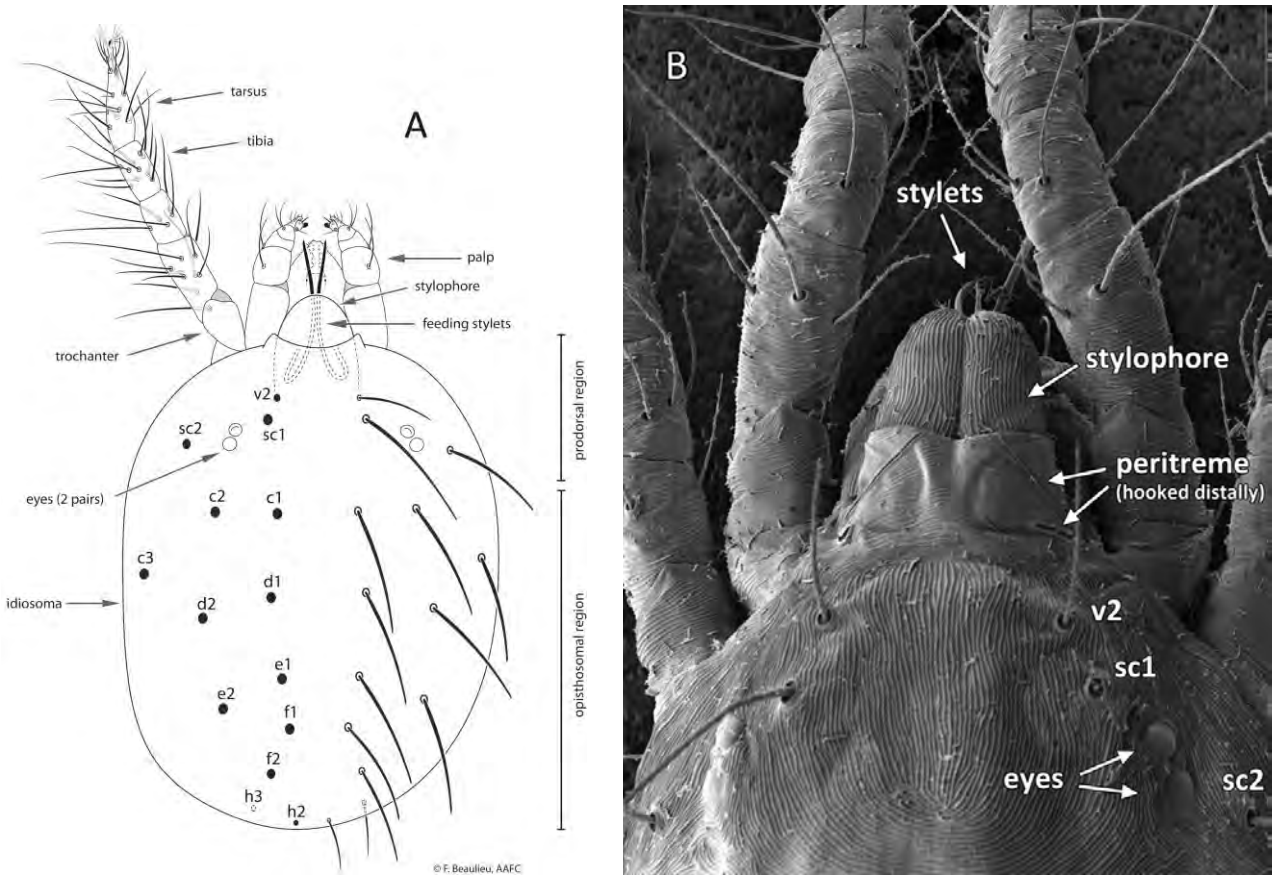

Fig. 2. (A) Dorsal view of female *Tetranychus* (showing only one leg), right side showing idiosomal setae, left side showing only the sockets of setae, and their names. **(B)** anterodorsal view of female *Tetranychus*, scanning electron micrograph. *Note that setae h1 are missing in *Tetranychus* (compare with Fig. 11A,C).

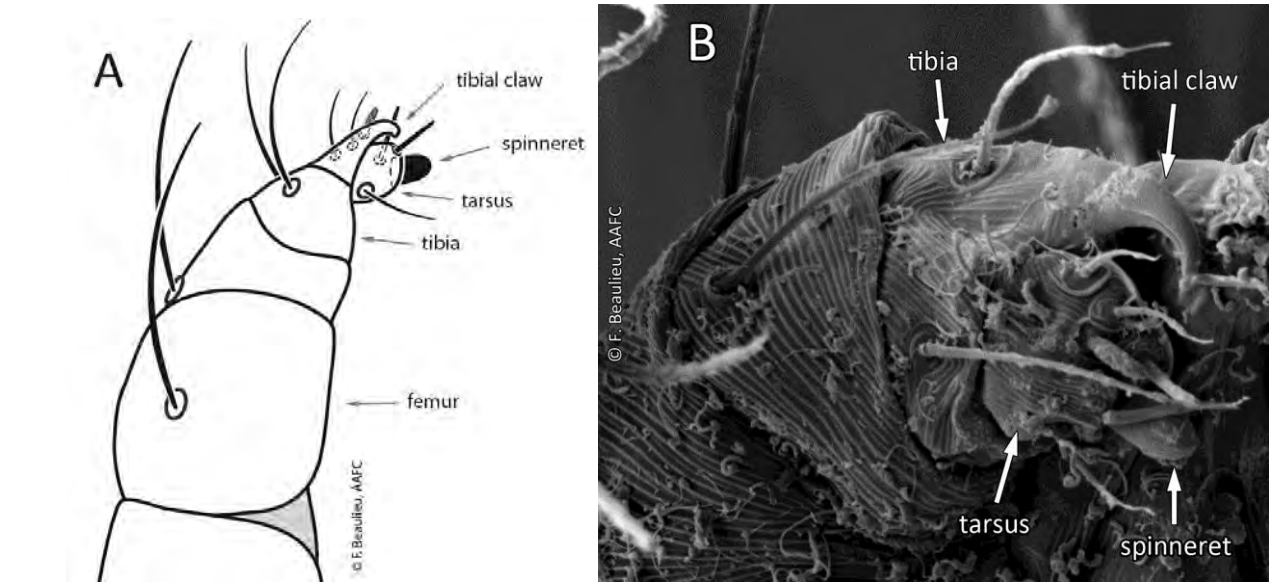

Fig. 3. Typical palp of female **(A)** *Tetranychus* and **(B)** *Schizotetranychus* spp.

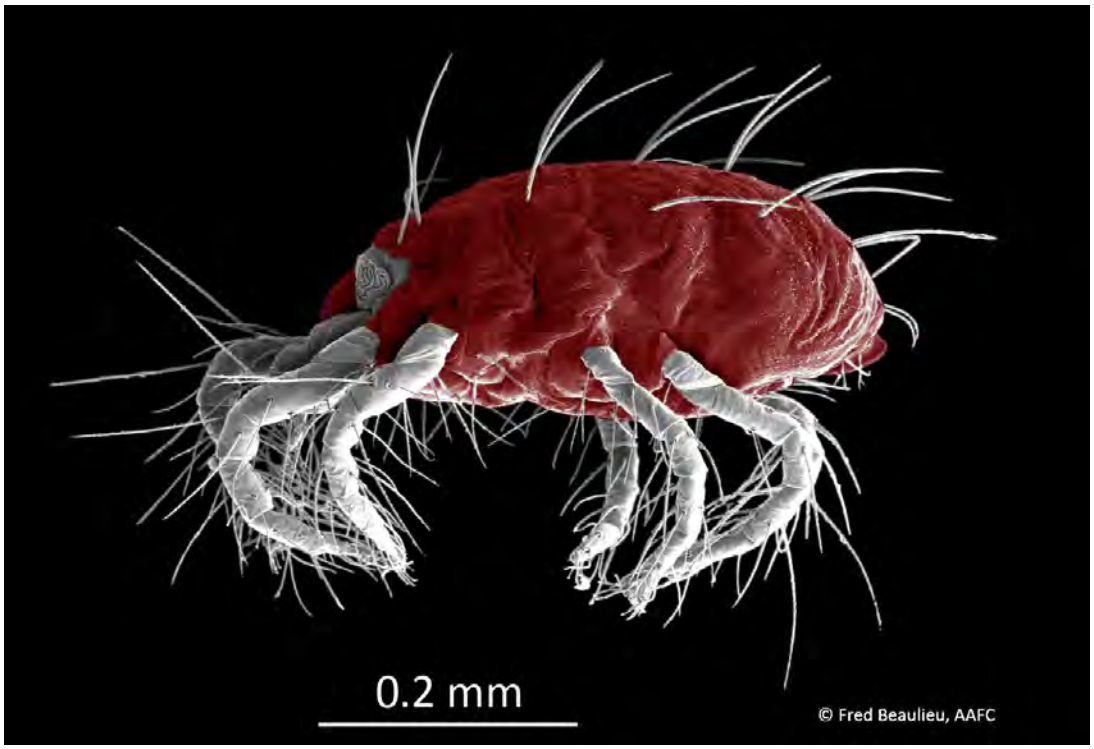

Fig. 4. Lateral view of *Amphitetranychus viennensis*. Scanning electron micrograph, colorized based on colors of live specimens.

