PLANT HEALTH AUSTRALIA
NATIONAL DIAGNOSTIC STANDARDS DEVELOPMENT

National Diagnostic Standards for *Tetranychus* Spider Mites

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PART 1: *Tetranychus*

Introduction

Spider mites are among the best-known of the Acari, yet their identification remains a persistent challenge to experts and non-experts alike. The costs incurred from crop losses and control strategies are measured in millions of dollars, but agricultural entomologists frequently blame this damage on a few common species (e.g., Two-spotted spider mite or European red mite) without checking species identification. Our goal here is to demystify as much as possible spider mites of the genus *Tetranychus*. With some practice and a decent microscope, we hope that entomologists involved in the agricultural sector should be able to determine what species are causing damage. We also hope that our work allows the detection of exotic species prior to export, at the border or soon after entry into Australia.

A multitude of mites live on plants, where they feed on plant cells, fungi, pollen, and small arthropods – especially other mites. Common families in agricultural ecosystems include the Eriophyidae (rust, erinose and gall mites), Tetranychidae (spider mites), Tenuipalpidae (false spider mites), Tarsonemidae (mostly fungivorous, although the broad mite is phytophagous), Tydeidae (generally predators and fungivores) and Phytoseiidae (predatory mites often used in biocontrol). With some practice these groups can be easily distinguished without the need for slide-mounting specimens.

Spider mites belong to the family Tetranychidae, a group comprising over 1,200 described species in 6 tribes and 71 genera (Bolland *et al*. 1998). The genus *Tetranychus* (141 spp.) is one of the largest genera of the Tetranychidae, being one of the five genera represented by more than 100 known species. The other major genera are *Bryobia* (129 spp.), *Eotetranychus* (184 spp.), *Oligonychus* (199 spp.) and *Schizotetranychus* (116 spp.). The current document deals with the species of *Tetranychus* recorded in Australia and 14 of the most agriculturally important species overseas.

The most economically important species feed on many host plants, and the more polyphagous the pest the more likely it is to be introduced. The average number of host species recorded for *Tetranychus* species that are already introduced to Australia is 252 (range 18 - 933, n = 8, s.e. = 116); for exotic *Tetranychus* deemed economically important the average is 70 (range 15 - 193, n = 13, s.e. = 17); for exotic *Tetranychus* of lesser importance the average is 3.4 (range 1-32, n = 111, s.e. = 0.4) (data from Bolland *et al.* 1998). Therefore, spider mites are a global plant health problem that affects every plant-based industry, and quarantine officers and agricultural

entomologists must be aware that every plant is a potential host for exotic species of spider mite.

General life history

Spider mites lay eggs, have four active life stages (larva, protonymph, deutonymph, adult) and a resting period between each of these active life stages. They overwinter as either eggs or adult females in nooks and crannies on bark and stems, or at the base of plants in the leaf litter and the upper soil layer. All species of *Tetranychus* overwinter as adult females that are coloured orange or red. In tropical and subtropical areas the mites may remain active year-round.

Recognising damage

Plants with low numbers of spider mites show no symptoms, so examination of leaves with at least a hand-lens is the best way to detect them. When populations become large, spider mites should be easily detected on leaves. Damaged leaves are characteristically speckled, the result of spider mites sucking the contents out of each plant cell (Photos: damage to beans, to frangipani, to coral tree, to mock orange, to sugar cane). The common name ”spider mites” is derived from their ability to produce silk, which many species use to build nests in which they live and feed. The webbing is spun from their palps and, when populations are very large, it is immediately apparent and characteristic of this group (Photo: mites and sparse webbing on *Monadenium*).

Female and nymphal spider mites tend to be slower moving (Video 1, Video 2: *Tetranychus*) compared with some other plant mites, such as the fast-moving predatory phytoseiids (Video 3, Video 4: Phytoseiidae). Nymphs are similar to adult females but smaller. Male mites are roughly diamond-shaped, smaller than female mites, usually yellow to green in colour (never red) and move more quickly (e.g., Video 2; Video 5). The females are more egg-shaped, usually about 0.5 mm long and are yellow, green, red, or brown and may have black spots which are especially obvious in pale mites (Video 6: *Tetranychus*). Mites similar to spider mites include: the Tenuipalpidae, which have flattened bodies and a delicate slow motion (Video 7: *Tenuipalpus*; Video 8: *Brevipalpus*); the stunning Tuckerellidae, with leaf-like setae with long posterior filaments (Video 9, Video 10: *Tuckerella*); and the Tydeidae, diminutive pale mites that are common on plants and have a stop-start scuttling motion (Video 11).

According to Tuttle and Baker (1968), adult females from temperate regions are usually greenish and overwinter as non-feeding orange-coloured females. Mites in more tropical areas may reproduce year-round and are usually reddish in colour. However, these are broad generalisations, and colour can vary with age, rearing conditions and host plant.

Entry potential, Establishment potential and Spread potential

The entry, establishment and spread potential of exotic species of spider mite is largely determined by their host-range. Given the number of introduced species already in Australia, their small size, introductions into other countries

(e.g., *T. turkestani* around the world), and their notorious resistance to pesticides, spider mites should be listed as “high-risk” in each of these categories. Furthermore, one female mite is capable of starting a new population, irrespective of whether she is mated or not. An unfertilised female mite will produce male mites, with which she can mate and start producing female mites.

Entry and establishment potential of spider mites would be highest on nursery stock because spider mites tend to be associated with leaves. Spider mites may become associated with fruit and vegetables, especially when at high densities on leaves, or during autumn and winter when adult females search for overwintering sites. Fruit should be examined around the stem and calyx. Also, stems, bracts or small cracks should be examined as these places offer shelter, especially during winter or cold-storage.

Spider mites spread within a plant via walking and they may walk short distances between plants. However, the primary means of migration is via the wind. Spider mites may migrate at any time, but have a higher probability of engaging in wind migration when their populations become large, predators become abundant, or the quality of their food source declines. *Tetranychus urticae* will migrate in winds as low as 8 km/h, but prefer to migrate in stronger winds (Boykin & Campbell 1984).

Control strategies

Spider mites are perceived as a secondary problem in modern agriculture. The combination of a healthy host plant and natural populations of predators usually keep spider mite populations below damaging levels, but where pesticides must be used, spider mites become a major management issue. Their notorious resistance to insecticides leaves spider mites unharmed and yet their predators dead, and to exacerbate the problem, they develop resistance to acaricides rapidly.

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: 1. use of insecticides perceived as “soft” on predators such as predatory mites, thrips and tiny ladybirds; 2. rotating acaricides from different chemical groups to slow or prevent the development of resistance; and 3. timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular predatory mite, *Phytoseiulus persimilis* (Phytoseiidae), is available commercially from several companies. In some systems, predatory mites alone can control spider mite populations, for example, *Tetranychus pacificus* on grapes (Hanna *et al.* 1997).

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species

(egg-adult) at a constant temperature of around 30-35 ºC. Acaricides should be applied to the undersides of leaves as much as possible because most species feed beneath leaves.

Spider mite problems can increase due to several means, and these should be considered in any control program. Spider mites migrate via the wind and, given that all pestiferous species have many host plants, neighbouring crops and weeds serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other crops and weeds could also be host plants. Their wind migration is not only a source of new infestations, but new genetic material. For example, *T. pacificus* individuals resistant to a pesticide not registered for cotton but used in almond were recorded in a cotton crop, where they had migrated to from a nearby almond orchard (Grafton-Cardwell *et al.* 1991).

Plant health can also influence spider mite populations. Nitrogen fertilisation increases fecundity and development times of at least *T. pacificus* (Wilson *et al.* 1985) and *T. urticae* (Wermelinger *et al.* 1985). Water stress can also increase development times and fecundity. For example, fecundity and development rate of *T. pacificus* on almond increases with water stress, probably as a result of increased leaf temperature (Youngman *et al.* 1988; Oi *et al.* 1989).

Finally, an unusual method of control has been discovered for *T. pacificus* on grape. The introduction of an innocuous herbivore, *Eotetranychus willamettei* (Tetranychidae), prior to infestation with *T. pacificus* causes a systemic reaction that reduces the later infestation by *T. pacificus* (English-Loeb *et al.* 1993; Hougen-Eitzman & Karban 1995). However, this does not seem to work for all cultivars (Hanna *et al.* 1997).

Using the document

Make sure you select View – Document Map from the Microsoft Word menu. Minimise or expand each of the headings as required. Click on each of the headings to move through the document. The document is spilt into three main headings: ***Tetranychus*** (introduction to morphology, collecting, preparing slides and recognising species), **Naturalised species**, and **Quarantine concern**. If you have an unknown spider mite, use the keys to make a determination, and then check your identification with the diagnosis.

Some terms have “hyperlinks”; these are in blue text with an underline. By holding the control key down and clicking the mouse button at the same time, you can move to different parts of the document and see photos and videos.

Useful literature

Several books are available on spider mites and there is an extensive literature in scientific journals. Useful texts are:

Bolland, H.R., Gutierrez, J., & Flechtmann, C.H.W. (1998). A world catalogue of the spider mite family (Acari: Tetranychidae). Brill, Netherlands. *Keys to family, tribe and genera. Comprehensive list of species, host plants,*

geographical distribution and spider mite literature. Expensive at around AU$300, but an essential accompaniment to any laboratory involved in spider mite work.

Halliday, R.B. (1998). Mites of Australia, a checklist and bibliography. *Monographs on Invertebrate Taxonomy* **5**: 1-317. *Essential for any acarologist. The spider mite section is useful because it gives all Australian references to each species.*

Helle, W. & Sabelis, M.W. (eds) (1985). *Spider Mites. Their Biology, Natural Enemies and Control (World Crop Pests).* Amsterdam: Elsevier Vol. 1A and 1B. *A two-volume compendium – Volume 1A on many aspects of spider mites, Volume 1B on their predators. Expensive at around AU$350 per volume, researchers may be best served by using copies in libraries.*

Collecting and mounting spider mites

Collection

When searching for spider mites, look for damaged leaves and use a hand lens to examine around the mid-rib and veins. If you need to survey leaves that do not show damage, take leaves (without conscious bias) from throughout the plant, as some species prefer lower portions, others upper portions, of the foliage. Put collections into labelled paper or plastic bags and into an esky cooled with freezer-bricks. Leaves in paper bags tend to dry out very rapidly, and can only be stored for about 24 hours; however, mites will live on leaves in plastic bags in a fridge for up to a week. This fridge storage only works if the number of leaves is limited to about 5 x 15 cm small branches. If an excess of leaves is placed into plastic bags, too much transpired water gathers and the mites drown and the leaves start to rot. Mites from refrigerated leaf material that have only recently died can still be mounted and identified.

Examine each leaf under x10 and remove mites with a moistened paintbrush into 80% ethanol. Be sure to keep each host-plant sample separate and label your collections carefully, including place, date, collector and host plant, along with any damage to the plant and on which leaf surface the mites were feeding. Make a note of the colour of the body, legs, and gnathosoma of the adult females, males and nymphs. The specimens will lose their colour in ethanol. Spider mites can be stored indefinitely in 70-80% ethanol or in Koenike's Fluid. Mites tend to become hard and brittle in ethanol, and Koenike's Fluid helps keep specimens soft over time. This medium is prepared as follows:

Glacial acetic acid	10 parts
Glycerine	50 parts
Distilled water	40 parts

Equipment

Your laboratory must have:

- Good quality card/paper for labels
- Sticky labels for slides
- Pens (Uniball or Rotring/Staedler) for labels
- Fine marker pens for writing on slides (e.g., Sharpies)
- An oven set at 40-50 ˚C
- Glass microscope slides
- Coverslips of #0 thickness (12 or 16 mm diameter are good)
- An area where humidity is kept at less than 50%
- Microscope storage boxes
- Glass pipettes
- Micro-dissection tools: mounted micropins, some fashioned into a tiny loop
- Glass excavated blocks and covers
- Fine forceps
- Hot plate for warming slides

Clearing

Mites need to be cleared before mounting for microscopic examination. The best media are based on chloral hydrate, which can be difficult to obtain. Here we recommend two types of media:

1. Nesbitt's fluid:

Chloral hydrate	40 grams
Distilled water	25 ml
Concentrated HCl	2.5 ml

Some acarologists think Nesbitt's causes legs to curl and prefer to use Kono's Fluid. We have achieved satisfactory results with both media.

2. Kono's fluid:

Chloral hydrate	100 grams
Glycerine	10 grams
Concentrated HCl	1 ml
Distilled water	50 ml

Both of these clearing media work rapidly. Spider mites will clear in as little as 20 minutes, depending on how large the mites are. These clearing agents sometimes do not remove plant dyes and other pigments from within the mite.

To clear specimens, place a few drops of clearing fluid into an excavated block. Transfer your mites from 80% ethanol, using a mounted micropin or hook. Alternatively, you can place your mites, in 80% ethanol, into an excavated block and carefully pipette out the ethanol; then add the clearing fluid. Place a glass cover over the top, and label the cover with the collection details and the number of mites you put in. Placing the block of clearing fluid into an oven at 40 ˚C will dramatically speed up clearing time, but be careful, you might make them disappear! We tend to place only old and hence

difficult-to-clear mites into the oven. If fresh specimens are cleared in this manner, it may take only 10 minutes for them to clear and become nothing but glass shells.

Mounting

Spider mites should be mounted on glass slides under #0 coverslips. Although expensive, #0 coverslips are necessary for examination under x100 oil immersion. Oil immersion is essential for the diagnosis of spider mites.

Mounting media for mites are largely unsatisfactory. Permanent mounts made with Canada Balsam lack the low refractive index (RI) required to distinguish species. Euparol mounts tend to result in distortion or damage to specimens. The most popular medium for mounting mites is Hoyer's medium, a gum-arabic based media. This medium is easy to use and has excellent optical properties, but mounts are not permanent. A well-made slide will last for several decades, but a poor slide will spoil in as little as five years. Recently, new formulations of Heinze Polyvinyl alcohol have returned to favour, but our experience so far with these media is very poor. Our slides made with this medium have spoiled within five years. However, the experiences of other acarologists suggest that the quality of the Heinze media relies upon the quality of the Polyvinyl Alcohol (PVA) that is used in the formula. Apparently 71-30 Dupont PVA is the best.

Hoyer's medium comprises:

Distilled water	50 ml
Gum Arabic (amorphic)	30 g
Chloral hydrate	200 g
Glycerine	20 ml

The process for mounting spider mites is as follows:

Females and **Immature** life stages:

1. Place a small drop of Hoyer's medium in the centre of a slide. This should be enough to run just to the edge of the coverslip. You should, with practice, get a good feeling for how big the drop should be.

2. With your micro-tools, gently scoop a mite from the clearing fluid.

3. Place the mite into the centre of the drop. You should orient the mite so that it is dorsal side up and has its mouthparts are directed towards you. Push the mite through the drop of media so that it is resting on the glass; this helps the mite stay in place when you apply the coverslip.

4. With a pair of forceps, hold the coverslip so that it is just touching the edge of the drop and the glass slide is at a 45^0 angle to the slide, then, gently lower the coverslip down onto the drop.

5. Using the forceps, apply gentle pressure to the coverslip, as needed to spread the legs out.

6. With a fine marker, write the details of the collection on one side of the slide.

7. Hold the slide up so you are looking at its underside. On the bottom of the slide, put a ring around where the mite is located. This helps you locate the mite more easily when you put it under the slide microscope.

8. Repeat the above steps. You may wish to make some "squash mounts" by applying excessive pressure.

9. Put your slides onto a tray and into an oven set at between 45 and 50 ˚C. You should leave your slides in the oven for 2-4 weeks.

Males

Male mites are much trickier than females, but you must be able to make a good mount of a male to make a species diagnosis. Unlike females, male mites are mounted laterally for a view of the aedeagus.

1. With a mounted micropin, place a very tiny drop of Hoyer's medium on the centre of a slide.

2. With your micro-tools, transfer the male into the Hoyer's medium.

3. Orient the male on his side so that he faces left and his legs point away from you. It may take a little time to get him to sit in such a way that he doesn't roll over. You need to be careful at this stage because it's very important that you get a perfectly lateral view of the aedeagus. Some tips are: it can help if you spread the drop of Hoyer's out to form a thin layer, or to leave the drop for 5 minutes before you add the male, as this allows the drop to thicken a little, thus making it a little easier to keep the mite upright; it can also help if you clear the male for a little longer than you would the female so that he is quite soft and easier to manipulate; and lastly, it can also help if you try to squash him slightly once you get him lateral on the slide.

4. Gently move the slide onto the hot plate. Leave the slide on the plate for about 5 minutes and then check if he has rolled over. If so, adjust him and put the slide back on the hot plate for another 5-10 minutes. You need the Hoyer's medium to thicken, but you do not want the mite to dry out as this will distort the specimen. Some hours practice with a common species is advisable.

5. Apply a small drop of Hoyer's medium to the slide, on top of the male mite, as you do in Step 1 for making female/immature specimens.

6. With a pair of forceps, hold the coverslip so that it is just touching the edge of the drop and the glass slide at a 45^0 angle to the slide, then gently lower the coverslip down onto the drop.

7. You may apply pressure to spread the legs out and make the aedeagus pop out of the body. You can look at the mite under high-dry magnification (x40 objective) to get an idea of how the aedeagus is looking. Apply more pressure if necessary. Be careful not to get Hoyer's medium onto the objective lens!

8. With a fine marker, write the details of the collection on one side of the slide.

9. Hold the slide up so you are looking at its underside. On the bottom of the slide, put a ring around where the mite is located. This helps you locate the mite more easily when you put it under the slide microscope.

10. Put your slides onto a tray and into an oven set at between 45 and 50 ˚C. You should leave your slides in the oven for 2-4 weeks.

You can look at your specimens under high-dry (x40 objective) while they are still wet, but you must wait until the Hoyer's medium dries before you examine them under oil immersion (x100). Most genera and some very distinctive *Tetranychus* can be identified at x40 (e.g., *T. fijiensis*), but most species need to be examined at x100 for accurate diagnosis. To keep your slides for the long term, put one or two coats of Isonel or Glyptal around the edge of the coverslip and keep slides in a 40-50% humidity environment.

Morphology of spider mites

Understanding mite morphology can be daunting, but it's essential to have a good understanding of the characters used in these keys and descriptions. The most important characters are the body setae, striae and lobes, the tarsal morphology, and the male aedeagus. These characters are dealt with in the "spider mite primer" below.

General morphology: Most simply, a mite's body comprises six (larvae) or eight (nymphs and adults) pairs of legs, a "head" region called the *gnathosoma* and a "body" called the *idiosoma* (Photo: Male *Tetranychus* in lateral view).

Legs: The legs have six segments and in spider mites, five of these are visible. The *coxa* is fused to the body, so the first complete segment that can be seen is the *trochanter*. From the body outwards, the remaining segments are the *femur*, *genu*, *tibia* and *tarsus* (Photo: Male *Tetranychus* in lateral view). At the tip of the tarsus is a claw and several hairs, which together are called the *pretarsus* (Figure, female tarsus I, below).

Tarsi: The tarsi have three types of setae: normal or *tactile* setae, which are the most common; and *solenidia* and *eupathidia*, which are sensory setae and are fewer in number (Figure: female tarsus I, below). Tactile setae are solid and appear dark, are usually hair-like with a tapered tip, and can have a rough texture due to being lightly to heavily barbed. Sensory setae are hollow, have

a transparent appearance and have a blunt tip. Eupathidia are found distally on tarsus I and II but are absent from tarsus III and IV, and are of no taxonomic significance. Solenidia can be distinguished from eupathidia in that they have a ribbed texture along their entire length. Solenidia can be found in various combinations on all tarsi and on all stages of spider mites, and often on tibia I and rarely on other leg segments. Mites in the genus *Tetranychus* have solenidia on tarsi I-IV and tibia I.

Duplex setae are unique to spider mites, and comprise a small tactile seta, called a companion seta, and a solenidion, which have their setal bases coalesced. Duplex setae are important taxonomic characters for spider mite diagnoses. In the genus *Tetranychus*, tarsus I has two pairs of duplex setae, tarsus II has one pair, but neither tarsus III or IV have any. This combination varies between genera of spider mites, although no spider mite has duplex setae on either tarsus III or IV.

Pretarsi: A good lateral view of the pretarsus is required for identifications, and usually the empodia of legs III or IV give the best view. Be aware that sometimes only one half of the paired structures are visible, and in drawings only one half of the paired structures are drawn. For example, in the figure below, two tenent hairs and three proximoventral hairs are drawn, but the specimen has four tenent hairs and six proximoventral hairs.

The structure of the pretarsus is extremely important in spider mite taxonomy. Unfortunately, the morphology is so variable that interpreting these structures can be confusing. Most simply, the pretarsus comprises a pair of true *lateral claws* and a medial *empodium* (Figures 1-8 in key to genera). However, these are variously modified, and the trick to remember is, *no matter what they look like,* the two outer structures are lateral claws and the middle structure, *no matter what it looks like*, is the empodium. For example, in spider mites either or both the lateral claws and empodium can be claw-like (*uncinate*).

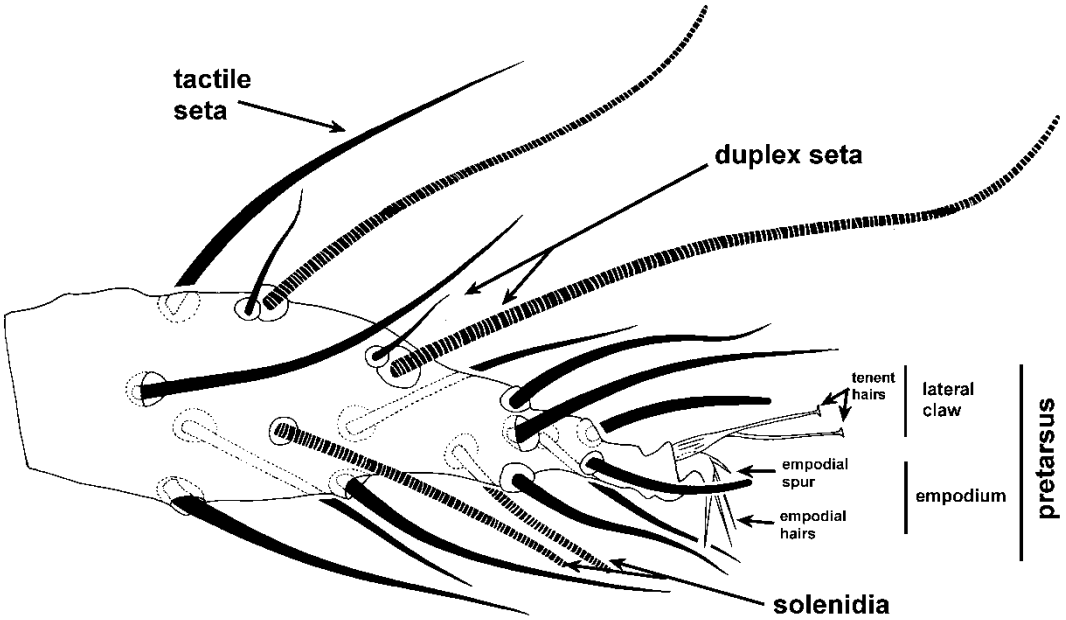
Tenent hairs are small, usually paired hairs that end in a “T” shape. The lateral claws and empodium can possess tenent hairs. To make things tricky, the lateral claws and empodium can also look like tenent hairs. For example, in the figure below the lateral claws are reduced to small pads each with a pair of tenent hairs - so that they look just like a pair of tenent hairs alone. Remember that, despite being nothing like a claw, the outer structures are still called the lateral claws.

The empodium can also have *proximoventral hairs*, which are fine branches of the empodium. They can be distinguished from tenent hairs by the lack of the “T”-shaped tip. Also, the empodium may have an *empodial spur*, which arises dorsally to the proximoventral hairs (Fig. 4 in key to genera), and probably represents a reduced uncinate empodium, such as the uncinate empodium of *Oligonychus* (Fig. 8 in key to genera).

The morphology of the pretarsus of legs I to IV in the female are generally the same. In male mites, the morphology of the pretarsus on legs I, and sometimes leg II, is usually different from the pretarsus of the other legs. In

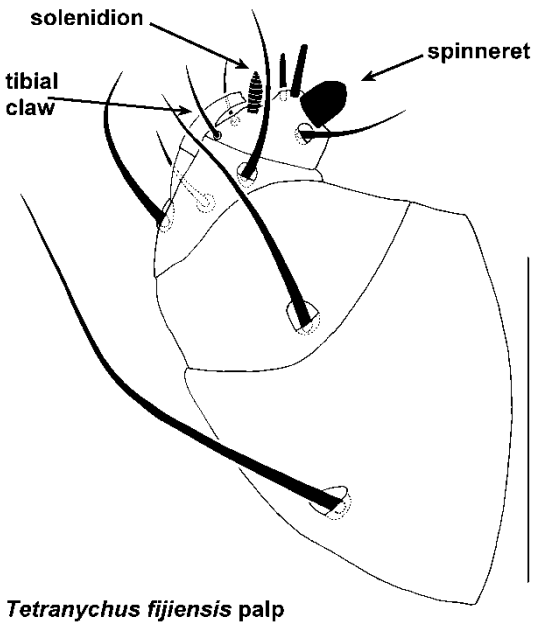
such cases, the proximoventral hairs of pretarsus I (and sometimes II) have fused into an *empodial claw*.

In the genus *Tetranychus*, the lateral claws are each reduced to a pair of tenent hairs and are never uncinate (claw-like). The empodium always has proximoventral hairs (usually three pairs) and is uncinate only on male pretarsus I and sometimes male pretarsus II, and the occasional species such as *T. bunda* where the empodial spur is exceptionally large.



<u>*Gnathosoma*</u>:
The *gnathosoma* comprises the small leg-like *palps* and a capsule (stylopore) that contains the mouthparts or *chelicerae*. The fused coxae of the palps form the basal capsule that houses the chelicerae. The most apparent features of the palp are a conspicuous tibial claw or 'thumb claw' and the tarsal 'thumb' (Figure: *Tetranychus fijiensis* palp, below). The tarsal 'thumb' is the sensory part of the palp, with 3 tactile setae, 3 eupathidia and 1 solenidion. One eupathidion is modified into the silk-producing spinneret, which was called a sensillum in the older literature. The dimensions of these modified setae have been used in the past to distinguish species, but we have found them to be of little use.

In spider mites the chelicerae are J-shaped needles which are used to puncture plant cells. Although the chelicerae of *Tetranychus* are not useful for distinguishing species, **the shape of these conspicuous chelicerae is used to distinguish the spider mite superfamily (Tetranychoidea) from all other mites**. Once you learn where to look for this distinguishing feature, you can spot spider mites and their relatives straight away.



***Tetranychus fijiensis* palp**

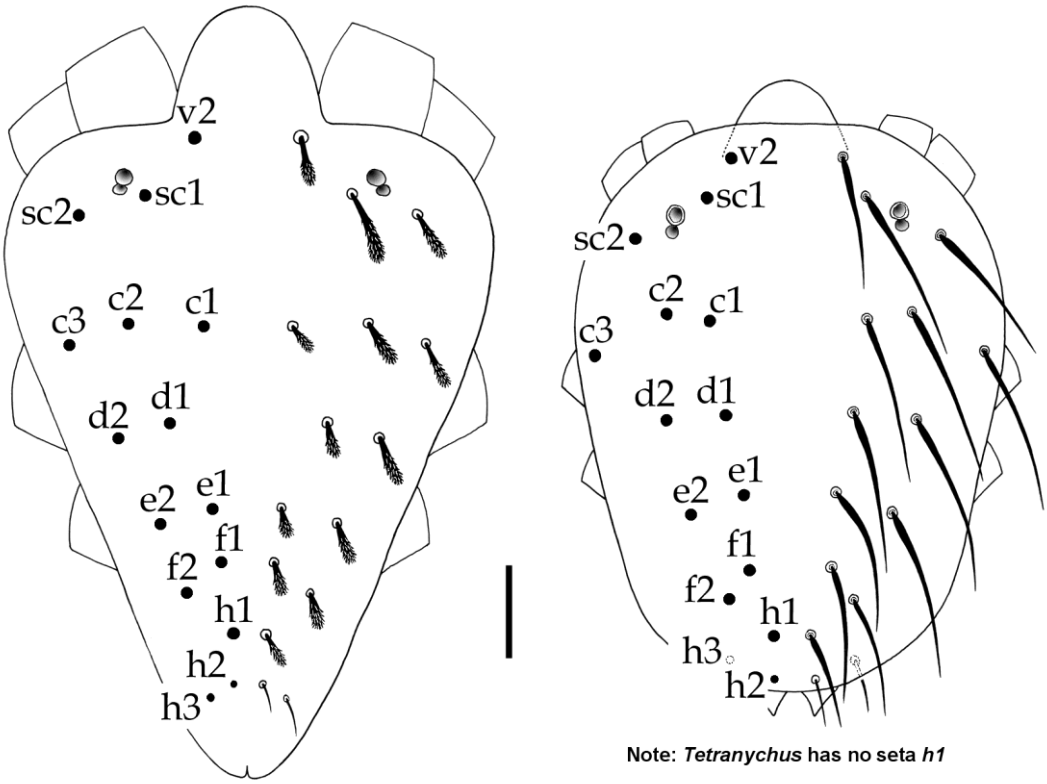
Body setae

The entire body is called the *idiosoma* and is split into two sections: the anterior *propodosoma* and the posterior *hysterosoma*. The split between these sections is not obvious, but is at the level between legs II and III. On the dorsum, the pattern of striae changes between the propodosoma and hysterosoma. A distinction between the front and rear-body is also sometimes used: the part of the body with the legs is the *prosoma* and the remaining posterior section is the *opisthosoma*.

