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Travelling with tea: a *Tuckerella*'s tale

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Abstract *Tuckerella japonica* Ehara appears strongly associated with tea (*Camellia sinensis* (L.) Kuntze, Theaceae) and, due to certain cultural practices in tea production, has in fact become a world traveller, accompanying the greatly coveted tea plant as it spread across the planet. The history of tea production and culture, and its arrival in the USA, provides the backdrop for this traveller's tale. *Tuckerella japonica* is morphologically similar to *T. flabellifera* Miller, described from Tasmania in Australia from *Bedfordia salicina* (Labill.) D.G. (Asteraceae). These two species have historically been misidentified as each other, creating inaccuracies in the collection records. The implications of this in terms of host plant lists and world distribution are discussed further, along with their morphological separation. The male and immature stages of *T. japonica* are described for the first time. *Tuckerella xinglongensis* Lin and Fu, from tea in China, is considered a junior synonym of *T. japonica*. The loss of the ancestral prostigmatan condition of three nymphal stages during ontogeny is confirmed for males of *T. flabellifera*, which do not retain a tritonymphal stage.

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Abbreviations

ANIC	Australian National Insect Collection, CSIRO Department of Entomology, Black Mountain, Canberra, Australia
AQIS	Australian Quarantine and Inspection Service, multiple collections in Brisbane (QLD), Sydney (NSW) and Melbourne (VIC), Australia
CNC	Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Ontario, Canada
MNH	Natural History Museum, London, UK
NSMT	National Science Museum, Shinjuku-ku, Tokyo, Japan
NZAC	New Zealand Arthropod Collection, Landcare Research, Auckland, New Zealand
QM	Queensland Museum, South Brisbane, QLD, Australia
SAM	South Australian Museum, North Terrace, Adelaide, SA, Australia
TDPIC	Tasmanian Department of Primary Industries Collection, New Town, Hobart, TAS, Australia
UPLBMNH	Museum of Natural History, University of The Philippines, Los Banyos, Laguna, Luzon, The Philippines
USNM	United States National Museum of Natural History, National Mite Collection, Systematic Entomology Laboratory, USDA Beltsville Agricultural Research Centre West, Beltsville, MD, USA

Introduction

Tuckerellidae: Peacock mites

The Tuckerellidae are becoming increasingly important in agriculture and quarantine as we learn more about their biology and ecology. Currently there are fewer than 30 known species of *Tuckerella*, and the family continues to remain monogeneric (Meyer and Ueckermann 1997; Corpuz-Raros 2001; Beard and Walter 2005). Most species appear to have restricted distributions; however, based on literature records and the United States National Museum of Natural History Mite Collection (Beltsville, MD, USA), there are three species with broad distributions, namely *T. ornata* (Tucker) originally described from South Africa, *T. knorri* Baker & Tuttle described from Thailand and *T. pavoniformis* (Ewing) described from Hawaii, USA. Based on our research, *T. japonica* Ehara should also be added to this list. Several species are known as pests, for example *T. knorri* on citrus (Ochoa 1989), and one major concern for quarantine is that *Tuckerella* spp. can often go undetected as they conceal themselves on the bark, stems and often the fruit of their host plant, rarely being found on the leaves.

Collection records from across the world indicate that tea, *Camellia sinensis* (L.) Kuntze (Theaceae), is a preferred host of *T. japonica*. This mite species was originally described from Japan and it has often been misidentified as *T. flabellifera* Miller from Australia and New Zealand. Due to the long history of human transportation of entire tea plants across the world, combined with the widespread cultural practise of using cuttings from mother plants to established new plantations (Ellis 1995), we propose that *T. japonica* has travelled the world as tea's hidden companion. Until now, *T. japonica* was known only from the type

specimens collected in Japan. Based on specimens examined from various countries across the world, we report here several new distribution records for *T. japonica*, along with new host plant records (see species description below).

Tea: the early history

Camellia sinensis, a native of southern China, has been known from very early times to Chinese botany and medicine, though the precise native region of *C. sinensis* has always been a little contentious due to natural morphological variation and centuries of cultivation. The current consensus places the natural origins of the tea plant in a region ranging from the upper reaches of the Brahmaputra River in the Indian province of Assam, the northern parts of Burma and Thailand and the Sichuan and Yunnan Provinces in south western China (Hasimoto and Simura 1978; Chang and Bartholomew 1984; Yu 1986; Yu and Chen 2001; Hasimoto 2001). The number of species recognised in the genus *Camellia* varies with the botanist and their taxonomy, ranging from 82 to 120 species (Sealy 1958; Chang and Bartholomew 1984; Banerjee 1992; Ellis 1995; Ming 2000). It seems to be generally accepted that the tea plant has two currently recognised subspecies, that each represent the two extremes of its geographic distribution and morphological variation and which have historically been considered separate species—*Camellia sinensis sinensis* originating from southern China, and *C. sinensis assamica* originating from the wetter parts of the species distribution throughout south and southeastern Asia.

The tea plant first enticed the human race many centuries ago, and has remained tightly interwoven in our history ever since, becoming an essential part of everyday life for the majority of people on the planet. The earliest recorded use of tea dates back to the ancient Ba people from the Sichuan Province during the West Zhou Dynasty ($\sim$1066–771 BC) (Liu et al. 2001; Gong et al. 2001), and the earliest written evidence of tea cultivation comes from the T'ang dynasty in 650 AD, indicating that cultivation was already widespread and various preparation techniques already established (Ellis 1995). After water, tea is the most consumed beverage in the world (Harbowy and Balentine 1997; Graham 1992; Katiyar and Mukhtar 1996; Kuriyama et al. 2006), and it has not strayed too far from us over the centuries, playing a key role in, and providing the backdrop for, many major events throughout human history.

Tea begins to travel

Tea and its cultivation began to spread across the world, increasing in popularity and value as it spread. It was first introduced to Japan by Buddhist monk Kūkai (774–835; also known as Kōbō-Daishi), though it was not until 1191 that the first tea was planted in Japan by Buddhist monk Myōan Eisai at the Senkōji Temple on Hirado (Dumoulin 2005). As the popularity of tea spread in Japan, so too did the Japanese tea ceremony created by Zen priest Murata Shuko. The ceremony called Cha-no-yu aims to celebrate the mundane aspects of everyday life, and was so revered that it elevated tea's status to a form of art, and almost to a religion. Kakuzo Okakura (2005) writes "It is essentially a worship of the imperfect, as it is a tender attempt to accomplish something possible in this impossible thing we know as life."

The first reference to tea in European literature appears in a collection of popular geographical accounts compiled by the Venetian geographer Ramusio (1559), as a China drink with excellent therapeutic properties called Chai. The earliest herbarium specimen known to Western science dates from 1698 and is located in the Sloane Herbarium of the

British Museum (Ellis 1995). The booming trade in tea inspired several attempts at tea cultivation in Europe, including several by Swedish botanist Carl Linnaeus. Linnaeus was so obsessed with naturalising tea in Sweden that upon receipt of a Chinese tea plant delivered by the Swedish East India Company in 1763, he announced his success in several dissertations (Cook 2010). His optimism however was unfounded and by 1765 the last remaining tea plant was nearly dead (Cook 2010).

When British-Chinese relations were strained, fears of losing access to tea eventually led to attempts to grow their own tea. Following suggestions made by British botanist Joseph Banks in 1778 that India would be an ideal climate to grow and cultivate tea (Sigmond 1839), Britain's first ambassador to China in 1793, Lord Macartney, collected several tea plants, complete with a large ball of adhering soil, from the southern tea districts in China, to establish plantations in India (Sigmond 1839; Robbins 1908). The British subsequently discovered that the native tea plants in India were more suited to the region (Griffiths 1967), and lead to the modern tea industry in India being derived from both imported plants from China and native tea plants (Harbowy and Balentine 1997).

Meanwhile, tea also made it to Brazil by the early 1800s (Smith 1848; Jones 1877) and tea production began in Russia and Turkey by the late 1800s (Bone 1963; Mair and Hoh 2009). The first propagation of tea plants in Africa took place in South Africa's Durban Botanical Gardens between 1850 and 1855 (Hutson 1978; McCracken 2011), and it was directly from this small private plantation that the region's tea industry began (McCracken 2011). Tea also spread to Southeast Asia. After earlier attempts using Chinese tea failed, a tea industry was finally established in Indonesia in 1878 using hybrid Indian–Chinese tea (Ellis 1995).

Tea arrives in America

As an ancient anonymous Chinese saying "better to be deprived of food for 3 days, than of tea for one" attests, tea had become a necessity of life. Tea had become not only culturally significant across the world, but also a greatly prized commodity and an obvious target for taxes by the Parliament of Great Britain. High taxes on tea sparked increased anti-British sentiment amongst the American colonists, and tea soon became a much detested symbol of tyranny. The mounting angst against oppression eventually led to the events of the Boston Tea Party by the end of 1773 and ultimately the American Revolution (Drake 1884).

As tea consumption grew in the colonies, the British took an early interest in establishing domestic tea production in the American south, and the early introductions of tea arose from imported plants as well as seed. The actual date of the first introduction of the tea plant to the USA is a little confused, but seems to have occurred sometime between 1736 and 1799. Moore visited the Trustee Garden in Savannah during his journey through Georgia in 1735–1736 and mentioned that tea seeds from the East Indies had been planted but did not grow (Moore 1744). Other sources record that it was Chinese tea seeds that were planted at the same gardens between 1772 and 1774 (Stedman 1858; Lippincott 1864; Phillips 2007). A further attempt was made in 1772, this time using imported plants instead of seed, and was apparently successful. Other sources say the first tea plants were planted in the USA, along with a *Camellia japonica* L. plant, by French botanist François André Michaux between 1799 and 1802 at Middleton Barony (now called Middleton Place) on the Ashley River, near Charleston, South Carolina (Mitchell 1908; Watson 1908; Walcott 1999; Ginsburgs 2011). By 1805, tea plants were recorded as growing on Skidaway Island near Savannah (Stedman 1858), but despite serious efforts to grow tea in Charleston, these

early plantings did not flourish, and tea failed to establish as a commercial crop, though the mother plants were not destroyed (Watson 1908; Phillips 2007).

In the years 1848–1852, a large number of Chinese tea plants and seeds were imported by the US Patent Office (later to become the United States Department of Agriculture) in South Carolina (Stedman 1858), and over 32,000 plants were growing in the Government Experimental and Propagation Garden in Washington DC (Gardener 1971). In the years after the importation, the Patent Office began to distribute the plants throughout the south eastern states. Jones (1877) provides details of letters from members of the public from 1857 to 1861, revealing the widespread and successful cultivation of these imported tea plants distributed by the Patent Office, mostly in South Carolina, but also North Carolina, Georgia and Florida. The local cultivation was so successful, that members of the public themselves began distributing the plants even further, for example as far as Texas and Maryland. There are even reports of tea having been grown in Calistoga, Napa County, California, and of a successful plantation being established at Modesto, in the foothills of the Sierra Nevada Mountains, Stanislaus County, California (Jones 1877).