Genus *Tetranychus*

Tetranychus species differ from other genera by having:

- **tarsi of leg I** with two pairs of 'duplex setae', relatively distant from each other pair (Fig. 6)
- **tarsi of leg II** with one pair of duplex setae
- **pretarsi** (Fig. 7A) with:

- female empodium (central appendage, originally pad-like) modified into 3 (rarely 2) pairs of hair-like processes, called 'proximoventral hairs', and a dorsal spur that can be absent to large; male empodium I (and sometimes II) claw-like
- two lateral appendages (originally claws) each modified into a pair of long, 'tenent' hairs (somewhat T-shaped, apically)

- **main body** with two pairs of *h* setae (the longer, more dorsal seta, *h1*, is absent)[1] and two pairs of *ps* setae (Fig. 2, Fig.5)
- a simple **peritreme**, often hooked distally (Fig. 8).

[1] Setae h2 and h3 are called *para-anal* setae by some authors (see Lindquist 1985 and Gutierrez 1985). When all h setae are present (h1-3; Fig. 9A,C), 2 pairs of para-anal setae are considered present (as h2-3). However, when only 2 pairs of h setae are present (putatively h2-3, while h1 is putatively absent, according to this document, see Fig. 1, and some authors; Seeman & Beard 2011), authors using the notation *para-anal* consider that only 1 pair of para-anal setae is present (corresponding to either h2 or h3; Gutierrez 1985; Smith Meyer 1974).

There are currently 147 described *Tetranychus* species worldwide (based on Migeon and Dorkeld 2013).

Tetranychus piercei McGregor 1950

Diagnostic. This species differs from other *Tetranychus* species by the combination of:

- a diamond-shape pattern between dorsal setae *e1-f1* (Fig. 9)
- tarsus I with sockets of 4 tactile setae proximal to proximal pair of duplex setae (occasionally 1 tactile seta overlapping with the socket of the proximal duplex setae)
- pregenital area with striae broken medially (see Fig. 3 for where is the pregenital area)
- female empodia I–IV each with a minute dorsal spur absent or small (0–2 µm long)
- male empodia I–IV with obvious dorsal spur (3–4 µm long**,** Fig. 7D); empodium I claw-like, empodia II–IV with proximoventral hairs as in female
- male aedeagus without distinct knob, with shaft tapering more or less into a weak S-shape (variations occur; Fig. 10).

Adults are dark red in colour (CABI 2008). From stylophore to abdomen tip, slide-mounted female specimens are about 401–423 µm long and 250–281 µm wide (diagnostics based on voucher specimens and McGregor (1950), Gutierrez (1979), and particularly Seeman & Beard (2011)).

Common name. None.

Hosts. At least 88 host plants recorded, including banana (*Musa* spp.), papaya (*Carica papaya*), some palms (*Arecaceae*), common bean (*Phaseolus vulgaris*), peanut (*Arachis hypogaea*), sweet potato (*Ipomoea batatas*), castor bean (*Ricinus communis*) (Bolland et al. 1998; Migeon and Dorkeld 2013)

Distribution. Reported from tropical and warm sub-tropical regions, in at least 14 countries in East and Southeast Asia and Australasia (Papua New Guinea) (Bolland et al. 1998; Migeon and Dorkeld 2013)

Biology. The species is poorly studied. On banana, *T. piercei* causes small brown spots, initially on the undersurface; high populations result in entire leaves turning reddish brown underneath, yellow above, and then the leaves turn necrotic and dry (Fu et al. 2002). Reared on *Phaseolus* sp. leaves at 26°C, fecundity was 82–83 eggs for unmated females and 149–163 for mated females (Gutierrez et al. 1979). Reared on banana leaves, the generation time ranged from 7.2 days at 36°C to 16.9 days at 20°C (Fu et al. 2002). The threshold temperature for the complete development of a female was 10.7°C; 26–32°C appeared as the most suitable conditions for the development and reproduction of the mites (Fu et al. 2002).

Economic importance*. Tetranychus piercei* is a pest of banana (Fu et al. 2002) and papaya (Lui and Lui 1986) in China, of palms in Malaysia (Gutierrez et al. 1979), and vegetable crops in China (Ho et al. 1997) and Japan (Ohno et al. 2009). See Cabi (2008) for more information.

Tetranychus truncatus Ehara 1956

Diagnostic. This species differs from other *Tetranychus* species by the combination of:

- a diamond-shape pattern between dorsal setae e1–f1 (Fig. 9)
- tarsus I with sockets of 4 tactile setae proximal to proximal pair of duplex setae
- pregenital striae entire, unbroken, but may be sparse medially (Fig.5)
- female empodia I–IV each with a minute dorsal spur (0–2 µm long) (Fig. 7A, spur absent)
- male empodia I–IV with obvious dorsal spur; empodium I claw-like, empodia II–IV with proximoventral hairs as in female
- male aedeagus with small knob, anterior projection rounded, posterior projection pointed, and dorsal surface somewhat flat with a medial indentation (Fig. 10).

The adults are carmine red and immatures are yellow to red (Sakunwarin et al. 2003).
From stylophore to abdomen tip, slide-mounted female specimens are about 401–423 µm long and 250–281 µm wide. (diagnostic based on voucher specimens and Ehara (1956), and Beard and Seeman (2011))

Synonyms or older combinations. None.
Common name. Cassava mite

Hosts. At least 80 host plants recorded, including *Prunus* sp.*, Pyrus pyrifolia,* and *Rosa hybrida* (Rosaceae); *Capsicum annuum*, *Solanum lycopersicum*, *S. melongena* (Solanaceae), *Phaseolus* spp., *Styphnolobium* (=*Sophora*) *japonicum* (Fabaceae), *Oryza sativa*, *Zea mays* (Poaceae) (Bolland et al. 1998; Migeon and Dorkeld 2013).

Distribution. Throughout Southeast and East Asia: China, Guam Island, Hainan Island, Indonesia, Japan, Korea, Mariana Islands, Philippines, Taiwan, Thailand, Vietnam (Bolland et al. 1998; Migeon and Dorkeld 2013).

Biology. *Tetranychus truncatus* feed mostly on the underside of leaves, and produce speckling on the leaves, resulting in large areas of yellowing of the foliage when populations are high (Chen et al. 1996; Sakunwarin et al. 2003). On *S. japonicum*, adult females overwinter under tree bark and at the base of plants in soil and leaf litter (Chen et al. 1996); on jujube trees, eggs overwinter in bark cracks (Li et al. 1998).

On mulberry leaflets maintained in the lab, *T. truncatus* can develop and reproduce relatively well at 20–35°C but optimally at 24–31°C (Sakunwarin et al. 2003). On this host, the developmental threshold temperature to complete development is 11.6°C. It takes 8.1 (at 35°C) to 17.4 days (at 20°C) to complete a generation (from egg to egg) on mulberry (Sakunwarin et al. 2003), 6.7 days at 28°C on pagoda (*S. japonicum*) trees (Chen et al. 1996), 11.6 days at 27°C on corn (Pang et al. 2004), and 9.3–11.6 days at 27°C on a range of greenhouse-grown vegetables (Pang et al. 2004), and 5.6 (at 35°), 9.0 (at 25°C) and 32.1 days (at 15°C) on potted pea leaves (Huang and Kuang

1992). Fecundity ranges from 40 to 66 eggs (from 3–31°C) on average on mulberry (Sakunwarin et al. 2003), 91 on corn (Pang et al. 2004), 38–76 on greenhouse vegetables (at 27°C), but has reached averages of 115 eggs (at 27°C) on soybean (Pang et al. 2004) and 182 eggs (at 30°C) on potted pea leaves (Huang and Kuang 1992). Population growth appears to be optimal during dry periods (CABI 2013b). See (CABI 2013b) for more information.