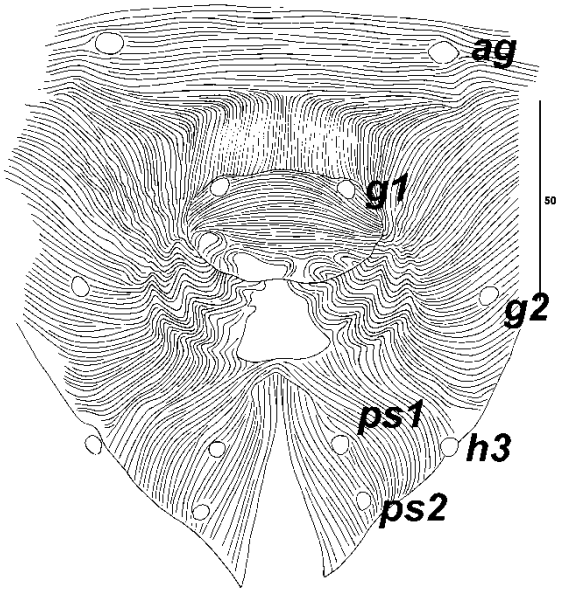
Each of the body setae has a letter and a number. On the dorsum, the letter refers to a setal "row" and the number to a setal "column". This system was developed to standardise the setal names across the acariform mites. Older literature uses a different system, one that is confusing and not based on homologies (see Helle and Sabelis Vol 1A pp. 8-9). The propodosoma of spider mites has three or four setae: *v1* (variable; absent in *Tetranychus*), *v2, sc1* and *sc2.* On the hysterosoma, the setal rows are *c, d, e, f* and *h* (Photo: (Photo: *Tetranychus* dorsum). There are 3 *c,* 2 *d*, 2 *e* and 2 *f* setae. Seta *h1* tends to be terminal, while *h2* and *h3* tend to be ventral and near the anus. In *Tetranychus* there are just two pairs of *h* setae, *h2* and *h3*. The anus has two pairs of setae (*ps1* and *ps2*) and the genital region has two pairs called *g1* and *g2*. Setae *g1* are on the genital flap. Setae *ag* lie between the genital region and the fourth pair of legs (Photo: *Tetranychus* venter).

Apart from the posterior setae in the anal/genital region, the ventral setae are consistently present. In adult *Tetranychus*, down the midline between the coxae you will see three pairs of setae: *1a* (between coxae I & II), *3a* (between coxae III), and *4a* (between coxae IV). Coxae I and II each have 2 pairs of setae, *1b*, *1c* and *2b*, *2c*, respectively, whereas coxae III and IV each have only one seta, *3b* and *4b* respectively (Photo: *Tetranychus* venter).

Body setae are useful for distinguishing genera, but we have found no useful body setae characters to distinguish species of *Tetranychus*, as the genus chaetotaxy appears consistent.



Note: *Tetranychus* has no seta *h1*



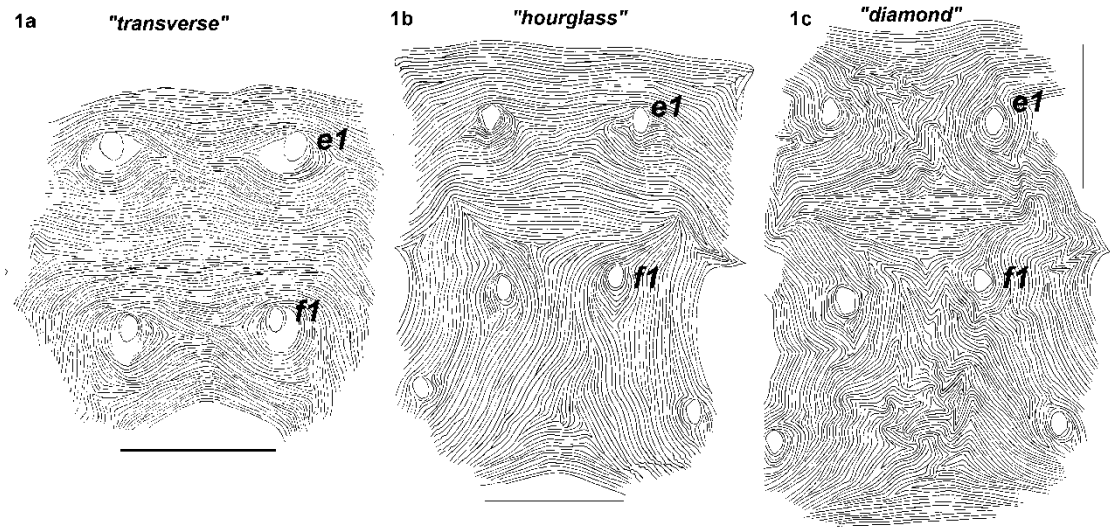
Striae and lobes

The integument of spider mites is covered with fine fingerprint-like striae. On female mites the pattern of these striae between dorsal setal pairs *e1* and *f1* has three major forms called "*entirely transverse*", "*hourglass-shaped*" and "*diamond-shaped*".

The "entirely transverse" pattern is literal: striae run transversely for the entire region between *e1-e1* to *f1-f1*. Sometimes the striae can be a little oblique, but they never run longitudinally (Figure 1a, below).

The "hourglass-shaped" pattern is more cryptic. Between setae *e1-e1* the striae are transverse, sometimes tending to oblique, but are not longitudinal. These transverse striae continue between *e1-e1* and *f1-f1*, but around the level of *f1-f1* they become strongly longitudinal. This pattern is somewhat reminiscent of an hourglass as it runs between setae *f1-f1* (Figure 1b, below).

The "diamond-shaped" pattern has longitudinal or oblique striae between setae *e1-e1* and between *f1-f1*, but within the *e1-f1* region is a large area of transverse striae. The shape of these transverse striae is roughly that of a diamond (Figure 1c, below).



The striae of most female *Tetranychus* (and males of a couple of species) comprise many tiny *lobes*, formed by regular incisions in the ridges of cuticle that make the striae. The shape of these lobes may be species specific, but we have avoided this characteristic here. Lobes are extremely tiny, their density and form is subject to variation according to the conditions the spider mite experienced during its life, and their form is also variable according to what part of the mite is examined and how the slide was prepared. However, the distribution of lobes on the body is significant. Some species are entirely without lobes, some have no lobes on the venter, and some have lobes extending variable distances from the venter up through the intercoxal region of the mite. Examples of lobes are: lobe-less striae (Photo: *T. lintearius*), few lobes on striae (Photo: *T. bunda* venter) and strongly-lobed striae (Photo: *T. gloveri* venter).

Distinguishing life stages and sexes

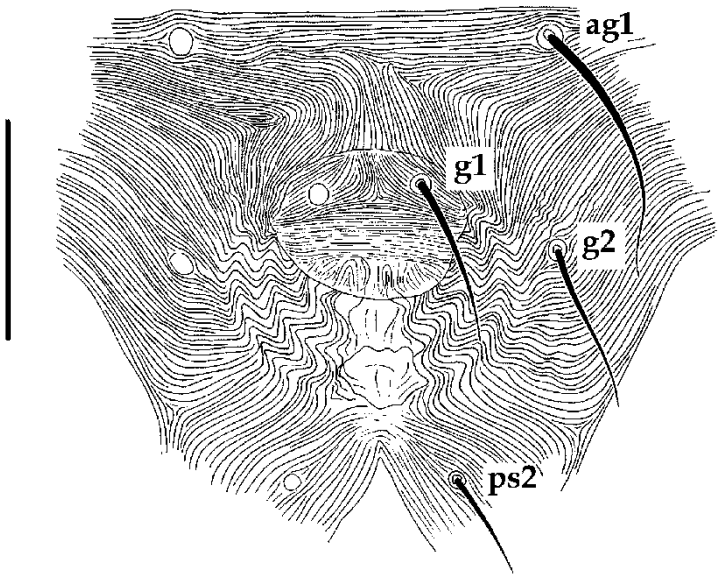
Larvae

Like most mites, larvae have just three pairs of legs. Larvae are small and often pale-coloured (Video 1, small mite top left).

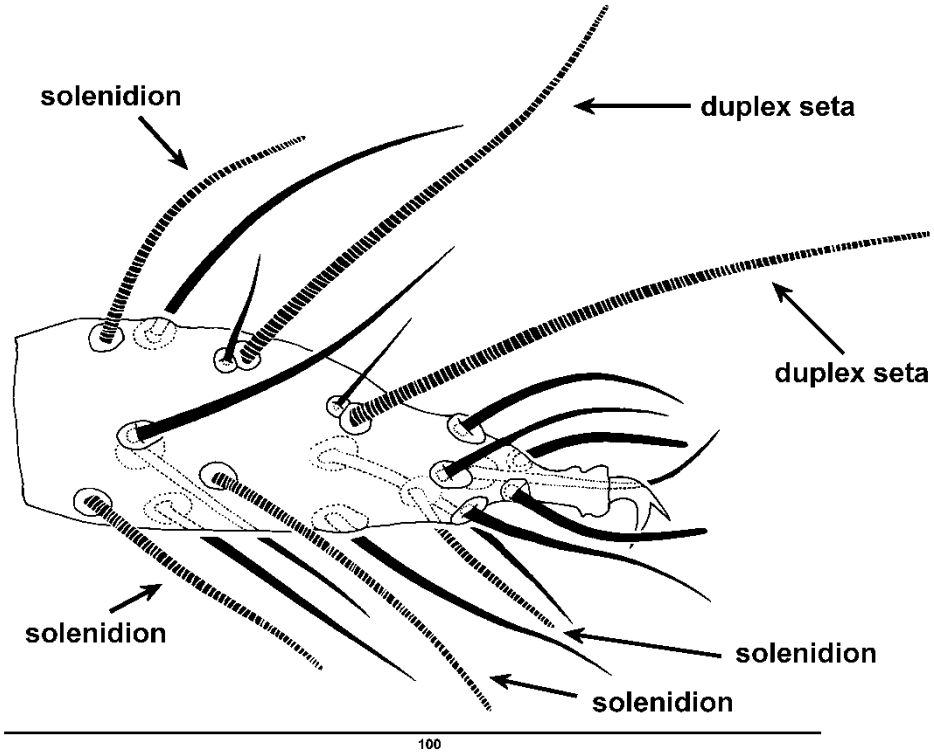
Nymphs and adults

Spider mites have two nymphal stages, the protonymph and deutonymph, and three quiescent (resting) stages, one each between the larva and protonymph, protonymph and deutonymph, and deutonymph and adult.

The adult female has an obvious genital area comprising many tight, wavy striae (Figure below; Photo: Deutonymph compared with female). Under the stereomicroscope, females are larger, plumper and often a different colour to nymphal mites (Video 2). Nevertheless, newly moulted females can look similar to mature deutonymphs. Spider mites overwinter as eggs or adult females; *Tetranychus* overwinter as adult females. Overwintering females are red to dark orange, making them appear strikingly different in species that are yellow-green during warmer months.

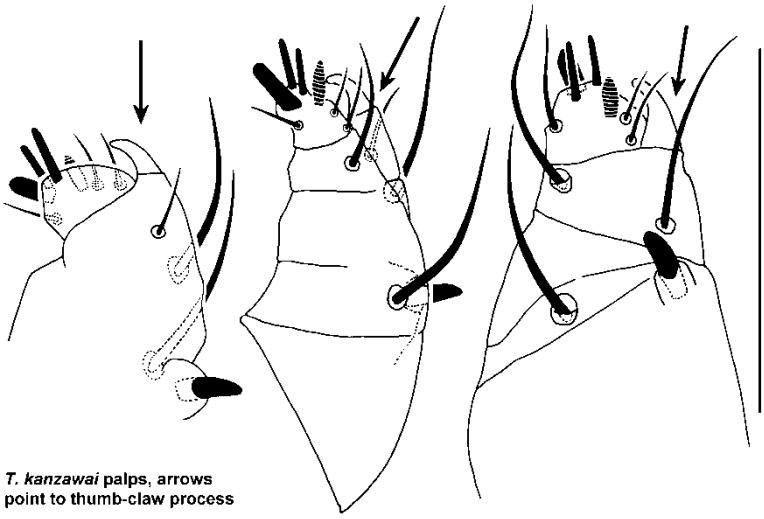


The adult male has an aedeagus (Photo: lateral view of male), a short blunt spur on the dorsal surface of the palp femur and a distinct leg-setal morphology; the most obvious is tarsus I, which has 4 solenidia (Figure below). The proximoventral hairs on empodium I are always fused into a claw. Under the stereomicroscope, males are smaller than females, often yellow to pale green in colour, have bodies that taper posteriorly to a blunt point, are often fast-moving, and can be seen guarding quiescent deutonymphs (Video 3: male guarding).



Distinguishing the Tetranychidae from other mites

The Tetranychidae belongs to the superfamily Tetranychoidea, a group distinguished by the morphology of the mouthparts. All tetranychoids have a distinctive stylophore (the capsule containing the mouthparts) containing a pair of recurved, long, whip-like chelicerae (Photo: Bryobiinae and Tetranychinae). These J-shaped chelicerae distinguish tetranychoids from all other mites. Of the tetranychoids, the Tetranychidae can be distinguished by the combination of a palp thumb-claw structure (figured below), lateral prodorsal eyes (Photo: Bryobiinae and Tetranychinae), and the absence of long filamentous setae on the posterior of the mite (Photo: Tetranychinae).



T. kanzawai palps, arrows point to thumb-claw process

Distinguishing *Tetranychus* from other Tetranychidae

The family Tetranychidae is split into two subfamilies, the Bryobiinae and Tetranychinae, with *Tetranychus* belonging to the latter subfamily. The subfamilies are distinguished by the form of the empodia in the female mite: only the Bryobiinae have tenent hairs on the empodium (Figs 1 and 2, below). In the Tetranychinae, the tenent hairs are not associated with the empodium. In the Tetranychinae the empodium can be absent (Fig. 3), claw-like (Figs 5-6), comprising only of fine hairs (empodial or proximoventral hairs) (Fig. 7), a claw with basal fine hairs (empodial or proximoventral hairs) (Fig. 8), or it can have a dorsal spur, as in Fig. 4. *Tetranychus* tends to have an empodium consisting of proximoventral hairs with or without a dorsal spur (Fig. 7), except for the male empodium I (and sometimes II) where it is claw-like (Fig. 6). The dorsal spur on the empodium of *Tetranychus* is absent to large in different species, and is a useful diagnostic character.

After determining the structure of the empodium, the next step is to look for dorsal seta *h1*. The setae on the hysterosoma of spider mites are arranged loosely in rows *c, d, e*, *f* and *h*. Rows *c, d* and *e* form clearly transverse rows, but those of *f* and *h* are curved (Figs 9, 10). Row *h* is curved so much that setae *h3*, and sometimes *h2*, are placed on the ventral side of the mite (Fig. 10). When determining if *h1* is present, start at row *c* and count through the rows until you reach setal row *h*. If setae *h1* are present, they will be inserted in the next setal row behind and in line with *f1*. Setae *h1* when present tend to be the same morphology as the other dorsal setae, whereas setae *h2* and *h3* are shorter and thinner than *h1*, and are inserted more laterally (and/or ventrally) than *h1* (Figure 9). Setae *h2* and *h3* tend to be lateral of the anus (Fig. 11). Be sure to identify the anal setae (*ps1* and *ps2*, on the anal valves) the genital setae, *g1* and *g2*, which are on the genital plate and flanking the genital region, respectively (Fig. 11). All *Tetranychus* have only two pairs of *h* seta, *h2* and *h3*, and only the two genera *Tetranychus* and *Amphitetranychus* have empodia comprising just fine hairs (Fig. 7) <u>and</u> *h1* absent. These two genera can be distinguished by their peritremes: in *Tetranychus* they are hook-like (Fig. 12), but in *Amphitetranychus* they are anastomosing (branching). *Amphitetranychus* is absent in Australia and contains the economically-important species *A. viennensis* (Zacher).

Simple key to distinguish *Tetranychus* from other tetranychids

1 **Female:** Empodia II-IV with tenent hairs (Bryobiinae) (Figs 1, 2) *OR* empodia II-IV absent (Fig. 3), *OR* claw-like (Figs 4, 5, 6) .....**Not *Tetranychus***

\- **Female:** Empodia II-IV claw-like with fine proximoventral hairs at its base (Fig. 8) *OR* comprised fine hairs only with or without dorsal spur (Fig. 7) 2

2 **Female:** Empodial claw as long as or longer than proximoventral hairs (Fig. 8) .....**Not *Tetranychus***

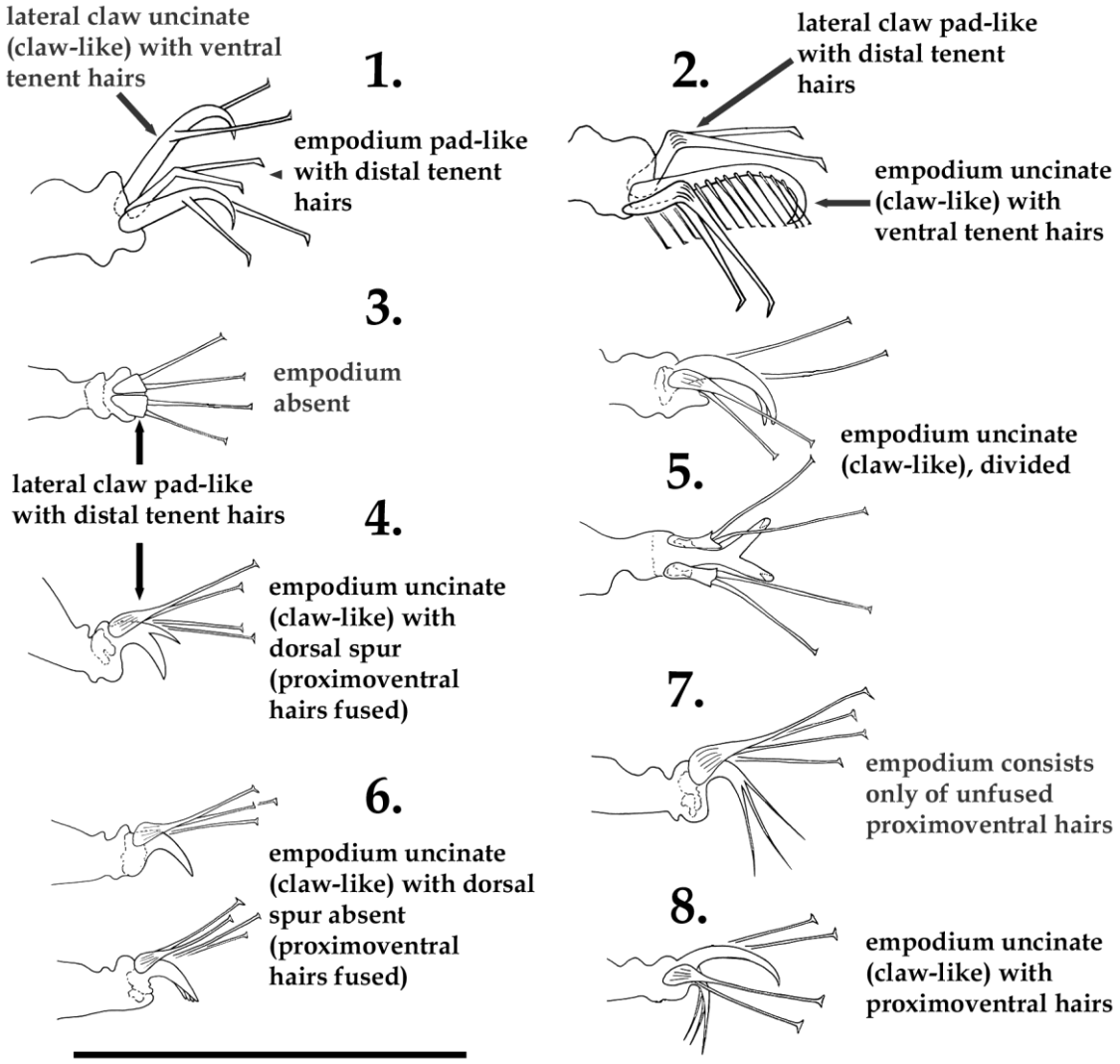
- **Female:** Empodium with proximoventral hairs only (Fig. 7) OR empodial claw when present only a short spur, usually much shorter than proximoventral hairs (note *T. bunda* has long dorsal spur, but it is shorter than proximoventral hairs) ..3

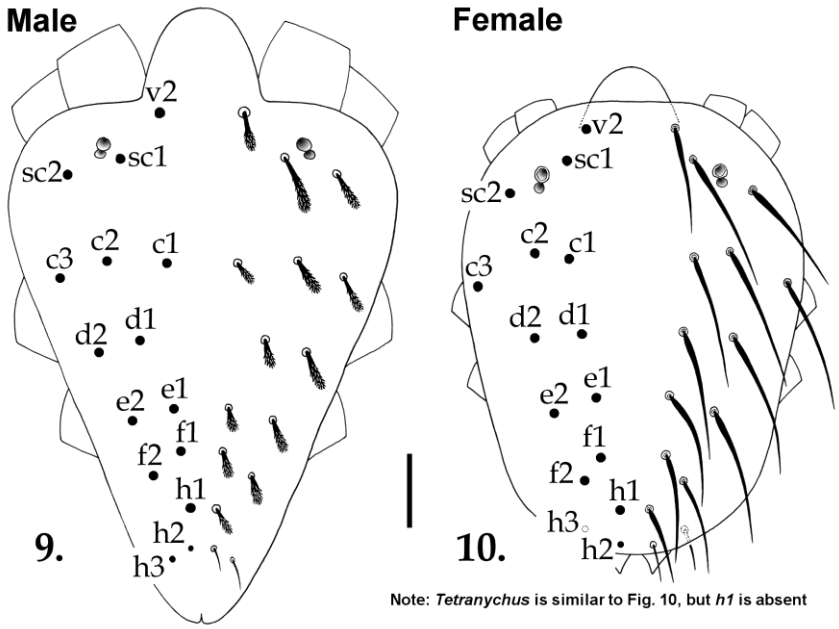
3 **Female:** 3 pairs of *h* setae (*h1*, *h2*, *h3*) (Figs 9, 10, 11).....**Not *Tetranychus***

- **Female:** 2 pairs of *h* setae (formerly called para-anal setae) (*h2*, *h3*) 4

4 **Female:** Peritreme hooked (Fig. 12).....***Tetranychus***

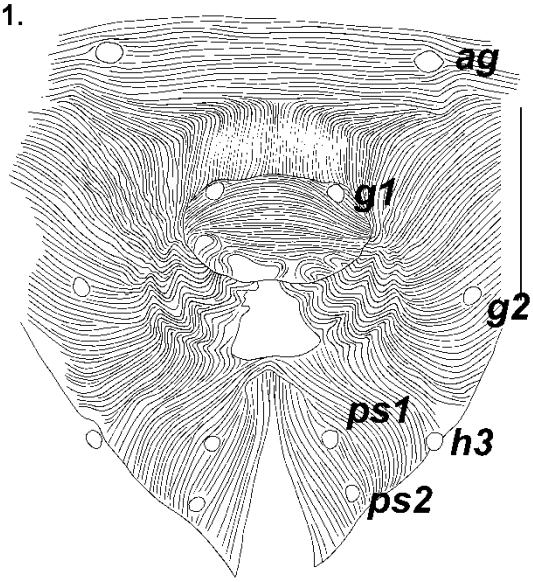
- **Female:** Peritreme anatomising (branching) ..... ***Amphitetranychus***





Note: *Tetranychus* is similar to Fig. 10, but *h1* is absent

11.



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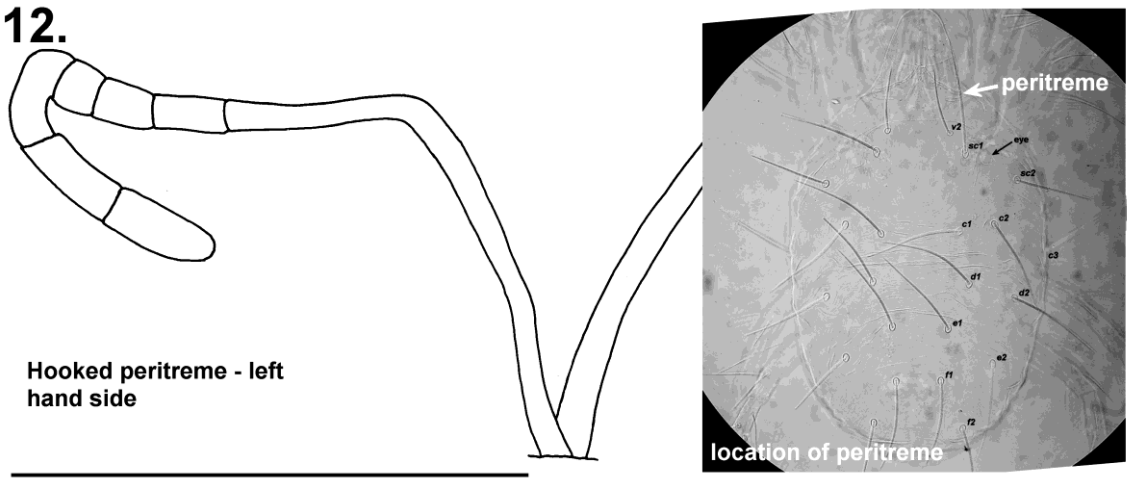


Hooked peritreme - left hand side

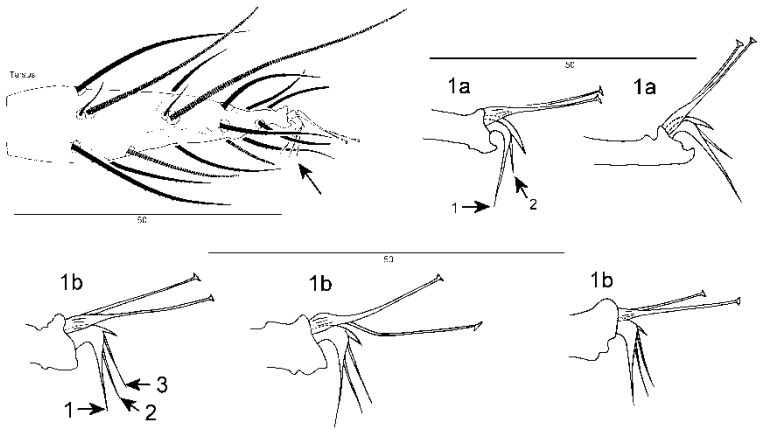
Key to the Genus *Tetranychus*: Naturalised Species and Exotic Species of Quarantine Concern to Australia.

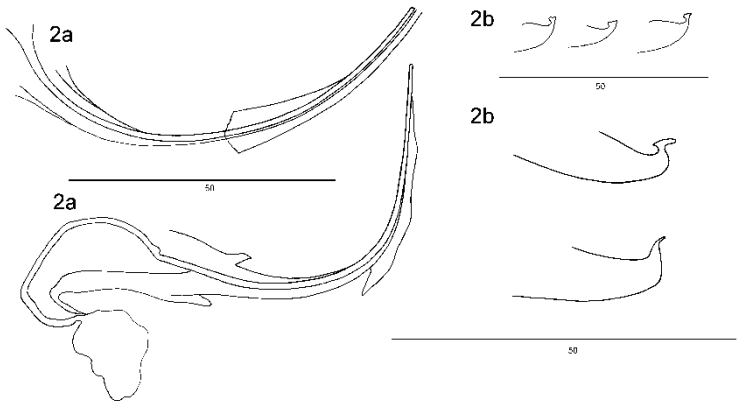
Female and male mites are required for this key. Male mites must be mounted laterally.

