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Two new species of *Selitrichodes* (Hymenoptera: Eulophidae: Tetrastichinae) inducing galls on *Casuarina* (Casuarinaceae)

NICOLE FISHER¹, AUBREY MOORE², BRADLEY BROWN³, MATTHEW PURCELL³,
GARY S. TAYLOR⁴ & JOHN LA SALLE^{1,5}

¹Australian National Insect Collection, CSIRO Ecosystem Sciences, GPO Box 1700, Canberra, ACT 2601, Australia.

E-mail: nicole.fisher@csiro.au

²Western Pacific Tropical Research Center, University of Guam Station, Mangilao, Guam, 96923, USA.

E-mail: amoore@uguam.uog.edu

³USDA ARS Australian Biological Control Laboratory, CSIRO Ecosystem Sciences, 120 Meiers Road, Indooroopilly, QLD 4068, Australia. E-mail: bradley.brown@csiro.au; matthew.purcell@csiro.au

⁴Australian Centre for Evolutionary Biology and Biodiversity and School of Earth and Environmental Sciences, The University of Adelaide, North Terrace, Adelaide, SA 5005, Australia. E-mail: gary.taylor@adelaide.edu.au

⁵Atlas of Living Australia, CSIRO Ecosystem Sciences, GPO Box 1700, Canberra, ACT 2601, Australia.

E-mail: john.lasalle@csiro.au

Abstract

Two new species of gall-inducing wasps, *Selitrichodes casuarinae* Fisher & La Salle **sp. n.** and *Selitrichodes utilis* Fisher & La Salle **sp. n.**, are described from Micronesia (Guam, Rota and Palau Islands) and Australia respectively. These species induce galls on *Casuarina* and can cause extensive damage to the trees. Their status as pest or beneficial species is discussed.

Key words: gall induction, invasive species, Micronesia, Guam, Rota, Palau, sheoak

Introduction

Casuarina (Casuarinaceae) is native to Australasia, southeastern Asia, South America and the islands of the western Pacific Ocean. Casuarinas (commonly known as sheoak, ironwood, or beefwood) are commonly grown in tropical and subtropical areas throughout the world. The plants are very tolerant of windswept locations, and are widely planted as windbreaks, although usually not in agricultural situations.

In January 2009, a new species of gall-inducing wasp, described here as *Selitrichodes casuarinae* Fisher & La Salle, was discovered inducing galls on *Casuarina equisetifolia* in Guam. In March and April 2009, a second species, described here as *Selitrichodes utilis* Fisher & La Salle, was found in Australia inducing galls on *Casuarina glauca*.

Pest/invasive or Beneficial?

Casuarina wood has many uses, including fuelwood, poles, posts, beams, oxcart tongues, shingles, panelling, fence rails, furniture, marine pilings, tool handles, and cabinets (Morton 1980). Species such as *Casuarina equisetifolia*, *Casuarina cunninghamiana* and *Casuarina glauca* occur extensively throughout the South Pacific, where they are generally considered to be beneficial and have a variety of uses (Whistler & Elevitch 2006). On Guam, *C. equisetifolia* is widely planted as an agricultural windbreak, as a shade tree in parks, and for erosion control on beaches. These trees are currently in general decline and dying throughout Guam. *Selitrichodes casuarinae* was discovered during surveys aimed at finding the causes of this decline (Schlub *et al.* 2011; Schlub 2013).

The same three *Casuarina* species considered as beneficial in the South Pacific have, however, been introduced into many countries where they are not as welcome. In Florida, these species are now considered to be serious invasive pest species where they pose a variety of environmental problems including interfering with endangered species, contributing to erosion, and public safety (Wheeler *et al.* 2011). There is evidence that the three species are now hybridizing, potentially adding an additional level of complexity to their management (Gaskin *et al.* 2009). Surveys for biological control agents have been conducted since the 1980's but as yet no insects have been introduced into Florida.

Whether the new gall inducing species described here are pests or beneficials clearly depends on whether the *Casuarina* species are viewed as beneficial plants or invasive species. These would not be the first examples of a species potentially being considered as a pest or beneficial depending on perspective, and a review of pest insects associated with *Eucalyptus* in California discussed this subject (Paine *et al.* 2010).