Economic importance*.* In China, it is an important pest of corn (Chen et al. 1999; and Mongolia Pang et al. 2005), cotton (CABI 2013b) and pagoda trees (Chen et al. 1996). This mite can also infest jujube trees (Li et al. 1998), and cause significant damage to mulberry (Sakunwarin et al. 2003), and vegetable crops such as cucumber, kidney beans and eggplant (Ho et al. 1997; Pang et al. 2004)

Genus *Amphitetranychus*

Amphitetranychus species are very similar to *Tetranychus* species (see the diagnosis for *Tetranychus* above) but can be distinguished by:

- their **peritreme anastomosed** distally (Fig. 8)
- transverse striae between dorsal setae e1–f1 (as some *Tetranychus* species; Fig. 9B).
- empodia I–IV without dorsal spur.

There are currently three described species of *Amphitetranychus* (based on Migeon and Dorkeld 2013), and *A. viennensis* is the most widespread.

***Amphitetranychus viennensis* (Zacher 1920)**

Diagnostic. It differs from other *Amphitetranychus* species by having:

- aedeagus knob extended postero-dorsally into a spear-shaped process, nearly as long as shaft (Fig. 10)
- a peritreme ending in a large (diameter 27–42 µm) cluster of anastomosed grooves (Fig. 8).

Summer females are bluish-violet or carmine red with whitish legs and white to pink gnathosoma (Fig. 4). Overwintering females are bright red, also with pale legs. Larvae and nymphs yellow to yellowish-green (Jeppson et al. 1975; CABI 2012). From stylophore to abdomen tip, slide-mounted female specimens are 550–600 µm long and 375–450 µm wide. (diagnosis based on voucher specimens and Ehara and Gotoh (1990) and Tseng (1990)).

Synonyms. *Tetranychus crataegi* Hirst, *Apotetranychus longipenis* Ugarov and Nikolskii, *Apotetranychus virginis* Ugarov

Older combinations. *Tetranychus* (*Epitetranychus*) *viennensis*, *Tetranychus (Amphitetranychus) viennensis*, *Tetranychus (Armenychus) viennensis*

Common name. Hawthorn spider mite (most common); sweet cherry spider mite, fruit tree spider mite.

Hosts. 44 host plants recorded belonging to 8 families; 37 species from the Rosaceae alone, including 4 *Crataegus* spp., 4 *Malus* spp., 15 *Prunus* spp., 4 *Pyrus* spp., 2 *Rubus* spp., 2 *Sorbus* spp. (Bolland et al. 1998; Migeon and Dorkeld 2013)

Distribution. Throughout Europe and Asia: Armenia, Austria, Azerbaijan, Belgium, Bulgaria, China, Czech Republic, France, Germany, Greece, Georgia, Hungary, Iran, Italy, Japan, Kazakhstan, Korea, Lebanon, Lithuania, Moldova, Netherlands, Poland, Portugal, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Taiwan, Tajikistan, Turkey, Ukraine, United Kingdom, Uzbekistan (Bolland et al. 1998; Migeon and Dorkeld 2013).

Biology. *Amphitetranychus viennensis* feeds on the terminal shoots and underside of leaves of its hosts, causing a yellowing of leaves. Fertilized females overwinter mainly under bark scales or among epiphytes on the bark of the host trees (CABI 2012).

The threshold temperature for the development of *A. viennensis* is 10°C. This mite shows a potential for rapid population growth at 20–30°C. It took 18.0 (at 35°C) to 26.8 days (at 20°C) for females to complete a generation on peach (Ji et al. 2005) and 19.6–23.1 days (at 25°C) across several apple cultivars (Kasap 2003), but shorter periods have been observed (12–14.5 days at 22–25°C; Jeppson et al. 1975). In the laboratory, females laid 85–105 eggs on the leaves of various apple cultivars and cherry at 25°C (Gotoh and Takayama 1992; Kasap 2003), whereas on black cherry and peach, a fecundity within the range of only 24–52 eggs per female was observed at 23–25°C (Golpayegani et al. 2004; Li et al. 2009); in another study, between 99 (at 15°C) and 157 eggs (at 35°C) were laid on average on peach (Ji et al. 2005). It favours dryer climates (Jeppson et al. 1975).

Economic importance. This mite is a pest of several fruit trees of the Rosaceae family, including apple, pear, peach, cherry, plum, quince, and apricot in Europe and Asia. It is also recorded from hazelnut. Heavy infestations can cause premature leaf drop and seriously hamper fruit production. Its impact is worse during dry years (CABI 2012).

Genus *Eutetranychus*

Eutetranychus species share many characteristics with *Tetranychus* species (see the diagnosis for *Tetranychus* above) but can be distinguished from them by (1) the absence of empodial claw; (2) the absence of duplex setae, and the presence of 1 pair of loosely associated setae (i.e. 2 setae separated by about the diameter of their socket); (3) usually shorter, thicker and often spatulate (or club-shaped) setae; and (4) the presence of setae h1 (Fig. 11A; compare with Fig. 2, where h1 is absent; see footnote 1 on page 11 for more details). There are currently 33 described species of *Eutetranychus* (based on Migeon and Dorkeld 2013).

***Eutetranychus orientalis* (Klein 1936)**

Diagnostic. It differs from other *Eutetranychus* species by the combination of:

- dorsocentral setae (c1, d1, e1, f1, h1) subspatulate (slightly club-shaped), short, and vary in length among individuals, reaching 0.3–0.5 times the distance to bases of next dorsocentral setae (Fig. 11A).
- tibiae II, III, IV with 6, 6, 7 setae, respectively
- genu III with 2 setae
- femora I and IV with 8 and 3 setae, respectively
- coxa II with 1 seta
- female spinneret about 3 times as long as broad
- striae between pairs of setae d1 and e1 forming a V-shaped, or almost longitudinal pattern
- aedeagus knob hook-shaped (Fig. 10)
- female with pointed spermatheca.

Females are pale brown, brownish green or dark green, with darker spots, and legs yellowish brown. From stylophore to abdomen tip, slide-mounted specimens are approximately 313 µm long and 258 µm wide (diagnostics based on voucher specimens and Chaudhri (1974), Smith Meyer (1974; 1987), Gupta and Gupta (1994), and Walter et al. (1995)).

Synonyms. *Eutetranychus anneckei* Meyer, *Eutetranychus monodi* André, *Anychus ricini* Rahman & Sapra, *Eutetranychus sudanicus* El Badry.

Older combinations. *Anychus orientalis* Klein

Common name. Citrus brown mite, Lowveld citrus mite (in South Africa), citrus mite, oriental mite, oriental red mite.

Hosts. 216 host plants recorded belonging to 66 families, including 9 *Citrus* species (Rutaceae), 30 Fabaceae, 10 Rosaceae, 10 Asteraceae, 10 Apocynaceae, 8 Cucurbitaceae, and 5 Solanaceae (Bolland et al. 1998; Migeon and Dorkeld 2013).

Distribution. Widespread in the Old World; **Africa**: Cape Verde, Ethiopia, Kenya, Malawi, Mali, Mauritania, Mozambique, Nigeria, South Africa, Swaziland; **Asia**: Afghanistan, China, Egypt, India, Indonesia, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Malaysia, Pakistan, Philippines, Saudi Arabia, Spain, Taiwan, Thailand, Tunisia, Turkey, Vietnam, Yemen; **Europe**: Cyprus, Greece; **Oceania**: Australia (Bolland et al. 1998; Migeon and Dorkeld 2013).

Biology. On citrus, *Eutetranychus orientalis* produces bronzing or whitish spots on the upper leaf surfaces where it feeds, resulting in leaf drops when populations are high, and sometimes in the death of young plants. It produces little webbing. Its impact is worse during dry conditions (Siddig

and Elbadry 1971; Jeppson et al. 1975; Al-Gboori 1991; Walter et al. 1995; Chen et al. 1996; Sakunwarin et al. 2003; Imani and Shishehbor 2009; CABI 2014).

The reported threshold temperature for the development of *Eutetranychus orientalis* varies from 6.4 (Imani and Shishehbor 2009) to 11°C (Jeppson et al. 1975). Females require 305 degree-days on average, and took 12.4 (at 30°C) to 22.3 days (at 20°C) to develop from egg to adult on castor bean (Imani and Shishehbor 2009), and 11.9 days (at 28°C) on mandarin (Al-Gboori 1991). Over 25 generations could occur per year under optimal conditions (Siddig and Elbadry 1971; Smith Meyer 1981), whereas ten generations were reported to occur from July to December in southern Iran (Assari 2001 in Imani and Shishehbor 2009). Fecundity is relatively low, with 14.6–16.3 eggs per female at 25–30°C on lebbek leaves (Imani and Shishehbor 2009), 17 eggs on lemon at 28–30°C (Assari 2001; and Saeedi 2006 in Imani and Shishehbor 2009), and between 2.4 eggs (on shaddock) and 35.2 (on lemon) across a range of *Citrus* spp. at 28°C (Al-Gboori 1991). It favours warmer, subtropical climates.