This key is a modification of several existing keys, notably Baker & Tuttle (1994) and Flechtmann and Knihinicki (2002). Species names in green are naturalised species, species in red are not known from Australia, with the exception of *T. fijiensis*, which may still be of concern to places outside of the Northern Territory.

1 **Female:** Empodia with 2 pairs of proximoventral hairs, the dorsal being much smaller than the ventral (1a). **Male:** aedeagus very long and tapered (2a) .... ***T. fijiensis***

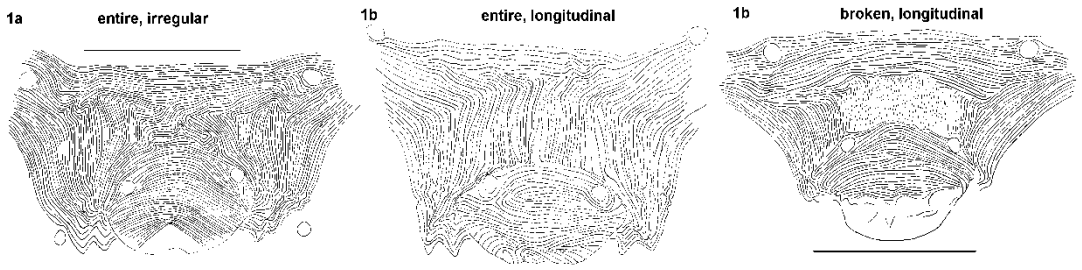
- **Female:** Empodia with 3 pairs of proximoventral hairs (1b). **Male:** aedeagus usually with an apical knob, if without apical knob then aedeagus not very long (2b) 2





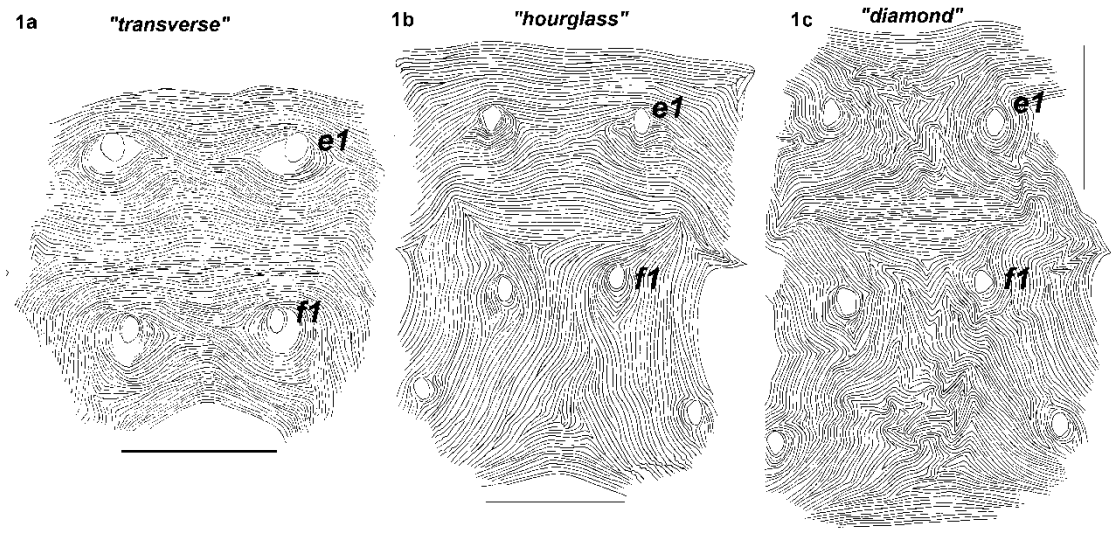
2 **Female:** Pregenital striae entire *and* irregular, comprising oblique and longitudinal sections (1a). Known only from *Rhagodia* (Chenopodiaceae) in Tasmania ..... ***T. rhagodiae***

- **Female:** Pregenital striae broken or entire, sometimes nearly absent medially, but comprising only longitudinal striae (1b) 3



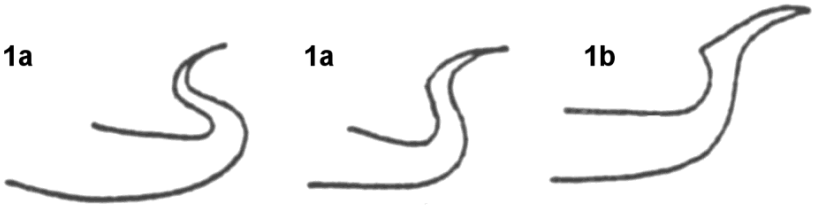
3 **Female:** Dorsal opisthosomal striae entirely transverse, no longitudinal striae present (1a) 4

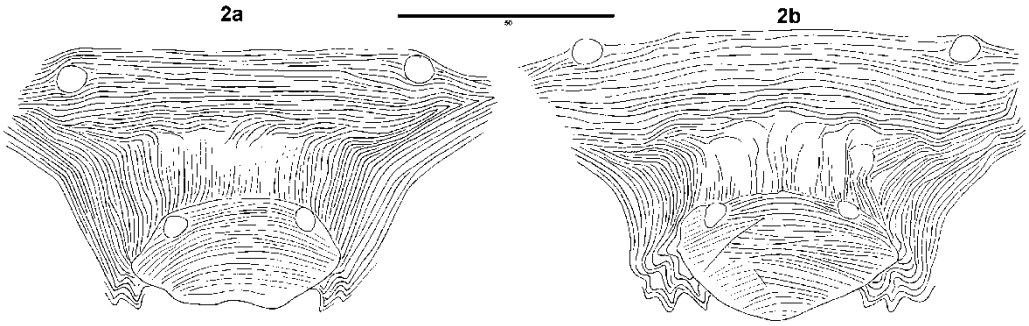
- **Female:** Dorsal opisthosomal striae with at least some longitudinal striae, usually between setae *f1-f1* and/or *e1-e1* (1b, 1c) 5



4 **Male:** Aedeagus strongly sigmoid, tapering strongly distally, without a distinct apical knob (1a). **Female:** Pregenital striae a mixture of broken and solid lines (2a); dorsal striae mostly without lobes.....***T. mcdanieli***

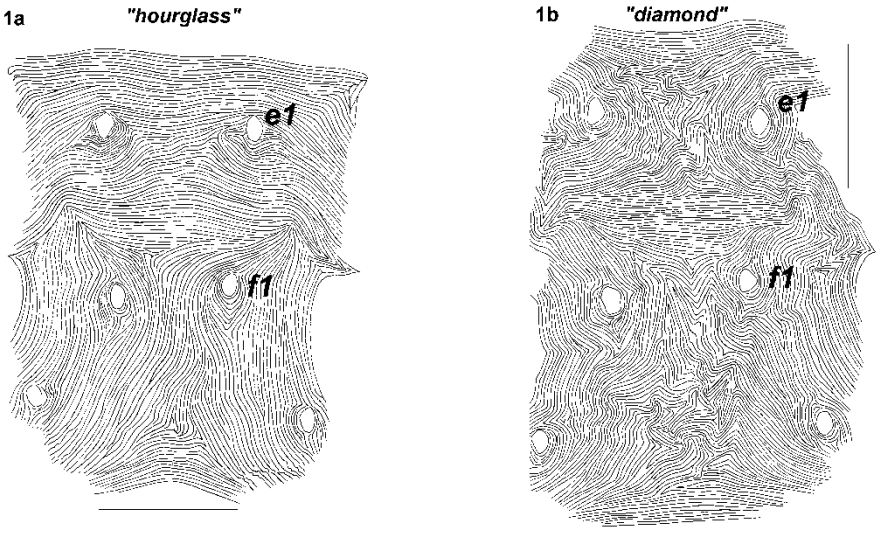
- **Male:** Aedeagus angular, with large tapered posterior projection, anterior projection small, angular (1b). **Female:** Pregenital striae irregular and vague (2b); dorsal striae with lobes .....***T. pacificus***





5 **Females:** Dorsal striae transverse between setae *e1-e1* and setae *e1-f1*, striae longitudinal between setae *f1-f1* (1a) .....*canadensis* species group, **6**

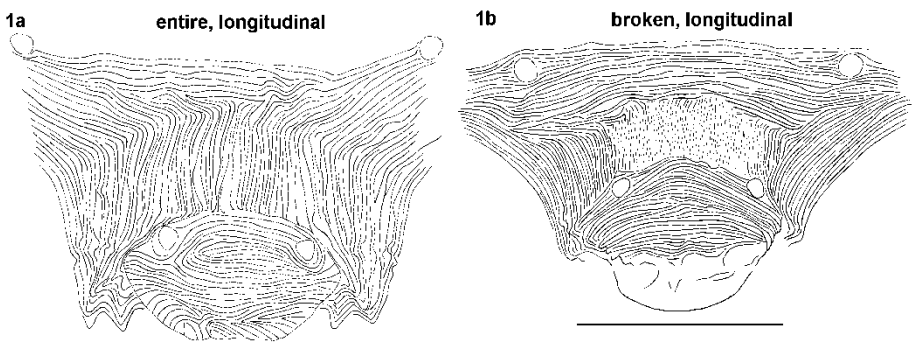
- **Females:** Dorsal striae longitudinal and/or oblique between setae *e1-e1* and between setae *f1-f1* (1b) 7



6.* **Females:** Pregenital striae unbroken solid longitudinal lines (1a) ....***T. canadensis***

- **Females:** Pregenital striae a mixture of broken and solid longitudinal lines (1b).... ..... ***T. schoenei***

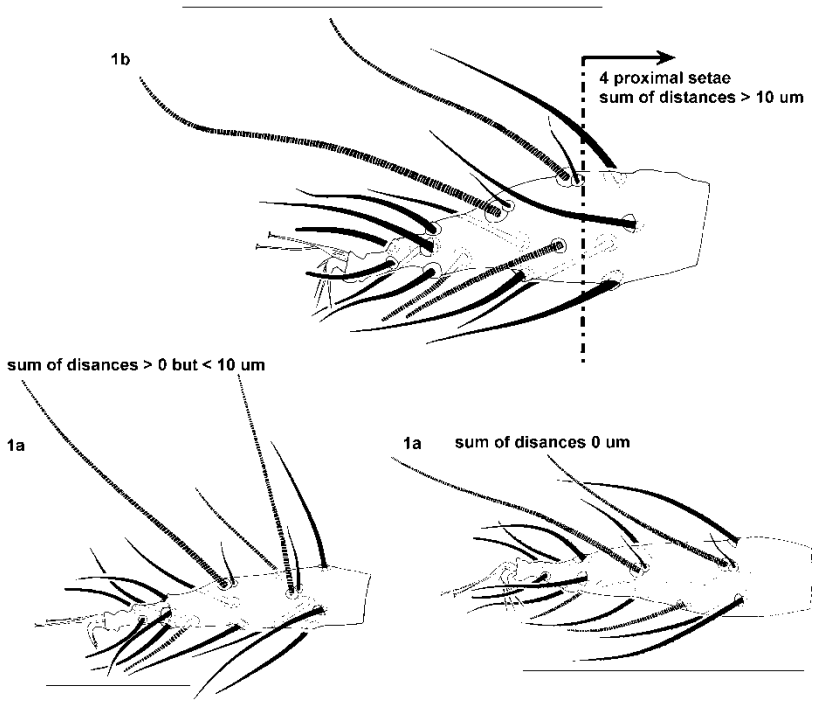
* Note: *T. lambi* may sometimes key to here if the dorsal striae were interpreted as hourglass-shaped. *T. lambi* has unbroken pregenital striae (often bearing lobes), the striae between *e1-e1* are irregular or oblique, and the aedeagus has a large posterior projection with a flat dorsal surface.



7 **Females:** Tarsus I with the additive distances between each of the proximal setae and the proximal pair of duplex setae < 10 µm*, the base of proximal pair of duplex setae overlapping with the bases of 2-5 (usually 3 or 4) proximal tactile setae (1a) **8**

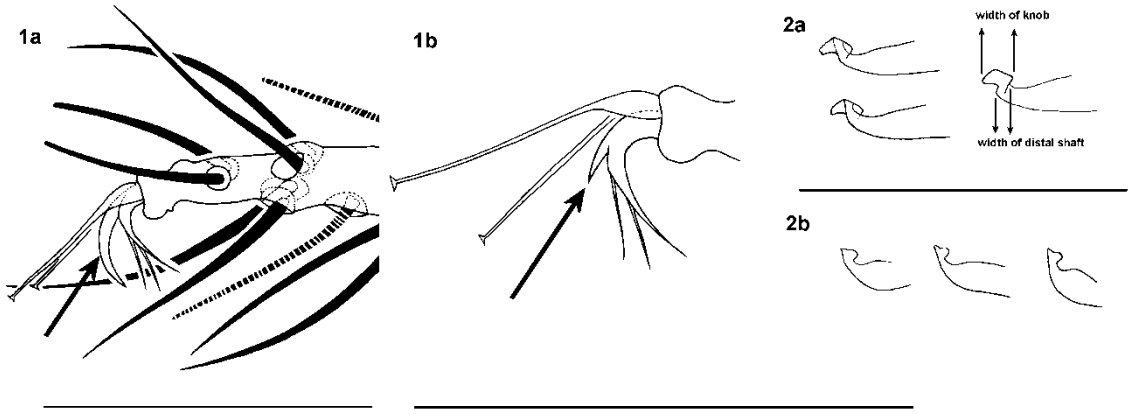
- **Females:** Tarsus I with the additive distances between each of the proximal setae and the proximal pair of duplex setae > 10 µm*, the base of proximal pair of duplex setae usually distal to the bases of 4 proximal tactile setae (1b), but some specimens may have 1-2 setae overlapping with base of proximal pair of duplex setae **13**

* Note: Some specimens exhibit variation in the number of proximal setae overlapping with the proximal duplex seta, and some may possess the male compliment of tarsal solenidia (up to 4 instead of 1). Where possible, examine several specimens and look at both left and right tarsi.



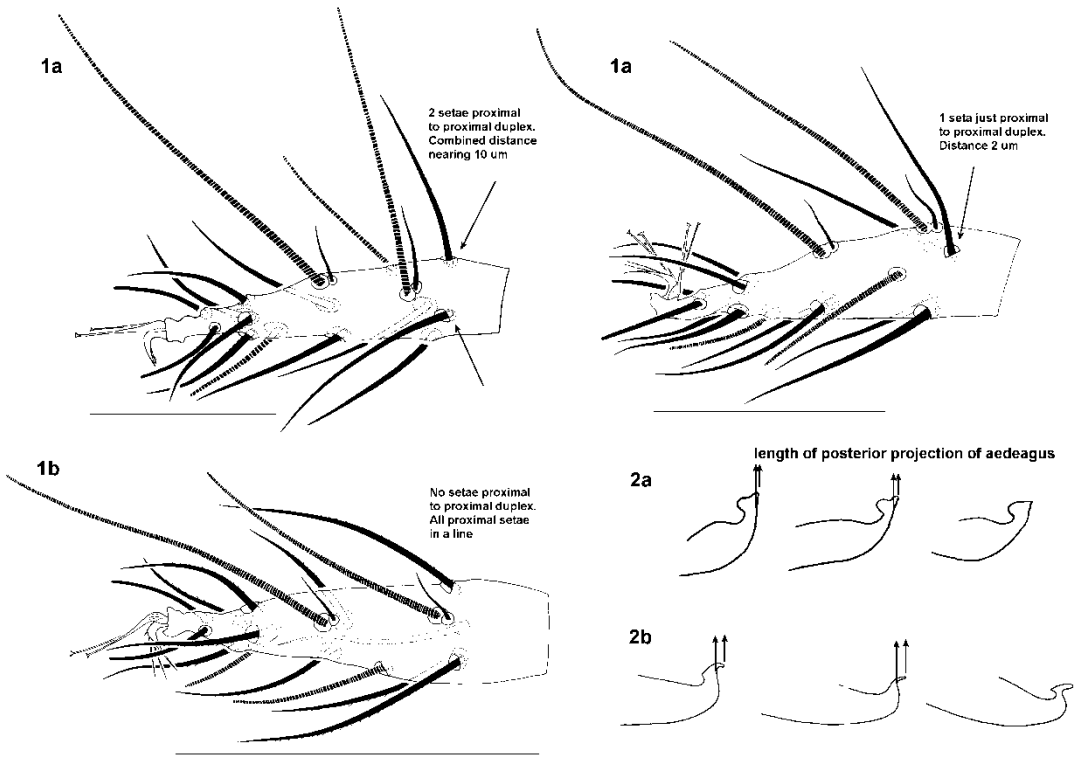
8 **Female:** Empodium of tarsus I with long (> 20 µm long) spur (1a); **Male:** Length of knob of aedeagus > 2x the width of the most distal part of the shaft (2a) .... ***T. bunda***

- **Female:** Empodium of tarsus I with small (< 5 µm long) spur (1a). **Male:** Length of knob of aedeagus variable, but knob of aedeagus < 2x width of the most distal part of the shaft (2b) **9**



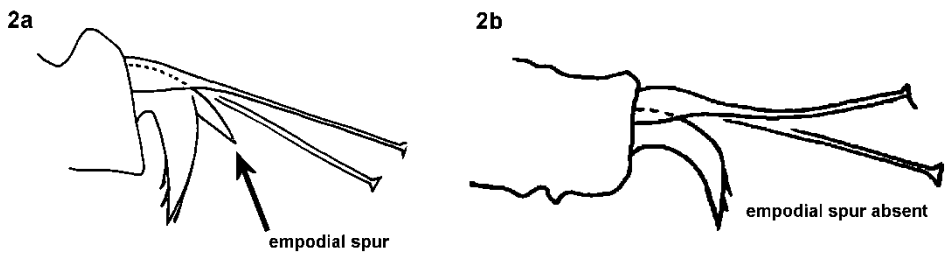
9 **Female:** Tarsus I with 1-2 tactile setae completely proximal to the proximal edge of the base of the proximal pair of duplex setae (1a), the additive distance of the proximal setae to the proximal pair of duplex setae 2-10 µm. Lobes present on ventral striae. **Male:** Posterior projection of aedeagus present, but length of aedeagus knob barely greater than the width of the most distal part of the shaft (2a) **10**

- **Female:** Tarsus I with no tactile setae completely proximal to the proximal edge of the base of proximal pair of duplex setae (1b). Lobes present or absent on ventral striae. **Male**: Posterior projection of aedeagus absent *OR* when present the length of aedeagus knob much greater than width of most distal part of the shaft, and knob directed dorsally or bent sharply downwards (2b)..... ..... *desertorum* species group **11**



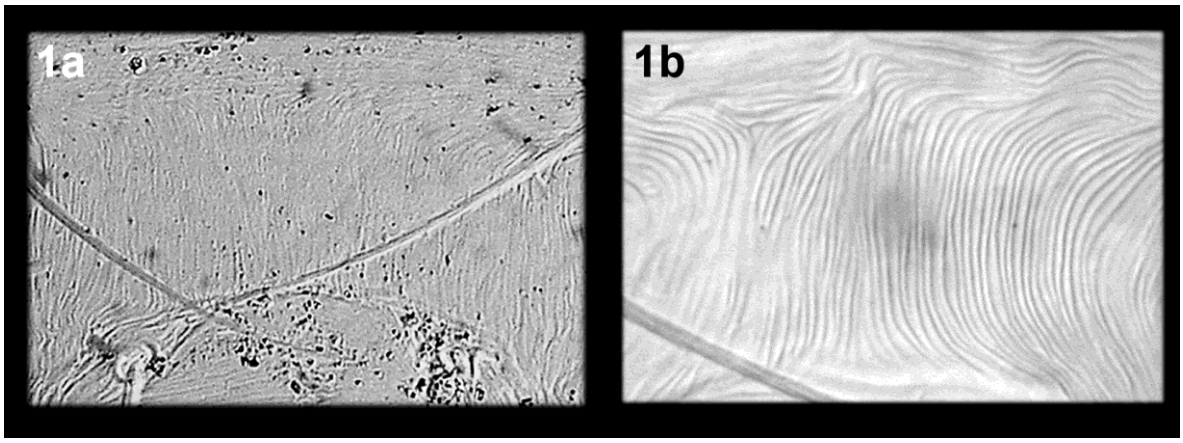
10 **Female:** Base of most proximal tactile seta on tarsus I just proximal to the proximal duplex seta (ca. 2 µm), other 3 proximal tactile setae clearly overlapping with duplex seta (see Couplet 9, Fig. 1a, RHS). Lobes on ventral striae between genital area and setae *1a*. **Male:** All empodia with large (4 µm) dorsal spurs (2a) ..... ***T. macfarlanei***

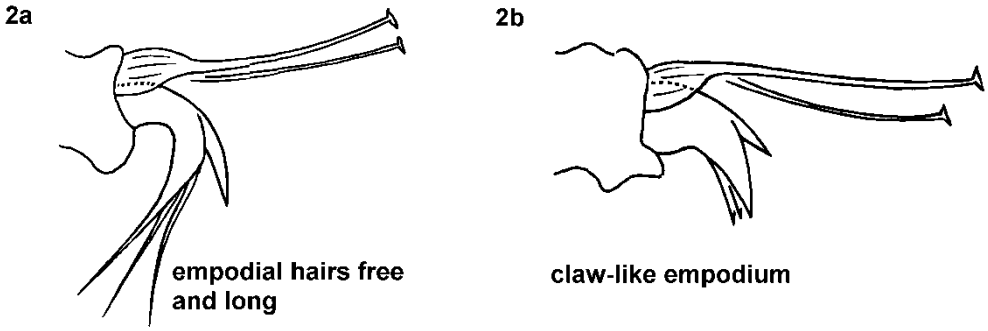
- **Female:** Base of most proximal tactile seta on tarsus I 5-7 µm from the proximal edge of the proximal duplex seta, the bases of the other 3 proximal tactile setae just overlapping or just proximal to the proximal edge of the proximal duplex seta (see Couplet 9, Fig. 1a, LHS). Lobes on ventral striae only between genital region and setae *4a*. **Male:** All empodia with small (2 µm) spurs or spurs absent (2b)..... ..... ***T. yusti***

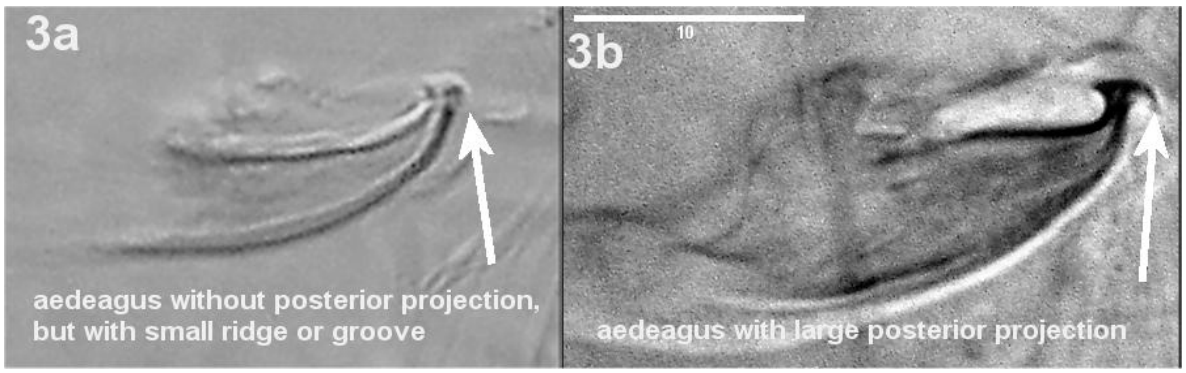


11 **Female:** Pregenital striae broken anteromedially (1a). Lobes present on ventral striae, extending at least to setae *2a*. **Male:** Empodia II with long, thin hairs, unlike empodia I, similar to empodia III-IV (2a). Aedeagus with knob directed anteriorly, dorsal groove, and posterior margin smoothly curved/rounded and posterior projection absent (3a)..... ***T. ludeni***

- **Female:** Pregenital striae entire (1b), but may be sparse medially with small breaks. Lobes absent on ventral striae. **Male:** Empodia II claw-like with stout hairs, like empodia I, different from empodia III-IV (2b). Posterior projection of aedeagus present (3b) **12**

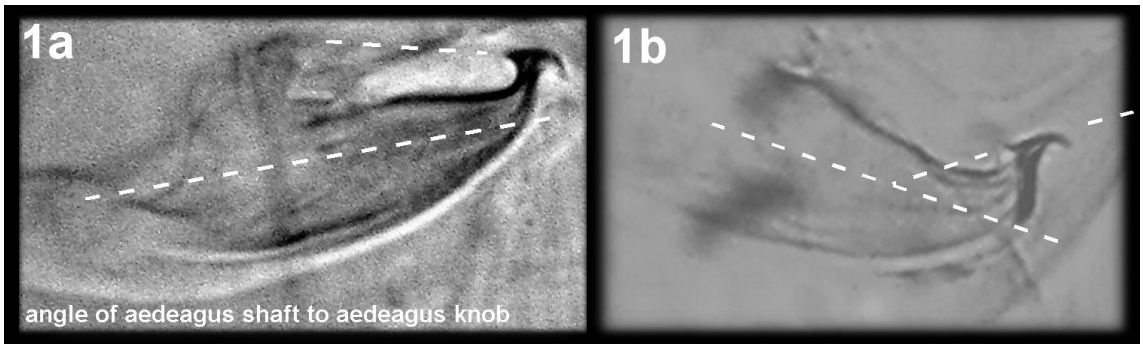






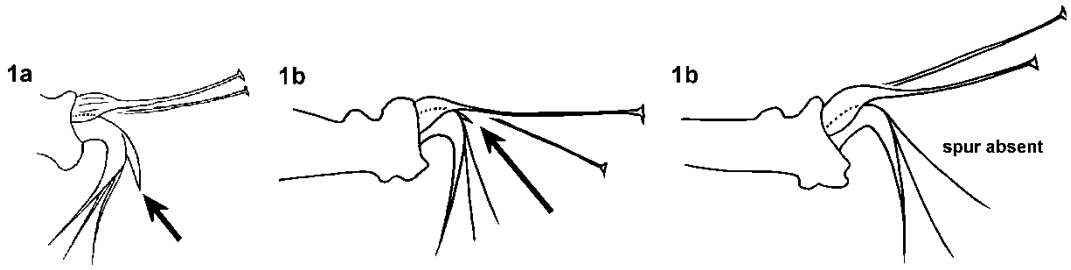
12 **Male:** Knob of aedeagus with axis parallel or at slight angle to that of the main shaft; posterior projection of aedeagus a large sharp hook, bent downwards (1a). **Female:** Pregenital striae entire and dense laterally and medially ... ***T. desertorum***

- **Male:** Knob of aedeagus directed dorsally, at a distinct angle to that of the main shaft; posterior projection not as long or as strongly bent (1b). **Female:** Pregenital striae entire, sometimes sparse and slightly broken medially..... ***T. evansi***



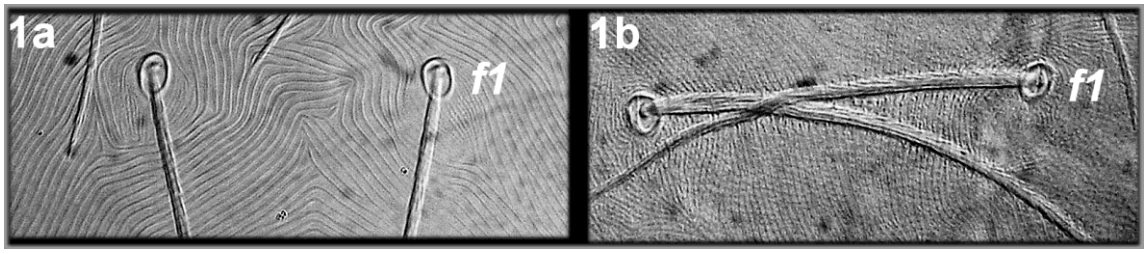
13 **Female:** Empodia I-IV with a large (≥ 4µm long) spur (1a) **14**

- **Female:** Empodia I-IV with spur absent or small (≤ 2µm long) (1b).....**16**