Material and methods

Terminology used in this paper is taken from Gibson (1997) and Graham (1987). Abbreviations used are: CC, costal cell; MV, marginal vein; OOD, ocellar–ocular distance; POD, post-ocellar distance; SMV, submarginal vein; STV, stigmal vein; PMV, postmarginal vein; F1–3, funicular segments 1–3.

Acronyms used in the text are as follows: ANIC, Australian National Insect Collection, CSIRO Ecosystem Sciences, Canberra, Australia; BMNH, The Natural History Museum, London, UK; ESUG, University of Guam Insect Collection, Mangilao, Guam, USA; QMB, Queensland Museum, Brisbane, Australia; USNM, United States National Museum of Natural History, Washington, D.C., USA.



FIGURES 1–4. Damage to *C. equisetifolia* on Guam. 1. Adult *S. casuarinae* on *Casuarina* stem. 2 and 3. Stunting caused by *S. casuarinae*. 4. *S. casuarinae* exit hole in tip of stem.



FIGURES 5–7. Damage to *C. glauca* at USDA ARS, Australian Biological Control Laboratory in Brisbane. 5 and 6. Leaf bulb galls on colony plant, *C. glauca*. 7. Colony plant 7 days after adults of *S. utilis* introduced.

Pictures of infested plants (Figs 1–4) were taken by Aubrey Moore using a Leica EZ4 digital microscope and a Nikon D90 camera; and (Figs 5–7) by Bradley Brown using a Canon 5D Mark II and a Sanyo Xacti E6. Habitus, wing, antenna and SEM images were taken by Nicole Fisher. Habitus images of *S. casuarinae* and *S. utilis*. (Figs 8, 14) were taken using a Canon 5DmkII, wing and antenna images (Figs 9–11, 15) were captured using a Leica M205 C microscope. SEM images (Figs 12, 13, 16–19) were photographed using a Zeiss Evo Series Scanning Electron Microscope using a Carl Zeiss SmartSEM software.

On Guam, a survey was done to measure damage to *C. equisetifolia* by *S. casuarinae* (Moore, unpublished). The most horizontally protruding branch with a height of between 2 to 3 meters was cut from each tree. The branch sample was trimmed so that it contained only the terminal foot (30.5 cm) of woody tissue. All branchlets were removed and tips were examined under a Leica EZ4 digital microscope. Branchlets from each branch sample were sorted into two groups: those with and without tip galls. Biomass was determined for each group by weighing after drying in an oven for 48 hours.

***Selitrichodes* Girault**

Selitrichodes Girault, 1913[145]: 104–105. Type species: *Selitrichodes fasciiventris* Girault, original designation.

Zagrammosomoides Girault, 1913[146]: 177. Type species *Zagrammosomoides fasciatus* Girault, original designation, Synonymy by Kim *et al.*, 2008: 8.

Epomphaloides Girault, 1913[156]: 49–50. Type species *Epomphaloides flavus* Girault, original designation. Synonymy by Kim *et al.*, 2008: 8.

Remarks. *Selitrichodes* was treated by Kim *et al.* (2008), who removed it from synonymy under *Aprostocetus* Westwood, provided a generic diagnosis, recognized 12 valid species, and pointed out that this genus would probably contain many more species. Although exact biology and host plants are unknown for most species, most of them appear to be associated with galls in some manner. Two species have been subsequently described in this genus: *S. globulus* La Salle & Gates as an invasive gall inducer on *Eucalyptus globulus* in California (La Salle *et al.* 2009), and *S. neseri* as a parasitoid of the invasive gall inducer *Leptocybe invasa* (Kelly *et al.* 2012).

A key to Australian Tetrastichinae genera was provided by Bouček (1988), but did not recognise *Selitrichodes* as distinct from *Aprostocetus*. A key to North American Tetrastichinae genera was provided by La Salle (1994), and keys to all North American Eulophidae genera were supplied by Schauff *et al.* (1997). In these keys *Selitrichodes* would key to *Baryscapus* or *Aprostocetus*, but can be distinguished by the diagnostic characters given in Kim *et al.* (2008), which are repeated below.