Economic importance. It is primarily a pest of citrus spp. (e.g. lemons, mandarins, oranges), but also injure a diversity of other crops (e.g. almonds, banana, cassava, cotton, frangipani, grapevine, pears, peaches, quinces, sunflower, watermelon, and ornamentals e.g. lebbek) (Imani and Shishehbor 2009; CABI 2014).

Genus *Oligonychus*

Oligonychus species share many characteristics with *Tetranychus* species (see the diagnosis for *Tetranychus* above) but can be distinguished from them by having (1) empodia claw-like, with proximoventral hairs (Fig. 7C); (2) the 2 pairs of duplex setae of tarsus positioned relatively close to each other, separated by about 1–1.5 times the diameter of their sockets (relatively to the longitudinal axis of the tarsus). There are currently 205 described *Oligonychus* species worldwide (based on Migeon and Dorkeld 2013).

Oligonychus mangiferus (Rahman and Sapra 1940)

Diagnostic. The female is very similar to that of other members of the *Oligonychus ununguis* species subgroup, and all have:

- Elongated dorsal setae, posteriorly extending beyond the base of the following setae (Fig. 11Fig. 11B).
- Tibia I with seven tactile setae (+1 solenidion);
- Tarsus I with four tactile setae (+1 solenidion) proximal to the two pairs of duplex setae
- Tibia 2 with 5 tactile setae;
- Tarsus 2 with 3 tactile (+1 solenidion) proximal to duplex setae.

The female of *O. mangiferus* also has:

- Genital flap with transverse striae (Fig.5)
- Pregenital area with longitudinal striae (similar to Fig.5)

- Palp spinneret about as long as, slightly longer than wide, or almost twice as long as wide.

The male of the species may be distinguished from other members of the *O. ununguis* species subgroup by the shape of the male aedeagus (Fig. 10), which follows a strong ventral (slightly acute) bent; the ventral bend or extension then gradually tapers into a blunt point, which may be slightly bent apically. However, other *Oligonychus* species may be indistinguishable morphologically from *O. mangiferus*, and therefore, some of the previous records of *O. mangiferus* around the world may represent other (misidentified) species. Alternatively, *O. mangiferus* may be synonymous with other *Oligonychus* species. The species concepts need revision.

Adults have dark red bodies, and are paler mediodorsally (Gupta 1976). From stylophore to abdomen tip, slide-mounted specimens are approximately 312–380 µm long and 220–225 µm wide (diagnosis based on Rahman (1940), Pritchard and Baker (Pritchard and Baker 1955), Tseng (1990), and Gupta and Gupta (1994)).

Synonyms or older combinations. *Paratetranychus insularis* McGregor, *Paratetranychus terminalis* Sayed, *Oligonychus terminalis* (Sayed)

Common name. Mango spider mite or mango red spider mite

Hosts. Recorded from 55 host plants, including: mango *(Mangifera indica),* cotton (*Gossypium* spp.), grape (*Vitis* spp.), avocado *(Persea americana),* peach *(Prunus persica), Rubus* and *Rosa* spp., quince (*Cydonia* sp.), pomegranate *(Punica granatum),* grape (*Vitis* sp.), sweetsop (*Annona squamosa*), loquat (*Eriobotrya japonica*), common fig *(Ficus carica*)*,* and castor oil plant (*Ricinus communis*) (Migeon and Dorkeld 2013). Note that a possible future change in the species concept (see notes under 'Diagnostic') may result in significant changes in host range.

Distribution. Originally described from Pakistan. Now recorded from 18 countries around the globe in tropical and temperate regions, in South and Central America, southern Africa, Middle East, Southeast Asia and Australia.

Biology. The mite inhabits the upper leaves of mango (Rahman and Sapra 1940; Jeppson et al. 1975; Gerson 1986) and grapes (Gupta 1976). Infested mango leaves show profuse webbings and extensive mottling (Rahman and Sapra 1940), with yellow patches later turning brown (Gupta 1976), and feeding can produce a drying effect and premature leaf drop (Jeppson et al. 1975; Gupta 1976).

The lower temperature developmental thresholds of the immature stages were 11.1°C for females, and 11.6°C for males (Lin 2013); Fu and Zhang (2002) found 11.1°C as the threshold for pre-oviposition period. Reared on mango, generation time ranged from 27.4 days at 31°C (65% RH), to 48.1 days at 15°C (75% RH) in Abou-Awad (2011), from 9.2 days at 32°C to 29.1 days at 16°C in Fu and Zhang (2002), and from 12.6 days at 33°C to 46.0 days at 17°C in Lin (2013). On mango, 26 generations are estimated to reproduce in Thailand (Lin 2013), and 14–20 in Egypt (Zaher and Shehata 1972; Abou-Awad et al. 2012). Average fecundity ranged from 11.6 eggs per female at

15°C to 46 eggs at 31°C in Abou-Awad et al. (2011), but only 7.4–26 eggs at 17–33°C (highest at 29°C) in Fu and Zhang (2002); it was 20–40 eggs per female when reared on sweet potato (Zaher and Shehata 1972)(it is not mentioned if sweet potato is a natural host). The optimal condition for the development of these mites, based on laboratory rearings on mango, were considered to be 15–31°C and 65–75% R.H. by Abou-Awad et al. (2011), and 24–28°C by Fu and Zhang (2002).

Economic importance. *Oligonychus mangiferus* is a major mango pest in Taiwan, and also a pest in many other countries where mango is grown (Lin 2013), as well as of cotton, pomegranate, loquat, peach, quince, and pear (Jeppson et al. 1975). It is also recorded from other crops (see 'Hosts' above), some of which are shown to be suitable for feeding and breeding (Sadana and Chander 1978).

Genus *Schizotetranychus*

Schizotetranychus species share many characteristics with *Tetranychus* species (see the diagnosis for *Tetranychus* above) but can be distinguished from them by (1) empodia split into 2 or 3 claw-like structures (which may bear dorsal appendant hairs), and with (2) no proximoventral hairs (Fig. 7B); (3) three pairs of h setae (h1–3) present on dorsal opisthosoma (compare with Fig. 2, where h1 absent; see footnote 1 on page 11 for more details); (4) the 2 pairs of duplex setae of tarsus usually positioned relatively close to each other, almost overlapping each other (relatively to the longitudinal axis of the tarsus). There are currently 116 described species of *Schizotetranychus* (based on Migeon and Dorkeld 2013).

Schizotetranychus hindustanicus (Hirst 1924)

Diagnostic. This species differs from other *Schizotetranychus* species by the combination of:

- Dorsal setae relatively short, with c1–c2 and d1–d2 reaching 0.5–0.7 x distance between their socket and that of the next setae posteriorly (Fig. 11C)
- Dorsal f1 setae well separated, with distance f1–f1 2.0–2.5 x distance e1–e1 (usually equidistant in other species)
- Female pregenital with arched striation
- Male aedeagus (Fig. 10) with distal part curving dorsad (usually curving ventrad in other species) and strongly and sharply S-shaped distally, with last curve narrowly rounded (acute corner in close relative *S. schizopus*), and may appear slightly hooked at the tip.

Immatures and adults are yellowish with dark lateral spots after feeding (Navia and Marsaro 2010). From stylophore to abdomen tip, slide-mounted specimens are approximately out 372 µm long and 250 µm wide (diagnosis based on voucher specimens and Hirst (1924), Gupta and Gupta (1994), and Navia and Marsaro (2010)).

Synonyms or older combinations. *Tetranychus (Schizotetranychus) hindustanicus*
Common name. Citrus hindu mite or citrus nest-webbing mite.

Hosts. Five host plants recorded: *Cocos nucifera* (Arecaceae), *Acacia* sp. (Fabaceae), *Azadirachta indica*, *Melia azedirachta* (Meliaceae), *Sorghum vulgare* (Poaceae), *Citrus* sp. (Rutaceae) (Gupta and Gupta 1994; Migeon and Dorkeld 2013).

Distribution. Originally only reported from India, now also in Brazil and Venezuela.

Biology. The species is poorly studied. Lemon trees that are affected by the mite present uniformly distributed circular whitish spots (1–3 mm) on the leaf upper surfaces and fruits, which become uniformly distributed in time. These spots correspond to the webbing produced by the female to protect the colony. Fruits become silvery and hard after extensive infestation (Navia and Marsaro 2010; Quirós and Geraud-Poney unpubl. data in Navia and Marsaro Jr 2010).