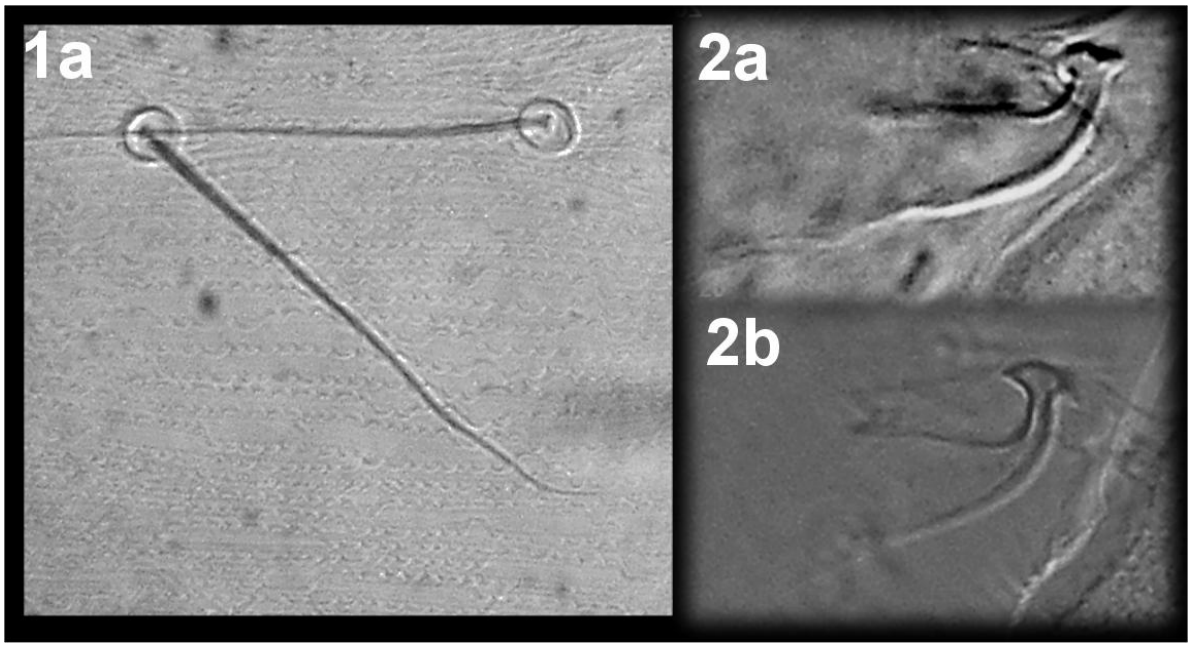
14 **Female:** Lobes entirely, or almost entirely, absent on dorsal striae (1a). Rarely found on host plants other than *Ulex* spp. (gorse) ..... ***T. lintearius***

- **Female:** Lobes present on dorsal striae (1b) **15**



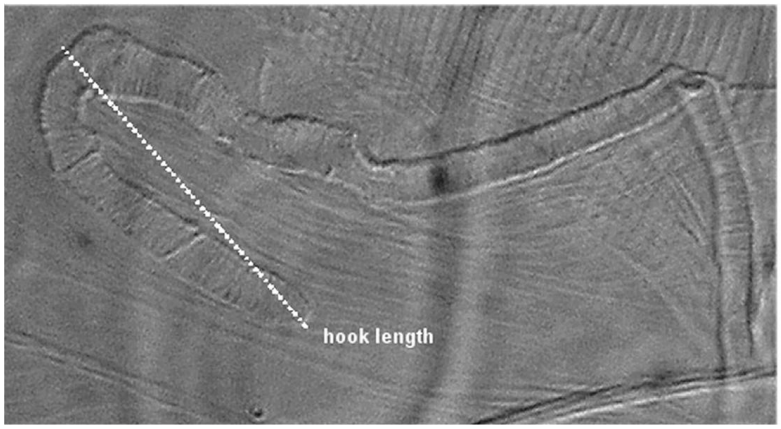
15 **Female:** Lobes present on ventral striae between genital region and setae *1a* (1a). **Male:** Knob of aedeagus ≤ 2x the width of the most distal part of the shaft; posterior projection tiny, its length about half the width of the most distal part of the shaft (2a) ..... ***T. gloveri***

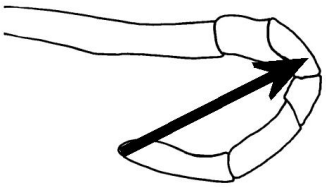
- **Female:** Lobes absent on ventral striae. **Male:** Knob of aedeagus 2-3x the width of the most distal part of the shaft; anterior and posterior projections long, their length longer than the width of the most distal part of the shaft (2b) .... ***T. mexicanus***



16 **Female:** Peritreme with hook 10-12 µm long (see Fig. below) ..... ***T. dianellae***

- **Female:** Peritreme with hook > 15 µm long **17**

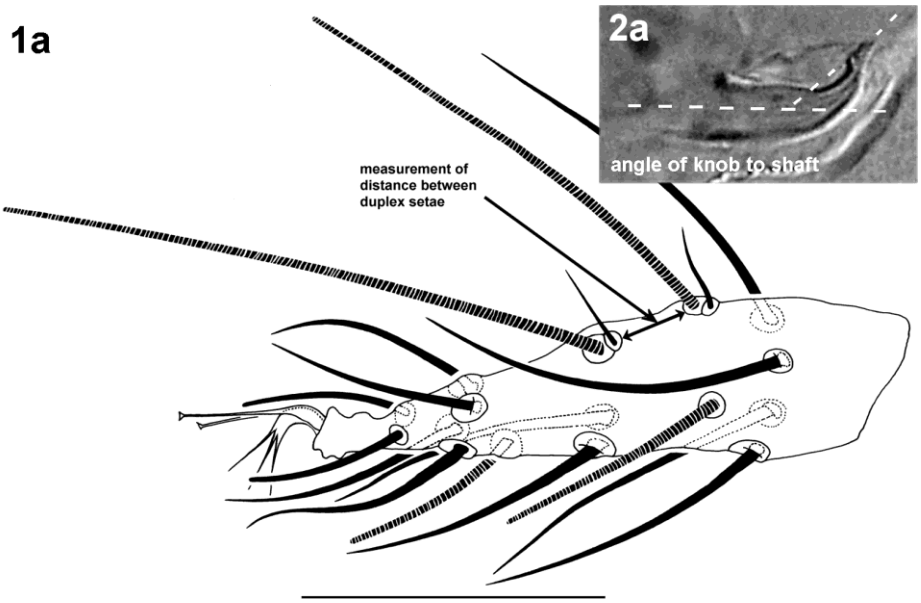




measurement of hook length

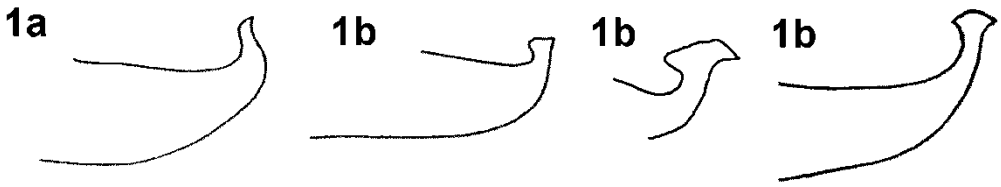
17 **Female:** Distance between duplex setae on tarsus I > 20 µm (1a); **Male:** Knob of aedeagus at a conspicuous angle (30 – 45 º) to the main shaft of aedeagus (2a) .... ***T. marianae***

- **Female:** Distance between duplex setae on tarsus I < 16 µm (1a) **Male:** Knob of aedeagus parallel to shaft of aedeagus, or nearly so, no more than and angle of 20 º *OR* knob of aedeagus small or absent **18**



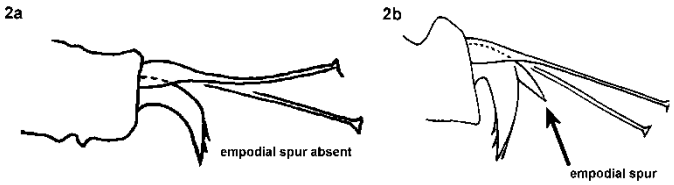
18 **Male:** Aedeagus weakly sigmoid, with shaft tapering to a pointed tip, a distinct knob absent (1a) .....***T. piercei***

- **Male:** Aedeagus with a distinct knob (1b) **19**



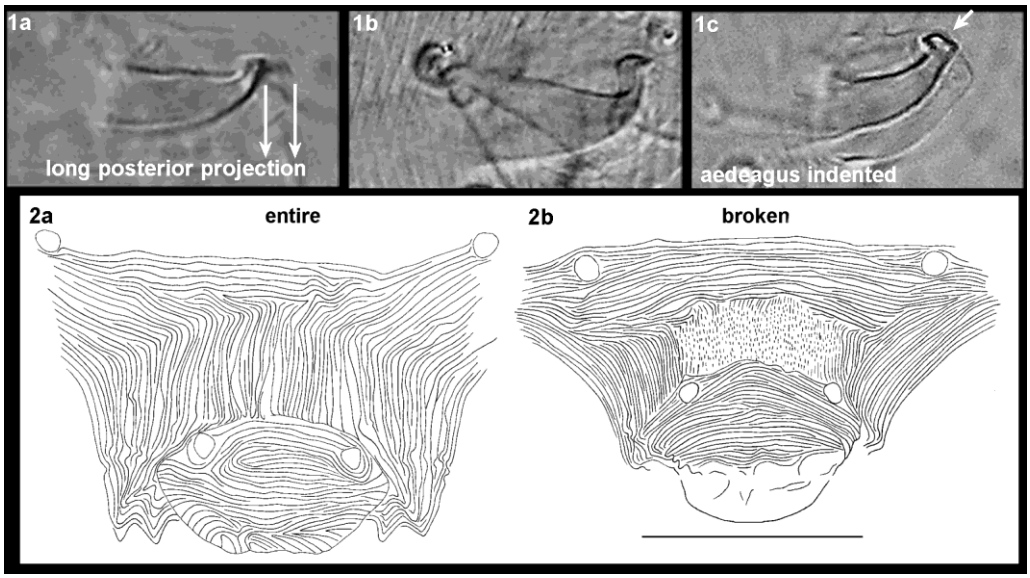
19 **Male:** Empodia I-IV with spurs minute or absent, ≤ 2 µm long (2a) **20**

- **Male:** Empodial I-IV with spurs small ≥ 3 µm long (2b) **22**



20 **Male:** Knob of aedeagus with posterior projection longer than the width of the most distal part of the main shaft (1a). **Female:** Pregenital striae entire, sometimes with lobes (2a) ..... ***T. lambi***

- **Male:** Knob of aedeagus with posterior projection shorter than the width of the most distal part of the main shaft (1b, 1c). **Female:** Pregenital striae broken, always without lobes (2b). **21**



21 M**ales:** Dorsal margin of knob of aedeagus without medial indentation (1b, couplet 20) .....***T. lombardinii***

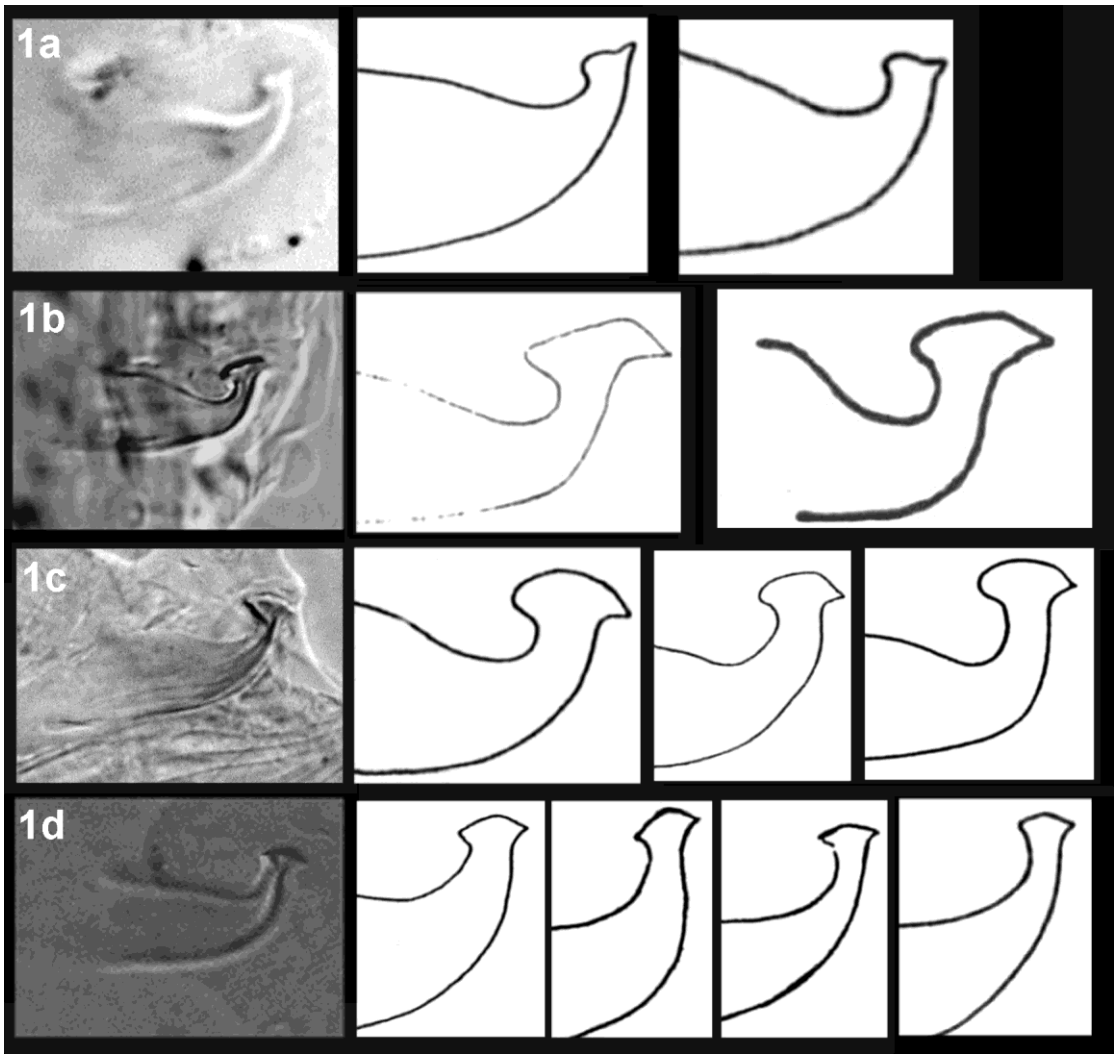
- M**ales:** Dorsal margin of knob of aedeagus with medial indentation (1c, couplet 20) .....***T. neocaledonicus***

22 **Male:** Dorsal margin of knob of aedeagus with a medial indentation (couplet 23: 1a).....***T. truncatus***

- **Male:** Dorsal margin of knob of aedeagus flat or smoothly rounded (couplet 23: 1b, 1c, 1d) **23**

23 **Male:** Aedeagus with the length of the posterior projection approximately equal to the width of the most distal part of the main shaft; dorsal margin of the aedeagus angulate (1b). ..... ***T. turkestani***

- **Male:** Aedeagus with the length of the posterior projection less than the width of the most distal part of the main shaft; dorsal margin of the aedeagus rounded or angulate (1c, 1d).....**24**



24 **Male:** Knob of aedeagus large, twice as long as the width of the most distal part of the main shaft; dorsal margin of aedeagus tends to be rounded (couplet 23:1c). **Female:** Females collected in summer are red ..... ***T. kanzawai***

\- **Male:** Knob of aedeagus small, less than twice as long (about 1.5x) as the width of the most distal part of the main shaft; dorsal margin of aedeagus tends to be angulate (couplet 23: 1d). **Female:** Females collected in summer are green, yellow or red ..... ***T. urticae***

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(Alphabetical order: Those in Diagnostic Protocols are in chronological order)

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Boykin, L.S. & Campbell W.V. (1984). Wind dispersal of the two-spotted spider mite (Acari: Tetranychidae) in North Carolina peanut fields. *Environmental Entomology* **13**: 221-227.

English-Loeb, G.M., Karban, R., & Hougen-Eitzman, D. (1993). Direct and indirect competition between spider mites feeding on grapes. *Ecological Applications* **3**: 699-707.

Grafton-Cardwell, E.E., Granett, J., & Normington, S.M. (1991). Influence of dispersal from almonds on the population dynamics and acaricide resistance frequencies of spider mites infesting neighbouring cotton. *Experimental and Applied Acarology* **10**: 187-212.

Hanna R., Wilson L.T., Zalom F.G., & Flaherty D.L. (1997). Effects of predation and competition on the population dynamics of *Tetranychus pacificus* on grapevines. *Journal of Applied Ecology* **34**: 878-888.

Helle, W. & Sabelis, M.W. (eds) (1985). *Spider Mites. Their Biology, Natural Enemies and Control (World Crop Pests).* Amsterdam: Elsevier Vol. 1A and 1B.

Hougan-Eitzman, D. & Karban, R. (1995). Mechanisms of interspecific competition that result in successful control of Pacific mites following inoculations of Willamette mites on grapevines. *Oecologia* **103**: 157-161.

Oi, D.H., Sanderson, J.P., Youngman, R.R., & Barnes, M.M. (1989). Development times of the Pacific spider mite (Acari: Tetranychidae) on water-stressed almond trees. *Environmental Entomology* **18**: 208-212.

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Wilson, L.T., Smilanick, J.M., Hoffman, M.P., Flaherty, D.L., & Riuz, S.M. (1988). Leaf nitrogen and position in relation to population parameters of Pacific spider mite, *Tetranychus pacificus* (Acari: Tetranychidae) on grapes. *Environmental Entomology* **17**: 964-968.

Youngman, R.R., Sanderson, J.P., & Barnes, M.M. (1988). Life history parameters of *Tetranychus pacificus* McGregor (Acari: Tetranychidae) on almonds under differential water stress. *Environmental Entomology* **17**: 488-495.

PART 2: Naturalised *Tetranychus* spp.

T. bunda Flechtmann & Knihinicki 2002

Synonyms or Changes in Combination or Taxonomy:
None.

Common names:
None.

Hosts:
Florida beggarweed, *Desmodium tortuosum* (Fabaceae) (Flechtmann & Knihinicki 2002)

Distribution:
Australia (Flechtmann & Knihinicki 2002 [N.T.])

Part of Plants Affected:
Foliage

Features:
Female: Empodia with 6 hairs; spurs on empodia I-IV present and large (20 µm long) (Photo Tbu1; Figure Tbu1); tarsus I with base of 1 tactile seta proximal to base of the proximal duplex seta and another 3 tactile setae in line with the base of the proximal duplex seta, OR just 1-2 tactile seta just proximal to the base of the duplex seta (Photo Tbu2; Figure Tbu1); additive distances between the base of each proximal seta and the base of proximal duplex seta = 3-8 µm; tarsus I, distance between the base of proximal duplex seta and the base of distal duplex seta = 15-19 µm (Photo Tbu2); peritreme hook = 20-25 µm long (Photo Tbu3); dorsal striae between setae *e1-e1* and *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse, forming a diamond-shaped (Photo Tbu4); dorsal striae with lobes; ventral striae from genital region to setae *3a* with lobes (Photo Tbu5); pregenital striae broken (Photo Tbu6).

Male: Empodia I-IV each with long (20 µm) dorsal spur; empodia I claw-like (uncinate) (Photo Tbu7), empodia II-IV with long and free proximoventral hairs (Photo Tbu8). Aedeagus as in Photo Tbu9 and Figure Tbu2.

Biology:
Tetranychus bunda is known only from two collections made in Darwin during November 1999 on Florida beggarweed *Desmodium tortuosum*

(Fabaceae). The mites were common, with over 200 individuals on some leaves, and most occurred on the underside of leaves (Flechtmann & Knihinicki 2002). Live newly-moulted female mites are initially light to dark green, but become light to deep purple and dark-orange upon maturity. The legs are pale yellow. Live male mites are pale to light green (Flechtmann & Knihinicki 2002). Webbing is sparse and damage is the yellow-white speckling of leaves characteristic of spider mites. The host plant is not native to Australia, so this species either has an unknown native Australian host or it is an exotic species not yet known in its native range. Florida beggarweed is native to Central America (Flechtmann & Knihinicki 2002).

Economic Importance:

Not significant.

Reference:

Flechtmann, C.H.W. & Knihinicki, D.K. (2002). New species and new record of *Tetranychus* Dufour from Australia, with a key to the major groups in this genus based on females. *Australian Journal of Entomology* **41**: 118-127 (**holotype** as *T. bunda*)

T. desertorum Banks 1900

Note:

For more information see *T. desertorum* under Quarantine Concern species section. This species was first reported by Dodd (1929) but no specimen record exists. Where reported in Australia, the species is *T. ludeni*, not *T. desertorum*.

T. dianellae Davis 1967

Synonyms or Changes in Combination or Taxonomy:
None.

Common names:
None.

Hosts:
Dianella caerulea (Phormiaceae) (Davis 1967)

Distribution:
Australia: Queensland (Nambour) (Davis 1967)

Part of Plants Affected:
Foliage

Features:
Female: Empodia with 6 hairs; spurs on empodia I-IV minute or absent (Photo Tdi1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tdi2); additive distance between the base of each proximal seta and the base of proximal duplex seta = 19-23 µm; tarsus I, distance between the base of proximal duplex seta and the base of distal duplex seta = 11-12 µm (Photo Tdi2); peritreme hook < 15 µm long (10-12 µm) (Photo Tdi3); dorsal striae between setae *e1-e1* longitudinal with or without some oblique; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse, forming a diamond-shape (Photo Tdi4); dorsal striae with lobes; lobes present on ventral striae between genital region and setae *3a* (Photo Tdi5); pregenital striae broken, sometimes appearing to have lobes (Photo Tdi6).

Male: Empodia I-IV each with minute-absent dorsal spur; empodia I claw-like (uncinate) with little or no dorsal spur (Photo Tdi7), empodia II-IV with proximoventral hairs long and free (Photo Tdi8). Aedeagus as in Photo Tdi9.

Biology:
Known only from its type locality and host plant, Perwillowen (near Nambour) on blue-berry lily, respectively. *Dianella caerulea* is native to Australia, but grown throughout the world via the nursery trade.

Economic Importance:
Not significant.

Reference:

Davis, J.J. (1967). Studies of Queensland Tetranychidae. II. *Tetranychus dianellae sp. n.*, a spider mite found on *Dianella caerulea* Sims. *Queensland Journal of Agricultural and Animal Science* **24**: 201-205.

T. fijiensis Hirst 1924

Hosts:

Frangipani, betel palm, Macarthur feather palm (Flechtmann & Knihinicki 2002)

Distribution:

Australia (Flechtmann & Knihinicki 2002 [N.T.])

Note:

For more information see *T. fijiensis* Hirst 1924 under species of Quarantine Concern. This species was first detected in the Northern Territory in 2002, where it has been present since at least 1992.

Reference:

Flechtmann, C.H.W. & Knihinicki, D.K. (2002). New species and new record of *Tetranychus* Dufour from Australia, with a key to the major groups in this genus based on females. *Australian Journal of Entomology* **41**: 118-127.

T. gloveri Banks 1900

Note:

Tetranychus gloveri was recorded in Australia (Womersley 1942; Bolland *et al.* 1998; Halliday 2000), but the original record (Womersley 1942) is incorrect. Womersley actually had specimens of *Oligonychus*, an error noted by Davis (1968). We have examined these specimens and we concur with Davis (1968). For more information see *T. gloveri* in the Quarantine Concern section.

Reference:

Davis J.J. (1968). *Oligonychus araneum* sp.n. and *Oligonychus digitatus* Davis (Acarina: Tetranychidae). *Journal of the Australian Entomological Society* **7**: 123-126.

T. kanzawai Kishida 1927

Synonyms or Changes in Combination or Taxonomy:

T. hydrangeae Pritchard & Baker 1955
Synonymy by Wainstein (1960); also Navajas *et al.* (2001)

Common names:

Kanzawa spider mite (CABI CPC)
Tea red spider mite (AICN version 1.31)

Hosts:

Numerous. Australian records are beans, *Hydrangea* and *Polyanthes* (Gutierrez & Schicha 1983). Bolland *et al.* (1998) records 106 host species.

Distribution:

Australia (Qld, Davis 1968; NSW, Gutierrez & Schicha 1983; N.S.W. Dept. Agric. 1975), China, Colombia, Congo, Greece, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Mexico, Okinawa Island, Papua New Guinea, Philippines, South Africa, Taiwan, Thailand, USA (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage. Foliage of hydrangeas become mottled and flower heads become deformed and reduced in size (Gutierrez & Schicha 1983).

Features:

Female: Empodia with 6 hairs; spurs on empodia I-IV minute or absent (Photo Tka1; Figure Tka1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Figure Tka2); additive distance between the base of each proximal seta and the base of proximal duplex seta = 22-29 µm; tarsus I, distance between the base of proximal duplex seta and the base of distal duplex seta = 9-13 µm (Photo Tka2; Figure Tka2); peritreme hook = 24-27 µm long (Photo Tka3; Figure Tka3); dorsal striae between setae *e1-e1* and *f1-f1* longitudinal and oblique; striae between setae *e1* and *f1* transverse, forming a diamond-shape (Photo Tka4; Figure Tka4; Figure Tka5); dorsal striae with lobes; ventral striae without lobes; pregenital striae generally entire, sometimes sparse with small breaks medially (Photo Tka5; Figure Tka6). Palps as in Figure Tka7.

Male: Empodia I-IV each with strong dorsal spur 4 µm long; empodia I claw-like (uncinate) (Photo Tka6; Figure Tka8; Figure Tka9), empodia II-IV with proximoventral hairs long and free (Photo Tka7). Aedeagus as in Photo Tka8, Photo Tka10, Figure Tka11. Palp as in Figure Tka12.

Female mites collected in summer are carmine (Gutierrez & Schicha 1983).

DNA: CO1 mtDNA gene (Navajas *et al*. 1996).

Biology:

Nothing is known of the biology of *T. kanzawai* in Australia, but the species is reasonably well-studied in Japan. Although it is well-known from tea and hydrangea, mulberry is a better host plant (Gotoh & Homi 2003). At 25 ºC, development of egg-adult ranges from 9.3 to 12.2 days (females) and 8.6 – 11.6 days (males), with variation resulting mostly from host plant differences (Gotoh & Gomi 2003).

Economic Importance:

Tetranychus kanzawai occasionally causes significant damage to crops (e.g., tea), nursery plants and plants in urban landscaping (Ehara 1956; Ehara & Masaki 1989; Jeppson *et al.* 1975).

References:

Kishida, K. (1927). Notes on *Tetranychus kanzawai* n. sp., a new tetranychid mite injurious to leaves of the mulberry in Japan. *Zool. Mag. (Tokyo)* **39**: 105-107 (**holotype** as *Tetranychus kanzawai*)

Ehara, S. (1956). Tetranychoid mites of mulberry in Japan. *Journal of the Faculty of Science, Hokkaido University, Series VI, Zoology* **12**: 499-510.

Wainstein, B.A. (1960). Tetranychoid mites of Kazakhstan (with revision of the family). *Kazakh. Akad. Sel'sk. Nauk. Nauch. Issled. Inst. Zashch. Rast. Tr.* **5**: 1-276.

Davis, J.J. (1968). Studies of Queensland Tetranychidae. 3. Records of the genus *Tetranychus*. *Queensland Journal of Agricultural and Animal Science* **25**: 57-67 (as *T. hydrangeae*)

Jeppson, L.R., Keifer, H.H. & Baker, E.W. (1975). *Mites Injurious to Economic Plants.* Berkeley: University of California Press.

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Ehara, S. & Masaki M. (1989). Notes on two Japanese species of *Tetranychus* (Acarina: Tetranychidae). *Acta Arachnologica* **38**: 49-54.

Navajas, M., Gutierrez, J., Lagnel, J. & Boursot, P. (1996). Mitochondrial cytochrome oxidase I in tetranychid mites: a comparison between molecular phylogeny and changes of morphological and life history traits. *Bulletin of Entomological Research* **86**: 407-417.

Bolland, H.R., Gutierrez, J. & Flechtmann, C.H.W. (1998). *World Catalogue of the Spider Mite Family (Acari: Tetranychidae).* Leiden, Boston: Brill.

Halliday, R.B. (1998). *Mites of Australia*. A Checklist and Bibliography. *Monographs on Invertebrate Taxonomy* **5**: 1-317. (as *T. kanzawai* and *T. hydrangeae*)

Navajas, M., Gutierrez, J., Williams, M. & Gotoh, T. (2001). Synonymy between two spider mite species, *Tetranychus kanzawai* and *T. hydrangeae* (Acari: Tetranychidae), shown by ribosomal ITS2 sequences and cross-breeding experiments. *Bulletin of Entomological Research* **91**: 117-123.

Flechtmann, C.H.W. & Knihinicki, D.K. (2002). New species and new record of *Tetranychus* Dufour from Australia, with a key to the major groups in this genus based on females. *Australian Journal of Entomology* **41**: 118-127.

Gotoh, T. & Gomi, K. (2003). Life-history of the Kanzawa spider mite *Tetranychus kanzawai* (Acari: Tetranychidae). *Applied Entomology and Zoology* **38**: 7-14.