In 1848, Junius Smith made the first attempt at commercial production of tea in South Carolina establishing his Golden Grove plantation, mostly derived from the imported Patent Office material and possibly with some plants imported from the East Indies via his daughter (Jones 1877; Huff 1995). This experiment was ultimately abandoned after he died in 1853 (Lippincott 1864; Mitchell 1908; Leroy Pond 2007). Tea had also been planted in Georgia by Dr Jones in 1850. This plantation was later used by the Department of Agriculture in 1880 for tea growing experiments (Mitchell 1908). A follow up attempt at tea production was made by Dr Alexis Forster 1874 in Georgetown, South Carolina. However, his tea plantation was also abandoned after his death in 1879 (Walcott 1999). In 1888, Dr Charles Shepard, United States Department of Agriculture Special Agent for Tea Culture, founded the Pinehurst Tea Plantation in Summerville, South Carolina (Shepard 1893, 1899; Hemphill 1907; Watson 1908), growing the plants imported by the US Patent Office. As a result of the work and achievements of Dr Shepard, the American Tea Company began the establishment of a large tea garden in Colleton County, and elsewhere across the state tea plants were being grown for home consumption (Watson 1908). Pinehurst was abandoned when Shepard died in 1915, and 1000s of tea bushes were transplanted from Pinehurst to nearby Rantowles, South Carolina, by Major Roswell Trimble and Colonel Augustus C. Tyler. Colonel Tyler died in 1905 and soon after the company was dissolved in 1907, thus ending commercial production of tea in the US yet again. That is until the Thomas J. Lipton Company established a tea research station on Wadmalaw Island, South Carolina, in 1963. Tea bushes from the nearby abandoned Pinehurst plantation were also incorporated into the Wadmalaw plantation. In 1987, the research station became the Charleston Tea Plantation, and the *American Classic Tea* brand was created. Nearly two centuries after the earliest attempts to cultivate tea on US soil, Charleston Tea Plantation is the only large scale commercial tea plantation remaining in the country. All clones on this plantation are direct descendents of Shepard's original plantation of plants imported more than 100 years ago (Phillips 2007), and it is here that *T. japonica* was first found on US soil by Carl Childers.

Taxonomic history of *Tuckerella japonica*

Tuckerella japonica was originally collected in Japan from the Muku tree, *Aphananthe aspera* (Thunb.) (Ulmaceae). Muku grows in the lowlands of central and southern Japan, on hills and stream sides, at an elevation of 100–600 m, and also grows in northern and

eastern China at 500–1,000 m. Muku flowers from April to May and its seeds ripen September to October, the same time as tea, though tea can be cultivated at elevations up to 2,300 m (Eden 1976; Manivel 1998).

Tuckerella japonica is newly recorded from Australia, China, Italy, New Zealand, The Philippines, Turkey, USA, and Vietnam. Many of these specimens had been misidentified as *T. flabellifera*, for example the Philippine record and several specimens intercepted in USA. The distribution of *T. flabellifera* remains Australia and New Zealand, though we report two new host plants (see species description below).

The male of *T. japonica* is here described for the first time. As no male was identified among the hundreds of specimens collected from tea in the USA, it was originally assumed that males were not produced by this species; however males were eventually collected from the ornamental relative of tea, *C. japonica*, in Australia.

Collection records from across the world indicate that tea is a preferred host of *T. japonica*. The mites spend most of their lives on the bark of older twigs of tea plants (Childers unpublished data) and on the thick walled woody fruit when it is present (pers. obs. Beard, Ochoa, Childers). The fruit takes almost a year to fully develop, usually being set in September to October and maturing the following year. As the mite completely avoids the green shoots and leaves that make up the harvestable portion of the plant (Childers unpublished data), it is not known to be of economic significance to tea producers. The cultural practise of removing the fruit, a preferred feeding site for *Tuckerella*, to allow the plant to use all its nutrients in the production of new shoots (pers. comm. William B. Hall), as opposed to leaving the fruit on the plants in a more natural state, may in fact be a fortuitous form of cultural control and could play a significant role in reducing *Tuckerella* populations on the tea. Even though the mite can be found in significant numbers on tea (approx. 10–30 individuals per 15 cm of branch; Childers unpublished data), the overall effects of *Tuckerella* feeding on the plant remain unknown.

Taxonomic history of *Tuckerella flabellifera*

Miller (1964) was the first to describe all life stages of a *Tuckerella* species. He described *T. flabellifera* from a type series collected on Tasmanian blanketleaf, *Bedfordia salicina* (Labill.) D.C. (Asteraceae), in Tasmania, Australia. Further material was collected from several other host plant species in a range of families. Miller discusses the apparent misidentification by Womersley (1940), also highlighted by Baker and Pritchard (1953). According to Baker and Pritchard (1953) the specimens Womersley had used to erect the new genus were actually *T. pavoniformis*, not *T. ornata* as Womersley had indicated. Womersley originally stated that the species had "a tuft of 10–12 ciliated setae". Miller (1964) examined seven slides of Womersley's *T. ornata,* covering all the localities and hosts listed by Womersley (1940), and discovered that only two of the slides were adult females and the remaining specimens were nymphs. All the specimens examined had five pairs of caudal setae, but Miller was unsure whether there was further material in the series. Miller (1964) concluded that the seven slides originally identified as *T. ornata* by Womersley (1940) and later identified as *T. pavoniformis* by Baker and Pritchard (1953) were neither *ornata* nor *pavoniformis*, but were in fact his new species, *T. flabellifera*.

Separating *Tuckerella japonica* and *T. flabellifera*

Ehara (1975) noted that *T. japonica* is similar to *T. flabellifera* but differs in having setae *f2* less than twice as wide as *f1* and in having the paraxial solenidion on tarsus I less than half

as long as the antiaxial solenidion. Ehara's statement is true if the type specimens are compared; however, an examination of many specimens indicates that the setae are more variable in length. We provide additional key characters that can be used to separate the two species in Remarks for each species.

Abbreviations

ANIC	Australian National Insect Collection, CSIRO Department of Entomology, Black Mountain, Canberra, Australia
AQIS	Australian Quarantine and Inspection Service, multiple collections in Brisbane (QLD), Sydney (NSW) and Melbourne (VIC), Australia
CNC	Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Ontario, Canada
MNH	Natural History Museum, London, UK
NSMT	National Science Museum, Shinjuku-ku, Tokyo, Japan
NZAC	New Zealand Arthropod Collection, Landcare Research, Auckland, New Zealand
QM	Queensland Museum, South Brisbane, QLD, Australia
SAM	South Australian Museum, North Terrace, Adelaide, SA, Australia
TDPIC	Tasmanian Department of Primary Industries Collection, New Town, Hobart, TAS, Australia
UPLBMNH	Museum of Natural History, University of The Philippines, Los Banyos, Laguna, Luzon, The Philippines
USNM	United States National Museum of Natural History, National Mite Collection, Systematic Entomology Laboratory, USDA Beltsville Agricultural Research Centre West, Beltsville, MD, USA

Specimens were examined using a Zeiss Axioplan microscope (Differential Interference Contrast). All measurements are presented in micrometres (μm). Setae were measured from the centre of the setal base to the tip of the seta; distances between setae were

Fig. 1 Adult female *Tuckerella japonica* on tea fruit (photo: Paul Skelley, DPI, Florida)

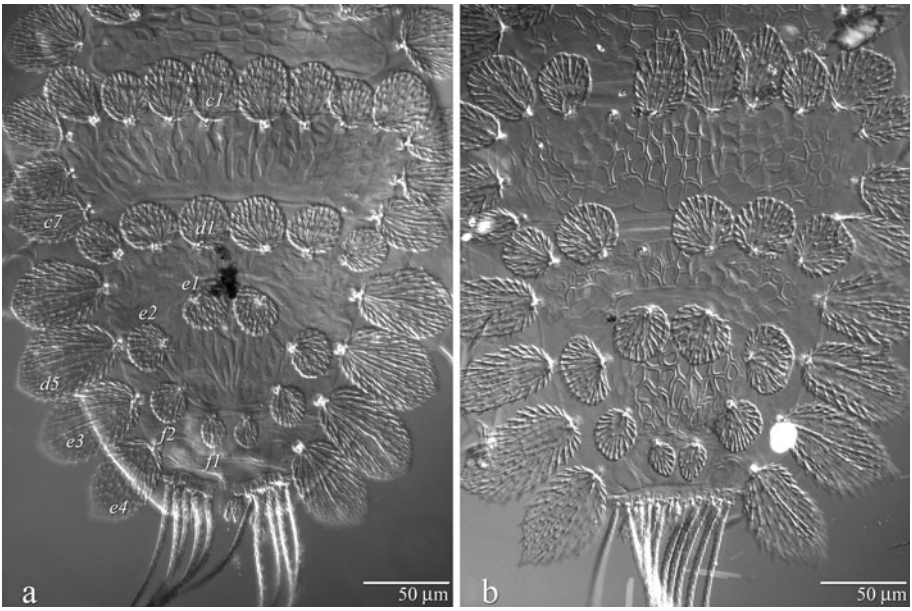

Fig. 2 Dorsal opisthosoma. **a** Adult female *Tuckerella japonica*; **b** adult female *Tuckerella flabellifera*. Differential Interference Contrast (DIC) images

measured as the distance from the inside edge of one setal base to the other (i.e., the minimum distance between two setal bases). Setal measurements for adult females are presented as a range (including paratype measurements) followed by the holotype in square brackets, all other stages are presented as a range, which may include paratype measurements. Body measurements include *v2–h1* and *sc2–sc2*, following Saito et al. (1999). Leg setal numbers are written as the total number of setae followed by the number of solenidia in parentheses. Adult body chaetotaxy is derived from Quiros-Gonzalez and Baker (1984), and leg chaetotaxy is derived from Lindquist (1985).

***Tuckerella japonica* Ehara** (Figs. 1; 2a; 3a, b; 4a, b; 5a–c; 6a, b; 7a, b)

Tuckerella xinglongensis Lin and Fu (1997, pp. 311–312). New synonym.

Material examined **Holotype. Female, Japan**, ex. *Aphananthe aspera* (Ulmaceae), Shiroyama, Tokushima City, Shikoku Island, 26.viii.1971, S. Ehara (NSMT). *Paratype*. Female, same data as holotype.