Diagnosis. SMV usually with 2 or 1 (more rarely 3) dorsal setae. PMV developed, although shorter than stigmal vein. Propodeum without a raised lobe of callus which partially overhangs outer rim of spiracle. Cercal setae short and subequal in length. Mesosternum anterior to trochantal lobe convex and without a precoxal suture. Malar sulcus generally curved, and gena may be somewhat swollen. Most species are non-metallic, ranging from black or brown to yellow. The two species described in this paper can have slight metallic tinges. All funicular segments subquadrate or slightly transverse (except *S. utilis* described in this paper with elongate funicular segments). Males with 3 funicular segments, as opposed to 4 segments as is typical in Tetrastichinae.

The two newly described species that form galls on *Casuarina* are clearly related and can be distinguished from other species of *Selitrichodes* based on their distinctive colour markings: mesosoma and head generally black, but with bright yellow face, at least fore and middle coxae bright yellow. The following key will distinguish females of the two *Selitrichodes* species known to induce galls on *Casuarina* (males are unknown for *S. utilis*).

Key to *Selitrichodes* species known to induce galls on *Casuarina* (based on females)

- 1 Malar sulcus with black mark at junction with eye. F1 distinctly (up to 1.5×) longer than wide (Fig. 16). Basal vein without setae or with only 1 seta (Fig. 15).....*S. utilis*
 1' Malar sulcus completely yellow. F1 quadrate to wider than long (Fig. 10). Basal vein with 3 or 4 setae (Fig. 9).....*S. casuarinae*

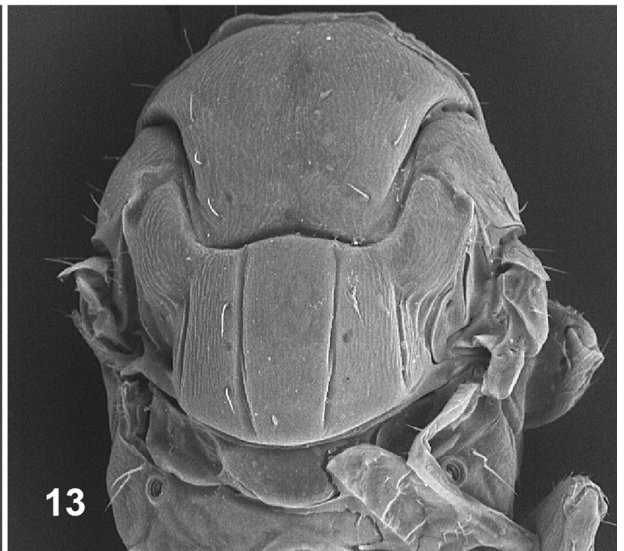
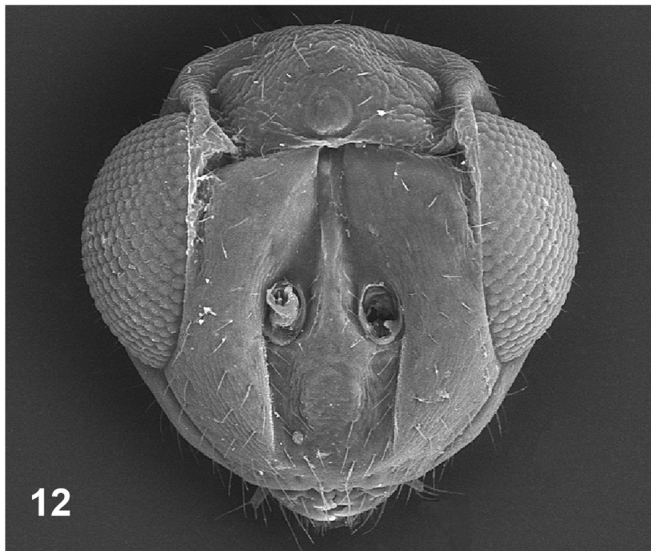
Selitrichodes casuarinae Fisher & La Salle, sp. n.

(Figs 8–13)

Female. Length 0.7–1.2 mm. Head generally yellow, with the area bordering eye margin posteriorly light brown to dark brown, covering the ocellar triangle, and back of head. Clypeus light brown ventrally. Antenna with scape yellow, dorsal margin light brown; flagellum light brown to yellow. Mesosoma dark brown (may have metallic reflections), with yellow markings as follows: dorsellum (may range to light brown in some specimen), tegula, and small patch on mesopleuron just ventral to tegula. Gaster dark brown, with transverse yellow to light brown stripes of varying strength along posterior margin of each tergite. Fore and middle coxae yellow, hind coxa dark brown to lighter yellow apically; trochanters light yellow; femora light yellow, fore tibia light brown to yellow; middle and hind tibiae yellow, tarsi light yellow, dark brown apically.