T. lambi Pritchard & Baker 1955

Synonyms or Changes in Combination or Taxonomy:

Tetranychus cordylinicolus Lo 1969
Synonymy by Tseng (1990)

Common names:

Strawberry spider mite (AICN version 1.31)
Banana spider mite

Hosts:

Numerous. Australian records include Fabaceae, strawberry, banana, pumpkin, cotton and foxtail millet (Gutierrez & Schicha 1983). Bolland *et al.* (1998) records 64 host species.

Distribution:

Australia (Tas, Miller 1966; Qld, Davis 1968, Hassan 1977, Brough *et al.* 1994; NSW, Gutierrez & Schicha 1983; WA, pers. collection), American Samoa, Cook Islands, Fiji, French Polynesia, Iran, New Caledonia, New Zealand, Papua New Guinea, Taiwan, Tonga, Vanuatu, Wallis and Futuna, Western Samoa (Bolland *et al.* 1998)

Part of Plants Affected:

Foliage. On bananas, *T. lambi* causes flecking and mottling of leaves, and also can infest fruit, causing extensive brown skin blemishes and loss of market value (N.S.W. Dpt. Agric. 1975; Gutierrez & Schicha 1983).

Features:

Female: Empodia with 6 hairs; spurs on empodia I-IV minute or absent (Photo Tla1); tarsus I usually with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tla2), occasionally base of 1 tactile setae overlapping with the level of base of the proximal duplex seta; additive distance between the bases of each proximal seta and the base of proximal duplex seta = 13-30 µm; tarsus I, distance between the base of proximal duplex seta and base of distal duplex seta = 7-10 µm (Photo Tla2); peritreme hook = 15-20 µm long (Photo Tla3); dorsal striae between setae *e1-e1* longitudinal and/or oblique; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse, forming a diamond shape (Photo Tla4); dorsal striae with lobes; ventral striae with (Queensland and New Zealand specimens, Photo Tla5) or without (some Tasmanian specimens, Photo Tla6) lobes, if with lobes, then lobes extend from genital region to *1a*; pregenital striae entire and with (Qld, Photo Tla7) or without (Tas, Photo Tla8) lobes.

Male: Empodia I-IV each with minute dorsal spur; empodia I short, thick, claw-like (uncinate) (Photo Tla9), empodia II-IV with

proximoventral hairs long and free (Photo Tla10). Aedeagus as in Photo Tla11.

These mites are small in comparison to other naturalised species of *Tetranychus* (Gutierrez & Schicha 1983), although this is hard to determine from slide-mounted specimens. Females are green or yellowish with dark spots along each side of body (Davis 1968; Gutierrez & Schicha 1983).

The specimens we have examined are variable. Tarsus I of female mites have 0-1 proximal setae overlapping with the base of the duplex seta, and specimens from Queensland and New Zealand have lobes on the ventral striae while some specimens from Tasmania do not. We consider the variation in tarsus I to be intraspecific because this variation was sometimes present on one leg but not the other on a single specimen. However, the differences in lobe distribution may represent different species, as could the differences in dorsal striation (see below).

There is considerable confusion over the pattern of striae between setae *e1* and *f1*. According to Pritchard & Baker (1955), *T. lambi* has longitudinal striae between setae *f1-f1*, and the striae between *e1* and *f1* form the hourglass pattern; but according to Jeppson *et al.* (1975), it has a diamond-shape, and to Flechtmann & Knihinicki (2002), the species has entirely transverse striae. We have examined specimens from New Zealand and the collections of Davis (Qld) and Miller (Tas) and all but one collection (Tasmania, from *Goodenia*) has a diamond-shaped striae pattern; the exception has an hourglass-shaped pattern. We cannot explain this disagreement in interpretation, but the diamond and hourglass-shaped patterns could be confused due to more than one species being identified as *T. lambi*. Furthermore, the diamond-shape is not as pronounced in *T. lambi* as in other species, being oblique or irregular between *e1-e1* rather than transverse or longitudinal. Thus, some authors may choose to call the pattern an hour-glass shape.

Biology:

Collected from many introduced plants in Queensland (Davis 1968) and New South Wales (Gutierrez & Schicha 1983).

Economic Importance:

Can be significant on strawberries (Davis & Heather 1962) and bananas in tropical Queensland (*pers. obs*.). An occasional pest on other crops.

References:

Pritchard, A.E. & Baker, E.W. (1955). *A Revision of the Spider Mite Family Tetranychidae.* San Francisco: Pacific Coast Entomological Society 472 pp. (**holotype** as *T. lambi*)

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Miller, L.W. (1966). The tetranychid mites of Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* **100**: 53-66.

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Lo, P.K.C. (1969). Tetranychoid mites infesting special crops in Taiwan. *Bull. Sun Yat-Sen Cult. Found.* **4**: 43-82.

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Tseng, Y.H. (1990). A monograph of the mite family Tetranychidae (Acarina: Trombidiformes) from Taiwan. *Taiwan Museum Special Publications, Series 9, Taipei, Rep. China.* 1-226.

Brough, E.J., Elder, R.J. & Beavis, C.H.S. (Eds) (1994). *Managing Insects & Mites in Horticultural Crops.* Queensland: Department of Primary Industries.

Bolland, H.R., Gutierrez, J. & Flechtmann, C.H.W. (1998). *World Catalogue of the Spider Mite Family (Acari: Tetranychidae).* Leiden, Boston: Brill.

T. lintearius Dufour 1832

Synonyms or Changes in Combination or Taxonomy:

Tetranychus ulicis Jourdain ????
Synonymy by Andre 1933

Tetranychus linearicus Oudemans 1937 [sic]
Tetranychus lintearius van Eyndhoven 1967 (re-established species)

Common names:

Gorse spider mite

Hosts:

Calicotome villosa, *Ulex europaeus*, *Ulex nanus*, *Ulex parviflorus* (Bolland *et al.* 1998).

Distribution:

Australia (Tas, Ireson *et al.* 1999), Algeria, Belgium, France, Hawaii, Italy, New Zealand, Portugal, Spain, UK (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage

Features:

Female: Empodia with 6 proximoventral hairs; spurs on empodia I-IV 4 µm long (Photo Tli1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tli2); the additive distance between the bases of each proximal seta and the base of proximal duplex seta = 26-42 µm; tarsus I, distance between the base of proximal duplex seta and the base of distal duplex seta = 11-13 µm (Photo Tli2); peritreme hook = 19-22 µm long (Photo Tli3); dorsal striae between setae *e1-e1* and *f1-f1* longitudinal and oblique; striae between setae *e1* and *f1* transverse, forming a diamond-shape (Photo Tli4); dorsal striae without lobes; ventral striae without lobes; pregenital striae entire (Photo Tli5).

Male: Empodia I-IV each with obvious dorsal spur 4-5 µm long; empodia I claw-like (uncinate) (Photo Tli6), empodia II also claw-like (uncinate) (Photo Tli7), empodia III-IV with free proximoventral hairs. Aedeagus as in Photo Tli8.

Biology:

Gorse spider mite is specific to its host plants, especially *Ulex europaeus*, a serious weed species in temperate Australia. *Tetranychus lintearius* creates masses of webbing over its host plant.

Economic Importance:

The species has established in Tasmania where it is a biological control agent for gorse.

References:

Dufour, L. (1832). Description et figure du *Tetranychus linearicus*, Arachnide nouvelle de la tribu des Acarides. *Ann. Sci. Nat. Paris* **25**: 276 (**holotype** as *Tetranychus lintearius*)

Andre, M. (1933). Sur la biologie des Tétranyques tisserands. *Rev. Pathol. Vég. Entomol. Agric.* **1**: 8-25 (as *Tetranychus lintearius*)

Oudemans, A.C. (1937). Kritisch Historisch Overzicht der Acarlogie. 3(C): IX-XXIII + 799-1348 (as *Tetranychus lintearicus*)

Eyndhoven, G.L. Van (1967). *Tetranychus lintearius* Dufour, 1832, is a valid species (Acar.). Notulae ad Tetranychidas 11. *Entomol. Ber., Amst.* **27**: 90-100 (as *Tetranychus lintearius*)

Ireson, J.E., Gourlay, A.H., Kwong, R.M., Holloway, R.J. & Chatterton, W.S. (1999). Progress on the rearing, release and establishment of the gorse spider mite, *Tetranychus lintearius* Dufour, for the biological control of gorse in Australia. *Proceedings of the XIIth Australian Weeds Conference*, 12-16 September 1999, Hobart, Tasmania (Eds Bishop A.C., Boersma, M., & Barnes, C.D.), pp. 320-324.

T. lombardinii Baker & Pritchard 1960

Synonyms or Changes in Combination or Taxonomy:

None.

Common names:

Crimson spider mite (AICN version 1.31)

Hosts:

Bolland *et al.* (1998) records 115 host species.

Distribution:

Australia (NSW, Gutierrez & Schicha 1983), India, Indonesia, Kenya, Madagascar, Malawi, Mozambique, Namibia, South Africa, Zaire, Zambia, Zimbabwe (Bolland *et al*. 1998).

Part of Plants Affected:

Foliage

Features:

Female: Empodia with 6 proximoventral hairs; spurs on empodia I-IV minute (< 2 µm) or absent (Photo Tlo1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tlo2); the additive distance between the base of each proximal seta and the base of proximal duplex seta variable = 13-33 µm; tarsus I, distance between the base of proximal duplex seta and the base of distal duplex seta = 12-15 µm (Photo Tlo2); peritreme hook = 28-34 µm long (Photo Tlo3); dorsal striae between setae *e1-e1* longitudinal and/or oblique; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming diamond-shape (Photo Tlo4); dorsal striae with lobes; ventral striae between genital region and setae *3a* with lobes (Photo Tlo5); pregenital striae broken, but not strikingly so (Photo Tlo6).

Male: Empodia I-IV each with minute dorsal spur (< 2 µm) or absent; empodia I claw-like (uncinate), empodia II-IV with proximoventral hairs long and free (Photo Tlo7). Aedeagus as in Photo Tlo8.

Females are dark-red with dark spots on each side of the body; males are greenish-yellow (Gutierrez & Schicha 1983).

Biology:

Recorded in Australia from just a single collection in Sydney on *Passiflora* sp. (Gutierrez & Schicha 1983).

Economic Importance:

Although reported damaging several crops, especially cotton, the actual impact of this species has never been examined (Jeppson *et al*. 1975). In Australia, the species has been recorded just once,

suggesting it is not an important species or is frequently confused with other species. We were unable to borrow the single known collection from Australia to confirm its identification.

References:

Baker, E.W. & Pritchard, A.E. (1960). The tetranychoid mites of Africa. *Hilgardia* **29**(11): 445-574. (**holotype** as *T. lombardinii*)

Jeppson, L.R., Keifer, H.H. & Baker, E.W. (1975). *Mites Injurious to Economic Plants.* Berkeley: University of California Press.

Gutierrez, J. & Schicha, E. (1983). The spider mite family Tetranychidae (Acari) in New South Wales. *International Journal of Acarology* **9**: 99-116.

Bolland, H.R., Gutierrez, J. & Flechtmann, C.H.W. (1998). *World Catalogue of the Spider Mite Family (Acari: Tetranychidae).* Leiden, Boston: Brill.

T. ludeni Zacher 1913

Synonyms or Changes in Combination or Taxonomy:

Epitetranychus ludeni (Zacher) Zacher 1921

Tetranychus ludeni Zacher, Pritchard & Baker 1955

Tetranychus salvae Oudemans 1931
Synonymy by Pritchard & Baker 1955

Septanychus deviatarsus McGregor 1950
Synonymy by Pritchard & Baker 1955

T. desertorum in Ehara (1956)
misidentification, corrected by Ehara & Masaki (1989)

Common names:

Bean spider mite (AICN version 1.31)
European red mite (more commonly used for *Panonychus ulmi*)
Red spider mite (CABI CPC)

Hosts:

In Australia: Cotton, beans, strawberry (Davis 1968). Elephant's ear plant, clover, bread fruit, capeweed, horseradish, cobbler's pegs, *Citrus* spp., cucumber, *Crotalaria*, *Dahlia*, thornapple, *Erigeron floribundus*, *Gerbera*, glycine, *Hibiscus*, sweet potato, *Ipomoea cairica*, marshmallow, French bean, wild gooseberry, frangipani, apple, castor oil plant, sage, shoko, *Tetrapanax papyriferum*, white clover (Gutierrez & Schicha 1983).

Bolland *et al.* (1998) records 264 host species. Zhang (2002) records another 10 species from New Zealand.

Distribution:

Australia (Qld, Davis 1968; Tas, Miller 1966; NSW, N.S.W. Dept. Agric. 1975, Gutierrez & Schicha 1983), Algeria, Argentina, Brazil, Canary Islands, Chile, China, Colombia, Cook Islands, Costa Rica, El Salvador, Fiji, France, French Polynesia, Germany, Greece, Hawaii, Honduras, India, Iraq, Japan, Kenya, Madagascar, Madeira Island, Malawi, Mauritius, Mexico, Morocco, Mozambique, New Caledonia, New Zealand, Nicaragua, Paraguay, Portugal, South Africa, Spain, Swaziland, Taiwan, Thailand, USA, Venezuela, Zambia, Zimbabwe (Bolland *et al.* 1998).

Part of Plants Affected:

Leaves; moderate populations can cause severe bronzing of foliage and large populations kill plant (Gutierrez & Schicha 1983).

Features:

Female: Empodia with 6 proximoventral hairs; spurs on empodia I-IV minute or absent (Photo Tlu1); tarsus I with bases of 4 tactile setae overlapping with the base of the proximal duplex seta (Photo Tlu2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 0 µm; tarsus I, distance between the base of proximal duplex seta and the base of distal duplex seta = 21 µm (Photo Tlu2); peritreme hook = 25-31 µm long (Photo Tlu3); dorsal striae between setae *e1-e1* longitudinal and/or oblique; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Tlu4); dorsal striae with lobes; ventral striae between genital region and setae *1a* with lobes (Photo Tlu5); pregenital with obviously broken striae (Photo Tlu6).

Male: Empodia I-IV each with strong dorsal spur 4 µm long; empodia I claw-like (uncinate), empodia II-IV with proximoventral hairs long and free (Photo Tlu7). Aedeagus as in Photo Tlu8 and Photo Tlu9.

Female mites are dark red, male mites are orange-yellow (Boudreaux & Dosse 1963; Gutierrez & Schicha 1983).

This species is often confused with *T. desertorum*; for example, *T. desertorum* identified in Walter (1999) is *T. ludeni*. The problem arises because *T. ludeni* has a grooved or ridged aedeagus, and as one focuses up and down on the aedeagus, it can appear to have a strong hook not unlike *T. desertorum*. Be sure to focus up and down on the aedeagus to build a 3-dimensional picture of the aedeagal knob.

Biology:

Widespread in eastern Australia, especially coastal areas, and on numerous host species (Miller 1966; Davis 1968; Gutierrez & Schicha 1983). *Tetranychus ludeni* is often found in mixed populations with *T. urticae* (Gutierrez & Schicha 1983).

Economic Importance:

A pest species of many crops (Jeppson *et al.* 1975), sometimes requiring management through application of pesticides and natural enemies.

References:

Zacher, F. (1913). Untersuchungen über spinnenmilben. *Mitt. K. Biol. Anstalt Land- Forst.* **14**: 37-41. (**holotype** as *T. ludeni*)

Zacher, F. (1921). Neue und wenig bekannte Spinnmilben. *Z. Angew. Entomol.* **7**: 181-187.

Oudemans, A.C. (1931). Acarologische Aanteekeningen CVII. *Entomol. Ber., Amst.* **8**: 221-236.

McGregor, E.A. (1950). Mites of the family Tetranychidae. *American Midland Naturalist* **44**: 257-420.

Ehara, S. (1956). Notes on some tetranychid mites of Japan. *Japanese Journal of Applied Entomology and Zoology* **21**: 139-147 (as *T. desertorum*)

Boudreaux, H.B. & Dosse, G. (1963). The usefulness of new taxonomic characters in females of the genus *Tetranychus* Dufour (Acari: Tetranychidae). *Acarologia* **5**: 13-33.

Miller, L.W. (1966). The Tetranychid mites of Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* **100**: 53-66.

Davis, J.J. (1968). Studies of Queensland Tetranychidae. 3. Records of the genus *Tetranychus*. *Queensland Journal of Agricultural and Animal Science* **25**: 57-67.

Jeppson, L.R., Keifer, H.H. & Baker, E.W. (1975). *Mites Injurious to Economic Plants.* Berkeley: University of California Press.

New South Wales Department of Agriculture (1975). Spider mites. *Entomology Branch Insect Pest Bulletin.* **37**: 1-11.

Gutierrez, J. & Schicha, E. (1983). The spider mite family Tetranychidae (Acari) in New South Wales. *International Journal of Acarology* **9**: 99-116.

Ehara, S. & Masaki, M. (1989). Notes on two Japanese species of *Tetranychus* (Acarina: Tetranychidae). *Acta Arachnologica* **38**: 49-54.

Bolland, H.R., Gutierrez, J. & Flechtmann, C.H.W. (1998). *World Catalogue of the Spider Mite Family (Acari: Tetranychidae).* Leiden, Boston: Brill.

Zhang, Z-Q. (2000). Taxonomy of *Tetranychus ludeni* (Acari: Tetranychidae) in New Zealand and its ecology on *Sechium edule*. *New Zealand Entomologist* **25**: 27-34.

T. marianae McGregor 1950

Synonyms or Changes in Combination or Taxonomy:

None.

Common names:

Tropical red spider mite (AICN version 1.31)

Systematic note:

Taxonomic research done on *T. marianae* by Silva (1954) and Moutia (1958) was really dealing with *T. evansi.*

Hosts:

Numerous, in Australia its only record is cotton (Davis 1968); Bolland *et al.* (1998) records 82 host plants.

Distribution:

Australia (Qld, Davis 1968, 1969), American Samoa, Argentina, Bahamas, Brazil, Columbia, Costa Rica, Cuba, Fiji, French West Indies, Guam Island, Honduras, Mariana Islands, Marshall Islands, Mexico, Nicaragua, Papua New Guinea, Philippines, Puerto Rico, Solomon Islands, Thailand, USA, Vanuatu, Vietnam, West Indies, Western Samoa (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage

Features:

Female: Empodia with 6 proximoventral hairs; spurs on empodia I-IV minute or absent (Photo Tmar1); tarsus I with bases of 3 tactile setae in line with the base of the proximal duplex seta, 1 tactile seta proximal to base of proximal duplex seta (Photo Tmar2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 5 µm; tarsus I, distance between the base of proximal duplex seta and the base of distal duplex seta = 32 µm (Photo Tmar2); peritreme hook = 28 µm long (Photo Tmar3); dorsal striae between setae *e1-e1* longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming diamond-shape (Photo Tmar4); dorsal striae with lobes; ventral striae between genital region and setae *1a* with lobes (Photo Tmar5); pregenital striae entire.

Male: Empodia I-IV each with small dorsal spur 2 µm long; empodia I claw-like (uncinate) (Photo Tmar6), empodia II-IV with proximoventral hairs long and free (Photo Tmar7). Aedeagus as in Photo Tmar8.

Biology:

Recorded from just a single collection on cotton in Northern Queensland (Davis 1968, 1969). We have examined these mites and they match the written descriptions of *T. marianae*.

Economic Importance:

Although recorded as a pest of cotton (Jeppson *et al.* 1975) and as an important pest of tomato in Texas (Schuster 1959), the effect of this species on plants is largely unknown. This species is probably of only minor importance in Australia because it has not been collected since its initial discovery (Davis 1968).

References:

McGregor, E.A. (1950). Mites of the family Tetranychidae. *American Midland Naturalist* **44**: 257-420. (**holotype** as *T. marianae*)

Silva, P. (1954). A new noxious mite on tomato in Bahia. *Bol. Inst. Biol. Bahia, Brazil* **1**: 1-20 (reported as *T. marianae*, but is really *T. evansi*)

Pritchard, A.E. & Baker, E.W. (1955). *A Revision of the Spider Mite Family Tetranychidae.* San Francisco: Pacific Coast Entomological Society 472 pp.

Moutia, L.A. (1958). Contribution to the study of some phytophagous Acarina and their predators in Mauritius. *Bulletin of Entomological Research* **49**: 59-75 (reported as *T. marianae*, but is really *T. evansi*)

Schuster, M.F. (1959). Chemical control of *Tetranychus marianae* McG. on tomatoes in the lower Rio Grande Valley. *Journal of Economic Entomology* **52**: 763-764.

Davis, J.J. (1968). Studies of Queensland Tetranychidae. 3. Records of the genus *Tetranychus*. *Queensland Journal of Agricultural and Animal Science* **25**: 57-67.

Davis, J.J. (1969). A note on cuticular lobes of *Tetranychus marianae* McGregor (Acarina : Tetranychidae) from Papua. *Journal of the Australian Entomological Society* **8**: 112.

Jeppson, L.R., Keifer, H.H. & Baker, E.W. (1975). *Mites Injurious to Economic Plants.* Berkeley: University of California Press.

Bolland, H.R., Gutierrez, J. & Flechtmann, C.H.W. (1998). *World Catalogue of the Spider Mite Family (Acari: Tetranychidae).* Leiden, Boston: Brill.

T. neocaledonicus (Andre) 1933

Synonyms or Changes in Combination or Taxonomy:

Eotetranychus neocaledonicus Andre 1933

Tetranychus neocaledonicus Andre, Andre 1959

Tetranychus cucurbitae Rahman & Sapra 1940
Synonymy by Andre (1959)

Tetranychus equatorius McGregor 1950
Synonymy by Pritchard & Baker (1955)

Common names:

Vegetable spider mite (AICN version 1.31, Jeppson *et al.* 1975)

Hosts:

In Australia: *Citrus* sp., custard apple (Gutierrez & Schicha 1983), *Cassia*, nasturtium, kangaroo apple (our collections). Bolland *et al.* (1998) records 432 host plants.

Distribution:

Australia (Qld, Davis 1968; NSW, Gutierrez & Schicha 1983).
Pantropical distribution: Bolland *et al.* (1998) records 61 countries (e.g., South Africa to USA).

Part of Plants Affected:

Foliage

Features:

Female: Empodia with 6 proximoventral hairs; spurs on empodia I-IV minute or absent (Photo Tne1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tne2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 23-28 µm; tarsus I, distance between the base of proximal duplex seta and the base of distal duplex seta = 13-14 µm (Photo Tne2); peritreme hook = 20-26 µm long (Photo Tne3); dorsal striae between setae *e1-e1* longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming diamond-shape (Photo Tne4); dorsal striae with lobes; ventral striae without lobes; pregenital striae broken (Photo Tne5).

Male: Empodia I-IV each with minute dorsal spur; empodia I claw-like (uncinate) (Photo Tne6); empodia II-IV with proximoventral hairs long and free (Photo Tne7). Aedeagus as in Photo Tne7 and Photo Tne8.

The aedeagus is berry-like (Gutierrez & Schicha 1983), but it is not as distinctive as many authors suggest, and we have noticed variation in

specimens identified as *T. neocaledonicus* from Australia. Care should be taken not to confuse this species with those with small aedeagal knobs, such as *T. urticae* and *T. lombardinii*.

Live females are bright red with pale white legs; males are greenish-yellow (Gutierrez & Schicha 1983).

DNA: CO1 mtDNA gene (Navajas *et al*. 1996).

Biology:

Not a major pest in N.S.W., and is probably restricted to warmer areas where the temperature rarely goes below 10 °C (Gutierrez & Schicha 1983). *Tetranychus neocaledonicus* is common in Brisbane on many weeds and cultivated plants (Davis 1968; *pers. obs*.).

Economic Importance:

This is a major pest species (Jeppson *et al.* 1975) and can require management through biological control or miticides.

References:

André, M. (1933). Note sur un Tétranyche nuisible au cotonnier i Nouvelle-Calédonie. *Bull. Mus. Natl. Hist. Nat.* **5**: 302-308 (**holotype** as *T. neocaledonicus*)

Rahman, K.A., & Sapra, A.N. (1940). Biology of the mite *Paratetranychus indicus* Hirst, a pest of sugar cane in the Punjab. *Indian Journal of Entomology* **2**: 201-212.

Pritchard, A.E. & Baker, E.W. (1955). *A Revision of the Spider Mite Family Tetranychidae.* San Francisco: Pacific Coast Entomological Society.

André, M. (1959). Note complémentaire sur *Tetranychus neocaledonicus* André. *Acarologia* **1**: 53-55.

Davis, J.J. (1968). Studies of Queensland Tetranychidae. 3. Records of the genus *Tetranychus*. *Queensland Journal of Agricultural and Animal Science* **25**: 57-67.

Gutierrez, J. & Schicha, E. (1983). The spider mite family Tetranychidae (Acari) in New South Wales. *International Journal of Acarology* **9**: 99-116.

Navajas, M., Gutierrez, J., Lagnel, J. & Boursot, P. (1996). Mitochondrial cytochrome oxidase I in tetranychid mites: a comparison between molecular phylogeny and changes of morphological and life history traits. *Bulletin of Entomological Research* **86**: 407-417.

Bolland, H.R., Gutierrez, J. & Flechtmann, C.H.W. (1998). *World Catalogue of the Spider Mite Family (Acari: Tetranychidae).* Leiden, Boston: Brill.

T. rhagodiae Miller 1966

Synonyms or Changes in Combination or Taxonomy:
None.

Common names:
Saltbush spider mite (AICN version 1.31)

Hosts:
Rhagodia billardieri (Miller 1966).

Distribution:
Australia (Tas, Miller 1966).

Part of Plants Affected:
Foliage

Features:
Female: Empodia with 6 proximoventral hairs; spurs on empodia I-IV minute or absent (Photo Trh1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Trh2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 37-47 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 6-7 µm (Photo Trh2); peritreme hook = 10-12 µm long (Photo Trh3); dorsal striae between setae *e1-e1* transverse and oblique; dorsal striae between setae *f1-f1* mixed, mostly oblique; dorsal striae between setae *e1* and *f1* transverse and oblique forming a weak-diamond shape (Photo Trh4; Figure Trh1); dorsal striae with lobes; ventral striae without lobes; pregenital striae generally entire, not all longitudinal (some oblique) (Photo Trh5; Figure Trh2).

Male: Empodia I-IV each with minute dorsal spur; empodia I claw-like (uncinate), empodia II also claw-like, empodia III-IV with proximoventral hairs long and free. Aedeagus as in Figure Trh3.

Biology:
This species is known only from the Tasmanian saltbush.

Economic Importance:
None.