At 25 ±2°C, it takes 30–31 days to complete development, with fecundity ranging from 11–13 eggs per female on various citrus fruits in Venezuela (Nienstaedt and Marcano 2009a).

Economic importance. The mite is reported as a sporadic pest of citrus in India (Gupta 1976), and a pest of *Citrus* spp., mostly lemon, in Venezuela and Brazil (Nienstaedt and Marcano 2009b; Quirós and Geraud-Poney unpubl. data in Navia and Marsaro Jr 2010; Navia and Marsaro 2010).

Spider mite pest species that may be intercepted but are already occurring in one or more countries of the NAPPO region (number of hosts recorded, and distribution essentially based on Migeon and Dorkeld 2013)

Bryobia rubrioculus (Scheuten 1857). Widespread pest of apple and other Rosaceae. Recorded from Canada, United States, Mexico; 62 hosts recorded.

Oligonychus coffeae (Nietner 1861). Widespread pest; but in the NAPPO region, only recorded from Florida (USA). Considered a serious pest of many crops, including mango, tea, coffee, cotton and jute in tropical and subtropical regions (Jeppson et al. 1975; Gotoh and Nagata 2001; CABI and EPPO 2013). At least 133 hosts recorded. This species is similar to other species of Oligonychus that may be confused with it. These species may need clarification of their species concepts using morphological and molecular analyses.

Oligonychus ilicis (McGregor 1917). Recorded in Louisiana and several other states in eastern USA; and in Brazil, Paraguay, Italy, Netherlands, Japan, and South Korea; 39 hosts recorded, including ornamental plants such as azaleas and camellia, as well as coffee and *Oryza* (Knihinicki et al. 1999).

Oligonychus punicae (Hirst 1926). Recorded on avocado *(Persea americana)* from California and Florida (USA), on grapes (*Vitis vinifera*) and pomegranate (*Punica granatum*) in tropical Asia and Central and South America, and coffee and *Camellia* sp. (Jeppson et al. 1975; Baker and Tuttle 1994).

Oligonychus yothersi (McGregor 1914). Recorded from a few states in eastern USA, as well as from Central and South America, and China. A pest of avocado in Florida (Jeppson et al. 1975). Recorded from 60 host plants belonging to many families, including Rosaceae.

Tetranychus evansi Baker and Pritchard, 1960. Widespread pest of Solanaceae; 107 hosts recorded in southern USA.

Tetranychus kanzawai Kishida 1927. Apparently native to Southeast Asia, where it is a pest of various crops including deciduous fruit trees, and tea; introduced to North America and several other countries; 182 host plants recorded.

Tetranychus turkestani (Ugarov and Nikolskii, 1937). A widespread, serious pest of many rosaceous fruits and other crops (e.g. cotton). Widespread in USA (Baker and Tuttle 1994), but also recorded from Mexico (Tuttle et al. 1976); 211 host plants recorded.

Tetranychus urticae Koch 1836. Cosmopolitan, attacking a wide range of crops, including many fruits. Recorded from over 1000 host plants.

Panonychus ulmi (Koch 1836). Recorded from 144 hosts; a major, widespread pest of deciduous fruit crops in temperate regions, such as apple and grapevine.

Panonychus citri (McGregor 1916). Recorded from 112 hosts, but mainly a pest of *Citrus* worldwide.

Spider mite pest species that may represent a threat to the NAPPO region

Oligonychus perditus Pritchard and Baker, 1955. Recorded from Japan, China and Taiwan. Primarily on cupressaceous conifers *(e.g. Chamaecyparis, Juniperus*, *Thuja* spp.). It may cause significant damage on certain species. *Prunus salicina* (Chinese or Japanese plum) and *Camellia sinensis* (tea) are also included in the 12 hosts recorded in total, but these hosts could be accidental, or another, morphologically similar mite species may have been misidentified as *O. perditus* (CABI 2013a).

Key to the main genera of Tetranychidae and genera with quarantine species for North America. This key is a simplified and modified version of the key in Gutierrez (1985).

1. Chelicerae modified into long, recurved, J-shaped stylets (Figure 1, Fig. 2A); palp curved inward and with a thumb-claw structure (Fig. 3**Error! Reference source not found.**); lateral eyes on prodorsum 2
- Chelicerae not long and J-shaped (NOT Tetranychoidea), or palp linear or without thumb-claw, or eyes absent ..... **NOT Tetranychidae**

2. Empodia with tenent (T-shaped) hairs **Bryobiinae** 3
- Empodia without tenent hairs (Fig. 7), or empodia absent; may bear attenuated, fine hairs distally or proximo-ventrally **Tetranychinae** 4

3. True claws claw-like, empodia pad-like; setae h1–3, ps1–3 present, and all 4 pairs of prodorsal setae present; prodorsum with prominent lobes projecting forward .....***Bryobia***
- Without the above combination of characters ..... **Other Bryobiinae**

4. Empodia claw-like when present; tarsus I with 0–1 pair of duplex setae (1 pair of duplex = 1 short tactile setae + 1 long solenidion, with their sockets touching or merged), or if with 2 pairs, then tarsus II without duplex setae **Eurytetranychini** 5
- Empodia claw-like or divided into fine hairs; tarsus I with 2 pairs of duplex setae (Fig. 6), and tarsus II with 1 pair 6

5. Tarsus I without duplex setae, only with 1 pair of loosely associated setae (i.e. 2 setae separated by about the diameter of their socket); empodial claw apparently absent; 3 pairs of h and 2 pairs of ps setae present; opisthosoma with 10 pairs of setae, including seta c2 ..... ***Eutetranychus***
- Without the above combination of characters ..... **Other Eurytetranychini**

6. Opisthosoma with seta f1 in normal position (Fig. 2), away from margin **Tetranychini** 7
- Opisthosoma with seta f1 near margin of dorsum ..... **Tenuipalpoidini**

7. Opisthosoma with setae h2-3 present, h1 absent (*see footnote p. 11) 8
- Opisthosoma with setae h1-3 present (h1 usually longer and more dorsal than h2–3) 11

8. Empodia divided bilaterally into 3 (or rarely 2) pairs of hairs (may seem as only 3 hairs from lateral view (Fig. 7A), sometimes with dorsal spur[1]; the 2 pairs of duplex setae of tarsus I well separated, by about 2–3 times the diameter of their sockets (Fig. 6) 9
- Empodia claw-like with proximoventral hairs; the 2 pairs of duplex setae of tarsus I distal (in the distal half of tarsus) and relatively close to each other, separated by about 1–1.5 times the diameter of their sockets 10

9. Peritreme simply hooked distally (Fig. 8) ..... ***Tetranychus***
- Peritreme anastomosted distally (Fig. 8) ..... ***Amphitetranychus***

10. Dorsal opisthosoma with 10 pairs of setae, including seta c2 (Fig. 2A); two pairs of anal setae (ps1–2; Fig.5); most or all legs with empodial claws about as long or longer than the proximoventral hairs[2] ..... ***Oligonychus***
- Without the above combination of characters ..... **Other Tetranychini**

11. Empodia divided bilaterally into 3 (rarely 2) pairs of hairs (similar to Fig. 7A)[3] 12
Empodia claw-like, or divided bilaterally into 2 claws (Fig. 7B,C); may bear proximoventral hairs . 13

12. Opisthosoma with transversal striae between setae e1; each dorsal seta about as long or longer than distance between its base and that of successive seta; dorsal opisthosomal setae not set on tubercles; 3 pairs of h setae and 2 pairs of ps setae present ..... **Eotetranychus**
- Without the above combination of characters ..... **Other Tetranychini**

13. Empodia a single claw-like structure (Fig. 7C); with or without proximoventral hairs 14
- Empodia split into 2 claw-like structures (Fig. 7B); may bear dorsal appendant hairs; without proximoventral hairs 15

14. Empodia with proximoventral hairs; empodial claw about as long or longer than proximoventral hairs, which are at right angles to the claw[2] ..... ***Panonychus***
- Without the above combination of characters ..... **Other Tetranychini**

15. dorsal opisthosoma with 10 pairs of setae, including setae c2 and f2 (Fig. 11C) .... ***Schizotetranychus***
- Without the above combination of characters ..... **Other Tetranychini**

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[1] Empodia I, or I and II claw-like in many males and a few females, with hairs of empodia I–II variously merged in males.
[2] claws are measured from junction with proximoventral hairs
[3] The most basal pair of hairs may be thickened, but finely tapers distally, as opposed to claw-like structures, which end bluntly

Key to species of *Tetranychus* and *Amphitetranychus* as potential quarantine pests or that may be present in fruit commodities imported in North America. Both female and male mites are required for this key. In part based on Seeman and Beard 2011 (to be consulted for more species details or illustrations).