Fore wing (Fig. 9) hyaline. Submarginal vein usually with 3 dorsal setae. Relative length of wing veins: CC: MV: STV: PMV = 0.2–0.22 : 0.24–0.25 : 0.065–0.075 : 0.03–0.035. PMV one-third to one-half length of stigmal vein. Speculum small, partially closed posteriorly with cubital line of setae extending almost to basal vein. Basal vein with 3 or 4 setae. Wing disk beyond speculum densely pilose.

Antenna (Fig. 14) with 3 funicular segments and a 3 segmented club. F1–F3 quadrate, each successive funicle segment increasingly broader than the last. Length/width ratio of F1 0.35–0.4; F2 0.4–0.45; F3 0.5–0.55. Clava 2.0× longer than wide, wider than funicle, without distinct terminal spine; C3 very short and its end broad, not tapering apically. Scape slightly flattened ventrally.



FIGURES 8–13. *Selitrichodes casuarinae*. 8. Holotype ♀, habitus, lateral view. 9. Fore wing, ♀. 10. Antenna, ♀. 11. Antenna, ♂. 12. Head, frontal view, ♀. 13. Mesosoma, dorsal view, ♀.

Head (Fig. 12). Ocellar triangle not surrounded by grooves. POL about 1.5× as long as OOL. Scrobal area without distinct median carina. Torulus located at middle of face, above level of lower margin of eye. Face with a broad depression (supraclypeal area) below torulus extending to clypeus and with some pilosity. Gena only slightly swollen and with malar sulcus somewhat curved near mouth margin. Mandible bidentate. Clypeal margin bilobed. Pronotum very short medially in dorsal view. Midlobe of mesoscutum without median groove and with one row of 3 or 4 adnotaular setae on each side; notauli quite deep. Mesosternum convex just in front of the trochantal lobes and without precoxal suture. Scutellum with 2 pair of setae. Dorsellum rounded posteriorly and slightly overhanging propodeum. Propodeum medially shorter than dorsellum in dorsal view; with median carina. Propodeal spiracle with entire rim exposed and separated from anterior margin of propodeum by less than half its longest diameter. Paraspircular carina absent. Propodeal callus with 2 setae.

Metasoma. Gaster slightly shorter than mesosoma in dried specimens. Hypopygium reaching more than half the length of the gaster. Cercus with 4 slightly curved setae; longest 2 cercal setae subequal in length, relatively short and similar to surrounding setae. Epipygium wider than long. Ovipositor sheaths not protruding beyond apex of gaster.

Male. Length 0.75–1.25 mm. Body color pattern similar to female, but with more dark brown markings on mesosoma and gaster. Dorsellum light brown to yellow. Antenna (Fig.11) with a ventral plaque on scape, the plaque less than one-third length of scape, and situated near apex of scape.

Type material. Holotype ♀: USA: Guam, Polaris Pt., 6 Jan. 2009, Aubrey Moore, ex *Casuarina equisetifolia*, Database no. 32-022423 (ANIC).

11♀, 29♂ Paratypes. 8♀, 26♂: same data as holotype (4♀, 17♂ ANIC; 1♀, 3♂ QMB; 1♀, 3♂ USNM; 2♀, 3♂ ESUG). 6♀, 3♂: Palau, Koror, 12 Mar. 2009, J.Miles, ex *Casuarina* (3♀, 3♂ ANIC; 1♀ QMB; 1♀ USNM; 1♀ ESUG).

Distribution. Micronesia: Guam, Rota and Palau. This species is presumed to be Australian in origin, although its distribution in Australia is still unknown.

Etymology. Named for the host plant.

Pest status. A damage survey on Guam showed that *C. equisetifolia* branchlets with galled tips were noticeably stunted in comparison to those that were not attacked. Dry biomass of branchlets with galled tips was reduced by 35% (t-test; $t = 3.06$, $df = 13$, $p\text{-value} = 0.009$).