Other material examined **Australia:** 17 females, 8 males, 3 tritonymphs, 1 pharate tritonymph, 9 deutonymphs, 2 pharate deutonymphs, 7 protonymphs, 3 pharate protonymphs, 5 larvae, ex. *C. japonica* (Theaceae), Sydney Girls Grammar School, corner Anzac Parade and Cleveland Street, Sydney (NSW, Australia), 33°52′31″S 151°12′45″E, 15.i.2011, J.J. Beard (QM, USNM, ANIC). **Italy:** deutonymph, ex. kiwi fruit, *Actinidia deliciosa* (A. Chev.) C.F. Liang and A.R. Ferguson (Actinidiaceae), intercepted in Sydney (NSW, Australia), 19.i.2001 (AQIS NSW); female, deutonymph, same data, except 25.i.2001; 2 females, same data except 18.i.2005 (1 slide); deutonymph, same data except

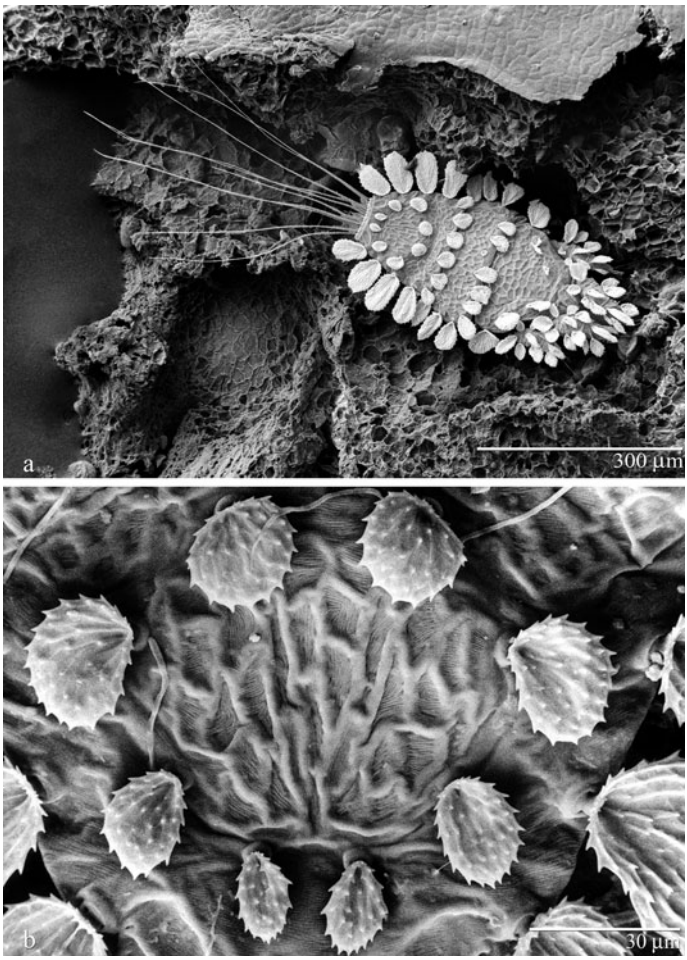

Fig. 3 Adult female *Tuckerella japonica*, low temperature scanning electron micrograph (LTSEM). **a** Dorsal habitus; **b** dorsal cuticle between setal rows E–F (images: Eric Erbe, USDA)

22.i.2007; deutonymph, ex. kiwifruit (*A. deliciosa*) intercepted in Brisbane (QLD, Australia), 6.i.2003 (AQIS QLD); female, same data except 14.i.2003. **Japan:** female, tritonymph, protonymph, ex. fruits of *Camellia sasanqua* Thunb. (Theaceae), intercepted in Washington (DC, USA), 19.ix.1955, H.Y. Gouldman (USNM); 8 females, 2 deutonymphs, 2 protonymphs, ex. *Juniperus* sp., intercepted in Seattle (WA, USA), 18.ix.1968, H.C. Nelson (USNM, 2 slides); pharate protonymph, pharate larva, ex. *C. japonica*, intercepted in USA, 23.vi.1995, L. Schnider (USNM); female, ex. *Diospyros kaki* Thunb. (Ebenaceae), intercepted in Hawaii, USA, 8.xii.1996, W. Keneshige (USNM); female, ex. *C. japonica*, intercepted in Seattle (WA, USA), 21.xi.2003, R. Sarmiento (USNM); female, ex. *C. sinensis* imported into Tasmania (pers. comm. M. Steiner), grown at Somersby Research Station, Gosford (NSW, Australia), 4.iii.2005, (ref. no. 1,112) M. Steiner (ANIC); female, pharate larva, same data except 1.ii.2006, (ref. no. 1,163), M. Steiner (ANIC); female, same data except 19.i.2006, (ref. no. 1,160), M. Steiner (ANIC). **New Zealand:** female, ex. blueberry *Vaccinium* sp. (Ericaceae), intercepted in

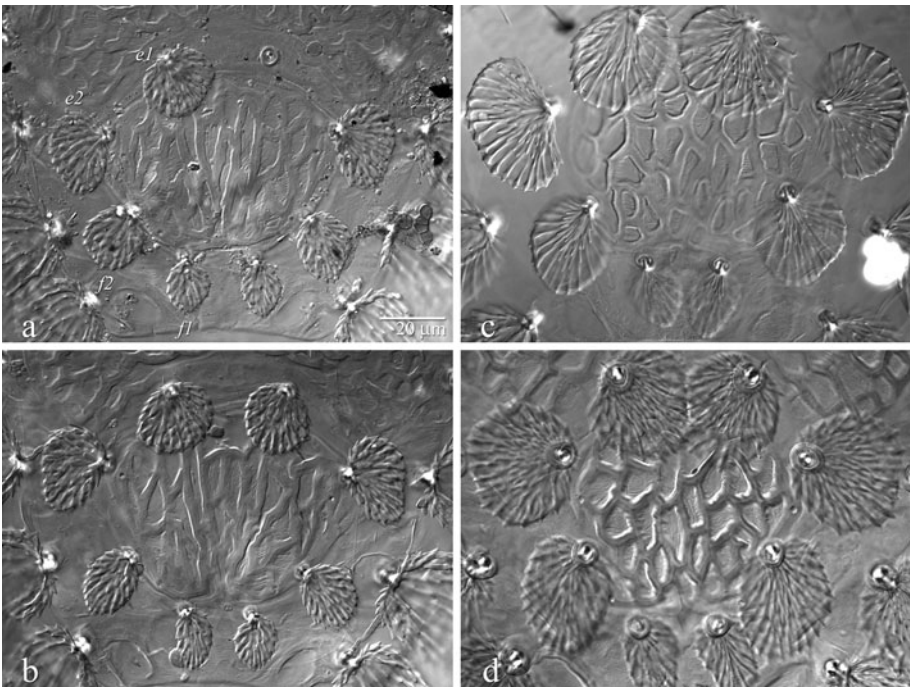

Fig. 4 Dorsal cuticle between setal rows E–F. **a**, **b** Adult female *Tuckerella japonica*; **c**, **d** adult female *Tuckerella flabellifera*. DIC images

Melbourne (VIC, Australia), 21.ii.2002 (AQIS VIC); female, same data except 2.ii.2004; female, ex. blueberry *Vaccinium* sp. (Ericaceae), intercepted in Sydney (NSW, Australia), 23.iii.2004 (AQIS NSW); female, same data except 25.ii.2005; female, same data except 11.ii.2006; female, same data except 24.ii.2006; female, ex. blueberry *Vaccinium* sp. (Ericaceae), intercepted in Brisbane (QLD, Australia), 8.iii.2005 (AQIS QLD). **The Philippines:** female, ex. Chaulmogra fruit, UPLB Forestry Campus, Mt Makiling, Los Banos, Laguna, Luzon, 4.ii.1999, R.C. Garcia (USNM, gifted from UPLBMNH, identified as *T. flabellifera*); female, ex. unknown plant, Mt Makiling, Kapos, San Rafael, St Tomas, Batangas, Luzon, 8.vii.1993, R.C. Garcia (USNM, gifted from UPLBMNH, identified as *T. flabellifera*). **Turkey:** female, ex. Tea, *C. sinensis* (Theaceae), Tea Research Institute, Pazar, 1.vii.2005, S. Ozman-Sullivan (USNM); 2 females, same data except 6.vii.2005 (USNM); protonymph, Zorlu Koyü, Hopa, 6.vii.2005, S. Ozman-Sullivan (USNM); protonymph, same data except Sumeryali (USNM); protonymph, same data except 1.vii.2005 (USNM). **USA:** all material collected from twigs and fruit of tea plants, *C. sinensis* (Theaceae), Wadmalaw Island (SC, USA)—2 females, 28.x.1994, C.C. Childers; deutonymph, 15.ii.1995, C.C. Childers; 4 larvae, 28.iv.1995; female, 5.vii.1995, C.C. Childers; 3 females, deutonymph, 5 protonymphs, larva, 17.vii.1995, C.C. Childers; tritonymph, 2 deutonymphs, 15.viii.1996, C.C. Childers; tritonymph (pharate female), 19.viii.1995, C.C. Childers; tritonymph, deutonymph, 5.xii.1995, C.C. Childers; 2 females, tritonymph (1 slide), 14.viii.2008, J.J. Beard and R. Ochoa (100s of additional specimens, USNM). **Vietnam:** female, 5.ii.1995, ex. *Ziziphus* sp. (Rhamnaceae), intercepted in New York (NY, USA), L. Schroeder (USNM).

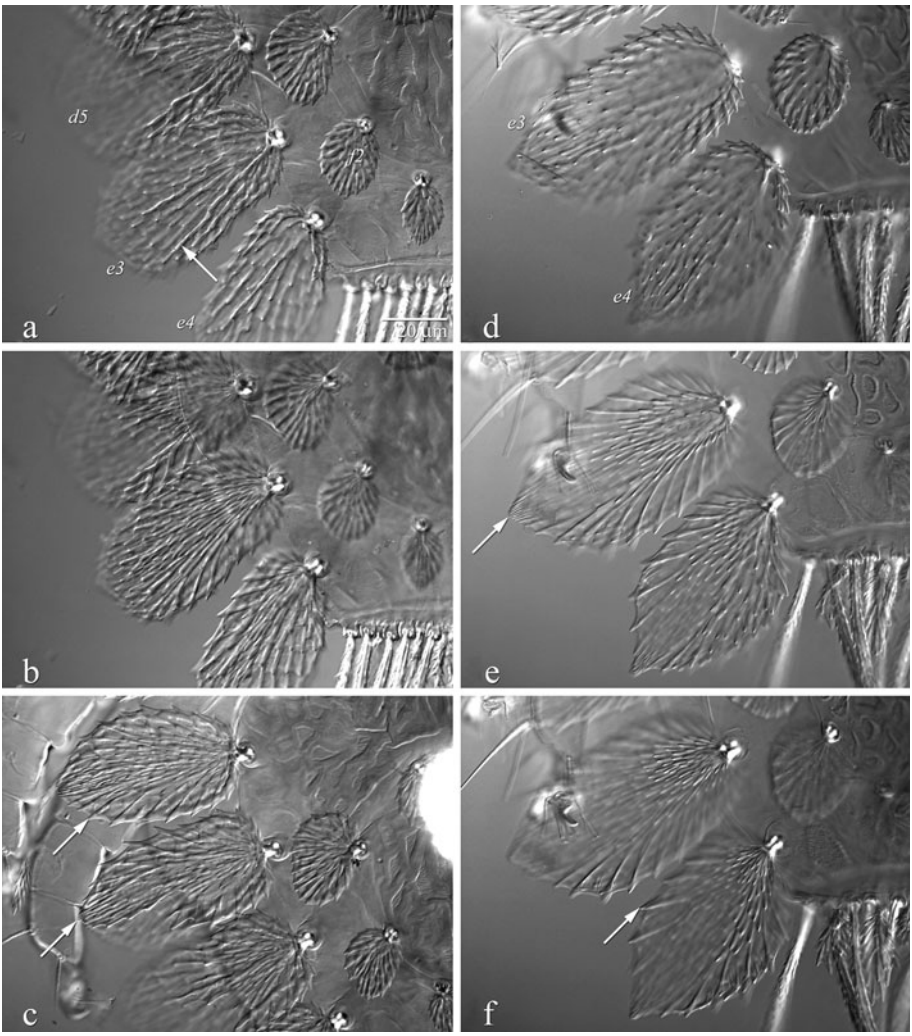

Fig. 5 **a–c** Adult female *Tuckerella japonica*. **a** Dorsal view of setae *d5*, *e3*, *e4*, *arrow* indicates dorsal ridges; **b** ventral view; **c** ventral view, *arrows* indicate oblique ridge terminating in lateral spine, and weakly tapered distal margin. **d–f** Adult female *Tuckerella flabellifera*, **d** dorsal view of setae *e3*, *e4*; **e** ventral view, *arrow* indicates distal margin tapered with parallel ridges; **f** ventral view, *arrows* indicate oblique ridge terminating in lateral spine. DIC images

Diagnosis Adult female: setal row H with five pairs of long flagellate setae (*h2*, *h4–5*, *h7–8*) and three pairs of short foliate setae (*h1*, *h3*, *h6*). Setae *f1* inserted posterior to setae *f2*. Setae *v1* rounded distally or with blunt distal projection, surface with network of fine ridges and few fine longitudinal spinules. Cuticle between setal rows E–F with longitudinally elongate, narrow cells. Setae *f2* are longer than wide (20–29 × 17–22). Posterior lateral dorsal setae *d4–5*, *e3–4* with distinct ridges on the dorsal surface, ridges with spinules, and distal margin bluntly rounded or weakly tapered.