1. Female with dorsal striae between setae e1–f1 forming a diamond-shape (Fig. 9A): striae longitudinal and/or oblique between setae e1–e1 and between setae f1–f1, and striae transversal in the central area between e1 and f1 setae. ***Tetranychus urticae* species group** (=subgenus *Tetranychus*, sensu Tuttle & Baker 1968)..... 4
- Female with dorsal striae between setae e1–e1 transversal, or all striae between e1–f1 transversal 2

2. Female with dorsal striae between setae e1–f1 essentially transversal (Fig. 9B); peritreme anastomosed distally (Fig. 8); aedeagus bending into a spear-shaped process, nearly as long as (longitudinal) shaft (Fig. 10)..... ***Amphitetranychus viennensis***
- Peritreme simply hooked distally (Fig. 8). **Other *Tetranychus* species** 3

3. Female with dorsal striae between setae e1-f1 all transversal (Fig. 9C) .... ***Tetranychus pacificus* species group** (=group (=subgenus *Armenychus*, sensu Tuttle & Baker 1968)
- Female with dorsal striae between setae f1 longitudinal (Fig. 9D)..... ***Tetranychus canadensis* species group** (=subgenus *Polynychus*, sensu Tuttle & Baker 1968)

4. Tarsus I with the sockets (bases) of the 4 most proximal tactile setae inserted proximally to (not overlapping with) the socket of proximal pair of duplex setae, although some specimens may have 1–2 setae overlapping (Fig. 6), showing only 1 seta that is almost overlapping); Female empodia I-IV with spur absent or small (≤2 µm long) (Fig. 7A), male empodia I–II with larger spurs, ≥2.5 µm long. 6
- Tarsus I with the sockets of 2–5 proximal tactile setae inserted at a level that overlaps with the socket of proximal pair of duplex setae 5

5. Male with empodia II claw-like (Fig. 7D), like empodia I, different from empodia III–IV; knob of aedeagus directed at dorsal angle to axis of shaft (Fig. 10); female with pregenital striae entire, sometimes sparse and slightly broken medially. *Widespread, southern USA* .. ***T. evansi***
- Without the above combination of characters ..... **Other species of *T. urticae* group**

6. Aedeagus with a distinct knob, which is nearly parallel to shaft of aedeagus; posterior projection of knob ≤0.6x the width of the aedeagus' neck (Fig. 10); female pregenital striae generally entire, although sometimes weak or sparse medially (Fig.5). 7
- Aedeagus without distinct knob, with shaft tapering into a weak S-shape (Fig. 10); female pregenital striae broken medially. *Southeast Asia* ..... ***T. piercei***

7. Knob of aedagus small, with dorsal margin medially concave (Fig. 10). East and Southeast Asia ..... ***T. truncatus***
- Dorsal margin of knob of aedeagus convex, and smoothly rounded or angular 8

8. Knob of aedeagus with large posterior projection, which is approximately as long as the width of the neck; dorsal margin of the knob forming an angle (Fig. 10). Widespread, North America ..... ***T. turkestani***
- Knob of aedeagus with smaller posterior projection, which is shorter than the width of the neck; dorsal margin of the knob rounded or angular 9

9. Knob of aedeagus large, about twice as long as the aedeagus' neck; dorsal margin of aedeagus usually rounded (Fig. 10); females collected in summer are red. East and South East Asia, possibly in USA ..... ***T. kanzawai***
- Knob of aedeagus small, less than twice as long (~1.5x) as the aedeagus' neck, and dorsal margin of knob somewhat angulate (Fig. 10); females collected in summer are green, yellow or red. *Cosmopolitan* ..... ***T. urticae***

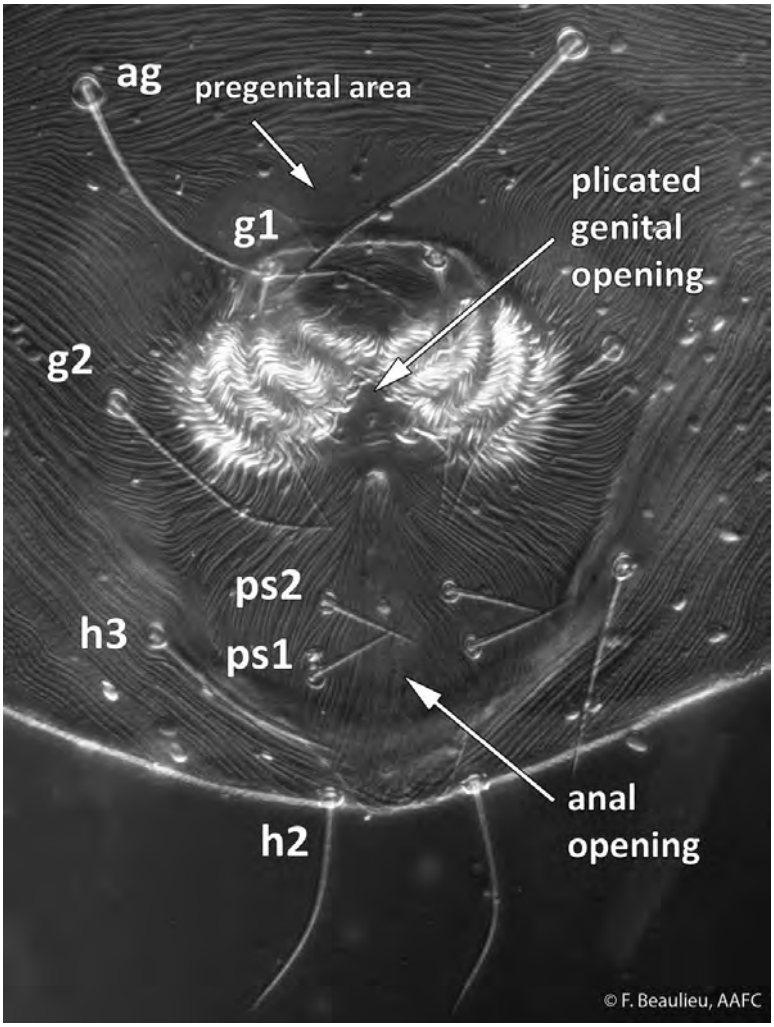

Fig.5. Posteroventral region of female body, showing genital (g) and anal (ps) setae. Such folded cuticle around the genital opening is indicative of females, as males do not have such folded cuticle.

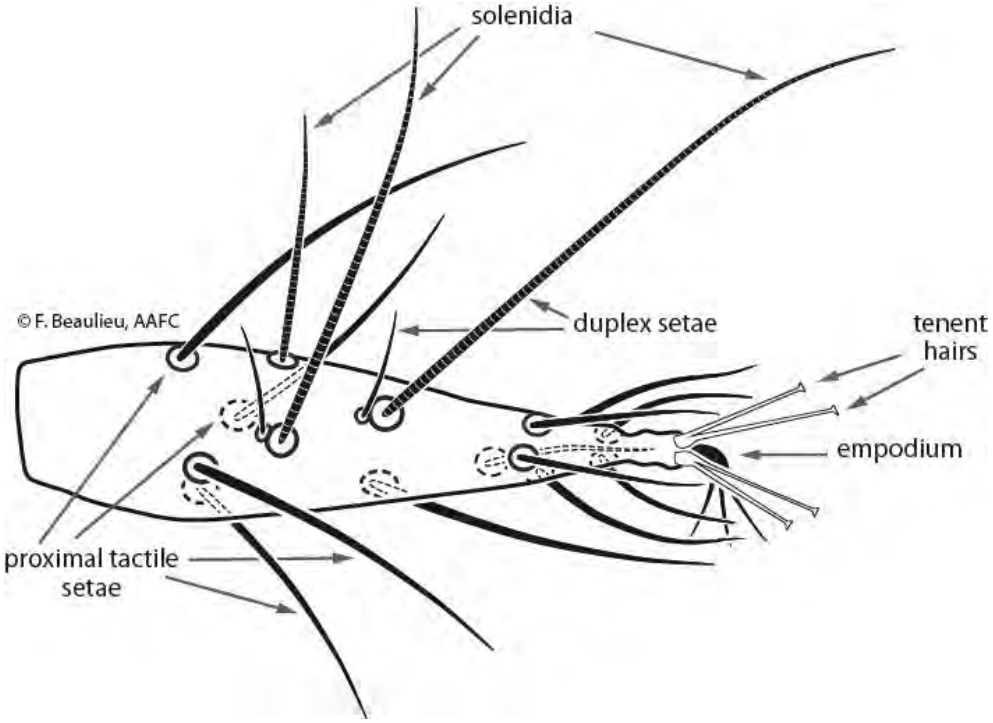

Fig. 6. Tarsus of leg I (*Tetranychus truncatus*). Note: only 1 of the 4 proximal tactile seta is slightly overlapping with the proximal pair of duplex setae.