Reference:

Miller, L.W. (1966). The tetranychid mites of Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* **100**: 53-66 (**holotype** as *T. rhagodiae*)

T. urticae Koch 1836

Synonyms or Changes in Combination or Taxonomy:
(From Bolland *et al.* (1998), references not listed)

Acarus telarius Linnaeus 1758
Tetranychus telarius (L.) Dugès 1834
Synonymy: Smith & Baker 1968

Acarus sambuci Schrank 1781
Tetranychus sambuci (Schrank) Koch 1842
Epitetranychus sambuci (Schrank) Oudemans 1931
Synonymy: Pritchard & Baker 1955

Acarus textor Fourcroy 1785
Tetranychus textor (Fourcroy) Oudemans 1929
Synonymy: Pritchard & Baker 1955

Tetranychus russeolus Koch 1838
Synonymy: Pritchard & Baker 1955

Tetranychus viburni Koch 1838
Schizotetranychus viburni (Koch)
Synonymy: Pritchard & Baker 1955

Tetranychus fervidus Koch 1841
Synonymy: Pritchard & Baker 1955

Acarus cucumeris Boisduval 1867
Tetranychus cucumeris (Boisduval) Murray 1877
Synonymy: Pritchard & Baker 1955

Acarus rosarum Boisduval 1867
Tetranychus rosarum (Boisduval) Murray 1877
Synonymy: Pritchard & Baker 1955

Acarus cinnabarinus Boisduval 1867
Tetranychus cinnabarinus (Boisduval) Boudreaux 1956
Synonymy: Dupont 1979

Acarus haematodes Boisduval 1867
Tetranychus haematodes (Boisduval) Murray 1877
Synonymy: Smith & Baker 1968

Acarus ferrugineus Boisduval 1867
Tetranychus ferrengineus (Boisduval) Murray 1877
Synonymy: Pritchard & Baker 1955

Acarus vitis Boisduval 1867

Tetranychus vitis (Boisduval) Murray 1877
Synonymy: Pritchard & Baker 1955

Distigmatus pilosus Donnadieu 1875
Synonymy: Pritchard & Baker 1955

Tetranychus major Donnadieu 1875
Synonymy: Pritchard & Baker 1955

Tetranychus piger Donnadieu 1875
Synonymy: Pritchard & Baker 1955

Tetranychus minor Donnadieu 1875
Synonymy: Pritchard & Baker 1955

Tetranychus longitarsus Donnadieu 1875
Synonymy: Pritchard & Baker 1955

Tetranychus plumistoma Donnadieu 1875
Synonymy: Pritchard & Baker 1955

Tetranychus plumistoma Donnadieu 1875
Synonymy: Pritchard & Baker 1955

Tetranychus fici Murray 1877
Synonymy: Pritchard & Baker 1955

Tetranychus eriostemi Murray 1877
Synonymy: Pritchard & Baker 1955

Tetranychus dugesii Cano & Alcacio 1886
Synonymy: Estebanes & Baker 1968)

Tetranychus inaequalis Targioni Tozzetti 1878
Synonymy: Pritchard & Baker 1955

Tetranychus bimaculatus Harvey 1892
Synonymy: Pritchard & Baker 1955

Tetranychus altheae von Hanstein 1901
Epitetranychus altheae (von Hanstein) Zacher 1916
Synonymy: Pritchard & Baker 1955

Epitetranychus aequans Zacher 1916
Synonymy: Pritchard & Baker 1955

Epitetranychus alceae Oudemans 1928
Synonymy: Pritchard & Baker 1955

Tetranychus reinwardtiae Oudemans 1930

Epitetranychus reinwardtiae (Oudemans) Oudemans 1931
Synonymy: Pritchard & Baker 1955

Epitetranychus caldarii Oudemans 1931
Tetranychus caldarii (Oudemans) Geijskes 1939
Synonymy: Pritchard & Baker 1955

Tetranychus aspidistrae Oudemans 1931
Synonymy: Pritchard & Baker 1955

Tetranychus choisyae Oudemans
Synonymy: Pritchard & Baker 1955

Tetranychus fragariae Oudemans 1931
Synonymy: Pritchard & Baker 1955

Tetranychus fransseni Oudemans 1931
Synonymy: Pritchard & Baker 1955

Tetranychus manihotis Oudemans 1931
Synonymy: Pritchard & Baker 1955

Tetranychus stellariae Oudemans 1931
Synonymy: Pritchard & Baker 1955

Tetranychus violae Oudemans 1931
Synonymy: Pritchard & Baker 1955

Eotetranychus inexspectatus Andre 1933
Synonymy: Pritchard & Baker 1955

Eotetranychus curcurbitacearum Sayed 1946
Synonymy: Pritchard & Baker 1955

Tetranychus multisetis McGregor 1950
Synonymy: Pritchard & Baker 1955

Tetranychus arabicus Attiah 1967
Synonymy: Meyer 1987

Tetranychus aduncus Flechtmann & Baker 1967
Synonymy: Flechtmann & Baker 1970

Tetranychus ricinus Saba 1973
Synonymy: Meyer 1987

Common names:

Carmine spider mite (CABI CPC, for *T. cinnabarinus*)
Common red spider mite (CABI CPC, for *T. cinnabarinus*)
Glasshouse red spider mite (CABI CPC, for *T. urticae*)

Hop red spider mite (CABI CPC, for *T. urticae*)
Linden mite
Red spider mite (CABI CPC, for *T. cinnabarinus*)
Tropical red spider mite (CABI CPC, for *T. cinnabarinus*)
Two-spotted spider mite

Systematic note:

Here, *T. urticae* is considered the same as *T. cinnabarinus* after Dupont (1979). *Tetranychus cinnabarinus* is usually the carmine form of the two-spotted spider mite, but some are also green (Zhang & Jacobson 2000). Nevertheless, the red and green forms are often split into *T. cinnabarinus* and *T. urticae*, respectively. These taxa comprise populations that, in some localities, seem to be distinguishable (Zhang & Jacobson 2000). Nevertheless, research shows the forms can exhibit a wide degree of reproductive compatibility (Sugasawa *et al*. 2002) suggesting that the species-boundary between *T. urticae* and *T. cinnabarinus* is a complex issue and one that is yet to be resolved.

Zhang & Jacobson (2000) recommended morphological characters to distinguish the species. The procedure is to mount 10 female mites and take measurements of:

(a) Number of solenidia on tibia I;
(b) Ratio of the length of seta *v2* to the distance between seta *v2* and seta *sc1*, i.e., *v2*/(*v2-sc1*);
(c) Distance between the genital setae *g1-g1*;
(d) Ratio of the length of the subcapitular seta to the distance between the subcapitular setae, i.e., *m*/(*m-m*).

Tetranychus urticae and *T. cinnabarinus* are distinguished by the following characteristics (Zhang & Jacobson 2000):

T. urticae: (a) 9 setae and 1 solenidion on tibia I; (b) *v2*/(*v2-sc1*) = 3.06 ± 0.06; (c) *g1-g1* 38.1 ± 0.07; (d) *m*/(*m-m*) = 0.93 ± 0.01.

T. cinnabarinus: (a) 9 setae and 1-4 solenidia on tibia I; (b) *v2*/(*v2-sc1*) = 3.18 ± 0.02; (c) *g1-g1* 31.5 ± 0.4; (d) *m*/(*m-m)* = 0.88 ± 0.01.

Note that the species cannot be distinguished without a significant sample of mites: at least 5 and preferably 10 adult female specimens.

We have examined Australian *T. urticae*, but these characters do not match Australian specimens. The tibial solenidia can be variable (we have found one population of *T. urticae* with 1 or 4 tibial solenidia), but variability in the number of tibial solenidia was also observed in other species and was usually the female expressing the male condition. More significantly, the other characters were never close to the means of either *T. urticae* or *T. cinnabarinus*. Although none of our collections had the ten specimens recommended, we would have expected the

means to at least be close to those reported by Zhang & Jacobson (2000), should their diagnosis be useful on a global scale. Our data, expressed as ranges, are:

T. urticae, cotton, Forest Hill, Qld, 7 females: Tibia I=9+1; v2/(v2-sc1) = 4.11-4.76; g1-g1 = 26-28; m/(m-m) = 1.08 – 1.19.
T. urticae, Ormiston DPI, Qld, 8 females: Tibia I=9+1; v2/(v2-sc1) = 3.85-4.72; g1-g1 = 25-30; m/(m-m) not measured.
T. urticae, violet, Cambridge, Tas., 3 females: Tibia I=9+1; v2/(v2-sc1) = 4.00-4.47; g1-g1 = 25-33; m/(m-m) = 1.07 – 1.10.
T. urticae, nasturtium, Woolloongabba, Qld, 8 females: Tibia I=9+1 or 9+4; v2/(v2-sc1) = 4.04-4.41; g1-g1 = 25-29; m/(m-m) = 0.92 – 1.04.

Cuticular lobes have also been used to distinguish *T. cinnarbarinus* and *T. urticae* (Brandenburg & Kennedy 1981), but this character of limited use due to variation in lobe shape within species (Mollet & Sevacherian 1984; Carbonnelle & Hance 2004). Additionally, Carbonnelle & Hance (2004) report some *T. urticae* with no lobes on their dorsal and ventral surfaces. Here, we have avoided using lobe shape as a diagnostic character, but the distribution of lobes on the body has proven useful for some species determinations.

Hosts:

Numerous, Bolland *et al.* (1998) lists 933 host plants.

Distribution:

Australia: Published records from throughout Australia, except Northern Territory (Rainbow 1906; Froggatt 1921; Womersley 1940; Evans 1942; Miller 1966; Davis 1968; Readshaw 1975; Southcott 1976; Hassan 1977; Southcott 1978; Lee & Southcott 1979; Carmody *et al.* 1981; Edge & James 1982; Gutierrez & Schicha 1983; James 1990; James & Whitney 1991). World-wide: e.g., Norway, Indonesia, New Zealand (Bolland *et al.* 1998).

Part of Plants Affected:

Leaves, green stems, fruit. These mites can cause extensive damage and plant death.

Features:

Female: Empodia with 6 proximoventral hairs; spurs on empodia I-IV absent (Photo Tur1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tur2); the additive distance between the base of each proximal seta and the base of the proximal duplex seta = 25 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 10-12 µm (Photo Tur2); peritreme hook ca. 25 µm long (Photo Tur3); dorsal striae between setae *e1-e1* longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Tur4); dorsal striae with lobes; ventral striae

without lobes; pregenital striae generally entire (Photo Tur5), sometimes sparse and with small breaks medially (Photo Tur6).

Male: Empodia I-IV each with strong dorsal spur 4 µm long; empodia I claw-like (uncinate) (Photo Tur7), empodia II-IV with proximoventral hairs long and free (Photo Tur8). Aedeagus as in Photo Tur9.

Green forms are collected in cool temperate climates, carmine forms in warm temperate and subtropical zones. The carmine forms can reproduce all-year round, but green forms have a diapause form that is yellow-orange in colour (Gutierrez & Schicha 1983). Summer females have a dark spot on each side of the body (Gutierrez & Schicha 1983).

T. urticae belongs in a group of species that can only be distinguished by the shape of the male aedeagus.

DNA: ITS2 region of the nuclear ribosomal DNA (Navajas *et al.*1992; Knapp *et al.* 2003); CO1 mtDNA gene (Navajas *et al*. 1996; Navajas & Boursot 2003).

Biology:

Overwintering adults on ground or in sheltered places such as bark (Gutierrez & Schicha 1983). Life tables for this species are provided by Carey & Bradley (1982).

Economic Importance:

Amongst the most damaging of mite pests; heavy infestations can destroy crops and kill trees. Control is usually achieved through careful applications of pesticides and the use of natural enemies as part of a pest-management program. Outbreaks of this species are often caused by the over-use of insecticide intended for other pests.

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PART 3: *Tetranychus* spp. of Quarantine Concern

T. canadensis (McGregor 1950)

Synonyms or Changes in Combination or Taxonomy:

Septanychus canadensis McGregor 1950
Tetranychus canadensis (McGregor) Pritchard & Baker 1952

Common names:

Four-spotted spider mite

Hosts:

Abelmoschus esculentus, *Aesculus hippocastanum*, *Althaea rosea*, *Asclepias* sp., *Atriplex canescens*, *Atriplex polycarpa*, *Atriplex semibaccata*, *Azadirachta indica*, *Carya cordiformis*, *Castanea* sp., *Cryptanthus angustifolia*, *Diervilla* sp., *Echinochloa colona*, *Fagus grandifolia*, *Fraxinus pennsylvanica, Gossypium hirsutum*, *Gymnocladus canadensis*, *Hamamelis virginiana*, *Hordeum vulgare*, *Ipomoea batatas*, *Lycopersicon esculentum*, *Maclura pomifera*, *Magnolia* sp., *Malus domestica*, *Malus* sp., *Melia* sp., *Phaseolus* sp., *Polygonatum biflorum*, *Populus* sp., *Potentilla hippiana*, *Prunus americana*, *Prunus domestica*, *Prunus* sp., *Prunus virginiana*, *Pyrus baccata*, *Rhus hirtellum*, *Rosa multiflora*, *Rosa* sp., *Secale cereale*, *Thalictrum fendleri*, *Tilia americana, Tilia* sp., *Trifolium pratense*, *Triticum aestivum*, *Ulmus americana*, *Ulmus laevis*, *Ulmus rubra*, *Ulmus* sp., *Viburnum opulus*, *Zanthoxylum americanum*, *Zea mays*. (Bolland *et al.* 1998).

Distribution:

Canada, Hungary, Poland, USA (Bolland *et al.* 1998). Claims that this species is also in Africa and Middle-East (Jeppson *et al*. 1975) cannot be substantiated by specimens or published records (e.g., the species is not reported in Smith-Meyer's review of African Tetranychidae (1987)).

Part of Plants Affected:

Foliage.

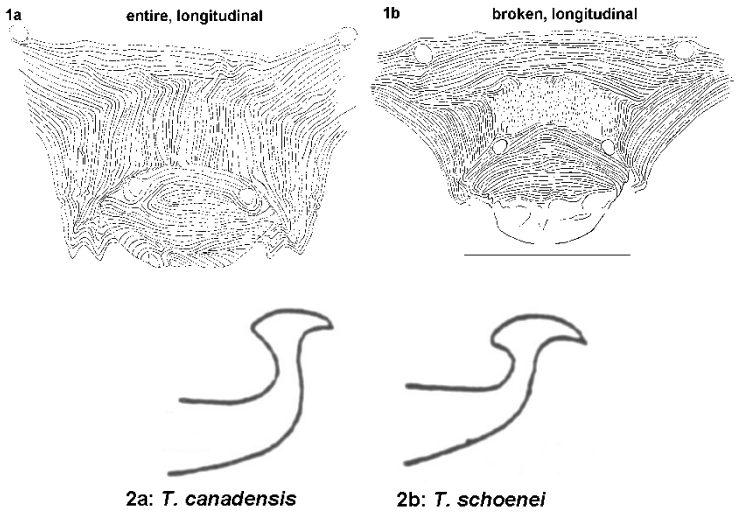
Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with minute-absent dorsal spur (Photo Tca1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tca2);

the additive distance between the base of each proximal seta and the base of proximal duplex seta = 20-28 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 7-8 µm (Photo Tca2); peritreme hook = 19-22 µm long (Photo Tca3); dorsal striae between setae *e1-e1* and *e1-f1* transverse, dorsal striae between *f1-f1* longitudinal (Figure Tca1, Photo Tca4); dorsal striae without lobes (Photo Tca4) in specimens we examined, but reputedly there are numerous small lobes in other specimens (Baker & Tuttle 1994); ventral striae without lobes (Photo Tca5); pregenital striae entire (Photo Tca6; 1a below).

Male: Empodia I-IV each with dorsal spur. Aedeagus as in 2a (below) and somewhat discernable in Photo Tca7 (poor specimen).

This species is almost identical to *T. schoenei* except that female *T. canadensis* have entire pregenital striae (1a), while female *T. schoenei* have broken pregenital striae (1b). The male aedeagus is very similar in both species, but *T. schoenei* purportedly has a longer posterior projection and a more acute curve in the anterior margin (2b) than does *T. canadensis* (2a). Jeppson *et al.* (1975) and Reece (1963) distinguish *T. canadensis* from *T. schoenei* on the basis of the aedeagal shape alone. We were unable to source specimens of this *T. schoenei* for comparison.



Biology:

Life history

Although Jeppson *et al.* (1975) records this species as a pest on several crops, we have not found data on the biology of this species. They cause typical spider mite damage: rusty-speckling of leaves followed by leaf senescence. Damage from *T. canadensis* is typically confined to tree-tops (Jeppson *et al.* 1975). These mites produce little webbing in their colonies. Females overwinter on tree-trunks and in soil at the base of trees (Jeppson *et al.* 1975). Its distribution suggests that *T. canadensis* is a cool-climate species.

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as "soft" on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

Their presence in Poland and Hungary shows they have the capacity to be moved long distances. Their overwintering life stage is probably obligate (Jeppson *et al.* 1975), thus, overwintering females may hide in natural cavities in produce and nursery stock.

Establishment potential

Their reasonably extensive and diverse host-list of 51 spp. suggests that the mites have a high chance of establishment on live plants. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus canadensis* occurs in

cool temperate countries, so we would expect this species to spread through southern Australia.

Economic Importance:

This species is occasionally a pest of apple, plum and cotton (Pritchard & Baker 1955), and damage has been recorded on apple, barley, beans, corn, cotton, crab apple, elm, horse chestnut, linden, Osage orange, okra, peach, poplar, plum, red clover, rose, rye, sweet potato, tomato, umbrella tree, wheat, and several ornamental species (Jeppson *et al.* 1975). The occurrence of damage to wheat, barley and rye seems unusual for a *Tetranychus*, as does the record of damage to citrus. In a recent review of mite pests of *Citrus*, *T. canadensis* was not mentioned, yet another 15 species of *Tetranychus* were considered as minor pests (Gerson 2003).

Consequences:

The paucity of literature on *T. canadensis* supports Pritchard & Baker's (1955) observation that the species is an occasional pest. Thus, we would expect *T. canadensis* to cause sporadic damage to a variety of hosts, especially in southern parts of Australia. However, markets for pome and stone fruit and grapes could be affected. For example, South Africa prohibits apple and pear imports from areas infested with *T. canadensis*.

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T. desertorum Banks 1900

Note:

For more information see *T. desertorum* under Naturalised species.

Synonyms or Changes in Combination or Taxonomy:

Tetranychus opuntiae Banks 1908
Tetranychus thermophilus Ewing 1926
Septanychus argentinus McGregor 1943
Septanychus deserticola McGregor 1950
Septanychus taxazona McGregor 1950
All synonymised by Baker & Pritchard (1953)

Common names:

Desert spider mite (CABI CPC, Jeppson *et al.* 1975)
Prickly pear spider mite (AICN version 1.31)
Prickly pear red spider mite (AICN version 1.31)

Hosts:

Numerous: Bolland *et al*. (1998) records193 host plants.

Distribution:

Argentina, Australia, Bolivia, Brazil, Chile, China, Colombia, Costa Rica, Haiti, Hawaii, Mexico, Nicaragua, Okinawa Island, Paraguay, Peru, Puerto Rico, USA, Venezuela (Bolland *et al*. 1998).

The record of *T. desertorum* in Japan by Bolland *et al.* (1998) is an error: although originally reported (Ehara 1956), this identification was later changed to *T. ludeni* (Ehara & Masaki 1989).

The record of *T. desertorum* in Australia by Walter (1999) is a misidentification; the specimens are *T. ludeni* (*pers. obs*.). The original records of *T. desertorum* (Dodd 1929, 1940) are unsubstantiated and this species should be considered absent from Australia.

Part of Plants Affected:

Foliage.

Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with small to minute dorsal spur (≤2 µm) (Photo Tde1); tarsus I with bases of 4 tactile setae overlapping (sometimes 1-2 setae up to 2 µm proximal) with the base of the proximal duplex seta; the additive distance between the base of each proximal seta and the base of proximal duplex seta = 0-2 µm; tarsus I, the distance between the base of proximal duplex seta and base of distal duplex seta = 23-25 µm; peritreme hook ca. 30 µm long; dorsal striae between setae *e1-e1* mixed oblique, transverse and longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between *e1* and *f1* transverse/oblique

forming a diamond-shape (Photo Tde2); dorsal striae with lobes; ventral striae without lobes; pregenital striae entire (Photo Tde3).

Male: Empodia I-IV each with obvious dorsal spur 3-4 µm long; empodia I claw-like (uncinate) (Photo Tde4), empodia II claw-like (uncinate), or with free proximoventral hairs – we feel there are different species labelled *T. desertorum* amongst the specimens we borrowed – empodia III-IV with proximoventral hairs long and free (Photo Tde5). Aedeagus as in Photo Tde6.

Biology:

Life history

Confusion of *T. desertorum* with *T. ludeni* makes interpreting host-lists and records on its biology prone to error. Its distribution is likely to be tropical to sub-tropical, and the mites are a pest problem in warm, humid zones (Jeppson *et al.* 1975). Damage is of the typical spider mite type: speckling of leaves eventually causing leaf senescence.

Egg-adult takes 5.8 to 11.2 days, averaging 8.3 days. The average time for the egg to hatch is 2 days in summer and 4 to 5 days in winter. The optimum temperature for development was 30 ºC when tested at 17, 25, 30 and 33.5 ºC and 85-90% RH. The mites do not survive for extended periods below 10 ºC (Nickel 1960; Jeppson *et al.* 1975).

In winter, these mite occur on “native” hosts in Paraguay (but these are weeds in Australia, such as sow thistle, horehound and *Verbena*), where they prefer low-growing hosts that are protected (presumably from frosts) by grasses. In mid-late spring the mites attack seedling cotton and maximum reproduction occurs in mid-summer. Heavy rains apparently adversely affect populations (Jeppson *et al.* 1975).

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development

rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

The presence of *T. desertorum* in China may represent an introduction, but may also represent their natural range or confusion with *T. ludeni*. Overwintering females may hide in natural cavities in produce and nursery stock. However, their reported inability to survive at low temperatures would reduce the chance of survival on produce in cold-storage.

Establishment potential

The reasonably extensive and diverse host-list of *T. desertorum* of 193 spp. demonstrates a high chance of establishment on live plants, although this number of hosts may be inflated by confusion with *T. ludeni*. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they would have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately..

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus desertorum* occurs in tropical and sub-tropical zones, so we would expect this species to spread through similar areas of Australia.

Economic Importance:

The species is an important pest of cotton in the southern USA (Baker & Pritchard 1953). Jeppson *et al.* (1975) considers this species a pest in Argentina, Brazil, Nicaragua, Paraguay, Peru, Australia, Japan, and Mexico. However, we have no evidence of this species in Australia, let alone it being recorded as a pest species.

Consequences:

Overseas, the species is apparently a major pest in tropical and subtropical areas, at least on cotton. We would expect its incursion to result in a significant cost in the management of mite pests. However, the impact of *T. desertorum* on many of its hosts is poorly known, especially because the confusion between *T. ludeni* and *T. desertorum* raises questions about past identifications.

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Ewing, H.E. (1926). Two new spider mites (Tetranychidae) from Death Valley, California (Acarina). *Entomological News* **37**: 142-143 (as *T. thermophilus*)

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Walter, D.E. (1999). Cryptic inhabitants of a noxious weed: mites (Arachnida: Acari) on *Lantana camara* L. invading forests in Queensland. *Australian Journal of Entomology* **38**: 197-200.

T. evansi Baker & Pritchard 1960

Synonyms or Changes in Combination or Taxonomy:

None.

Common names:

Red spider mite (CABI CPC)
Tobacco spider mite

Hosts:

Abelmoschus esculentus, *Amaranthus retroflexus*, *Anacardium occidentale*, *Arachis hypogaea*, *Arachis prostrata*, *Artemisia douglasiana*, *Asystasia gangetica*, *Bixa orellana*, *Capsicum annuum*, *Carica papaya*, *Convolvulus arvensis*, *Cupressus sempervirens*, *Datura stramonium*, *Dieffenbachia picta*, *Gossypium* sp., *Ipomoea batatas*, *Lycopersicon esculentum*, *Lycopersicon* sp., *Malva sylvestris*, *Nicandra physalodes*, *Nicotiana glauca*, *Nicotiana tabacum*, *Pelargonium* sp., *Phacelia* sp., *Phaseolus vulgaris*, *Physalis peruviana*, *Physalis* sp., *Psidium guajava*, *Pyrus communis*, *Rosa* sp., *Salpichroa origanifolia*, *Sida acuta*, *Solanum americanum*, *Solanum elaeagnifolium*, *Solanum incanum*, *Solanum jilo*, *Solanum mauritianum*, *Solanum melongena*, *Solanum nigrum*, *Solanum panduraeforme*, *Solanum* sp., *Solanum tuberosum*, *Triumfetta semitriloba*, *Triumfetta* sp. (Bolland *et al.* 1998).

Distribution:

Brazil, Congo, Mauritius, Morocco, Mozambique, Puerto Rico, Reunion, Rodrigues Island, Seychelles, Spain, Tunisia, USA, Virgin Islands, Zambia, Zimbabwe (Bolland *et al*. 1998); Portugal (Bolland & Vala 2000).

Part of Plants Affected:

Foliage.

Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with minute dorsal spur (< 2 µm) (Photo Tev1; Figure Tev1); tarsus I with bases of 4 tactile setae overlapping with the base of the proximal duplex seta (Photo Tev2; Figure Tev2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 0 µm; tarsus I, the distance between the base of proximal duplex seta and base of distal duplex seta = 18-25 µm (Photo Tev2; Figure Tev2); peritreme hook = 33-41 µm long (Photo Tev3; Figure Tev3); dorsal striae between setae *e1-e1* longitudinal and oblique; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Tev4); dorsal striae with lobes; ventral striae without lobes; pregenital striae entire (Photo Tev5; Figure Tev5), but striae can be weak medially (Figure Tev6).

Male: Empodia I-IV each with obvious dorsal spur 4 µm long; empodia I claw-like (uncinate) (Photo Tev6; Figure Tev7), empodia II uncinate (Photo Tev7; Figure Tev7), empodia III-IV with proximoventral hairs long and free (Photo Te7; Figure Tev7). Aedeagus as in Photo Tev8 and Figure Te8.

Female mites initially lay deep-orange orange, becoming light orange as eggs are laid until females lay transparent eggs; all eggs become rust-red prior to hatching (Qureshi *et al.* 1969, Bolland & Vala 2000). Larvae and nymphs are greenish-yellow except when newly moulted they are cream-coloured; adult males are light-orange, adult females are reddish-orange (Qureshi *et al.* 1969).

DNA: RFLP of the ITS2 region of the nuclear ribosomal DNA, see Knapp *et al.* (2003).

Biology:

Life history

Tetranychus evansi is a well-known pest of several crops, but the main crop attacked is tomato. The species has a tropical and sub-tropical distribution. Colonies usually occur beneath leaves, but at high humidity they also infest the dorsal surfaces. High populations of *T. evansi* can create extensive webbing over their host plants (Qureshi *et al.* 1969). Although they can overwinter, they often remain active throughout the year where winters are mild (Qureshi *et al.* 1969; Jeppson *et al.* 1975).

Life-cycle data is conflicting, but broadly confirms their preference for warm climates. At 22.8 ºC and 19.5 ºC, egg-adult takes 6.5 days and 17.5 days, respectively (Jeppson *et al.* 1975). The lower development threshold is 10ºC (Bonato 1999) to 13ºC (de Moraes & McMurtry 1987). Their highest intrinsic rate of increase is 0.432 at 35 ºC (de Moraes & McMurtry 1987) or 0.355 at 31ºC (Bonato 1999). Bonato (1999) concluded that 34 ºC would be the optimum temperature for *T. evansi.* This temperature is apparently similar to the optimum temperatures of *T. mcdanieli* and some populations of *T. urticae*, but warmer than the 30 ºC reported for *T. desertorum, T. neocaledonicus* and some other populations of *T. urticae*.

Qureshi *et al.* (1969) reported an egg-adult time of 8.9 days at 23.3 ºC, and a preoviposition period of 21.5 hours. Each female produced an average of 164 eggs over 26.7 days. Bonato (1999) recorded a maximum fecundity of 123.3 eggs/female at 31 ºC.

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as

predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

Their wide distribution reflects several introduction events, at least in Portugal and southern Africa. In the latter countries this species has caused significant damage to tomato crops. Overwintering females may hide in natural cavities in produce and nursery stock.

Establishment potential

Their host-list of 44 spp. represents a diversity of plants, but especially hosts in the Solanaceae. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they would have a high chance of establishing a population. *Tetranychus evansi* has apparently established on several occasions in other countries.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can quickly become unmanageable once this happens. *Tetranychus evansi* occurs in tropical and sub-tropical zones, so we would expect this species to spread through agricultural regions of northern Australia.

Economic Importance:

This species of mite may severely damage and kill its host plant in 3-5 weeks after infestation, especially tomato, potato, peanut and eggplant (Qureshi *et al.* 1969).

Consequences:

Tetranychus evansi is a major pest in many countries, especially in tropical and subtropical regions. Its incursion into Australia would be expected to have significant economic impact on primary producers through loss of yield and increased costs in control measures for this pest.

References:

Baker, E.W. & Pritchard A.E. (1960). The tetranychoid mites of Africa. *Hilgardia* **29**: 455-574 (**holotype** as *Tetranychus evansi*)

Qureshi, A.H., Oatman, E.R. & Fleschner, C.A. (1969). Biology of the spider mite, *Tetranychus evansi. Annals of the Entomological Society of America* **62**: 898-903.

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T. fijiensis Hirst 1924

Note:

For more information see *T. fijiensis* Hirst 1924 under Naturalised species section. This species was first detected in the Northern Territory in 2002, where it has been present since at least 1992.

Synonyms or Changes in Combination or Taxonomy:

Pritchardina fijiensis (Hirst) Rimando 1962
Tetranychus fijiensis Hirst, Manson 1963

Common names:

None.

Hosts:

Actinophloeus macarthurii, *Areca catechu*, *Carica papaya*, *Citrus medica*, *Citrus paradisi, Citrus reticulata*, *Citrus* sp., *Cocus nucifera*, *Cyrtosperma chammissonis*, *Dieffenbachia picta*, *Dieffenbachia* sp., *Disoxylum bijugum*, *Latania* sp., *Morus alba*, *Prunus persica*, *Ptychosperma macarthurii*, *Ptychosperma* sp., *Pyrus communis*, *Seaforthia* sp. (Bolland *et al.* 1998). Also: frangipani, betel palm, Macarthur feather palm (Flechtmann & Knihinicki 2002).

Distribution:

Australia (N.T., Flechtmann & Knihinicki 2002), Carolina Islands, Fiji, Hainan Island, India, Kiribati, Malaysia, Mariana Islands, Marshall Islands, New Caledonia, Papua New Guinea, Philippines, Seychelles, Taiwan, Thailand (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage.