Female. ***Dorsum*** (Figs. 1, 2a, 3a) Body measurements: length between setae *v1–h1* 307–362 [325], *v1–f1* 278–327 [294], *e1–f1* 62–72 [63], width between setae *sc2–sc2*

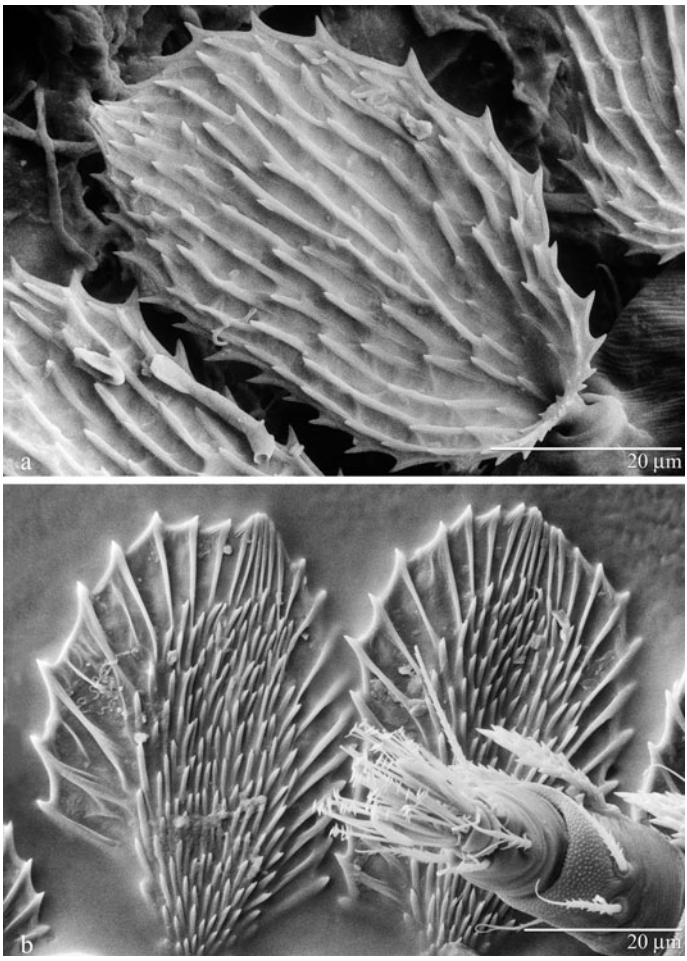

Fig. 6 Adult female *Tuckerella japonica* posterior lateral opisthosomal setae LTSEM. **a** Dorsal surface of seta *e3*; **b** ventral surface of setae *d5* and *e3*, with tarsus III (images: Eric Erbe, USDA)

157–182 [164], *c5–c5* 167–194 [172], *d4–d4* 134–147] 134, *e2–e2* 67–75, *e4–e4* 75–87 [77]. Prodorsal cuticle with shallow, thick walled regular to irregularly shaped cells, cells slightly wider than long, weakly striate cuticle visible inside cells; cells between setal rows C–D longitudinally elongate (Fig. 2a); longitudinally elongate, narrow cells between setal rows E–F (Figs. 2a, 3b, 4a, b). Eyes present. Dorsal setae measurements: *v1* 42–57 [43], *v2* 34–48 [34], *sc1* 35–46 [33], *sc2* 41–55 [47] (48–55 wide), *c1* 32–47 [35], *c2* 31–41 [32], *c3* 28–35 [28], *c4* 33–46 [33], *c5* 38–53 [44], *c6* 48–61 [48], *c7* 45–59 [45], d1 28–35, d2 27–32, *d3* 26–35 [25], *d4* 54–65 [56], *d5* 56–70 [61], e1 20–27 (22–29 wide), *e2* 21–27 [22] (23–32 wide), *e3* 55–70 [62], e4 54–66, *f1* 17–24 [19] (11–15 wide), *f2* 20–29 [23] (17–22 wide), *h1* 18–29 [26], *h2* 394–440 [386*], *h3* 3–51 [33], *h4* 396–438 [399], *h5* 382*–407 [391], *h6* 17–28 [18], *h7* 372–430 [390], *h8* 382–440 [309*] (*: obviously broken). Dorsal surface of posterior lateral setae with spinules associated with strong longitudinal ridges (Figs. 5a, 6a). Ventral surface of posterior lateral setae with longitudinally aligned spinules, concentrated mesally (Figs. 5b, c, 6b); with oblique ridges

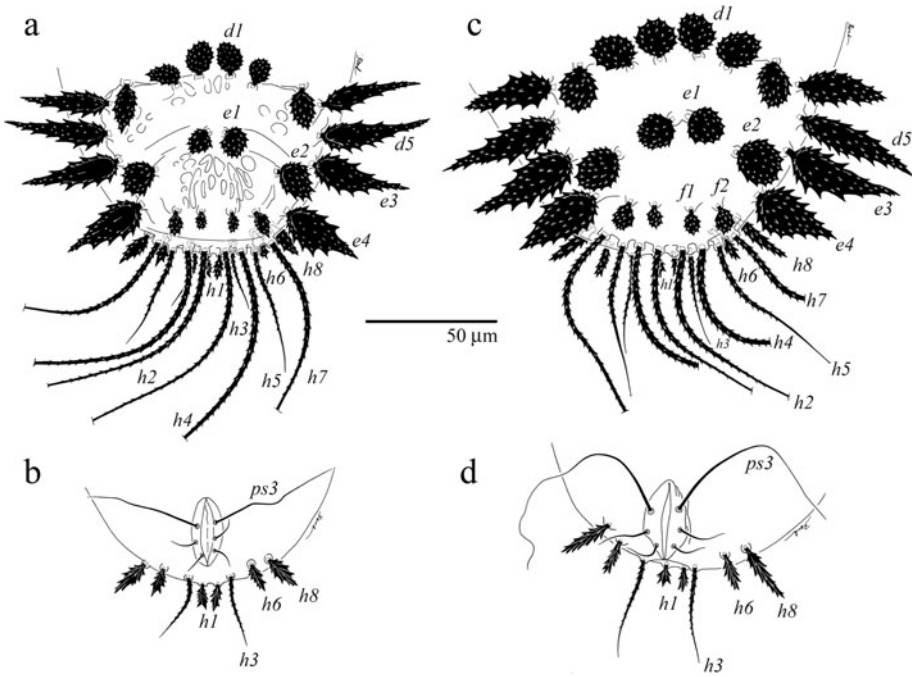

Fig. 7 **a**, **b** *Tuckerella japonica* larva, **a** posterior dorsal opisthosoma; **b** posterior ventral opisthosoma; **c**, **d** *Tuckerella flabellifera* larva, **c** posterior dorsal opisthosoma; **d** posterior ventral opisthosoma

laterally, each ridge terminating in a strong spine on the setal margin (Figs. 5c, 6b). Posterior lateral setae with distal margin rounded or weakly tapered (Fig. 5c). Seta *v1* rounded distally or with blunt distal projection, with network of fine ridges and few fine longitudinal spinules; *v2*, *sc1* fan shaped, rounded; seta *sc2* weakly auriform (ear shaped, asymmetrically wider than long); *c1–4* oval, rounded; *c6–7* tapered to point; *d1–3*, *e1* circular; *e2* oval to auriform; setae *f1* oval; *f2* longer than wide, circular to oval. Seta *h1*, *h3*, *h6* foliate, setae *h2*, *h4–5*, *h7–8* flagellate.

Palpi Palpi segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion 8–11 [11] and two eupathidia 9–11 [11], 10–12 [12]. Palp tibial claw striate laterally, striations forming herring–bone pattern or chevrons on ventral surface of claw.

Venter Most ventral setae lightly barbed at base, often difficult to see. Setal taper to fine tips, difficult to distinguish. Setal measurements: *1a* 104*–163 [139], *1b* 38–52 [51], *1c* 29–41 [33], *2b* 37–51 [38–39], *2c* 29–58 [41–44], *3a* 26–39 [30], *3b* 26–33 [29], *4a* 28–35 [29], *4b* 26–30 [28] (*: broken). Four pairs of genital setae (*g1–4*) present, setae *ag1*, *ag2* present. Some asymmetry is apparent, with several females having 2–3 pairs of genital and/or one pair aggenital setae present. Distance from tip of hypostome to ventral hypostomal seta *m*, 65–76 [69].

Spermatheca A cluster of small, membranous, bulbous lobes; appears to be 2–3 small subequal lobes surrounding 1–2 larger lobes. Most commonly appears to be one central lobe with two smaller lateral lobes.

Legs Setal formula for legs I–IV: cx 2, 2, 1, 1; tr 1, 1, 2, 1; fe 7, 7, 2, 1; ge 7, 6, 3, 2; ti 8(1), 5, 5, 4; ta 14(2), 11(1), 7, 7 (trochanters sometimes with missing setae). Tarsus I with two solenidia (paraxial 6–10 [8], antiaxial 14–21 [19]) and three eupathidia distally (paraxial 18–22 [22], dorsal 35–43 [37], antiaxial 26–32 [30]); tarsus II with one solenidion 7–11 [8] and two eupathidia distally (paraxial 14–18 [16], antiaxial 23–29 [26]); tibia I with one solenidion 8–14 [13]. All tactile setae on tarsi lightly barbed. Number of foliate/thickened setae present on legs I–IV: fe 3, 4, 1, 0; ge 5, 4, 2, 1; ti 5, 3, 2, 1. Thickened, barbed seta present on cx II (seta *2c*) 29–58 [41–44], fe II 23–40 [31], tr III 35–56 [24–40] and fe III 25–42 [29–31]. Claw IV 13–15 [13].

Male. ***Dorsum*** Body measurements: length between setae *v1–h1* 247–286, *v1–f1* 219–257, *e1–f1* 36–42, width between setae *sc2–sc2* 133–160, *c5–c5* 136–163, *d4–d4* 105–123, *e2–e2* 45–54, *e4–e4* 66–76. Prodorsal cuticle with fine longitudinal striae, a pattern of rounded cells sometimes apparent within the striae; with some weak reticulate pattern posterior to *sc1–sc2*. Opisthosomal cuticle between setal rows C–D and E–F with fine longitudinal striae, with some weakly developed narrow longitudinally elongate cells. Setal measurements: *v1* 28–35, *v2* 51–58, *sc1* 41–49, *sc2* 35–39, *c1* 44–53, *c2* 36–47, *c3* 29–32, *c4* 36–42, *c5* 32–37, *c6* 34–46, *c7* 33–42, *d1* 30–32, *d2* 27–32, *d3* 28–34, *d4* 44–56, *d5* 54–61, *e1* 21–26 (15–17 wide), *e2* 21–26 (15–18 wide), *e3* 54–66, *e4* 49–57, *f1* 14–18 (8–10 wide), *f2* 20–23 (12–15 wide), *h1* 14–15, *h3* 26–32, *h6* 18–20; *h2*, *h4–5*, *h7–8* 335–395; *h8* tends to be slightly shorter than the other flagellate setae (335–370). Dorsal surface of opisthosomal setae with evenly spaced spinules. Ventral surface of opisthosomal setae evenly covered with fine spinules; radiating oblique ridges absent. Lateral setae rounded distally, with small central point on distal margin. Setae *v1* broad, resemble butterfly scales, not tapering, truncate with dentate distal margin, covered in fine longitudinal ridges; with a different surface texture to all other dorsal setae. Setae *v2*, *c1* distinctly elongate; *d1–2*, *e2* and *f2* circular; bases of *e1* adjacent, almost touching; setae *f1* and *f2* oval. Setae *h1*, *h3*, *h6* foliate, setae *h2, h4–5*, *h7–8* flagellate, subequal in length.