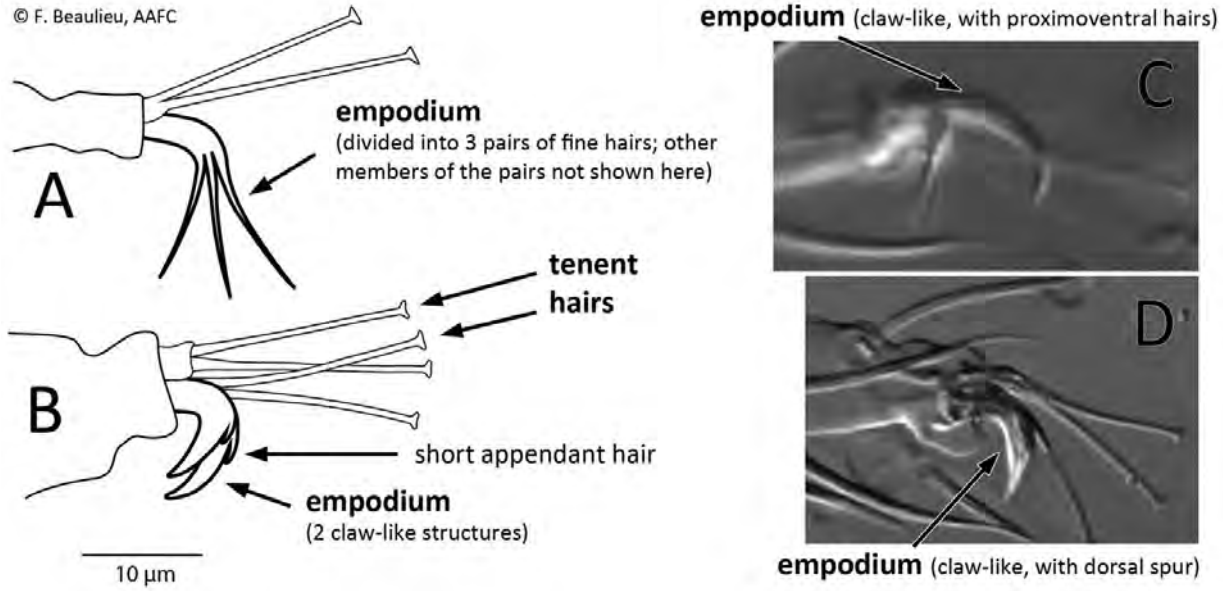

Fig. 7. Examples of leg I pretarsi of (**A**) *Tetranychus* female, (**B**) *Schizotetranychus* female, (**C**) *Oligonychus* female, and of the male of (**D**) *Tetranychus evansi*. All images are at the same scale.

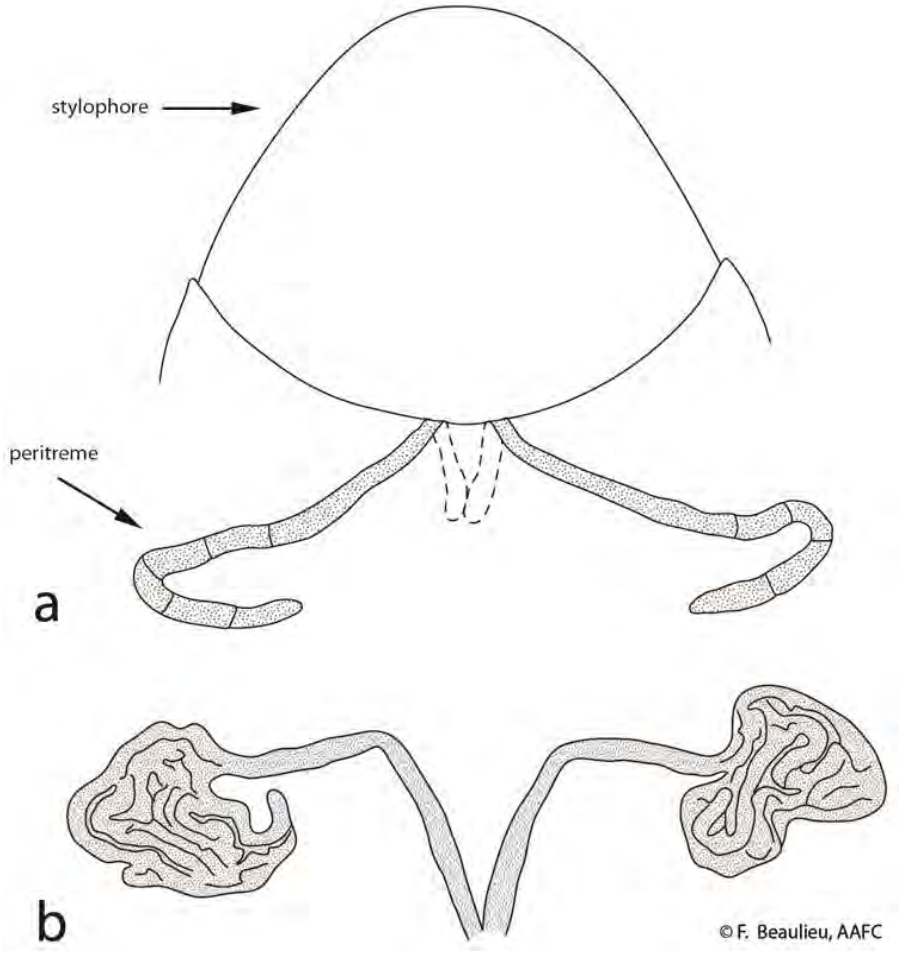

Fig. 8. Peritremes of (a) *Tetranychus* species and (b) *A. viennensis.* The only meaningful distinction is the distal part of the peritreme: simply hooked in *Tetranychus* spp., anastomosed in *A. viennensis*.