Features:

This species is distinguished by the extremely long aedeagus in the male (Figure Tfi1), and the presence of 4, not 6, proximoventral hairs on the empodia of the female, and obvious dorsal spurs (Figure Tfi2). Females also have a very short peritreme hook (Figure Tfi3), pregenital striae entire though can be weak medially (Figure Tfi4). Male with: empodia I claw-like (uncinate), with obvious dorsal spur (Figure Tfi5), empodia II-IV with proximoventral hairs free and obvious dorsal spur (Figure Tfi6).

Females are orange-red, eggs are light purple to purple, nymphs are pale yellow to green (Daniel 1977).

Biology:

Life history

Tetranychus fijiensis is known from a relatively small list of 21 host species, and is best-known as a pest of palm trees. The species has a

tropical distribution. On coconut, mites are most abundant in early summer and mid-autumn, reaching densities of 5-6 mites per leaflet (Sarkar & Somchoudhury 1989). On betelnut, they are most abundant in summer (Daniel 1977). This species is recorded as an occasional problem on these host plants.

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as "soft" on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

Tetranychus fijiensis was first collected in the Northern Territory in 1992 (Flechtmann & Knihinicki 2002), but it remained undiagnosed for about a decade.

Establishment potential

Once a suitable host is found, spider mites should have little problem establishing a population. Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

The species is likely to spread via wind migration and through movement of plant material within Australia, at least throughout tropical zones.

Economic Importance:

Tetranychus fijiensis is common on coconut in India, but damage is not serious (Gupta & Gupta 1994), although Sarkar & Somchoudhury (1989) suggest otherwise. This species has also been recorded as a minor pest of *Citrus* spp. (Gerson 2003).

Consequences:

Minor. This species is unlikely to cause more than sporadic damage to some commercial species of palms.

References:

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Rimando, L. (1962). The tetranychoid mites of the Philippines. *Univ. Philipp. Coll. Agric. Techn. Bull.* **11**: 1-52 (as *Pritchardina fijiensis*)

Manson, D.C.M. (1963). Mites of the families Tetranychidae and Tenuipalpidae associated with citrus in South East Asia. *Acarologia* **5**: 351-364.

Daniel, M. (1977). The spidermite *Tetranychus fijiensis* Hirst on the betelnut palm. *Acarologia* **19**: 220-221.

Sarkar, P.K. & Somchoudhury, A.K. (1989). Influence of major abiotic factors on the seasonal incidence of *Raoiella indica* and *Tetranychus fijiensis* on coconut. In: Progress in Acarology, Vol. 2 (Eds Channabasavanna, G.P. and Viraktamath, C.A.). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. pp. 59-65.

Gupta, S.K. & Gupta, Y.N. (1994). A taxonomic review of the Indian Tetranychidae (Acari: Prostigmata) with descriptions of new species, re-descriptions of known species and keys to genera and species. *Memoirs of the Zoological Survey of India* **18**: 1-196.

Gerson, U. (2003). Acarine pests of citrus: overview and non-chemical control. *Systematic & Applied Acarology* **8**: 3-12.

T. gloveri Banks 1900

Synonyms or Changes in Combination or Taxonomy:

Tetranychus quinquenychus McGregor 1914
Tetranychus antillarum Banks 1917
Both synonymised by Boudreaux (1979).

Tetranychus tumidus Boudreaux 1958

Tetranychus gloveri Boudreaux 1979
Note: from Boudreaux (1958) until Boudreaux (1979), the names *T. tumidus* and *T. gloveri* were used interchangeably, i.e., *T. tumidus* = *T. gloveri* and vice-versa. Since Boudreaux (1979), authors may still erroneously mix the names up (e.g., Baker & Tuttle 1994). *Tetranychus tumidus* is largely confined to water hyacinth (Halliday 2000).

Common names:

Bank's spider mite (CABI CPC)
Cotton spider mite
Glover's spider mite (CABI CPC)
Tumid mite (in reference to its confused species name)

Systematic note:

The original and only record of *T. gloveri* in Australia (Womersley 1942) was incorrect: Womersley really had specimens of *Oligonychus digitatus* (Davis 1968). We have examined the specimens in question, and concur with Davis. Therefore, *T. gloveri* is absent from Australia.

Hosts:

Numerous: 88 recorded in Bolland *et al.* (1998).

Distribution:

American Samoa, Bermuda, Brazil, Colombia, Costa Rica, Cuba, French Polynesia, French West Indies, Guam Island, Hawaii, Honduras, Mariana Islands, Mexico, Panama, Puerto Rico, Surinam, Trinidad, USA, Venezuela (Bolland *et al*. 1998). Absent from Australia (see our systematic note).

Part of Plants Affected:

Foliage.

Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with obvious dorsal spur on 4-5 µm long (Photo Tgl1); tarsus I with bases of 1-3 tactile setae overlapping with the base of the proximal duplex seta (Photo Tgl2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 10-12 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 16-19 µm (Photo Tgl2); peritreme hook = 21-27 µm

long (Photo Tgl3); dorsal striae between setae *e1-e1* longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Tgl4); dorsal striae with lobes; ventral striae between genital area and setae *1a* with lobes (Photo Tgl5); pregenital striae broken, becoming dots medially, and sometimes appearing to have lobes (Photo Tgl6).

Male: Empodia I-IV each with obvious dorsal spur 4-5 µm long; empodia I claw-like (uncinate) (Photo Tgl7), empodia II-IV each with proximoventral hairs long and free (Photo Tgl8). Aedeagus as in Photo Tgl9, and is apparently different from *T. tumidus* by its larger aedeagal knob (Boudreaux 1979).

Females are red (Jeppson *et al*. 1975), eggs are colourless when laid, as opposed to *T. tumidus* which have red eggs when laid (Boudreaux 1979).

In the specimens we examined, there was variation in the number of proximal setae on tarsus I that overlap with the proximal duplex seta.

DNA: CO1 mtDNA gene (Navajas *et al*. 1996).

Biology:

Life history

Tetranychus gloveri is reported as a serious pest of cotton, celery, beans, eggplant, beetroot, okra, peas and sweet potato, where it causes rusty speckling and blotches on leaves and the eventual death or the host (Jeppson *et al.* 1975). Despite reports of its seriousness, little seems to be known of the biology of *T. gloveri*. The species prefers tropical and warm sub-tropical climates.

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development

rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

This species is widespread in the Pacific and the Americas, which may represent its natural range. Overwintering females may hide in natural cavities in produce and nursery stock.

Establishment potential

Tetranychus gloveri is known from 88 spp. host species. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they would have a high chance of establishing a population. Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately..

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus gloveri* occurs in tropical and warm sub-tropical zones, so we would expect this species to spread through agricultural regions of northern Australia.

Economic Importance:

Although reported as major pest of several crops (Jeppson *et al.* 1975), the impact of *T. gloveri* has been measured only for cotton, where infestations cause leaf senescence and can decrease yield of the crop by 45% (Roussel *et al.* 1951).

Consequences:

Tetranychus gloveri would probably attack plants already used by naturalised pest species such as *T. ludeni* and *T. urticae*, especially cotton. Economic impacts would result from additional pest management required due to increased pest pressure. Management of pesticide resistance may also become more costly when more species are involved.

References:

Banks, N. (1900). The red spiders of the United States (*Tetranychus* and *Stigmaeus*). *United States Department of Agriculture, Division of Entomology Technical Series* **8**: 65-77 (**holotype** as *Tetranychus desertorum*)

McGregor, E.A. (1914). Four new tetranychids. *Annuls of the Entomological Society of America* **7**: 354-364. (as *Tetranychus quinquenychus*)

Banks, N. (1917). New mites, mostly economic (Arach. Acar.). *Entomoloigcal News* **28**: 193-199. (as *Tetranychus antillarum*)

Womersley, H. (1942). Miscellaneous additions to the acarine fauna of Australia. *Transaction of the Royal Society of South Australia* **66**: 85-92 pl. III (as *Septanychus tumidus*)

Roussel, J.S., Webber, J.C., Newsom, L.D., & Smith, C.E. (1951). The effect of infestation by spider mite, *Septanychus tumidus* on growth and yield of cotton. *Journal of Economic Entomology* **44**: 523-527.

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Davis, JJ. (1968). *Oligonychus araneum* sp.n. and *Oligonychus digitatus* Davis (Acarina: Tetranychidae) as pests of grasses in Eastern Australia. *Journal of the Australian Entomological Society* **7**: 123-126.

Jeppson, L.R., Keifer, H.H. & Baker, E.W. (1975). *Mites Injurious to Economic Plants.* Berkeley: University of California Press 614 pp. (as *Allonychus braziliensis*)

Boudreaux, B. (1979). Confusion of names for the spider mites *Tetranychus tumidus* and *T. gloveri*. pp. 395-398 *in* Rodriguez, J.G. (ed.) *Recent Advances in Acarology. Proceedings of the Fifth International Congress of Acarology (East Lansing, 1978).* New York: Academic Press Vol. 2 (returned to *Tetranychus gloveri*).

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Bolland, H.R., Gutierrez, J. & Flechtmann, C.H.W. (1998). *World Catalogue of the Spider Mite Family (Acari: Tetranychidae).* Leiden, Boston: Brill 392 pp.

Halliday, R.B. (2000). Additions and corrections to *Mites of Australia: A Checklist and Bibliography*. *Australian Journal of Entomology* **39**: 233-235.

T. macfarlanei Baker & Pritchard 1960

Synonyms or Changes in Combination or Taxonomy:

None.

Common names:

Macfarlane spider mite
Red spider mite
Vegetable mite

Hosts:

Abelmoschus esculentus, *Anthyllis vulneraria*, *Arachis hypogaea*, *Citrullus lanatus*, *Clerodendrum inerme*, *Cucumis sativus*, *Curcurbita maxima*, *Curcurbita* sp., *Gossypium* sp., *Hibiscus* sp., *Ipomoea* sp., *Lablab purpureus*, *Lagenaria siceraria*, *Luffa cylindrica*, *Musa sapientum*, *Operculina turpethum*, *Phaseolus lunatus*, *Phaseolus* sp., *Pueraria phaseoloides*, *Ricinus communis*, *Sechium edule*, *Solanum melongena*, *Solenum* sp. (Bolland *et al.* 1998).

Distribution:

Canary Islands, India, Madagascar, Mauritius (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage

Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with dorsal spur 2-3 µm long (Photo Tmac1; Figure Tmac1); tarsus I with the bases of 3 tactile setae overlapping with the base of the proximal duplex seta, base of 1 tactile seta proximal to base of proximal duplex seta (Photo Tmac2; Figure Tmac2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 2 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 20-24 µm (Photo Tmac2; Figure Tmac2); peritreme hook not measurable in specimens we examined; dorsal striae between setae *e1-e1* longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and f1 transverse forming a diamond-shape (Photo Tmac3); dorsal striae with lobes; ventral striae between genital region and setae *1a* with lobes (Photo Tmac4); pregenital striae almost entire but broken medially (Photo Tmac5; Figure Tmac3).

Male: Empodia I-IV each with obvious dorsal spur 4 µm long; empodia I claw-like (uncinate) (Photo Tmac6), empodia II-IV each with proximoventral hairs long and free (Photo Tmac7). Aedeagus as in Photo Tmac8.

Newly-emerged female mites are bright-red and become deep-red with age (Jose & Shah 1989a).

Biology:

Life history

This species is known from tropical and warm sub-tropical zones where it reputedly causes severe damage to cucumber, eggplant, gourd, okra and pumpkin (Jeppson *et al.* 1975). In India, it is an occasional pest of eggplant (Gupta & Gupta 1994). At an average temperature of 32 ºC and an average R.H. of 74.3%, *T. macfarlanei* complete egg-egg generation times in 7.67 days and laid an average of 138 eggs per female (Jose & Shah 1989a). Like many spider mites, *T. macfarlanei* are able to use weeds as a host when host crops are not available (Jose & Shah 1989b). Damage is typical for spider mites: yellowish speckling, followed by leaf senescence.

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as "soft" on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

Their presence in the Canary Islands shows they have the capacity to be moved long distances. Overwintering females may hide in natural cavities in produce and nursery stock.

Establishment potential

Their limited host-list of 23 spp. represents a reasonable diversity of host plants, suggesting that the mites have a high chance of living on

many more species. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus macfarlanei* occurs in tropical and warm sub-tropical zones, so we would expect this species to spread throughout northern Australia.

Economic Importance:

A sporadic pest of eggplant in south India, causing leaf fall (Gupta & Gupta 1994), but also reported as a serious pest of cotton, eggplant and okra (Jose & Shah 1989b).

Consequences:

We would expect this species to become a persistent problem on several vegetable crops in tropical Australia. Costs incurred would be through decreasing plant health, cost of control, and shortening the life of acaricides through development of resistance.

References:

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Gupta, S.K. & Gupta, Y.N. (1994). A taxonomic review of the Indian Tetranychidae (Acari: Prostigmata) with descriptions of new species, re-descriptions of known species and keys to genera and species. *Memoirs of the Zoological Survey of India* **18**: 1-196.

T. mcdanieli McGregor 1931

Synonyms or Changes in Combination or Taxonomy:

none

Common names:

McDaniel spider mite

Hosts:

Acer saccharum, *Fragaria virginiana*, *Lonicera japonica*, *Malus domestica*, *Morus* sp., *Phleum pratense*, *Prunus americana*, *Prunus avium*, *Prunus persica*, *Ribes* sp., *Rubus idaeus*, *Thalictrum fendleri*, *Thermopsis pinetorum*, *Ulmus americana, Vitis vinifera* (Bolland *et al*. 1998). Cultivated raspberry (McGregor 1950).

Distribution:

USA, Canada, France (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage, buds.

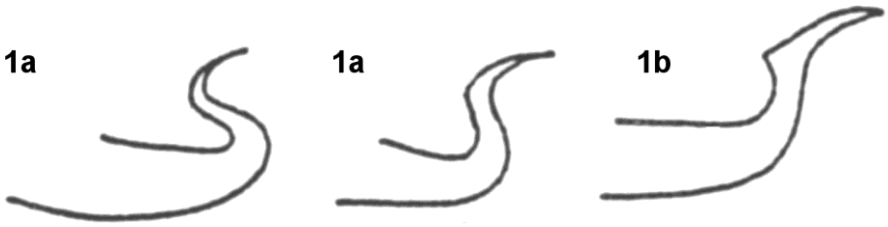
Features:

Tetranychus mcdanieli and *T. pacificus* are similar species, both having transverse striae between setae *e1-e1, e1-f1* and *f1-f1* (Photo Tmc1). According to Baker & Tuttle (1994), female *T. mcdanieli* can be distinguished from *T. pacificus* by having broken pregenital striae, whereas the pregenital striae are almost absent in *T. pacificus*. However, using the specimens we had available to us, we could not easily split *T. mcdanieli* (Photo Tmc2; Figure Tmc1) and *T. pacificus* (Photo Tpa2; Figure Tpa1) on the basis of pregenital striae. But one obvious difference was the lobes on the dorsal striae: they were absent on *T. mcdanieli* (Photo Tmc1) but present on specimens identified as *T. pacificus* (Photo Tpa1). We do not know if this character is consistent throughout the range of both species. Therefore, we recommend differences in DNA sequences to confirm a species diagnosis, using the techniques of Navajas *et al.* (1992, 1996).

Male *T. mcdanieli* have a strongly sigmoid aedeagus, lacking a anterior projection (Figures 1a, below, anterior margin is smooth, rounded), while those of *T. pacificus* have a small angular anterior projection (Figure 1b, below, anterior margin elbowed).

Females are a deep amber colour with blackish spots around body margin and the legs are about same colour as the body (McGregor 1950).

DNA: ITS2 spacer of rDNA (Navajas *et al*. 1992); CO1 mtDNA gene (Navajas *et al*. 1996).



Biology:

Life history

Tetranychus mcdanieli is a temperate-zone species known to cause serious damage to raspberries (Roy *et al.* 1999) and is also reported damaging deciduous fruit trees, grapes and ornamental plants (Jeppson *et al.* 1975). Like most pest spider mites, *T. mcdanieli* thrives on weed species, which act as reservoirs for the pest (Nielsen 1958). The adult females overwinter under bark and in the soil (to at least 15 cm depth) at the base of host trees (Nielsen 1958). In hot weather under field conditions, egg to adult takes 8 days (range 16.3 days at 20 ºC to 6.3 days at 35 ºC) and the optimum temperature for oviposition is 29 to 32 ºC. Mites die at 40 ºC (Nielsen 1958). Infestations are initially restricted to ventral surface of the leaves, but mites will use the upper surfaces when the population density becomes higher. Webbing can become thick (Nielsen 1958).

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions. In Canada, control of *T. mcdanieli* is achieved through application of acaricides

combined with biological control, especially during withholding periods (Roy *et al.* 1999).

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

Their presence in France, in addition to north America, indicates they have the capacity to be moved long distances. Overwintering of females is probably obligate, so they may hide in natural cavities in produce and nursery stock, especially on produce in cold storage.

Establishment potential

Their limited host-list of 15 spp. seems to under-represent reports of this species causing damage to several crops. Jeppson *et al.* (1975) claims that the species can live on "more than 30 species of weeds", citing Reeves (1963), but Reeves does not make this claim. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus mcdanieli* occurs in temperate zones, so we would expect this species to spread throughout southern Australia.

Economic Importance:

This major pest of raspberries (Roy *et al.* 1999) would probably also have significant impacts on pome fruit and viticulture industries.

Consequences:

Tetranychus mcdanieli would be expected to cause significant impacts through decreasing plant health, more frequent implementation of control strategies, and more frequent development of acaricide resistance in spider mite populations. Markets for pome and stone fruit and grapes could be affected. For example, South Africa prohibits pome and stone fruit imports from infested areas, as does Chile for grape imports.

References:

McGregor, E.A. (1931). A new spinning mite attacking raspberry in Michigan. *Proceedings of the Entomological Society of Washington* **33**: 193-195 (**holotype** as *Tetranychus mcdanieli*)

McGregor, E.A. (1950). Mites of the family Tetranychidae. *The American Midland Naturalist* **44**: 257-420.

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Roy, M., Brodeur, J. & Cloutier, C. (1999). Seasonal abundance of spider mites and their predators on red raspberry in Quebec, Canada. *Environmental Entomology* **28**: 735-747.

T. mexicanus (McGregor 1950)

Synonyms or Changes in Combination or Taxonomy:

Septanychus mexicanus McGregor 1950
Tetranychus mexicanus (McGregor) Pritchard & Baker 1955

Common names:

Mexican spider mite

Hosts:

Numerous, Bolland *et al.* (1998) records 90 species.

Distribution:

Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, Honduras, Mexico, Nicaragua, Paraguay, Peru, USA, Uruguay (Bolland *et al.* 1998), China (Cheng 1994).

Part of Plants Affected:

Foliage

Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with obvious dorsal spur 4-6 µm long (Photo Tme1); tarsus I with the bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tme2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 19-25 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 19-25 µm (Photo Tme2); peritreme hook ca. 28 µm long (Photo Tme3); dorsal striae between setae *e1-e1* transverse; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Tme4); dorsal striae with lobes; ventral striae mostly without lobes, low lobes present between setae *4a*; pregenital striae weak and broken medially (Photo Tme5).

Male: Dorsal striae with lobes (Photo Tme6, Photo Tme7 – difficult to capture by photography); empodia I-IV each with obvious dorsal spur 5-6 µm long; empodia I claw-like (uncinate), but with separate tines (Photo Tme8); empodia II-IV with proximoventral hairs long and free (Photo Tme9). Aedeagus as in Photo Tme10.

Biology:

Life history

Tetranychus mexicanus is known from tropical and subtropical countries where, although recorded from 90 spp. of host plants, it is only occasionally a pest (Jeppson *et al.* 1975; Bolland *et al.* 1998). Water stressed plants are probably more susceptible to attack (Quiros-Gonzalez 2000), and it occasionally reaches damaging levels on citrus (Quiros-Gonzalez 2000; Gerson 2003).

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as "soft" on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

Their occurrence in China in addition to the Americas, demonstrates they have the capacity to be moved long distances. Overwintering females may hide in natural cavities in produce and nursery stock.

Establishment potential

Their extensive host-list of 90 spp. suggests not only a high chance of being on imported plant material, but also increases their chances of finding a suitable host and establishment. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus mexicanus* occurs in

tropical and subtropical zones, so we would expect this species to spread throughout northern and coastal Australia.

Economic Importance:

Although recorded from many host plants, *T. mexicanus* is not a species of great importance. Its impacts seem sporadic and restricted to unhealthy plants (Quiros-Gonzalez 2000; Gerson 2003).

Consequences:

This species would have a minor impact on citrus (Gerson 2003), and probably a small impact on several other cropping systems in tropical and warm subtropical areas. Costs would be associated with managing these additional mite problems.

References:

McGregor, E.A. (1950). Mites of the family Tetranychidae. *The American Midland Naturalist* **44**: 257-420. (**holotype** as *Septanychus mexicanus*)

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Quiros-Gonzalez, M. (2000). Phytophagoous mite populations on Tahiti lime, *Citrus latifolia*, under induced drought conditions. *Experimental and Applied Acarology* **24**: 897-904.

Gerson, U. (2003). Acarine pests of citrus: overview and non-chemical control. *Systematic and Applied Acarology* **8**: 3-12.

T. pacificus McGregor 1919

Synonyms or Changes in Combination or Taxonomy:

None.

Common names:

Four-spotted spider mite
Pacific spider mite
Six-spotted mite (confusingly shared with *Eotetranychus sexmaculatus*)
Yellow mite

Hosts:

Numerous, including: almond, apple, apricot, banana-squash, blackberry, *Brassica* sp., cherry, Chinaberry, choke-cherry, cotton, fig, gourds, grape, grapefruit, horehound, *Jugulans californica*, lemon, locust, *Malva* sp., milkweed, morning-glory, native lily, osoberry, peach, pear, *Philadelphus* sp., pigweed, plum, prune, *Prunus* sp., *Ribes* sp., *Rubus* sp., *Stachys* sp., *Vicia* sp., vinegar-weed, walnut (McGregor 1950).

Additionally: *Asarum* sp., *Asclepias* sp., *Bocconia* sp., *Ceanothus fendleri*, *Ceanothus* sp., *Cotoneaster* sp., *Cucurbitia* sp., *Eschscholtzia californica*, *Ficus carica*, *Gossypium* sp., *Helianthus annuus*, *Jugulans regia*, *Magnolia fraseri*, *Malus domestica*, *Medicago sativa*, *Morus* sp., *Phaseolus* sp., *Philadelphus gordonianus*, *Prunus armeniaca*, *Prunus domestica*, *Prunus persica*, *Pyrus communis*, *Phamnus betulaefolia*, *Ribes* sp., *Robinia pseudoacacia*, *Salvia* sp., *Solanum melongena*, *Syringa* sp., *Thermopsis pinetorum*, *Trifolium* sp., *Ulmus* sp., *Vicia* sp., *Vitis* sp., *Zea mays* (Bolland *et al.* 1998).

Distribution:

USA (McGregor 1950 [British Columbia, Washington, Oregon, California, Idaho, Utah, Colorado]), Canada, Mexico (Bolland *et al.* 1998).

Part of Plants Affected:

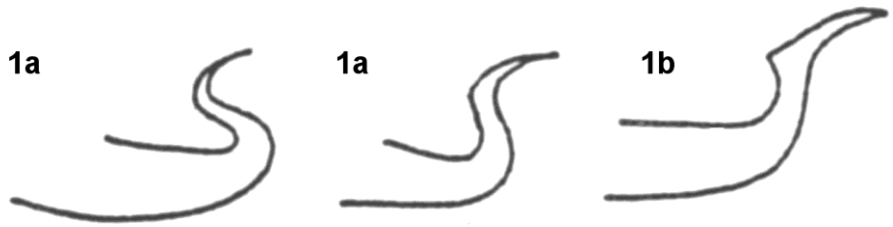
Foliage and, to a lesser extent, fruit.

Features:

Tetranychus mcdanieli and *T. pacificus* are similar species, having transverse striae between setae *e1-e1* (transverse/oblique), *e1-f1* and *f1-f1* (Photo Tpa1). According to Baker & Tuttle (1994), female *T. pacificus* can be distinguished from *T. mcdanieli* by the almost absent pregenital striae (Photo Tpa2; Figure Tpa1), whereas the pregenital striae of *T. mcdanieli* are a mixture of broken and solid lines (Figure Tmc2). However, using the specimens we obtained, we could not easily split *T. mcdanieli* (Photo Tmc2) and *T. pacificus* (Photo Tpa2) on the basis of pregenital striae. An alternative obvious difference was the lobes on the dorsal striae: they were absent on *T. mcdanieli* (Photo

Tmc1) but present on the specimens identified as *T. pacificus* (Photo Tpa1). We do not know if this character is consistent throughout the range of both species. Therefore, we recommend differences in DNA sequences to confirm a species diagnosis, using the techniques of Navajas *et al.* (1992, 1996).

Male *T. pacificus* have a weakly sigmoid aedeagus with an anterior projection (Figure 1b, below; anterior margin elbowed), whereas the aedeagus of *T. mcdanieli* is strongly sigmoid and lacks an anterior projection (Figures 1a, below; anterior margin smooth, rounded).



Living female *T. pacificus* are variable in colour: amber, salmon, orange-red, greenish-yellow, or other colours depending on the food plant, stage of development, or season. Female dorsum unspotted or with as many as 4 blackish spots along each side. Legs and palps pale (McGregor 1950). Overwintering females are deep amber, shiny and lack food spots. Nymphs are pale amber with several food spots. Eggs are initially colourless, becoming deep amber (McGregor 1950).

DNA: ITS2 spacer of rDNA (Navajas *et al.* 1992); CO1 mtDNA gene (Navajas *et al*. 1996).

Biology:

Life history

Tetranychus pacificus is a serious pest throughout its range, from the warm subtropical areas of northern Mexico into temperate Canada, especially common in the interior agricultural areas (Jeppson *et al.* 1975). Damage is similar to that of other spider mites, except that low populations seem to cause inordinate damage, suggesting that the mites inject toxins into their host plants (Jeppson *et al.* 1975). Damage on trees usually begins within the crowns, starting with characteristic speckling but soon turning the leaves brown. The damage can appear as though the tree crowns have been burnt by fire (Jeppson *et al.* 1975). The species is unusual amongst *Tetranychus* in its use of corn as a host plant.

This species can exist throughout a wide range of climes. In warm subtropical zones mites do not overwinter, but in temperate zones females overwinter in cracks and crevices on stems and in soil (Laminman 1935; Jeppson *et al.* 1975), and their presence in Canada

shows they can tolerate very low temperatures. At 23.8 ºC, females laid 78.9 eggs/female, and at 29.4 ºC, females laid 68.3 eggs per female. Offspring are 57% female. Females lived for 12.71 days at 23.8 ºC and 8.91 days at 29.4 ºC (Carey & Bradley 1982), during which females lay 50-100 eggs (Jeppson *et al.* 1975). Conditions of high temperature and low humidity seem to promote damage. Grape, prune and almond seem to be highly susceptible, with populations reaching 1400 mites per leaf on grapes (Laminman 1935). This species is sometimes found in mixed populations with *Tetranychus urticae*.

Nitrogen fertilisation increases fecundity and development times of at least *T. pacificus* (Wilson *et al.* 1985) and *T. urticae* (Wermelinger *et al.* 1985). Also, fecundity and development rate of *T. pacificus* on almond increases with water stress, probably as a result of increased leaf temperature (Youngman *et al.* 1988; Oi *et al.* 1989).

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Predator mites alone can control *Tetranychus pacificus* populations (Hanna *et al.* 1997).

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

An unusual method of control is used for *T. pacificus* on grapes. The introduction of an innocuous spider mite, *Eotetranychus willamettei*, prior to infestation with *T. pacificus*, causes a systemic reaction that reduces later infestation by *T. pacificus* (English-Loeb *et al.* 1993; Hougen-Eitzman & Karban 1995). However, this does not seem to work for all cultivars (Hanna *et al.* 1997).

Entry potential

Tetranychus pacificus has not yet been spread to countries outside of north America, but in a survey of nectarine fruit packed in California, *T. pacificus* was one of the more common species found (10-60/100,000 fruit) (Curtis *et al.* 1992). *Tetranychus pacificus* has also been detected on squash entering Japan (from reference in CABI CPC). Overwintering females may hide in natural cavities in produce and nursery stock, especially on produce in cold storage.

Establishment potential

The host-list of 35 spp. represents a reasonable diversity of host plants, suggesting a good chance of establishment. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they should have a moderate to high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus pacificus* occurs in temperate to subtropical zones, so we would expect this species to spread throughout most of Australia.