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (8–9) and two eupathidia (9–10, 10–11).

Venter Setal measurements: *1a* 112–148, *1b* 36–44, *1c* 22–28, *2b* 28–37, *2c* 27–33, *3a* 24–29, *3b* 21–28, *4a* 25–28, *4b* 21–24, *ag1* 22–25, *ag2* 17–21, *g1* 17–20, *ps1* 11–14, *ps2* 18–21, *ps3* 19–25. Distance from tip of hypostome to ventral hypostomal seta *m*, 57–60.

Aedeagus The aedeagus of *Tuckerella* is a morphologically complicated structure. The entire system is 76–90 long.

Legs Setal formula for legs I–IV: cx 2, 2, 1, 1; tr 1, 1, 2, 1; fe 7, 7, 2, 1; ge 7, 6, 3, 2; ti 8(1), 5, 5, 4; ta 14(2), 11(1), 8(1), 8(1). Tarsus I with two solenidia (adaxial 13–19, abaxial 19–21) and three eupathidia (paraxial 17–21, dorsal 31–41, antiaxial 26–32); tarsus II with one solenidion (11–13), and two eupathidia distally (paraxial 12–16, antiaxial 23–28); tarsus III and IV each with one antiaxial solenidion broader than those on ta I–II (ta III 9–11, ta IV 9–11); tibia I with one solenidion (10–12). Number of foliate/thickened setae present on legs I–IV: fe 3, 4, 1, 0; ge 5, 4, 2, 1; ti 5, 3, 2, 1. Thick barbed seta present on cx II 27–33 (=*2c*), fe II 20–28, tr III 29–35 and fe III 22–26. Claw III 10–12.

Tritonymph. ***Dorsum*** Body measurements: length between setae *v1–h1* 314–352, *v1–f1* 289–324, *e1–f1* 47–53, width between setae *sc2–sc2* 149–165, *c5–c5* 161–172, *d4–d4* 125–134, *e4–e4* 72–81, *e2–e2* 61–64. Prodorsal cuticle with shallow rounded cells, striate cuticle visible inside cells. Dorsal setae measurements: *v1* 47–53, *v2* 36–42, *sc1* 33–39, *sc2*

43–54, *c1* 32–36, *c2* 29–34, *c3* 27–31, *c4* 41–51, *c5* 45–60, *c6* 52–66, *c7* 55–63, *d1* 25–27, *d2* 23–26, *d3* 26–35, *d4* 55–63, *d5* 59–69, *e1* 19–23 (19–21 wide), *e2* 19–25 (22–30 wide), *e3* 56–67, *e4* 55–67, *f1* 15–18 (9–11 wide), *f2* 20–24 (14–16 wide), *h1* 16–23, *h2* 340–375, *h3* 27–45, *h4* 342–372, *h5* 337–362, *h6* 16–23, *h7* 341–382, *h8* 87–303. Dorsal surface of setae with strong spines. Ventral surface with longitudinal spines concentrated mesally, with strong radiating ridges laterally terminating in large spine on setal margin. Seta *v1* more elongate than adult female, slightly tapered distally to rounded tip without point, with network of fine ridges; *v2*, *sc1* rounded fan shaped; *sc2* broad leaf shaped with distal point, or auriform; *c5–7*, *d4–5*, *e3–4* with distal point; *d1–2* circular; *d3* oval; setae *f1*, *f2* oval; insertion of *f1* posterior (13) to insertion of *f2*. Setae *h1*, *h3*, *h6* foliate, setae *h2, h4–5*, *h7–8* flagellate, *h8* shorter (with significant variation in length from obviously shorter to only slightly shorter than other flagellate H setae).

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (8–9) and two eupathidia (8–10, 9–10).

Venter Setal measurements: *1a* 112–130, *1b* 35–49, *1c* 25–34, *2b* 36–45, *2c* 42–48, *3a* 28–33, *3b* 23–30, *4a* 23–28, *4b* 22–25, *ag1* 21–24, *ag2* 22–24, *g1* 21–23, *g2* 23–25, *ps1* 18–20, *ps2* 31–34, *ps3* 36–42. Setae *ag1*, *ag2*, *g1* and *g2* present; setae *g3* and *g4* absent. Distance from tip of hypostome to ventral hypostomal seta *m*, 60–68.

Legs Setal formula for legs I–IV: cx 2, 2, 1, 1; tr 1, 1, 2, 1; fe 7, 7, 2, 1; ge 7, 6, 3, 2; ti 8(1), 5, 5, 4; ta 14(2), 11(1), 7, 7. Tarsus I with two solenidia (paraxial 5–7, antiaxial 14–17) and three eupathidia distally (paraxial 16–18, dorsal 31–36, antiaxial 24–27); tarsus II with one solenidion (6–7) and two eupathidia distally (paraxial 12–18, antiaxial 21–23); tibia I with one solenidion (8–10). Number of foliate/thickened setae present on legs I–IV: fe 3, 4, 1, 0; ge 5, 4, 2, 1; ti 5, 3, 2, 1. Foliate/thickened setae present on cx II (*2c*) 41–48, fe II 28–40, tr III 39–49, fe III 22–34. Claw IV 12–13.

Deutonymph. ***Dorsum*** Body measurements: length between setae *v1–h1* 254–311, *v1–f1* 238–288, *e1–f1* 37–48, width between setae *sc2–sc2* 135–146, *c5–c5* 141–157, *d4–d4* 111–124, *e4–e4* 63–75, *e2–e2* 52–57. Prodorsal cuticle with shallow rounded cells, striate cuticle visible inside cells. Dorsal setae measurements: *v1* 42–50, *v2* 27–33 (35–44 wide), *sc1* 26–39 (37–46 wide), *sc2* 41–54, *c1* 25–31, *c2* 23–30, *c3* 21–31, *c4* 39–45, *c5* 41–54, *c6* 50–61, *c7* 48–60, *d1* 21–24, *d2* 20–22, *d3* 23–30, *d4* 47–60, *d5* 53–65, *e1* 18–20 (15–17 wide), *e2* 18–25 (20–27 wide), *e3* 45–61, *f1* 10–16 (7–8 wide), *f2* 17–21 (11–13 wide), *h1* 11–22, *h2* 290–343, *h3* 24–42, *h4* 294–341, *h5* 276–334, *h6* 14–20, *h7* 293–331, *h8* 49–229 (commonly 49–107). Dorsal surface of setae with strong spines on ridges. Ventral surface with longitudinal spinules concentrated mesally, with strong radiating ridges laterally terminating in large spine on setal margin. Seta *v1* elongate, rounded distally, mostly smooth with few fine ridges; *v2*, *sc1* broad fan shaped to weakly auriform; *sc2* broad leaf shaped, tapered to distal point; *c4*, *d3* circular; *c5–7*, *d4–5*, *e3–4* tapered to point; *e1* auriform; setae *f1*, *f2* oval; insertion of *f1* posterior (10–13) to insertion of *f2*. Setae *h1*, *h3*, *h6* foliate, setae *h2, h4–5*, *h7–8* flagellate; *h8* often obviously shorter.

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (7–8) and two eupathidia (7–9, 9–10).

Venter Setal measurements: *1a* 73*–123, *1b* 27–41, *1c* 19–28, *2b* 21–33, *2c* 37–44, *3a* 23–30, *3b* 20–27, *4a* 18–29, *4b* 16–27, *ag1* 21–23, *ag2* 17–19. Setae *ag1*, *ag2* present; no

g setae present (one specimen with one *g* seta present). Distance from tip of hypostome to ventral hypostomal seta *m*, 53–63. (*: broken).

Legs Setal formula for legs I–IV: cx 2, 2, 1, 1; tr 0, 0, 1, 0; fe 5, 5, 2, 1; ge 5, 3–4, 1–2, 1–2; ti 6(1), 5, 5, 4; ta 13(2), 11(1), 7, 7. Tarsus I with two solenidia (paraxial 3–5, antiaxial 11–15) and three eupathidia distally (paraxial 13–18, dorsal 24–30, antiaxial 21–25); tarsus II with one solenidion (6–7) and two eupathidia distally (paraxial 11–16, antiaxial 18–21); tibia I with one solenidion (8–10). Number of foliate/thickened setae present on legs I–IV: fe 3, 4, 1, 0; ge 3, 2, 1, 1; ti 3, 3, 2, 1 (extra seta sometimes present on ge III–IV). Foliate/thickened setae present on cx II (*2c*) 32–44, fe II 25–38, tr III 33–47, fe III 19–30. Claw IV 11–12.

Protonymph. ***Dorsum*** Body measurements: length between setae *v1–h1* 209–242, *v1–f1* 192–221, *e1–f1* 32–36, width between setae *sc2–sc2* 108–127, *c5–c5* 116–133, *d4–d4* 94–106, *e4–e4* 60–68, *e2–e2* 46–49. Prodorsal cuticle with shallow rounded cells, striate cuticle visible inside cells. Dorsal setae measurements: *v1* 32–40, *v2* 23–29 (28–37 wide), *sc1* 24–28 (30–35 wide), *sc2* 34–44, *c1* 20–29, *c2* 20–24, *c3* 17–21, *c4* 30–39, *c5* 36–42, *c6* 42–47, *c7* 39–48, *d1* 15–20, *d2* 14–17, *d3* 19–24, *d4* 38–43, *d5* 46–51, *e1* 13–16 (12–14 wide), *e2* 16–19 (12–14 wide), *e3* 40–48, *e4* 41–45, *f1* 8–10 (5–7 wide), *f2* 11–15 (8–9 wide), *h1* 10–16, *h2* 240–255, *h3* 18–33, *h4* 232–265, *h5* 113–229, *h6* 10–13, *h7* 210–260, *h8* 23–40. Dorsal surface of setae with strong spines on ridges. Ventral surface with longitudinal spinules concentrated mesally; strong radiating ridges laterally terminating in large spine on setal margin. Seta *v1* elongate, rounded distally, with network of fine ridges; *v2*, *sc1* weakly auriform; *sc2* broad leaf shaped with distal point; *c5–7*, *d5*, *e3–4* narrow, elongate, tapered to point; *c4*, *d4* rounded distally; *d1–2*, *e1–2* circular; setae *f1*, *f2* oval; insertion of *f1* slightly posterior (6–7) to insertion of *f2*. Setae *h1*, *h3*, *h6* foliate (*h3* sometimes short flagellate); setae *h2, h4–5*, *h7–8* flagellate; *h5* thinner, fewer barbs, slightly shorter; *h8* obviously short.

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (6–8) and two eupathidia (6–7, 8–9).

Venter Setal measurements: *1a* 73–92, *1b* 23–38, *2c* 27–38, *3a* 18–21, *3b* 15–20, *ag1* 16–18; setae *1c*, *2b*, *4a*, *4b* absent. Setae *ag1* present; setae *ag2*, *g1–4* absent. Distance from tip of hypostome to ventral hypostomal seta *m*, 42–47.