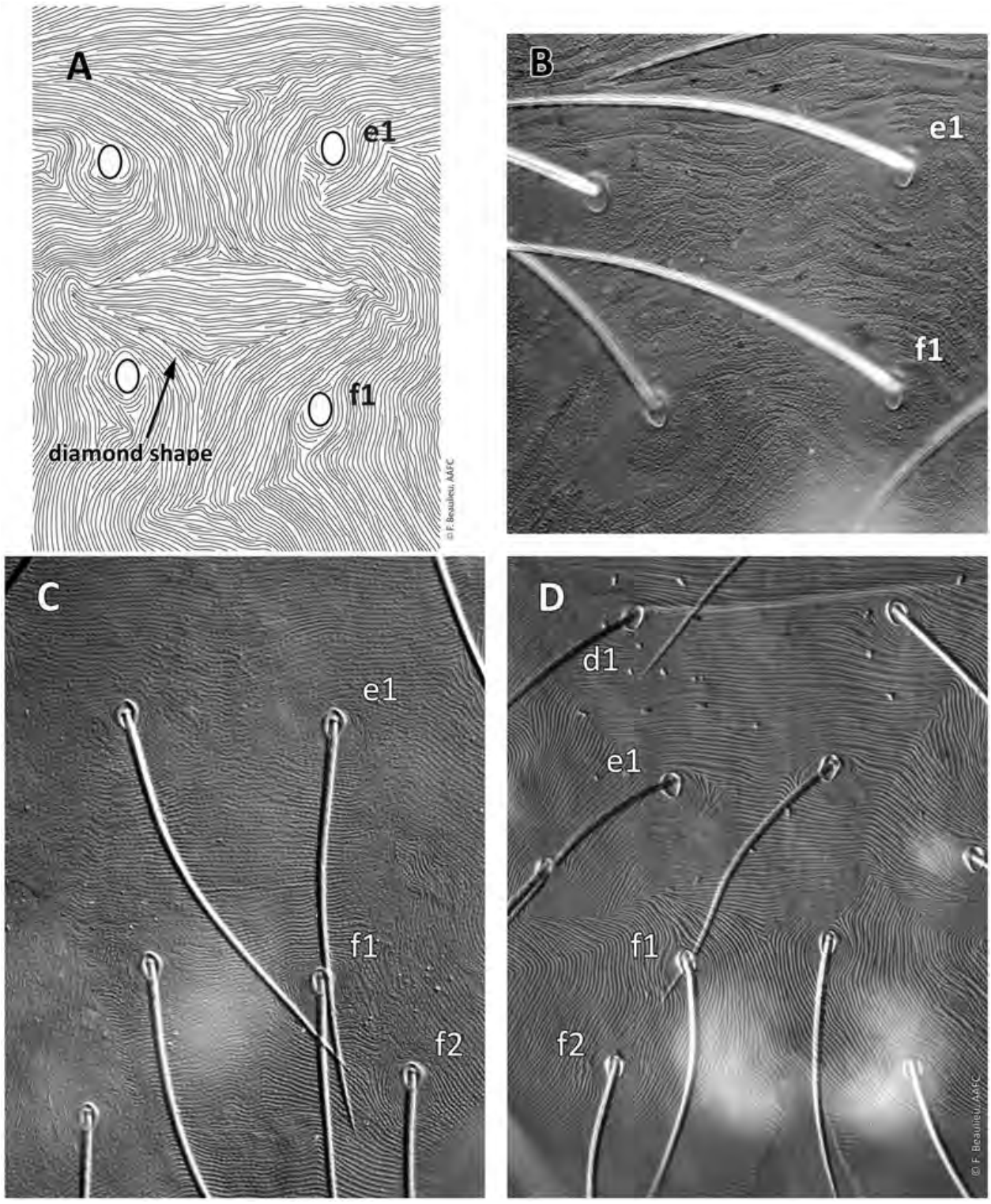

Fig. 9. Dorsal striae between pairs of setae e1 and f1, showing: (**A**) the diamond pattern characteristic of the females of the *Tetranychus urticae* species group, with striae longitudinal between e1 setae and between f1 setae; (**B**, **C**) striae essentially transversally oriented (sometimes wavy) between the entire e1–f1 area in *Amphitetranychus* (**B**) and *Tetranychus pacificus* species group (**C**); and (**D**) striae that are longitudinally oriented between f1 setae, and transversal elsewhere, as in the *Tetranychus canadensis* species group.

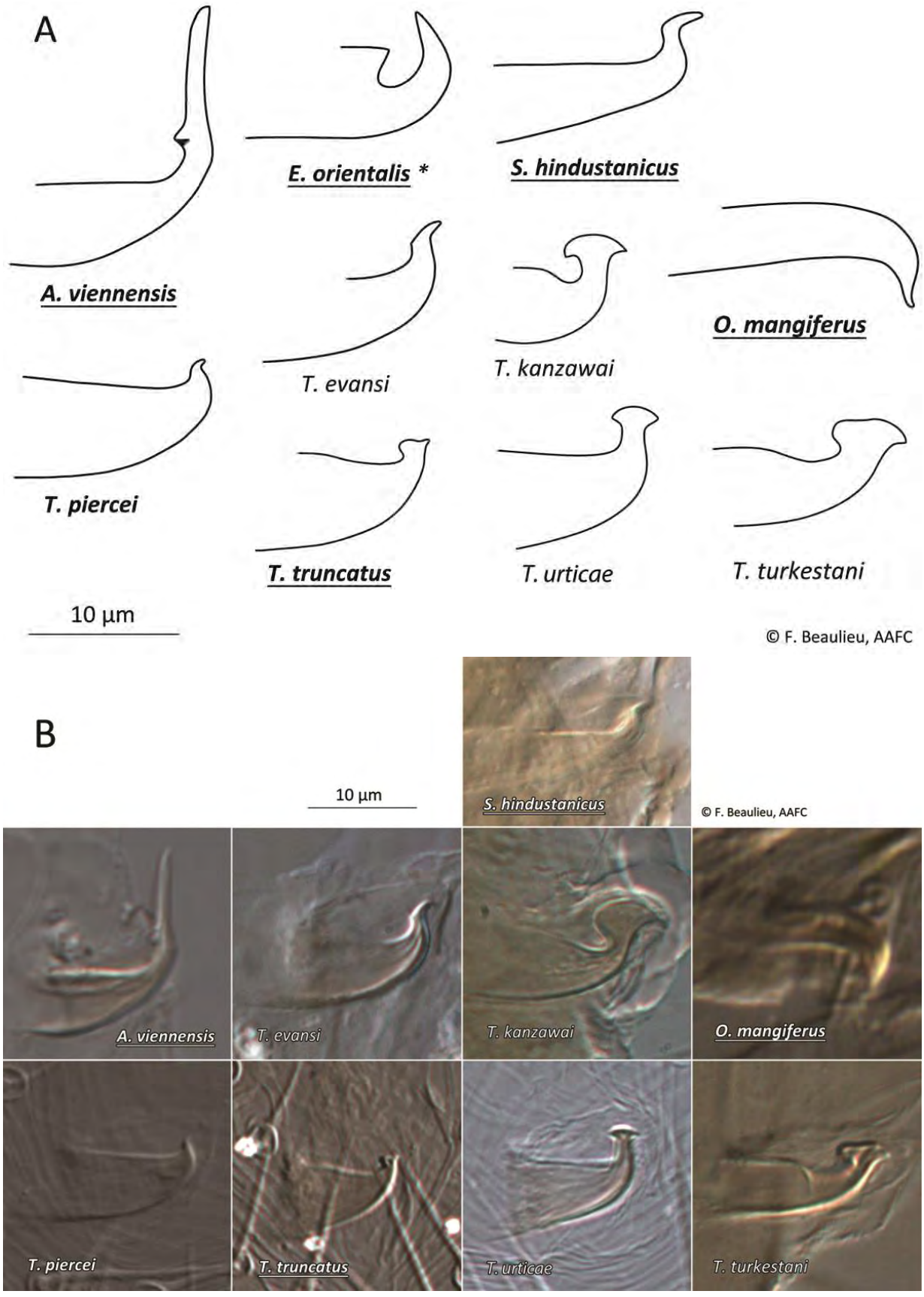

Fig. 10. Male aedagi of *Amphitetranychus*, *Tetranychus, Eutetranychus, Oligonychus*, and *Schizotetranychus* species of quarantine importance (names in bold+underlined) for Canada, USA,

and/or Mexico, that may represent a threat (bold), or other pest species (normal font) considered to be present in at least one of the three countries. Aedeagi of *E. orientalis* and *O. mangiferus* were reproduced and modified from Smith Meyer (1974), and Pritchard and Baker (1955), others from slide-mounted specimens; *aedeagus of *E. orientalis* is not to scale (scale unknown). **A**: line drawings; **B**: digital photographs.

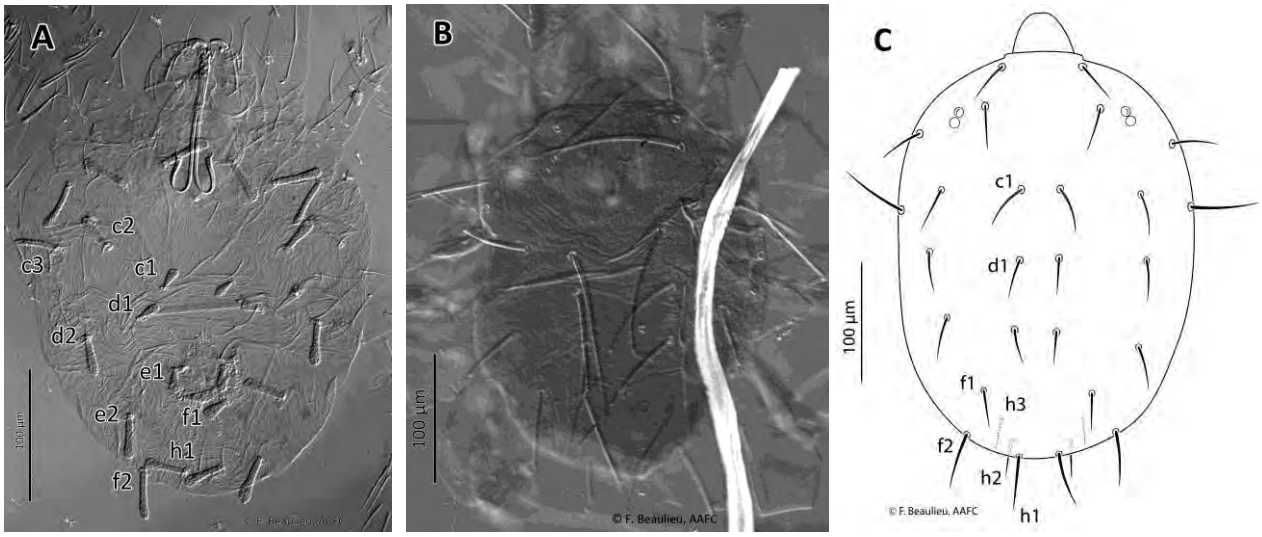

Fig. 11. Dorsal idiosoma of (**A**) *Eutetranychus orientalis*, (**B**) *Oligonychus mangiferus*. (**C**) *Schizotetranychus hindustanicus*.

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