Economic Importance:

Tetranychus pacificus is a serious pest and is amongst the *Tetranychus* species we consider the greatest threat to Australia's agricultural industries. McGregor (1950) considered *T. pacificus* as "one of the most destructive crop pests in the great agricultural interior valleys of the Pacific Coast. When crop plants, ornamental and shade trees are considered together, it may be the most serious pest of central California". This species is a major pest of almonds reducing tree growth and yield (Welter *et al*. 1984), and grapes are a primary host of great importance (e.g., Hanna *et al.* 1996, 1997).

Consequences:

We would expect substantial costs to be incurred in deciduous tree crops and viticulture, through losses in yield, costs of control, and increased chance of resistance to acaricides. Australian markets for pome and stone fruit and grapes could be affected. For example, South Africa prohibits apple and pear imports from areas infested with *T. pacificus*, and Brazil requires either area-freedom or fumigation of produce.

References:

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Laminman, J.F. (1935). The Pacific mite, *Tetranychus pacificus* McG., in California. *Journal of Economic Entomology* **20**: 900-903.

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Hanna, R., Wilson, L.T., Zalom, F.G., & Flaherty D.L. (1997). Effects of predation and competition on the population dynamics of *Tetranychus pacificus* on grapevines. *Journal of Applied Ecology* **34**: 878-888.

T. piercei McGregor 1950

Synonyms or Changes in Combination or Taxonomy:

Tetranychus manihotis Flechtmann 1981
Junior primary homonym of *T. manihotis* Oudemans 1931
Synonymy by Bolland *et al.* (1998).

Common names:

Pierce's spider mite

Hosts:

Ageratum conyzoides, *Ageratum esculenta*, *Ageratum* sp., *Asarum blumei*, *Canavalia maritima*, *Carica papaya*, *Cassia obtusifolia*, *Clitoria ternatea*, *Codiaeum variegatum*, *Colocasia esculenta*, *Curculigo orchioides*, *Elaeis guineensis*, *Houttuynia cordata*, *Ipomoea batatas*, *Lablab purpureus*, *Manihot esculenta*, *Manihot* sp., *Morus alba*, *Musa sapientum*, *Musa* sp., *Musa textilis, Passiflora foetida*, *Polygala paniculata, Prunus persica, Psophocarpus tetragonolobus*, *Pueraria montana*, *Rhamnus crenata*, *Ricinus communis*, *Solanum melongena* (Bolland *et al.* 1998)

Distribution:

Philippines (McGregor 1950 [Victorias Occ. Negros])
China, Hainan Island, Hong Kong, Indonesia, Japan, Malaysia, Okinawa Island, Papua New Guinea, Philippines, Surinam, Taiwan, Thailand, Vietnam (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage.

Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with minute or absent dorsal spur (Photo Tpi1; Figure Tpi1); tarsus I usually with bases of 4 tactile setae proximal to the base of the proximal duplex seta, occasionally base of 1 tactile setae overlapping with the level of base of the proximal duplex seta (Photo Tpi2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 14-28 µm (Photo Tpi2); tarsus I, distance between the base of proximal duplex seta and base of distal duplex seta = 14 µm (Photo Tpi2; Figure Tpi1); peritreme hook = 22-28 µm long (Photo Tpi3; Figure Tpi2); dorsal striae between setae *e1-e1* longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Tpi4); dorsal striae with lobes; ventral striae with small lobes from just posterior of setae *4a* to just anterior of setae *4a* (Photo Tpi5); pregenital striae broken (Photo Tpi6; Photo Tpi7), sometimes weakly so.

Male: Empodia I-IV each with an obvious dorsal spur 3-4 µm long; empodia I claw-like (uncinate) (Photo Tpi8; Figure Tpi4), empodia II-IV

each with proximoventral hairs long and free (Photo Tpi9; Figure Tpi5). Aedeagus as in Photo Tpi10 and Figure Tpi6.

In the specimens we examined, there was intra-population variance in the number of proximal setae overlapping with the proximal duplex seta on tarsus I (0-1 overlapping).

Biology:

Life history

Tetranychus piercei is a tropical and warm sub-tropical species of south-east Asia and the Indonesian region. The species seems to be only an occasional pest (Jeppson *et al.* 1975), and can reach high numbers on banana (Fu *et al*. 2002). Very little seems to be known about the biology of this species.

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

This species has probably not spread significantly from its south-east Asian distribution, but it still poses a risk because of the small size of spider mites in general and the high numbers they can reach on plants. Overwintering females may hide in natural cavities in produce and nursery stock.

Establishment potential

Tetranychus piercei has a relatively diverse host list of 29 spp., giving it a high chance of being on imported plant material, but also increases its chance of finding a suitable host. Palm and banana are atypical hosts for many *Tetranychus* spp., but large populations of *T. mexicanus* have been recorded on them. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus piercei* occurs in tropical and warm subtropical zones, so we would expect this species to spread throughout northern Australia.

Economic Importance:

The impact of this species is unknown, but it is recorded to reach large numbers on banana (Fu *et al*. 2002). We would expect it to be a sporadic problem on several crops, such as palms, banana and eggplant.

Consequences:

The introduction of this species may occasionally increase costs in banana, with potential to affect productivity and plant health. Otherwise, this species is probably a minor pest for other crops.

References:

McGregor, E.A. (1950). Mites of the family Tetranychidae. *The American Midland Naturalist* **44**: 257-420 (**holotype** as *Tetranychus piercei*)

Jeppson, L.R., Keifer, H.H. & Baker, E.W. (1975). *Mites Injurious to Economic Plants.* Berkeley: University of California Press 614 pp.

Flechtmann, C.H.W. (1981). The cassava mites complex. II. New records and description of two new species in the genus *Tetranychus* from Asia. *International Journal of Acarology* **7**: 87-90 (as *Tetranychus manihotis*)

Fu, Y., Zhang, F., Peng, Z., Liu, K. & Jin, Q. The effects of temperature on the development and reproduction of *Tetranychus piercei* McGregor (Acari: Tetranychidae) in banana. *Systematic and Applied Acarology* **7**: 69-76.

T. schoenei McGregor 1941

Synonyms or Changes in Combination or Taxonomy:

Septanychus schoenei McGregor 1950
Tetranychus schoenei Pritchard & Baker 1955

Common names:

Schoene's spider mite

Hosts:

Numerous, Bolland *et al.* (1998) records 50 host plants.

Distribution:

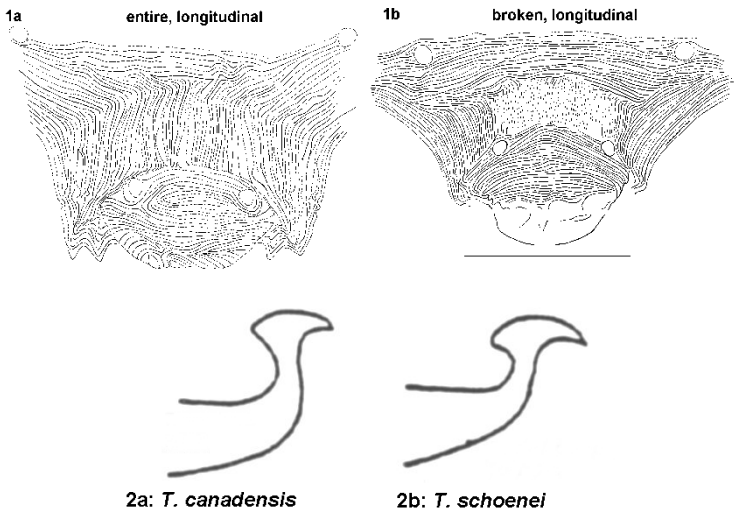
USA (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage.

Features:

This species is almost identical to *T. canadensis* except that female *T. schoenei* have broken pregenital striae (1b), while female *T. canadensis* have entire pregenital striae (1a). The male aedeagus is very similar in both species, but *T. schoenei* purportedly has a longer posterior projection and a more acute curve in the anterior margin (2b) than does *T. canadensis* (2a).



Jeppson *et al.* (1975) and Reece (1963) distinguish *T. canadensis* from *T. schoenei* on the basis of the aedeagal shape alone. We were unable to source specimens of *T. schoenei*, but from the literature this species should have the features of *T. canadensis* described below, except where noted.

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with minute or absent dorsal spur (Photo Tca1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Tca2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 20-28 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 7-8 µm (Photo Tca2); peritreme hook = 19-22 µm long (Photo Tca3); dorsal striae between setae *e1-e1* transverse; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse (Figure Tca1, Photo Tca4); pregenital striae broken (2b, above; different from *T. canadensis* 2a above).

Male: Empodia I-IV each with dorsal spurs. Aedeagus as in 2b (above; different from *T. canadensis* 2a above).

The summer female *T. schoenei* is faded green to dark green (but this can depend on the food plant) with four dark spots, the most anterior pair being the largest. These spots appear only after feeding commences. Larvae and protonymphs have only two spots. Male mites are pale yellowish-green and have four tiny spots. Hibernating female mites are orange (Cagle 1943).

Biology:

Life history

This species is prevalent throughout the eastern USA where it is an occasional pest in several crops, such as beans, pome fruit, raspberries and cotton (Jeppson *et al.* 1975). When *T. schoenei* is a pest, it causes the typical bronzing of foliage and eventual leaf senescence, but can also prevent fruit from ripening. *Tetranychus schoenei* readily spins webbing.

Life-history data derives from Cagle (1943). Eggs take 3 days to hatch at 27.5 ºC and 25 days at 11.5 ºC. At 25 ºC, larvae and protonymphs take less than one day each to reach their quiescent stages, compared with 4-5 and 5-6 days, respectively, at 12-15 ºC. The quiescent larval stage ranges from <1 to 3 days (25 ºC compared with 15 ºC) and the quiescent protonymphal stage ranges from <1 to 6 days (25 ºC compared with 15 ºC). The feeding time for the deutonymph was <1 to 8 days and the quiescent time was <1 to 12 days at 25-26 ºC and 12-15ºC, respectively. At these upper temperatures, egg-adult duration is 5 days. The preoviposition period takes 1 day at 25-28 ºC, and females lay up to 106 eggs each over a maximum of 38 days. Average numbers of eggs per day range from 2.1-3.7 eggs/day (Cagle 1943).

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as

predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

This species has not spread from the eastern USA, but it still poses a risk because of the small size of spider mites and the high numbers they can reach on plants. Overwintering is probably obligate over most of its range, and females may hide in natural cavities in produce and nursery stock, especially goods in cold storage.

Establishment potential

Tetranychus schoenei has a diverse host list of 50 spp., giving it a high chance of being on imported plant material, but also increases its chances of finding a suitable host. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus schoenei* occurs in warm temperate to subtropical zones of eastern USA, so we would expect this species to spread throughout much of coastal Australia.

Economic Importance:

Damage to apple can be severe, causing bronzing of foliage, failure of fruit colouring and subsequent down-grading of fruit (Cagle 1943).

However, serious infestations are likely to be sporadic rather than a persistent annual event.

Consequences:

We would expect this species to have a small but significant impact on the production of several crops, especially pome and stone fruit. In years where outbreaks are experiences, growers could suffer crop losses, costs associated with the control of the mite, and shortened life of acaricides through the development of resistance. Existing Australian markets for pome and stone fruit and grapes could be affected if this species is introduced into this country. For example, South Africa prohibits apple and pear imports from areas infested with *T. schoenei*.

References:

McGregor, E.A. (1941). A new spider mite from Virginia (Acarina: Tetranychidae). *Proceedings of the Entomological Society of Washington* **43**: 223-225 (**holotype** as *Tetranychus schoenei*)

Cagle, L.R. (1943). Life history of the spider mite *Tetranychus schoenei* MCG. *Virginia Agricultural Experimental Station Technical Bulletin* **87**: 1-15.

McGregor, E.A. (1950). Mites of the family Tetranychidae. *The American Midland Naturalist* **44**: 257-420 (as *Septanychus schoenei*)

Pritchard, A.E. & Baker, E.W. (1955). *A Revision of the Spider Mite Family Tetranychidae.* San Francisco: Pacific Coast Entomological Society 472 pp.

Jeppson, L.R., Keifer, H.H. & Baker, E.W. (1975). *Mites Injurious to Economic Plants.* Berkeley: University of California Press 614 pp.

T. truncatus Ehara 1956

Synonyms or Changes in Combination or Taxonomy:

None.

Common names:

Cassava mite
Red spider mite (uncommon, used loosely for other spider mites)

Hosts:

Numerous, Bolland *et al.* (1998) records 61 host plants.

Distribution:

China, Guam Island, Hainan Island, Indonesia, Japan, Korea, Mariana Islands, Philippines, Taiwan, Thailand (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage.

Features:

Female: Empodia with 6 proximoventral hairs, empodia I-IV each with a minute spur (< 2 µm long) (Figure Ttr1); tarsus I with bases of 4 tactile setae proximal to proximal pair of duplex setae; the additive distance between each base of the proximal setae and the base of the proximal duplex seta > 20 µm (Figure Ttr1); tarsus I, the distance between base of proximal duplex seta and base of distal duplex seta < 16 µm (Figure Ttr1); peritreme hook > 20 µm long (Figure Ttr4); dorsal striae between setae *e1-e1* mixed longitudinal and oblique; dorsal striae between setae *f1-f1* longitudinal (sometimes combined with oblique); dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Ttr1; Figure Ttr2; Figure Ttr3), pregenital striae entire, unbroken (but may be sparse medially) (Photo Ttr2; Figure Ttr5).

Male: Empodia I-IV with obvious dorsal spur (Photo Ttr6; Figure Ttr8); empodium I claw-like (uncinate) (Photo Ttr5; Figure Ttr7); empodia II-IV with proximoventral hairs free and long (Photo Ttr6; Figure Ttr8); knob of aedeagus as in (Photo Ttr3, Photo Ttr4; Figure Ttr6).

The adult female is carmine red (Jeppson *et al*. 1975).

Biology:

Life history

This species occurs throughout south-east Asia and Indonesia, extending to Japan and Korea, covering tropical and temperate zones. This wide distribution is reflected by the range of temperatures, 24-31 ºC, at which development is optimal (Sakunwarin *et al*. 2003). On mulberry leaflets, threshold temperatures range from 9.91 – 12.51 ºC; day-degree requirements for the egg, larva, protonymph, deutonymph and a generation are 65.52, 15.38, 11.36, 11.76 and 142.83 Dº

respectively (Sakunwarin *et al*. 2003). Generation times average 6.7 days on corn at 27ºC and 72% R.H. (Chen *et al.* 1996). Like most species of *Tetranychus*, *T. truncatus* tends to feed on the underside of leaves (Sakunwarin *et al.* 2003).

Damage is typical for spider mites; speckling of leaves, leading to large areas of yellowing and bronzing of foliage, and populations seem to thrive during drier periods (Chen *et al.* 1996). Females overwinter under bark and at the base of plants in the upper soil layer and leaf-litter.

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as "soft" on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around 30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

This species has not spread from south-eastern Asia, but within the region it is difficult to determine if their range has extended from their original distribution of Japan and the Philippines (Jeppson *et al.* 1975). Overwintering females may hide in natural cavities in produce and nursery stock, especially goods in cold storage.

Establishment potential

The host list of 61 spp. is an extensive range, increasing the chances of finding a suitable host and its establishment. On fruit and vegetables, the chance of transfer from table to garden is very low, but

once a plant is encountered, the species will have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. The distribution of *T. truncatus* comprises tropical, subtropical and temperate zones, so we expect this species could spread throughout most agricultural areas of Australia.

Economic Importance:

Tetranychus truncatus can be a significant component of the *Tetranychus* species that attack crops. Damage can be significant, at least on eggplant, corn and cotton (Ehara & Wongsiri 1975; Li *et al.* 1988; Chen *et al.* 1999; Sakunwarin *et al*. 2003).

Consequences:

This species could be an occasional problem throughout Australia. Costs would be associated with minor crop losses, increased investment in spider mite control, and shortened life-expectancy of acaricides via higher probability of resistance developing. Agricultural industries may also experience market restrictions; for example, *T. truncatus* is of quarantine concern for quince exported to Canada.

References:

Ehara, S. (1956). Tetranychoid mites of mulberry in Japan. *Journal of the Faculty of Science, Hokkaido University (Series 6) Zoology* **12**: 499-510 (**holotype** as *T. truncatus*)

Ehara, S. & Wongsiri, T. (1975). The spider mites of Thailand (Acarina: Tetranychidae). *Mushi, Fukuoka*, 1-30.

Jeppson, L.R., Keifer, H.H. & Baker, E.W. (1975). *Mites Injurious to Economic Plants.* Berkeley: University of California Press 614 pp.

Li, X.J., Win, X.J., & Sun, S.X. (1998). The biological characteristics of *truncatus* mite, and its control in jujube trees. *China Fruits* **4**: 11-14.

Chen, X.Y., Zhang, Z.Y. & Li, J.H. (1996). Study on the bionomics and control of *Tetranychus truncatus* Ehara. *Scientia Silvae Sinicae* **32**: 144-149.

Chen, X.Y., Zhang, M.R., & Zhang, X. (1999). Study on the bionomics and ecological control tactics of *Tetranychus truncatus* Ehara in corn field in Shaanxi province. *Acta Phytophylacica Sinica* **26**: 7-12.

Sakunwarin, S., Chandrapatya, A. & Baker, G.T. (2003). Biology and life table of the cassava mite, *Tetranychus truncatus* Ehara (Acari: Tetranychidae). *Systematic and Applied Acarology* **8**: 13-24.

T. turkestani (Ugarov & Nikolskii 1937)

Synonyms or Changes in Combination or Taxonomy:

Eotetranychus turkestani Ugarov & Nikolskii 1937
Tetranychus turkestani (Ugarov & Nikolskii) Wainstein 1959

Tetranychus atlanticus McGregor 1941
Synonymy by Wainstein (1961)

Common names:

Atlantic spider mite
Strawberry spider mite (CABI CPC)

Hosts:

Numerous, Bolland *et al.* (1998) records 187 host plants.

Distribution:

Algeria, Bulgaria, CIS, Canary Islands, China, Costa Rica, France, Greece, Hungary, Iran, Iraq, Israel, Japan, Kuwait, Mexico, Morocco, New Zealand, Pakistan, Poland, Portugal, South Africa, Spain, Switzerland, The Netherlands, Turkey, USA, Yugoslavia (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage.

Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with minute or absent dorsal spur (Photo Ttu1; Figure Ttu1); tarsus I with bases of 4 tactile setae proximal to the base of the proximal duplex seta (Photo Ttu2; Figure Ttu2); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 22-23 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 9-10 µm (Photo Ttu2; Figure Ttu2); peritreme hook = 22-24 µm long (Photo Ttu3); dorsal striae between setae *e1-e1* longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Ttu4); dorsal striae with lobes; ventral striae without lobes; pregenital striae becoming sparse and broken medially (Photo Ttu5; Figure Tu5).

Male: Empodia I-IV each with an obvious dorsal spur 3-4 µm long (Figure Ttu6); empodia I uncinate or claw-like (Photo Ttu6; Figure Ttu6), empodia II-IV with proximoventral hairs long and free (Photo Ttu7; Figure Ttu6). Aedeagus as in Photo Ttu8 and Figure Ttu7.

The colour of adult females varies, but there a large spot on either side of the body, and sometimes with an additional pair of spots near the posterior tip of the mite (Jeppson *et al*. 1975).

DNA: ITS2 spacer of rDNA (Navajas *et al*. 1992); COI of mtDNA (Navajas & Boursot 2003).

Biology:

Life history

Tetranychus turkestani has a wide distribution covering temperate zones to subtropical areas of Europe, Asia, Africa, Japan and New Zealand. Bright-orange females spend winter hibernating beneath bark or at the base of plants in upper soil layers (Mellot & Connell 1965; Baker & Tuttle 1994). Damage is the typical speckling of foliage, leading to bronzing, leaf senescence and sometimes complete defoliation (Jeppson *et al.* 1975). This defoliation may be associated with a toxin injected by the mites during feeding (Simons 1964). Mites prefer the underside of leaves, and large populations produce copious amounts of webbing, sometimes binding leaves together (Jeppson *et al.* 1975).

Egg to adult time for female mites is 29, 18, 17.4, 10.7 and 6.4 days at 15.5, 18.3, 21.1, 23.8 and 29.4 ºC, respectively. The preovipositional period and fecundity is 1.17 and 0.79 days and 85.6 and 73.5 eggs at 23.8 ºC, respectively. Sex ratios are approximately 1.26 females per male. Females live for an average of 12.5 and 8.8 days at 23.8 and 29.4 ºC, respectively (data from Carey & Bradley 1982). In cotton, *T. turkestani* thrives during dry warm periods (Canerday & Arant 1964).

Bailly *et al.* (2004) demonstrated that the large host range of this species represents the true host-plant range rather than an array of cryptic species, a result probably true for many species of *Tetranychus*.

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of 30-35

ºC. Always find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

This species has spread further than any of the species not present in Australia, and has the greatest number of known host plants. Thus, *T. turkestani* has the highest chance of entering Australia of any *Tetranychus*. Overwintering females may hide in natural cavities in produce and nursery stock, especially goods in cold storage.

Establishment potential

The host list of 187 spp. is one of the most extensive host-ranges of all the *Tetranychus* of quarantine concern, increasing the chances of *T. turkestani* finding a suitable host and establishing. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus turkestani* occurs over a wide area comprising subtropical and temperate zones, so we would expect this species to spread throughout most agricultural areas of Australia.

Economic Importance:

A widespread and serious pest of many crops throughout the world (Jeppson *et al.* 1975). For example, on cotton they cause defoliation and a decrease in yield (Canerday & Arant 1964; Simons 1964).

Consequences:

Establishment of this species in Australia would affect several industries, although those likely to be affected probably already have pest spider mites in their crops. However, significant costs would be incurred from increased requirement for control, yield losses, and higher probability of chemical resistance. Some quarantine restrictions could also restrict market access, particularly to South America where the species is not present.

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T. yusti McGregor 1955

Synonyms or Changes in Combination or Taxonomy:

Tetranychus lobosus Boudreaux 1956
Synonymy by Jeppson *et al.* (1975)

Common names:

none

Hosts:

Abelmoschus esculentus, *Amaranthus gangeticus*, *Arachis hypogaea*, *Baltimora recta*, *Buettneria aculeata, Cajanus cajan*, *Caladium hortulanum, Calendula officinalis*, *Camellia* sp., *Cassia* sp., *Centrosema pubescens*, *Clitoria ternatea*, *Colocasia* sp., *Cucumis* sp., *Cynodon dactylon, Echinochola colonum, Eleusine indica, Fragaria* sp., *Glycine max*, *Gossypium* sp., *Helianthus annuus*, *Hordeum vulgare, Ipomoea batatas*, *Macroptilium atropurpureum*, *Manihot esculenta*, *Melilotus alba*, *Lathyrus odoratus, Lolium temulentum, Lonicera* sp., *Medeola carolinensis*, *Musa cavendishii*, *Musa* sp., *Panicum miliaceum, Passiflora* sp., *Phaseolus* sp., *Phaseolus vulgaris*, *Pisum sativum, Plumeria* sp., *Pueraria phaseoloides*, *Richardia scabra, Rosa* sp., *Sida rhombifolia, Sonchus oleraceus, Solanum* sp., *Syngonium* sp., *Tagetes* sp., *Trifolium repens*, *Triticum sativum, Vigna unguiculata*, *Xanthosoma sagittifolium*, *Zea mays* (Saba 1971, Bolland *et al.* 1998).

Distribution:

Brazil, Cape Verde Islands, Colombia, Cook Islands, Ecuador, El Salvador, French Polynesia, Greece, Honduras, Mexico, Nigeria, Thailand, USA, Venezuela (Bolland *et al.* 1998).

Part of Plants Affected:

Foliage.

Features:

Female: Empodia with 6 proximoventral hairs; empodia I-IV each with minute or absent spur (Figure Tyu1); tarsus I usually with bases of 3 tactile setae overlapping with the base of the proximal duplex seta, AND 1 tactile seta proximal to base of proximal duplex seta (Photo Tyu1), but sometimes up to three setae are just proximal to the base of the proximal duplex seta (Figure Tyu1); the additive distance between the base of each proximal seta and the base of proximal duplex seta = 5-7 µm; tarsus I, the distance between the base of proximal duplex seta and the base of distal duplex seta = 15 µm (Photo Tyu1; Figure Tyu1); peritreme hook = 21-23 µm long (Photo Tyu2); dorsal striae between setae *e1-e1* longitudinal; dorsal striae between setae *f1-f1* longitudinal; dorsal striae between setae *e1* and *f1* transverse forming a diamond-shape (Photo Tyu3); dorsal striae with lobes; ventral striae

between genital region and setae *4a* with lobes (Photo Tyu4); pregenital striae almost entirely broken (Photo Tyu5; Figure Tyu2).

Male: Empodia I-IV each with small dorsal spur 2 µm long; empodia I claw-like (uncinate) (Photo Tyu6), empodia II-IV with proximoventral hairs long and free (Photo Tyu7). Aedeagus as in Photo Tyu8 and Figure Tyu3.

Female: Summer female is deep carmine-red, except on legs and stylopore (Boudreaux 1956), with dark spots of different sizes (Saba 1971).

Biology:

Life history

Tetranychus yusti is mostly tropical and subtropical in distribution, although it has also been recorded in Greece. Their diverse host-plant list of 51 spp. includes many species of economic importance, but also many weeds (Saba 1971; Bolland *et al.* 1998). Adult females are a deep-red colour with several dark spots of varied size; male and immature life stages are pale green (Saba 1971). Damage is the typical speckling of foliage followed by browning off of leaves. Although the species can be common, such as on soybeans (Baker & Connell 1961), the species seems to be an infrequent pest.

Female mites require 9-10 days for egg-adult at 25.5ºC and 75% R.H. and male mites take 8.5-9.5 days under the same conditions. Female mites lay an average of 4.5 eggs per day, with a maximum of 11 eggs per day and 158 for their lifetime. Adult females live for up to 35 days; 50% of females die by 21 days old (Saba 1971).

Control strategies

Management techniques usually combine several strategies to control spider mites and we recommend consultation with people experienced in dealing with mite problems in specific cropping systems before implementing a control program. Good practice usually involves: use of insecticides perceived as “soft” on predators of spider mites, such as predatory mites, thrips and tiny ladybirds; rotating acaricides from different chemical groups to slow or prevent the development of resistance; and timed releases of predatory mites. The latter technique is highly successful for spider mite control. The most popular species is *Phytoseiulus persimilis,* and is available commercially from several companies. Sometimes predator mites alone can control spider mite populations.

When applying acaricides, two applications are sometimes necessary because eggs are more resistant to chemicals. Enough time should be left between applications of acaricides to allow for the development and hatching of eggs that may have survived the first application. Seven days is usually sufficient because 6-7 days is the fastest development rate for most species (egg-adult) at a constant temperature of around

30-35 ºC. Under all circumstances, find out what chemicals are currently registered and follow the label instructions.

Managers of a mite problem should also be aware that neighbouring crops and weeds could serve as a reservoir for spider mites. Consequently, if an incursion is detected on a particular crop, other nearby crops and many weeds will be potential host plants.

Entry potential

Tetranychus yusti is probably an American species that has spread to Thailand and Greece, showing its potential to enter Australia. Its host plant list of 51 spp. indicates it could be present on a variety of plant material entering Australia. Overwintering females may hide in natural cavities in produce and nursery stock, especially goods in cold storage.

Establishment potential

The diverse host list of 51 spp. increases the chances of *T. yusti* finding a suitable host and establishing. On fruit and vegetables, the chance of transfer from table to garden is very low, but once a plant is encountered, they have a high chance of establishing a population.

Spider mites do not need to be fertilised to produce young: an unfertilised female will produce males, with which she can mate and start producing more females, while a mated female is ready to start a new colony immediately.

Spread potential

Spider mites migrate via the wind, so an outbreak can become unmanageable once this happens. *Tetranychus yusti* occurs over a wide area of mostly subtropical and tropical zones, so we would expect this species to spread throughout most agricultural areas of northern and coastal Australia.

Economic Importance:

Tetranychus yusti is a tropical and subtropical species known to cause significant damage to soybeans (Baker & Connell 1961; Jeppson *et al*. 1975). However, this species is not as significant as most other *Tetranychus* in cropping systems (Saba 1971).

Consequences:

We would expect *T. yusti* to become a widespread but sporadic pest species in Australia, probably affecting mostly cotton and soybean crops (Jeppson *et al.* 1971). Increased costs would be incurred through occasional decrease in yield, control methods, and shortened lifetime of acaricides through increased chance of mites developing resistance.

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