Legs Setal formula for legs I–IV: cx 1, 1, 1, 0; tr 0, 0, 1, 0; fe 3, 3, 1, 1; ge 4, 3, 1, 0; ti 6(1), 5, 5, 3; ta 12(1), 11(1), 7, 4. Tarsus I with solenidion (10–13) and two eupathidia distally (paraxial 13–16, antiaxial 19–22); tarsus II with one solenidion (5–6) and two eupathidia distally (paraxial 10–12, antiaxial 15–17); tibia I with one solenidion (6–7). Number of foliate/thickened setae present on legs I–IV: fe 1, 2, 0, 0; ge 3, 2, 1, 1/0; ti 3, 3, 2, 0. Foliate/thickened setae present on cx II (*2c*) 27–38, fe II 22–29, tr III 25–31. Claw IV 10–11.

Larva. ***Dorsum*** (Fig. 7a) Body measurements: length between setae *v1–h1* 184–193, *v1–f1* 160–182, *e1–f1* 26–32, width between setae *sc2–sc2* 92–106, *c5–c5* 98–109, *d4–d4* 81–91, *e4–e4* 54–61, *e2–e2* 44–48. Prodorsal cuticle with weak shallow rounded cells, striate cuticle visible inside cells. Dorsal setae measurements: *v1* 19–22, *v2* 15–23, *sc1* 26–34, *sc2* 35–43, *c1* 19–23, *c2* 17–20, *c3* 12–16, *c4* 23–33, *c5* 24–38, *c6* 33–40, *c7* 29–36, *d1* 13–16, *d2* 13–16, *d3* 14–20, *d4* 27–38, *d5* 37–43, *e1* 11–14, *e2* 15–18, *e3* 35–39, *e4* 32–39, *f1* 8–9, *f2* 9–12, *h1* 8–11, *h2* 244–263, *h3* 25–28, *h4* 259–292, *h5* 39–54, *h6* 9–13,

h7 110–180, *h8* 13–17. Dorsal surface of setae with few short spinules; posterior lateral setae with U-shaped ridge basally (Fig. 7a). Ventral surface with few longitudinal spinules, with strong radiating ridges (Fig. 7b). Seta *v1* similar to *v2*, spined, fan shaped; *sc1*, *sc2* elongate, tapered to point; *c5–7*, *d4–5*, *e3* narrow, elongate, tapered to point; *e4* broader, tapered to point; *d1–2*, *e1–2* circular; setae *f1*, *f2* oval; insertion of *f1* in transverse line with, or slightly anterior (1–3) to, insertion of *f2*. Setae *h1*, *h6*, *h8* foliate; setae *h2–5*, *h7* flagellate; *h3*, *h5* obviously short (Fig. 7b).

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (5–6) and one eupathidion (6–7), slightly sickle shaped.

Venter Setal measurements: *1a* 53–81, *1b* 20–30, *3a* 12–18; setae *1c*, *2b*, *2c*, *3b*, *4a*, *4b* absent. No aggenital (*ag*) or genital (*g*) present. Hypostomal seta *m* absent.

Legs Setal formula for legs I–III: cx 1, 0, 0; tr 0, 0, 0; fe 3, 3, 1; ge 3, 3, 1; ti 6(1), 5, 5; ta 10(1), 9(1), 5. Tarsus I with solenidion (9–11) and two eupathidia distally (paraxial 11–12, antiaxial 16–17); tarsus II with one solenidion (4–6) and two eupathidia distally (paraxial 8–10, antiaxial 13–18); tibia I with one solenidion (5–6). Number of foliate/thickened setae present on legs I–IV: fe 1, 2, 0; ge 2, 2, 1; ti 3, 3, 2. Foliate/thickened setae present on fe II 20–26. Claw IV 9–10.

Hosts Type host: *Aphananthe aspera* (Ulmaceae). New host records include: *Actinidia deliciosa* (Actinidiaceae); *Camellia sinensis*, *C. japonica* (Theaceae); *Diospyros kaki* (Ebenaceae); *Juniperus* sp. (Cupressaceae); *Vaccinium* sp. (Ericaceae); *Ziziphus* sp. (Rhamnaceae).

Distribution Australia*, China*, Italy*, Japan, New Zealand*, The Philippines*, Turkey*, USA*, Vietnam*. (*: new record)

Remarks The pattern of cuticle between setal rows E–F is a strong and consistent difference between *T. japonica* and *T. flabellifera*–*T. japonica* has longitudinally elongate cells (Fig. 4a, b), whereas the same cuticle on *T. flabellifera* has much broader, not elongate cells (Fig. 4c, d). In addition, *T. japonica* has smaller dorsal setae than *T. flabellifera* in general, with some obviously smaller setae, for example the E row setae, *e1* 20–27 versus 28–35, *e2* 21–27 versus 26–33, *e3* 55–70 versus 75–84, *e4* 54–66 versus 64–73. Setae *f2* are longer than wide on *T. japonica* (20–29 × 17–22), whereas they are as long as broad on *T. flabellifera* (22–32 × 22–32) (Figs. 2, 4). The posterior lateral dorsal setae (*d4–5*, *e3–4*) differ between the two species in the following: *T. japonica* has distinct ridges (with associated spinules) on the dorsal surface (Figs. 5a, 6a), whereas these ridges are absent on *T. flabellifera* and the dorsal surface is spinulate (Fig. 5d); the distal margins are bluntly rounded or weakly tapered in *T. japonica* (Fig. 5c), whereas the distal margins of the same setae on *T. flabellifera* are distinctly tapered to a point (Fig. 5e); and the spinules on the ventral surface of these setae are less concentrated on *T. japonica* (Fig. 5b, c) than they are on *T. flabellifera* (Fig. 5e, f).

There are also differences between the immature stages of each species, and these differences again reflect the difference in size of the two species. For example, some larval H row setae differ in length (*japonica* vs *flabellifera*)—*h3* 25–28 versus 32–36, *h5* 39–54 versus 58–63, *h8* 13–17 versus 16–26 (Fig. 7a–d).

The leg chaetotaxy of the deutonymph varies on genua II–IV. Seta *v"* on genua II is occasionally absent, seta *d* is occasionally present on genua III, and seta *v'* is occasionally present on ge IV.

The holotype of *T. xinglongensis* was collected from *Polyscias fruticosa* var. *plumata* (Araliaceae), in Xinglong, Hainan Province, China, and the paratypes were collected from tea (*C. sinensis*), in Wuzhishan, Hainan Province. The synonymy is based on the illustrations and description. We were unable to examine the types, despite several attempts to borrow the specimens.

Ehara et al. (2009) lists the holotype as a male, though this is incorrect, both type specimens are female. The Philippine host plant listed as Chaulmogra fruit, could be the species *Hydnocarpus anthelmintica* (Flacourtiaceae), which is also recorded as a host for *Tuckerella filipina* Corpuz. The family level placement of this plant genus seems to be a little uncertain due to emerging molecular data.

Etymology This species was named for the country in which it was first collected.

***Tuckerella flabellifera* Miller** (Figs. 2b; 4c, d; 5d–f; 7c, d)

Material examined **Holotype. Female, Australia**, ex. *Bedfordia salicina* (Asteraceae), Mt Wellington (approx. 335 m), Tasmania, Australia, 10.viii.1961 (ANIC). *Allotype.* male, same data as holotype. *Paratypes*. 19 females, 8 males, 3 tritonymphs, 2 deutonymphs, 3 protonymphs, 3 larvae, same data as holotype (TDPIC); deutonymph, protonymph, larva same data as holotype; female, male, tritonymph, same data as holotype, except 15.viii.1961 (ANIC); tritonymph (labelled as female), same data as holotype except 15.viii.1961 (J12117) (SAM); male, same data as holotype (J12188) (SAM). Details of the collector were not provided, it is assumed to be L.W. Miller.

Other material examined **Australia:** female, 2 deutonymphs, protonymph, 2 pharate protonymphs, 2 larvae, ex. *Olearia curgophylla* (Asteraceae), Lilly Pilly Gully, Wilson's Promontory National Park, Victoria, 3.iii.1993, D.E. Walter and V. Barnes (5 slides; QM); pharate male (in deutonymph), same host, Chinaman Creek, Wilson's Promontory National Park, Victoria, 18.ii.1993, V. Barnes and D.E. Walter (QM). **New Zealand:** 10 females, ex. *Podocarpus totara* G. Benn. ex. Don (Podocarpaceae), Palmers Bush, Eve's Valley, near Nelson, 2.ii.1966, E. Collyer (BMNH, one slide); 10 females, same data except 20.x.1966, E. Collyer (NZAC, one slide); 12 females, same data except 10.i.1967; 7 females, ex. *Podocarpus dacrydioides* A. Rich. (Podocarpaceae), Aniseed Valley, near Nelson, 1.v.1966, E. Collyer (USNM, one slide); female, pharate female, tritonymph, ex. kiwifruit *Actinidea deliciosa* (Actinideaceae), 25.vii.1969, L.R. Gillogy (USNM, one slide); 2 females, 2 deutonymphs, ex. kiwifruit (*A. deliciosa*), intercepted in Brisbane (QLD, Australia), 8.v.2002 (AQIS QLD); female, same data except 16.v.2002; 2 protonymphs, same data except 24.v.2004; male, tritonymph, same data except 1.ix.2004; male, protonymph, ex. kiwifruit (*A. deliciosa*), intercepted in Melbourne (VIC, Australia), 7.vi.2007 (AQIS VIC); male, protonymph, same data except 12.vi.2007; male, nymph, ex. *Malus pumilia* (Rosaceae), intercepted in Canada, 8.v.2007 (CNC).

Diagnosis Adult female: setal row H with five pairs of flagellate setae (*h2*, *h4–5*, *h7–8*) and three pairs of short foliate setae (*h1*, *h3*, *h6*). Setae *f1* inserted posterior to setae *f2*. Setae *v1* rounded distally or with blunt distal projection, surface of setae with network of fine ridges and few fine longitudinal spinules. Cuticle between setal rows E–F with broad, slightly longitudinally elongate, cells. Setae *f2* are as long as wide (22–32 × 22–32). Posterior lateral dorsal setae *d4–5*, *e3–4* with spinulate dorsal surface, without distinct ridges, and distal margins are distinctly tapered to a point.