***Selitrichodes utilis* Fisher & La Salle, sp. n.**

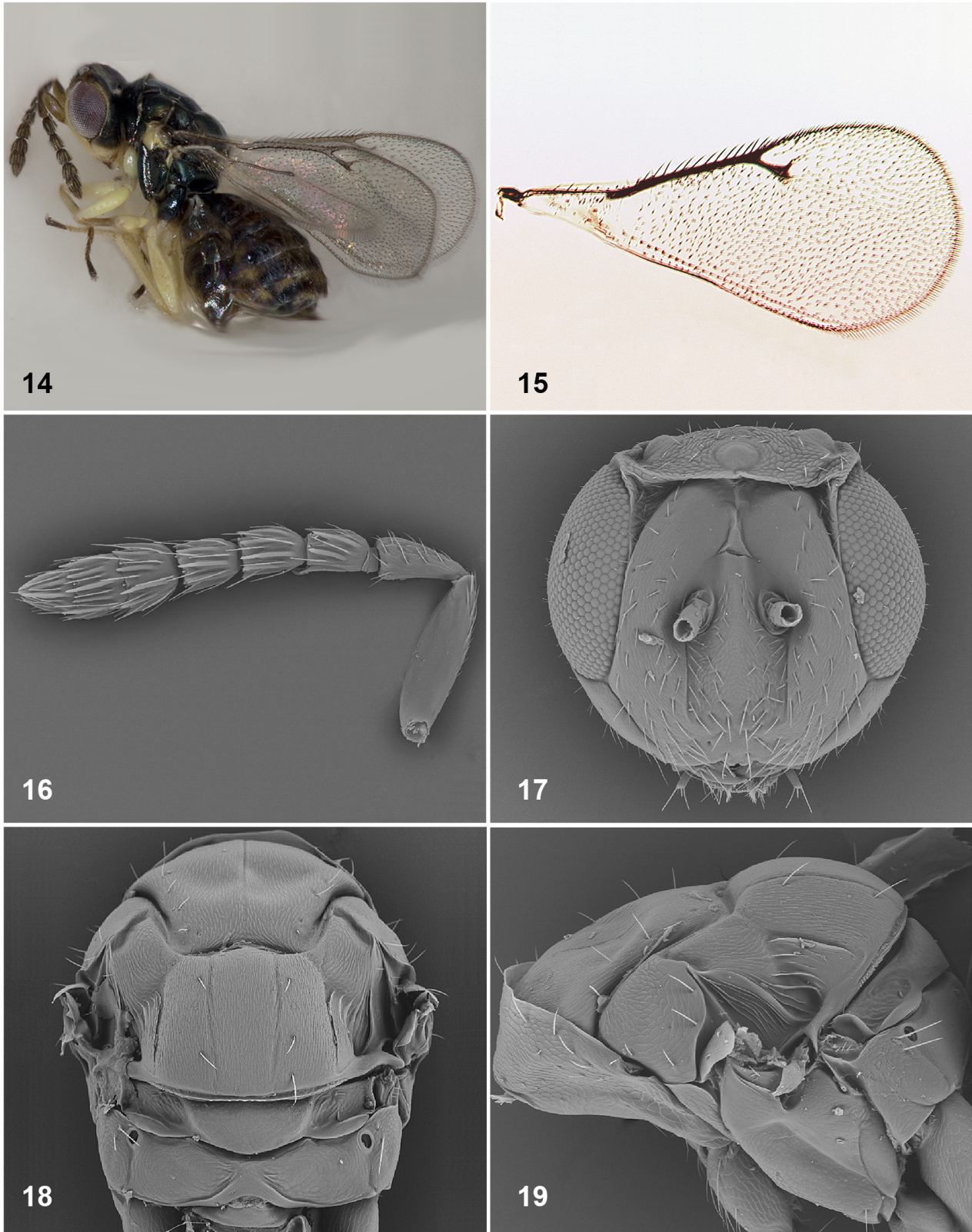
(Figs 14–19)

Female. Length 0.85–1.55 mm. Head generally dark brown to metallic green, with the following areas light brown to yellow: eye margin, both anteriorly and posteriorly, extending from ventral eye margin to vertex (although weaker on vertex) and frontovertex extending from ocelli down to clypeus. Malar sulcus with a dark mark near junction with eye. Antenna with scape light brown on dorsal margin; yellow on lateral and ventral margins; flagellum light brown. Mesosoma with a distinct dark metallic green tinge, tegulae and notauli yellow. Gaster light brown to yellow; gastral tergites dark brown along posterior margin. Fore coxa yellow; middle coxa brown, yellow apically; hind coxa dark metallic green; trochanters, femora and tibiae yellow; tarsi light brown, dark brown at tip.

Fore wing (Fig. 15) hyaline, venation pale brown. Submarginal vein usually with 3 dorsal setae; tapering apically and joining with parastigma at base of parastigma. Veins light brown to brown. Stigma darker and swollen compared to other veins. Relative length of wing veins: CC: MV: STV: PMV = 0.27–0.36 : 0.26–0.37 : 0.09–0.11 : 0.05–0.07 . PMV over half the length of STV vein. Speculum small and open below; cubital line of setae not extending to basal vein, basal vein usually without setae or with 1 seta. Wing disk beyond speculum densely pilose.

Antenna (Fig. 16) with 3 funicular segments and 3 segmented club. Length/width ratio of F1 0.7–0.4; F2 0.65–0.45; F3 0.65–0.60. Clava 2.5× longer than wide, wider than funicle, and with distinct terminal spine. Sensilla nearly as long as the funicular segments. Scape slightly flattened ventrally.

Head (Fig. 17). Ocellar triangle not surrounded by grooves. POL about 1.5× as long as OOL. Scrobal area with a small cracklike suture present about halfway between frontal suture and torulus. Torulus located at middle of face, above level of lower margin of eye. Face with a broad depression (supraclypeal area) below torulus extending to clypeus and with pilosity. Malar sulcus slightly curved. Mandible bidentate. Clypeal margin bilobed.



FIGURES 14–19. *Selitrichodes utilis*, ♀. 14. Holotype, habitus, lateral view. 15. Fore wing. 16. Antenna. 17. Head, frontal view. 18. Mesosoma, dorsal view. 19. Mesosoma, lateral view.

Mesosoma (Figs 18,19). Pronotum very short medially in dorsal view. Mid lobe of mesoscutum with a very weak median groove and with one row of 4 or 5 adnotaular setae on each side; notauli quite deep. Mesosternum convex just in front of the trochantal lobes and without precoxal suture. Scutellum with 2 pairs of setae,

occasionally a third seta may be present. Dorsellum rounded posteriorly and very slightly overhanging propodeum. Propodeum with median carina, medially shorter than dorsellum in dorsal view. Propodeal spiracle with entire rim exposed and separated from anterior margin of propodeum by less than half its longest diameter, with shallow groove descending from spiracle to posterior margin of propodeum. Paraspicular carina absent. Propodeal callus with 2 setae.

Metasoma. Gaster equal in length to mesosoma. Hypopygium reaching nearly two-thirds the length of gaster. Cercus with 3 setae, 2 longest subequal in length and slightly curved. Ovipositor sheaths slightly protruding beyond apex of gaster.

Male. Unknown.

Type material. Holotype ♀: AUSTRALIA: Qld, 5.3km SSW Brisbane, Long Pocket Labs., 27°30.70'S 152°59.81'E, 2 Nov. 2010, B.Brown, em. tip of *Casuarina glauca* ABCL 2009071.V076-100, Database no. 32-059016 (ANIC).

53♀ Paratypes. 20♀: same data as holotype (11♀ ANIC; 3♀ QMB; 3♀ USNM; 3♀ ESUG). 1♀: same data as holotype except 2 Nov. 2010, ABCL 2009071.V075 (ANIC). 18♀: same data as holotype except 21 Oct. 2010, ABCL 2009071.V049-071 (ANIC). 8♀: same data as holotype except 13 Mar. 2009, ABCL 2009029.V012-022 (ANIC). 6♀: same data as holotype except 6 Apr. 2009, ABCL 2009071 V001-007 (ANIC).

Distribution. Australia: Queensland (Brisbane) and New South Wales (Byron Bay).

Etymology. The Latin word *utilis* indicates the useful or beneficial nature of this species, which is being investigated as a biological control agent against invasive *Casuarina* species in North America.

Acknowledgments

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