Female. ***Dorsum*** (Fig. 2b) Body measurements: length between setae *v1–h1* 323–373 [347], *v1–f1* 285–339 [315], *e1–f1* 62–76 [73], width between setae *sc2–sc2* 172–193 [186], *c5–c5* 184–208 [201], *d4–d4* 141–165 [151], *e2–e2* 67–74 [71], *e4–e4* 83–92 [83]. Prodorsal cuticle with thick walled, regular to rounded cells, cells as wide as long, with weakly striate cuticle visible inside cells. Reticulation strong over whole dorsum; with broad, slightly elongate cells between setal rows C–D (Fig. 2b); with broad, slightly elongate cells between setal rows E–F (Figs. 2b, 4c, d). Eyes present. Dorsal setae measurements: *v1* 45–52 [52], *v2* 39–51 [50], *sc1* 41–49 [46], *sc2* 47–61 [54], *c1* 43–56 [53–55], *c2* 39–51 [50], *c3* 32–46 [41], *c4* 42–48 [45–46], *c5* 48–54 [51], *c6* 53–67 [56], *c7* 53–62 [61], *d1* 32–42 [38–40], *d2* 31–41 [40], *d3* 31–41 [38], *d4* 67–80 [68–69], *d5* 69–82 [73–75], *e1* 28–35 [32–35] (28–37 [32] wide), *e2* 26–33 [30–32] (31–42 [40] wide), *e3* 75–84 [77], *e4* 64–73 [70], *f1* 21–30 [27] (13–16 [15] wide), *f2* 22–32 [29] (22–32 [32] wide), *h1* 23–33 [20–22], *h3* 35–41 [40–41], *h6* 22–27 [25–26], *h2*, *h4–5*, *h7–8* 415–470. Dorsal surface of posterior lateral setae with evenly spaced short spinules (Fig. 5d). Ventral surface of posterior lateral setae with short spinules concentrated mesally, aligned longitudinally (Fig. 5e, f); with oblique ridges laterally terminating in strong spine on lateral margin of seta (Fig. 5f); distal margin tapered to a point, ventral surface of point with series of fine longitudinal ridges (Fig. 5e). Seta *v1* elongate, rounded distally with or without short mesal blunt projection, with fine longitudinal spinules and network of fine ridges; with a different surface texture to all other setae. Setae *v2* and *sc1* rounded fan shaped; *sc2* weakly auriform; *c1* slightly longer than *c2–4*; *c6* and *c7* tapered to point; *d1–3*, *e1*, *f2* circular; setae *e2* auriform; setae *f1* oval. Setae *f2* as long as broad (Fig. 4c, d). Setae *h1*, *h3*, *h6* foliate; setae *h2, h4–5*, *h7–8* flagellate.

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion 11–12 [11] and two eupathidia 11–12 [12], 12–14 [13]. Palp tibial claw-like seta with corrugated ventral surface, ventral margin finely serrate in lateral view.

Venter Setal measurements: *1a* 123–165 [134], *1b* 42–52 [52], *1c* 31–34 [32], *2b* 42–51 [49], *2c* 45–60 [45–52], *3a* 32–39 [34], *3b* 28–32 [30], *4a* 24–36 [24], *4b* 26–31 [28], *ag1* 26–34 [26], *ag2* 23–35 [23], *g1* 30–37 [32], *g2* 32–46 [33–35], *g3* 29–41 [29–32], *g4* 34–41 [34–35], *ps1* 24–38 [34–35], *ps2* 41–54 [41–43], *ps3* 41–58 [41–48]. Setae *ag1–2*, *g1–4* present. Distance from tip of hypostome to ventral hypostomal seta *m*, 86–91 [91].

Spermatheca Difficult to determine; two membranous vesicles visible. Appears to be similar to that of *T. japonica*.

Legs Setal formula for legs I–IV: cx 2, 2, 1, 1; tr 1, 1, 2, 1; fe 7, 7, 2, 1; ge 7, 6, 3, 2; ti 8(1), 5, 5, 4; ta 14(2), 11(1), 7, 7. Tarsus I with two solenidia (paraxial 9–12 [10], antiaxial 15–22 [17]) and three eupathidia distally (paraxial 19–24 [23], dorsal 35–44 [42], antiaxial 24–32 [30]); tarsus II with one solenidion (8–11 [9]) and two eupathidia distally (paraxial 13–18 [17], antiaxial 24–28 [27]); tibia I with one solenidion (11–14 [13]). Number of foliate/thickened setae present on legs I–IV: fe 3, 4, 1, 0; ge 5, 4, 2, 1; ti 5, 3, 2, 1. Thick barbed setae present on cx II 45–62 [45–52] (=*2c*), fe II 34–47 [47], tr III 40–72 [59–60] and fe III 30–47 [47]. Claw IV 15–18 [16].

Male. ***Dorsum*** Body measurements: length between setae *v1–h1* 248–298, *v1–f1* 223–266, *e1–f1* 38–49, width between setae *sc2–sc2* 132–155, *c5–c5* 137–160, *d4–d4* 106–122, *e2–e2* 45–52, *e4–e4* 67–80. Prodorsal cuticle with strong reticulate pattern of shallow, thick walled cells, with finely striate cuticle visible inside cells. Opisthosomal cuticle between setal rows C–D and E–F with longitudinally elongate, broad thick walled

cells as in female. Setal measurements: *v1* 32–43, *v2* 53–58, *sc1* 45–50, *sc2* 36–42, *c1* 46–50, *c2* 42–46, *c3* 33–36, *c4* 35–44, *c5* 33–42, *c6* 40–49, *c7* 38–45, *d1* 30–36, *d2* 30–35, *d3* 32–40, *d4* 47–52, *d5* 55–61, *e1* 22–27 (17–22 wide), *e2* 22–28 (17–19 wide), *e3* 58–67, *e4* 55–59, *f1* 16–20 (10–12 wide), *f2* 21–24 (12–16 wide), *h1* 14–17, *h3* 21–29, *h6* 18–28; *h2*, *h4–5*, *h7–8* 380–400. Dorsal surface of opisthosomal setae with evenly spaced spinules. Ventral surface of opisthosomal setae with fine spinules, concentrated mesally, with fine lateral oblique ridges ending in a spine on lateral margin, ridges radiate from centre of setae. Lateral setae rounded distally, with small central point on distal margin. Setae *v1* broad, resemble butterfly scales, not tapering, truncate with dentate distal margin, covered in fine longitudinal ridges; with a different surface texture to all other dorsal setae. Setae *v2*, *c1* distinctly elongate; *d1–2*, *e2* and *f2* circular; bases of *e1* adjacent, almost touching; setae *f1* and *f2* oval to circular. Setae *h1*, *h3*, *h6* foliate, setae *h2, h4–5*, *h7–8* flagellate, subequal in length.

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (6–9) and two eupathidia (9–10, 10–11).

Venter Setal measurements: *1a* 108–138, *1b* 38–47, *1c* 26–32, *2b* 26–46, *2c* 30–44, *3a* 29–33, *3b* 23–28, *4a* 28–30, *4b* 22–26, *ag1* 23–31, *ag2* 22–25, *g1* 21–30, *ps1* 16–18, *ps2* 25–28, *ps3* 28–30. Distance from tip of hypostome to ventral hypostomal seta *m*, 65–74.

Aedeagus The aedeagus of *Tuckerella* is a morphologically complicated structure. The entire system is 75–80 long.

Legs Setal formula for legs I–IV: cx 2, 2, 1, 1; tr 1, 1, 2, 1; fe 7, 7, 2, 1; ge 7, 6, 3, 2; ti 8(1), 5, 5, 4; ta 14(2), 11(1), 8(1), 8(1). Tarsus I with two solenidia (adaxial 13–15, abaxial 13–20) and three eupathidia (paraxial 18–21, dorsal 37–43, antiaxial 28–29); tarsus II with one solenidion (9–12), and two eupathidia distally (paraxial 14–15, antiaxial 20–25); tarsus III and IV each with one antiaxial solenidion broader than those on ta I–II (ta III 9–11, ta IV 8–11); tibia I with one solenidion (10–12). Number of foliate/thickened setae present on legs I–IV: fe 3, 4, 1, 0; ge 5, 4, 2, 1; ti 5, 3, 2, 1. Thick barbed seta present on cx II 30–44 (=*2c*), fe II 21–31, tr III 33–45 and fe III 19–23. Claw III 12–14.

Tritonymph. ***Dorsum*** Body measurements: length between setae *v1–h1* 291–338, *v1–f1* 265–309, *e1–f1* 48–58, width between setae *sc2–sc2* 142–178, *c5–c5* 151–176, *d4–d4* 122–138, *e2–e2* 61–66, *e4–e4* 74–85. Dorsal cuticle finely plicate, with rounded thick walled cells developing within the cuticle. Dorsal setae measurements: *v1* 45–57, *v2* 35–44, *sc1* 40–44, *sc2* 48–60, *c1* 35–42, *c2* 29–38, *c3* 26–32, *c4* 44–50, *c5* 52–63, *c6* 57–68, *c7* 60–68, *d1* 30–33, *d2* 22–29, *d3* 31–37, *d4* 54–65, *d5* 64–72, *e1* 23–30 (18–29 wide), *e2* 22–29 (22–36 wide), *e3* 61–72, *e4* 59–68, *f1* 16–19 (9–12 wide), *f2* 22–26 (15–23 wide), *h1* 18–22, *h3* 34–38, *h6* 19–23; *h2*, *h4–5*, *h7* subequal in length 340–370, *h8* 230–320. Dorsal surface of setae with short spines; ventral surface with longitudinally aligned spinules, concentrated mesally, with strong oblique ridges terminating laterally in a strong spine on setal margin. Lateral dorsal setae tapered to an obvious point; ventral surface of point with series of fine parallel longitudinal rigdes. Seta *v1* with network of fine ridges, slightly tapered distally to rounded tip; with a different surface texture to all other setae. Setae *v2*, *sc1* wider than long; *sc2* with broad base, tapering to point; *d3* circular; bases of *e1* adjacent, almost touching; setae *f1*, *f2* oval. Setae *h1*, *h3*, *h6* foliate, setae *h2, h4–5*, *h7–8* flagellate, *h8* slightly shorter.

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (8–10) and two eupathidia (8–10, 9–11).

Venter Setal measurements: *1a* 104–147, *1b* 34–38, *1c* 24–28, *2b* 33–39, *2c* 43–50, *3a* 26–29, *3b* 22–25, *4a* 22–27, *4b* 21–24, *ag1* 21–23, *ag2* 21–24, *g1* 22–23, *g2* 21–23. Setae *g3* and *g4* absent. Distance from tip of hypostome to ventral hypostomal seta *m*, 66–74.

Legs Setal formula for legs I–IV: cx 2, 2, 1, 1; tr 1, 1, 2, 1; fe 7, 7, 2, 1; ge 7, 6, 3, 2; ti 8(1), 5, 5, 4; ta 14(2), 11(1), 7, 7. Tarsus I with two solenidia (paraxial 6–8, antiaxial 12–14) and three eupathidia distally (paraxial 15–17, dorsal 22–30, antiaxial 23–26); tarsus II with one solenidion (6–7) and two eupathidia distally (paraxial 11–14, antiaxial 20–22); tibia I with one solenidion (8–10). Number of foliate/thickened setae present on legs I–IV: fe 3, 4, 1, 0; ge 5, 4, 2, 1; ti 5, 3, 2, 1. Foliate/thickened setae present on cx II 43–50 (=*2c*), fe II 32–41, tr III 44–58 and fe III 23–32. Claw IV 12–15.

Deutonymph. ***Dorsum*** Body measurements: length between setae *v1–h1* 243–294, *v1–f1* 222–269, *e1–f1* 36–45, width between setae *sc2–sc2* 129–146, *c5–c5* 132–156, *d4–d4* 106–128, *e2–e2* 48–56, *e4–e4* 61–76. Dorsal cuticle finely plicate, with shallow, thick walled, rounded cells. Dorsal setae measurements: *v1* 41–48, *v2* 32–37, *sc1* 32–37, *sc2* 40–58, *c1* 27–33, *c2* 26–31, *c3* 23–28, *c4* 40–46, *c5* 43–56, *c6* 48–62, *c7* 49–60, *d1* 22–24, *d2* 18–25, *d3* 26–36, *d4* 45–56, *d5* 47–62, *e1* 18–23 (15–23 wide), *e2* 19–29 (16–24 wide), *e3* 49–64, *e4* 48–58, *f1* 12–15 (7–10 wide), *f2* 16–22 (12–18 wide), *h1* 12–16, *h3* 24–32, *h6* 15–20; *h2, h4–5, h7* 280–340, *h8* 85–177. Lateral dorsal setae tapered to obvious point; ventral surface of point on posterior lateral setae with parallel longitudinal ridges. Setae *v1* with network of fine ridges, few longitudinal spinules, with a different surface texture to all other setae. Setae *v2*, *sc1* wider than long; *sc2* broad tapering to long distal point; *d1–2*, *e2* circular; bases of *e1* adjacent, almost touching; setae *f1* oval, *f2* circular. Setae *h1*, *h3*, *h6* foliate, setae *h2, h4–5*, *h7–8* flagellate, *h8* obviously shorter.

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (7–9) and two eupathidia (8–10, 9–11).

Venter Setal measurements: *1a* 96–131, *1b* 31–39, *1c* 24–26, *2b* 26–42, *2c* 36–46, *3a* 22–27, *3b* 21–25, *4a* 16–24, *4b* 14–24, *ag1* 17–28, *ag2* 16–27. Setae *g1–4* absent. Distance from tip of hypostome to ventral hypostomal seta *m*, 51–65.

Legs Setal formula for legs I–IV: cx 2, 2, 1, 1; tr 0, 0, 1, 0; fe 5, 5, 2, 1; ge 5, 3–4, 1–2, 1; ti 6(1), 5, 5, 4; ta 13(2), 11(1), 7, 7. Tarsus I with two solenidia (paraxial 3–5, antiaxial 10–13) and two eupathidia distally (paraxial 13–17, antiaxial 18–26); tarsus II with one solenidion (5–8) and two eupathidia distally (paraxial 10–14, antiaxial 17–23); tibia I with one solenidion (7–9). Number of foliate/thickened setae present on legs I–IV: fe 3, 3, 1, 0; ge 3, 2, 1–2, 1; ti 3, 3, 2, 1. Thick barbed setae on cx II 36–46, fe II 26–37, tr III 35–45 and fe III 22–27. Claw IV 10–12.

Protonymph. ***Dorsum*** Body measurements: length between setae *v1–h1* 224–267, *v1–f1* 206–248, *e1–f1* 30–40, width between setae *sc2–sc2* 112–122, *c5–c5* 122–132, *d4–d4* 99–107, *e2–e2* 47–50, *e4–e4* 59–68. Dorsal cuticle finely plicate with shallow, thick walled, rounded cells. Dorsal setae measurements: *v1* 37–41, *v2* 27–32, *sc1* 25–30, *sc2* 44–55, *c1* 23–26, *c2* 22–25, *c3* 19–21, *c4* 33–42, *c5* 43–51, *c6* 45–59, *c7* 46–59, *d1* 19–22, *d2* 16–20, *d3* 22–24, *d4* 42–54, *d5* 48–60, *e1* 15–17 (13–20 wide), e2 18–22 (14–18 wide), *e3* 48–56, *e4* 43–47, *f1* 10–11 (5–6 wide), *f2* 15–28 (7–12 wide), *h1* 8–15, *h3* 18–28, *h6* 13–20; *h2*, *h4*, *h7* 230–280; *h5* 120–180, *h8* 37–57. Lateral dorsal setae tapered to obvious point. Seta *v1* with network of fine ridges, few longitudinal spinules; *v2*, *sc1* wider than long; *d1–2*, *e2* circular; bases of *e1* adjacent, almost touching; setae *f1* oval, *f2* circular;

insertion of *f1* obviously posterior (12) to insertion of *f2*. Setae *h1*, *h3*, *h6* foliate, setae *h2, h4–5*, *h7–8* flagellate, *h5* thinner and shorter than other flagellate setae, *h8* obviously much shorter.

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (6–8) and two eupathidia (6–8, 8–9).

Venter Setal measurements: *1a* 87–110, *1b* 28–35, *2c* 28–34, *3a* 17–23, *3b* 19–21, ag1 19–21. Setae *g1–4*, *ag2* absent. Distance from tip of hypostome to ventral hypostomal seta *m*, 44–52.

Legs Setal formula for legs I–IV: cx 1, 1, 1, 0; tr 0, 0, 1, 0; fe 3, 3, 1, 1; ge 4, 3, 1, 0; ti 6(1), 5, 5, 3; ta 12(1), 11(1), 7, 3. Tarsus I with one solenidion (antiaxial 9–14) and two eupathidia distally paraxial 15–16, antiaxial 19–21); tarsus II with one solenidion (5–7) and two eupathidia distally (paraxial 10–11, antiaxial 15–16); tibia I with one solenidion (6–12). Number of foliate/thickened setae present on legs I–IV: fe 1, 2, 0, 0; ge 3, 2, 1, 0; ti 3, 3, 2, 0. Thick barbed setae on cx II 28–34, fe II 22–34 and tr III 26–31. Claw IV 10–11.

Larva. ***Dorsum*** (Fig. 7c) Body measurements: length between setae *v1–h1* 176–210, *v1–f1* 163–193, *e1–f1* 29–35, width between setae *sc2–sc2* 91–108, *c5–c5* 102–112, *d4–d4* 85–97, *e2–e2* 42–45, *e4–e4* 53–64. Dorsal cuticle finely plicate with large rounded, shallow cells. Dorsal setae measurements: *v1* 21–26, *v2* 22–27, *sc1* 26–34, *sc2* 34–42, *c1* 20–24, *c2* 21–23, *c3* 17–20, *c4* 23–31, *c5* 29–36, *c6* 35–48, *c7* 34–43, *d1* 13–17, *d2* 16–19, *d3* 16–19, *d4* 29–35, *d5* 41–51, *e1* 12–15 (11–13 wide), *e2* 18–20 (11–13 wide), *e3* 40–47, *e4* 28–37, *f1* 10–11 (4–5 wide), *f2* 11–13 (6–8 wide), *h1* 8–11, *h2* 225–270, *h3* 32–36, *h4* 270–310, *h5* 58–63, *h6* 12–16, *h7* 170–192, *h8* 16–26. Seta *v1* tapered to point, strongly spinulate; *v2* rounded fan shaped; *sc1*, *sc2* tapered to point; *c4–7*, *d4–5*, *e4* narrow, elongate, tapered to point; *e4* broad, tapered to point; *d1–3*, *e1–2* circular; bases of *e1* adjacent, almost touching; setae *f1*, *f2* oval; setae *f1* in more or less transverse line with setae *f2* (Fig. 7c). Setae *h1*, *h6*, *h8* foliate; setae *h2–5*, *h7* flagellate; *h3*, *h5* obviously short (Fig. 7c, d).

Palpi Palpi five segmented. Setal formula: 0, 0, 1, 3, 6(1). Palp tarsus with one solenidion (6–7) and one eupathidion (7–8).

Venter Setal measurements: *1a* 66–93, *1b* 26–35, *3a* 14–23, *ps1* 7–12, *ps2* 16–18, *ps3* 46–100 (fine, often broken). Setae *1c*, *2a*, *2b*, *3b*, *4a*, *4b*, *ag1*, *ag2*, *g1–4* absent. Ventral infracapitular setae, *m*, absent.

Legs Setal formula for legs I–III: cx 1, 0, 0; tr 0, 0, 0; fe 3, 3, 1; ge 3, 3, 1; ti 6(1), 5, 5; ta 10(1), 9(1), 5. Tarsus I with one antiaxial solenidion (9) and two eupathidia distally (paraxial 11–13, antiaxial 14–17); tarsus II with one solenidion (5–6) and two eupathidia distally (paraxial 10–11, antiaxial 14); tibia I with one solenidion (6–7). Number of foliate/thickened setae present on legs I–IV: fe 1, 2, 0; ge 2, 2, 1; ti 3, 3, 2. Thick setae present on fe II 25–30. Claw III 10–11.

Host Type host: *Bedfordia salicina* (Asteraceae). Other hosts include: *Acacia dealbata* Link. (Mimosaceae); *Actinidia deliciosa* (Actinidiaceae)*; *Callistris tasmanica* (Benth.) B. and S. (Cupressaceae); *Grevillea robusta* Cunn. (Proteaceae); *Leucopogon parviflorus* (Andr.) Lindl. (Epacridaceae); *Notelaea ligustrina* Vent. (Oleaceae); *Olearia curgophylla* (Asteraceae)*; *Podocarpus dacrydioides*, *P. totara* (Podocarpaceae) (Collyer 1969; Miller 1964) (*: new record).

Distribution Australia, New Zealand.

Remarks See Remarks for *T. japonica*. We report here for the first time that *T. flabellifera* displays the same ontogenetic modification as that previously reported for *T. saetula* and *T.* nr *pavoniformis* (Beard and Ochoa 2010) in that the ancestral prostigmatan condition of three nymphal stages during ontogeny is lost. Male *T. flabellifera* do not retain a tritonymphal stage during ontogeny, but instead they moult directly from the deutonymph. All material examined was measured for the descriptions. The holotype female is over cleared and details are difficult to see. The leg chaetotaxy of the deutonymph varies on genua II and III. Seta *v"* on genua II is equally present or absent (rarely absent on *T. japonica*), and seta *d* is usually absent on genua III but is present on a paratype deutonymph (also occasionally present on *T. japonica*). The protonymph paratype is in poor condition and needs remounting.

Etymology The Latin word *flabellum* means "fan".

Discussion

The great value placed on tea, both socially and economically, led to a long history of human transportation of entire tea plants across the world. Based on this, combined with the widespread cultural practise of using cuttings from mother plants to established new plantations, we predict that most long-established tea plantations, especially those that leave the fruits on the plants, would harbour populations of *T. japonica*. More recently, however, movement of entire plants is a less common practise and many tea plantations established in the last 50–60 years were developed from seed and seedling planting material (Ellis 1995), or even more recently from an increasing number of clonal cultivars developed through vegetative propagation or germplasm (Ellis 1995; Zee et al. 2003). Thus, *T. japonica* is less likely to be present in such plantations, though the mite could arrive on other hosts including ornamental camellias, *C. japonica* and *C. sasanqua*. Relatively recently established tea plantations in northern Australia (from seed) (Chudleigh 1999; Drinnan 2008) and Hawaii (from clonal cultivars) (Zee et al. 2003; pers. comm. Zee) were sampled by generous colleagues, and as expected, *T. japonica* was not located, though it should be pointed out that only minimal sampling was undertaken. In order to produce the large numbers of seeds required to start a new plantation, seed orchards are established in which tea plants are allowed to grow unchecked, and the fruit is not pruned (Willson 1992). Such orchards potentially host large populations of *T. japonica*.

The ability to feed on the bark of stems, twigs, fruit and roots of its host no doubt contributed to successful spread of this mite. Hidden in cracks in the bark of its host plant, *Tuckerella* are much harder to detect than other phytophagous mites that feed on leaves and create obvious damage that is easily detected visually by humans. The inability to easily detect this genus in quarantine is of growing concern as interceptions of *T. japonica* on kiwi fruit, *T. ornata* and *T. knorri* on citrus and mango, and *T. pavoniformis* on avocados, increase every year. An overriding complicating factor in the detection and identification of *Tuckerella* is the generally poor ecological and taxonomic understanding of the group. For example, until now *T. japonica* remained an obscure species, not recollected for years, often being confused with the geographically restricted *T. flabellifera*, until it was collected in South Carolina, USA. We do not yet fully understand the impact that *Tuckerella* feeding has on a host plant. However, as they can often be found in significant numbers on a plant, the group is of ever increasing concern to quarantine and agriculture world-wide.

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